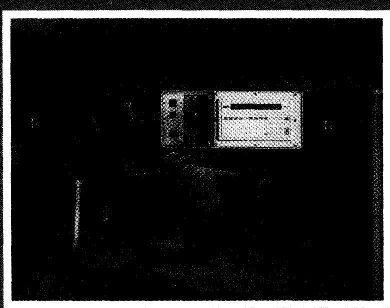
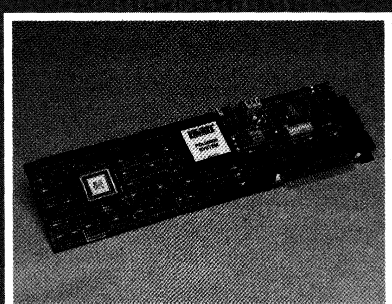
BURR-BROWN®

The Handbook of Personal Computer Instrumentation

Data Acquisition, Test, Measurement, and Control

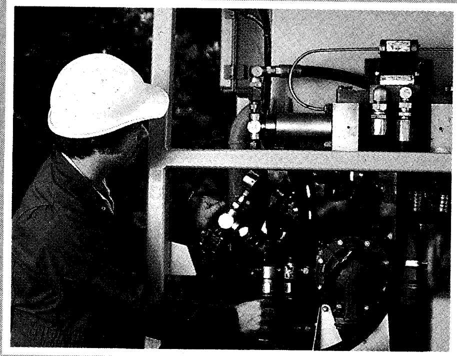
Fifth Edition



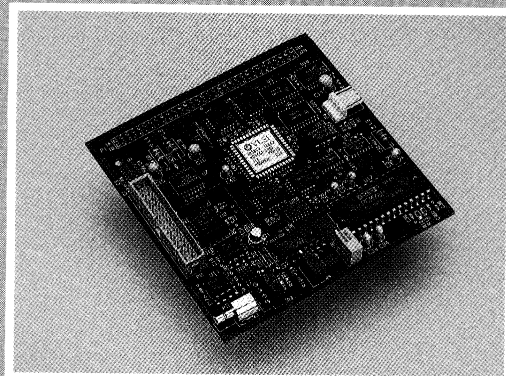


NEW DATA ACQUISITION PRODUCTS

In this, the Fifth Edition of the PCI Handbook, we have greatly expanded our line of personal computer data acquisition systems. Among these exciting new products, you will find powerful new data acquisition products for the IBM PS/2 (Micro Channel bus) and the Apple Macintosh II (NuBus). These new product lines include state-of-the-art hardware, extensive software support, and compatibility with our broad line of signal conditioning accessories. The NuBus product line includes the innovative NuCarrier which taps the power of our PCI-20000 I/O modules and the I³ Bus (see page 1-5) to offer the industry's most flexible line of data acquisition products for the Mac II.

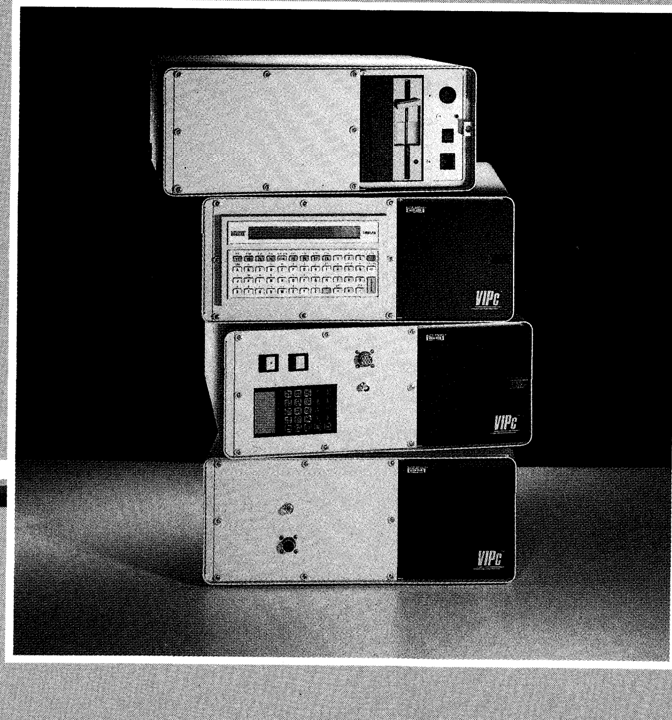


In another major broadening of our product line, we are introducing a complete new line of IEEE-488 compatible products, with support for PC/XT/AT/EISA, PS/2, and Macintosh computers. These products are ideal for those who want to integrate systems incorporating external test instruments as well as PCI hardware and software. These new GPIB interface products include driver software that is fully compatible with the IEEE-4888 standard. They are also compatible with high-level software such as LABTECH NOTEBOOK, ASYST, DADiSP, and others.

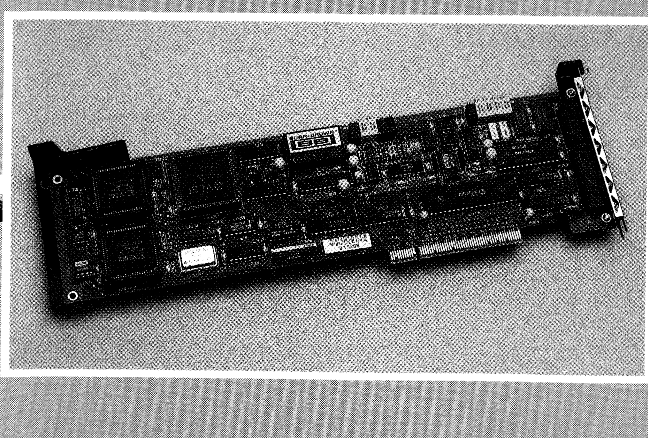


Our versatile new instrumentation platform, the VIPc, is a giant step forward in easing the task of integrating a user-defined, personal computer based system. Completely PC/XT/AT compatible, the VIPc incorporates the features most needed by designers and integrators of industrial and laboratory systems for data acquisition, test, measurement, and control. We're confident that you'll find it to be the platform of choice for your next PC/XT/AT system design.

We've also expanded our line of digital signal processing products for PC/XT/AT/EISA and compatible personal computers. New higher speed DSP hardware combines with high level software to yield intelligent systems for data acquisition, test, measurement, and control. We've also added a fast, 16-bit A/D capability to our analog input module family. This new module is useful for both DSP applications and for general-purpose data acquisition of low-level signals.



Our signal conditioning, front-end products are designed to preserve the integrity of your input signals, recognizing that the ultimate performance of your data acquisition system depends on the quality of the acquired data. New products here include low-noise isolation blocks, a new family of Euro-Style signal termination panels, and appropriate (shielded) cables.



P.v. Deane
April 91

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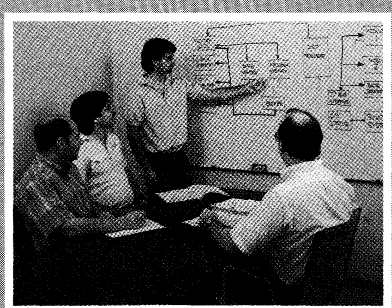

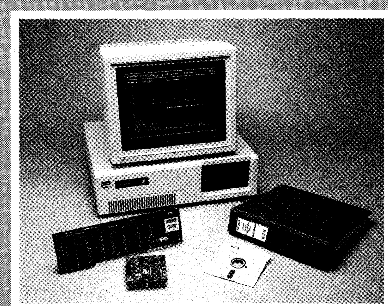

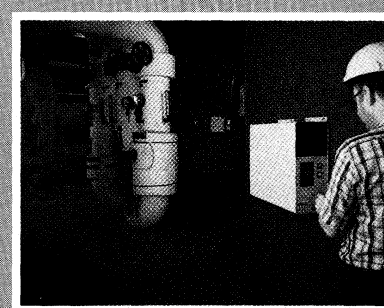

BURR-BROWN®

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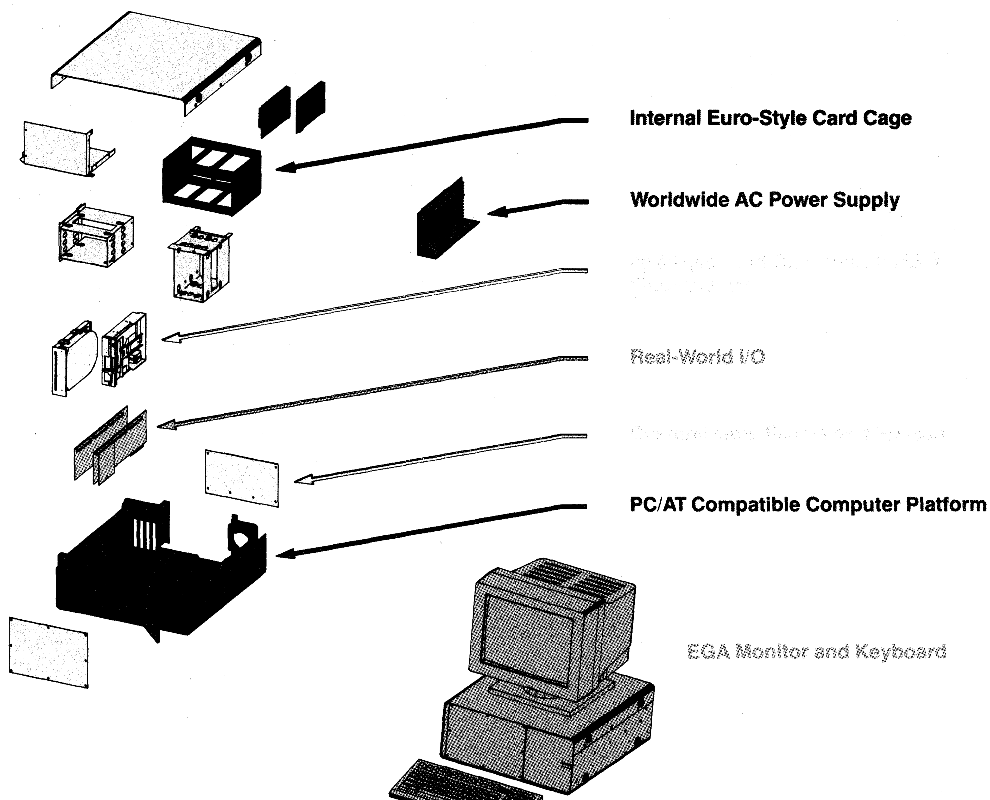
VIPc Is Ideal For OEM, VAR, System Integrator, And In-House Test Applications



The Burr-Brown VIPc has something for everyone. It is an "embeddable" personal computer, an elastic computer...a computer to be molded into a final form. It can be the foundation for a system or part of a larger system. Certainly it has the features of a powerful PC/AT-class machine; disk drives, EGA graphics, keyboard, communications ports, etc. But that is only the beginning. VIPc is more than a PC. Much more!

VIPc is an adaptable intelligent instrumentation platform. Up to four PCI-20000 data acquisition and control boards can plug directly into the available PC/AT expansion slots. It contains an internal EMI-shielded card cage that can hold up to 10 signal and field wiring termination panels.

VIPc is a hardware prototyping shell. The platform lets you embed the power of a computer directly into your system, product or application. The front panel, back panel, and the top cover can be easily removed and customized. Switches, indicators, an alphanumeric display, and connectors can be installed. There is also room for a Burr-Brown Microterminal or various displays. In addition to termination panels, the built-in card cage can also hold 3U-size VME boards.

VIPc is an industrial-grade computer. The disk drives are shock-mounted and protected from dust by a door plus filtered, positive pressure, air. Mounting options allow for installation in a standard 19-inch equipment rack, or on a desk, or under a factory conveyer, or on a wall. VIPc can be a transportable workstation. With its removable carrying handle it can be carried on most airlines. Weight is less than 30 pounds (13.6Kg).

VIPc is a tool. Think of it as a standard component, destined to be transformed into something new and different. It is the skeleton of your computer-based system design. It supports you through the classic three-step transformation process that includes development, design prototyping, and the refined end-product. VIPc will be what you make it...a laboratory data acquisition system, automotive engine analyzer, factory-floor programmable controller, weather-trend data logger, specialized point-of-sale terminal, production-line test controller, etc.

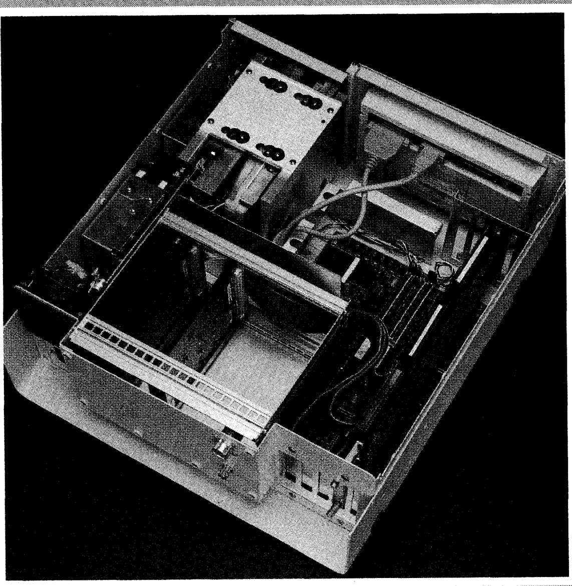
VIPc does the job. It keeps cost low and shortens development time. VIPc gives you options and keeps you in command.

Basic Features

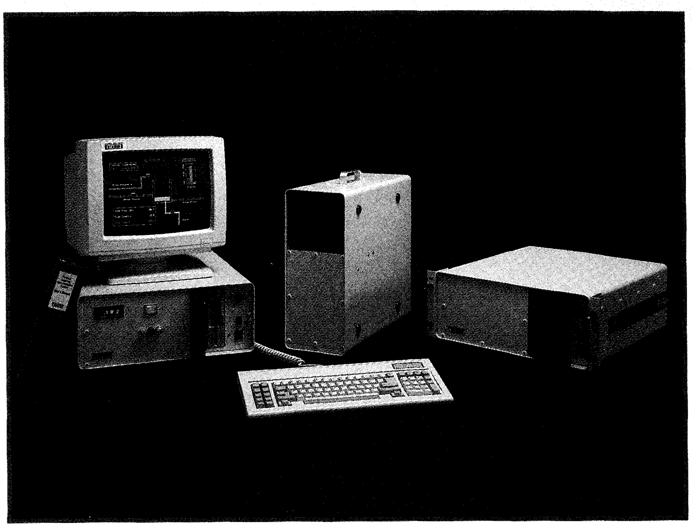
VIPc integrates an adaptable rack-mountable enclosure, an internal Euro-Style card cage, and a fully compatible PC/AT-class computer. The rugged motherboard contains all essential PC functions, including RAM, a graphics adapter, a disk controller, serial and parallel ports, and a real-time clock/calendar with battery backup. Standard monochrome, Hercules, CGA, and EGA compatible monitors can be used. There are two serial ports (RS-232 type), a parallel (printer) port and four PC/AT bus expansion slots (three 16-Bit and one 8-Bit) that accept a wide range of analog and digital I/O products such as the powerful PCI-20000 family for data acquisition. The disk drive controller can support two ANSI type floppy disk drives (5-1/4" or 3-1/2"), and up to two hard disk drives, in any combination.

Customer Modifiable Features

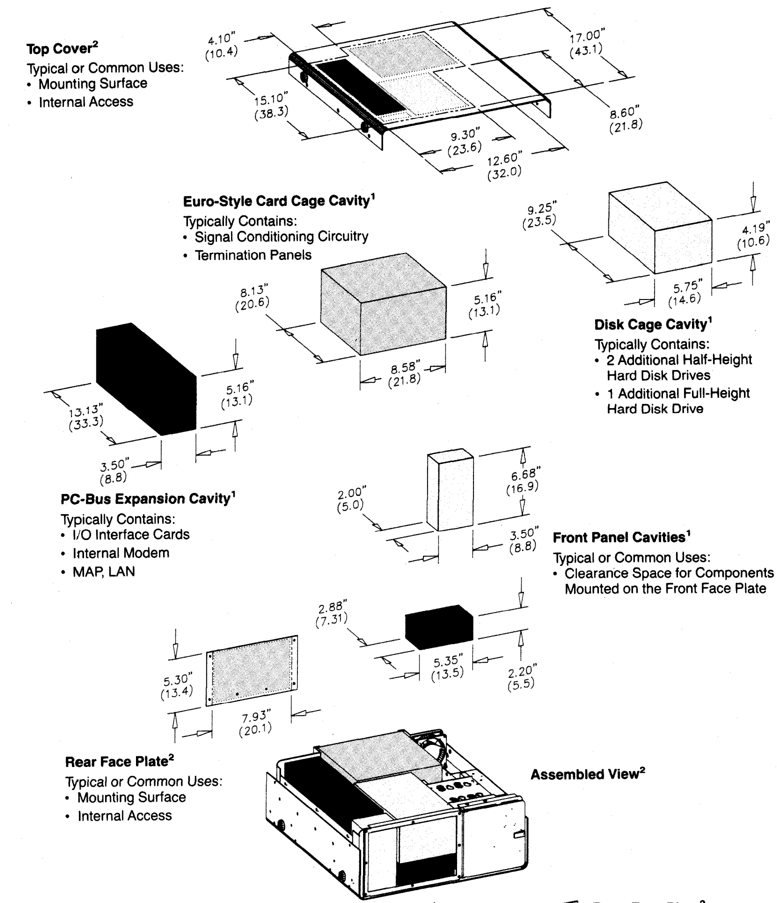
VIPc is housed in an easily adaptable enclosure. Many of its panels and internal spaces are specifically designed for user customization. Its "elastic" character readily conforms to your application. Both of the face plates and the top cover can be easily removed, drilled, punched, or painted again as needed. For example, an external monitor or other equipment could be directly fastened to the cover. There is even sufficient room behind the front faceplate to permit devices (e.g., connectors, switches, keypad, microterminal, LCD monitor, etc.) to be installed internally. Likewise, the rear faceplate can also accommodate connectors and other devices. Signal wiring from the panel is easily routed to the card cage and other internal circuitry. When using "short" I/O boards, the PC-Bus card-guide bracket (located behind the front panel) can be removed, freeing additional space.



A custom application of VIPc with an I/O board, a microterminal, and Euro-Style termination panels installed. Note rear faceplate signal connectors.



User-Definable Surfaces and Spaces



Figures in parenthesis ( ) represent centimeter measurements.
1) *When these spaces are not used for the "typical" functions indicated, other components can be installed.*
2) *Color-coded dotted lines show "projected" locations of internal cavities. Black phantom lines define the boundries of customizable areas.*

VIPc FEATURES BY MODEL NUMBER

PCI MODEL NUMBER	TABLETOP MONITOR 100/110V	220/240V	512K RAM	1M RAM	2M RAM	20Mbyte HARD DISK	40Mbyte HARD DISK	80287 COPROCESSOR	MS-DOS VER. 3.3
PCI-5001H-1	X	-	-	-	X	-	X	X	X
PCI-5001H-2	-	X	-	-	X	-	X	X	X
PCI-5002H-1	-	-	-	-	X	-	X	X	X
PCI-5003H-1	X	-	X	-	-	-	X	-	X
PCI-5003H-2	-	X	X	-	-	-	X	-	X
PCI-5004H-1	-	-	X	-	-	-	-	-	-
PCI-5016H-1	-	-	-	X	-	X	-	-	X
PCI-5017H-1	-	-	-	X	-	-	X	-	X

NOTE: All VIPc models shown above include a 12.5 MHz, PC/AT compatible CPU, hard and floppy disk controller, EGA/CGA/Hercules graphics interface, 2 serial ports, 1 parallel port, coprocessor socket, international power supply, 1.2M floppy disk drive, 101-key keyboard, 4 expansion slots for I/O or other purposes, internal EMI-shielded Euro-Style card enclosure, positive-pressure filtered air-cooling, front/rear/top customizable covers and faceplates.

OPTIONAL ACCESSORIES

PCI-2500-1 Numeric keypad with mounting kit
PCI-8500-1 Alphanumeric keyboard with mounting kit
PCI-5005A-1 2Mbyte RAM expansion kit
PCI-5006A-1 80287-8 Coprocessor
PCI-5007A-1 40Mbyte (28mS) hard disk
PCI-5008A-1 Rack-mount hardware for VIPc base unit
PCI-5009A-1 Internal disk drive mounting cage
PCI-5010A-1 EGA Monitor, tabletop, 100/110/120VAC
PCI-5010A-2 EGA Monitor, tabletop, 220/240VAC
PCI-5012A-1 Vertical-mount base plate
PCI-5013A-1 Extra front faceplate
PCI-5014A-1 Extra rear faceplate
PCI-5015A-1 Front door without logos
PCI-5024A-1 3.5-inch floppy disk drive, 1.4MB
PCI-5027A-1 EGA Monitor, industrial, rack-mount, universal power supply
PCI-20000 Data acquisition products

Other combinations of standard features are available on special order in OEM quantities. Please contact your local Burr-Brown sales engineer for additional information.

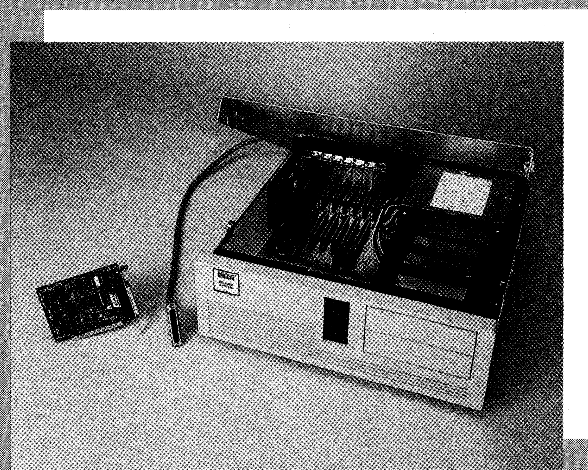
PC EXPANDER

For the IBM PC Bus

PCI-20055H-3
(90-132 VAC, 47-63 Hz)
PCI-20055H-4
(180-264 VAC, 47-63 Hz)
PCI-20063A-1,
PC Host Interface Board

- 7 Slot Capacity
- 200 Watt Internal Power Supply
- Bench-Top or Rack-Mount Installation
- Easy-Access Flip-Top Lid
- Compatible with PCI-20000 System Components

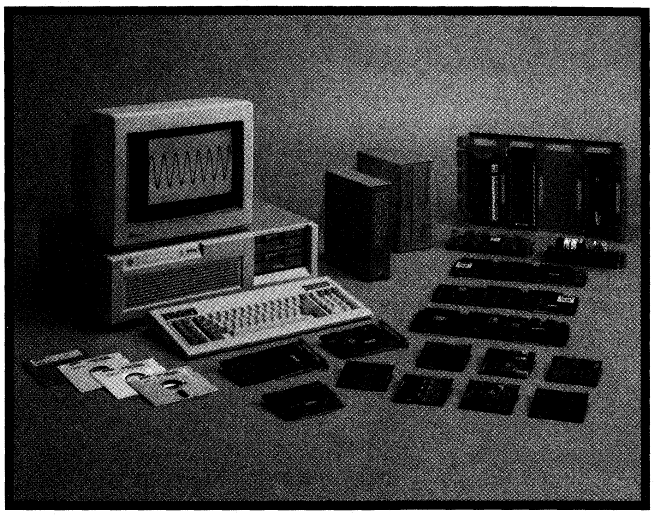
The PC Expander is designed to enhance the expandability and power handling capabilities of any IBM compatible personal computer (PC) used in data acquisition, test, measurement and control applications. The PC Expander extends the application potential of a computer by adding up to 7 additional expansion slots and a fan cooled 200 watt internal power supply. The combination of increased power and expandability permits the construction of medium to large-scale installations. Systems containing 300 to 600 channels are easily accommodated. In addition, multiple PC Expanders can be used when even larger configurations are required. The convenient, flip-top lid on the Expansion Box provides easy access to a test and measurement system without disturbing the host computer. Both desktop and rack installations are supported by the attractive housing. The width of the enclosure is 17.4 inches (44cm) allowing convenient tray mounting in a standard 19-inch rack. The only component that goes into the host PC is a half-size, plug-in, interface driver board (PCI-20063A-1). This board is essential for operation of the PC Expander. Interface boards are sold individually so that one PC Expander-based system can be shared (only one is connected at a given time) by several computers, each with a PCI-20063A-1 installed.



The high speed of the interconnection hardware allows the PC Expander to be used with virtually all PC compatible machines with *bus speeds* up to 10MHz. It is important to note that most compatible computers with CPU speeds in excess of 8MHz divide the clock speed to 8MHz (or less) before connection to the expansion bus. This is done to maintain compatibility with the wide range of add-in boards available. Thus, even most 80286 and 80386 computers running at 12, 16 and even 20MHz are still compatible with the PC Expander.

PCI Modular System: The Industry's Most Flexible Data Acquisition Product Line

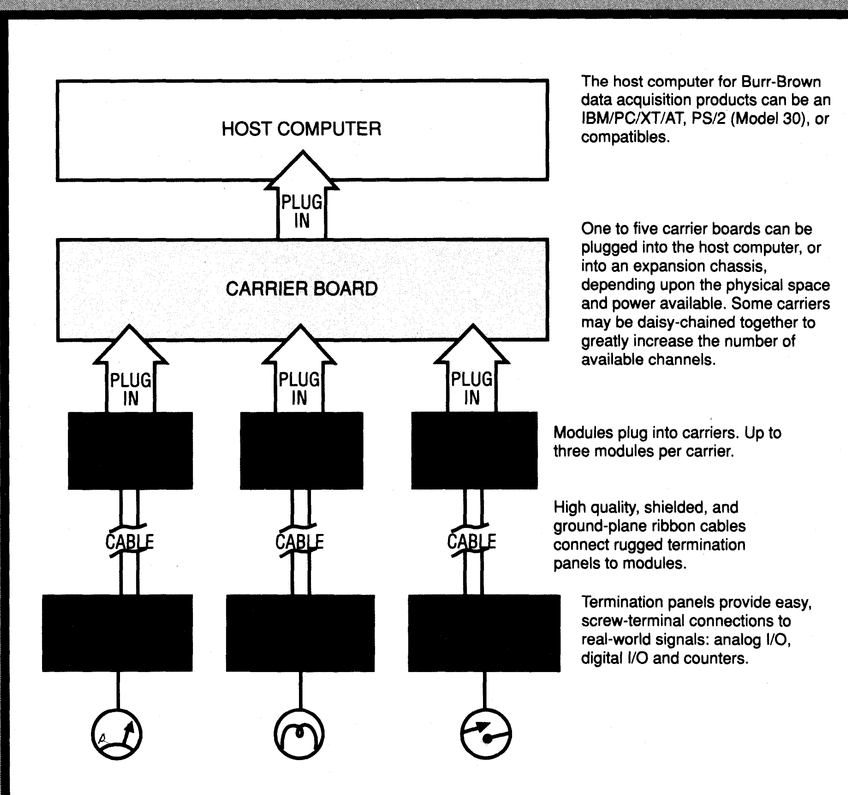
Burr-Brown's PCI Modular Data Acquisition System provides the ultimate in cost-efficient, flexible, expandable data acquisition systems. The PCI-20000 System is based on the concept of a Carrier, a board that plugs directly into the PC Bus and provides mounting space for up to three I/O Modules. The plug-in Modules determine the exact functionality of the System. Modules such as A/D converters, D/A converters, and counter/timers communicate with one another via the Intelligent Instrumentation Interface—the I³ Bus—that resides on the Carrier. The I³ Bus allows each Module to send and receive analog, digital and synchronization signals to and from adjacent Modules and, in some cases, to and from adjacent Carriers. This allows the combining of Modules into sophisticated systems for a variety of tasks. The Carrier also provides high-quality power supply voltages to each module on the I³ Bus, plus other functions such as digital I/O, a pacer clock, and high speed DMA transfers (depending on the exact Carrier model chosen).



The I³ Bus permits new Modules with more features or higher performance to be added to a system as technology improves. Also, a system can be expanded, if the number of channels or types of measurements or controls required increase, by adding Modules to vacant positions on a Carrier, and by adding additional Carriers to accommodate the new Modules as required.

A wide variety of I/O types are supported: analog input (voltage, current, thermocouple, etc...), simultaneous multiple channel readings, analog output, digital input, digital output, counter input, frequency measurement, pulse generation along with high speed triggering and alarm monitoring.

Relatively large numbers of channels can be accommodated. Up to 128 digital I/O points or 80 analog inputs or 24 analog outputs or 12 counter/timer ports can be configured on a single Carrier, using the Modules available. For larger systems, multiple Carriers can be used simultaneously.

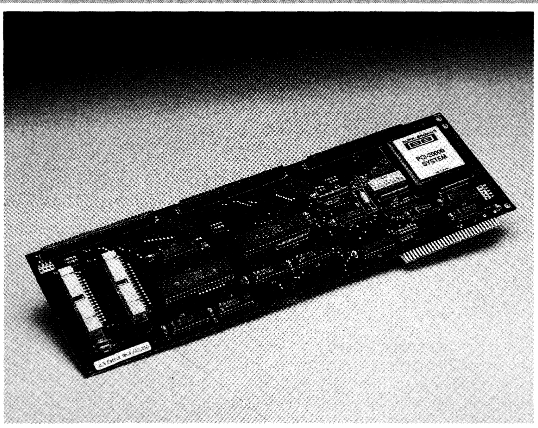


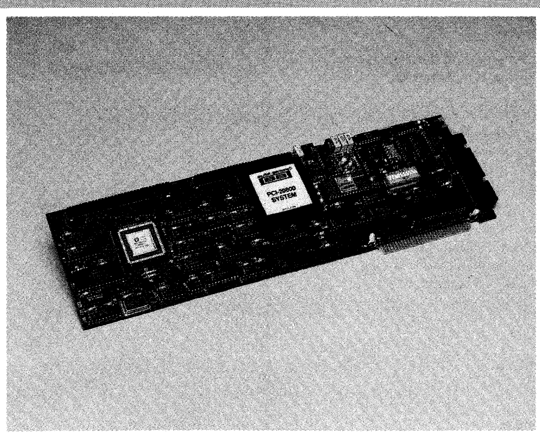
In addition to the memory and digital I/O connections provided by a standard computer bus, the internal Intelligent Instrumentation Interface (I³) Bus also provides for analog, synchronization, and trigger signal routing. This facility allows the chaining of analog signals from one module to another as well as the triggering and synchronizing of events on a particular Module by another Module.

Hundreds of different system configurations can be assembled by intermixing the wide variety of components within the PCI System family. This permits each unique application to be satisfied without cost and performance compromises.

PCI-20000 CARRIER FAMILY

All PCI-20000 Carriers are designed to interface directly with any IBM PC/XT/AT/EISA compatible computer through a PC Bus expansion slot. The growing family of PCI-20000 Carriers offers extensive capabilities for data acquisition, signal processing and control, making possible many exciting new applications. The Carriers of the PCI-20000 family share a number of major features, including the Intelligent Instrumentation Interface (I^3) Bus, with its capacity to support the PCI-20000 I/O Modules. The I^3 Bus supports analog, digital, and sync signal communications between the PC Bus and the Modules, and from Module to Module. The sync lines make possible the coordination (timing) of various system elements. The differential analog chain within the I^3 Bus allows any Module to pass its output signal to, or receive an analog signal from, an adjacent Module on the Carrier. Bus translation circuitry links the PC Bus to the I^3 Bus. Logic for interrupt control, Carrier identification and Module selection is also included. Each Carrier is addressed into the memory map of the PC, and requires one kilobyte of space. DIP switches (or software selection on some Carriers) allow placing the Carrier anywhere within the one megabyte of available memory address space. The actual I/O functionality of the Carrier and Module combination is determined by the characteristics of the Carrier and by the specific combination of I/O Modules. Because the PCI-20000 product line now contains at least six different Carriers and at least 14 different I/O Modules, the possible number of combinations is extremely large. This allows the user to select a configuration which is closely matched to his requirements, with a minimum of unused functionality, while retaining the flexibility for future system expansion or modification.





Each of the Carriers provides mounting positions for either two or three I/O modules (see Selection Guide on page 1-7). All power is derived from the +5VDC power supply of the host computer. A DC/DC converter on the Carrier generates regulated ± 15VDC for use by the Modules. Several Carriers can be installed in one PC, up to the limits on available expansion slots. A Carrier fully loaded with Modules occupies two expansion slots in the PC.

The PCI-20000 Modular System is supported by a very wide range of powerful and useful software. For those who desire to write their own applications programs, software drivers are available to execute all operating modes and features of the Carriers and Modules. These drivers, which are described in more detail on pages 1-18, 1-19, and 1-20, are available in BASIC, TURBO PASCAL, and C language versions. In addition, a wide variety of menu-driven software is available for use with the PCI-20000 System in applications ranging from laboratory automation to signal processing and industrial control. Carriers are shipped with a diagnostic software package which enables the user to easily verify proper installation and operation of the PCI-20000 hardware in his system.

General Purpose Carriers

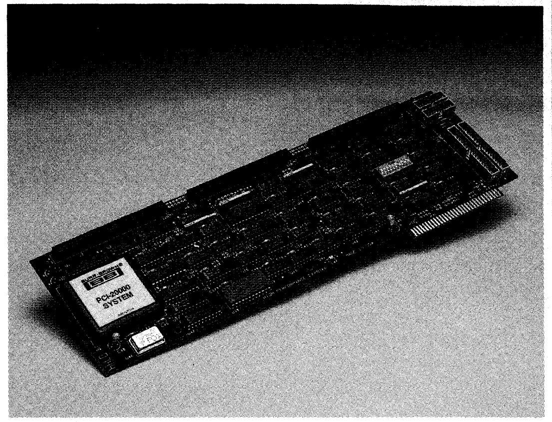
The PCI-20001C-2A is the simplest and lowest cost of the Carriers. It supports up to three I/O Modules and provides mounting space, regulated DC power, I^3 Bus communications, and PC Bus interfacing. The PCI-20001C-2A also provides 32 points of fully buffered TTL compatible digital I/O. The 32 points of digital I/O are arranged in four bytes of eight bits each. Each byte can, under software control, be configured for either input or output use. This on-board digital I/O capability leaves all three Module positions free for additional I/O functions.

Super Carrier

The PCI-20098C-1 is a multifunction "Super" Carrier that provides on-board, 12-bit analog to digital conversion for as many as 16 single-ended input signals (8 differential). This analog input channel count can be expanded in 32 channel increments up to a total of 80 channels by the use of analog expander Modules from the PCI-20000 line. The user has software programmed control over every aspect of the data acquisition process, including programmed selection of gain (x1, x10, or x100), A/D converter input ranges (±5, 0 to 10, or ±10 volts full scale), input channel selection, and the choice of single-ended or differential input configuration. No hardware jumpers are required!

The digital section of the Super Carrier contains 16 channels of digital I/O, a programmable burst/rate generator and two general-purpose counters. The crystal controlled burst/rate generator is very useful for establishing an accurate and dependable timebase for data acquisition. Bursts of pulses can be generated with a specified pulse spacing and an independently set repetition rate. This allows a group of channels to be scanned very rapidly, and at an independently determined, programmable repetition rate.

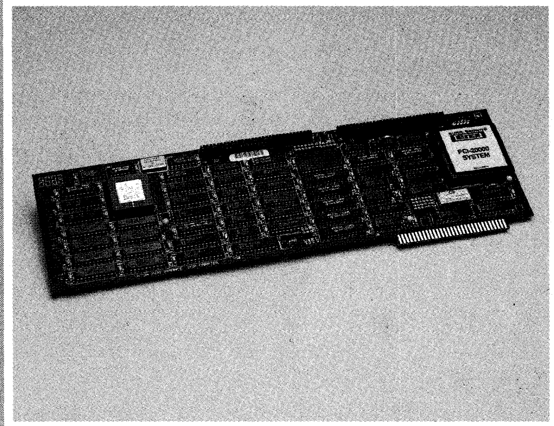
The 16 channels of TTL compatible digital I/O are arranged in two byte size ports (8 channels each) that can be programmed for either input or output use. In addition, all outputs are buffered. Full handshake and interrupt capabilities are supported. Up to 64 additional channels of digital I/O can be added by plugging digital I/O Modules into the two Module positions on the Carrier.



High Performance Carriers

The PCI-20041C-2A and PCI-20041C-3A Carriers are optimized for high speed operation and for use in systems involving considerable sophistication and as many as several hundred I/O channels. Each of these Carriers has 32 points of fully buffered digital I/O, usable as either inputs or outputs. Both also include an 8 MHz programmable pacer clock for use in the timing of data acquisition and in DMA transfers of data to and from memory. Both Carriers can operate in the programmed transfer mode, using either "polling" or "interrupt" techniques.

Continuous transfers of data to a circular buffer can be used to give pre- and post-trigger information. This allows the capture of data both before and after the occurrence of a random critical event.



Smart Carriers

For applications requiring the processing of high speed signals in real time, it sometimes is necessary to augment the computing speed of the personal computer. This is most effectively done by the use of an auxiliary digital signal processor (DSP) board. Burr-Brown has now added DSP capability to the already powerful features available in PCI-20000 Carriers. These new "Smart Carriers," using normal PCI-20000 analog input Modules, can acquire incoming data at very high speed, processing it as it is acquired. These new "Smart Carrier" products are discussed in more detail on pages 1-10 and 1-11.

Also available: NuBus Carrier for Macintosh II. See page 1-14.

SELECTION GUIDE FOR PCI-20000 CARRIERS

ON-CARRIER CAPABILITIES									
PCI MODEL NUMBER	**I/O MODULES ACCEPTED**	**ANALOG INPUT**	**DIGITAL, TTL I/O**	**PACER CLOCK**	**DMA CAPABILITY**	**INTERCARRIER BUS**	**ON-CARRIER PROCESSOR**	**ON-CARRIER MEMORY**	**ADD-ON MEMORY**
PCI-2001C-2A	3	No	32 Channels	No	No	No	No	No	No
PCI-20041C-2A	3	No	32 Channels	Yes	No	Yes	No	Frame Map	No
PCI-20041C-3A	3	No	32 Channels	Yes	Yes, For all I/O types, 360K Bytes/Sec	Yes	No	Frame Map	No
PCI-20098C-1	2	16 Channels 12 Bits 32kHz	16 Channels	Yes	Yes, For A/D Data	No	No	Channel Scan List Gain List	No
PCI-20202C-1	2	No	No	Yes	Yes, For all I/O types 400K Bytes/Sec	No	TMS320C25 (28 Mhz)	16K Program 16K Data	16K Program 48K Data Mem. Module
PCI-20202C-2	2	No	No	Yes	Yes, For all I/O types 400K Bytes/Sec	No	TMS320C25 (40 MHz)	16K Program 16K Data	16K Program 48K Data Mem. Module

PCI-20000 I/O MODULE FAMILY

The Modules of the PCI-20000 family encompass a wide range of capabilities and performance. Because this family is continually expanding, and because of the flexibility of the modular approach to PC data acquisition, the PCI-20000 System never becomes obsolete. Its capabilities continue to expand and its performance continues to benefit from new developments in technology. Each of the existing Modules of the family is described below and in the Selection Guide on page 1-9.

General Purpose 12-Bit Analog Input

PCI-20002M-1

This is the most versatile of the analog data acquisition Modules. Through its software programmable gain amplifier, the PCI-20002M-1 is able to handle both low-level and high-level signals. Gains of 1, 10, 100, and 1000 are selectable. Resolution of the A/D is 12 bits and its input ranges may be set to ± 5V, ± 10V, and 0 to 10V. The input multiplexer selects any one of 16 single-ended input channels or, alternatively, one of 8 differential input channels.

High Speed 12-Bit Analog Input

PCI-20019M-1A

The PCI-20019M-1A features general-purpose, higher speed operation for high-level or pre-conditioned signals. It provides 12-bit A/D conversion for eight single-ended input channels at conversion speeds up to 89,000 channels/second.

Very High Speed 12-Bit Analog Input

PCI-20023M-1

The PCI-20023M-1 is capable of 12-bit A/D conversion at rates of up to 180kHz. It also includes a high speed sample/hold and an input mutiplexer which scans up to 8 single-ended inputs. Input ranges are 0 to +10V, ±5V, and ±10V. It is particularly userful in DMA and DSP applications.

16-Bit High-Resolution Analog Input

PCI-20341M-1

The PCI-20341M-1 is a high-speed (up to 100kHz throughput), 16-Bit, data acquisition Module with four differential inputs (or one single-ended input). The differential inputs pass through a programmable gain amplifier. A high-speed sample/hold amplifier is also included. Capture of pre-trigger data, hardware and software pacing, and automatic channel advance are possible.

Analog Expander/Sequencer

PCI-20031M-1

The PCI-20031M-1 Analog Expander/Sequencer Module provides 32 additional multiplexed input channels.

Dual 12-Bit Analog Output

PCI-20003M-2 Voltage Out

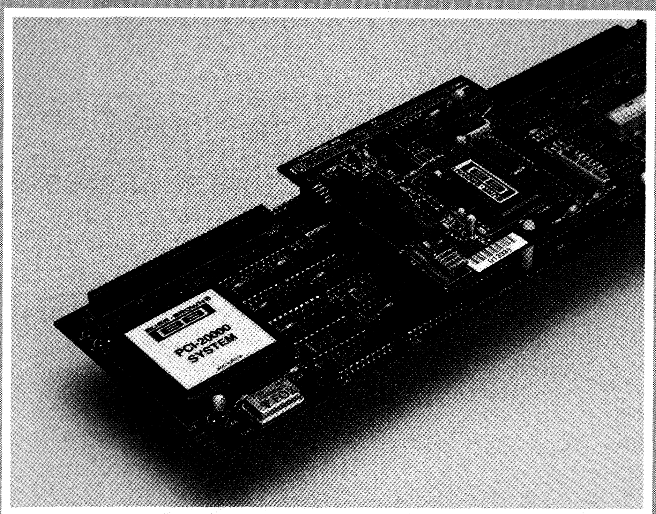
PCI-20003M-4 Current Out

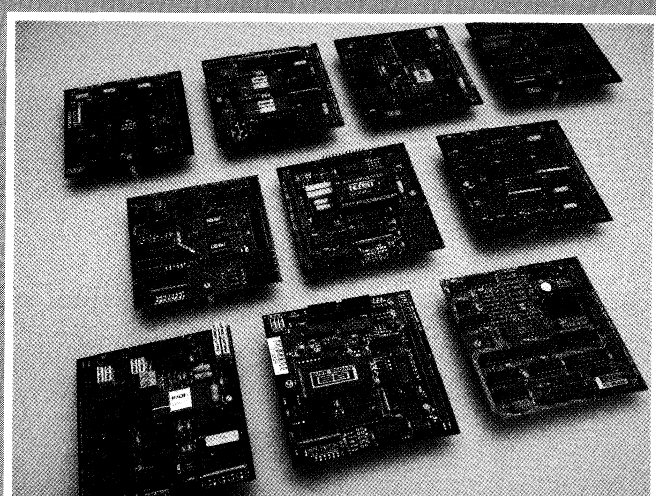
The PCI-20003M-2 accepts digital inputs from the PC and generates analog output voltages in the range of ±10V. The PCI-20003M-4 is similar except that, in addition to ±10V, it can also generate 4 to 20mA current outputs. Each of the two output channels utilizes a separate 12-bit D/A converter which yields a 3 microsecond settling time for a 10V output step.

16-Bit High-Resolution Analog Output

PCI-20006M-2 Two Channel

This high-resolution analog output Module accepts digital code from the PC and generates corresponding output voltages in the range of ±10V. Each channel of the PCI-20006M-2 contains a 16-bit D/A. Each D/A converter can be programmed for ±5V, 0 to 10V, and ±10V full scale output ranges. The settling time of each D/A is 8 microseconds for a full scale output step.





8-Channel, 12-Bit Analog Output

PCI-20021M-1B

This analog output Module generates eight channels of output voltage, each of which has 12-Bit resolution. The user can select either ±5V or ±10V full-scale ranges. A multiplexed, dynamic refreshing technique is utilized. On-board memory holds the digital equivalents of the desired output voltages, which are consecutively read by a single D/A converter.

Counter/Timer/Pulse Generator

PCI-20007M-1

This multi-function Module can perform a number of software controlled time domain operations involving pulse counting and generation. Based on an accurate 8MHz crystal controlled oscillator, the Module contains a rate generator and four independent counter/timer blocks.

Simultaneous Sample/Hold

PCI-20017M-1

The PCI-20017M-1 is a 4-channel simultaneous sample and hold amplifier Module with provisions for passive signal conditioning built in. Each channel contains a differential amplifier with jumper programmable gains of 1, 10, 100, and 1000.

Trigger/Alarm Module

PCI-20020M-1

The Trigger/Alarm Module monitors one or two analog signals and generates a digital output when pre-programmed conditions are detected. Thresholds in the range of ±10V are software programmed by a pair of 8-bit D/A converters. Two high-speed comparators are used, either separately or in combination to detect any of the following conditions: Input below limit, Input above limit, or Input between limits.

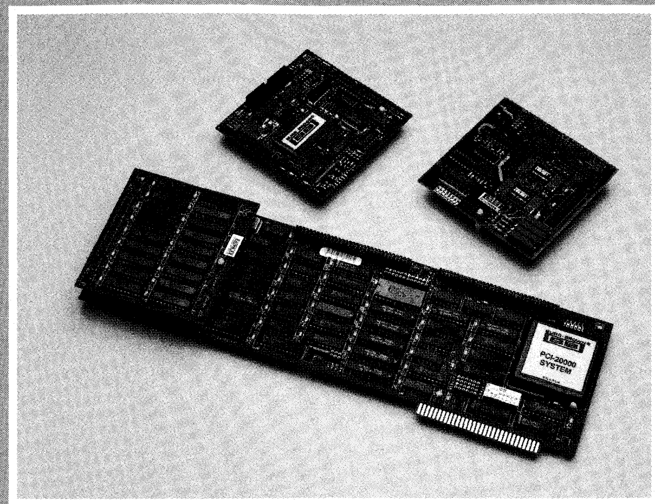
SELECTION GUIDE FOR PCI-20000 I/O MODULES

MODEL NUMBER	BASIC FUNCTION	NUMBER OF CHANNELS	DESCRIPTION OF FEATURES
PCI-20002M-1	Analog Data Acquisition	16 SE or 8 differential	12-Bit A/D conversion, PGA with gains of 1-10-100-1000, Sample/Hold, Multiplexer, up to 32kHz sample rate.
PCI-20019M-1A	Analog Data Acquisition	8 SE	12-Bit A/D conversion, Sample/Hold, Multiplexer, Automatic input channel advance, up to 89kHz sample rate.
PCI-20023M-1	Analog Data Acquisition	8 SE	12-Bit A/D conversion, Sample/Hold, Multiplexer, Automatic input channel advance, up to 180kHz sample rate.
PCI-20341M-1	Analog Data Acquisition	4 differential or 1 SE	16-Bit A/D conversion, Sample/Hold, Software and hardware pacing, Automatic input channel advance, up to 100kHz throughput.
PCI-20031M-1	Analog Multiplexer	32 SE or 16 differential	Adds 32 single-ended or 16 differential channels of input expansion for PCI-20019M-1A or PCI-20023M-1 A/D modules, or for input expansion of A/D on PCI-20098C-1 Carrier. On-board channel list memory.
PCI-20003M-2	Analog Output	2	2 output channels, 12-Bit resolution, 3 microseconds settling time. Output ranges: ± 10V, ± 5V, 0 – 10V.
PCI-20003M-4	Analog Output	2	Similar to PCI-20003M-2 (above), except also offers optionally selectable 4-20mA outputs.
PCI-20006M-2	Analog Output	2	2 output channels, 16-Bit resolution, 8 microsecond settling time. Output ranges: ±10V, ± 5V, 0 – 10V.
PCI-20021M-1B	Analog Output	8	8 output channels, 12-Bit resolution, 500 microsecond settling time. Output ranges: ± 5V and ± 10V.
PCI-20004M-1	Digital I/O	32	32 TTL-compatible channels, programmable as inputs or outputs in groups of 8 channels, buffered outputs.
PCI-20007M-1	Counter/Timer	4 (+ rate gen.)	4 counter/timer input channels, Count and measure frequency, 1 programmable output pulse generator, 8 MHz clock rate, ± 0.008% accuracy.
PCI-20017M-1	Simultaneous Sample/Hold	4	4 differential input channels, Selectable gains: 1-10-100-1000, 20 nanosecond time skew between channels.
PCI-20020M-1	Trigger/Alarm	1 or 2	Two channels of High-low comparisons, or one channel of window comparison, response time 3.5 microseconds.

THE DATA PROFESSIONAL SYSTEM

For High-Speed Data Acquisition and Digital Signal Processing (DSP)

- Multi-Channel, High Speed Analog Input and Output Capabilities
- Based Upon the Industry Standard TMS320C25 Processor, Offering:
  — Up to 10MIPS (100nS Instruction Cycle)
  — Comprehensive Software Support
- Both 28 MHz and 40 MHz Models Available
- Up to 96KWords in Internal High Speed Memory, Zero Wait State
- DMA Interface to Host PC at 400 Kbytes/Sec
- Continuous Data Conversions To/from ALL Available Host Memory
- Serial Port for External Connections
- Internal Timebase/Rate Generator
- Programmable for High-level Languages. Extensive Subroutine Libraries and Hardware Drivers Available
- Menu-Driven FFT Analyzer Software Available
- Suitable as an OEM Component



The Burr-Brown DATA PROFESSIONAL System begins with high performance "Smart" Carriers designed for the IBM personal computer bus. These Smart Carriers are compatible with standard, PCI-20000 Data Acquisition Modules. It is now possible, at low-cost, to utilize real-time data acquisition and digital signal processing (DSP) techniques in a wide variety of applications. These Smart Carriers are based upon the highly regarded Texas Instruments TMS320C25 processor. TMS320s are the most widely used, tested, and supported processors available. By using this high-performance signal processor, we are able to process data at rates 20 to 200 times faster than by using the PC alone. Furthermore, background processing is provided. When used as an attached processor, both the control of the input/output process (i.e., analog-to-digital and digital-to-analog conversion) and the desired mathematical analysis (i.e. window, FFT, filter, etc.) can be performed independently of the host PC.

The PCI-20202C Smart Carrier is available in two versions. Running at 28MHz, the PCI-20202C-1 is optimized for high performance at the lowest possible cost. Its 140ns instruction cycle achieves 7MIPS (Million Instructions Per Second). The PCI-20202C-2 is equipped with 25ns memory and runs at 40MHz. The result is state-of-the-art 10MIPS operation. Both Smart Carriers utilize a zero wait state memory design insuring the maximum data transfer rate.

The personal computer contributes only the human interface and supervisory functions. For example, the PC downloads programs to the TMS processor, exchanges control parameters, permanently stores data, and displays results. When used as a coprocessor, the Smart Carrier can transfer a data array from the host computer's memory, process the data, and return the result to the PC's memory using direct memory access (DMA). So applying high speed data acquisition, control or DSP techniques has never been easier. The modular PCI-20000 hardware supports analog inputs, analog outputs, digital inputs, digital outputs, counters and timers. With appropriate modules, up to 64 digital I/O, 40 analog inputs, or 16 analog outputs can be accommodated on a single Smart Carrier.

Extensive Software Support

Powerful software is available to suit a range of applications and user experience levels. For spectrum analysis our exclusive DSPview is menu-driven and ready-to-run. For other applications, complete programming tools are available. These include a comprehensive library of input/output, processing and analysis algorithms that are compatible with popular high-level languages. To program unique or special algorithms there are facilities for generating optimized assembly language code.

The extensive Digital Signal Processing Library, DSP Library Plus (PCI-20203S family), implements 75 functions, all callable from one of several popular high-level languages, including BASIC, C, TURBO PASCAL, and FORTRAN.

This library allows the user to perform the following tasks very quickly:
— Data Acquisition and Control
— Transient Capture
— Digital Filtering
— Spectral Analysis
— Waveform Generation
— Data Compression and Interpolation

Each function is performed with proven algorithms, without having to write any DSP-specific code. No detailed knowledge of the hardware is required, and no TMS320 code need be generated.

The major Library functions include:
— FFT Routines for 64 to 8192 Data Points
— Windowing Functions
— A/D and D/A Conversion Including Triggering
— FIR and IIR Filter Design and Execution
— Auto- and Cross-correlation
— General Vector Operations
— Data Compression and Interpolation

The DSP Software Development Pak (PCI-20204S-1) is available for those who wish to create their own algorithms. This package operates with the industry standard Microsoft Macro Assembler.

Companion DSP Carrier Drivers (PCI-20206S family) assist the programmer in communicating with the Smart Carriers from a high-level language. While they do not perform any DSP functions themselves, they are used to download TMS programs, to transfer data between the carrier and the PC, and to monitor and control many other carrier functions.

Hypersignal-Workstation Software

- Completely Menu Driven, No Programming Required
- Continuous Acquisition and Playback:
  —Sample Rates Up To 55kHz, Up To 32 Input Channels
- Difference Equations: Provide For Complete Math, Signal Arithmetic, and Signal Manipulation Capabilities — Operates On Entire Waveforms — Can Generate Arbitrary Waveforms
- High Speed FFT Processing (1024 Point, 50mS to Disk)
- Wide Range of Display Formats:
  —Dual-Channel Digital Oscilloscope
  —Real-time Spectrum Analyzer
  —Linear/Log 2-D and 3-D Spectrograms
  —Pole/Zero Plots, Group Delay
- Convolution and Autocorrelation
- Signal Editing — Cut and Paste Capability
- On-Screen Context-Dependent Help Facility

Hypersignal-Workstation provides a new level of support for digital signal processing (DSP) applications. The extensive menu-driven facilities allow any scientist, engineer, physician, or other researcher the ability to acquire, analyze, display, modify, generate, and output intricate signals (waveforms). The software (PCI-20210S-1) complements the growing family of low cost "DATA PROFESSIONAL" data acquisition hardware for IBM compatible PCs. Control of all analog input and output hardware functions is fully integrated with the software's comprehensive signal manipulation and presentation capabilities.

DATA PROFESSIONAL SOFTWARE PRODUCTS — MAJOR FUNCTIONS

PRODUCT NAME	PCI MODEL NUMBER	MENU DRIVEN	H/W DRIVER	DATA ACQUISITION	SIGNAL OUTPUT	ANALYSIS	GRAPHICS	SPECIAL FUNCTION
Hypersignal-Workstation	**PCI-20210S-1**	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DSP Library Plus, BASIC	**PCI-20203S-1**	No	Yes	Yes	Yes	Yes	No	No
DSP Library Plus, C	**PCI-20203S-2**	No	Yes	Yes	Yes	Yes	No	No
DSP Library Plus, TURBO PASCAL	**PCI-20203S-3**	No	Yes	Yes	Yes	Yes	No	No
DSP Libray Plus, FORTRAN	**PCI-20203S-4**	No	Yes	Yes	Yes	Yes	No	No
DSP Library Plus, All Languages	**PCI-20203S-5**	No	Yes	Yes	Yes	Yes	No	No
Software Development Package	**PCI-20204S-1**	No	No	Yes	Yes	Yes	No	No
DSPview, FFT Analysis	**PCI-20205S-1**	Yes	Yes	Yes	No	Yes	Yes	Yes
Drivers, BASIC	**PCI-20206S-1**	No	Yes	—	—	No	No	Yes
Drivers, C	**PCI-20206S-2**	No	Yes	—	—	No	No	Yes
Drivers, TURBO PASCAL	**PCI-20206S-3**	No	Yes	—	—	No	No	Yes
Drivers, FORTRAN	**PCI-20206S-4**	No	Yes	—	—	No	No	Yes
Macro Assembler	**PCI-20208S-1**	No	No	No	No	No	No	Yes
DADiSP/PC (Post Analysis)	**PCI-20067S-1**	Yes	No	No	No	Yes	Yes	Yes

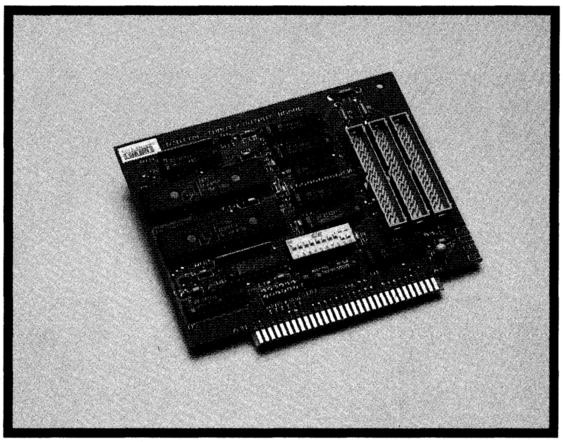
Super Boards For PC/XT/AT

Low Cost, Easy-To-Use, Analog Input, Analog Output, And Digital I/O

Now, short-length Super Boards fit into the expansion slots in PC/XT/AT/EISA and compatible computers, plus some will fit into the short slot in XT type machines. Each provides a self-contained, data-acquisition function, such as analog input, analog output, or digital I/O. Start with a single Super Board, then expand into the powerful PCI-20000 Modular Data Acquisition System. Burr-Brown's family of single-board products complements their well known, modular, carrier-based systems.

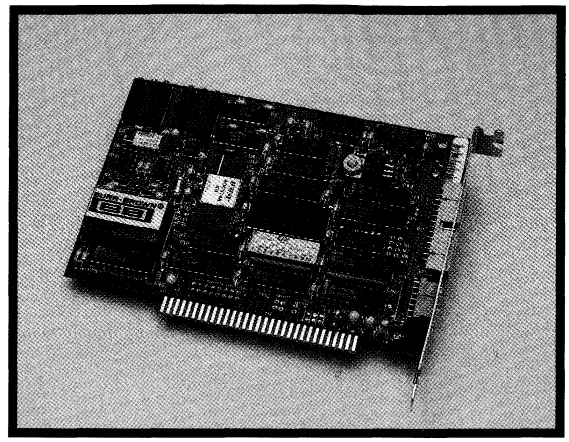
Single boards also offer a lower-cost alternative for OEMs or others with well-defined or smaller applications. These Input/Output Boards require just one plug-in expansion slot.

Each Super Board is also shipped, at no extra charge, with BASIC software drivers and with SYSCHECK PC, the system assurance utilities and diagnostics software package.



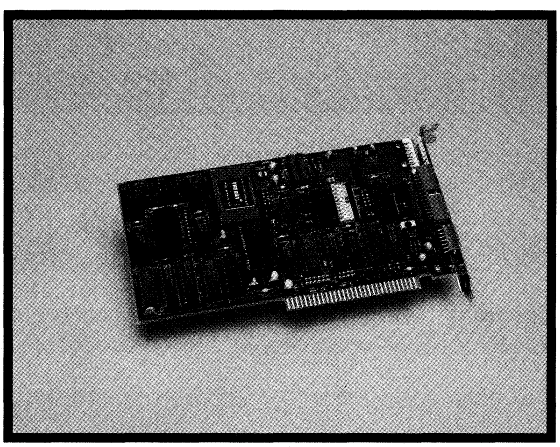
Digital Input/Output Board
PCI-20087W-1

- 40 Digital I/O Channels
- Synchronization/Handshaking Capability
- Interrupt on Digital Input or Handshake Signal
- Half-size Board Fits Into PC/XT Short Slot



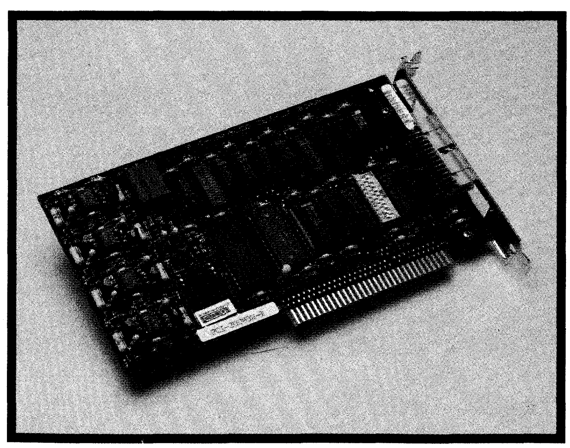
Analog Input Board
PCI-20089W-1

- 16/8 Analog, 12-Bit Input Channels, up to 32kHz
  PGA: Gain = 1, 10, 100
- Independent Counter Channel
- Half-size Board Fits Into PC/XT Short Slot



High-Speed Analog Input Board
PCI-20091W-1

- 8 Analog, 12-Bit Input Channels, SE
  Up to 89kHz, DMA Support
  Automatic Channel Advance
- Internal Timebase/Rate Generator



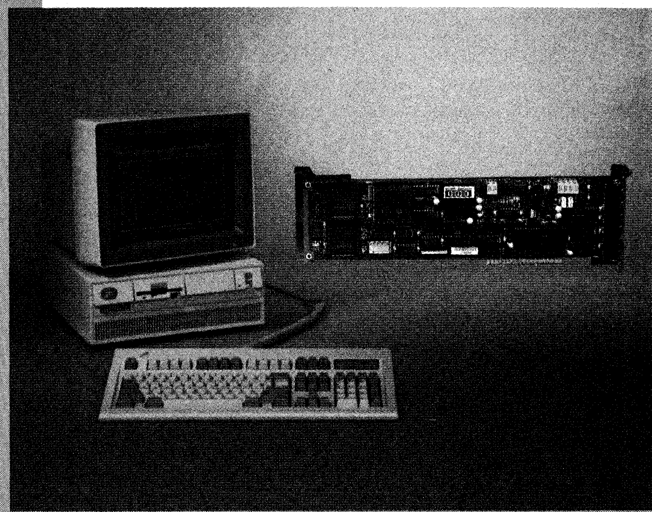
8-Channel Analog Output Board
PCI-20093W-1

- 8 Analog, 12-Bit Output Channels
  Voltage and Current Outputs
  Up to 31,200 Outputs/Sec., Total Throughput
  Up to 3,900 Outputs/Sec., Per Channel

PS/2 Micro Channel I/O Boards

PCI-601W and PCI-602W

- 16/8 Analog Input Channels (12-Bits)
- Programmable Gain and Channel Scanner
- No Hardware Jumpers, All Functions are Software Programmable
- Up to 70 kHz Sample Rate
- Internal Timebase/Burst/Rate Generator
  —Unique circuit allows fast channel-group measurements at programmable repetition rates
- 2 Independent Counter Channels
  —16/32-Bit operation
  —Events, Divider, Frequency, Period, Pulse Width
- 16 Digital I/O Channels
- 2 16-Bit Analog Outputs (PCI-602W Only)
- DMA, Interrupt Drive, or Polled Modes
- Supported by Powerful Software Drivers in BASIC, C, and TURBO PASCAL
- Supported by LABTECH NOTEBOOK and LABTECH CONTROL
- Supplied with SYSCHECK PS/2 Software



Burr-Brown now offers two, multifunction, I/O boards for the PS/2 Micro Channel Bus. These multifunction boards are supported by complete sets of software drivers for BASIC, C, and TURBO PASCAL high-level languages. Also, the boards are supported by LABTECH NOTEBOOK and LABTECH CONTROL, powerful, menu-driven data acquisition and control software. A system assurance utility and diagnostics software package, SYSCHECK PS/2, is included with each board at no extra charge. This menu-driven software verifies proper installation and function utilization.

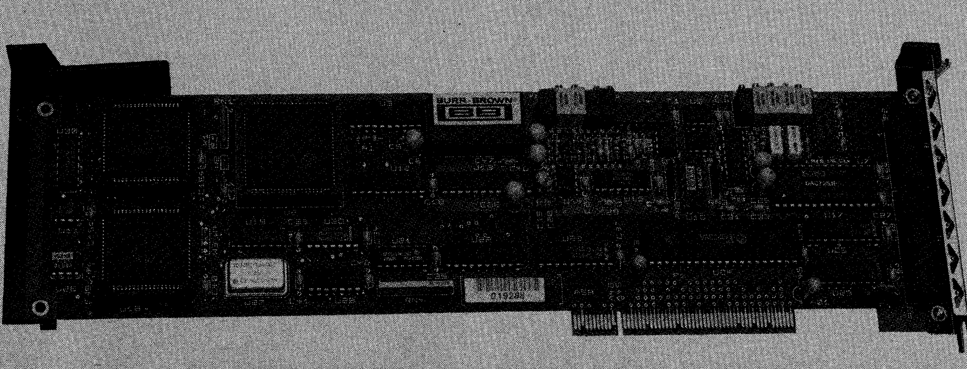
The I/O boards are also supported by a complete line of high-quality, shielded cables and termination panels for field wiring. These boards and termination panels insure compatibility for a wide variety of analog voltages and currents (thermocouples, RTD's, strain gages, load cells, etc.), as well as digital and pulse signals (switch closures, optical/magnetic pickups, etc). All options and functions are under software control. No "jumpers" are required.

The boards are almost identical, except that the PCI-602W has two high-resolution, analog-output channels. These are high-speed, 250kHz, 16-Bit DAC outputs.

Both boards offer superior digital circuitry. The 16 digital I/O channels can be programmed in byte-sized blocks (8 channels each) for either inputs or outputs. In addition, all outputs are buffered, and full handshake and interrupt capabilities are supported. The two 16-Bit counters can be used separately, or as one 32-Bit counter. They can be used to count events, to divide, or to measure speed, frequency, pulsewidth, or period. The programmable timer/burst/rate generator can generate continuous clock rates form 0.002 Hz to 2MHz, or the user can program bursts of pulses with a specified pulse spacing and an independent repetition rate. This innovation makes it practical to perform almost simultaneous readings of multiple channels at programmed repetition rates!

Separate "bulkhead" connectors are provided on the boards to better insure that high-level digital signals do not degrade the analog channels. Cables connect the bulkhead connectors to standard PCI Termination Panels to accept field wiring.

Burr-Brown also offers a complete set of optional software drivers in BASIC (PCI-603S), C (PCI-604S), TURBO PASCAL (PCI-605S), and a combination package of all three (PCI-606S).



MACINTOSH II NUBUS I/O BOARDS

NuCarrier (PCI-701C)

MacPilot Module (PCI-702M)

- Bus Master /Slave Configurations with Optional MacPilot DMA/Master Module
- NuCarrier On-Board Functions
  - —Analog Inputs
    - 16 Single-Ended (8 Diff) Channels
    - 12-Bit Resolution
    - Programmable Gain: 1, 10, 100, 200
    - Channel Scan with Independent Gains
    - Up to 70 kHz Sample Rate
  - —Burst Generator
    - Programmable Clock for Synchronizing Events
  - —Digital I/O
    - 16 Channels
    - Separate Handshaking Lines
  - —Counter/Timers
    - Two 16-Bit Counters, Cascadable for 32-Bits
    - Measure Frequency, Period, and Pulse width
    - Event Counter or Frequency Divider
    - Variable Duty Cycle Generator
  - —No Jumpers; All Functions Software Programmable
- Compatible with PCI Modules, Termination Panels, and Cables
- Complete with Multi-Language Software Drivers
- Complete with SYSCHECK Mac, Setup and Diagnostic Software

The Burr-Brown NuCarrier System is the broadest and most flexible data acquisition system for Macintosh II personal computers. NuCarrier itself (PCI-701C) is a multifunction Carrier that plugs into a Macintosh II NuBus slot. It is supported by all Macintosh II personal computers running System 6.0.3 or later. NuCarrier provides a complete set of on-board I/O functions for analog input, clock/timing, digital I/O, counting, frequency measurement, and pulse generation. All I/O functions are controlled by software. There are no hardware jumpers on NuCarrier to change. NuCarrier comes both with MacAdapt (PCI-703S) general-purpose software drivers and with SYSCHECK Mac (PCI-705S) system set-up and diagnostic software.

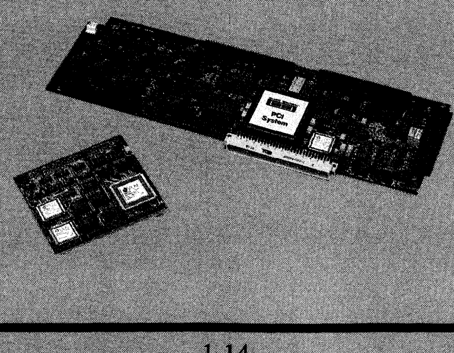
The on-board capabilities of NuCarrier can easily be expanded to fit large or changing applications by adding appropriate plug-in Modules from the PCI Family. For example, NuCarrier used alone is a slave in the Macintosh system, but with MacPilot Module (PCI- 702M) plugged into it, the combination then becomes a NuBus Master that, under DMA control, can transfer data to and from all I/O types directly into and out of the host RAM. This NuBus Master can also control data acquisition on other NuCarriers if many more data acquisition channels are needed.

Other PCI Modules from the PCI-20000 Series can expand analog input or digital I/O up to 80 channels on each NuCarrier. Still more PCI Modules can add functions such as analog output (12-Bit or 16-Bit), trigger/alarm, simultaneous sample/hold, or higher speed/resolution analog input.

NuCarrier contains a programmable timing generator with burst capability that can create a series of closely spaced pulses with the pulse groups occurring at a specified repetition rate. This feature allows accurate data acquisition by approximating a "simultaneous" reading of multiple channels. Users can specify the number of pulses per burst, the time between pulses, and the time between bursts. Burst acquisition of a given list of channels is also supported.

Software

MacAdapt general-purpose drivers (PCI-703S) and MacExpedite DMA drivers (PCI-704S) are included with NuCarrier and MacPilot Module respectively. They provide an interface between the Carrier/Module and any of the program languages that can call the Macintosh Device Manager. Some of these languages include MPW C, MPW PASCAL, Microsoft QuickBASIC, THINK C, THINK PASCAL, TML PASCAL II, TURBO PASCAL, and Language Systems FORTRAN.



IEEE-488 (GPIB) Interface Products

- Adds IEEE-488 (GPIB) Capability to PC/XT/AT/EISA, PS/2 Micro Channel, and Macintosh Personal Computers
- Interfaces Standard Laboratory Instruments to Your PC
- Internal and External Hardware Options
- Complete Software Support
- High Data Transfer Rates
- 100% Support of the IEEE-488 Standard

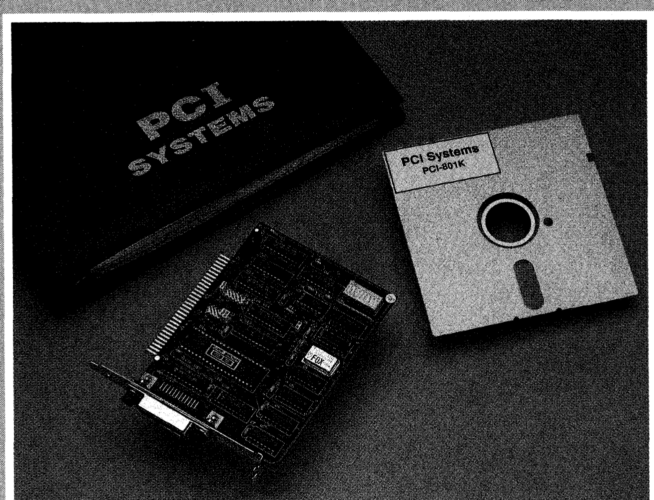
The PCI-800 Series is designed to link the wide range of IEEE-488 compatible laboratory instruments to personal computers. Complete hardware and software support is provided for popular PC's. The three types of interface products offered are direct plug-in boards for PC/XT/AT/EISA and PS/2 and Macintosh II Style computers, SCSI connection for Macintosh, and serial connection (RS-232/422). All hardware and software models support the IEEE-488 standard 100%.

PCI-801K, IEEE-488 Board with DOS Device Driver (PC/XT/AT/EISA)

The PCI-801K includes the PCI-803W interface board and IEEE-488 DOS device driver software designed to operate with PC/XT/AT/EISA computers. Programming is easy using Hewlett-Packard style commands, and most popular graphics and analysis software is compatible with the PCI-801K.

PCI-802K, IEEE-488 Board with DOS Device Driver (PS/2 Micro Channel)

The PCI-802K includes both board and software to interface with the PS/2 computer. It is designed for easy programming and offers direct inputs to popular spreadsheet programs.



PCI-803W, IEEE-488 Board (PC/XT/AT/EISA)

PCI-804W, IEEE-488 Board (PS/2 Micro Channel)

The PCI-803W and PCI-804W are boards for PC/XT/AT/EISA and PS/2 computers, respectively. They are economical IEEE-488 solutions for users that have their own software. They are compatible with IEEE-488 software from LABTECH NOTEBOOK, ASYST, DADiSP and others who support the NEC 7210 device.

PCI-805W, IEEE-488 Controller (Macintosh II)

PCI-806H, SCSI IEEE-488 Controller (Macintosh II)

The PCI-805W installs in a standard Macintosh NuBus slot. The PCI-806H uses the SCSI interface on a Macintosh II computer. Driver software is included for each.

PCI-807H, Serial RS-232 to IEEE-488 Converter

The PCI-807H is a transparent interface between RS-232/RS-422 and IEEE-488. It provides bi-directional communications between each protocol.

PCI-808A through PCI-812A Cables

A complete line of connecting cables is available for IEEE, 9 and 25 pin serial ports, SCSI Connector, IBM and Macintosh computers.

Signal Conditioning Products

The PCI product line contains a large selection of signal conditioners for analog and digital signals, active and passive signal terminations, high quality shielded cables, and rugged signal conditioning enclosures. The entire family of signal conditioning products is designed to assure that reliable, rugged, and convenient connections are possible from the PC to the outside world. All of these products are described further in the Product Summary section of this Handbook. Detailed technical information is given in the Data Sheet section.

Signal Termination Panels

Signal termination panels are printed circuit assemblies which contain active and passive signal conditioning, screw-terminal barrier strip connectors for easy and reliable connections to field wiring, and provision for user-added circuitry on the terminal panel itself. Space is provided on most of the termination panels for the installation of custom signal conditioning, such as filtering, amplification, voltage attenuation, current-to-voltage conversion, surge suppression, bridge completion, etc. In addition, a number of the analog panels are designed to accommodate thermocouple signals, including the provision of the cold-junction compensation (CJC) information for use by the PC. Because of the breadth of the product line, we are able to offer panels which emphasize a high density of I/O connections, and others which provide maximum convenience and flexibility for the addition of customized signal conditioning.

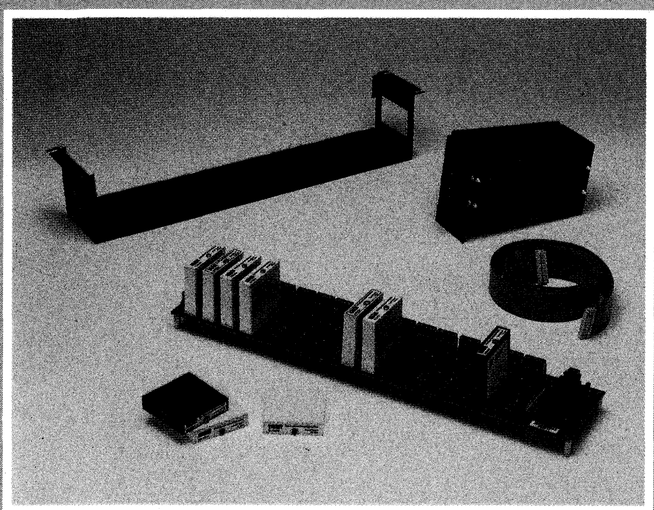
Our new family of terminal panels in the standardized Euro-Style 3U format provides high density of packaging, and the convenience of the plug-in, card-file approach. With this approach, all field connections are readily available at barrier strip connectors mounted on each of these new panels. This popular and rapidly growing family of signal conditioning products is also fully compatible with our VIPc instrumentation platform making possible the integration of a fully self contained intelligent instrument, tester or controller.

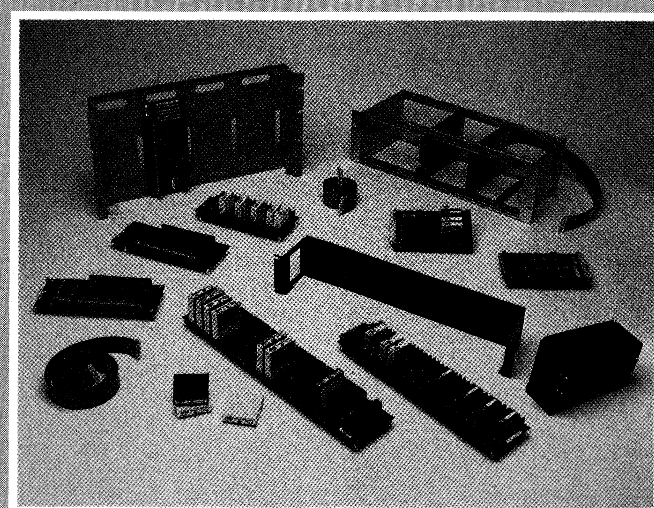
Cables

High quality ribbon cables, shielded for analog signals and containing a ground plane for digital signals, connect the various panels to the I/O Modules, Boards and Carriers. This minimizes noise interference with low-level input signals and ensures low electromagnetic emission from high-speed digital, timing, and transient signals.

Signal Conditioning Enclosures

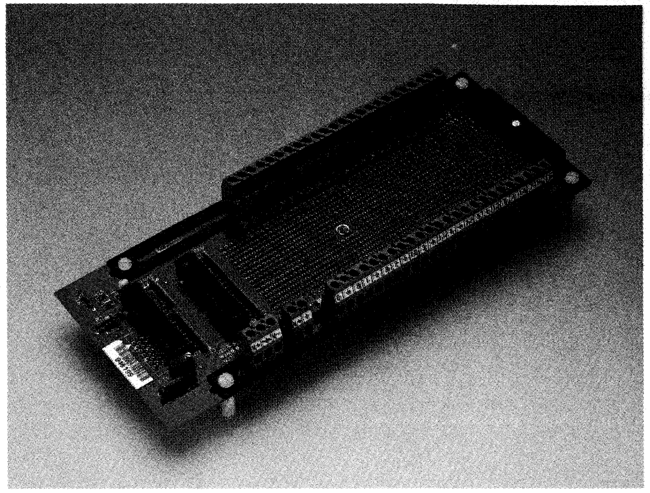
The PCI family of termination panel enclosures provides convenient mounting space for any of the termination panels, providing both mechanical and electrical protection of the panels and preventing personnel from accidentally contacting electrical signals. Optional shielded power supplies are available for use with termination panels where appropriate. These power supplies acre completely enclosed in metal cases and can be mounted either inside or on the rear of the termination panel enclosures. The model PCI-20338A-1 can also be mounted directly in a card slot of the same Euro-Style enclosure used for mounting the Euro-Style signal termination panels.





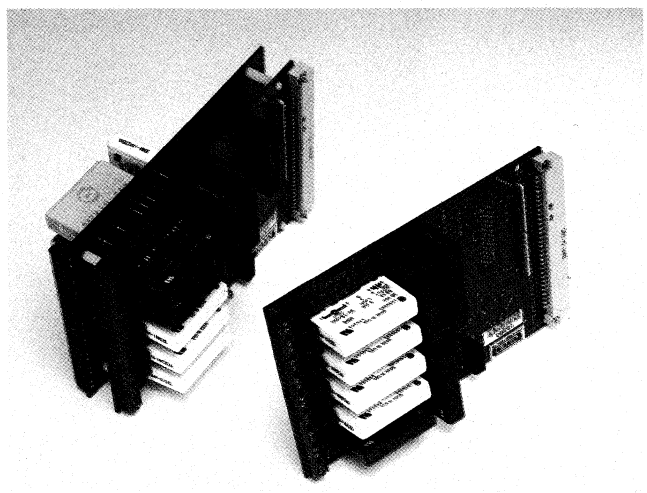
Modular Isolation Systems

For applications where it is critical to assure high isolation voltage between the field signals and the computer system, we offer our popular modular isolation products. This product group includes a variety of single channel, isolated devices, referred to as Blocks, which are optimized for handling a particular type transformer-coupled amplification, filtering, and specialized signal conditioning. Because they can be selected and applied on a per channel basis, they offer the most flexible approach to configuring an isolated "front-end" for your intelligent instrumentation system. Specialized termination panels, designed to preserve the high isolation capability of the individual Blocks, provide mounting space for the Blocks and barrier strip connectors for field signals. These special termination panels are available both in the standard 19-inch rack format and in the new Euro-Style format. Appropriate enclosures and isolated power supplies are also available.



Digital Isolation Blocks

Digital Isolation Blocks are designed to interface TTL circuitry to high-level AC or DC voltage or current levels, while providing isolation for up to 4000 volts of common mode voltage. One Isolation Block is required for each I/O channel. Both input and output types are available in six different models for a wide range of applications. These Isolation Blocks plug into specially designed signal termination panels and may be intermixed in any combination.

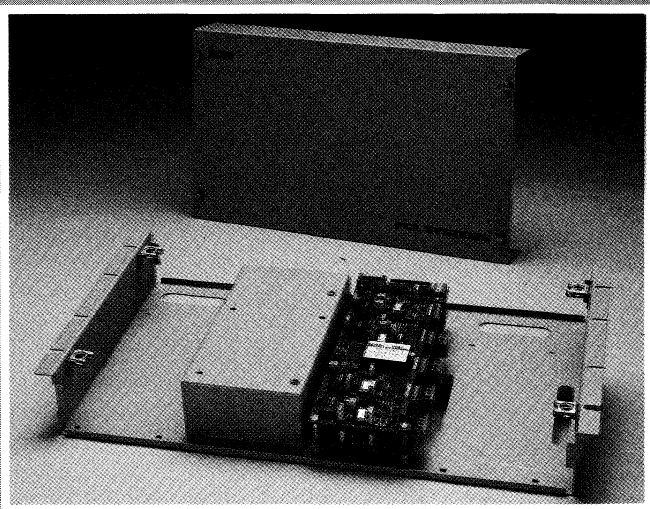


Input Blocks accept either AC or DC voltages and provide a TTL output to drive a standard PCI digital input. Each Block incorporates 4000V of optical isolation between field signals and the computer system. Blocks are protected from damage due to high-voltage transients on the input signal lines.

Output Blocks are available in both AC and DC types. These units enable TTL outputs from the PCI system to switch high-level AC or DC loads, such as relays, solenoids, motor starters or indicator lamps. All output Blocks also provide up to 4000V of optical isolation between the computer and the devices being controlled.

Analog Isolation Blocks

Each analog I/O Block in the PCI-5B Series provides a single channel of analog input signal conditioning, including filtering, isolation, and conversion to a high level analog voltage suitable for A/D conversion and processing by the hardware and software of a PCI System. Transformer coupling provides up to 1500 volts of isolation protection between field devices and the computer. A four-pole filter gives 80 dB of normal-mode rejection at 50 Hz and 60 Hz. Special input circuitry provides protection of the Block against accidental connection of power-line voltages up to 240VAC. All modules are powered from +5VDC, ±5%.



Voltage input Blocks are provided for ranges from ±10 mV to ±10 V. Thermocouple versions for J, K, and T types include cold-junction compensation and open thermocouple detection.

All models may be intermixed in any combination on the special termination panels described in this Handbook.

POWERFUL SOFTWARE FOR DATA ACQUISITION,

Burr-Brown offers a complete selection of powerful software to complement the industry's most powerful hardware. An extremely wide range of software is available.

General-Purpose Software

PCI-20026S Series for PC, XT, AT, EISA

- **BASIC Language Interface Drivers**
  PCI-20026S-1 (5.25 inch)
  PCI-20026S-5 (3.5 inch)

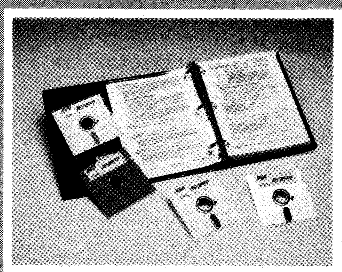
BASIC is the most popular of all personal computer languages. It is easy to learn and easy to use.

- **C Language Interface Drivers**
  PCI-20026S-2 (5.25 inch)
  PCI-20026S-6 (3.5 inch)

"C" is an efficient high-level language that allows high-speed operations. The PCI-20026S Series supports Lattice or Microsoft C compilers (through compiler version 5.X).

- **TURBO PASCAL Language Interface Drivers**
  PCI-20026S- 3 (5.25 inch)
  PCI-20026S-7 (3.5 inch)

Pascal is a structured language for organized programming, and it also provides high efficiency. TURBO PASCAL is a version of Pascal published by Borland International. It is fast and is very easy to learn.



Combination Software Package of Drivers
PCI-20026S-4 (5.25 inch)
PCI-20026S-8 (3.5 inch)
A combination of the three software packages listed above (one each: BASIC drivers, C drivers, and TURBO PASCAL drivers).

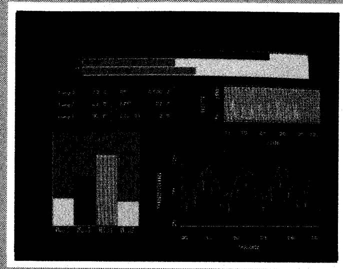
Each of the PCI-20026S Series Interface Packages includes these features:

— Optimized I/O Routines. Internal routines are written in assembly language to provide maximum speed.

— Assembly Language. Each package includes detailed instructions showing how to access the assembly language routines directly.

— Thermocouple Interfacing. Linearization andcold-junction compensation for J, K, and T thermocouples are included in each interface package at no extra cost to the user! Analog readings may be returned directly in degrees, or the user may access the linearization and compensation routines to post-process his data.

— Tutorial and Error Checking. Each of the PCI-20026S language support packages provides tutorial and demonstration material to aid a new user in getting started with the system. Error-checking capability is also included in each package with appropriate error codes to describe difficulties encountered.



PS/2 Software Drivers

Burr-Brown offers a complete set of software drivers for PS/2 Micro Channel boards in the same popular languages listed for the PC, XT, AT.

- **BASIC, PCI-603S**
- **C Language, PCI-604S**
- **TURBO PASCAL, PCI-605S**
- **Combination Package, PCI-606S**

Macintosh II NuBus Software Drivers

MacAdapt (PCI-703S) Drivers provide high-level interface to any of the programming languages that can be called from the device manager toolbox. These languages include: MPW-PC, MPW-Pascal, THINK-C, THINK-Pascal, Quick BASIC, TURBO PASCAL, Semper S, and Language Systems FORTRAN.

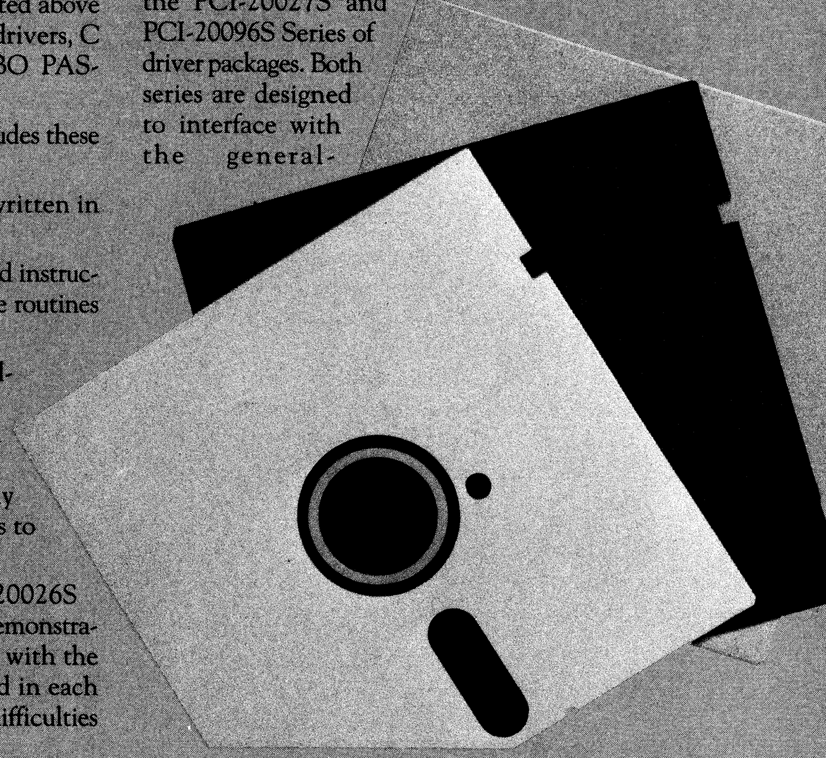
IEEE-488 Software

Burr-Brown provides interface drivers at no extra charge for its complete line of IEEE-488 Boards that offer IEEE capability for the popular buses (PC, XT, AT, PS/2 Micro Channel, and Macintosh II NuBus). Also LABTECH GPIB software (PCI-20342S-1) offers support as does ASYST Module 4 (PCI-20301S-4).

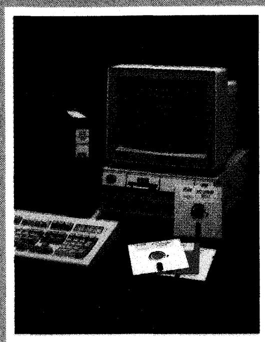
High-Performance Software

High-Speed/DMA Drivers for PC, XT, AT, EISA

High-performance software products include the PCI-20027S and PCI-20096S Series of driver packages. Both series are designed to interface with the general-



purpose PCI-20026S Series to greatly increase the capabilities and speed of the PCI-20000 System. In use, the PCI-20026S, PCI-20027S and PCI-20096S can be coupled together. However, only the PCI-20026S can be used alone.

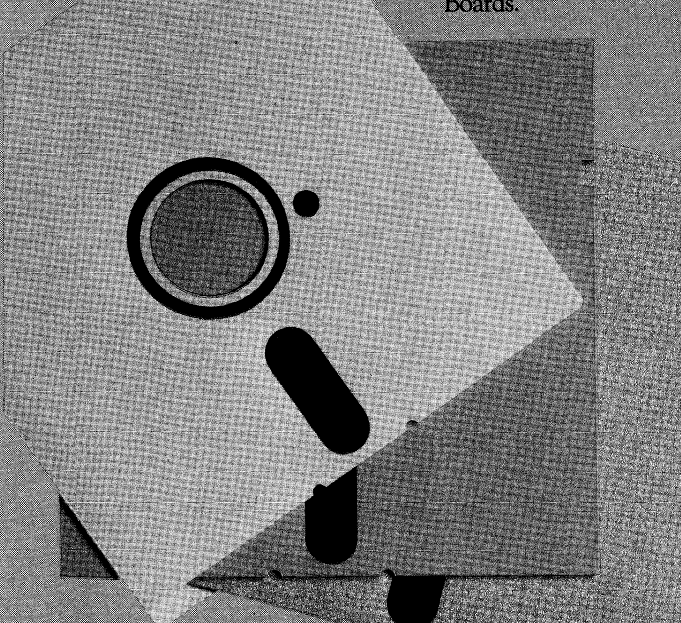


The PCI-20027S Series is used with the PCI-20026S Series to greatly increase the speed of the PCI-20000 System and/or to provide DMA capability when used with appropriate Carriers.

- **BASIC Language Interface Drivers**
  PCI-20027S-1 (5.25 inch)
  PCI-20027S-5 (3.5 inch)
- **C Language Interface Drivers**
  PCI-20027S-2 (5.25 inch)
  PCI-20027S-6 (3.5 inch)
- **TURBO PASCAL Language Interface Drivers**
  PCI-20027S-3 (5.25 inch)
  PCI-20027S-7 (3.5 inch)
- **Combination Package**
  PCI-20027S-4 (5.25 inch)
  PCI-20027S-8 (3.5 inch)

Direct-to/from-Disk Streaming Software

The PCI-20096S Series TURBO Stream Software interfaces to both the PCI-20026S and PCI-20027S Series (all three are required) to add high speed direct-to/from-disk capabilities to the PCI family of DMA Carriers and Boards.



- **BASIC Language Interface Drivers**
  PCI-20096S-1 (5.25 inch)
  PCI-20096S-4 (3.5 inch)
- **C Language Interface**
  PCI-20096S-2 (5.25 inch)
  PCI-20096S-5 (3.5 inch)
- **TURBO PASCAL Language Interface**
  PCI-20096S-3 (5.25 inch)
  PCI-20096S-6 (3.5 inch)

Macintosh NuBus High-Performance Drivers

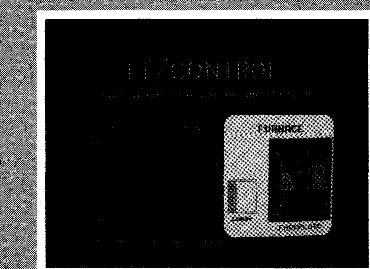
MacExpedite (PCI-704S) Drivers provide high-speed DMA support to the NuCarrier (PCI-701C). Support is provided to any of the programming languages that can be called from the Device Manager Toolbox.

LABTECH NOTEBOOK (PCI-20040S-1).

This is a menu-driven software package for real-time data acquisition, process control and/or data analysis. LABTECH NOTEBOOK offers curve-fitting and Fast-Fourier-Transform (FFT) routines, on-line help and tutorials, graphic data display and automatic interfacing to spreadsheet packages such as Lotus 1-2-3 and Symphony. It is excellent for users wanting a software package that requires minimum computer programming skills.

LABTECH CONTROL (PCI-20097S-1).

A menu driven process monitoring and control software package. LABTECH CONTROL is a "superset" of LABTECH NOTEBOOK. It includes the NOTEBOOK functions plus PID algorithms, real-time trending, alarms, data archiving and animated flow diagrams. It supports up to 600 channels with Burr-Brown's extensive I/O hardware products.



LABTECH GPIB (PCI-20342S-1).

Operates with either LABTECH NOTEBOOK or LABTECH CONTROL to allow addressing of instruments on an IEEE-488 bus.

DADiSP (PCI-20067S-1).

A menu driven, graphical, data analysis package that is often called a scientific spreadsheet. It performs post-acquisition signal analysis and display.

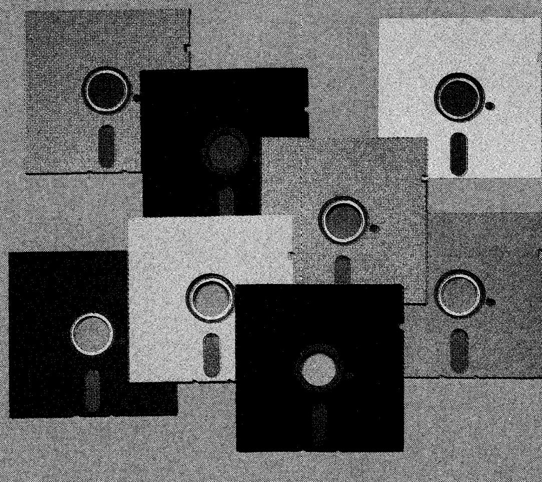
SNAPSHOT STORAGE SCOPE (PCI-20068S-1).

A menu driven waveform-capture system. Useful for transient analysis and general digital oscilloscope applications. Other family members include:

PCI-20068S-2 SNAP-Calc
PCI-20068S-3 SNAP-FFT
PCI-20068S-4 SNAP-Filter

(cont. on next page)

POWERFUL SOFTWARE (continued from page 1-19)



(cont. from previous page)
PCI-20068S-5 SNAP-Action
PCI-20068S-7 SNAP-Generator
PCI-20068S-8 SNAP-Stream

ASYST is a software scientific language. It is offered as PCI-20301S (ASYST Modules 1 and 2) and as PCI-20301S-3 (ASYST Module 3).

ASYST can be compared to BASIC, C, or TURBO PASCAL in that they are all high-level programming languages. What is different is the way in which ASYST integrates the total acquisition, analysis, and presentation process. "Calls" for hardware control, signal collection, math manipulation, statistics, automatic plotting, curve fitting, integration, convolution, FFT, signal output, and many other functions are included.

PCI-20301S-1 ASYST Modules 1 and 2
Module 1 provides System/Graphics/Statistics. It establishes an environment for the scientific programming language. It provides data representation storage, math functions, text editor, file manipulation, plotting, and graphics display. Module 2 is the analysis extension to Module 1.

PCI-20301S-3 ASYST Module 3
This integrated interface couples Modules 1 and 2 to the PCI-20000 data acquisition and control hardware. It supports analog input, analog output, digital I/O, and counter/timer functions for the PCI-20098C-1 Carrier.

PCI-20301S-4 Combination Package
Includes PCI-20301S-1 and PCI-20301S-3.

PCI-20301S-5 ASYST Module 4
Operates with the PCI-20301S-1 to allow addressing of instruments on an IEEE-488 bus.

System Assurance Software

SYSCHECK (PCI-20074S-1), SYSCHECK PS/2 (PCI-607S), and SYSCHECK Mac (PCI-607S) are our system assurance utilities and diagnostics software packages. SYSCHECK is completely menu driven and requires no programming to operate. This software is included at no extra charge with all Carrier and single-board products, where appropriate. (Smart Carriers with on-board processors use another check-out software package which is included with them.)

Demonstration Diskettes

Several demonstration diskettes provide a clear and concise overview of PCI products. All diskettes run on IBM (and compatible) personal computers that contain a Color Graphics Adaptor (CGA) card or equivalent. For your demonstration diskette, please call your local sales engineer (listed in the back of this Handbook).

LABTECH NOTEBOOK Demo	**PCI-20064S-1**
LABTECH CONTROL Demo	**PCI-20099S-1**
SNAPSHOT Demo	**PCI-20069S-1**
DADiSP Demo	**PCI-20072S-1**
ASYST Demo	**PCI-20328S-1**

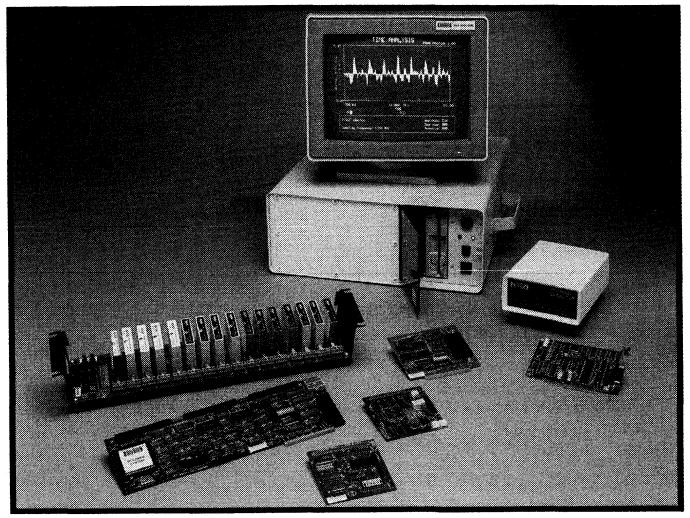
DATA PROFESSIONAL Software

Software for the DATA PROFESSIONAL Series of Smart Carriers used for Digital Signal Processing (DSP) and High-Speed Data Acquisition is shown on pages 1-10 and 1-11. Available software includes an extensive driver family plus function libraries and menu-driven analysis software (Hypersignal-Workstation, PCI-20210S-1).

PRODUCT SELECTION GUIDE

The Burr-Brown Personal Computer Instrumentation (PCI) family consists of many different types of products. These incude: Software, Input/Output Hardware, Computer Platforms, Signal Conditioning Products, Data Converters and Bus Interfaces. Virtually every data acquisition, test, measurement and control application can be satisfied with SOLUTIONS from Burr-Brown. Whether you need a plug-in component to complement an existing installation or a complete system, Burr-Brown can deliver! This Summary Section starts with suggestions on how to go about selecting the right PCI products to satisfy your particular requirements. A detailed overview of available PCI products is presented from several perspectives: Software Characteristics, Input/Output Signal Types, Computer Platform Type, Communications Interface, and Signal Conditioning Requirements.

Additional information on the referenced PCI model numbers can be found in the Data Sheet Section that follows this Summary. The individual product data sheets are arranged in numerical order for easy access. A separate product data sheet is included for each major product. Secondary items (cables, enclosures, etc.) are described on the related product data sheet. The Subject Index at the rear of this Handbook cross references all PCI model numbers.



Burr-Brown Offers a Complete Family of Data Acquisition, Test, Measurement, and Control Products for Use with Personal Computers.

TABLE OF CONTENTS
PRODUCT SUMMARY AND SELECTION GUIDE

System Configuration

Projects involving basic research, engineering, and manufacturing automation usually include test, measurement, monitoring, and control operations. Burr-Brown is a world leader in combining the latest in electronic signal processing technology with the modern personal computer to provide SOLUTIONS in these important areas.

This Handbook describes the state of the art in personal computer-based software and hardware products. The lineup is comprehensive. Most applications can be served with off-the-shelf components. Even the most demanding custom requirements can be satisfied with Burr-Brown's modular "building block" approach.

Selecting the right components has never been easier:

a) Define your needs.
b) Select the software that best satisfies the technical and user interface requirements.
c) Select the right computer platform.
d) Select compatible input/output hardware.

"User interface" refers to how the operators interact with the process. Do they read a computer screen, type on a keyboard, respond to audible alarms, push buttons, issue voice commands... or what? Software defines the look and feel of the solution. Therefore, we suggest that you select suitable software *before* choosing hardware. By first specifying the user interface and selecting the most suitable software, you are most likely to arrive at an optimum configuration.

The major types of software include **application packages** and **drivers.** Application packages are complete, menu-driven products that transform PCI hardware into a virtual "instrument" (process controller, spectrum analyzer, etc.). Software drivers are tools that help the programmer by eliminating the need to be involved with the physical details of the hardware (registers, multiplexers, amplifiers, converters, etc.).

Partition your requirements:

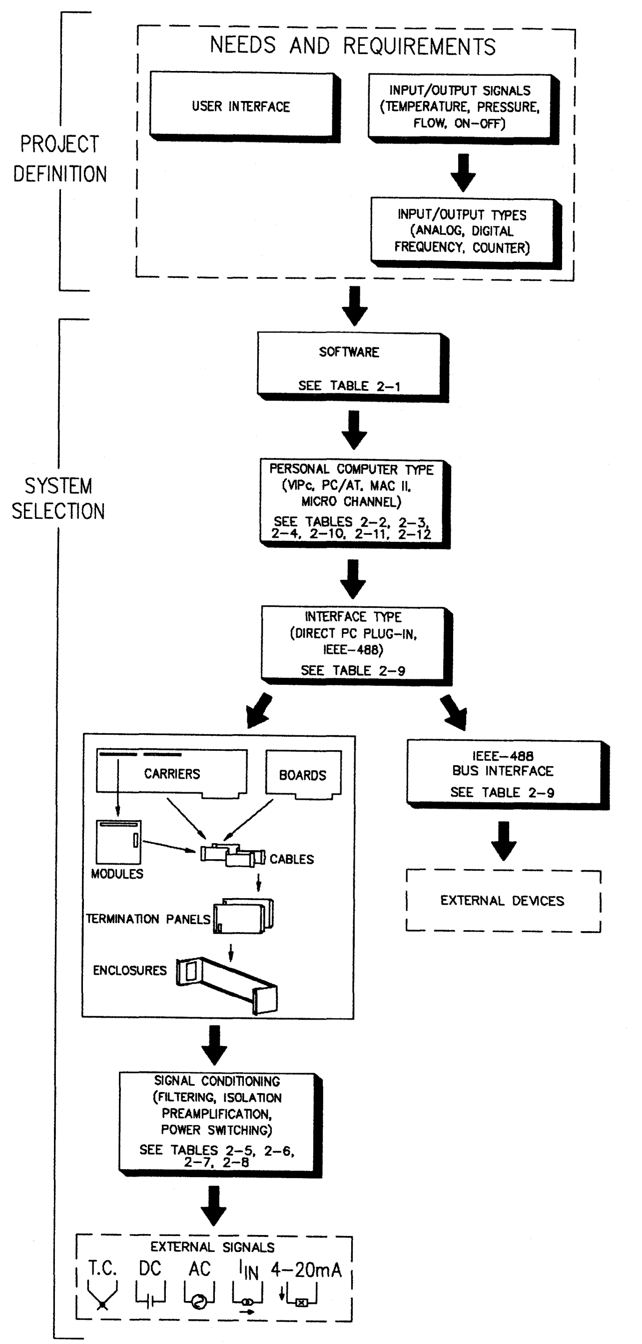
a) What are the signal input and output types? How many of each? How fast are the signals?
b) Is analysis required? Real-time or post process?
c) Display? Real-time or post process?
d) Signal generation?
e) Control? Open or closed loop?
f) Report generation?

PCI hardware products consist of **boxes, plug-in devices,** and **accessories.** Boxes include **computer platforms, PC bus expanders,** and **bus interfaces.** Devices that plug inside a PC are known as **carriers, modules,** and **boards.** These are supported by **termination panels, signal conditioners, cables,** and **enclosures. Blocks** are single-channel signal conditioners that are installed on compatible termination panels.

Remember—It's Best To Select Software First!

QUESTIONS? Contact your local Burr-Brown Sales Engineer or our Factory Application Engineers. We can help!

Factors To Consider



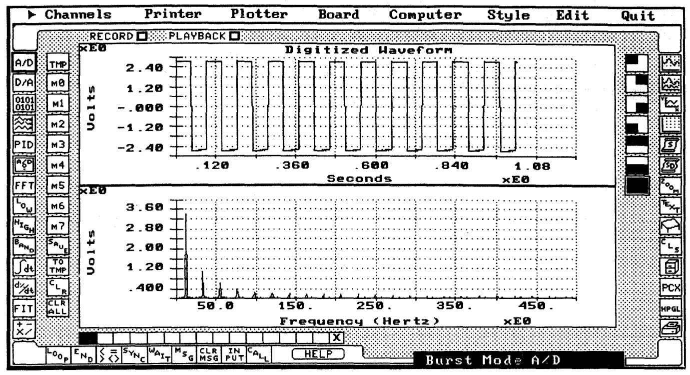
Arriving at the Optimum SOLUTION for a Given Application Is Made Easier by First Defining Your Needs and Then Selecting the Best SOFTWARE.

Software Products

Burr-Brown offers a complete line of software products to support most needs. Application software packages turn your PC and PCI I/O hardware into a state-of-the-art instrument. All are completely menu-driven so that no software programming is required. Data logging, signal generation, frequency analysis, transient recording, process control, product testing, and noise measurement are just a few of the available off-the-shelf capabilities. Therefore, these packages offer high performance with unparalleled ease-of-use.

For those who want to program, software drivers are also available. These tools are ideal for applications that require custom features. Drivers insulate the programmer from the details of the hardware. For example: high-speed analog and digital I/O, pulse generation, frequency measurement, continuous recording to disk, and thermocouple/RTD readings are reduced to a few simple, high-level, command statements. Most I/O operations can be programmed from BASIC, C, TURBO-PASCAL or ASYST.

The most popular software products are summarized below. Please refer to the individual data sheets for additional information.



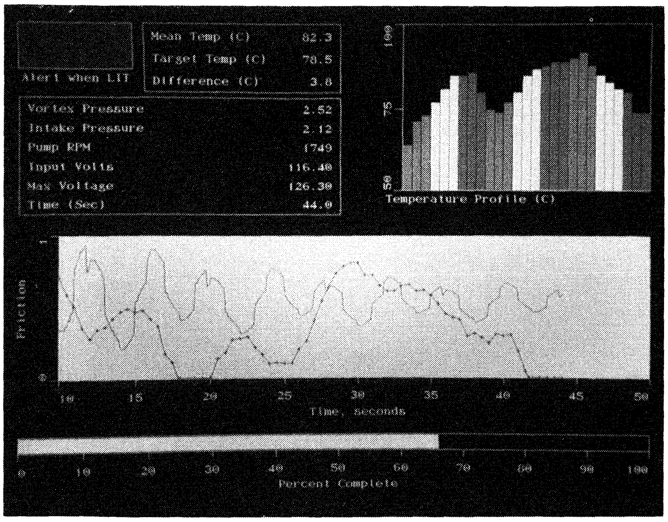
EASYEST (PCI-20348S-1). Icon-driven Signal Acquisition, Control, Analysis, and Display Software.

Please note the other high-level software displays (LABTECH, SNAP-SERIES, and HYPERSIGNAL-WORKSTATION) on the next page.

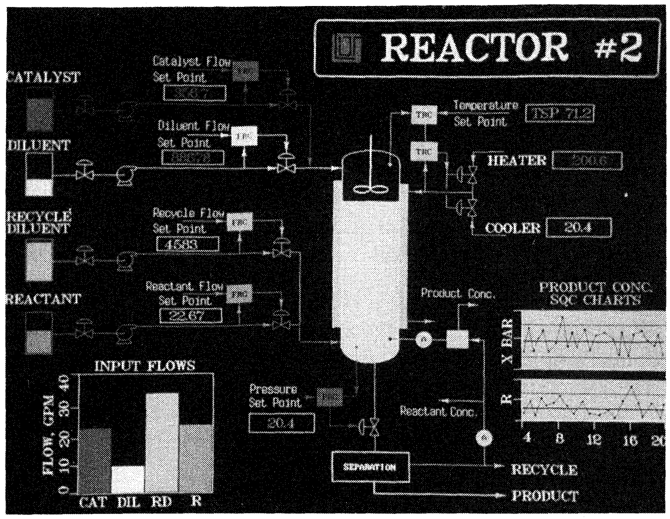
TABLE 2-1. PRODUCT SUMMARY— SOFTWARE

PCI MODEL NUMBER	BUS TYPE	PRODUCT NAME	MENU-DRIVEN	PROGRAMMING TOOL	H/W DRIVER[2]	SIGNAL INPUT	SIGNAL OUTPUT	PROCESS CONTROL	ANALYSIS/ GRAPHICS
PCI-603S	MCA	Drivers, BASIC	No	Yes	Yes	Yes	Yes	No	No
PCI-604S	MCA	Drivers, Microsoft C	No	Yes	Yes	Yes	Yes	No	No
PCI-605S	MCA	Drivers, PASCAL[1]	No	Yes	Yes	Yes	Yes	No	No
PCI-703S	Mac II	Drivers, General-purpose	No	Yes	Yes	Yes	Yes	No	No
PCI-704S	Mac II	Drivers, DMA	No	Yes	Yes	Yes	Yes	No	No
PCI-706S	Mac II	Virtual Instrument Library for LabVIEW 2	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PCI-20040S-1	PC, MCA	LABTECH NOTEBOOK	Yes	No	Yes	Yes	Yes	Yes	Yes
PCI-20097S-1	PC, MCA	LABTECH CONTROL	Yes	No	Yes	Yes	Yes	Yes	Yes
PCI-20026S-1	PC	Drivers, BASIC	No	Yes	Yes	Yes	Yes	No	No
PCI-20026S-2	PC	Drivers, C	No	Yes	Yes	Yes	Yes	No	No
PCI-20026S-3	PC	Drivers, PASCAL[1]	No	Yes	Yes	Yes	Yes	No	No
PCI-20027S-1	PC	Drivers, Extended—BASIC	No	Yes	Yes	Yes	Yes	No	No
PCI-20027S-2	PC	Drivers, Extended—C	No	Yes	Yes	Yes	Yes	No	No
PCI-20027S-3	PC	Drivers, Extended—PASCAL[1]	No	Yes	Yes	Yes	Yes	No	No
PCI-20096S-1	PC	TURBO STREAM, BASIC	No	Yes	Yes	Yes	Yes	No	No
PCI-20096S-2	PC	TURBO STREAM, C	No	Yes	Yes	Yes	Yes	No	No
PCI-20096S-3	PC	TURBO STREAM, PASCAL[1]	No	Yes	Yes	Yes	Yes	No	No
PCI-20203S-1	PC	DSP Library, BASIC	No	Yes	Yes	Yes	Yes	No	No
PCI-20203S-2	PC	DSP Library, C	No	Yes	Yes	Yes	Yes	No	No
PCI-20203S-3	PC	DSP Library, PASCAL[1]	No	Yes	Yes	Yes	Yes	No	No
PCI-20203S-4	PC	DSP Library, FORTRAN	No	Yes	Yes	Yes	Yes	No	No
PCI-20204S-1	PC	DSP Development Package	No	Yes	Yes	Yes	Yes	No	No
PCI-20205S-1	PC	DSPview, FFT Analyzer	Yes	No	Yes	Yes	No	No	Yes
PCI-20206S-1	PC	*Smart* Drivers, BASIC	No	Yes	Yes	No	No	No	No
PCI-20206S-2	PC	*Smart* Driver, C	No	Yes	Yes	No	No	No	No
PCI-20206S-3	PC	*Smart* Drivers, PASCAL[1]	No	Yes	Yes	No	No	No	No
PCI-20206S-4	PC	*Smart* Drivers, FORTRAN	No	Yes	Yes	No	No	No	No
PCI-20208S-1	PC	MicroSoft Macro Assembler	No	Yes	No	No	No	No	No
PCI-20067S-1	PC, MCA	DADiSP/PC	Yes	No	No	No	No	No	Yes
PCI-20068S-1	PC	SNAP-Series	Yes	No	Yes	Yes	Yes	Yes	Yes
PCI-20210S-1	PC	Hypersignal-Workstation	Yes	No	Yes	Yes	Yes	No	Yes
PCI-20301S Series	PC	ASYST Language Series	No	Yes	Yes	Yes	Yes	Yes	Yes
PCI-20348S-1	PC	Easyest	Yes	Yes	Yes	Yes	Yes	Yes	Yes

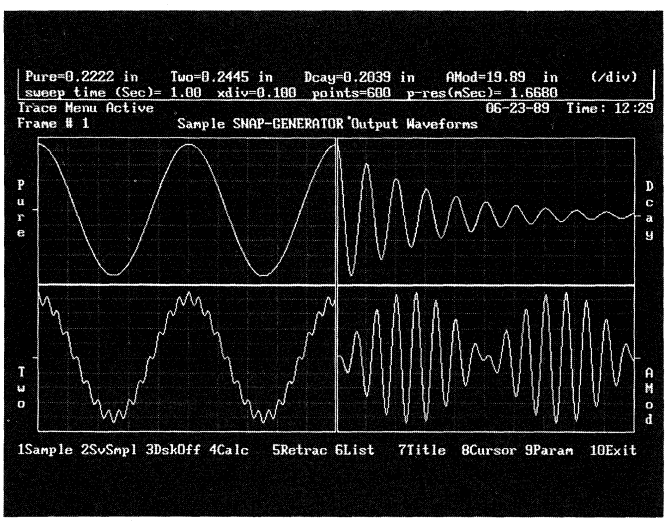
Notes: (1) Borland's TURBO-PASCAL.
(2) Indicates if direct control of one or more PCI hardware products is included.



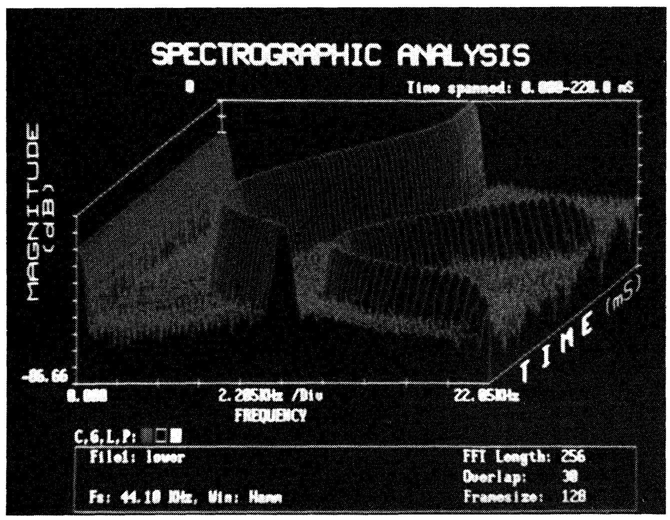
LABTECH NOTEBOOK (PCI-20040S-1). A Complete, General-purpose, Software Package for Real-time Data Acquisition, Control, Analysis, and Display. NOTEBOOK Is Totally Menu-driven so that No Programming Skills Are Required. On-line Help and Tutorials Make Operation Easy to Learn. An Ideal Research and Development Tool. Includes Drivers for Most PCI Hardware.



LABTECH CONTROL (PCI-20097S-1). Specifically Designed for Industrial Monitoring and Process Control. Completely Menu-driven. Capabilities Include Data Logging, PID Control, Analysis, Alarm Logging, Password Security, Network Compatibility, and Animated Real-time Color Graphics Displays. Includes Drivers for Most PCI Hardware.



SNAP-SERIES (PCI-20068S). Menu-driven Waveform Acquisition, Analysis, Display and Signal Generation Software. Useful for Transient Analysis and General Digital Oscilloscope Applications. Comprehensive Math, Digital Filtering, FFT, Decision Making, Signal Generation, and Continuous, High-speed, Direct-to-disk Storage Capabilities. Includes Drivers for Most PCI Hardware.



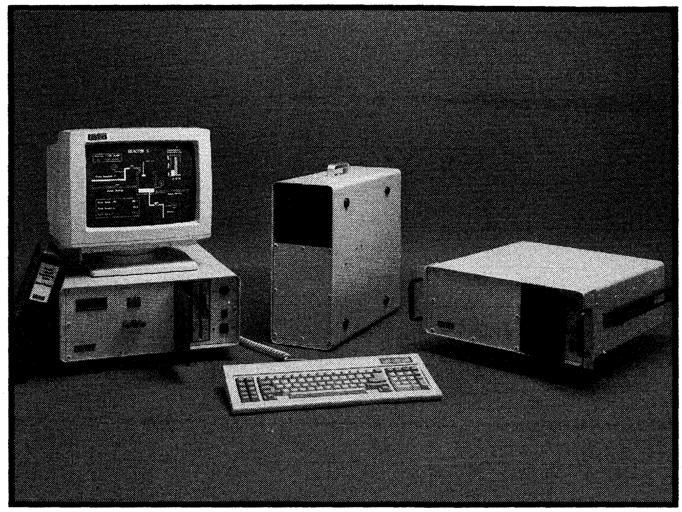
HYPERSIGNAL-WORKSTATION (PCI-20210S-1). Integrates Digital Signal Processing (DSP) Capabilities with *DATA PROFESSIONAL* (PCI-20202C Family) Hardware Control. High-speed Acquisition, FFT, Convolution, Autocorrelation, Digital Filtering, and Signal Editing Are Included. Speech and Signal Analysis Are Facilitated with a Wide Range of Display Formats: Time Domain Oscilloscope, Real-time Spectrum Analyzer, 2-D and 3-D Spectrograph, Pole-zero, Etc. As a Post-Analysis Tool, Hypersignal Can Be Used with Most Data Files Recorded with Any PCI Hardware.

PCI Computer Platforms

Two major types of products are included in this section: Personal Computer Platforms (VIPc) and PC Bus Expansion Enclosures.

All VIPc systems (PCI-5000H Series) include a fully compatible PC/AT computer platform. The unique enclosure is designed for desktop, rack-mount, wall-mount and portable applications. Of special interest are the removable panels and the internal card cage. The card cage accepts a variety of Euro-Style, 3U-size, panels to facilitate field wiring terminations and signal conditioning. The front and rear panels, as well as the top cover, can be easily modified for custom applications. These features allow a VIPc-based product to be transformed into a completely self-contained custom "instrument".

The PCI-20055H Series is designed to add bus expansion space to an existing VIPc or other PC/XT/AT/EISA compatible system. The added slots can be used for any combination of PCI I/O boards and carriers. This can be useful in constructing large systems or when it is desirable to have the data acquisition hardware outside the PC. It is often appropriate to share a single "measurement setup" (PCI-20055H plus other PC compatible I/O products) among several PCs. This is readily accomplished with the companion PC interface board (PCI-20063A-1) and interconnecting cable.



A Complete Family of PC/XT/AT/EISA Compatible Computer Platforms Are Available for Custom Instrumentation Applications.

TABLE 2-2. PRODUCT SUMMARY— PC COMPUTER PRODUCTS

PCI MODEL NUMBER	DESCRIPTION	CPU TYPE	CPU SPEED	BUS SPEED	SLOTS[1]	BUS WIDTH	HARD DISK	FLOPPY DISK	COPROCESSOR	MONITOR	RAM	AC POWER RANGE
PCI-5001H-1	VIPc computer	80286	12.5MHz	8MHz	4	16-bit	40MB	1.2MB	80287	PCI-5010A-1	2MB	90-130V
PCI-5001H-2	VIPc computer	80286	12.5MHz	8MHz	4	16-bit	40MB	1.2MB	80287	PCI-5010A-2	2MB	180-260V
PCI-5002H-1	VIPc computer	80286	12.5MHz	8MHz	4	16-bit	40MB	1.2MB	80287		2MB	85-264V
PCI-5003H-1	VIPc computer	80286	12.5MHz	8MHz	4	16-bit	40MB	1.2MB		PCI-5010A-1	512KB	90-130V
PCI-5003H-2	VIPc computer	80286	12.5MHz	8MHz	4	16-bit	40MB	1.2MB		PCI-5010A-2	512KB	180-260V
PCI-5004H-1	VIPc computer	80286	12.5MHz	8MHz	4	16-bit		1.2MB			512KB	85-264V
PCI-5016H-1	VIPc computer	80286	12.5MHz	8MHz	4	16-bit	20MB	1.2MB			1MB	85-264V
PCI-5017H-1	VIPc computer	80286	12.5MHz	8MHz	4	16-bit	40MB	1.2MB			1MB	85-264V

Note: (1) Available for installation of PCI or other I/O products.

TABLE 2-3. PRODUCT SUMMARY— EXPANSION ENCLOSURES

PCI MODEL NUMBER	DESCRIPTION	BUS SPEED[1]	BUS WIDTH	HARD DISK	FLOPPY DISK	EXPANSION SLOTS	AC POWER RANGE
PCI-20055H-3	PC expander	10MHz	8-bit	(Space for 3)		7	90-132V
PCI-20055H-4	PC expander	10MHz	8-bit	(Space for 3)		7	180-264V
PCI-20063A-1	PC interface board	10MHz	8-bit				

Note: (1) Maximum allowable expansion bus speed of the host computer (most computers, regardless of CPU speed, limit the expansion bus speed to 8MHz).

TABLE 2-4. PRODUCT SUMMARY— PC COMPUTER ACCESSORIES

PCI MODEL NUMBER	PRODUCT DESCRIPTION	NOTES
PCI-5005A-1	2Mbyte RAM expansion kit	VIPc has room for 4MBytes of RAM.
PCI-5006A-1	80287-8 coprocessor	For use with PCI-5003H Series and PCI-5004H-1.
PCI-5007A-1	40Mbyte hard disk (28mS)	Disk expansion for all VIPc models.
PCI-5008A-1	Rack-mount hardware	For VIPc base unit.
PCI-5009A-1	Internal disk drive mounting cage	To add more than 2 drives in VIPc.
PCI-5010A-1	EGA/VGA monitor, tabletop	For 100/110/120VAC applications.
PCI-5010A-2	EGA/VGA monitor, tabletop	For 220/240VAC applications.
PCI-5012A-1	Vertical-mount base plate	For "tower" mount installations.
PCI-5013A-1	Extra front faceplate (blank)	For customization.
PCI-5014A-1	Extra rear faceplate (blank)	For customization.
PCI-5015A-1	Front door without logos	For resale applications.
PCI-5024A-1	3.5" floppy disk drive	1.44Mbyte.
PCI-5027A-1	EGA monior, industrial rack-mount	For 90/260VAC applications.
PCI-2500-1	Numeric keyboard microterminal with mounting kit	Can replace keyboard on VIPc.
PCI-8500-1	Alpha/numeric keyboard microterminal with mounting kit	Can replace keyboard and monitor on VIPc.

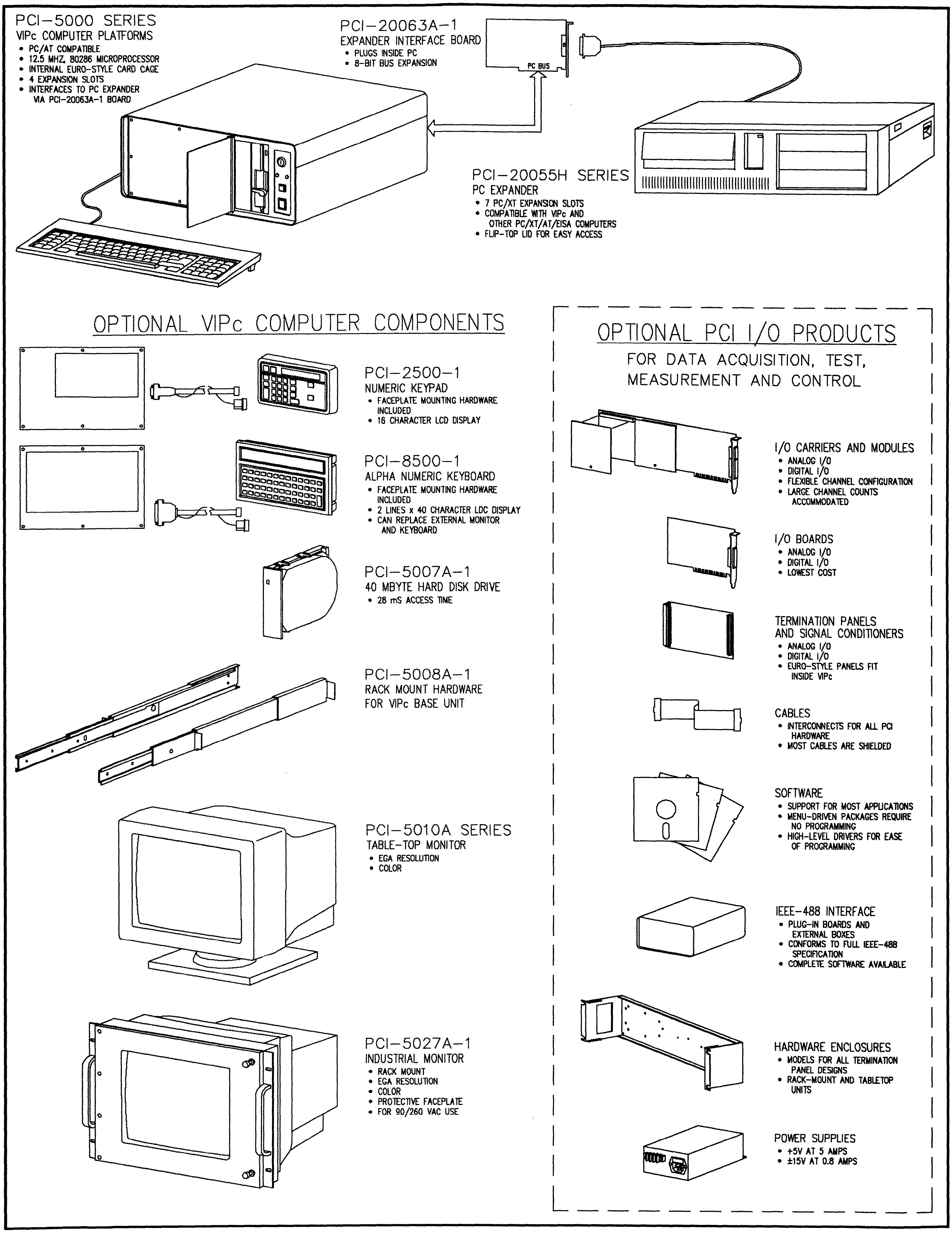
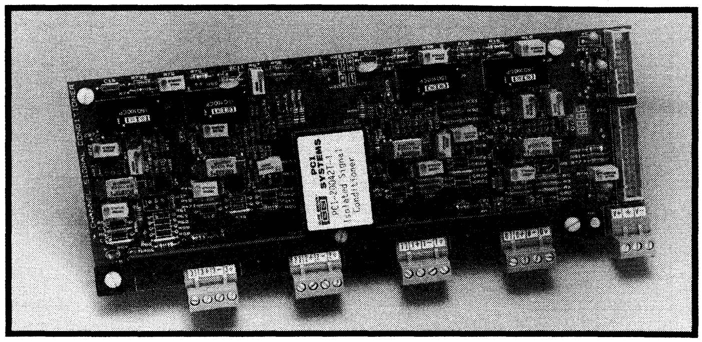


FIGURE 2-1. Products Include Customizable PC Compatible Instrumentation Platforms, Optional Accessories and an Expansion Enclosure.

Signal Conditioning Products

"Signals" are the electronic signature of physical phenomena: speed, intensity, temperature, pressure, motion, closed-open, start-stop, etc. These real-world values are converted to voltages, currents, frequencies or pulse-widths by transducers. Thermocouples, strain gages, and optical encoders are examples of transducers. Motors, heaters and valves are examples of control devices. Signals come *from* transducers or go *to* control devices. Digital signals have discrete levels, while analog signals take on a range of values.

A data acquisition system includes digital I/O ports, analog-to-digital and digital-to-analog converters, and counter/timers to transform an application's external signal characteristics to the requirements of the PC. However, these subsystems also expect/generate signals within a finite range: ±10V for analog and 0 to 5V for digital. Very small voltages (mV), high voltages (greater than 10V), and current levels greater than a few milliamps need additional processing. These scaling operations (along with isolation, filtering, cold-junction compensation (CJC), and surge protection) are known as signal conditioning.



PCI-20042T-1 Isolated, Analog Signal Conditioning Panel.

Provisions for some types of signal conditioning (amplification, CJC, etc.) are included as an integral part of the I/O subsystem. The PCI products described below complement the system's internal capabilities. Please refer to the individual data sheets for additional information.

TABLE 2-5. PRODUCT SUMMARY— SIGNAL CONDITIONERS (TYPICAL SPECIFICATIONS)

PCI MODEL NUMBER	PRODUCT TYPE	DESCRIPTION	CHANNELS	PRODUCT GROUP[1]	SPEED/ BANDWIDTH	INPUT RANGE	OUTPUT RANGE	OUTPUT CURRENT	ISOLATION RATING
PCI-1101	Block	AC/DC digital input	1	18T, 48T	5mS	10-32V	TTL		4000V
PCI-1102	Block	AC/DC digital input	1	18T, 48T	20mS	90-140V	TTL		4000V
PCI-1103	Block	DC digital output	1	18T, 48T	1mS	TTL	5-60V	3A	4000V
PCI-1104	Block	AC digital output	1	18T, 48T	8mS	TTL	12-140VAC	3A	4000V
PCI-1105	Block	AC/DC digital input	1	18T, 48T	5mS	10-32V	TTL		4000V
PCI-1106	Block	AC digital output	1	18T, 48T	20mS	TTL	24-280VAC	3A	4000V
PCI-1107	Block	AC/DC digital input	1	324T-326T	5mS	10-32V	TTL		4000V
PCI-1108	Block	AC/DC digital input	1	324T-326T	20mS	90-140V	TTL		4000V
PCI-1109	Block	DC digital output	1	324T-326T	1mS	TTL	5-60V	3A	4000V
PCI-1110	Block	AC digital output	1	324T-326T	8mS	TTL	12-140VAC	3A	4000V
PCI-1111	Block	AC/DC digital input	1	324T-326T	5mS	10-32V	TTL		4000V
PCI-1112	Block	AC digital output	1	324T-326T	20mS	TTL	24-280VAC	3A	4000V
PCI-5B30-01	Block	Analog input	1	5B01	4Hz	±10mV	±5V		1500V
PCI-5B30-02	Block	Analog input	1	5B01	4Hz	±50mV	±5V		1500V
PCI-5B30-03	Block	Analog input	1	5B01	4Hz	±100mV	±5V		1500V
PCI-5B31-01	Block	Analog input	1	5B01	4Hz	±1V	±5V		1500V
PCI-5B31-03	Block	Analog input	1	5B01	4Hz	±10V	±5V		1500V
PCI-5B37J	Block	Thermocouple input	1	5B01	4Hz	Type J T.C.	0-5V		1500V
PCI-5B37K	Block	Thermocouple input	1	5B01	4Hz	Type K T.C.	0-5V		1500V
PCI-5B37T	Block	Thermocouple input	1	5B01	4Hz	Type T T.C.	0-5V		1500V
PCI-5B39-02	Block	Analog output	1	5B01	400Hz	±5V	4-20mA		1500V
PCI-20008A-1B	Cable	High-density	16	5B01					
PCI-20009A-1B	Cable	High-density	16	325T					
PCI-20012A-1	Cable	Standard	8	42T-45T					
PCI-20013A-1	Cable	Standard	16	18T, 48T					
PCI-20311A-1	Cable	Standard	16	324T					
PCI-5B01-1	Panel	Analog I/O	16	5B blocks					
PCI-20018T-1	Panel	Digital I/O	8	1101-1106					
PCI-20042T-1	Panel	Isolated conditioner	4		30-100Hz	±10mV-±10V	±10V		750V
PCI-20043T-1	Panel	Isolated expander	4		30-100Hz	±10mV-±10V	±10V		750V
PCI-20044T-1	Panel	Signal conditioner	4		30-30kHz	±10mV-±10V	±10V		
PCI-20045T-1	Panel	Expander	4		30-30kHz	±10mV-±10V	±10V		
PCI-20048T-1	Panel	Digital I/O	16	1101-1106					
PCI-20324T-1	Panel	Digital I/O	8	1107-1112					
PCI-20325T-1	Panel	Digital I/O	8	1107-1112					
PCI-20326T-1	Panel	Digital I/O	8	1107-1112					
PCI-20038A-1, 3, 4	Power	±15V power supply		42T-45T		85-264VAC	±15V	0.8A	
PCI-20338A-1	Power	5V power supply		5B Series		85-264VAC	5V	3A	
PCI-20029A-1	Rack	19″ rack enclosure		18T, 42T-45T					
PCI-20308H-1	Rack	19″ rack enclosure		Euro panels					
PCI-20339A-1	Rack	19″ rack enclosure		5B, 48T					
PCI-20343A-1	Rack	Tabletop enclosure		Euro panels					

Note: (1) The numbers shown are abbreviated PCI part numbers.

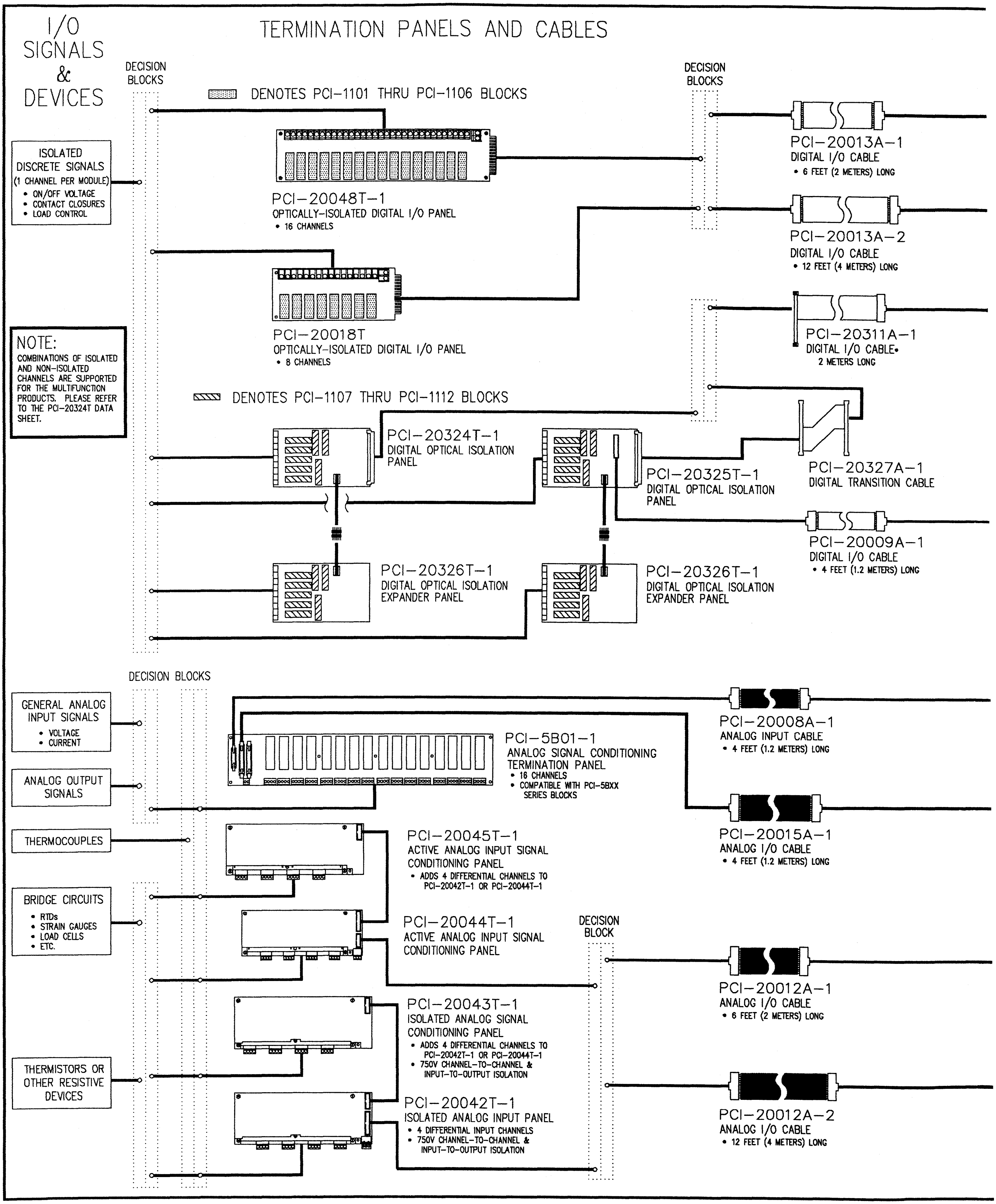
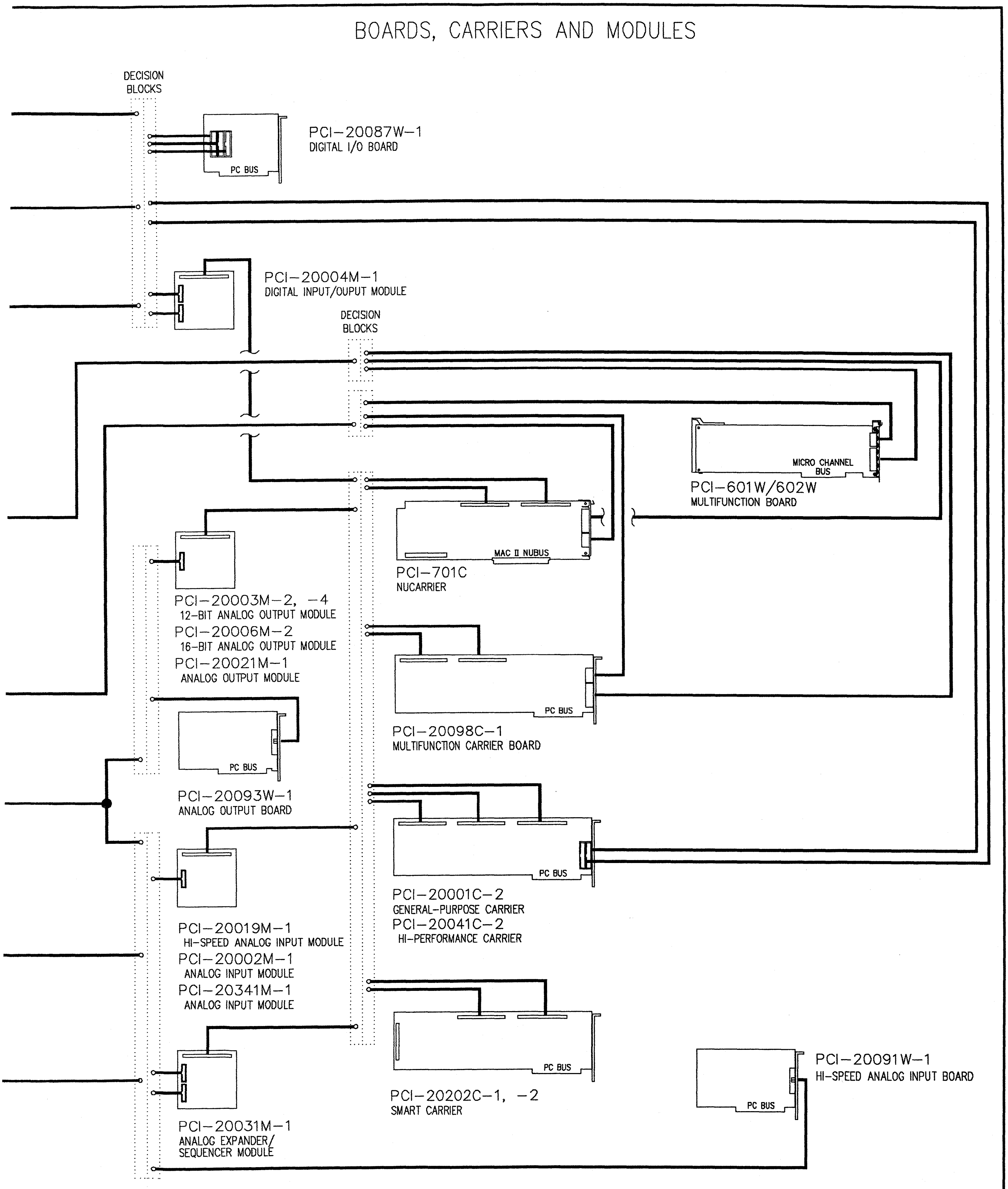


FIGURE 2-2. Real-world Signals Can Be Easily Interfaced to a Data Acquisition System Using Burr-Brown's Signal Conditioning Products.



BOARDS, CARRIERS AND MODULES
DECISION BLOCKS
PCI–20087W–1
DIGITAL I/O BOARD
PC BUS
PCI–20004M–1
DIGITAL INPUT/OUPUT MODULE
DECISION BLOCKS
MICRO CHANNEL BUS
PCI–601W/602W
MULTIFUNCTION BOARD
MAC II NUBUS
PCI–701C
NUCARRIER
PCI–20003M–2, –4
12–BIT ANALOG OUTPUT MODULE
PCI–20006M–2
16–BIT ANALOG OUTPUT MODULE
PCI–20021M–1
ANALOG OUTPUT MODULE
PC BUS
PCI–20098C–1
MULTIFUNCTION CARRIER BOARD
PC BUS
PCI–20093W–1
ANALOG OUTPUT BOARD
PC BUS
PCI–20001C–2
GENERAL–PURPOSE CARRIER
PCI–20041C–2
HI–PERFORMANCE CARRIER
PCI–20019M–1
HI–SPEED ANALOG INPUT MODULE
PCI–20002M–1
ANALOG INPUT MODULE
PCI–20341M–1
ANALOG INPUT MODULE
PC BUS
PCI–20202C–1, –2
SMART CARRIER
PC BUS
PCI–20091W–1
HI–SPEED ANALOG INPUT BOARD
PCI–20031M–1
ANALOG EXPANDER/ SEQUENCER MODULE

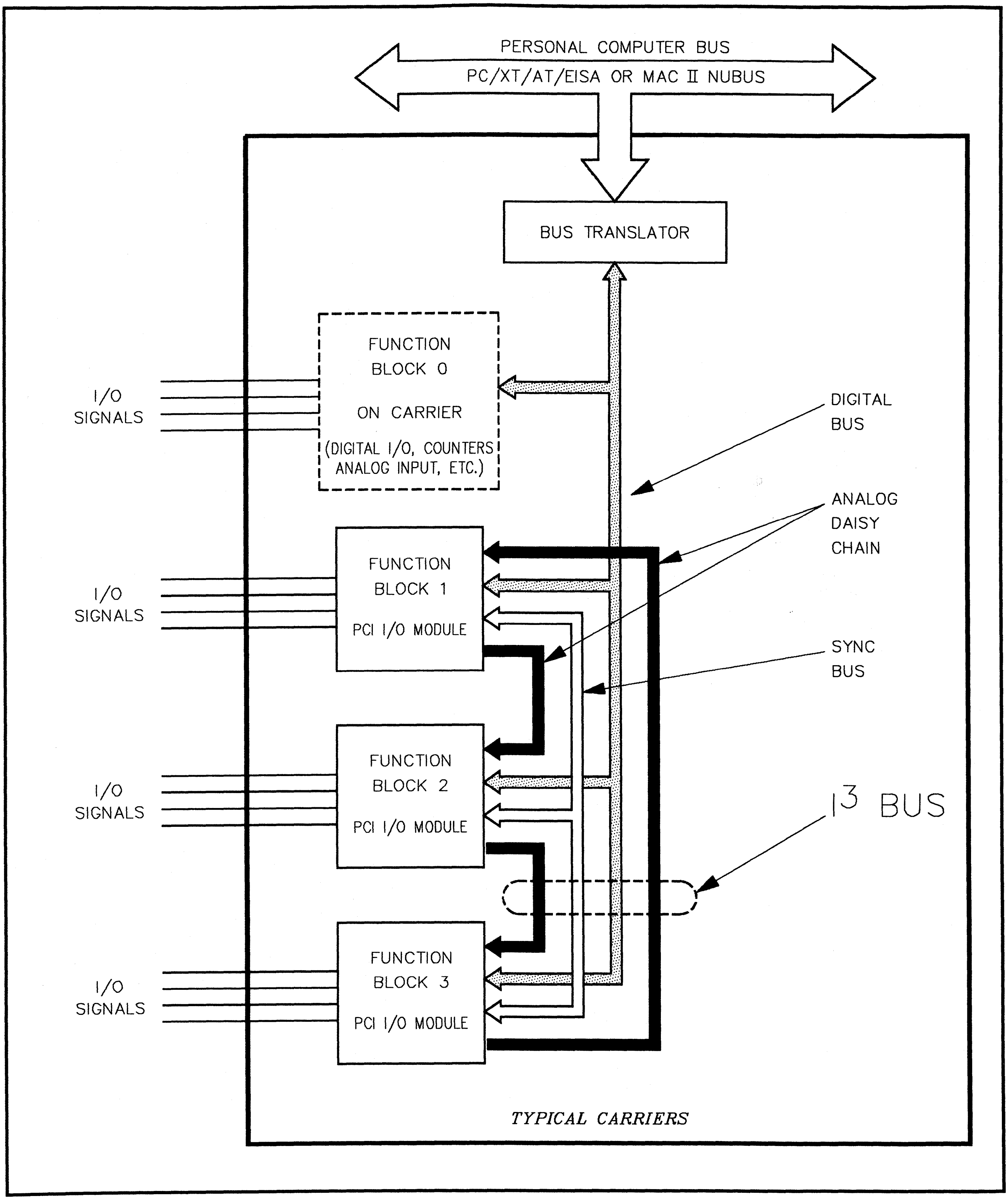


FIGURE 2-3. A Key Feature of the Burr-Brown Modular, Carrier-based, System Is Its Unique Bus Structure. The I^3 Bus Supports Digital, Syncronization, and Analog Signal Transfers Between I/O Modules. This Supports a Range of Important Functions Including Low-cost Channel Expansion.

Analog Input Products

Signals can be classified as either analog or digital. The information or data in an analog signal is conveyed by "how big" (amplitude) it is. In contrast, digital data is communicated by the signal's "state", high or low. Common analog signals range from -10 to +10 volts and can have any value in between.

Physical parameters such as temperature, pressure, flow, speed, weight, and position are all fundamentally analog in nature. One of the functions of a data acquisition system is to convert analog signals to the digital language of the PC. This process is known as digitizing. Here the infinite possible amplitudes of an analog signal are grouped into a manageable number of states that can be represented by digital numbers. For example, a 12-bit system differentiates between 4096 (2^{12}) different states. The system's analog-to-digital (A/D) converter performs this task.

Table 2-6 shows the range of PCI products that support analog input signals. The major characteristics of each model are compared. FIGURE 2-4 indicates how the various components interconnect with each other. The recommended cables, termination panels and signal conditioners are also shown. Other PCI products are available for special applications. Please contact your local Burr-Brown representative for additional information.

TABLE 2-6. PRODUCT SUMMARY— ANALOG INPUT (TYPICAL SPECIFICATIONS)

PCI MODEL NUMBER	BUS[1] TYPE	PRODUCT TYPE	DESCRIPTION	A/D RESOLUTION	CHANNELS SE/DIFF	VOLTAGE GAINS	SAMPLE RATE[2]	DMA SUPPORT	TRIGGER TYPES
PCI-601W/602W	MCA	Board	Multifunction	12-bit	16/8	1, 10, 100, 200	70kHz	Yes	Hardware
PCI-20089W-1	PC	Board	A/D conversion	12-bit	16/8	1, 10, 100	32kHz	No	Hardware
PCI-20091W-1	PC	Board	High-speed A/D	12-bit	8/0	1	89kHz	Yes	Hardware
PCI-701C	Mac II	Carrier	Multifunction	12-bit	16/8	1, 10, 100, 200	70kHz	With PCI-702M	Hardware
PCI-20098C-1	PC	Carrier	Multifunction	12-bit	16/8	1, 10, 100	32kHz	Yes	Hardware
PCI-20002M-1	I^3	Module	A/D conversion	12-bit	16/8	1, 10, 100, 1K	13kHz	PCI-20041C-3A (1Ch)	Software
PCI-20017M-1	I^3	Module	Simultaneous S/H		4/4	1 thru 1K	8kHz[5]	No	Software
PCI-20019M-1A	I^3	Module	High-speed A/D	12-bit	8/0	1	89kHz	PCI-20041C-3A	Hardware
PCI-20020M-1	I^3	Module	Trigger/Alarm					PCI-20041C-3A/98C-1, PCI-701C/702M	Hardware
PCI-20023M-1	I^3	Module	High-speed A/D	12-bit	8/0	1	180kHz	PCI-20041C-3A, PCI-701C/702M	Hardware
PCI-20031M-1	I^3	Module	Multiplexer/Expander		32/16			PCI-20041C-3A/98C-1, PCI-701C/702M	Hardware
PCI-20341M-1	I^3	Module	High-speed A/D	16-bit	1/4	1, 10, 100, 200	85kHz	PCI-20041C-3A, PCI-20202C Series, PCI-701C/702M	Hardware
PCI-5B Series	All	Block	Signal conditioner		1/1	1 thru 1K[3]	4Hz		
PCI-5B01-1	All	Panel	Signal conditioner		16/16				
PCI-20024T Series	All	Panel	Custom termination		32/16				
PCI-20042T-1	All	Panel	Signal conditioner		8/8[4]	1 thru 1K			
PCI-20044T-1	All	Panel	Signal conditioner		8/8[4]	1 thru 1K			
PCI-20303T Series	All	Panel	General-purpose						
PCI-20304T Series	All	Panel	High-density						
PCI-20008A Series	All	Cable	High-density		16/8				
PCI-20012A Series	All	Cable	Standard						
PCI-20015A-1	All	Cable	Standard						
PCI-20310A Series	All	Cable	Euro-Style		16/8				
PCI-20029A-1	All	Enclosure	Rack-mount, standard						
PCI-20308H-1	All	Enclosure	Rack-mount, Euro						
PCI-20339A-1	All	Enclosure	Rack-mount, 5B01						
PCI-20343A-1	All	Enclosure	Tabletop, Euro						
PCI-603/604/605S	MCA	Software	High-level drivers					Yes	
PCI-703S	Mac II	Software	High-level drivers					No	
PCI-704S	Mac II	Software	High-level drivers					Yes	
PCI-706S	Mac II	Software	LabVIEW 2 drivers					Yes	
PCI-20026S Series	PC	Software	High-level drivers					No	
PCI-20027S Series	PC	Software	High-level drivers					Yes	
PCI-20040S-1	PC/MCA	Software	LABTECH NOTEBOOK					No	
PCI-20068S Series	PC	Software	SNAP-Series					Yes	
PCI-20096S Series	PC	Software	TURBO STREAM					Yes	
PCI-20097S-1	PC	Software	LABTECH CONTROL					No	
PCI-20203S Series	PC	Software	DSP Library Plus					Yes	
PCI-20204S-1	PC	Software	DSP Development Pak					Yes	
PCI-20210S-1	PC	Software	Hypersignal					No	
PCI-20301S Series	PC	Software	ASYST Language					Yes	
PCI-20348S-1	PC	Software	Easyest					Yes	

Notes:
(1) I^3 Bus products are compatible with all PCI Carriers. They are also ideal as building block components in OEM applications. "PC" implies VIPc and other PC/XT/AT/EISA compatible computers. "MCA" stands for Micro Channel computers. "Mac II" implies Macintosh II NuBus.
(2) Maximum sample rate in a 12MHz PC/AT compatible computer.
(3) Each block has a specific signal gain. Please refer to the PCI-5B Series Data Sheet for more information.
(4) The PCI-20042T-1 and PCI-20044T-1 support four channels each. Eight channels are available when used with a companion expander panel.
(5) On the PCI-20202C Series with PCI-20204S-1, the PCI-200017M-1 can reach speeds up to 175kHz total throughput rate.

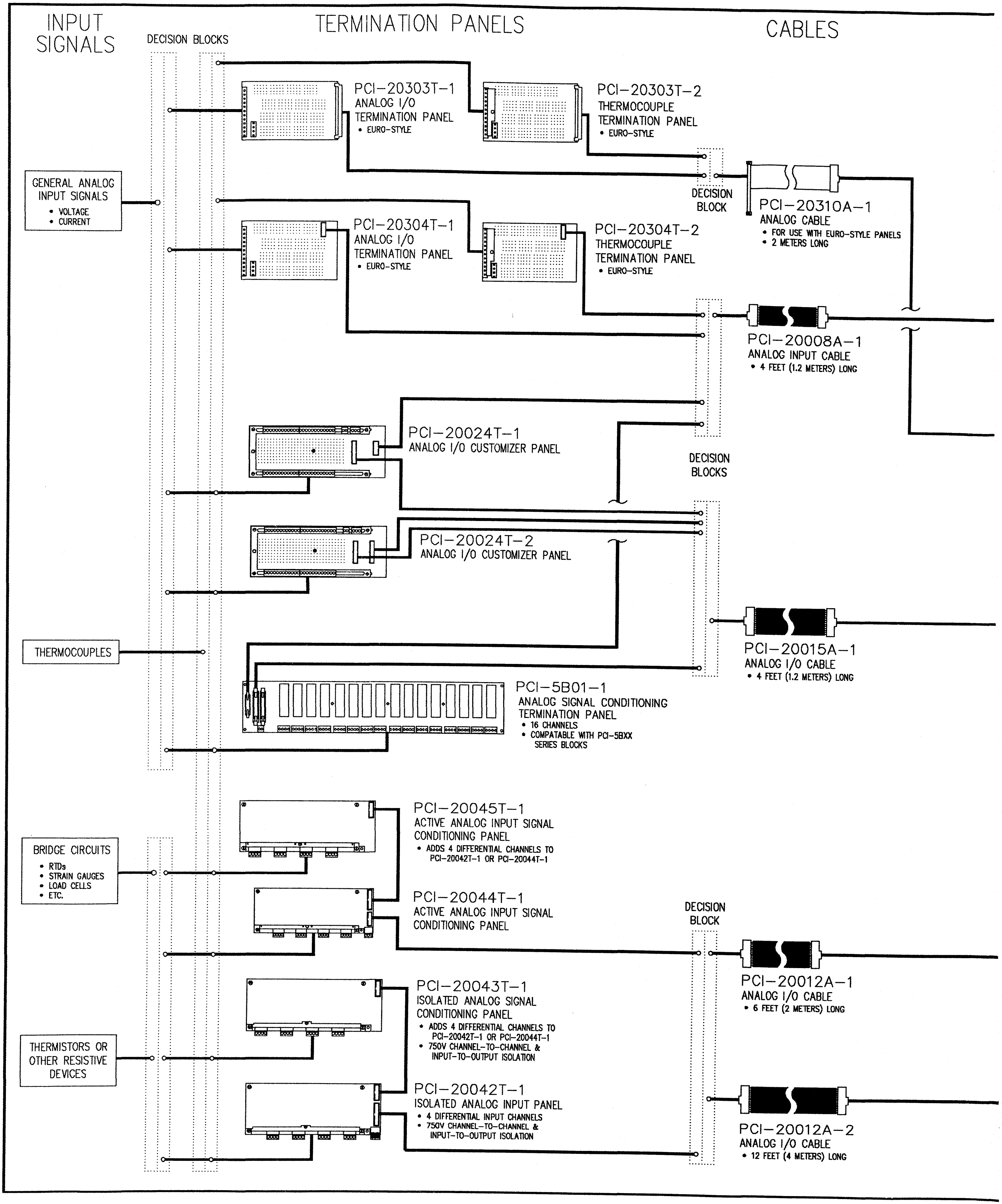
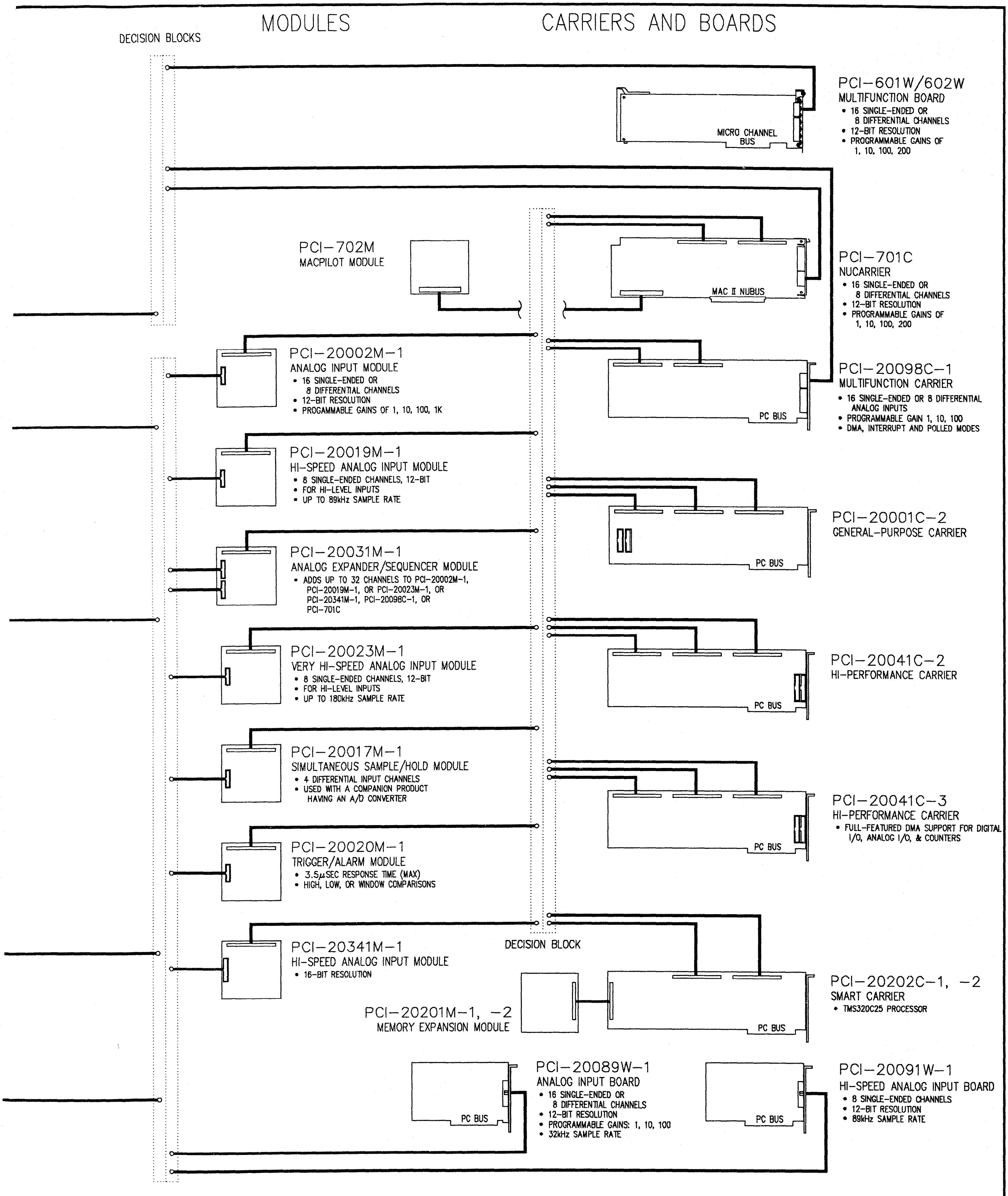
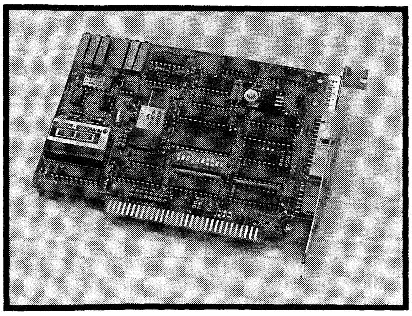


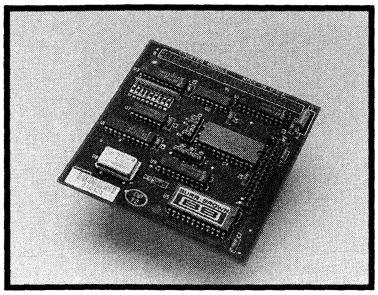
FIGURE 2-4. Analog Input Functions Are Supported by a Wide Range of Hardware and Software Products for All Major PCs.



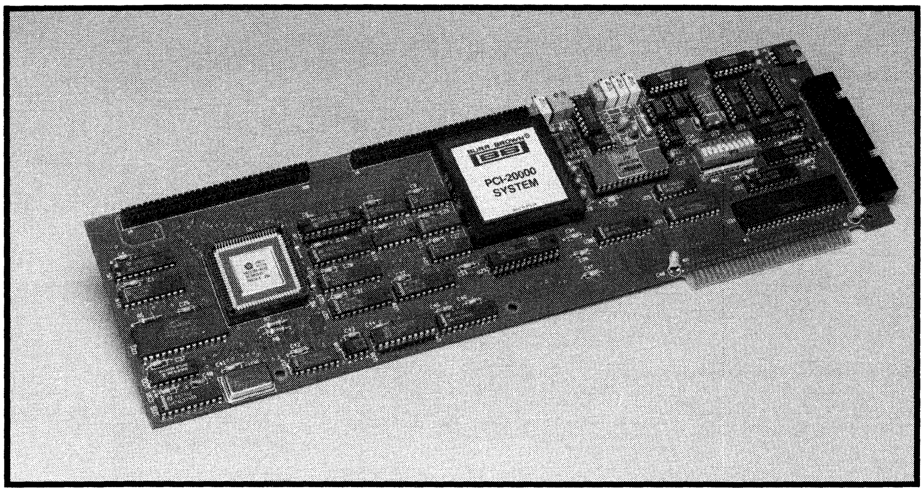
DECISION BLOCKS
MODULES
CARRIERS AND BOARDS
PCI–601W/602W
MULTIFUNCTION BOARD
• 16 SINGLE-ENDED OR 8 DIFFERENTIAL CHANNELS
• 12-BIT RESOLUTION
• PROGRAMMABLE GAINS OF 1, 10, 100, 200
MICRO CHANNEL BUS
PCI–702M
MACPILOT MODULE
MAC II NUBUS
PCI–701C
NUCARRIER
• 16 SINGLE-ENDED OR 8 DIFFERENTIAL CHANNELS
• 12-BIT RESOLUTION
• PROGRAMMABLE GAINS OF 1, 10, 100, 200
PCI–20002M–1
ANALOG INPUT MODULE
• 16 SINGLE-ENDED OR 8 DIFFERENTIAL CHANNELS
• 12-BIT RESOLUTION
• PROGAMMABLE GAINS OF 1, 10, 100, 1K
PCI–20098C–1
MULTIFUNCTION CARRIER
• 16 SINGLE-ENDED OR 8 DIFFERENTIAL ANALOG INPUTS
• PROGRAMMABLE GAIN 1, 10, 100
• DMA, INTERRUPT AND POLLED MODES
PC BUS
PCI–20019M–1
HI-SPEED ANALOG INPUT MODULE
• 8 SINGLE-ENDED CHANNELS, 12-BIT
• FOR HI-LEVEL INPUTS
• UP TO 89kHz SAMPLE RATE
PCI–20001C–2
GENERAL-PURPOSE CARRIER
PC BUS
PCI–20031M–1
ANALOG EXPANDER/SEQUENCER MODULE
• ADDS UP TO 32 CHANNELS TO PCI-20002M-1, PCI-20019M-1, OR PCI-20023M-1, OR PCI-20341M-1, PCI-20098C-1, OR PCI-701C
PCI–20023M–1
VERY HI-SPEED ANALOG INPUT MODULE
• 8 SINGLE-ENDED CHANNELS, 12-BIT
• FOR HI-LEVEL INPUTS
• UP TO 180kHz SAMPLE RATE
PCI–20041C–2
HI-PERFORMANCE CARRIER
PC BUS
PCI–20017M–1
SIMULTANEOUS SAMPLE/HOLD MODULE
• 4 DIFFERENTIAL INPUT CHANNELS
• USED WITH A COMPANION PRODUCT HAVING AN A/D CONVERTER
PCI–20041C–3
HI-PERFORMANCE CARRIER
• FULL-FEATURED DMA SUPPORT FOR DIGITAL I/O, ANALOG I/O, & COUNTERS
PC BUS
PCI–20020M–1
TRIGGER/ALARM MODULE
• 3.5μSEC RESPONSE TIME (MAX)
• HIGH, LOW, OR WINDOW COMPARISONS
DECISION BLOCK
PCI–20341M–1
HI-SPEED ANALOG INPUT MODULE
• 16-BIT RESOLUTION
PCI–20201M–1, –2
MEMORY EXPANSION MODULE
PCI–20202C–1, –2
SMART CARRIER
• TMS320C25 PROCESSOR
PC BUS
PCI–20089W–1
ANALOG INPUT BOARD
• 16 SINGLE-ENDED OR 8 DIFFERENTIAL CHANNELS
• 12-BIT RESOLUTION
• PROGRAMMABLE GAINS: 1, 10, 100
• 32kHz SAMPLE RATE
PC BUS
PCI–20091W–1
HI-SPEED ANALOG INPUT BOARD
• 8 SINGLE-ENDED CHANNELS
• 12-BIT RESOLUTION
• 89kHz SAMPLE RATE
PC BUS



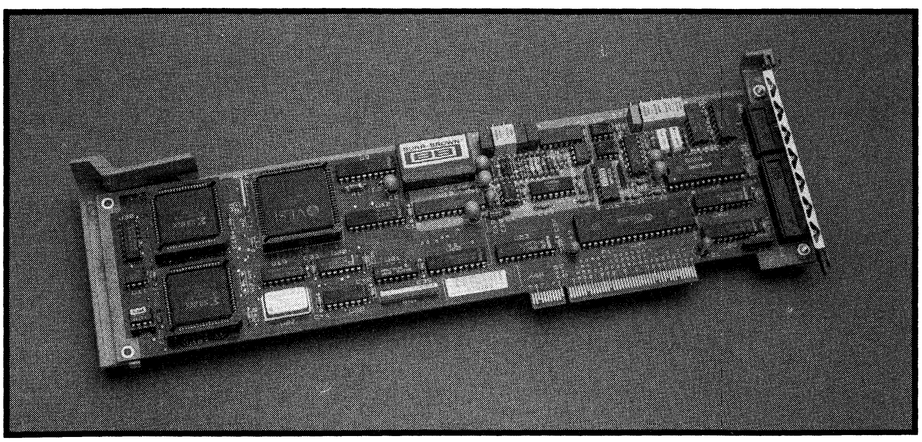
High-performance at the Lowest Possible Cost Per Channel Is Provided by the PCI Superboards (PCI-20087W-1, PCI-20089W-1, PCI-20091W-1 and PCI-20093W-1). Digital I/O, Analog Input and Analog Output are All Supported.



Sixteen Different I/O Modules Add Great Flexibility to PCI Carrier-based Products. These I/O Modules Can Also Be Used as Building Blocks in Custom (Perhaps Non-PC) Configurations.



Multifunction Carriers Are Available for the PC/XT/AT/EISA and Mac II Computers. In Addition to the Built-in Functions, I/O Modules Can Be Installed to Extend or Expand the I/O Capabilities.



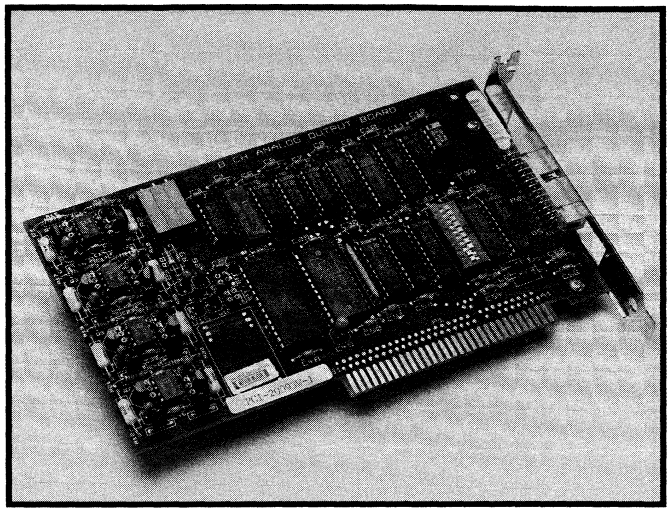
Special Multifunction Boards Are Provided for the Micro Channel Computers (IBM Models 50, 60, 70 and 80). The Most Popular I/O Functions Are Supported.

Analog Output Products

Signals can be classified as either analog or digital. The information or data in an analog signal is conveyed by "how big" (amplitude) it is. In contrast, digital data is communicated by the signal's "state", high or low. Common analog signals range from -10 to +10 volts and can have any value in between.

Physical processes such as varying the position of a valve, adjusting the intensity of a lamp, or smoothly controlling the temperature in a chamber all require proportional (analog) signals. One of the functions of a data acquisition system is to represent the two digital output states of the PC as many levels approximating an analog signal. For example, a 12-bit output system divides a given full scale range into 4096 (2^{12}) different levels. The system's digital-to-analog (D/A) converter performs this task.

Table 2-7 shows the range of PCI products that support analog output signals. The major characteristics of each model are compared. FIGURE 2-5 indicates how the various components interconnect with each other. The recommended cables, termination panels and signal conditioners are also shown. Other PCI products are available for special applications. Please contact your local Burr-Brown representative for additional information.



Analog Outputs for Test, Control and Waveform Generation Applications Are Easily Produced with PCI Boards and Modules. A Full Range of Software Support Is Also Available.

TABLE 2-7. PRODUCT SUMMARY— ANALOG OUTPUT (TYPICAL SPECIFICATIONS)

PCI MODEL NUMBER	BUS[1] TYPE	PRODUCT TYPE	DESCRIPTION	D/A RESOLUTION	CHANNELS	OUTPUT RATE[2]	DMA SUPPORT	OUTPUT VOLTAGE	OUTPUT CURRENT
PCI-602W	MCA	Board	Multifunction	16-bit	2	80K	Yes	±10V/5mA	
PCI-20093W-1	PC	Board	D/A conversion	12-bit	8	4K	No	±5V/1mA	0-20mA
PCI-20003M-2	I^3	Module	D/A conversion	12-bit	2	80K	PCI-20041C-3A	±10V/5mA	
PCI-20003M-4	I^3	Module	D/A conversion	12-bit	2	40K[3]	and	±10V/5mA	4-20mA
PCI-20006M-2	I^3	Module	D/A conversion	16-bit	2	80K	PCI-701C with	±10V/5mA	
PCI-20021M-1B	I^3	Module	D/A conversion	12-bit	8	2K	PCI-702M	±10V/1mA	
PCI-5B39-02	All	Block	Signal conditioner		1	400			4-20mA
PCI-5B01-1	All	Panel	Signal conditioner		16				
PCI-20024T Series	All	Panel	Custom termination		16				
PCI-20303T-1	All	Panel	General-purpose						
PCI-20304T-1	All	Panel	High-density						
PCI-20008A Series	All	Cable	High-density		16/8				
PCI-20015A-1	All	Cable	Standard						
PCI-20310A Series	All	Cable	Euro-Style		16/8				
PCI-20029A-1	All	Enclosure	Rack-mount, standard						
PCI-20308H-1	All	Enclosure	Rack-mount, Euro						
PCI-20339A-1	All	Enclosure	Rack-mount 5B01						
PCI-20343A-1	All	Enclosure	Tabletop, Euro						
PCI-603/604/605S	MCA	Software	High-level drivers				Yes		
PCI-703S	Mac II	Software	Drivers, general-purpose				No		
PCI-704S	Mac II	Software	Drivers, DMA				Yes		
PCI-706S	Mac II	Software	Drivers, LabVIEW 2				Yes		
PCI-20026S Series	PC	Software	High-level drivers				No		
PCI-20027S Series	PC	Software	High-level drivers				Yes		
PCI-20040S-1	PC/MCA	Software	LABTECH NOTEBOOK				No		
PCI-2068S Series	PC	Software	SNAP-Series				Yes		
PCI-20096S Series	PC	Software	TURBO STREAM				Yes		
PCI-20097S-1	PC	Software	LABTECH CONTROL				No		
PCI-20203S Series	PC	Software	DSP Library Plus				Yes		
PCI-20204S-1	PC	Software	DSP Development Pak				Yes		
PCI-20210S-1	PC	Software	HYPERSIGNAL				No		
PCI-20301S Series	PC	Software	ASYST Language				Yes		
PCI-200348S-1	PC	Software	Easyest				Yes		

Notes: (1) I^3 products are compatible with all PCI Carriers including the PC and Mac II. They are also ideal as building block components in OEM applications. "PC" implies VIPc and other PC/XT/AT/EISA compatible computers. "MCA" stands for Micro Channel computers.
(2) Maximum outputs per second in a 12MHz PC/AT compatible computer.
(3) 40K outputs/second in the current mode. 80K/second in the voltage mode.

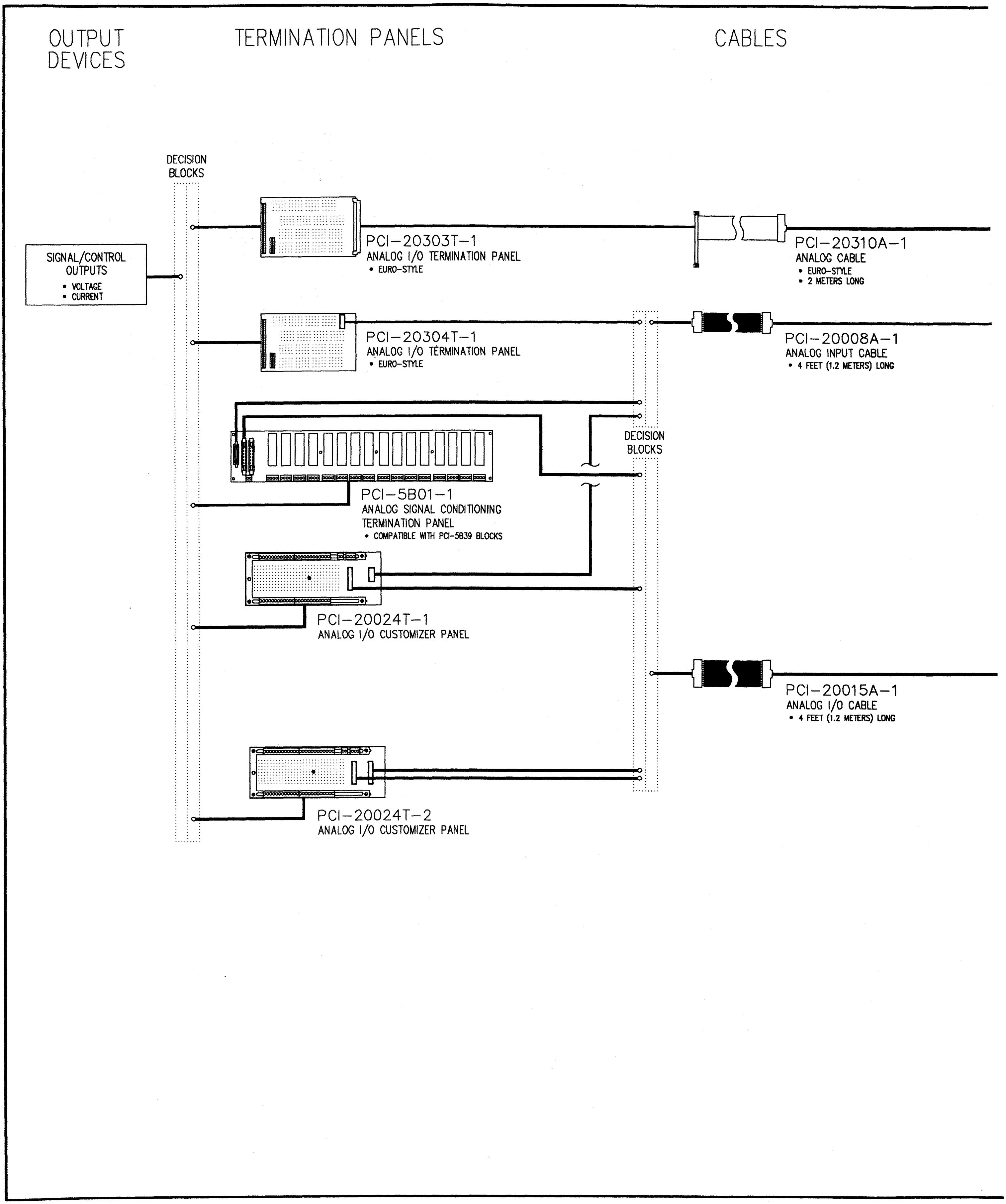
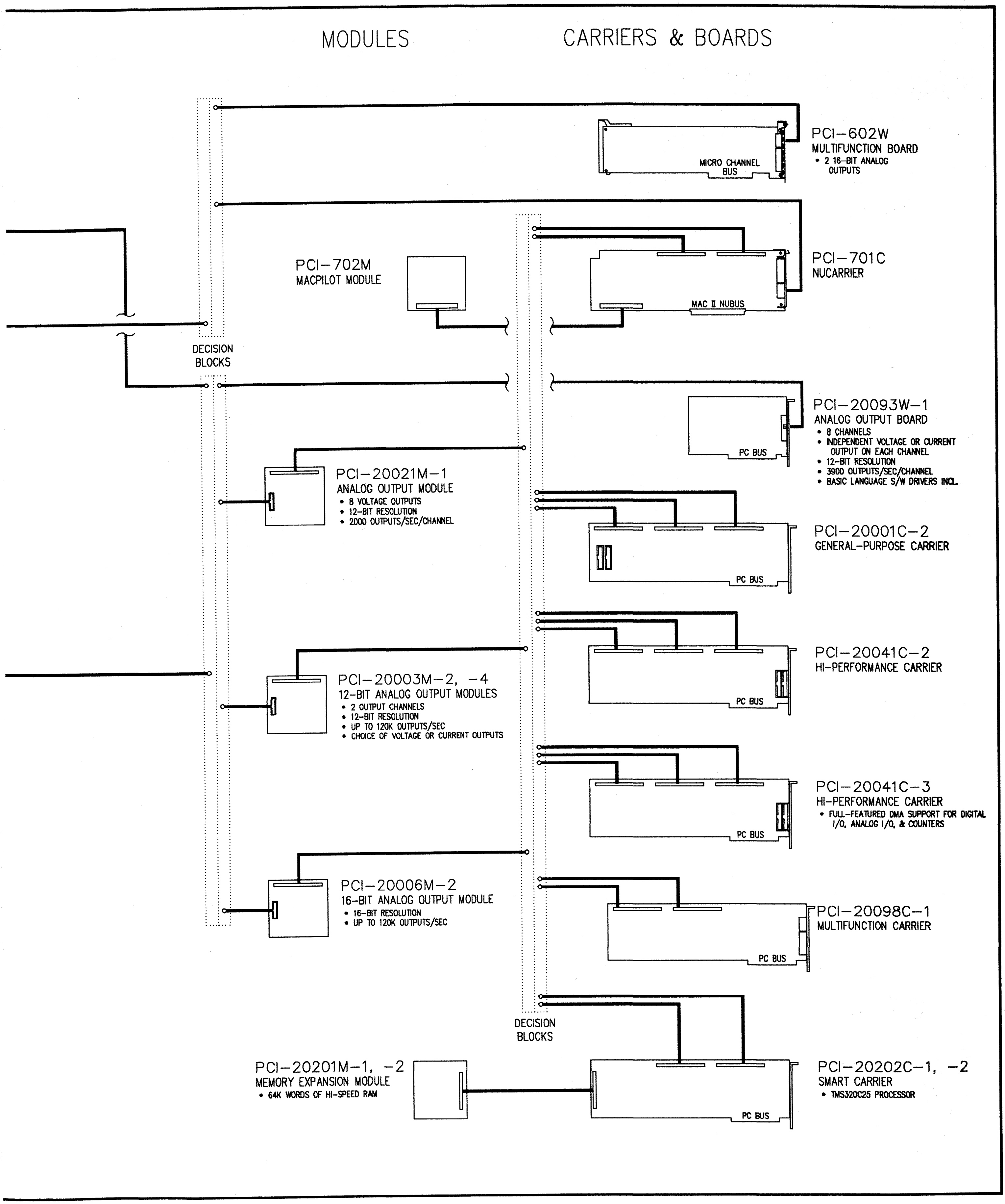
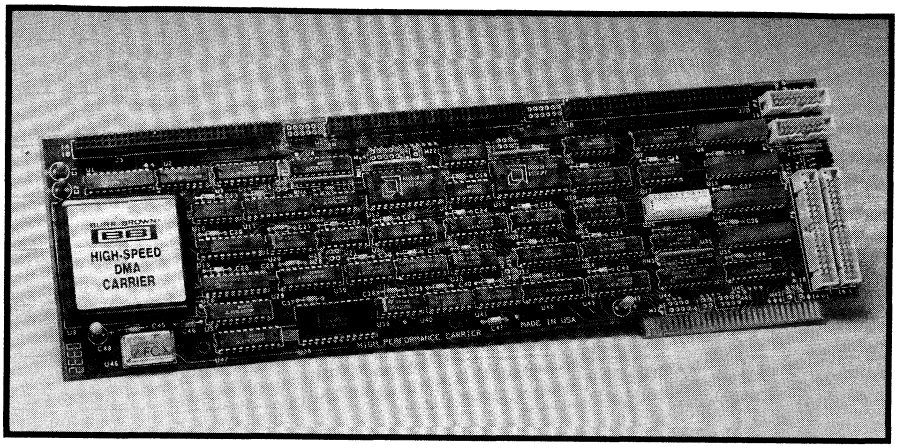


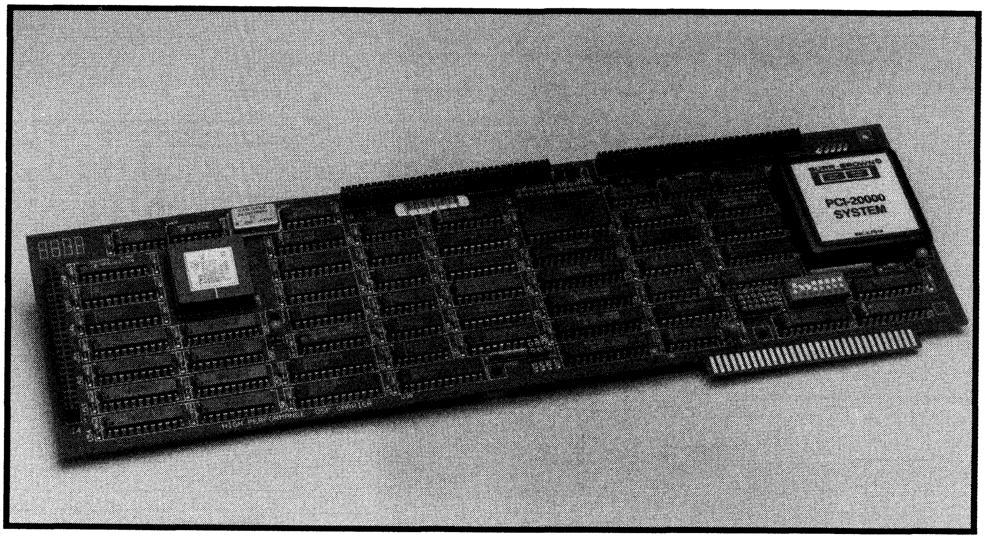
FIGURE 2-5. Analog Output Functions Are Supported by a Wide Range of Boards, Modules, Accessories, and Software.

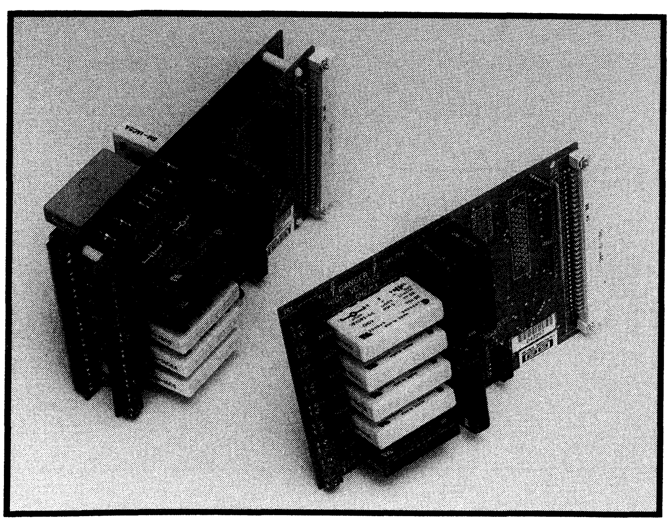

MODULES
CARRIERS & BOARDS
MICRO CHANNEL BUS
PCI-602W
MULTIFUNCTION BOARD
• 2 16-BIT ANALOG OUTPUTS
PCI-702M
MACPILOT MODULE
MAC II NUBUS
PCI-701C
NUCARRIER
DECISION BLOCKS
PC BUS
PCI-20093W-1
ANALOG OUTPUT BOARD
• 8 CHANNELS
• INDEPENDENT VOLTAGE OR CURRENT OUTPUT ON EACH CHANNEL
• 12-BIT RESOLUTION
• 3900 OUTPUTS/SEC/CHANNEL
• BASIC LANGUAGE S/W DRIVERS INCL.
PCI-20021M-1
ANALOG OUTPUT MODULE
• 8 VOLTAGE OUTPUTS
• 12-BIT RESOLUTION
• 2000 OUTPUTS/SEC/CHANNEL
PCI-20001C-2
GENERAL-PURPOSE CARRIER
PCI-20041C-2
HI-PERFORMANCE CARRIER
PCI-20003M-2, -4
12-BIT ANALOG OUTPUT MODULES
• 2 OUTPUT CHANNELS
• 12-BIT RESOLUTION
• UP TO 120K OUTPUTS/SEC
• CHOICE OF VOLTAGE OR CURRENT OUTPUTS
PCI-20041C-3
HI-PERFORMANCE CARRIER
• FULL-FEATURED DMA SUPPORT FOR DIGITAL I/O, ANALOG I/O, & COUNTERS
PCI-20006M-2
16-BIT ANALOG OUTPUT MODULE
• 16-BIT RESOLUTION
• UP TO 120K OUTPUTS/SEC
PCI-20098C-1
MULTIFUNCTION CARRIER
DECISION BLOCKS
PCI-20201M-1, -2
MEMORY EXPANSION MODULE
• 64K WORDS OF HI-SPEED RAM
PCI-20202C-1, -2
SMART CARRIER
• TMS320C25 PROCESSOR



The DMA Support Included on the PCI-20041C-3A Is Unique! It Is the ONLY PC Plug-in to Support Analog AND Digital I/O DMA Data Transfers. Both the On-board DI/O Ports and Any I/O Installed with the Plug-in Modules Can Use DMA.

DATA PROFESSIONAL **Products Include the PCI-20202C Series** ***Smart*** **Carriers. Its On-board Processor Promotes High-speed I/O and Data Manipulation. The Processor Is Optimized for DSP Functions Making** ***DATA PROFESSIONAL*** **the Only System of Its Kind to Accept Analog and Digital I/O Data. The** ***Smart*** **Carrier Works with All PCI I/O Modules.**





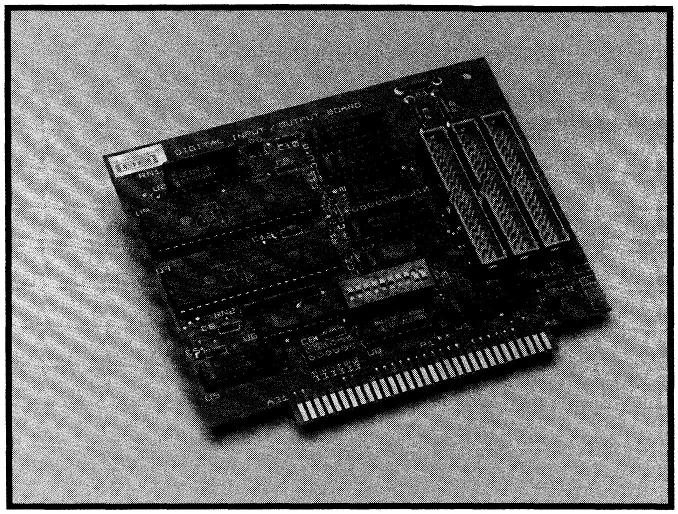
Digital I/O Applications Requiring Isolation, Signal-level Conversion, or Power Switching Capabilities Are Supported by the PCI-1100 Series Opto-blocks. Several Different Termination Panels Accept These Blocks.

Digital Input/Output Products

Digital signals can exist in only two possible states described as high-low, 1-0, etc. One of the most common types of digital signals is known as TTL. In TTL, the signal is either approximately zero (low) or approximately 5 volts (high). Data lies in the distinction between being high or low, not in the actual amplitude. Physical conditions such as a switch being opened or closed and power being on or off can be represented by discrete digital signals. Digital outputs can start a motor, sound an alarm, etc. Real-world digital signals commonly occur as AC or DC voltage levels in the range of 5 to 240 volts.

A pulse is a special kind of digital signal. It also can have only two amplitudes, but additional information is conveyed in its repetition frequency and width. Pulse frequency (number of pulses/second) often represents mechanical speed, while the total number of pulses can identify position.

One function of a data acquisition system is to translate the TTL signals of the PC to/from the desired external levels. The system's digital I/O and counter/timer/generator components perform these functions.



The PCI-20087W-1 Offers High-performance at the Lowest Cost-per-channel Available.

TABLE 2-8. PRODUCT SUMMARY— DIGITAL I/O (TYPICAL SPECIFICATIONS)

PCI MODEL NUMBER	BUS[1] TYPE	PRODUCT TYPE	DESCRIPTION	DI/O BITS	HANDSHAKE LINES	I/O RATE[2]	COUNTERS	TIMING GENERATOR	DMA SUPPORT
PCI-601W/602W	MCA	Board	Multifunction	16	Yes	250KB/sec	2	Burst	Yes
PCI-20087W-1	PC	Board	Digital I/O	40	Yes	11KB/sec			No
PCI-701C	Mac II	Carrier	Multifunction	16	Yes	300KB/sec	2	Burst	With PCI-702M
PCI-20001C-2A	PC	Carrier	General-purpose	32	No	11KB/sec			No
PCI-20041C-2A	PC	Carrier	High-performance	32	No	11KB/sec		Rate	No
PCI-20041C-3A	PC	Carrier	DMA	32	No	220KB/sec		Rate	Yes
PCI-20098C-1	PC	Carrier	Multifunction	16	Yes	11KB/sec	2	Burst	No
PCI-20004M-1	I^3	Module	Digital I/O	32	No	11KB/sec			PCI-20041C-3A
PCI-20007M-1	I^3	Module	Counter/Timer			110KB/sec	4	Rate	PCI-20041C-3A
PCI-20018T-1[3]	Most[3]	Panel	Signal conditioner	8					
PCI-20048T-1[3]	Most[3]	Panel	Signal conditioner	16					
PCI-20025T Series	All	Panel	Custom termination	32					
PCI-20305T-1	All	Panel	General-purpose	16					
PCI-20306T-1	All	Panel	High-density	16					
PCI-20307T-1	All	Panel	Expander	16					
PCI-20324T-1	All	Panel	Signal conditioner	8					
PCI-20325T-1	All	Panel	Signal conditioner	8					
PCI-20326T-1	All	Panel	Signal conditioner	8					
PCI-1100 Series	All	Block	Signal conditioner[4]	1					
PCI-20009A Series	All	Cable	High-density	16					
PCI-20013A Series	All	Cable	Signal conditioner	16					
PCI-20311A Series	All	Cable	Euro-Style	16					
PCI-20327A-1	All	Cable	Euro transition	16					
PCI-20029A-1	All	Enclosure	Rack-mount, standard						
PCI-20308H-1	All	Enclosure	Rack-mount, Euro						
PCI-20339A-1	All	Enclosure	Rack-mount, PCI-20048T						
PCI-20343A-1	All	Enclosure	Tabletop, Euro						
PCI-603/604/605S	MCA	Software	High-level drivers						Yes
PCI-703S	Mac II	Software	High-level drivers						No
PCI-704S	Mac II	Software	High-level drivers						Yes
PCI-706S	Mac II	Software	LabVIEW 2 drivers						Yes
PCI-20026S Series	PC	Software	High-level drivers						No
PCI-20027S Series	PC	Software	High-level drivers						Yes
PCI-20040S-1	PC/MCA	Software	LABTECH NOTEBOOK						No
PCI-20097S-1	PC	Software	LABTECH CONTROL						No
PCI-20204S-1	PC	Software	DSP Development Pak						Yes
PCI-20301S Series	PC	Software	ASYST Language						Yes
PCI-20348S-1	PC	Software	Easyest						Yes

Notes: (1) I^3 products are compatible with all PCI Carriers including the PC and Mac II. They are also ideal as building block components in OEM applications. "PC" implies VIPc and other PC/XT/AT/EISA compatible computers. "MCA" stands for Micro Channel computers.
(2) Maximum sample rate using PCI software: 16MHz 80386 PC/AT; PCI-701C with PCI-702M in a 16MHz Macintosh IIx.
(3) For use with Digital I/O products that have "standard" density connectors (PCI-20001C-1A, PCI-20004M-1, PCI-20007M-1, PCI-20041Cs, PCI-20087W-1).
(4) The PCI-1107 through 1112 are isolated signal conditioners and power switches. Please refer to the data sheet for individual ratings.

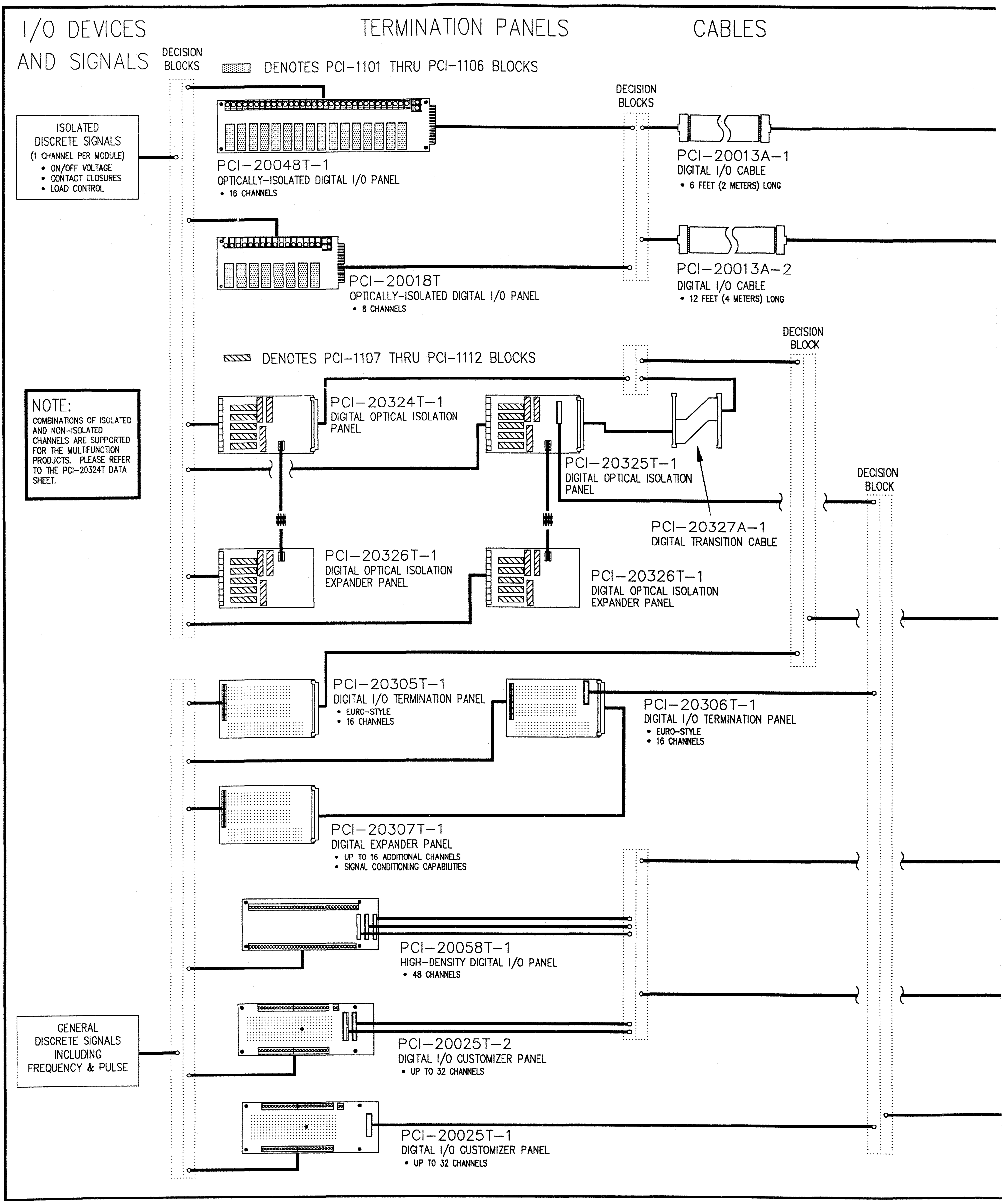
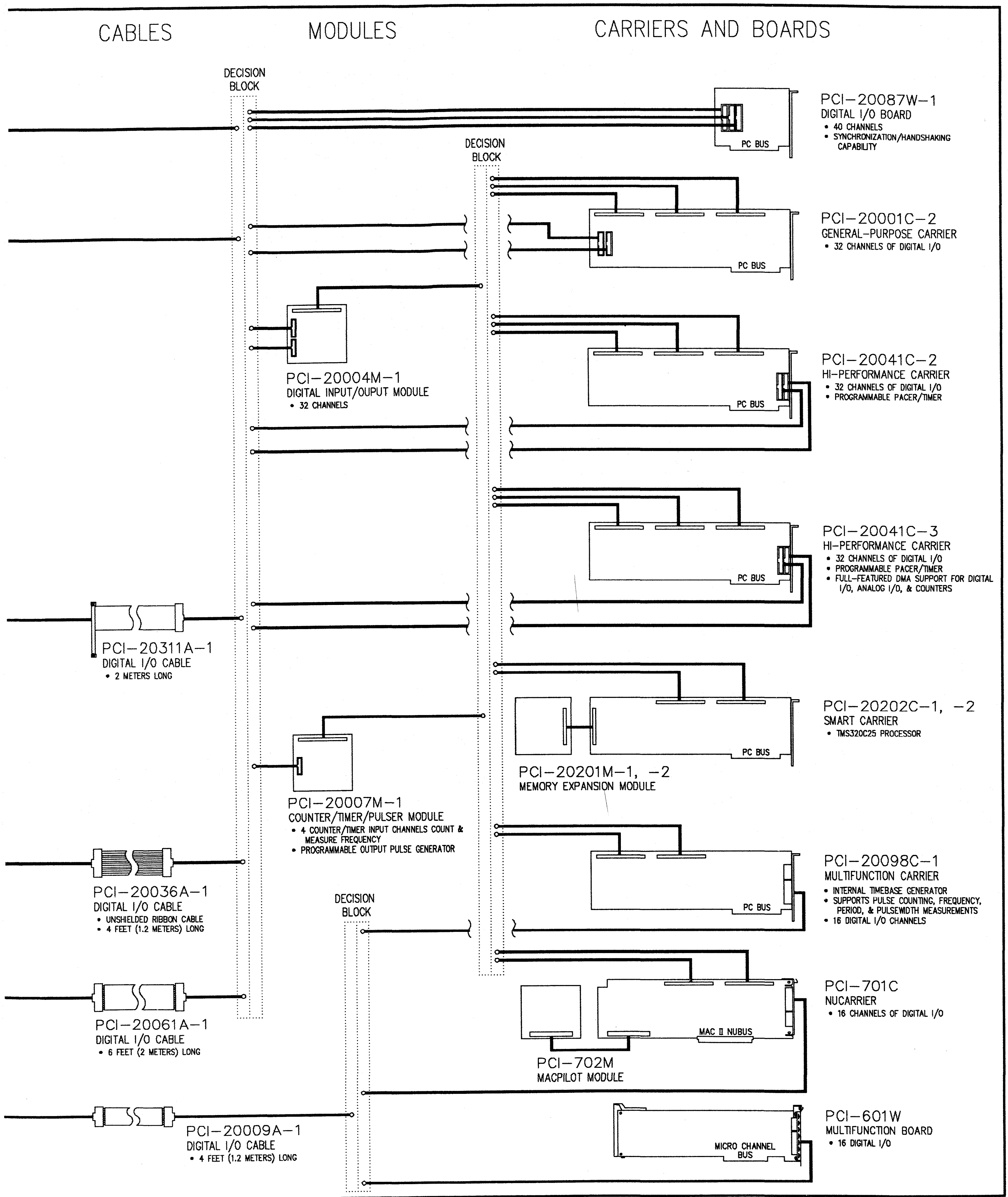
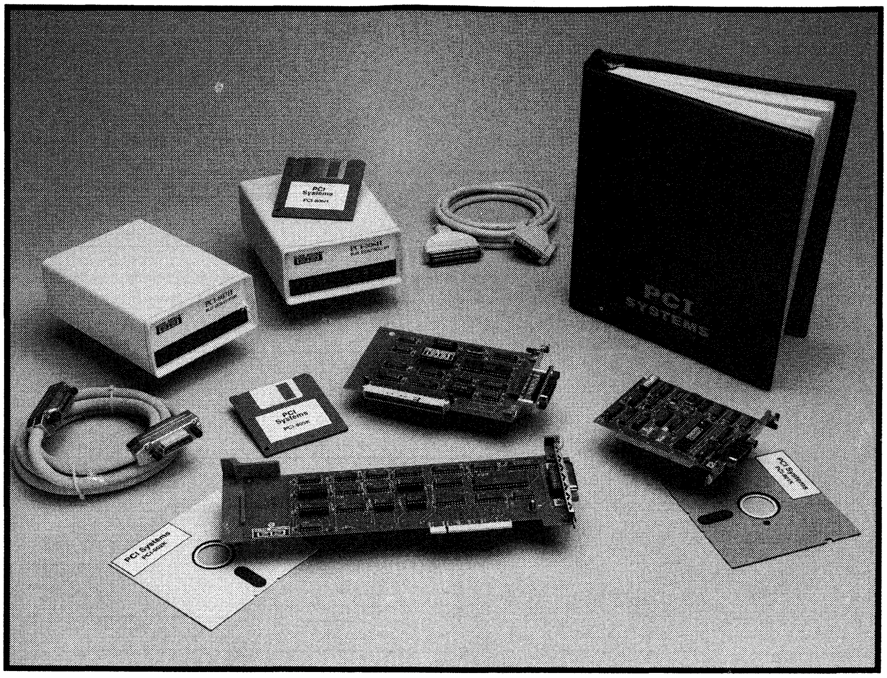
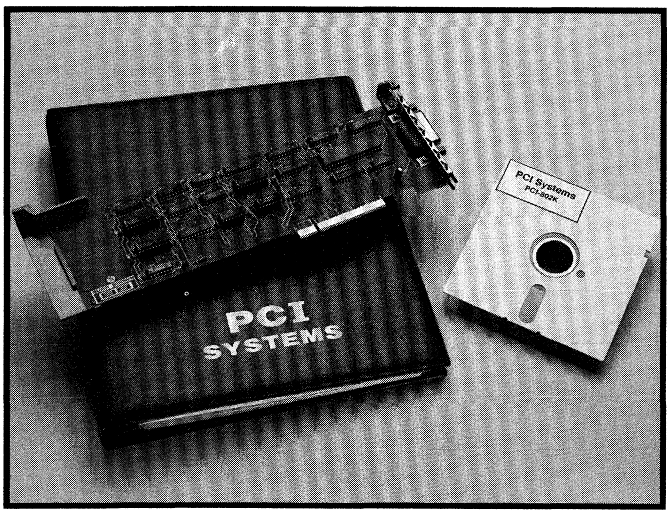


FIGURE 2-6 Digital Inputs and Outputs Are Supported by a Wide Range of PCI Boards, Carriers, Modules, and Software Products.


CABLES
MODULES
CARRIERS AND BOARDS
DECISION BLOCK
DECISION BLOCK
DECISION BLOCK
PC BUS
PCI-20087W-1
DIGITAL I/O BOARD
• 40 CHANNELS
• SYNCHRONIZATION/HANDSHAKING CAPABILITY
PCI-20001C-2
GENERAL-PURPOSE CARRIER
• 32 CHANNELS OF DIGITAL I/O
PCI-20004M-1
DIGITAL INPUT/OUPUT MODULE
• 32 CHANNELS
PCI-20041C-2
HI-PERFORMANCE CARRIER
• 32 CHANNELS OF DIGITAL I/O
• PROGRAMMABLE PACER/TIMER
PCI-20041C-3
HI-PERFORMANCE CARRIER
• 32 CHANNELS OF DIGITAL I/O
• PROGRAMMABLE PACER/TIMER
• FULL-FEATURED DMA SUPPORT FOR DIGITAL I/O, ANALOG I/O, & COUNTERS
PCI-20311A-1
DIGITAL I/O CABLE
• 2 METERS LONG
PCI-20202C-1, -2
SMART CARRIER
• TMS320C25 PROCESSOR
PCI-20201M-1, -2
MEMORY EXPANSION MODULE
PCI-20007M-1
COUNTER/TIMER/PULSER MODULE
• 4 COUNTER/TIMER INPUT CHANNELS COUNT & MEASURE FREQUENCY
• PROGRAMMABLE OUTPUT PULSE GENERATOR
PCI-20036A-1
DIGITAL I/O CABLE
• UNSHIELDED RIBBON CABLE
• 4 FEET (1.2 METERS) LONG
PCI-20098C-1
MULTIFUNCTION CARRIER
• INTERNAL TIMEBASE GENERATOR
• SUPPORTS PULSE COUNTING, FREQUENCY, PERIOD, & PULSEWIDTH MEASUREMENTS
• 16 DIGITAL I/O CHANNELS
PCI-20061A-1
DIGITAL I/O CABLE
• 6 FEET (2 METERS) LONG
PCI-701C
NUCARRIER
• 16 CHANNELS OF DIGITAL I/O
MAC II NUBUS
PCI-702M
MACPILOT MODULE
PCI-20009A-1
DIGITAL I/O CABLE
• 4 FEET (1.2 METERS) LONG
PCI-601W
MULTIFUNCTION BOARD
• 16 DIGITAL I/O
MICRO CHANNEL BUS



The IEEE-488 Interface Bus Makes Possible the Coordination of Complex Instrumentation Systems with a PC. A Typical Installation Could Include PCI Data Acquisition Boards within the PC Working with External Meters, Scopes, Generators, Etc. All Interconnected Via the IEEE-488 Bus.



Plug-in Boards for All Popular PCs Create a Fully Compatible IEEE-488 Port for Use with External Instruments.

Interface Boxes Provide Communications Between the PC's RS-232 or SCSI Port and External IEEE-488 Instruments.

IEEE-488 Interface Products

The IEEE-488 bus is an instrumentation communication standard adopted by the Institute of Electrical and Electronic Engineers. Prior to the adoption of this standard, most instrumentation manufacturers offered their own versions of computer interfaces. This placed the burden of interface hardware design on the end user. The popularity of the IEEE-488 interface (sometimes called the General Purpose Interface Bus or (GPIB) is due to the use of standard specifications for the electrical and mechanical interfaces, and the data transfer and control protocols. The IEEE-488 standard has removed the burden of interface design from the user and freed him to concentrate on the high-level software that is specific to the application.

The main purpose of the IEEE bus is to transfer information between two or more devices. Before information transfer can take place, it is first necessary to specify which device will talk (send data) and which device(s) will listen (receive data). The decision of who will talk and who will listen falls on the Active Controller.

To control a data transfer on the IEEE-488 bus, the Active Controller:

a) Asserts the Attention bus management line (ATN) to stop any data transfers.
b) Unlistens all devices to protect against eavesdroppers.
c) Designates which will Talk by Addressing a device to Talk.
d) Designates all the devices which are to Listen by Addressing those devices to Listen.
e) Indicates to all devices that the data transfer can take place by unasserting Attention.

Once data transfer has been started, the Active Talker waits until the Active Listeners are ready to receive a byte of data; it then places the first data byte on to the bus. After signalling that a valid data byte is present, it waits until that byte has been accepted by all listeners. Once it has been accepted, the talker places the next byte on the bus and waits until the listeners are again ready for data. When that occurs, the talker indicates that the data is valid, and the sequence repeats until the transfer is complete.

The IEEE-488 standard normally permits up to 15 devices to be supported within one network. Each of these devices has a unique IEEE bus address, a number in the range from 0 to 30. Some devices' addresses are set by DIP switches in hardware, others by software or by front panel controls.

A device becomes Addressed to Talk when it receives a Talk Address Group (TAG) multiline command (a byte transferred with ATN asserted) specifying its own address from the Active Controller. Similarly, it becomes Addressed to Listen when it receives a Listen Address Group (LAG) multiline command. Other address commands include My Talk Address (MTA) and My Listen Addresss (MLA), the TAG and LAG commands for the Active Controller, and Secondary Command Group (SCG) which are used to refer to sub-addresses or sub-functions within a particular device.

The System Controller is a device that always retains ultimate control of the bus. When the system is first powered-up, the System Controller is the Active Controller and controls all bus transactions. It is possible for the System Controller to Pass Control to a device, making it the new Active Controller which may, in turn, Pass Control to yet another device. Even if it is not the Active Controller, the System Controller maintains control of the Interface Clear (IFC) and Remote Enable (REN) bus management lines and can thus take control of the bus whenever it desires.

Burr-Brown has a complete line of products to support IEEE-488 communications using PC/AT, Micro Channel and Macintosh computers.

TABLE 2-9. PRODUCT SUMMARY— IEEE-488 INTERFACE (TYPICAL SPECIFICATIONS)

PCI MODEL NUMBER	BUS TYPE	PRODUCT TYPE	DESCRIPTION	DATA RATE	SETUP S/W INCLUDED	DRIVER S/W INCLUDED
PCI-801K	PC	Board	Internal plug-in	300KB/sec	Yes	Yes
PCI-802K	MCA	Board	Internal plug-in	300KB/sec	Yes	Yes
PCI-803W	PC	Board	Internal plug-in	300KB/sec	Yes	No
PCI-804W	MCA	Board	Internal plug-in	300KB/sec	Yes	No
PCI-805K	Mac II	Board	Internal plug-in	600KB/sec	Yes	Yes
PCI-806H	SCSI	Box	External box	800KB/sec	Yes	Yes
PCI-807H	RS-232	Box	External box	57K baud	Not applicable	Not applicable
PCI-808A	IEEE-488	Cable	IEEE Standard, 6 feet			
PCI-809A	SCSI	Cable	PCI-806H to Mac II, 6 feet			
PCI-810A	SCSI	Cable	PCI-806H to SCSI, 6 feet			
PCI-811A	RS-232	Cable	9-Pin Sub D, 6 feet			
PCI-812A	RS-232	Cable	25-Pin Sub D, 6 feet			

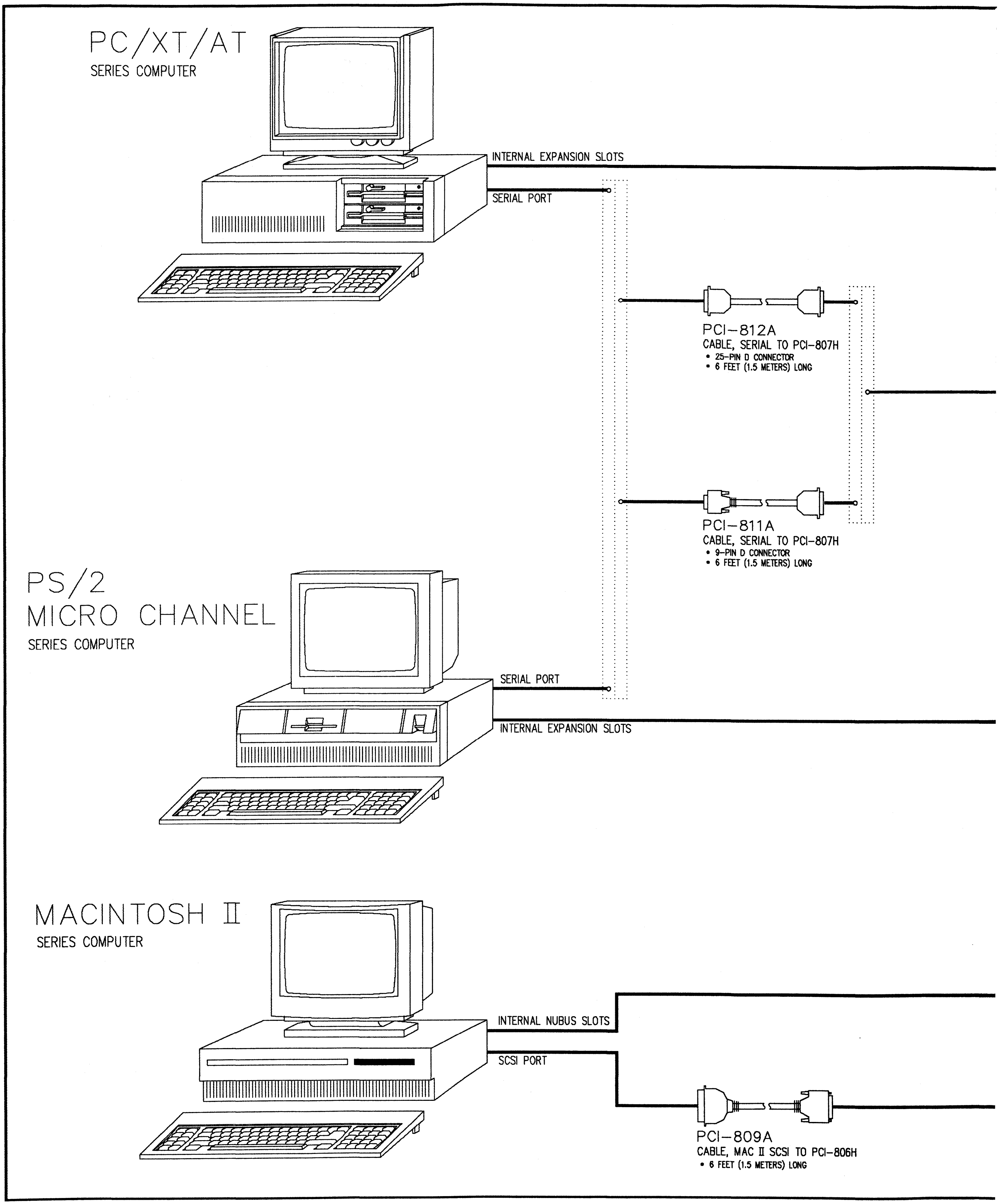
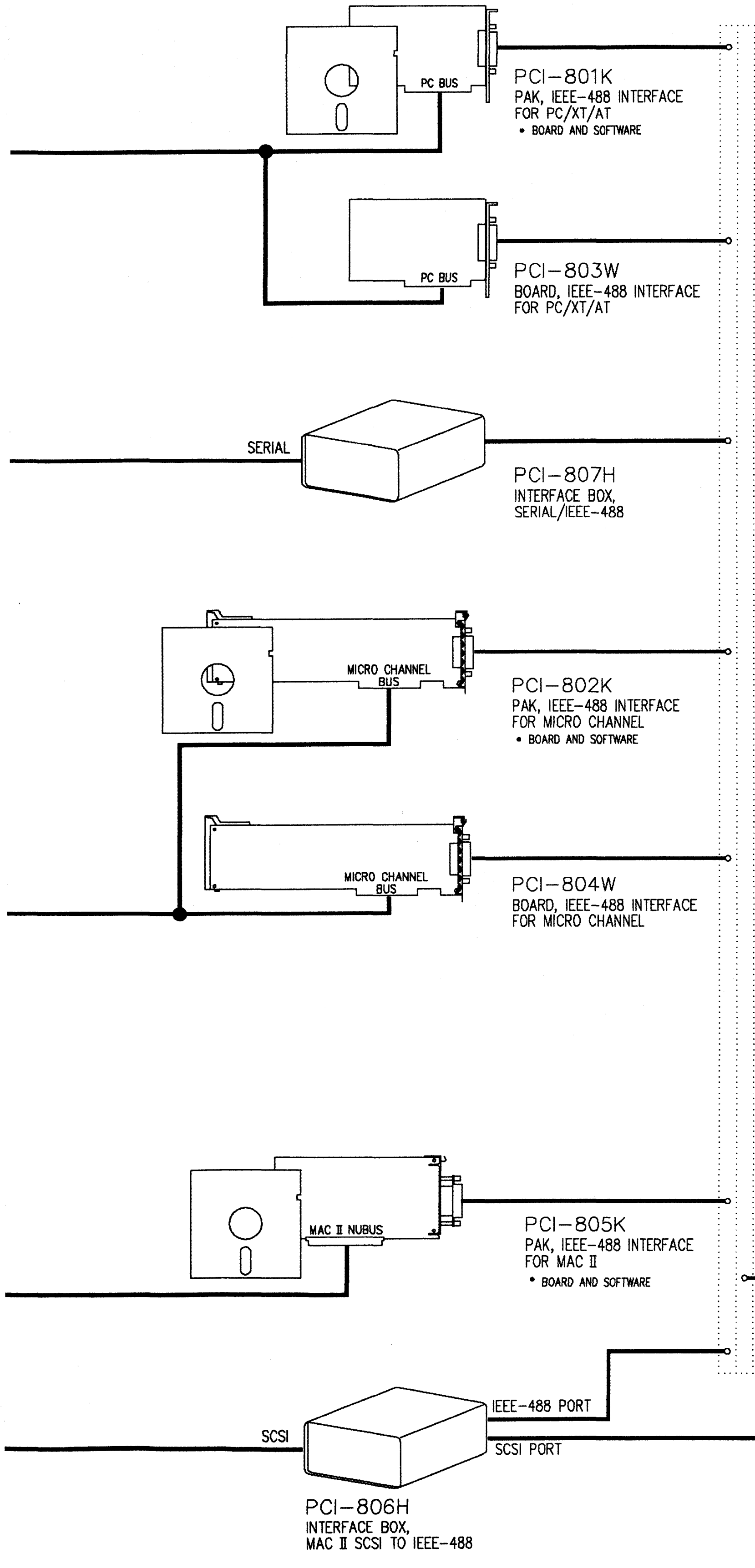
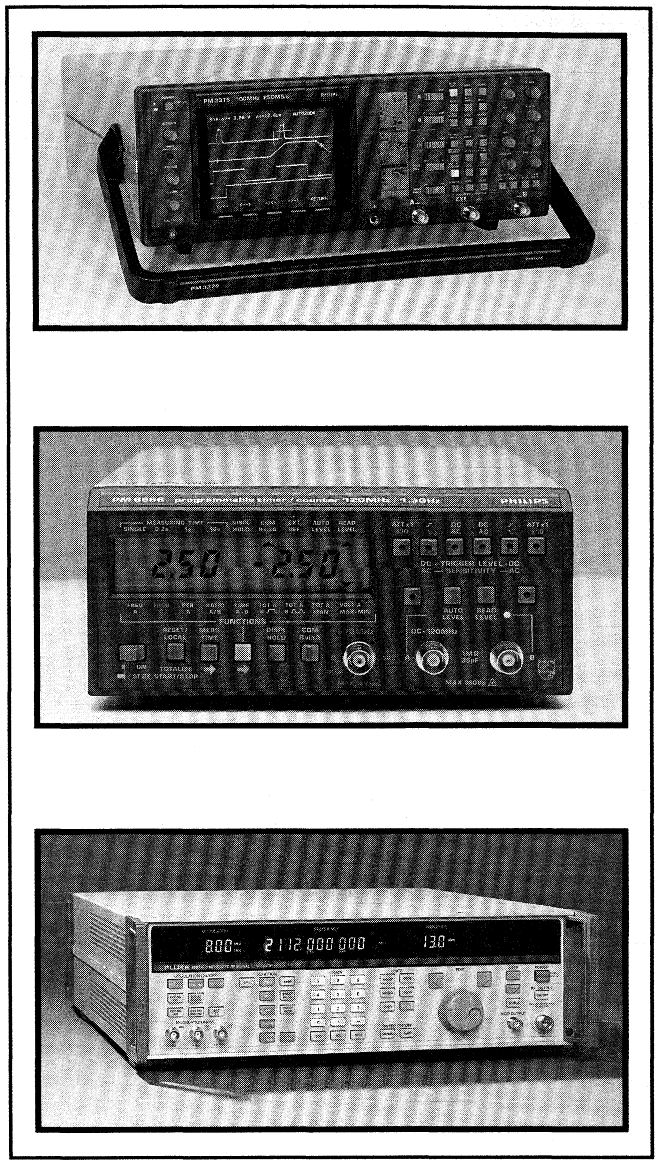
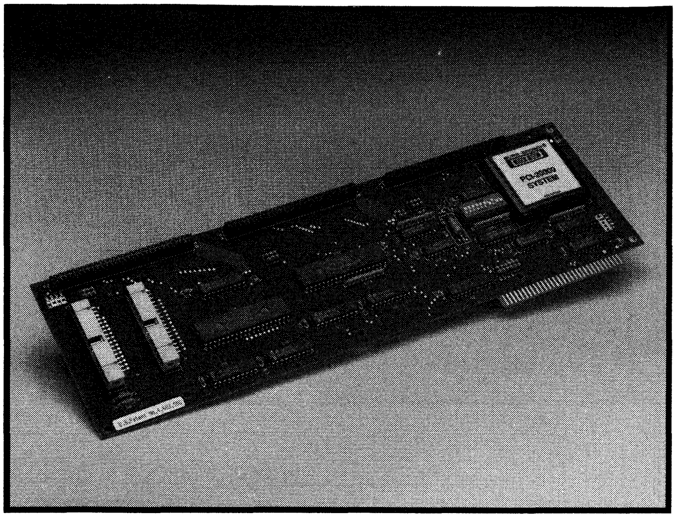


FIGURE 2-7. Plug-in Boards, Interface Boxes, Cables, and Software Provide Complete Compatibility with IEEE-488 Instruments.

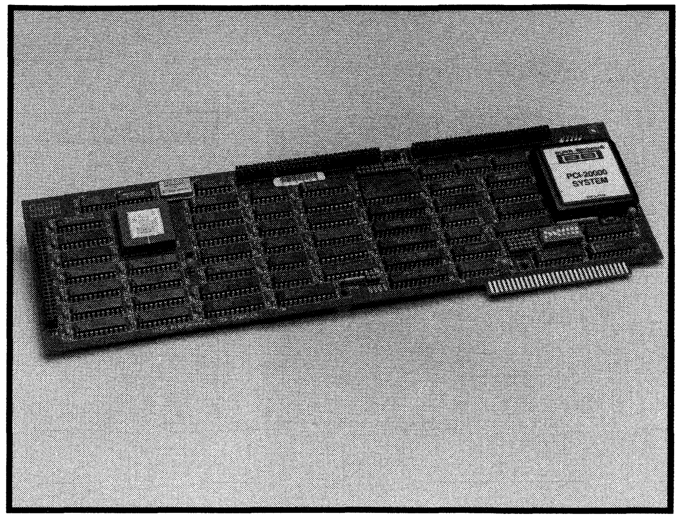




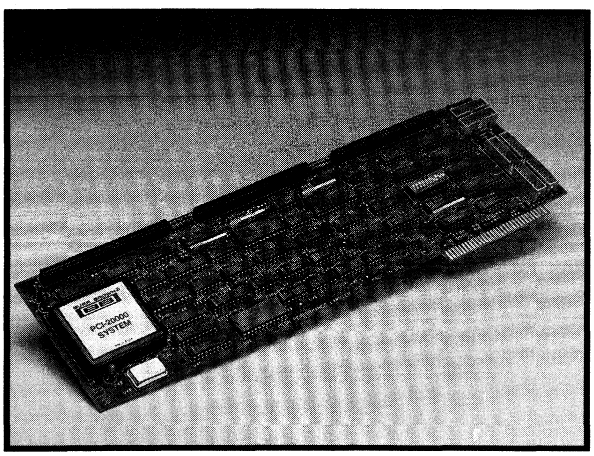
Typical IEEE-488 Instruments.



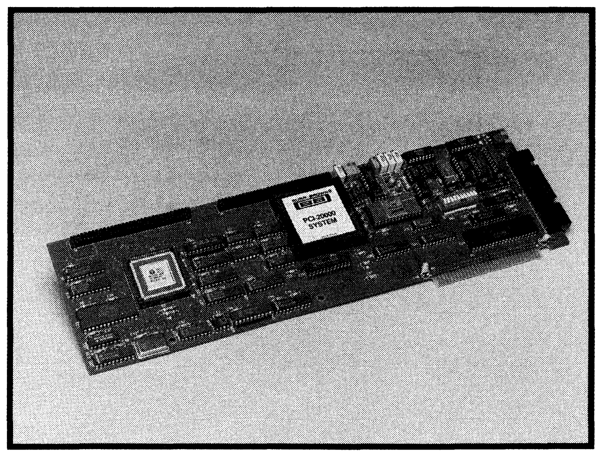
The PCI-20001C-2A Is a Low-cost Carrier Suitable for Many Applications. It Includes 32 Points of On-board DI/O Plus 3 I/O Module Positions.



The PCI-20202C Series of *Smart* Carriers Incorporate an Internal Processor to Greatly Enhance High-speed Signal I/O and Data Processing Capabilities. All PCI Modules Can Be Used.



The PCI-20041C-3A Is a High-performance Carrier That Includes DI/O, a Rate Generator, Extensive DMA Capabilities, Plus Three I/O Module Positions.



The PCI-20098C-1 Is a Multifunction Carrier That Combines the Most-needed I/O Functions. Additional Features Can Be Added with its Two Module Positions.

PC/XT/AT Bus Compatible Products

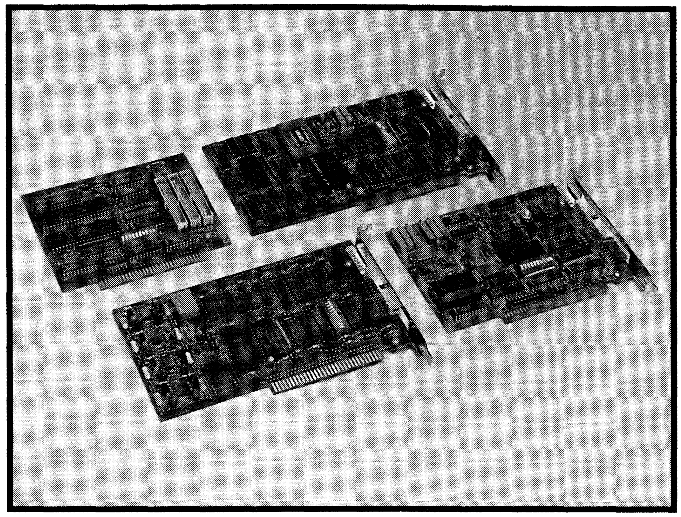
Four types of PC/XT/AT/EISA bus-related products are described below: Plug-In I/O Boards, Bus Interfaces, Bus Expanders, and PC compatible Computer Platforms.

The plug-in I/O products are intended to be installed internally to the PC. They make direct connection to the PC's expansion bus and offer very high I/O performance at the lowest possible cost.

Some applications require coordination between PC-based processing and external laboratory instruments such as digital meters, power supplies, and oscilloscopes. Many of these types of instruments are now accessible via the industry standard IEEE-488 (GPIB) interface port. The listed IEEE-488 products are ideal for linking different types of instruments to a PC.

To complement a test, measurement, or control system Burr-Brown also offers its line of PC compatible computer platforms. These VIPc machines include a high-performance PC/AT in a unique, customizable enclosure. The combination is ideal for new product development, integration, test, and production.

Large systems, with many I/O channels, sometimes require more expansion slots than are available inside a PC. These applications can be satisfied with the PC Bus Expander. In addition to providing seven more slots, accessibility to the data acquisition hardware is greatly improved.



PCI *Super Boards* Provide High-performance at the Lowest Possible Cost Per Channel.

TABLE 2-10a. PRODUCT SUMMARY— PC/XT/AT BUS COMPATIBLE

PCI MODEL NUMBER	PRODUCT TYPE	DESCRIPTION	I/O MODULE POSITIONS	ON-BOARD ANALOG I/O[1]	ON-BOARD DI/O	ON-BOARD COUNTERS	ON-BOARD TIMEBASE	DMA SUPPORT
PCI-20001C-2A	Carrier	General-purpose	3		32 bits			
PCI-20041C-2A	Carrier	High-performance	3		32 bits		Rate generator	
PCI-20041C-3A	Carrier	High-performance	3		32 bits		Rate generator	All I/O
PCI-20098C-1	Carrier	Multifunction	2	16/8 Ain	16 bits	2	Burst generator	Ain
PCI-20202C-1, -2	Carrier	*Smart* coprocessor, DSP	2				Rate generator	All I/O
PCI-20087W-1	Board	Digital I/O			40 bits			
PCI-20089W-1	Board	Analog input		16/8 Ain		1	Rate generator	
PCI-20091W-1	Board	High-speed analog input		8 Ain			Rate generator	Ain
PCI-20093W-1	Board	Analog output		8 Aout				

Notes: (1) "16/8" refers to 16 single ended or 8 differential inputs.

TABLE 2-10b. SPECIAL PRODUCTS

PCI MODEL NUMBER	PRODUCT TYPE	DESCRIPTION	NOTES
PCI-801K	Board	IEEE-488 interface	Plugs into internal expansion slot. Kit includes high-level software drivers.
PCI-803W	Board	IEEE-488 interface	Includes high-level software drivers.
PCI-807H	Box	Serial/IEEE-488 interface	RS-232/422 to/from IEEE-488.
PCI-5000 Series	VIPc	Computer platform	A complete family of PC/AT compatible products.
PCI-20055H-3, -4	Box	PC Bus expander	Adds PC bus expansion slots to host computer.
PCI-20063A-1	Board	PC Bus interface	Plugs into the host computer. Interfaces to PCI-20055H-3, -4.

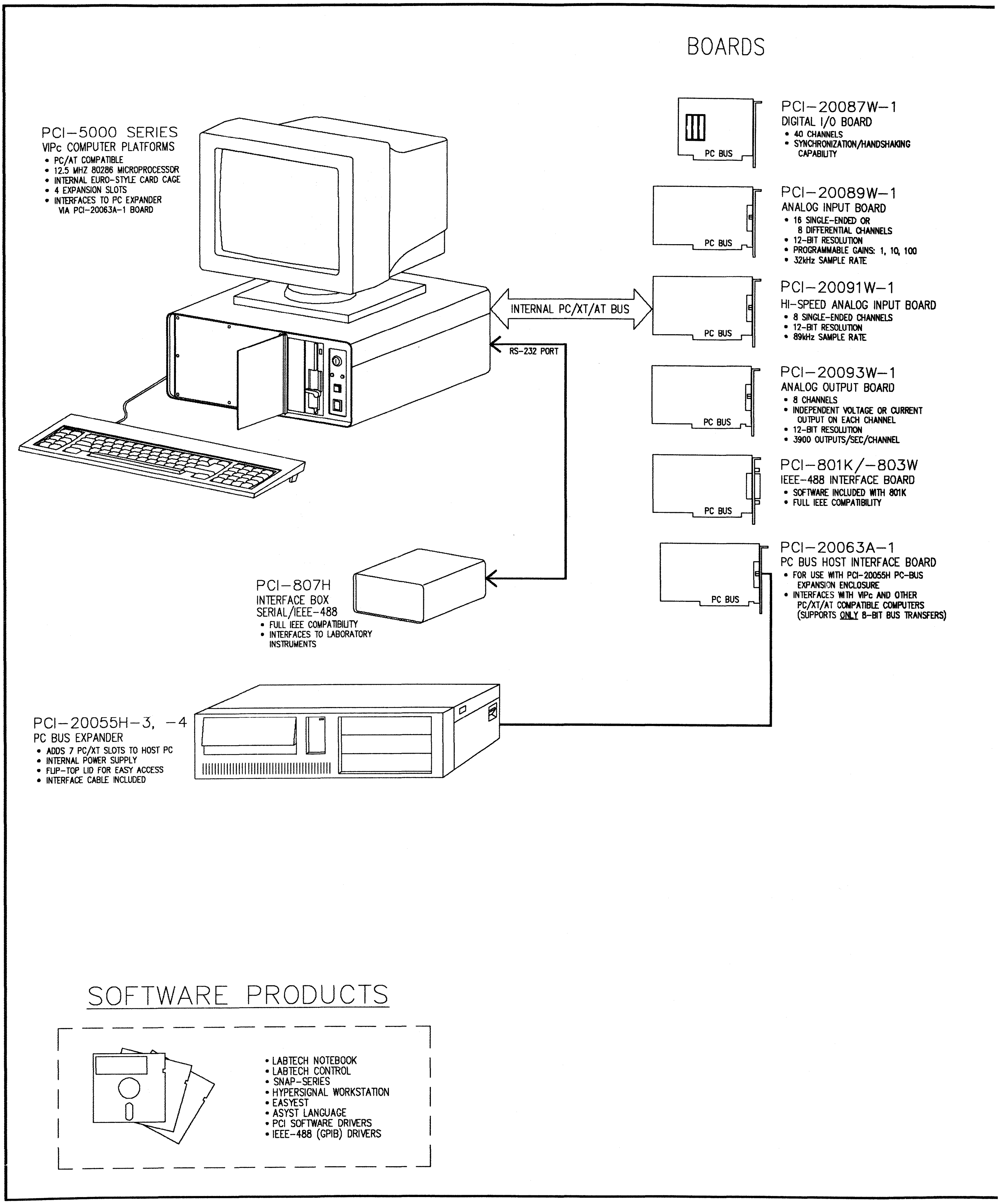
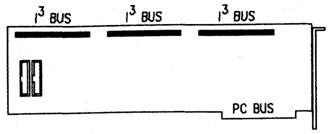
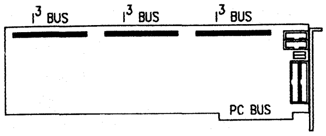


FIGURE 2-8. A Wide Range of I/O Boards, Carriers, and Bus Interface Products Are Available to Support PC/XT/AT/EISA Computer Users.

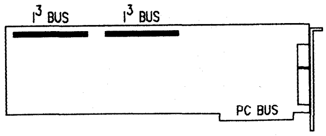
CARRIERS



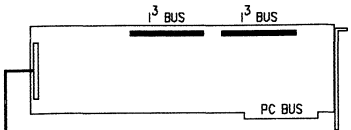
PCI–20001C–2
GENERAL-PURPOSE CARRIER
- 32 CHANNELS OF ON-BOARD DIGITAL I/O



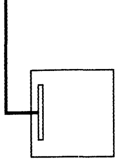
PCI–20041C–2
HI-PERFORMANCE CARRIER
- 32 CHANNELS OF ON-BOARD DIGITAL I/O
- PROGRAMMABLE PACER/TIMER



PCI–20098C–1
MULTIFUNCTION CARRIER
- 16 SINGLE-ENDED OR 8 DIFFERENTIAL ANALOG INPUTS
  - PROGRAMMABLE GAIN
  - 32kHz SAMPLE RATE
  - DMA, INTERRUPT, & POLLED MODES
- SUPPORTS PULSE COUNTING, FREQUENCY, PERIOD, & PULSEWIDTH MEASUREMENTS
- 16 DIGITAL I/O CHANNELS

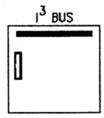


PCI–20202C–1, –2
SMART CARRIER
- TMS320C25 PROCESSOR
- 16KWORDS DATA MEMORY ON BOARD
- 16KWORDS PROGRAM MEMORY ON BOARD
- DMA TO PC AT 400K BYTES/SEC

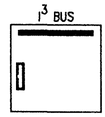


PCI–20201M–1, –2
MEMORY EXPANSION MODULE
- 64KWORDS OF HIGH-SPEED RAM EXPANSION (16KW PROGRAM, 48KW DATA MEMORY)

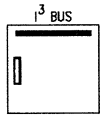
MODULES



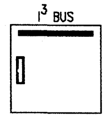
PCI–20002M–1
ANALOG INPUT MODULE
- 16 SINGLE-ENDED OR 8 DIFFERENTIAL CHANNELS
- 12-BIT RESOLUTION
- PROGAMMABLE GAINS OF 1, 10, 100, 1K



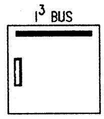
PCI–20017M–1
SIMULTANEOUS SAMPLE/HOLD MODULE
- 4 DIFFERENTIAL INPUT CHANNELS
- 20ns CHANNEL-TO-CHANNEL SCATTER
- SELECTABLE GAINS: 1, 10, 100, 1K



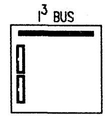
PCI–20019M–1
ANALOG INPUT MODULE
- 8 SINGLE-ENDED CHANNELS
- 12-BIT RESOLUTION
- UP TO 89kHz SAMPLE RATE



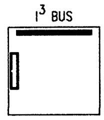
PCI–20020M–1
TRIGGER/ALARM MODULE
- 3.5μSEC RESPONSE TIME (MAX)
- HIGH, LOW, OR WINDOW COMPARISONS



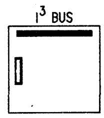
PCI–20023M–1
ANALOG INPUT MODULE
- 8 SINGLE-ENDED CHANNELS
- 12-BIT RESOLUTION
- UP TO 180kHz SAMPLE RATE



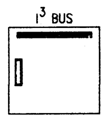
PCI–20031M–1
ANALOG EXPANDER/SEQUENCER MODULE
- ADDS UP TO 32 CHANNELS
- ON-BOARD CHANNEL LIST MEMORY



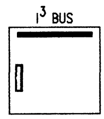
PCI–20341M–1
ANALOG INPUT MODULE
- 16-BIT RESOLUTION
- 4 DIFFERENTIAL INPUTS
- UP TO 100KHZ SAMPLE RATE



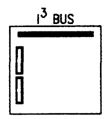
PCI–20003M–2, –4
12-BIT ANALOG OUTPUT MODULES
- 2 OUTPUT CHANNELS
- 12-BIT RESOLUTION
- UP TO 80K OUTPUTS/SEC
- RANGES: 0–10V, ±5V, ±10V, 4–20mA FS



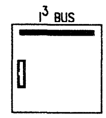
PCI–20006M–2
16-BIT ANALOG OUTPUT MODULE
- 2 VOLTAGE OUTPUT CHANNELS
- 16-BIT RESOLUTION
- UP TO 80K OUTPUTS/SEC
- RANGE: 0–10V, ±5V, ±10V FS



PCI–20021M–1
ANALOG OUTPUT MODULE
- 8 VOLTAGE OUTPUTS
- 12-BIT RESOLUTION
- RANGES: ±5 & ±10V FS
- 2000 OUTPUTS/SEC/CHANNEL

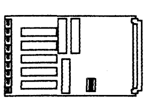
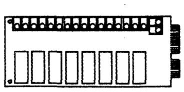
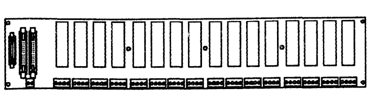


PCI–20004M–1
DIGITAL INPUT/OUPUT MODULE
- 32 CHANNELS
- TTL LEVELS
- BUFFERED OUTPUTS

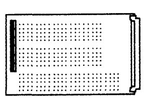
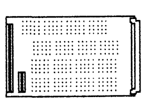
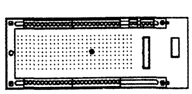


PCI–20007M–1
COUNTER/TIMER/PULSER MODULE
- 4 COUNTER/TIMER INPUT CHANNELS COUNT AND MEASURE FREQUENCY
- PROGRAMMABLE OUTPUT PULSE GENERATOR

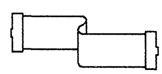
TERMINATION COMPONENTS

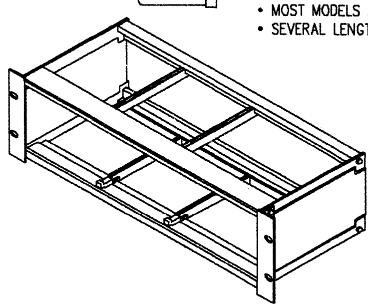
ANALOG AND DIGITAL SIGNAL CONDITIONERS
- ISOLATION
- FILTERING
- POWER SWITCHING

ANALOG AND DIGITAL SIGNAL TERMINATION PANELS
- CONVIENIENT SCREW TERMINALS
- COLD-JUNCTION COMPENSATION AVAILABLE FOR THERMOCOUPLES
- EASILY CUSTOMIZED FOR SPECIAL APPLICATIONS



A WIDE VARIETY OF CABLES ARE AVAILABLE FOR ALL APPLICATIONS
- MOST MODELS ARE SHIELDED
- SEVERAL LENGTHS ARE AVAILABLE



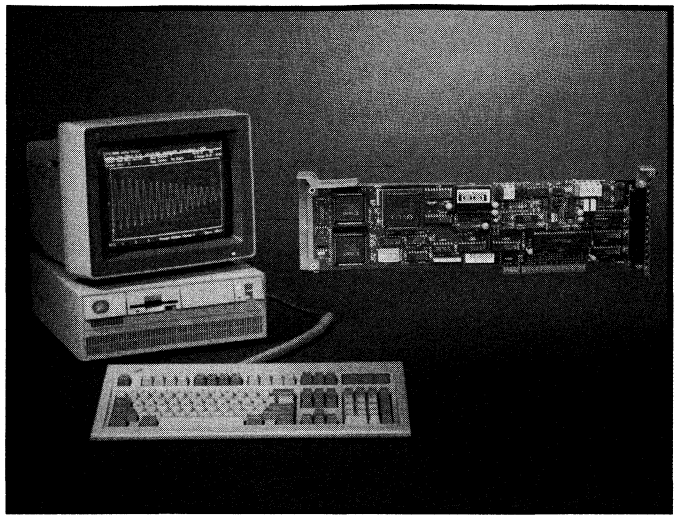
ENCLOSURES
- RACK MOUNT
- TABLETOP
- AVAILABLE FOR ALL PANEL TYPES

Micro Channel Compatible Products

Two types of Micro Channel bus-related products are described below: Plug-in I/O Boards and Bus Interfaces.

The plug-in I/O products are intended to be installed internally to the PC. They make direct connection to the PC's expansion bus and offer very high analog, digital, and counter/timer I/O performance at the lowest possible cost.

Some applications require coordination between PC-based processing and external laboratory instruments such as digital meters, power supplies, and oscilloscopes. Many of these types of instruments are now accessible via the industry standard IEEE-488 (GPIB) interface port. The listed IEEE-488 products are ideal for linking different types of instruments to a PC.



Micro Channel Computers Are Fully Supported by the PCI-601W and PCI-602W Boards. Analog, Digital, and Counter I/O Functions Are Included.

TABLE 2-11a. PRODUCT SUMMARY— PS/2 MICRO CHANNEL BUS COMPATIBLE

PCI MODEL NUMBER	PRODUCT TYPE	DESCRIPTION	ON-BOARD ANALOG I/O[1]	ON-BOARD DI/O	ON-BOARD COUNTERS	ON-BOARD TIMEBASE	DMA SUPPORT
PCI-601W	Board	Multifunction	16/8 A_{in}	16 bits	2	Burst generator	Analog input
PCI-602W	Board	Multifunction	16/8 A_{in}, 2 A_{out}	16 bits	2	Burst generator	Analog I/O

Notes: (1) "16/8" refers to 16 single-ended or 8 differential inputs.

TABLE 2-11b. SPECIAL PRODUCTS

PCI MODEL NUMBER	PRODUCT TYPE	DESCRIPTION	NOTES
PCI-802K	Board	IEEE-488 interface	Plugs into internal expansion slot. Kit includes high-level software drivers.
PCI-804W	Board	IEEE-488 interface	Includes high-level software drivers.
PCI-807H	Box	Serial/IEEE-488 interface	RS-232/422 to/from IEEE-488.

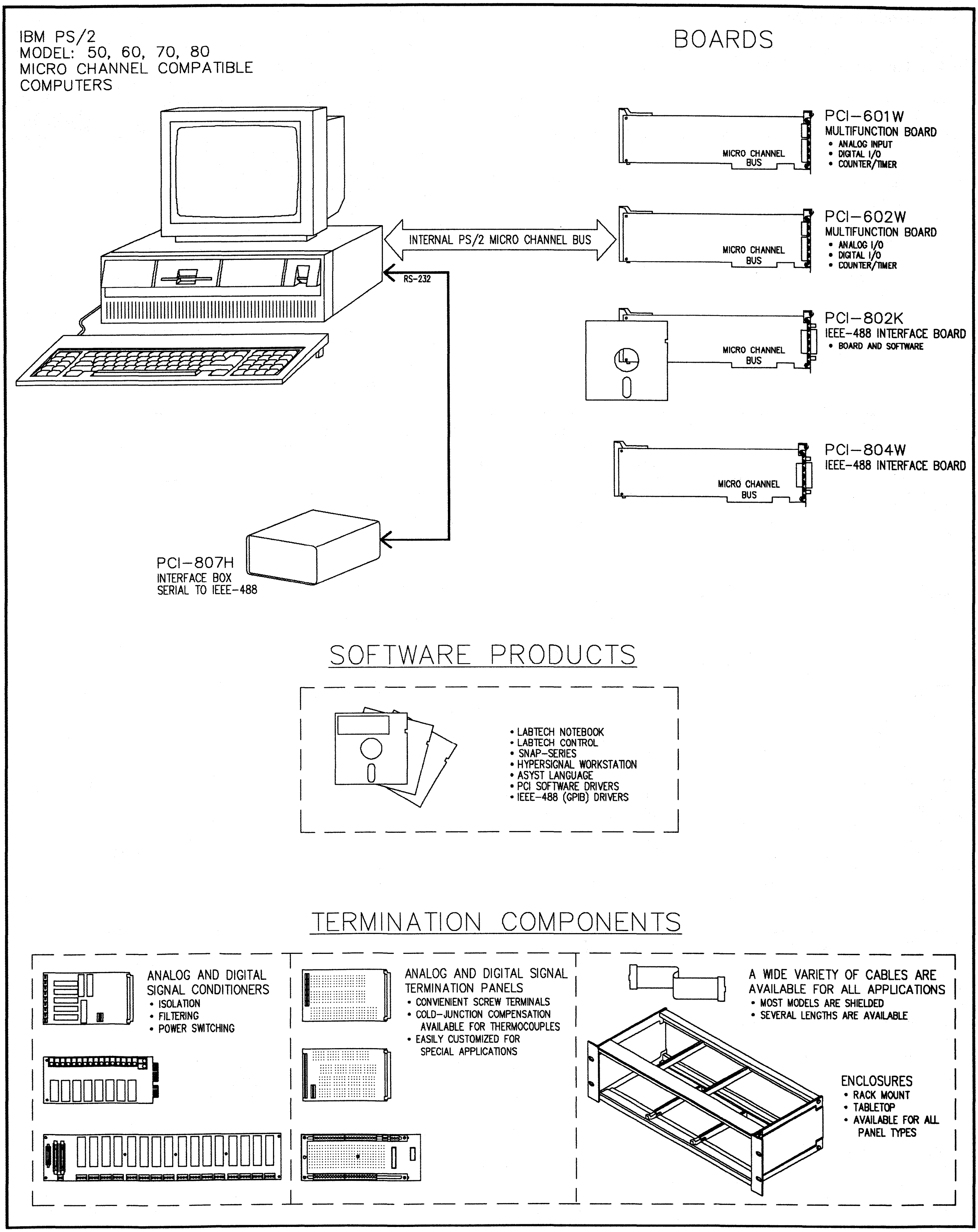


FIGURE 2-9. Micro Channel Computer Support Includes Both I/O and IEEE-488 Interface Boards.

Macintosh II NuBus Compatible Products

Two types of Macintosh II NuBus related products are described below: Plug-In I/O Boards and Bus Interfaces.

The plug-in I/O products are intended to be installed internally to the Mac II. They make direct connection to a NuBus slot and offer very high analog, digital, and counter/timer I/O performance at the lowest possible cost.

Some applications require coordination between PC-based processing and external laboratory instruments such as digital meters, power supplies, and oscilloscopes. Many of these types of instruments are now accessible via the industry standard IEEE-488 (GPIB) interface port. The listed IEEE-488 products are ideal for linking diffferent types of instruments to a PC.

The PCI-701C Multifunction *NuCarrier* Provides Extensive I/O Capabilities for the Mac II Family of Computers.

TABLE 2-12a. PRODUCT SUMMARY— Macintosh II NuBus COMPATIBLE

PCI MODEL NUMBER	PRODUCT TYPE	DESCRIPTION	I/O MODULE POSITIONS	SPECIAL MODULE	ANALOG I/O[1]	DI/O	COUNTERS	TIMEBASE	DMA SUPPORT
PCI-701C	Carrier	Multifunction	2	*MacPilot*	16/8 A_{in}	16 bits	2	Burst generator	All I/O types
Note: (1) Single-ended/differential									

TABLE 2-12b. PCI I/O MODULES (TYPICAL SPECIFICATIONS)

PCI MODEL NUMBER	PRODUCT TYPE	DESCRIPTION	NUMBER OF CHANNELS	RESOLUTION	MAXIMUM SPEED
PCI-20023M-1	Analog input	High-speed	8 Single-ended	12-bit	180k Samples/sec
PCI-20341M-1	Analog input	High-resolution	1 SE/4 differential	16-bit	85k Samples/sec
PCI-20031M-1	Multiplexer	Channel expander	32		Limited by A/D
PCI-20017M-1	Simultaneous S/H	20nS scatter	4		10k Frames/sec
PCI-20020M-1	Trigger/Alarm	Programmable levels	1 or 2		
PCI-20003M-2	Analog output	High-speed, voltage	2	12-bit	80k Points/sec
PCI-20003M-4	Analog output	High-speed, current or voltage	2	12-bit	40k Point/sec (I_{out})
PCI-20006M-2	Analog output	High-resolution, voltage	2	16-bit	80k Points/sec
PCI-20021M-1B	Analog output	General-purpose, voltage	8	12-bit	2k Points/sec
PCI-20004M-1	Digital I/O	Buffered ports	32		360Kbytes/sec
PCI-702M	Bus master	*MacPilot* DMA controller			

TABLE 2-12c. MACINTOSH II COMPATIBLE SOFTWARE

PCI MODEL NUMBER	DESCRIPTION	NOTES
PCI-703S	*MacAdapt* general-purpose software drivers for the *NuCarrier*.	Included with *NuCarrier*.
PCI-704S	*MacExpedite* DMA/Busmaster software drivers for *MacPilot*.	Included with *MacPilot*.
PCI-706S	Virtual Instrument Library for LabVIEW 2.	Used to interface to LabVIEW 2.

TABLE 2-12d. SPECIAL PRODUCTS

PCI MODEL NUMBER	PRODUCT TYPE	DESCRIPTION	NOTES
PCI-805K	Board	IEEE-488 interface	Plugs into internal NuBus slot. Kit includes high-level software drivers.
PCI-806H	Box	SCSI to IEEE-488 interface	Includes high-level software drivers.

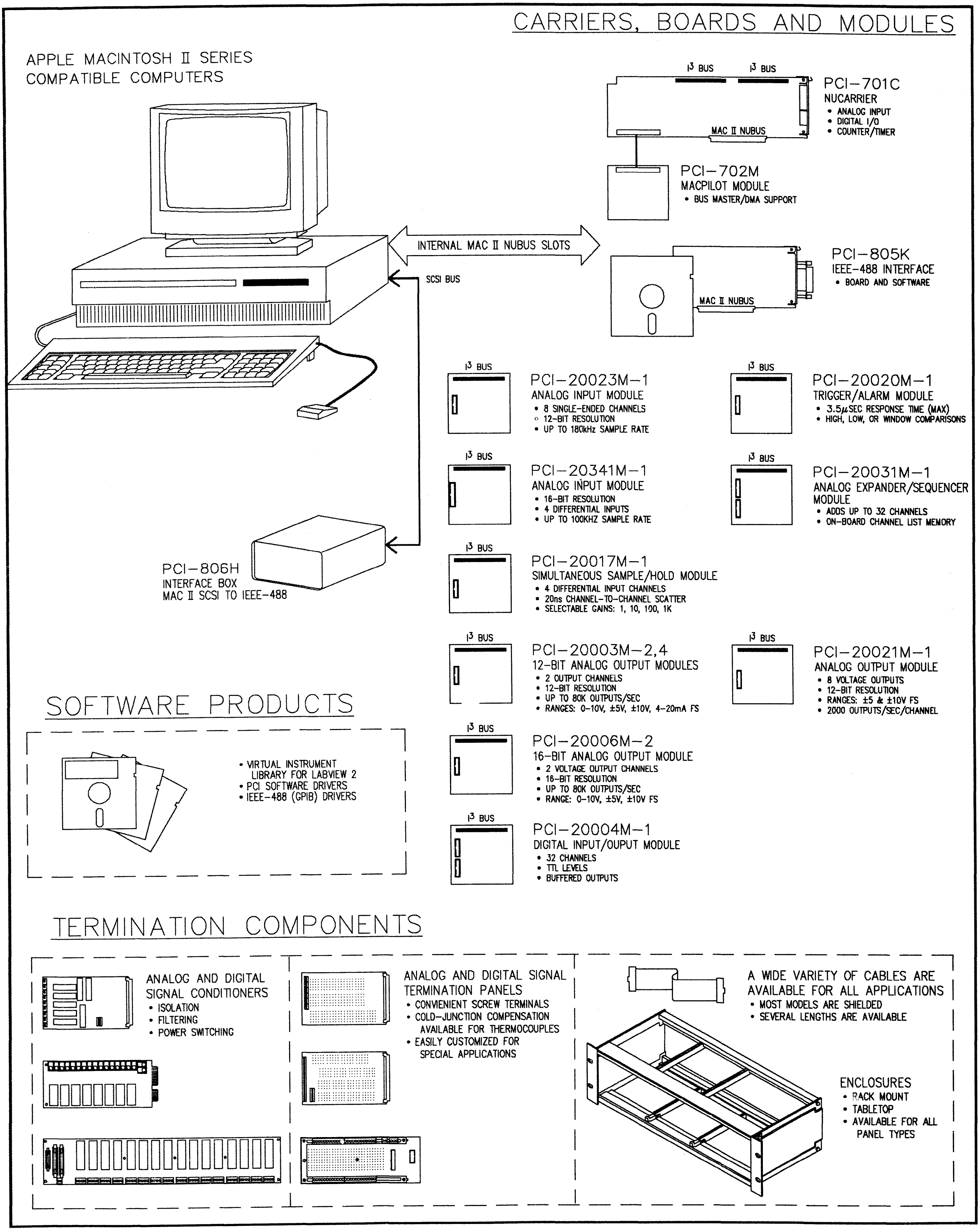


FIGURE 2-10. Data I/O to Mac II NuBus Computers Is Supported by a Multifunction Carrier, Many I/O Modules and IEEE-488 Interfaces. Software Is Included with All Products.

Glossary of PCI Terms

Analog Input Device. Converts signal sources (thermocouples, RTDs, pressure sensors, strain gages, etc.) to a digital representation (fixed amplitude, two states) that can be further processed by the host PC.

Analog Output Device. Converts digital data (fixed amplitude, two states) from the host PC into a signal with a wide range of amplitudes.

Block. A single channel signal conditioning device. Available for both analog and digital signal applications. In addition to usually providing isolation, they can offer filtering, amplification, power switching, and level translation functions.

Board. A fixed-function device that plugs inside a PC and makes direct electrical connection to the PC Bus. Available for analog I/O, digital I/O, and counter/timer/generator functions.

Box. An external device that connects to the host PC via RS-232, RS-422, or IEEE-488 (GPIB).

Bus Interface. A board or box product that converts a given bus protocol (PC/XT/AT, Micro Channel, NuBus, IEEE-488, RS-232, etc.) to some other bus protocol.

Cable. A multi-wire assembly used to interconnect related components of the system (e.g., I/O device to a signal conditioner, etc.). Shielded, flat ribbon cable is used in most applications.

Carrier. A multifunction device that plugs inside a PC and makes direct electrical connection to the PC Bus. It is distinguished from a "board" in that it can accept plug-in "modules" to add I/O capabilities. Carriers are available to support analog I/O, digital I/O, and counter/timer/generator applications.

Computer Platform. A personal computer suitable for integration with PCI I/O products for use in a wide variety of applications, including data acquisition, test, measurement, and control.

Counter/Timer Device. Converts time-dependent digital signals to a form that can be further processed by the host PC. Typical functions include pulse counting, frequency measurement, and pulsewidth measurement. This can relate to time, number of events, speed, etc.

Digital Input Device. Translates external discrete (on/off) conditions to a form that is electrically compatible with the host PC.

Digital Output Device. Translates on/off software instructions from the host PC to a form that is suitable for driving external digital devices.

Enclosure. A mounting and/or protective device. Usually associated with termination and signal conditioning panels.

Generator Device. A rate or burst generator used to produce TTL level signals for internal or external timing applications. Usually associated with establishing data acquisition sampling rate (speed).

Module. A specific I/O component that can be plugged onto a carrier ("motherboard"). Usually associated with adding or extending I/O functions in a carrier-based system.

PC. Personal computer such as an IBM PC/XT/AT/EISA compatible, PS/2 or Mac II computer system.

Power Supply. A device for generating desired DC voltages. Usually associated with powering signal conditioning products (blocks and panels).

Signal Conditioner. A panel or block specifically intended to provide signal scaling, filtering, linearization, cold-junction compensation, power gain, amplification, level translation, etc.

Software. A set of coded instructions that coordinates the activities of a computer-based product. Tools are available to aid the programmer in software development. Application packages are also offered that provide a menu-driven solution to a given class of tasks. These products require no programming by the end user. They are ideal for engineers, scientists and other researchers in laboratory, test, and manufacturing environments.

PRODUCT SPECIFICATIONS AND DATA SHEETS

This section includes detailed data sheets on all major PCI products. Included are written and graphic descriptions of the many **Software** products, **Computer Platforms, Signal Conditioners,** and **Bus Interfaces**, along with **Analog Input/Output**, **Digital Input/Output**, and **Counter/Timer/Generator Devices**. I/O devices consist of **Boxes, Boards, Carriers, Modules,** and **Blocks**. In support of the overall PCI system are an extensive line of **Cables, Power Supplies,** and **Enclosures.**

Products are arranged in numerical order: PCI-5B Series, PCI-600 Series, PCI-700 Series, PCI-800 Series, PCI-1100 Series, PCI-5000 Series, and PCI-20000 Series. The PCI-20000 Series includes termination and signal conditioning components that are compatible with both the PCI-600 and PCI-700 Series products.

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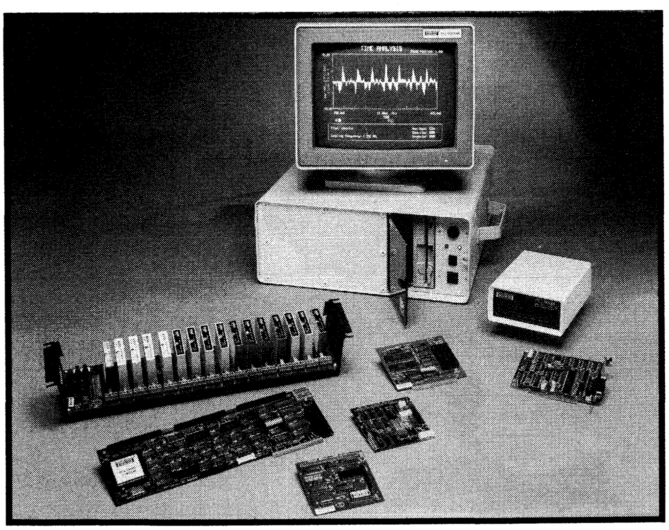
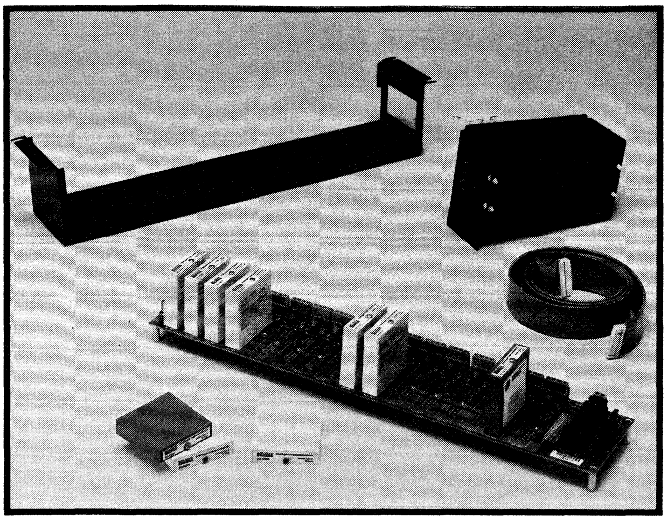




BURR-BROWN®

PCI-5B Series

Analog Signal Conditioning Products

FEATURES

- Analog Input Blocks for Direct Interface to Sensors and Signal Sources:
  - Thermocouples—J, K, and T
  - Millivolt and Voltage Sources
  - Process Currents (4-20ma)
- Analog Output Blocks for Process Control
- Interfaces to All PCI Analog Products
- High Accuracy, Low Drift
- Complete Signal Conditioning Functions
  - 1500Vrms Common-Mode Isolation
  - 240V Field Wiring Protection
  - Filtering
  - Amplification
  - IEEE-472 Transient Protection
- Mix and Match Block Capability

DESCRIPTION

The 5B Series represents a family of low-cost, high-performance plug in signal conditioners. Designed for both laboratory and industrial applications, these blocks incorporate an innovative circuit design utilizing transformer-based isolation. Combining 1500Vrms continuous common mode voltage isolation, ±0.05% accuracy, small size and low cost, the PCI-5B Series is an attractive alternative to expensive signal conditioners and in-house designs. All blocks are hard potted and identical in pin-out and size (2.25" x 2.25" x 0.6"). They can be mixed and matched and may be changed without disturbing field wiring.

A convenient termination panel (PCI-5B01-1), rack mount enclosure (PCI-20339A-1) and power supply (PCI-20338A-1) complete the signal conditioning solution for end users. The termination panel incorporates screw terminals for field wiring inputs and outputs as well as cold-junction compensation sensors for thermocouple applications. Mounted in the available enclosure, the panel can be readily installed in a standard 19-inch relay rack. The enclosure requires just 3.5 inches of height. Each panel can hold up to sixteen I/O blocks.

The PCI-5B Series signal conditioners are designed to provide an easy and convenient solution to signal conditioning problems for both designers and end users in measurement and control applications. They are ideally suited to applications where monitoring and control of temperature, pressure, flow and other analog signals are required. The PCI-5B Series can be used with all PCI data acquisition boards.

The 5B Series features ±0.05% calibrated accuracy, nonlinearity of only ±0.02% of span, and chopper-based amplification which assures low drift (±1μV/°C) and excellent long-term stability.

The PCI-5B01-1 is a16-channel termination panel that can accept any of the analog signal conditioning/isolation blocks listed below. It can be rack-mounted using the PCI-20339A-1 19-inch rack enclosure. A separate temperature sensor is mounted at each set of screw terminals to provide cold-junction compensation for thermocouples.

The PCI-5B Series of blocks interface to a wide range of input and output signals. The input blocks can accept signals from thermocouple, millivolt, volt and current sources. The output block can provide a 4-20mA current for a variety of control applications. All blocks are transformer-isolated to 1500Vrms.

Each of the voltage input blocks provides a single channel of analog input which is filtered, isolated, amplified and converted to a high-level analog voltage output.

Signal filtering is accomplished with a four-pole filter which provides 74dB of normal-mode-rejection at 50Hz or 60Hz. Two poles of this filter are on the field side of the isolation barrier, while the other two are in the output stage. Switched-capacitor filter techniques are used to provide superior rejection of transient noise.

VOLTAGE INPUT MODELS

PCI MODEL NUMBER	INPUT VOLTAGE RANGE	OUTPUT VOLTAGE RANGE	BANDWIDTH
PCI-5B30-01	±10mV	±5V	4Hz
PCI-5B30-02	±50mV	±5V	4Hz
PCI-5B30-03	±100mV	±5V	4Hz
PCI-5B31-01	±1V	±5V	4Hz
PCI-5B31-03	±10V	±5V	4Hz

THERMOCOUPLE INPUT MODELS

PCI MODEL NUMBER	INPUT TYPE AND RANGE	OUTPUT RANGE
PCI-5B37J	Type J, -100°C to 760°C (-148°F to 1400°F)	0 to +5V
PCI-5B37K	Type K, -100°C to 1350°C (-148°F to 2462°F)	0 to +5V
PCI-5B37T	Type T, -100°C to 400°C (-148°F to 752°F)	0 to +5V

CURRENT OUTPUT MODEL

PCI MODEL NUMBER	INPUT RANGE	OUTPUT RANGE	BANDWIDTH
PCI-5B39-02	±5V	4 to 20mA	400Hz

Isolation is provided by transformer coupling, using a technique which suppresses transmission of common-mode spikes or surges.

Thermocouple input blocks interface to industry standard type J, K, and T thermocouples. The output signal is in the range of 0 to +5V. Each block is cold-junction compensated to correct for the parasitic thermocouples formed by the thermocouple wire and the screw terminals on the termination panel. Upscale open thermocouple detection is provided by an internal pull-up resistor. Downscale indication can be implemented by installing an external resistor.

Linearization for these blocks can be provided in software. LABTECH NOTEBOOK/CONTROL supports the PCI-5B Series directly. When writing your own software, the PCI-20026S, PCI-603S/604S/605S and *MacAdapt* software drivers can be used to provide direct readings in degrees C.

A special input circuit within all of the blocks provides protection (up to 240VAC) against accidental connection of power-line voltages.

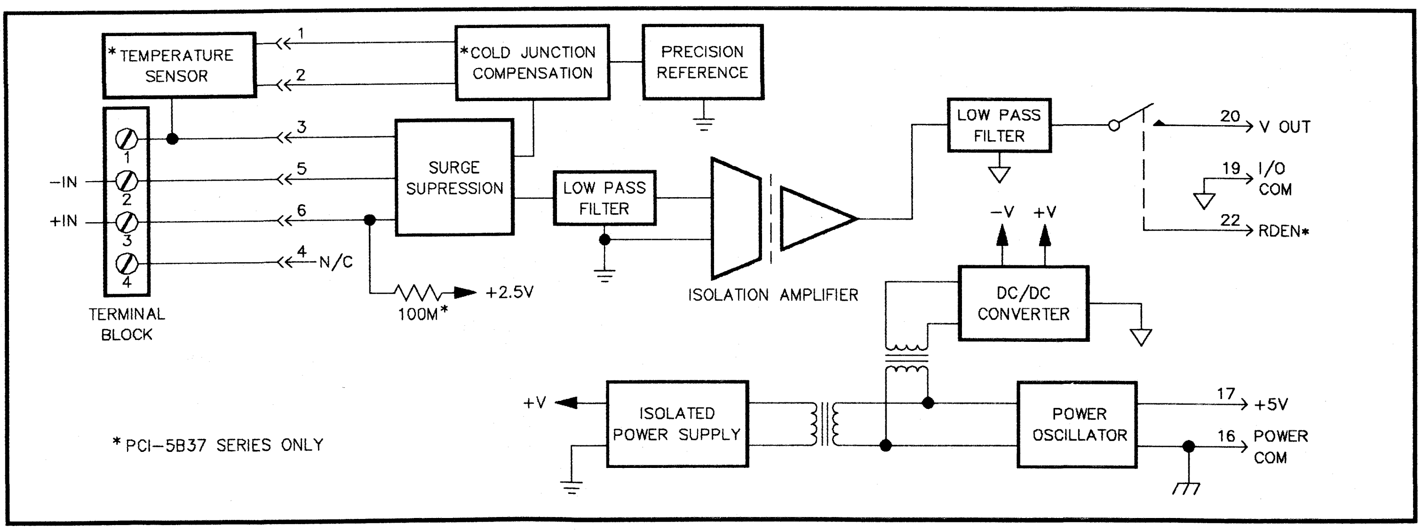
Each PCI-5B39 current output block provides a single channel of analog output. Each block provides signal buffering, isolation, filtering, and conversion to a current output.

The following cables are available from Burr-Brown for use with the PCI-5B01-1 Termination Panel:

PCI-20008A-1 A 4-foot (1.22 meter) shielded analog high-density cable assembly to connect to multifunction boards and carriers (these have high-density connectors).

PCI-20015A-1 A 6.56-foot (2-meter) shielded analog cable assembly to connect to standard PCI boards or modules.

If the total power requirement of the blocks you are using does not exceed 250mA, the 5VDC from your computer's power supply (available on the interconnecting cable) can be used. However, many applications will require an external +5VDC, ±5% power supply. An enclosed, rack-mountable power supply is available for this purpose. The PCI-20338A-1 power supply is recommended for use with the PCI-5B01-1 Termination Panel. The power supply can be mounted on the rear of the PCI-20339A-1 rack. Universal input voltage ranging (85VAC to 264VAC) allows this supply to be used in any country without the need to change jumpers or switch settings. The supply features 5-volt output at 3 amps with ±2mV regulation. It is short circuit protected and is UL, CSA and VDE approved.



Representative Diagram of Analog Input Blocks—PCI-5B Series.

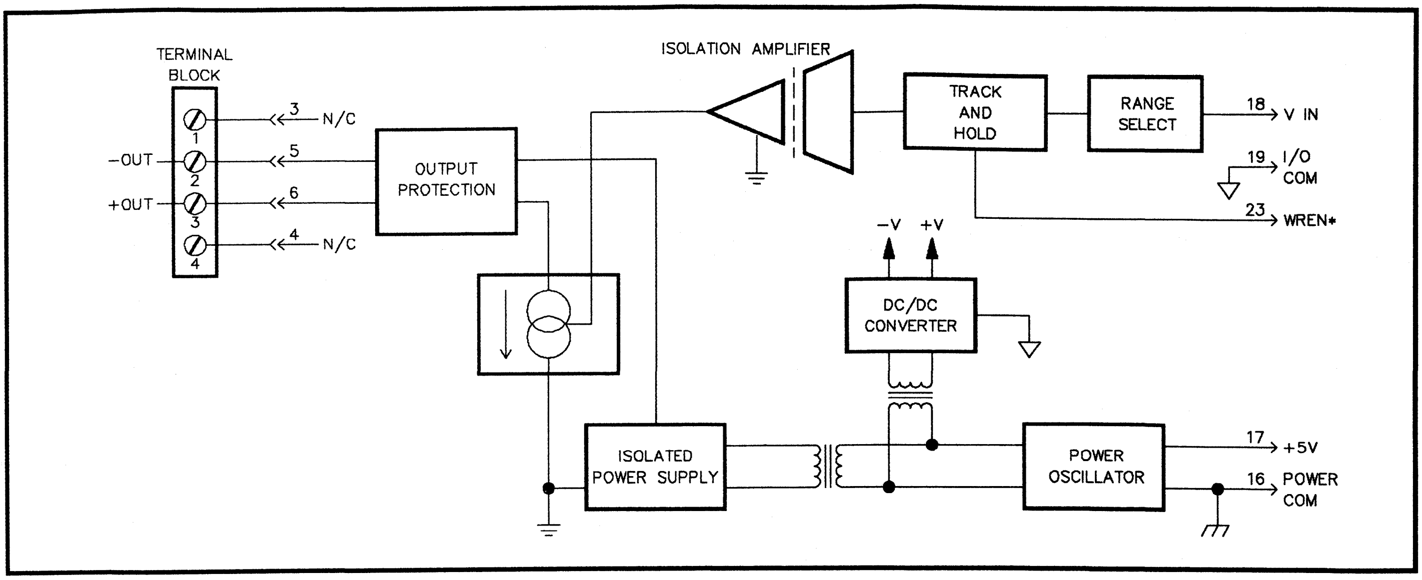


Diagram of Analog Output Block— PCI-5B39-02.

SPECIFICATIONS— ANALOG INPUT

All specifications are typical at +25°C unless otherwise noted.

BLOCKS	PCI-5B30-01,-02,-03	PCI-5B31-01, -03
Input Range	±10mV to ±100mV	±1V to ±10V
Input Bias Current	±3nA	±0.2nA
Input Resistance		
Normal	5M ohm	650K ohm
Power Off	40K ohm	650K ohm
Overload	40K ohm	650K ohm
Input Protection		
Continuous	240Vrms max	240Vrms max
Transient	IEEE-472	IEEE-472
CMV, Input to Output		
Continuous	1500Vrms max	1500Vrms max
Transient	IEEE-472	IEEE-472
CMR (50 or 60Hz)	160dB	160dB
NMR (50 or 60Hz)	60dB	60dB
Accuracy	±0.05% span	±0.05% span
Nonlinearity	±0.02% span	±0.02% span
Stability		
Input Offset	±1μV/°C	±2μV/°C
Output Offset	±20μV/°C	±20μV/°C
Gain	±25ppm of reading/°C	±50ppm of reading/°C
Noise		
Input, 0.1 to 10Hz	0.2μVrms	2μVrms
Output, 100kHz	200μVrms	200μVrms
Bandwidth, -3dB	4Hz	4Hz
Response Time, 90% Span	0.2S	0.2S
Output Range	±5V	±5V
Output Resistance	50 ohm	50 ohm
Output Protection	Continuous to ground	Cont. short to ground
Output Selection Time	20μS	20μsec
Output Enable Control		
Max logic "0"	1V	1V
Min logic "1"	2.5V	2.5V
Max logic "1"	36V	36V
Input Current "0"	400μA	400μA
Power Supply Voltage	5VDC ±5%	5VDC, ±5%
Power Supply Current	30mA	30mA

SPECIFICATIONS— THERMOCOUPLE INPUT

All specifications are typical at +25°C unless otherwise noted.

BLOCKS	PCI-5B37 SERIES
Input Range	J, K, T thermocouples
Input Bias Current	-25nA
Input Resistance	
Normal	5M ohm
Power Off	40K ohm
Overload	40K ohm
Input Protection	
Continuous	25/40Vrms max
Transient	IEEE-472
CMV, Input to Output	
Continuous	1500Vrms max
Transient	IEEE-472
CMR (50 or 60Hz)	160dB
NMR (50 or 60Hz)	60dB
Accuracy	±0.05% span
Nonlinearity	±0.02%
Stability	
Input Offset	±1μV/°C
Output Offset	±20μV/°C
Gain	±25ppm of reading/°C
Noise	
Input, 0.1 to 10Hz	0.2μVrms
Output, 100kHz	200μVrms
Bandwidth, -3dB	4Hz
Response Time, 90% Span	0.2S
Output Range	0 to 5V (linearization required)
Output Resistance	50 ohm
Output Protection	Continuous short to ground
Output Selection Time	20μS
Output Enable Control	
Max logic "0"	1V
Min logic "1"	2.5V
Max logic "1"	36V
Input Current "0"	400μA
Open Input Response	Upscale
Open Input Detection Time	10S
Cold-Junction Compensation	
Accuracy, 25°C	±0.25°C
Accuracy, 5°C to 45°C	±0.5°C
Power Supply Voltage	5VDC ±5%
Power Supply Current	30mA

SPECIFICATIONS— CURRENT OUTPUT

BLOCKS	PCI-5B39-02
Input Voltage Range **Input Voltage Maximum** **Input Resistance**	±5V ±10V (no damage) 5M ohm
Output Current Range **Load Resistance Range** **Output I Under Fault, Max** **Output Protection** Continuous Transient **CMR (50 or 60Hz)**	4 to 20mA 0 to 650 ohm 26mA 1500Vrms max IEEE-472 90dB
Accuracy **Nonlinearity** **Stability** Zero Span **Noise** Output Ripple, 100Hz Bandwidth **Bandwidth, -3dB**	±0.05% span ±0.02% span ±0.5mA/°C ±20ppm of reading/ °C 30μV P-P 400Hz
Track-and-Hold Enable Control Max logic "0" Min logic "1" Max logic "1" Input Current "0"	 1V 2.5V 36V 1.5mA
Power Supply Voltage **Power Supply Current**	5VDC ±5% 170mA

SPECIFICATIONS— MECHANICAL

BLOCKS	ALL PCI-5B SERIES
Mechanical Dimensions	2.25" x 2.25" x 0.60" (58mm x 58 mm x 15mm)
Environmental Operating Temperature Range Storage Temperature Range Relative Humidity RFI Susceptibility	 -25°C to 85°C -40°C to 85°C 0 to 95% noncondensing ±0.5% span error @ 400MHz, 5W, 3ft.

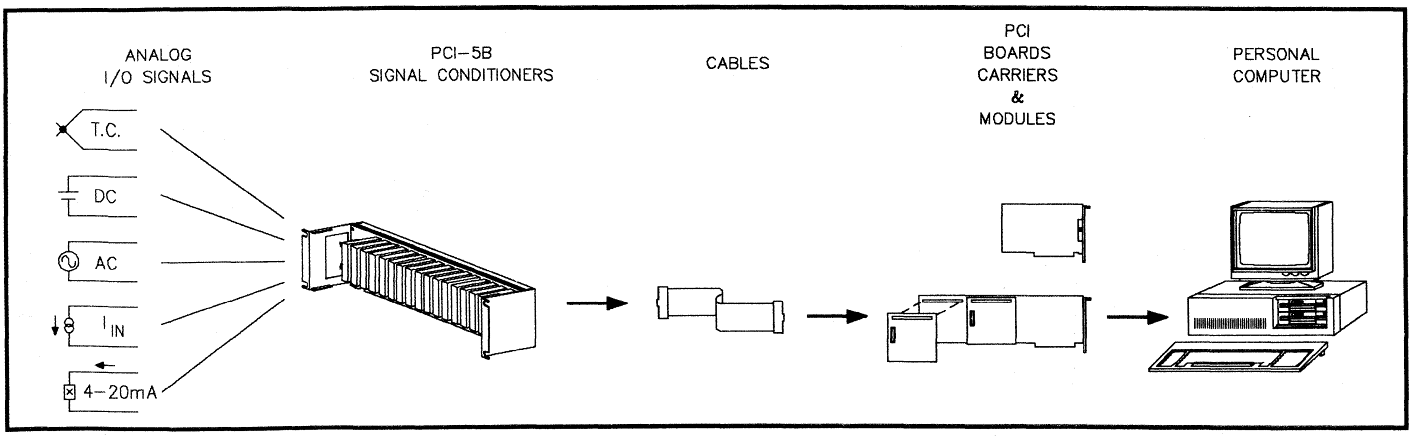
COMPATIBILITY TABLE— TERMINATION PANEL (PCI-5B01-1[2]—ANALOG I/O)

MODEL	TYPE	CHANNELS	DESCRIPTION	CARRIERS[1]	MODULES[1]	BOARDS[1]
PCI-20008A-1B	Cable	16	4-foot, high-density, shielded	PCI-20098C, PCI-701C		PCI-601W, PCI-602W
PCI-20008A-2B	Cable	16	1.5-foot, high-density, shielded	PCI-20098C, PCI-701C		PCI-601W, PCI-602W
PCI-20008A-3B	Cable	16	3-foot, high-density, shielded	PCI-20098C, PCI-701C		PCI-601W, PCI-602W
PCI-20015A-1	Cable	16	4-foot, shielded		PCI-20002M, 3M, 6M, 21M, 31M	PCI-20089W/93W
PCI-20338A-1	Power		+5V @ 3A			
PCI-20339A-1	Enclosure	Up to 16	19-inch rack/table mount			

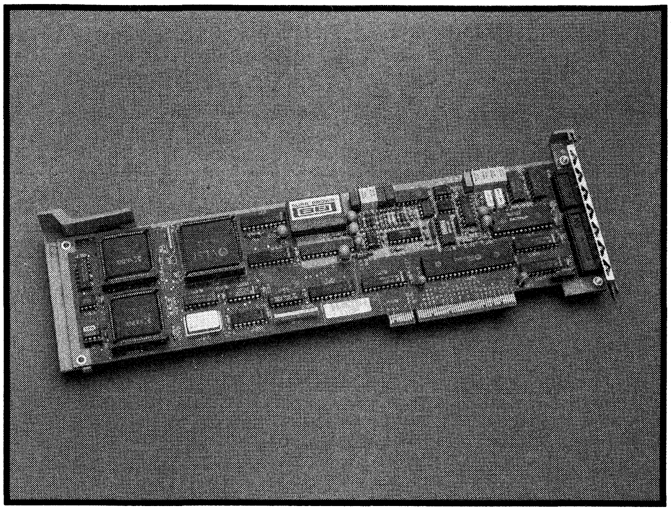
Notes: (1) When part numbers are shown without "dash" numbers, all versions apply.
(2) The PCI-5B01-1 has both a high-density and normal-density connector on it, only one of which can be used at a given time.

PRODUCT COMPATIBILITY— PCI-5B SERIES

	INPUT (PCI-5B30/PCI-5B31/PCI-5B37)		OUTPUT (PCI-5B39)	
Carriers	PCI-20098C-1 PCI-701C	Multifunction, PC Bus Multifunction, Mac II NuBus		
Modules	PCI-20002M-1 PCI-20031M-1	12-Bit Analog Input Multiplexer/Expander	PCI-20003M-2 PCI-20006M-2 PCI-20021M-1B	12-Bit Analog Output 16-Bit Analog Output 12-Bit Analog Output
Boards	PCI-20089W-1 PCI-601W/PCI-602W	12-Bit Analog Input, PC Bus Multifunction, Micro Channel Bus	PCI-20093W-1 PCI-602W	12-Bit Analog Output, PC Bus Multifunction, Micro Channel Bus
Termination Panels	PCI-5B01-1	16-Channel	PCI-5B01-1	16-Channel



Interconnection Diagram.



BURR-BROWN®

PCI 601W, PCI-602W

Multifunction I/O Boards for PS/2 Micro Channel Bus

FEATURES

- 16/8 Analog Input Channels
  - Single-Ended/Differential
  - 12-Bit Resolution
  - Programmable Gain = 1, 10, 100, 200
  - Up to 70kHz Sample Rate
- Internal Timebase/Burst/Rate Generator
- 2 Independent Counter Channels
  - Event Counter and Divider
  - Read Frequency, Period, and Pulsewidth
  - Variable Duty Cycle Generator
- 16 Digital I/O Channels
  - Handshaking Lines
- 2 Analog Output Channels (PCI-602W Only)
  - 16-Bit Resolution
- DMA, Interrupt-Driven or Polled Modes
- All Functions Software Programmable, No Jumpers Needed

DESCRIPTION

The PCI-601W and PCI-602W are multifunction input/output boards for IBM compatible Micro Channel computers. The boards interface directly to the internal bus of any IBM PS/2 model 50, 60, 70 or 80 type computer. They support a wide range of analog, digital, and counter/timer/generator functions. Typical applications for these products include data acquisition, test, measurement, and control in research laboratories, industry, utility plants, and education. Compatibility is insured for a wide variety of analog voltages and currents (thermocouples, RTD's, strain gages, load cells, etc.), as well as digital and pulse signals (switch closures, optical/magnetic pickups, etc.). All options and I/O functions are under software control. No "jumpers" are required.

The boards perform the necessary signal interface functions required to make input/output data compatible with your Micro Channel computer. This includes analog-to-digital (A/D) and digital-to-analog (D/A) conversion. The analog input multiplexer can select from among 16 single-ended or 8 differential channels. Each channel can be programmed independently for single-ended or differential use. Signal scaling and common-mode rejection are provided by a high-performance, differential input, programmable gain amplifier. Gains of 1, 10, 100, and 200 are provided. The 12-bit A/D converter can be configured for input ranges of ±5, 0 to 10 or ±10 volts full scale. Gain, A/D range, and the choice of single-ended versus differential input are all software programmable for each channel. A hardware channel scanner enhances high-speed and DMA performance. Not only can a given group of channels be scanned (channels 0 thru "n"), but each channel can have independent gain settings.

Both boards offer the same I/O capabilities, with the exception that only the PCI-602W has analog outputs. On the PCI-602W, analog signal generation and closed-loop control are supported by two high-speed, high-resolution, analog output channels. The ±10 volt range and 16-bit resolution provide for output step changes as small as 0.3 mV. Both channels can be operated under program or DMA control. Full scale output changes can be sustained at speeds up to 80kHz.

The digital sections of the boards contain the computer bus interface circuitry, 16 channels of digital I/O, a programmable burst/rate generator and 2 general-purpose counters. The crystal-controlled burst/rate generator is very useful for establishing an accurate and dependable timebase for data acquisition. In addition to generating continuous clock rates in the range of 0.002Hz to 2MHz, the user can program bursts of pulses. Using this feature, a desired number of pulses can be generated with a specified pulse spacing and an independent repetition rate. This innovation makes it practical to perform high-speed acquisitions ("simultaneous" readings) of multiple channels at programmable repetition rates.

The two 16-bit counters can be used separately, or they may be used in combination to form a 32-bit counter. Typical operations include event counting and dividing as well as speed, frequency, pulsewidth, and period measurement. Also, the counters can be configured to produce a variable duty cycle generator. The counter's separate clock, gate and output connections have independent, fully programmable active-high/low states. Input clock rates up to 16MHz are supported.

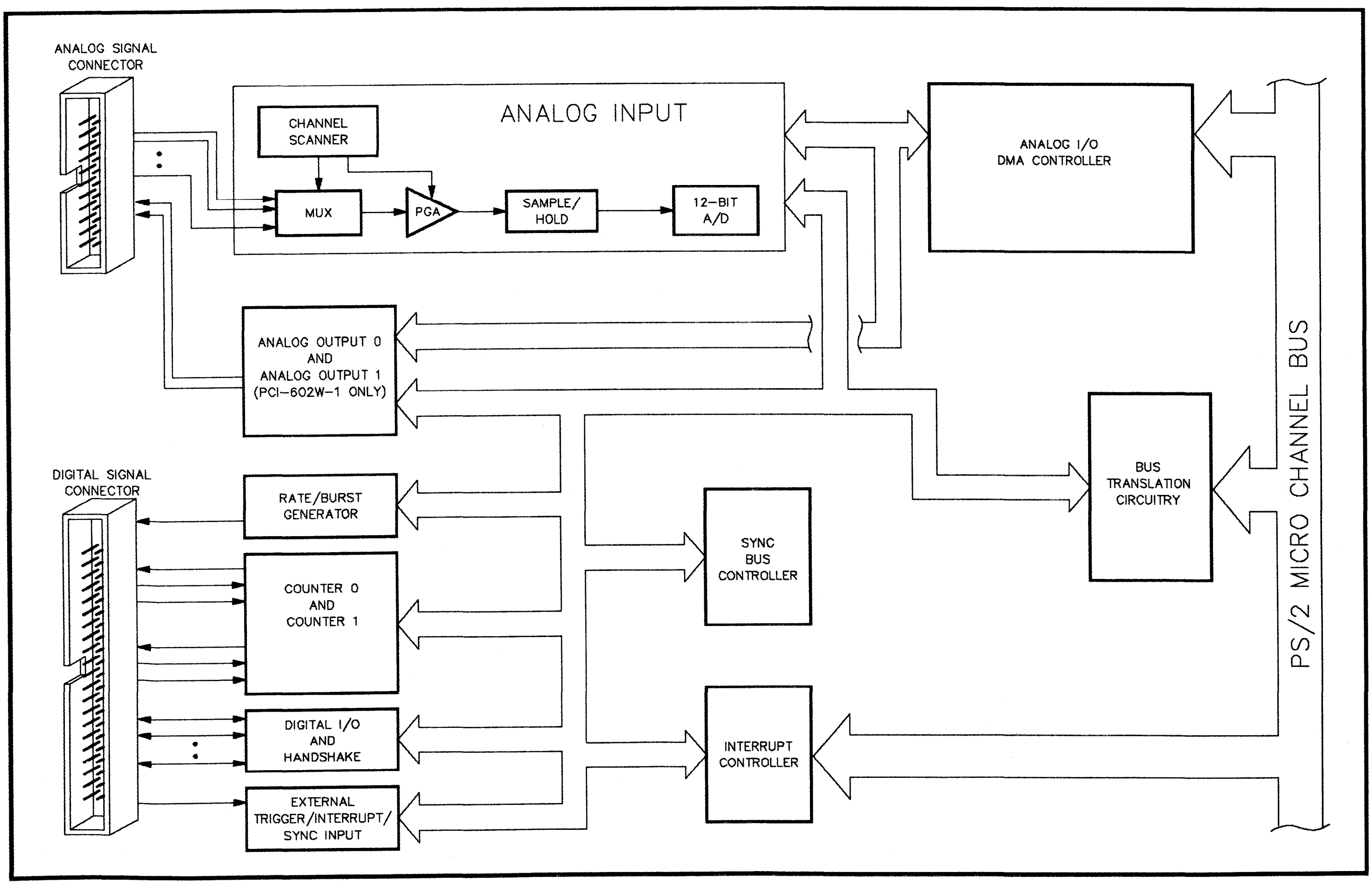
The 16 channels of TTL compatible digital I/O are arranged in two byte-size ports (8 channels each) that can be programmed for either input or output use. In addition, all outputs are buffered, and full handshake and interrupt capabilities are supported. Data transfer rates of 250Kbytes/second can be achieved. At "power-up" the ports are automatically placed in the input configuration.

Separate keyed "bulkhead" connectors are provided for both the analog and the digital signals. This is to insure that digital signals do not contaminate (degrade) the analog signals. External signal connections are conveniently located on the rear support bracket where cable connections can be made without opening the computer. Optional ribbon cables and termination panels are available to further facilitate external connections. The PCI-20304T Series for analog and the PCI-20306T-1 and PCI-20307T-1 for digital applications comprise the compatible Euro-Style panels. Termination panels provide convenient screw terminal blocks for fast external connections. Each panel also has ample space for the user to install custom signal conditioning networks including anti-aliasing filters, amplifiers, voltage dividers, surge suppressors, etc. Compatibility between the various termination panels, cables, and boards is described in the Termination Panel Compatibility Table on page 3-10. Please note that the PCI-602W (with analog output) requires the PCI-20304T Series of termination panels. The PCI-20008A-1B (analog) cable along with the PCI-20009A-1B (digital) cable completes the connection between the termination panels and the multifunction I/O boards.

Both the PCI-601W and PCI-602W are fully compatible with the industry-standard LABTECH NOTEBOOK (PCI-20040S-1) and LABTECH CONTROL (PCI-20097S-1). These software products provide extensive input/output, analysis, display and control capabilities. All features are menu-driven—no programming is required.

Optional software drivers are also available offering a wide range of capabilities in several programming languages. These include the PCI-603S (QuickBASIC), PCI-604S (Microsoft C), and PCI-605S (TURBO PASCAL). The PCI-606S is a combination package that includes drivers for all three languages at a reduced price. Software drivers provide a clear and consistent high-level interface to the board. They "insulate" the programmer from the particulars of the hardware, allowing code development by people not experienced in electronics. Complex sequences are reduced to simple "call" statements. The driver packages support all I/O functions, including high-speed analog readings and DMA. Built-in calls can read frequency, period, pulsewidth, counts, thermocouples, and RTDs. Output functions include analog, pulse, burst, and digital pattern generation.

Comprehensive documentation covering all aspects of installation, calibration and programming is included. Each board is shipped, at no extra charge, with Burr-Brown's innovative SYSCHECK PS/2 (PCI-607S), the System Assurance Utilities and Diagnostics Software Package for use with PCI Micro Channel products. This menu-driven product easily verifies proper installation and utilization of all PCI system components. Not only does SYSCHECK PS/2 greatly reduce the time required to confirm appropriate operation, but it provides a permanent resource for test and calibration. In addition, SYSCHECK PS/2 provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.



Block Diagram of PCI-601W/PCI-602W.

SPECIFICATIONS—PCI-601W AND PCI-602W

All specifications are typical at 25° C in a PS/2 Model 70 computer unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Board Addressing		Memory mapped
Size		1Kbytes
Analog Inputs		
Number of Channels	Single-ended	16
	Differential	8
Signal Range	Linear operation	±10V max
	Without damage, power on	±35V
	power off	±20V
Offset Voltage	Trimmable to 0	±0.5LSB
Common-Mode Range	$V_{cm}=CM_{range}-(V_{diff}$ Gain)/2	±10V
Rejection Error	60Hz, 100 ohm imbalance, 10V range	
	Gain = 1	0.04LSB/volt (-80dB)
	Gain = 10	0.13LSB/volt (-90dB)
	Gain = 100	0.73LSB/volt (-95dB)
	Gain = 200	1.5LSB/volt (-95dB)
Bias Current		500pA
Input Impedance		10^{11} Ω@ 75 pF
Source Impedance,	For 1LSB error	
Max Recommended	At 50kHz sample rate	5K ohms
	At 70kHz sample rate	4K ohms
Crosstalk	Channel to channel @ 1kHz, 1kΩ source impedance	±1LSB
Nonlinearity		0.2LSB (-90dB)
Gain, Selections	Software programmable	1, 10, 100, 200
Inaccuracy	Trimmable to 0	± 0.5LSB
A/D Converter		Fully programmable
Resolution	(1 part in 4096)	12-bit
Code	Unipolar	Binary
	Bipolar	Offset binary
Ranges		±5, ±10, 0-10V FS
Dynamic Performance	For 0.01% accuracy	
Total Throughtput	Gain = 1, 10	70kHz
	Gain = 100	48kHz
	Gain = 200	20kHz
Mux Settling Time		3.5μsec
S/H Capture Time		1μsec
A/D Conversion Time		13μsec maximum
PGA Settling Time	20 Volt Output Step, Gain = 1, 10	10μsec
	Gain = 100	20μsec
	Gain = 200	40μsec
Analog Outputs	(PCI-602W only)	
Channels	16-bit resolution	2
Gain Error	Adjustable to zero	±0.5LSB
Offset Error	Adjustable to zero	±0.5LSB
Monotonicity		13-bit, minimum
Code		Binary, twos complement
Range		±10V
Output Current	Short circuit protected	±5mA
Settling Time	20V step, 0.003%	4μsec
Throughput Rate		80kHz
Digital I/O[1]		Fully programmable
Number of Ports	8 channels each	2
Modes		Normal I/O, and handshake
Transfer Rate		250Kbytes/Sec
Digital and Strobe I/O		TTL compatible
Digital Outputs[2]		
Current Source	V_{out} = Low	-15mA
Current Sink	V_{out} = High	24mA
Rate Generator		Fully programmable
Output Frequency		0.002Hz to 2MHz
Resolution		125 nS
Stability	Crystal clock	±0.01%
Output Modes		Continuous and burst
High-level Voltage	I_{out} = Maximum	2.0V
Low-level Voltage	I_{out} = Maximum	0.8V
Current Source	V_{out} = Low	-8mA
Current Sink	V_{out} = High	8mA
Counters		Fully programmable
Number		1 (32-bit) or 2 (16-bit)
Clock Speed	Maximum	16MHz
Counter Inputs	Schmitt Trigger	TTL compatible

Continued...

SPECIFICATIONS...CONTINUED

PARAMETER	CONDITIONS	SPECIFICATION
Interrupts	Latched	Fully programmable
PC Levels		9 and 3 thru 7
Sources		Rate Generator, external TTL, End-of-Convert, End-of-Measurement, DMA terminal count, DMA Pacer, DI/O
Inputs	External	TTL Compatible
Power Requirements	From PC's +5V supply	1.60A max
Physical	Expansion slot requirements	1 Slot
Connectors (Mating)	Mount on bulkhead	Amphenol
	Analog	#845C026SALA00
	Digital	#845C050SALA00
Temperature Range	Board temperature	0 to 70°C

Notes: (1) All digital points are programmable as either inputs or outputs in byte size groups (8 channels each).
(2) All digital I/O ports are "inputs" at power up.

SOFTWARE COMPATIBILITY TABLE

(The PCI-601W/602W can be used with the following software.)

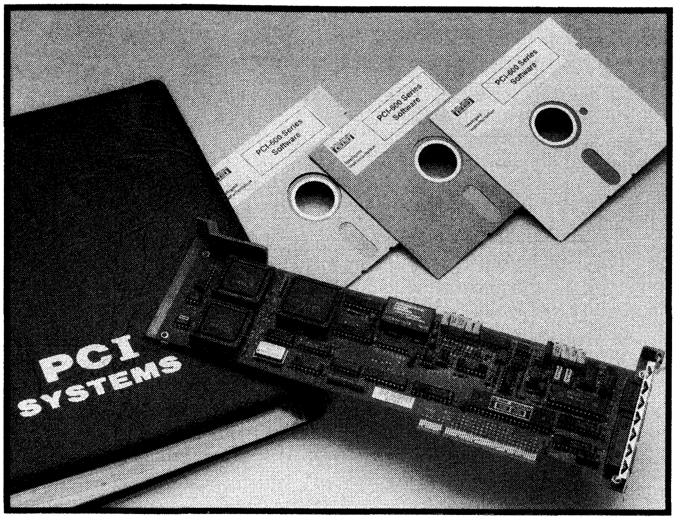
PCI MODEL NUMBER	NAME	MENU-DRIVEN	H/W DRIVER[1]	DMA SUPPORT
PCI-20040S-1	LABTECH NOTEBOOK	Yes	Yes	No
PCI-20067S-1	DADiSP/PC	Yes	No	No
PCI-20097S-1	LABTECH CONTROL	Yes	Yes	No
PCI-20210S-1	Hypersignal-Workstation	Yes	No	No
PCI-603S-1	Software Driver	No	Yes	Yes
PCI-604S-1	Software Driver	No	Yes	Yes
PCI-605S-1	Software Driver	No	Yes	Yes

Note: (1) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-603S, PCI-604S or PCI-605S drivers).

COMPATIBILITY TABLE— TERMINATION PANELS

I/O TYPE	TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURES
Analog Input/Analog Output	PCI-20304T-1	General-purpose	PCI-20008A-1B	PCI-20308H-1 and PCI-20343A-1
	PCI-20304T-2	Thermocouple	PCI-20008A-1B	PCI-20308H-1 and PCI-20343A-1
	PCI-20024T-1	Customizer	PCI-20008A-1B	PCI-20029A-1
	PCI-5B01-1	Signal conditioner	PCI-20008A-1B	PCI-20339A-1
Digital I/O, Counters and Burst Generator	PCI-20306T-1	General-purpose	PCI-20009A-1B	PCI-20308H-1 and PCI-20343A-1
	PCI-20025T-1	Customizer	PCI-20009A-1B	PCI-20029A-1
	PCI-20325T-1	Signal conditioner	PCI-20009A-1B	PCI-20308H-1 and PCI-20343A-1

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-603S, PCI-604S, PCI-605S, PCI-606S

Software Drivers Language Support for PS/2 Micro Channel Computers

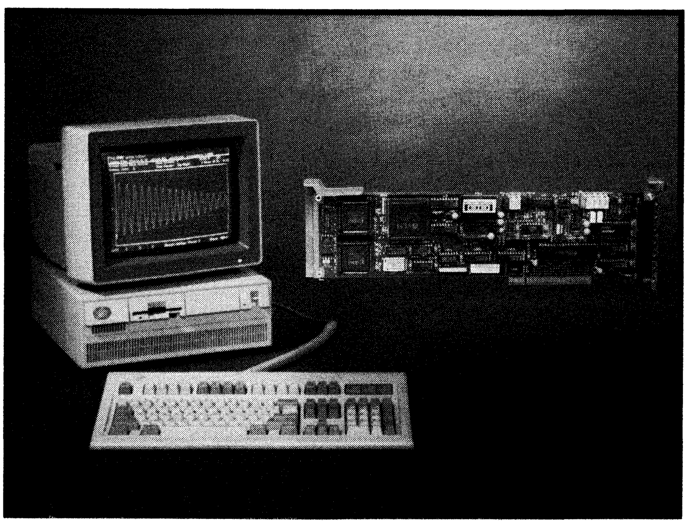
FEATURES

- Interfaces the PCI-601W and PCI-602W Multifunction I/O Boards to High-Level Programming Languages
- Works with Most Languages Running on PS/2 Models 50, 60, 70 or 80 Compatible Computers
- Easy-To-Use, High-Level Commands
- Increases Productivity by Isolating the Programmer from the Details of the Hardware

DESCRIPTION

The PCI-603S, PCI-604S and PCI-605S Software Drivers provide an uncomplicated interface between several of the most popular high-level languages and the PCI-601W and PCI-602W Multifunction I/O Boards. The use of this software greatly reduces the amount of knowledge the programmer must have of the hardware details. Long sequences of bit-oriented, register-specific setup calls are replaced with simple high-level calls.

PCI-606S is a combination package that includes the PCI-603S, PCI-604S and PCI-605S software drivers. This offers reduced cost to users of more than one language.



PCI-603S, PCI-604S, PCI-605S Software Supports Both the PCI-601W and PCI-602W in All PS/2 Micro Channel Computers.

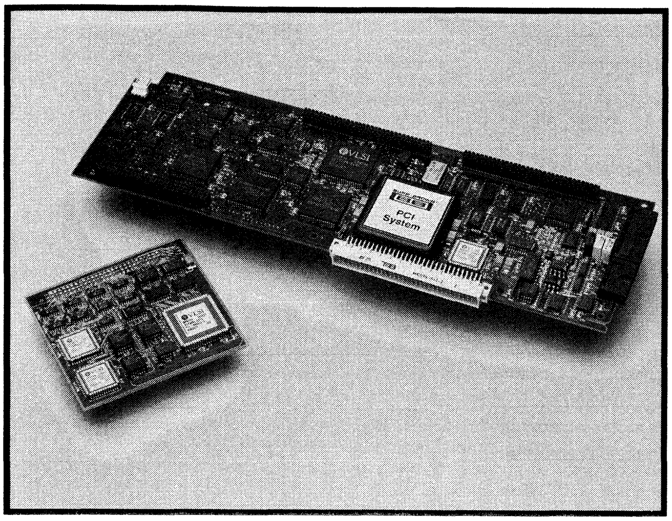
COMMAND SUMMARY TABLE— PCI-603S, PCI-604S, PCI-605S

COMMAND	DEFINITION
AnalogOutX(...)	Outputs a specified voltage on an analog output channel. X = 0 or 1; refers to the analog output channel to which the call is directed.
DifAnalogInput(...)	Acquires data from a differential analog input channel.
SeAnalogInput(...)	Similar to the above call, but is used for a single-ended analog input.
ThermocoupleTranslator(...)	A special case of 'DifAnalogInput', which supports the connection of types J, K, and T thermocouples. This call uses the NBS polynominals to process data acquired from a specified channel. Cold-junction compensation is supported.
AnalogWaveformRecorder(...)	Configures the analog input channel(s) to emulate an analog waveform recorder. DMA is used to transfer the acquired data to the host memory so the program may operate in the foreground while analog data is being acquired. Arguments passed to the call allow complete control over the operating modes (timebase, triggering, scanning of multiple channels, single-ended or differential configuration of channels, as well as gain and range of scanned channels).
SignalGenerator(...)	Configures an analog output as a signal generator. It supports the construction of a buffer which contains the data defining the signal to be generated. Arguments passed to the call specify the analog output channel to be used as the generator and the timebase used to pace the signal generation process. The resultant signal generation process runs in the foreground.
DigitalIOX(...)	Controls the digital I/O ports. It facilitates configuration of input and output, in both byte-wide and bit-oriented formats. For ports which have been configured for the handshake mode, it allows the status of those ports to be examined.
BoardX(...)	Where X ranges from 0 to 10. Refers to an entire board (a resource) to be allocated or de-allocated. This call is used to select the current board, to which future calls will be directed. Useful in multi-board configurations. This call may also be used to cause a board to generate a software interrupt, which may, in turn, be used to pace or trigger an analog waveform recorder acquisition.
BurstGenerator(...)	Used to configure and start/stop the burst generator. Arguments passed control the number of pulses-per-burst, the pulse period, burst period, and synchronization sources.
VariableDutyCycleGenerator(...)	Used to configure and start/stop the variable duty cycle signal generator. Arguments passed specify the duration of the high and low portions of the output pulse.

COMPATIBILITY TABLE— PCI-603S, PCI-604S, PCI-605S

PARAMETER	CONDITIONS	SPECIFICATION
Hardware	I/O Boards Computers	PCI-601W or PCI-602W Multifunction PS/2 Model 50, 60, 70 or 80 or compatibles
Software	PCI-603S PCI-604S PCI-605S PCI-606S	QuickBASIC, Version 4.0 (with upgrade) or higher Microsoft C, Version 5.1 or higher TURBO PASCAL, Version 5.0 or higher QuickBASIC, Microsoft C and TURBO PASCAL
Operating System	PC DOS	Version 3.2 or later

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-700 Series

Multifunction *NuCarrier* for the Mac II NuBus

FEATURES

- Bus Master / Slave Configurations with Optional *MacPilot* Module
  - On-Board Bus Master Module Can Control Multiple Carriers
- On-Carrier Functions:
  - Analog Inputs
    - 16 Single-Ended or 8 Differential Channels
    - On-Board Channel Scan List Memory
    - 12-Bit Resolution
    - Programmable Gain - 1, 10, 100, 200
    - Up to 70kHz Sample Rate
  - Burst Generator
    - Provides Programmable Clock for Synchronizing Events
  - Digital I/O Channels
    - 16 Channels
    - Programmable in 8-Bit Groups as Inputs or Outputs
    - Separate Handshaking Lines
  - Counter\Timers
    - Two 16-Bit Counters, Can Be Combined for 32-Bit Operation
    - Measure Frequency, Period, and Pulsewidth
    - Event Counter and Divider
    - Variable Duty Cycle Generator
  - All Functions Software Programmable -- No Jumpers Required
- Compatible with PCI Modules, Termination Panels, and Cables
- System Setup and Diagnostic Software Included
- Comprehensive, High-Level *MacAdapt* Software Drivers Included

DESCRIPTION

The PCI-701C *NuCarrier* is a multifunction input/output device that plugs directly into a NuBus slot within any Macintosh II Series (models II/IIx/IIcx/IIci/IIfx) personal computers. *NuCarrier* is supported by all Mac IIs running System 6.0.3 or later and comes complete with *MacAdapt* software drivers. *NuCarrier* provides a wide range of on-board functions for analog input, digital I/O, counting, frequency measurement, and pulse generation.

The on-board capabilities of *NuCarrier* can be expanded further with the addition of one or two compatible members of the PCI I/O module family. Modules can be used to expand the number of analog inputs and digital I/Os. They can also be used to add new functions such as analog output, higher speed analog input, simultaneous analog inputs, 16-bit A/D resolution, and trigger/alarm capabilities. When *NuCarrier* is configured with I/O modules, coordinated processing is enhanced by the on-board Intelligent Instrumentation Interface (I^3) Bus. This bus supports analog data flow between modules and provides both synchronization and trigger capabilities.

In its basic configuration, *NuCarrier* acts as a slave and is capable of programmed and interrupt-driven I/O transfers. The addition of the PCI-702M *MacPilot* Module transforms *NuCarrier* into a Bus Master that can transfer data from all I/O types directly to the host RAM under DMA control. A single *MacPilot* module can control all *NuCarriers* installed in a given computer. All functions and options on the carrier are controlled via software—no jumpers are used. Typical applications for this product include data acquisition, test, measurement, and control in research laboratories, utilities, industry, and education. A block diagram of the PCI-701C/PCI-702M Multifunction *NuCarrier* is shown on page 3-14.

Analog Input and Output

The carrier's on-board analog input section provides 16 single- ended or 8 differential channels (software programmable). The on-board 12-bit A/D converter can be programmed for input ranges of ±10, ±5, or 0 to 10 volts. With the addition of optional analog input expansion modules (PCI-20031M-1), *NuCarrier's* capacity can be increased in 32-channel increments to a maximum of 80 single-ended or 40 differential channels.

The analog input section includes a fully differential, programmable gain amplifier that can be set to gains of 1, 10, 100 or 200. Sampling rates up to 70kHz can be achieved. A channel scanner within the analog input section enhances high-speed and DMA performance by permitting random channel selection with independent gains.

Several modules are available for adding analog output capabilities to *NuCarrier*. These modules offer a choice of either 12-bit or 16-bit resolution. The PCI-20003M-2 and PCI-20006M-2 are high-speed modules with two output channels. The general-purpose PCI-20021M-1B has eight outputs. Thus, up to 16 analog outputs can be included on one carrier.

Digital I/O

Sixteen, buffered, TTL-level digital I/O channels are resident on *NuCarrier*. They are arranged in two, eight-channel ports that can be configured separately as inputs or outputs. In addition, handshaking lines are available for each port. At power-up, the channels in both ports are automatically configured as inputs.

Digital I/O can be expanded with the PCI-20004M-1, 32-channel digital I/O module. Up to 80 channels of digital I/O can be supported by *NuCarrier* with the addition of two of these modules.

Counter/Timer/Generator

The carrier includes a programmable timing generator with burst capabilities. This feature can create a series of closely spaced pulses at a desired repetition rate. This facilitates accurate data acquisition by approximating "simultaneous" reading of multiple channels. Users can specify the number of pulses per burst, the time between pulses, and the time between bursts. Burst acquisition of a list of channels is supported.

NuCarrier has two independent 16-bit counters that can be programmed separately or can be concatenated to operate as a single, 32-bit counter. The counters support signal measurement (frequency, period, or pulsewidth), event counting, dividing, and generation of variable-duty-cycle waveforms.

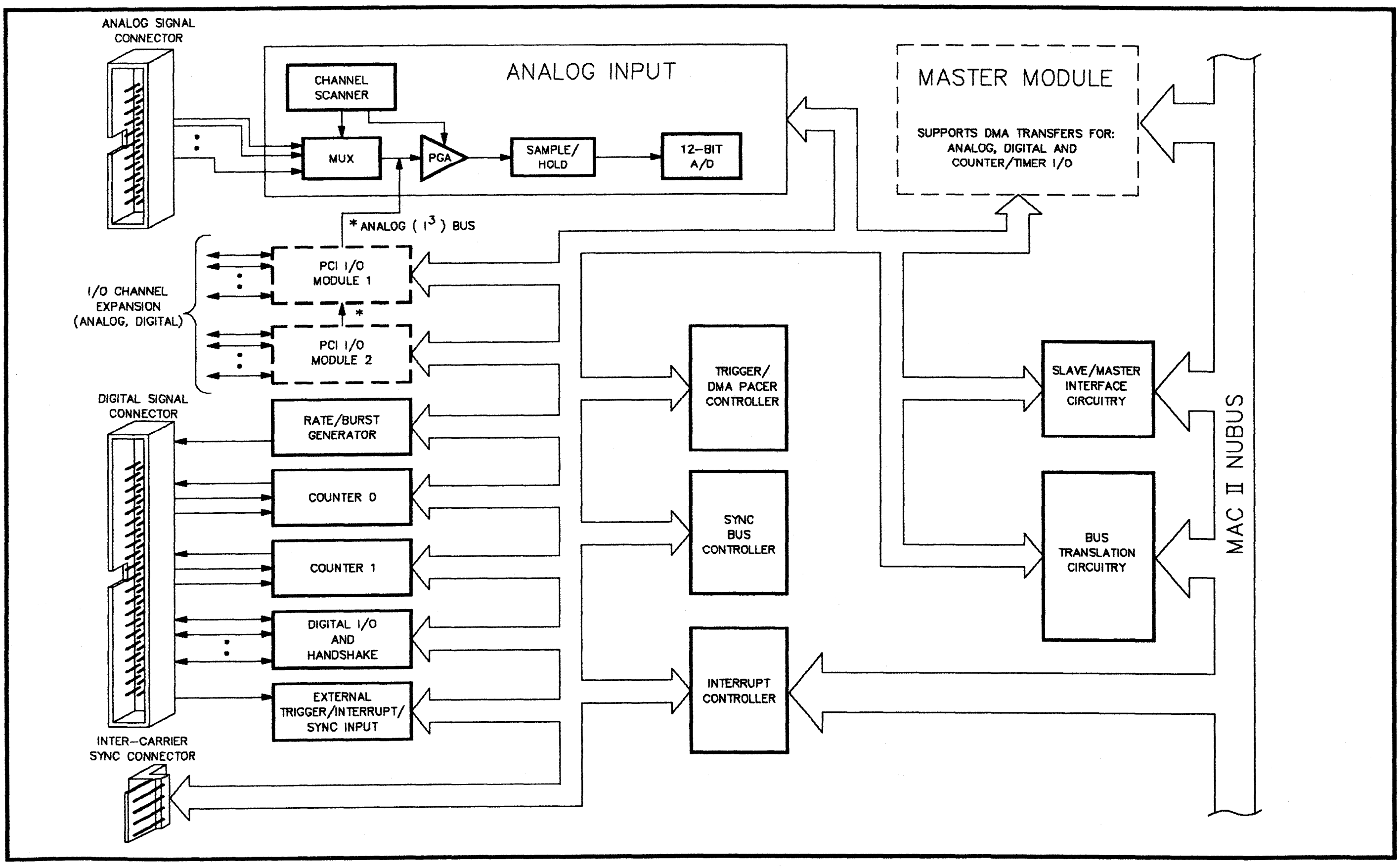
MacPilot Module Provides DMA Capabilities

The PCI-702M *MacPilot* Module plugs into a special connector on the PCI-701C *NuCarrier*. It provides the circuitry required for the carrier to operate as a Bus Master. *MacPilot* includes a 32-bit DMA controller and a 512-byte frame map. This allows any PCI carrier installed in the same Mac II to transfer data to or from the host's RAM without software intervention. Thus, a single *MacPilot* Module can direct the operation of its own host carrier (the Bus Master) and multiple slave carriers. *MacPilot* comes complete with *MacExpedite* software drivers.

Other Features

Separate keyed connectors are provided for the analog and digital signals to protect against signal degradation. These connectors are located on the rear support bracket (bulkhead) where cable connections can be made without opening the computer. Optional ribbon cables and termination panels are available from Burr-Brown to facilitate external connections and add signal conditioning capabilities. Additional information about the available modules can be found in the Hardware Compatibility Table on page 3-18 and in the related data sheets.

Like Burr-Brown's other PCI carriers, modules, and boards, the PCI-701C is compatible with existing PCI termination panels, including the PCI-5B Series Analog Signal Conditioning products and the PCI Euro-Style termination panels. These termination panels provide screw terminal blocks for fast external wiring connections. Each Euro-Style panel also has ample space for the user to install custom signal conditioning networks, including anti-aliasing filters, amplifiers, voltage dividers, surge suppressors, etc. The Hardware Compatibility Table provides more detailed product information.



Block Diagram of the PCI-701C Multifunction *NuCarrier*.

Software

Each *NuCarrier* is shipped with the *MacAdapt* software drivers and SYSCHECK Mac (PCI-705S), a system assurance utilities package. Using icons and pull-down menus to navigate through SYSCHECK Mac, users can easily verify proper installation and utilization of the PCI System. SYSCHECK Mac not only reduces the time required for test and calibration but also serves as a product tutorial.

Software drivers provide the interface between *NuCarrier* and any programming language capable of calling the Toolbox Device Manager. The software drivers include *MacAdapt* (PCI-703S), a general-purpose package, and *MacExpedite* (PCI-704S), a set of drivers for the *MacPilot* module. With these drivers, a programmer can invoke major functions without a detailed knowledge of the PCI hardware. To make interfacing to the drivers easier, interface libraries for the most popular compilers are also provided. These include: Language Systems FORTRAN, MPW C, MPW PASCAL, QuickBASIC, SemperSoft Modula-2, THINK C, THINK PASCAL, TML PASCAL, and TURBO-PASCAL.

MacAdapt—Programmer Support Software Drivers

MacAdapt Programmer Support Software provides an uncomplicated interface between several of the most popular high-level languages and the PCI-701C carrier and compatible PCI I/O modules. The use of this software greatly reduces the amount of knowledge the programmer must have of the hardware detail. Long sequences of bit-oriented, register-specific setup calls are replaced with simple high-level commands. Major features include:

— Interfaces the PCI-701C Carrier and PCI I/O Modules to high-level languages

— Works with most languages running on Mac II, IIx, IIci, IIcx, or IIfx computers

— Easy-to-use, high-level commands

— Decreases development time by isolating the programmer from the details of the hardware

COMMAND SUMMARY TABLE— *MacAdapt*

COMMAND	DEFINITION
Pregunta(...)	Returns a map of the hardware configuration.
ReadAI(...)	Configures an analog input channel and acquires one sample.
AcquireAI(...)	Begins buffered analog data acquisition.
SetPacerAI(...)	Assigns a pacer source (timebase) and sets its operating parameters for subsequent AcquireAI calls.
SetTriggerAI(...)	Configures and assigns the trigger device for subsequent AcquireAI calls.
ConfigureAI(...)	Configures an analog input channel list for subsequent AcquireAI calls.
AcquireSSH(...)	Begins buffered analog data acquisition from simultaneous sample/hold channels.
UnwindBuffer(...)	Time-orders data within a previously-acquired circular buffer.
UpdateAO(...)	Writes data to an analog output channel.
UpdateAllAO(...)	Writes data to all analog output channels on a given carrier or module.
ConfigureBG(...)	Sets operating parameters for a burst generator channel.
EnableBG(...)	Enables output from a burst generator channel.
DisableBG(...)	Disables output from a burst generator channel.
SetOptionsBS(...)	Sets the output polarity of a burst generator channel.
ConfigureCTR(...)	Sets operating parameters and modes for a counter channel.
SetOptionsCTR(...)	Sets operating options for a counter channel.
EnableCTR(...)	Enables a counter channel.
DisableCTR(...)	Disables a counter channel.
ReadCTR(...)	Reads the count value from a counter channel.
ReadAllCTR(...)	Reads the count values from all counter channels on a given carrier or module.
MeasureCTR(...)	Performs a frequency, period, or pulse-width measurement on a counter channel.
ConfigureDIO(...)	Configures a digital I/O port for input/output and handshake/no handshake.
ReadDIO(...)	Reads data present at a digital port which has been configured as an input.
WriteDIO(...)	Writes data to a digital port which has been configured as an output.
StatusDIO(...)	Returns the status of a digital port which has been configured for handshake mode.
ClearINTR(...)	Clears bits in the designated interrupt status register.
ReadINTR(...)	Reads the contents of the designated interrupt status register.
EnableINTR(...)	Enables/Disables hardware interrupts from the designated carrier or module.
ConvertRTD(...)	Converts readings to degrees C from an RTD connected to an analog input channel. 100 Ohm RTDs with alphas of 0.00385 or 0.00392 are supported.
ConvertTCPL(...)	Converts readings to degrees C from a thermocouple connected to an analog input channel. Type J, K, and T thermocouples are supported.
ConnectSYNC(...)	Specifies routing of synchronization signals on the designated carrier or module.
SoftwareInterruptSYNC(...)	Causes software interrupt to occur on the designated carrier or module.
ConfigureTRIG(...)	Initializes the threshold levels and operating mode for an analog trigger channel.
EnableTRIG(...)	Enables an analog trigger channel.
ResetTRIG(...)	Resets and disables an analog trigger channel.
StatusTRIG(...)	Returns the current status of an analog trigger channel.

SOFTWARE COMPATIBILITY TABLE— *MacAdapt and MacExpedite*

PARAMETER	CONDITIONS	SPECIFICATION
Hardware	Computer Carrier I/O Modules DMA Module	Mac II, IIx, IIci, IIcx or IIfx compatible computers PCI-701C PCI-20003M-2, PCI-20003M-4, PCI-20004M-1, PCI-20006M-2, PCI-20017M-1, PCI-20020M-1, PCI-20021M-1, PCI-20023M-1, PCI-20031M-1 and PCI-20341M-1 PCI-702M
Languages Supported		Language Systems' FORTRAN MPW C MPW PASCAL Microsoft QuickBASIC SemperSoft Modula-2 THINK C THINK PASCAL TML PASCAL II Borland TURBO PASCAL
Operating System	Macintosh	Version 6.0.3 and later

COMMAND SUMMARY TABLE— *MacExpedite*

COMMAND	DEFINITION
ConfigureDMA(...)	Configures a bus master process for the specified bus master module with a list of channels to be acquired or output.
SetBuffersDMA(...)	Specifies the buffer or buffers to be used for a subsequent bus master process.
SetPacerDMA(...)	Specifies the pacer (timebase) for a subsequent DMA process.
SetTriggerDMA(...)	Specifies the trigger for a subsequent DMA process.
AcquireDMA(...)	Starts a DMA data acquisition process.
OutputDMA(...)	Starts a DMA data output process.
StopDMA(...)	Stops an ongoing DMA process.
StatusDMA(...)	Returns the status of a DMA process.
DecodeDMA(...)	Decodes one or more clusters of data acquired via DMA.
EncodeDMA(...)	Encodes output data for a subsequent DMA output process.

MacExpedite—DMA Software Extensions

MacExpedite DMA Software Extensions add DMA support capability to *MacAdapt* Software Drivers. It provides an uncomplicated interface between several of the most popular high-level languages and the DMA capabilities of PCI-701C carriers which have been equipped with the PCI-702M *MacPilot* Bus Master/DMA Module. The use of this software greatly reduces the amount of knowledge the programmer must have of the hardware details. Long sequences of bit-oriented, register-specific setup calls are replaced with simple high-level commands. Major features include:

— Adds DMA capabilities to PCI-703S *MacAdapt* Programmer Support Software

— Compatible with most programming languages, running on Mac II, IIx, IIci, IIcx, IIfx computers

— Easy-to-use, high-level commands

— Decreases development time by isolating the programmer from the details of the hardware

LabVIEW 2 Software Drivers

Both *NuCarrier* and *MacPilot* are fully compatible with LabVIEW 2 when used in conjunction with the PCI-706S interface drivers. PCI-706S is a virtual instrument library that provides a transparent interface to the complete LabVIEW 2 programming environment.

The LabVIEW 2 software package requires PCI-706S when it is used with the PCI-701C *NuCarrier*. The LabVIEW 2 package is not available through Burr-Brown sales offices.

SPECIFICATIONS— PCI-701C AND PCI-702M

All specifications are typical at 25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility	DMA, program control, and interrupts	Mac II NuBus Series
I/O Configuration	Compatible with most PCI I/O modules	16/8 (SE/Diff) Ain, 16 DI/O with handshaking, 2 counters, burst generator, plus 2 I/O module positions
Analog Inputs	Expandable with modules	Fully programmable
Number of Channels	Single-ended	16
	Differential	8
Sample Rate, Throughput	PCI-701C hardware limited	
	G = 1, 10	70kHz
	G = 100	48kHz
	G = 200	20kHz
Non DMA[1]	Using PCI-703S, G = 1	To be determined
Non DMA[1]	Using PCI-703S, G = 1, PCI-20031M-1	To be determined
Non DMA[1]	Using PCI-703S, G = 1, PCI-20020M-1	To be determined
Non DMA[1]	Using PCI-703S, G = 1, PCI-20031M-1 and PCI-20020M-1	To be determined
DMA[1]	Using PCI-703S, PCI-704S, G = 1	To be determined
DMA[1]	Using PCI-703S, PCI-704S, G = 1, PCI-20031M-1	To be determined
Input Amplifier	Differential or single-ended inputs	
Gain Ranges	Software selectable	1, 10, 100, 200
Gain Inaccuracy	Trimmable to zero	±0.5LSB
Signal Range	Linear operation	±10V
	Without damage, power on	±35V
	power off	±20V
Settling Time	To 0.01% for a 20V Step	
	Gain = 1, 10	10μsec
	Gain = 100	20μsec
	Gain = 200	40μsec
Mux Settling Time	To 0.01% for a 20V Step	5μsec
Offset Voltage	Trimmable to zero	±0.5LSB
Common Mode Range	$V_{cm} = CM_{range} - (V_{diff} \cdot Gain)/2$	±10V
Rejection Error	60Hz, 100 ohm imbalance, 10V range	
	Gain = 1	0.01LSB/volt (-90dB)
	Gain = 10	0.07LSB/volt (-95dB)
	Gain = 100	0.73LSB/volt (-95dB)
	Gain = 200	1.5LSB/volt (-95dB)
Bias Current		500pA
Input Impedance		10^{10} Ω@75pF
Source Impedance	For 1LSB change at 50kHz sample rate	
Maximum Recommended		5K ohms
Crosstalk	Channel-to-channel at 1kHz, 1K ohm source impedance	0.2LSB (-90dB)
A/D Converter		
Resolution	1 part in 4096	12-bit
Code	Unipolar	Binary, left justified
	Bipolar	Offset binary, left justified
Ranges	Software selectable	0-10V, ±5V, ±10V
Conversion Time		13.5μsec
Acquistion Time, S/H	To 0.01% for a 10V Step	1μsec
Nonlinearity	Total, all sources	±1LSB
Digital I/O[2]		Fully programmable
Number of Ports	8 channels each	2
Handshaking Lines		Separate lines for each port
Signal Levels[3]	Voltage	TTL
I_{in}, High-Level	Input ports	20μA
	Handshake line	1μA
	Counters/external inputs	10μA
Low-Level	Input ports	-200μA
	Handshake line	-1μA
	Counters/external inputs	-10μA
I_{out}, High-Level	Output ports	-15mA
	Handshake line	-2.5mA
	Generator/counters	-8mA
Low-Level	Output ports	24mA
	Handshake lines	2.5mA
	Generator/counters	8mA
Counters	Fully programmable	
Input Type		Schmitt trigger
Number		Two 16-bit or one 32-bit
Clock Rate	Maximum	16MHz
Functions		Event counting; dividing; frequency, period and pulse-width measurement; variable-duty-cycle generation

Note: (1) 68030 at 16MHz/68030 at 25MHz.
(2) All Digital I/O points are programmable as either inputs or outputs in byte-size groups (8 channels each).
(3) All Digital I/O ports are "inputs" at power up. Note that TTL inputs normally "float" high when not terminated (pulled down).

Continued...

SPECIFICATIONS— CONTINUED

PARAMETER	CONDITIONS	SPECIFICATION
Burst Generator	Fully programmable	
Output Frequency		0.002Hz to 2MHz
Resolution		125nS
Stability		0.01%
Output Modes		Continuous and Burst
Interrupt	Fully programmable	Latched
Sources		Module 2 IRQ, module 1 IRQ, burst generator output, external interrupt, counter end of meausrement, DI/O port interrupts (0,1), end of conversion, terminal count (only with PCI-702M)
Power Requirements	From PC's +5V supply (carrier only)	1.75A max
Power Available	To modules, +15V	28mA
	-15V	36mA
Physical Size	Without modules installed	1 Slot
	With I/O module(s) installed	2 Slots (maximum)[1]
Temperature Range	Board surface temperature	0 to 70°C
Connectors (Mating)	Mounted at rear bracket	
	Analog	Amphenol #845C026SALA00
	Digital	Amphenol #845C050SALA00
	Mounted on carrier, intercarrier	Methode #1300-104-422

Note: (1) The width of an installed PCI-701C depends upon the number and position of modules installed.

HARDWARE COMPATIBILITY TABLE— MODULE COMPATIBILITY

MODULE	FUNCTION	NUMBER OF CHANNELS	RESOLUTION	SPEED	CABLE	TERMINATION PANELS	ENCLOSURES
PCI-20023M-1	Analog Input	8	12-bit	180,000Hz	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20341M-1	Analog Input	1/4[1]	16-bit	85,000Hz	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20031M-1	Analog Expansion	32/16[1]		Limited by A/D	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20017M-1	Simultaneous S/H	4/4[1]		10K Frames/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20020M-1	Trigger/Alarm	1		20nS Scatter	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20003M-2	Analog Output	2	12-bit	80,000 Pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20003M-4	Analog Output	2	12-bit	80,000 Pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20006M-2	Analog Output	2	16-bit	80,000 Pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20021M-1B	Analog Output	8	12-bit	2,000 Pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20004M-1	Digital I/O	32		280Kbytes/sec	PCI-20311A-1	PCI-20305T-1	PCI-20308H-1, PCI-20343A-1
PCI-20004M-1	Digital I/O	32		280Kbytes/sec	PCI-20311A-1	PCI-20324T-1	PCI-20308H-1, PCI-20343A-1

Note: (1) Single-Ended/Differential.

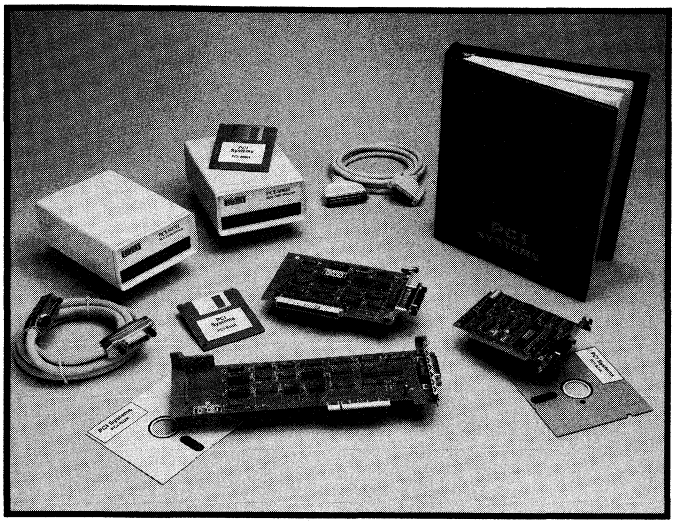
HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS (ON-BOARD CARRIER I/O)

I/O TYPE	TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
Analog Input	PCI-20304T-1	General-purpose	PCI-20008A-1B	PCI-20308H-1 and PCI-20343A-1
	PCI-20304T-2	Thermocouple	PCI-20008A-1B	PCI-20308H-1 and PCI-20343A-1
	PCI-20024T-1	Customizer	PCI-20008A-1B	PCI-20029A-1
	PCI-5B01-1	Signal conditioner[1]	PCI-20008A-1B	PCI-20339A-1
Digital I/O, Counters, and Burst Generator	PCI-20306T-1	General-purpose	PCI-20009A-1B	PCI-20308H-1 and PCI-20343A-1
	PCI-20025T-1	Customizer	PCI-20009A-1B	PCI-20029A-1
	PCI-20325T-1	Signal conditioner	PCI-20009A-1B	PCI-20308H-1 and PCI-20343A-1

Note: (1) The PCI-5B01-1 works in conjunction with the PCI-5B blocks.

For additional information, please refer to the configuration charts in the Summary Section.

BURR-BROWN®



PCI-800 Series

IEEE-488 Interface Products

FEATURES

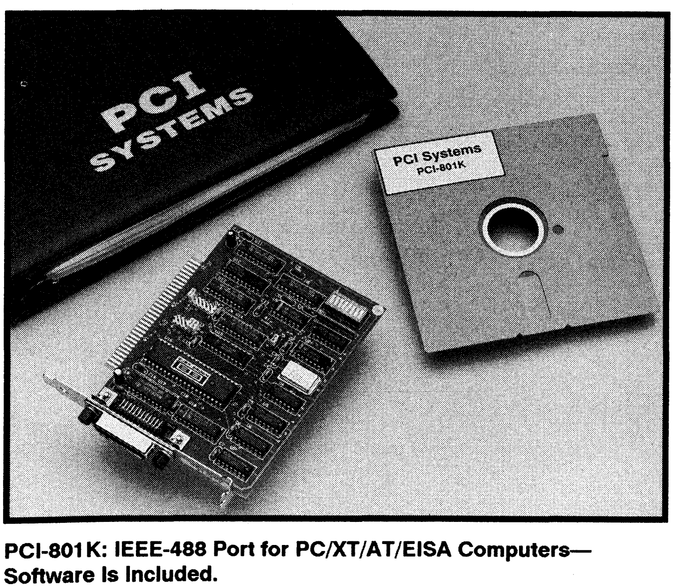
- Adds IEEE-488 (GPIB) Capability to All PC/XT/AT/EISA, Micro Channel and Macintosh Personal Computers
- Interfaces Standard Laboratory Instruments to Your PC
- Internal and External Hardware Options
- Complete Software Available
- High Transfer Rates
- 100% Support for the IEEE-488 Standard (GPIB)

OVERVIEW

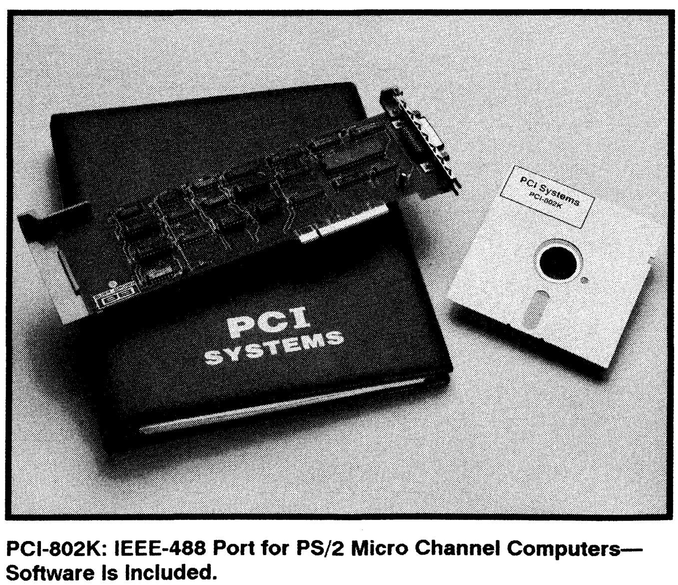
The PCI-800 Series is designed to link the wide range of IEEE-488 compatible laboratory instruments to personal computers. This connection makes possible almost unlimited test, measurement and control applications. Complete hardware and software support is provided for all popular PCs, including the Burr-Brown VIPc and all other PC/XT/AT/EISA compatible machines. For the increasing number of Micro Channel (PS/2) and Macintosh users, specific products for these buses are also included. Three types of interface connections are offered: direct plug-in, SCSI (for the Mac II) and serial (RS-232/RS-422). One hundred percent (100%) support for the IEEE-488 standard is maintained by all hardware and software models.

PCI-801K: IEEE-488 Board with DOS Device Driver for PC/XT/AT/386 and Compatible Computers

The PCI-801K adds IEEE-488 capability to VIPc and other PC/XT/AT/EISA and compatible computers. The kit includes the PCI-803W interface board and PCI/IEEE DOS device driver software. Programming is easy with familiar Hewlett-Packard style commands. All popular graphics and analysis software packages are compatible with these products.



PCI-801K: IEEE-488 Port for PC/XT/AT/EISA Computers—Software Is Included.



PCI-802K: IEEE-488 Port for PS/2 Micro Channel Computers—Software Is Included.

PCI-802K: IEEE-488 Board with DOS Device Driver for PS/2 Micro Channel Computers

The PCI-802K adds IEEE-488 capability to the IBM PS/2 Micro Channel family of personal computers. Compatibility is ensured with DOS and future operating systems through strict adherence to the IBM Micro Channel specification. The kit includes a PCI-804W IEEE interface board and PCI/IEEE DOS device driver software on a 3.5-inch diskette.

The PCI-801K and PCI-802K are complete hardware and software packages for all PC and PS/2 based IEEE-488 control applications. The boards plug directly into an expansion slot inside your PC. They support all instruments, plotters and printers that adhere to the IEEE-488 standard. Comprehensive documentation is supplied to make setup and operation easy to accomplish.

Both boards include the following features:

(1) 100% support for the IEEE-488 standard
(2) Talker, listener, controller, serial poll, parallel poll and SRQ
(3) Controller or peripheral operation, software selectable
(4) Control up to 14 IEEE devices per board

The included software drivers provide:

(1) Built-in support for all popular languages
(2) Direct input to spreadsheet programs such as Lotus 1-2-3
(3) Built-in error checking and error indication
(4) BASIC "ON SRQ GOSUB" capability

PCI-808A is a standard, six-foot, shielded IEEE cable. It is recommended for attaching these boards to another IEEE-488 device.

SPECIFICATIONS— PCI-801K and PCI-802K

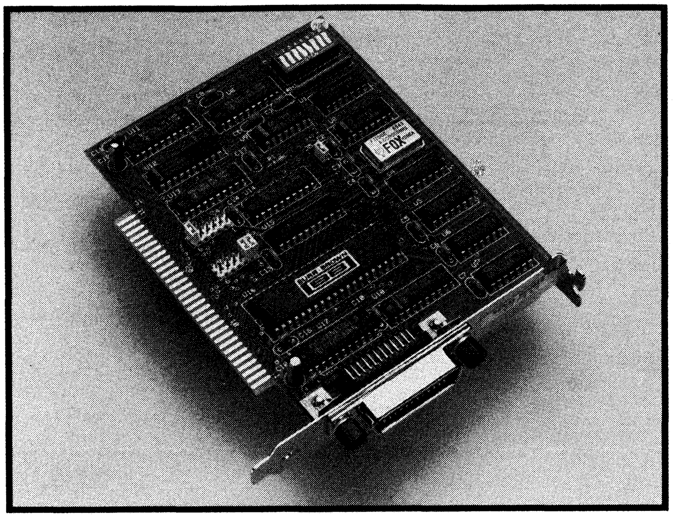
PARAMETER	SPECIFICATION
IEEE Controller Device	NEC 7210
Software	Included
Size PCI-801K PCI-802K	 Occupies one PC-compatible short slot Occupies one Micro Channel slot
Connector	Accepts standard IEEE-488 cable
Maximum Transfer Rate	300Kbytes/sec
Power PCI-801K PCI-802K	 650mA max @ +5V from PC 1A max @ +5V from PS/2

PCI-803W— PC/XT/AT/386 Plug-in Board

The PCI-803W is a short slot plug-in board that provides full IEEE capability for IBM PC/XT/AT/386 and compatibles. It is compatible with LABTECH NOTEBOOK, ASYST, DADiSP and other software that supports the NEC 7210 device. PCI-803W is an economical replacement for other manufacturers' boards, including IOtech, National Instruments and IBM.

PCI-804W— PS/2 Micro Channel Plug-In Board

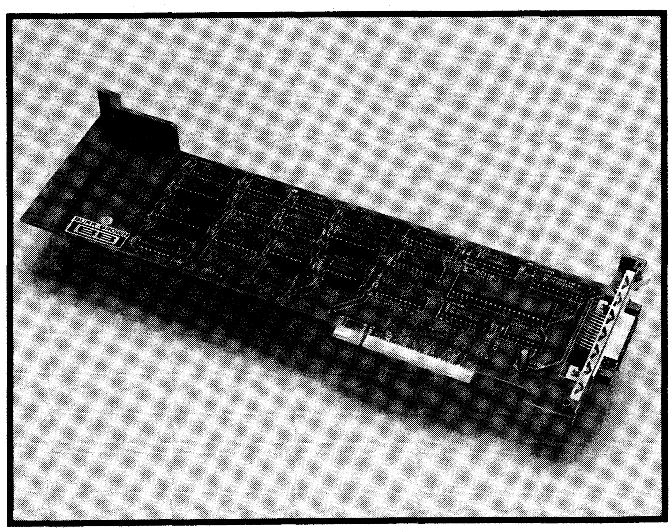
The PCI-804W provides full IEEE capability for the Micro Channel bus in the IBM PS/2 Models 50, 50Z, 60, 70 and 80. It is compatible with LABTECH, ASYST and DADiSP. The board strictly adheres to the IBM Micro Channel specification and has no jumpers or switches to be configured. A menu-driven program is included with the board which guides the user through its installation.



PCI-803W: IEEE-488 Port for PC/XT/AT Computers.

SPECIFICATIONS— PCI-803W

PARAMETER	SPECIFICATION
IEEE Controller Device	NEC 7210
Power Consumption	650 mA max @ +5V from PC supply
Connections	Accepts IEEE-488 connector with metric studs
Maximum Speed	300K bytes/sec
Environment	0 to 35°C; 0 to 70% RH
DMA	Channels 1, 2 or 3, jumper selectable. Multiple boards may share the same DMA channel
Interrupts	Levels 2 through 7, jumper selectable. Multiple boards may share the same interrupt channel
Base I/O Address	02E1 Hex, 22E1 Hex, 42E1 Hex, 62E1 Hex
Wait State Generator	Jumper selectable wait states
Interface Cable	6-foot, shielded (PCI-808A)



PCI-804W: IEEE-488 Port for Micro Channel Computers.

SPECIFICATIONS— PCI-804W

PARAMETER	SPECIFICATION
IEEE Controller Device	NEC 7210
Power Consumption	1A max from PS/2 supply
Connections	Accepts IEEE-488 connector with metric studs
Maximum Speed	300Kbytes/sec
Environment	0 to 35°C; 0 to 70% RH
DMA	Multiple boards may share the same DMA channel
Interrupts	Levels 2 through 7. Multiple boards may share the same interrupt channel
Base I/O Address	02E1 Hex, 22E1 Hex, 42E1 Hex, 62E1 Hex
Wait State Generator	Included
Interface Cable	6-foot, shielded (PCI-808A)

PCI-805K: Mac II IEEE-488 Controller

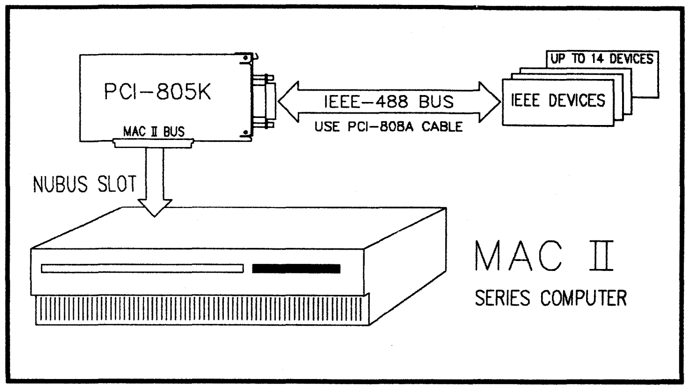
PCI-805K provides high-speed IEEE-488 control for the Macintosh II family of computers. The board installs into any of the standard NuBus slots in the Mac II and allows connection of up to 14 IEEE devices. The board design allows direct connection of IEEE devices using standard IEEE cables without requiring special adapters. High-speed circuitry provides data transfer rates of over 600K bytes per second.

PCI-805K is provided with an installable driver that provides IEEE control for most popular Macintosh languages. The driver provides a comprehensive set of high-level as well as low-level commands for accessing IEEE devices. The high-level commands are consistent with the popular Hewlett-Packard style.

Also included is a Macintosh desk accessory which provides IEEE control and data collection from any environment, including Microsoft Works, Excel and Parameter Manager Plus. This software is accessed in the same manner as other Macintosh desk accessories by selecting the Apple icon. Data collected is first stored on the clipboard or saved to disk and then imported directly into an application program.

SPECIFICATIONS—PCI-805K

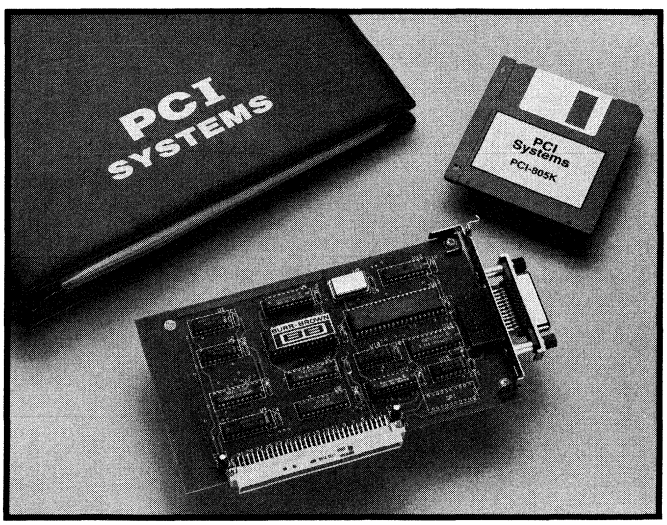
PARAMETER	SPECIFICATION
Compatibility	Mac II, IIx, or IIcx with Finder 6.0 or later
IEEE Controller Device	NEC 7210
Power Comsumption	850 mA max (+5V)
Dimensions	Occupies one Mac II NuBus slot
Connections	Accepts standard IEEE cables
Maximum Speed	600Kbytes/sec
Interrupts	NMRQ supported
Controller Subsets	C!, C2, C3, C4 and C10 of IEEE-488-1979
Interface Cable	6-foot, shielded (PCI-808A)



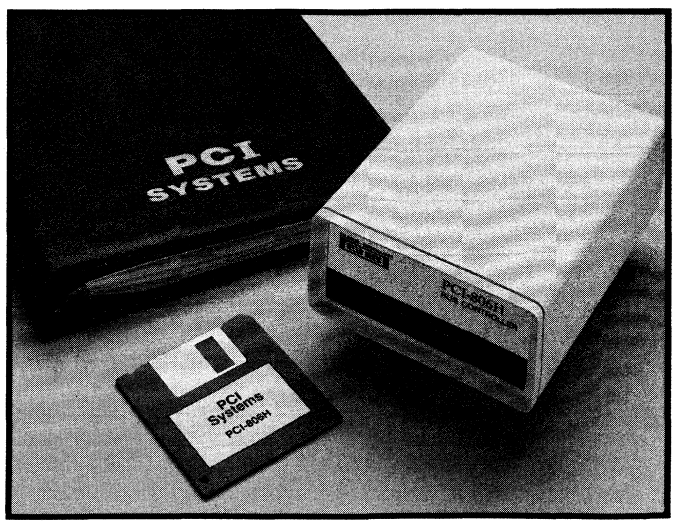
PCI-805K Interconnection Diagram.

PCI-806H: Mac/SCSI IEEE-488 Controller

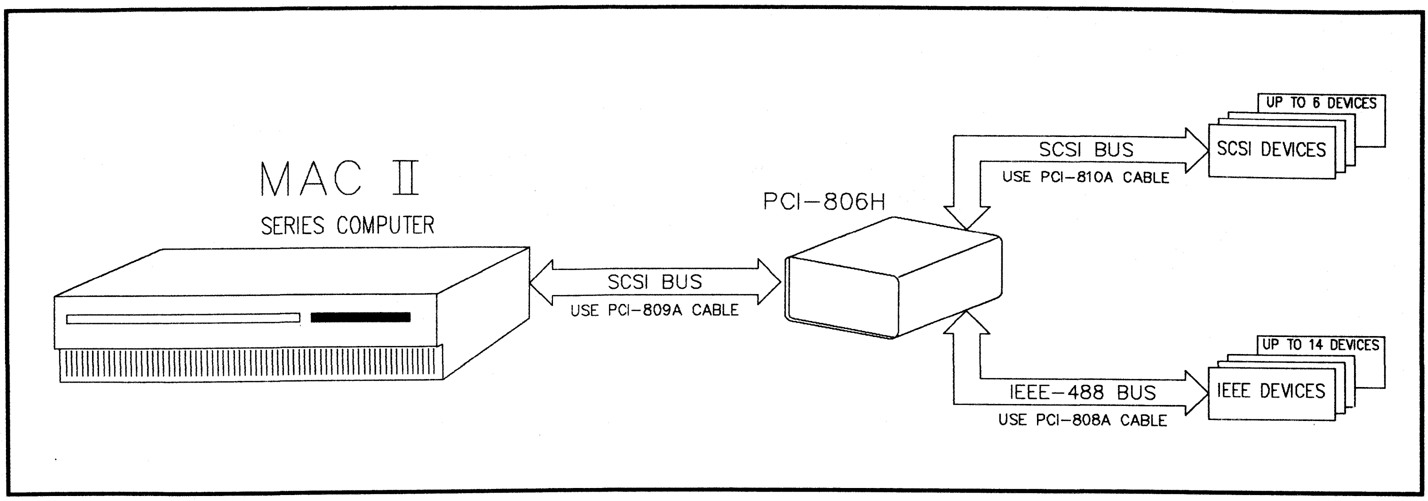
PCI-806H provides high-speed IEEE control for the complete line of Macintosh computers with a SCSI (Small Computer System Interface) port. The interface attaches to the SCSI port of the Macintosh in the same manner as an external SCSI disk drive. PCI-806H can be connected to the Macintosh SCSI port along with disk drives or other interfaces. Full IEEE functionality is provided, including control of up to 14 IEEE instruments, plotters and peripherals.



PCI-805K: IEEE-488 Port for Mac II Computers— Software Is Included.



PCI-806H: IEEE-488 Port for Mac II SCSI Bus.



Interconnection Diagram for PCI-806H, IEEE-488 to Mac II/SCSI.

SPECIFICATIONS—PCI-806H

PARAMETER	SPECIFICATION
Indicators	LEDs for IEEE Talk, IEEE Listen, IEEE SRQ, SCSI Send, SCSI Receive, Error, and Power
Weight	2.5 lbs. (1.1Kg.)
Dimensions	7.5" x 5.4" x 2.7" (190mm x 138mm x 68mm)
Power	105-125 or 205-250VAC 50-60 Hz 10VA max
Environment	0 to 50°C, 0 to 70% RH
System Requirements	
Macintosh	512K, Plus, SE, SE/30, II, IIx, IIcx or IIfx with Finder 6.0 or later
IEEE-488 Interface	
IEEE-488 Implementation	SH1, AH1, TE0, LE0, SR1, PPO, DC1, RL0, C0, E1
Controller Subsets	C1, C2, C3, C4, and C10
Connector	Standard IEEE-488 connector with metric studs
SCSI Interface	
SCSI Implementation	Asychronous data transfers, parity generation and checking, processor device, compliance with X3T9.2
Termination	Built-in, may be removed for chaining on the SCSI bus
Drivers/Receivers	Single-ended
Connector	50 pin shielded, ribbon contact (alternative 2 in X3T9.2)
Data Transfer Rate	Mac SE— 600Kbytes/second Mac II— 800Kbytes/second
Cables	
PCI-808A	6-foot shielded IEEE
PCI-809A	6-foot PCI-806H to Mac Plus, Mac SE and Mac II
PCI-810A	6-foot PCI-806H to standard SCSI (attaches to external SCSI drive)

Since it attaches to the external SCSI port on the Macintosh, the PCI-806H requires no disassembly of your computer to install. Residing external to the Macintosh, it does not consume valuable Macintosh expansion slots. The wide acceptance of the SCSI interface as an Apple and industry standard assures compatibility with future Macintosh computers.

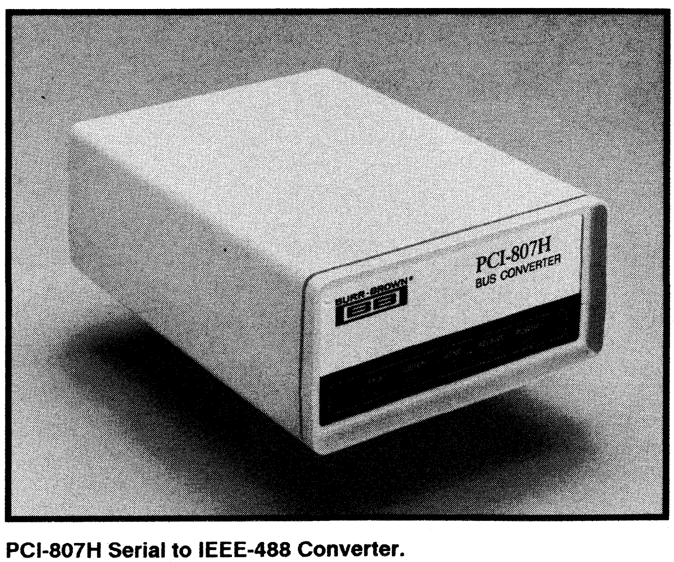
The PCI-806H supports data transfers of over 600Kbytes-per-second on the Macintosh SE, and over 800Kbytes-per-second on the Mac II.

An installable driver provides IEEE control for popular Macintosh languages. The driver provides a comprehensive set of high-level as well as low-level commands for accessing IEEE devices. These include support for Microsoft BASIC 3.0, MPW Pascal, TURBO PASCAL, MPW C, Lightspeed C, Hypercard and many more.

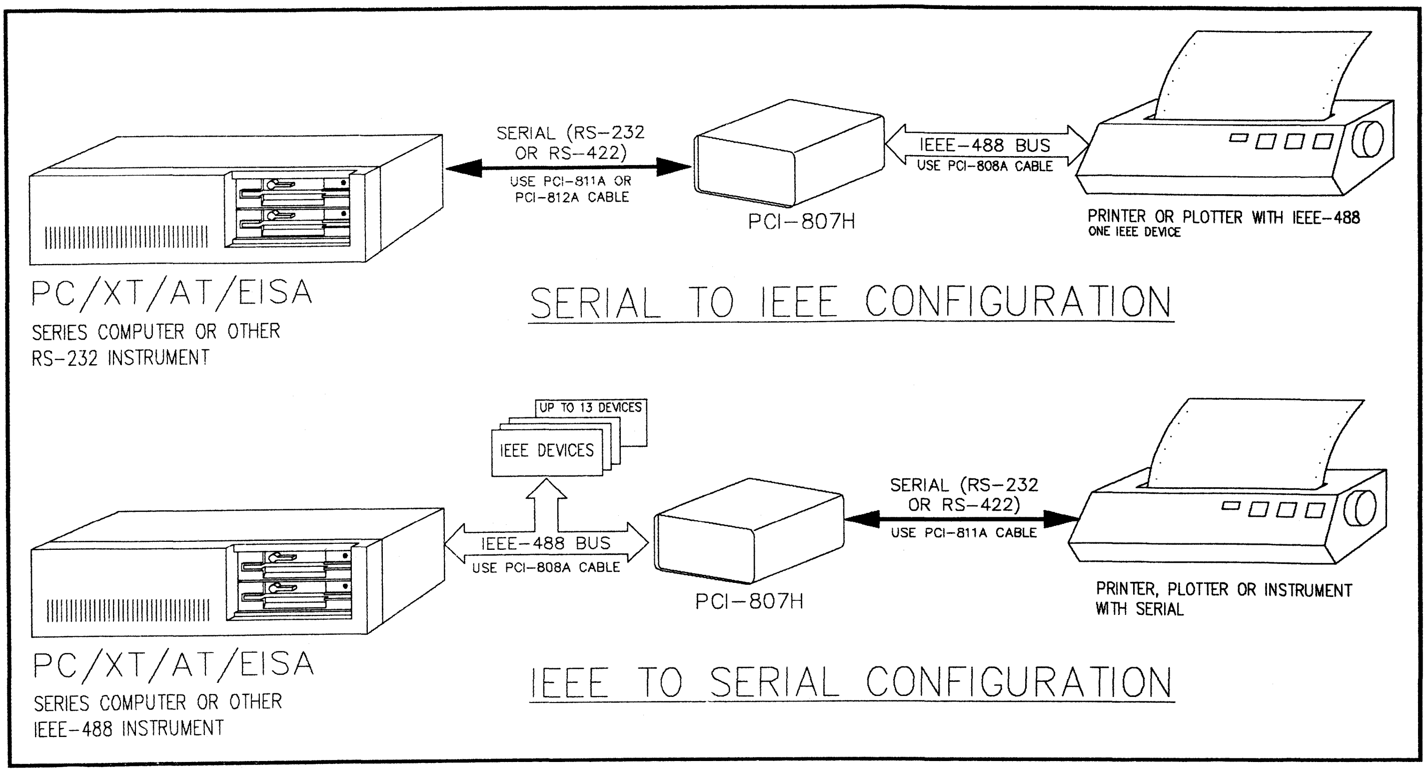
Also included is a Macintosh desk accessory that provides IEEE control and data collection from any environment, including Microsoft Works, Excel, WorkBench, LABTECH NOTEBOOK and Parameter Manager Plus. This software is accessed in the same manner as other Macintosh desk accessories by selecting the Apple icon. Data collected is first stored on the Clipboard and can be saved in a disk file or imported directly into an application.

PCI-807H—Serial/IEEE-488 Converter

The PCI-807H is a transparent interface between RS-232/RS-422 and IEEE-488 devices. An IEEE controller can communicate with an RS-232 printer or plotter via the PCI-807H. Conversely, the PCI-807H will enable a computer's RS-232 port to communicate with an IEEE printer or plotter. Built into the converter is a 32,000 character data buffer that frees the computer while slow devices are accepting data.



PCI-807H Serial to IEEE-488 Converter.



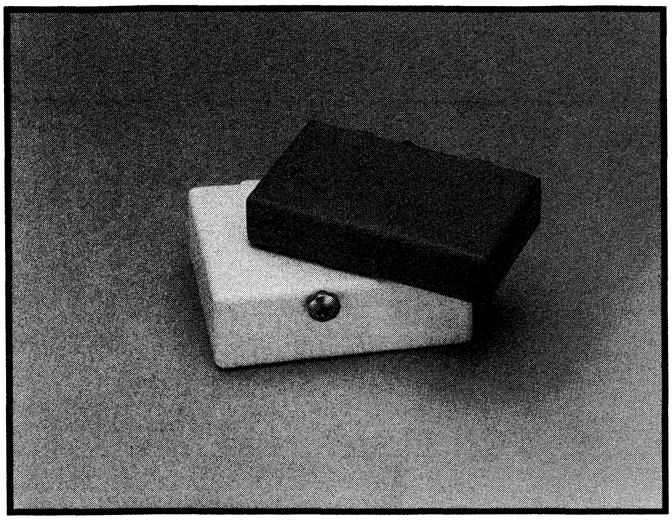
Interconnection Diagram for PCI-807H, Serial to IEEE-488 or IEEE-488 to Serial Devices.

SPECIFICATIONS— PCI-807H

All parameters are switch selectable.

PARAMETER	SPECIFICATION
Electrical Characteristics	Supports RS-232 or RS-422
Duplex	Full with echo/no-echo
Data Bits	7 or 8
Stop Bits	1 or 2
Parity	On transmit; odd, even, mark, space or disabled
Baud Rates	110, 300, 600, 1200, 1800, 2400, 3600, 4800, 7200, 9600, 19,200 and 57,600
Terminator	CR, LF, CR-LF or LF-CR
Control	Supports Clear To Send (CTS), Request To Send (RTS) or XON/XOFF
Connector (RS-232)	Accepts 25-Pin Sub-D male: DCE configured
IEEE-488 Interface	
Terminator	Software selectable CR, LF, CR-LF, LF-CR and/or EOI
Connector	Standard IEEE-488 connector with metric studs
General	
Data Buffer	32,000 characters
Indicators	LEDs for talk, listen, send, receive and power
Power	105-125V or 210-250V, 50, 60 Hz; 10 VA Max
Environment	0 to 35°C; 0 to 70% RH
Dimensions	7.5″ x 5.4″ x 2.7″ (190mm x 138mm x 68mm)
Weight	1.1 kg (2.5 lbs.)
Controls	Power switch (rear panel) Internal DIP switches for serial and IEEE parameters
Cables	
PCI-808A	6-foot shielded IEEE cable
PCI-811A	6-foot RS-232 cable (compatible with 9 pin IBM AT)
PCI-812A	6-foot RS-232 cable (compatible with 25 pin IBM PC)

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-1100 Series

Opto-Isolation Blocks

Standard: PCI-1101 through PCI-1106
Slimline: PCI-1107 through PCI-1112

FEATURES

- 4000 Volt Input/Output and Input/Input Isolation
- Convert a Wide Range of Voltages to TTL Levels
- Switch up to 60VDC and 240VAC at 3A
- Plug-in Compatible with PCI-20018T-1, PCI-20048T-1, and PCI-20324T-1 through PCI-20326T-1 Termination Panels

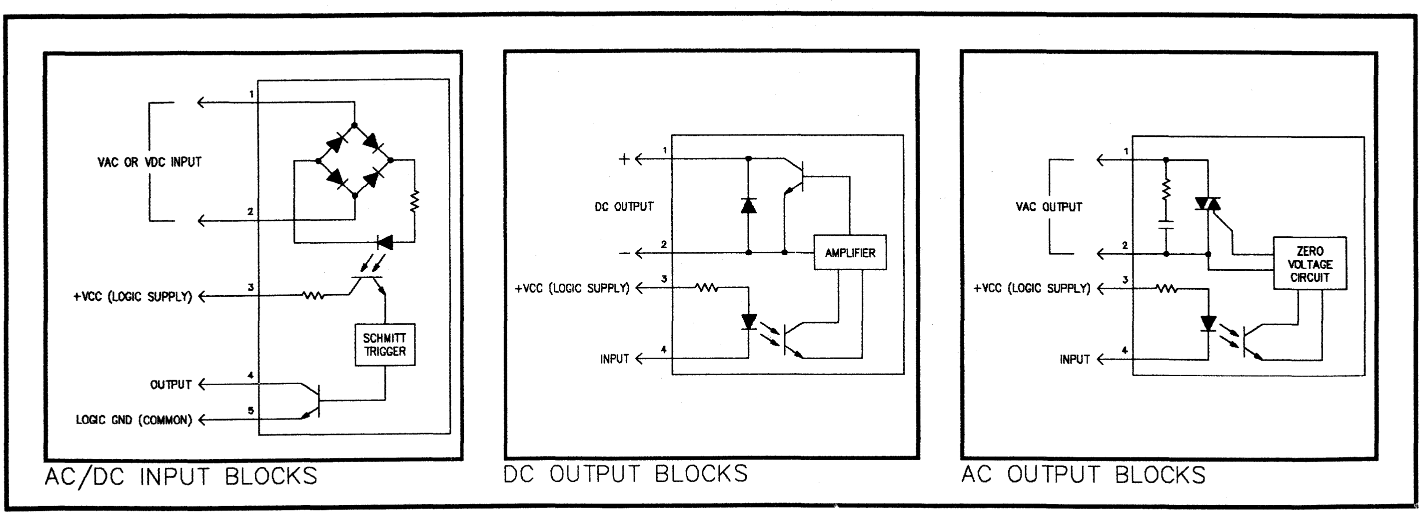
DESCRIPTION

The PCI-1100 Series are digital, optically isolated, signal conditioning blocks. A separate opto-block is used for each channel, allowing complete I/O flexibility. The twelve different opto-blocks are divided into two groups: standard and slimline. The standard models, PCI-1101 through PCI-1106, are intended for use with the PCI-20018T-1 and the PCI-20048T-1 termination panels. The slimline models, PCI-1107 through PCI-1112, are intended for use with the PCI-20324T-1, PCI-20325T-1, and the PCI-20326T-1 Euro-Style termination panels. While the electrical specifications of the standard and slimline opto-blocks are the same, their mechanical hold-down mechanisms are different. To avoid possible mechanical damage and thermal limitations, it is recommended that the individual opto-blocks be used only with the listed panels.

All input models (PCI-1101, PCI-1102, PCI-1105, PCI-1107, PCI-1108, and PCI-1111) accept both AC and DC voltages. Each provides a TTL output to drive a standard PCI digital input. Different models are provided for AC and DC outputs. These units convert TTL outputs from the PCI system to switch higher voltage (and current) load. The DC output devices (PCI-1103 and PCI-1109) present an open collector NPN transistor to the load. The AC output units (PCI-1104, PCI-1106, PCI-1110, and PCI-1112) contain zero crossing circuitry and switch their loads with triacs.

Various combinations of the available opto-blocks can be intermixed on one termination panel. However, each contiguous group of eight channels (starting with channel 0) must contain only input or output opto-blocks. This is because the digital channels on PCI carriers, modules, and boards are programmable as inputs or outputs in byte-size (8 channels) units.

The PCI-1100 Series opto-blocks, when used with the recommended termination panels and cables, are fully compatible with all PCI board, carriers, and modules. Please refer to the following tables for compatibility information.

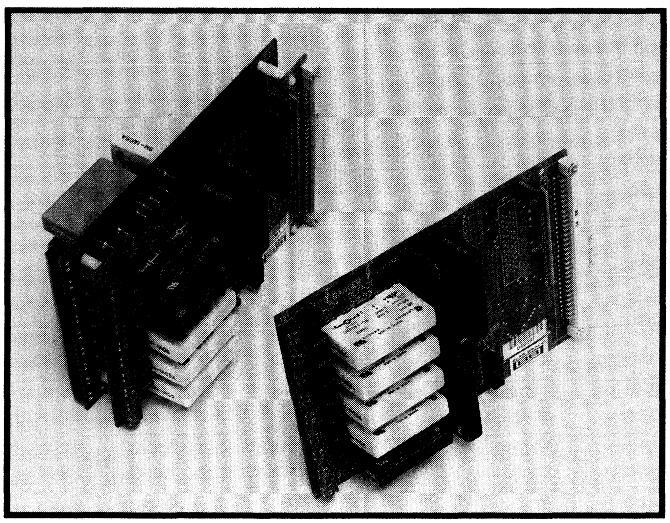


Digital I/O Opto-Isolation Blocks— PCI-1100 Series.

SPECIFICATIONS— PCI-1100 SERIES OPTO-ISOLATION BLOCKS

All specifications are typical at +25°C unless outherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Isolation	Input to output	4000V
Temperature Range	Case temperature	-30 to 70°C
PCI-1101/1107	AC or DC input	1 channel
Input, On	AC Input	15-32V/12-30mA
	DC Input	10-32V/8-30mA
Off	AC or DC input	3V/1mA
Output Levels		TTL
Switching Time	Turn-on/turn-off	5mS/5mS max
PCI-1102/1108	AC or DC input	1 channel
Input, On	AC or DC input	90-140V/6-10mA
Off	AC or DC input	45V/3mA
Output Levels		TTL
Switching Time	Turn-on/turn-off	20mS/20mS max
PCI-1103/1109	DC output	1 channel
Load Range	@ 45°C	5-60V/3A
Minimum Load Current		20mA
Voltage Drop	Across output transistor	1.6V max
Off Leakage	@ 60V	1mA
Switching Time	Turn-on/turn-off	100μS/750μS
PCI-1104/1110	AC output	1 channel
Load Range	@ 45°C	12-140V/3A
Minimum Load Current		20mA
Voltage Drop	Across output triac	1.6V max
Off Leakage	@ 120V, 60Hz	5mA
Input Levels		TTL
Frequency Range		25-65Hz
Switching Time	Turn-on/turn-off	1/2 cycle max
PCI-1105/1111	AC or DC input	1 channel
Input, On	AC or DC input	180-280V/4-7mA
Off	AC or DC input	80V/1mA
Output Levels		TTL
Switching Time	Turn-on/turn-off	20mS/20mS max
PCI-1106/1112	AC output	1 channel
Load Range	@ 45°C	24-280V/3A
Minimum Load Current		20mA
Voltage Drop	Across output triac	1.6V max
Off Leakage	@ 120V, 60Hz	5mA
Input Levels		TTL
Frequency Range		25-65Hz
Switching Time	Turn-on/turn-off	1/2 cycle max



PCI-20324T-1 Through PCI-20327T-1 Euro-Style Panels Support Digital Signal Conditioning.

HARDWARE COMPATIBILITY TABLE— PCI-1101 THROUGH PCI-1106 (STANDARD)

(The PCI-1101 thru PCI-1106 Opto-Blocks can be used in conjunction with the following hardware products.)

PCI MODEL NUMBER	DESCRIPTION	NUMBER OF CHANNELS	ENCLOSURE	CABLES	CARRIERS	MODULES1	BOARDS
PCI-20018T-1	DI/O Signal Conditioning Panel	8	PCI-20029A-1	PCI-20013A-1, PCI-20013A-2	PCI-20001C-2A, PCI-20041C-2A, and PCI-20041C-3A	PCI-20004M	PCI-20087W3
PCI-20048T-1	DI/O Signal Conditioning Panel	16	PCI-20329A-1	PCI-20013A-1, PCI-20013A-2	PCI-20001C-2A, PCI-20041C-2A, and PCI-20041C-3A[2]	PCI-20004M[2]	PCI-20087W[3]

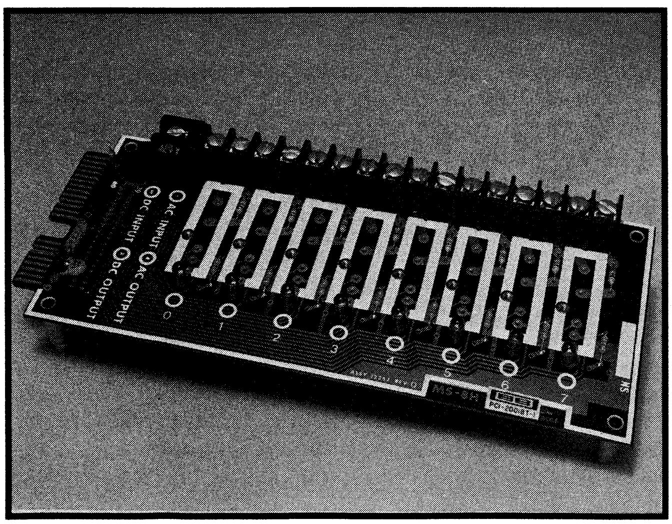
Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) Up to two PCI-20048T-1 termination panels and cables (32 channels) may be used with these carriers/modules.
(3) Up to two PCI-20048T-1 and one PCI-20018T-1 termination panels and cables (40 channels) may be used with these carriers/modules.

HARDWARE COMPATIBILITY TABLE— PCI-1107 THROUGH PCI-1112 (SLIMLINE)

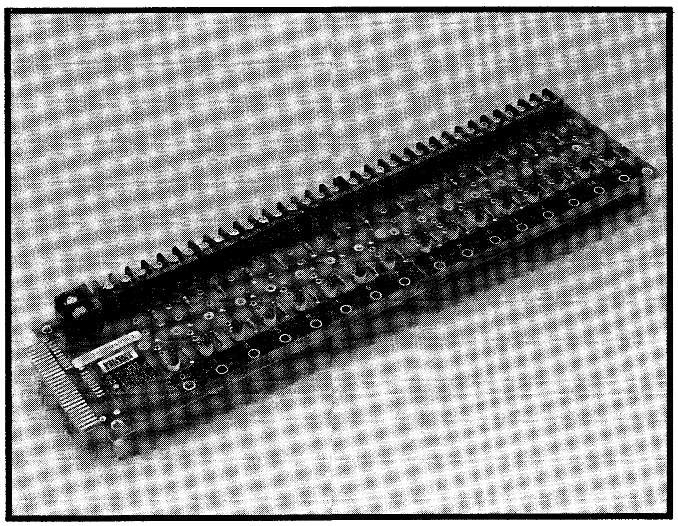
(The PCI-1107 thru PCI-1112 Opto-Blocks can be used in conjunction with the following hardware products.)

PCI MODEL NUMBER	DESCRIPTION	NUMBER OF CHANNELS	ENCLOSURE	CABLES	CARRIERS[1]	MODULES[1]	BOARDS[1]
PCI-20324T-1	Euro-Style DI/O Signal Conditioning Panel	8	PCI-20308H-1, 343A-1	PCI-20311A-1	PCI-20001C, 41C	PCI-20004M	PCI-20087W
PCI-20325T-1	Euro-Style DI/O Signal Conditioning Panel	8	PCI-20308H-1, 343A-1	PCI-20009A-1B	PCI-20098C, 701C		PCI-601W/602W
PCI-20326T-1	Euro-Style DI/O Expansion Panel[2]	16 Total					

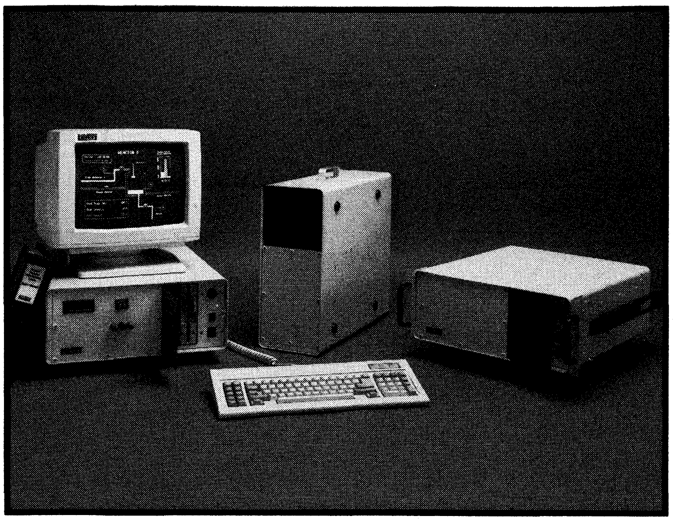
Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) The PCI-20326T-1 is used to add eight (8) additional channels to either the PCI-20324T-1 or the PCI-20325T-1 panels.



PCI-20018T-1 8-Channel Digital Signal Conditioning Panel.



PCI-20048T-1 16-Channel Digital Signal Conditioning Panel.



BURR-BROWN®

PCI-5000 Series

VIPc™ The Versatile Platform for PC-Based Applications

FEATURES

Much More Than a PC...

- A Total System for Product Investigation, Development, Testing, Prototyping, and Manufacturing
- Includes an IBM PC/XT/AT Compatible CPU
- Specifically Designed for Data Acquisition, Test, Measurement, Control, and Other Instrumentation Applications
- Internal, EMI-Shielded, Euro-Style Cage for Signal Conditioning
- Enclosure is Easily Customized to Suit Unique Requirements
- Ideal for OEM, VAR, System Integrator, and In-House Product Fabrication Applications
- Adaptable to Table, Rack, Wall, and Portable Configurations
- FCC (Class A) and VDE (Class B) Compliance
- Listed to UL478 and Certified to CSA C22.2
- Conforms to the Requirements of IEC950

DESCRIPTION

The Burr-Brown VIPc has something for everyone. It is an "embeddable" personal computer, an elastic computer... a computer to be molded into a final form. It can be the foundation for a system or part of a larger system. Certainly it has the features of a powerful PC/XT/AT/EISA-class machine; disk drives, EGA graphics, keyboard, communications ports, etc. But that is only the beginning. VIPc is more than a PC. Much more!

VIPc is an industrial-grade computer. The disk drives are shock-mounted and protected from dust by a door and filtered, positive pressure air. Mounting options allow for installation in a standard 19-inch equipment rack, on a desk, under a factory conveyer, or on a wall. VIPc can be a transportable workstation. With its removable carrying handle it can be carried on most airlines. Weight is less than 30 pounds (13.6kg).

VIPc is an adaptable intelligent instrumentation platform. Up to four PCI-20000 data acquisition and control boards can plug directly into the available PC/XT/AT expansion slots. It contains an internal shielded card cage that can hold up to 10 signal conditioning and field wiring Euro-Style termination panels.

VIPc is a hardware prototyping shell. The platform lets you embed the power of a computer directly into your system, product or application. The front faceplate, back faceplate, and the top cover can be easily removed and customized. Switches, indicators, an alphanumeric display, and connectors can be installed. There is also room for a Burr-Brown microterminal. Two different models including cutout faceplates and mounting hardware are available. In addition to termination panels, the built-in card cage can hold 3U-size VME boards, or it can be removed completely and replaced with something else... a small printer, magnetic card reader, custom circuitry--whatever might be appropriate for your application.

VIPc is a tool. Think of it as a standard component, destined to be transformed into something new, exciting, and different. It is the skeleton of your computer-based system design. It supports you through the classic three-step transformation process that includes development, design prototyping, and the refined end-product. VIPc will be what you make it--a laboratory data acquisition system, automotive engine analyzer, factory- floor programmable controller, weather-trend data logger, specialized point-of-sale terminal, production-line test. VIPc does the job. It keeps cost low and shortens development time. VIPc gives you options and keeps you in command.

VIPc Hardware System

VIPc is designed as a universal "platform" for user defined computer-based products. Its combination of features make it particularly well suited to applications with "real-world" signal interfaces. Standard VIPc system configurations are summarized at the end of this section. The many capabilities of VIPc can be divided into three general categories: Basic Features, Customer Modifiable Features, and Additional Options.

Basic Features

VIPc integrates an adaptable rack-mountable enclosure, an internal Euro-Style card cage, and a fully compatible IBM PC/XT/AT- class computer. The computer's 80286 microprocessor can be set with software to operate at either 6.25 or 12.5 megahertz. Therefore, VIPc is suitable for use with all software products intended for the MS-DOS environment. VIPc can be used in desk- top, rack-mount, wall-mount, under-shelf or vertical-tower configurations. Four brackets are supplied for horizontal and vertical mounting. It's lightweight (30 pounds, 13.6kg) and the included carrying handle makes VIPc a natural for transportable apparatus. An enhanced, AT-style keyboard (101 key) with twelve function keys plus a separate numeric keypad is included. The width of the keyboard permits rack shelf installation.

The rugged motherboard contains all essential PC functions, including RAM, a graphics adaptor, a disk controller, serial and parallel ports, and a real-time clock/calendar with battery backup. Standard monochrome, Hercules, CGA, and EGA compatible monitors can be used. External communications is supported with two serial ports (RS-232 type), a parallel printer port and four PC/AT bus expansion slots (three 16-bit and one 8-bit) that accept a wide range of analog and digital I/O products. The disk drive controller can support two ANSI type floppy disk drives (5 1/4-inch or 3 1/2-inch), and up to two hard disk drives, in any combination.

Real-world connections and signal conditioning are accommodated with optional termination panels that can be housed within VIPc's card cage. VIPc is well-suited for use worldwide. Its 110-watt power supply automatically accepts AC inputs of 85 to 264 volts at 47 to 440 Hertz.

The rugged enclosure provides shock-mountings for the disk drives, has removable rubber feet on the bottom and both sides, and is fully shielded. A rear-mounted 30cfm (850 liters per minute) fan maintains positive pressure inside the unit and cooling for the power supply and other internal components. Incoming air is screened by a washable, open cell, polyurethane filter. Two disk-drive cages can be installed with up to four total drives. Each can hold either one full-height or two half-height units. One cage has front-access, making it suitable for either floppy or hard drives. The additional internal cage is for mounting hard disks only. For convenience, a front panel keyboard lock, reset switch, and power-indicator LED are also provided. VIPc incorporates a removable hinged plexiglas door over the front-access drives and the control panel. This offers protection from dust, dirt, and accidental tampering. The exterior of the enclosure is painted with a thorough polyurethane coating that has exceptional chemical, abrasion, and corrosion resistance.

Customer Modifiable Features

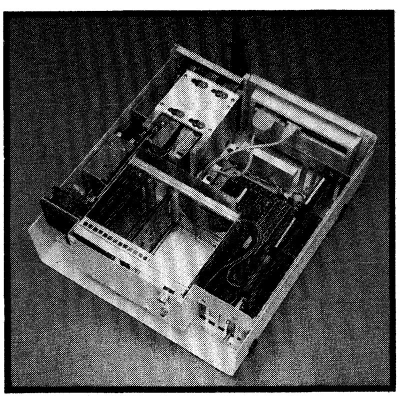
VIPc is housed in an easily adaptable enclosure. Many of its panels and internal spaces are specifically designed for user customization. Its "elastic" character readily conforms to your application. Both of the faceplates and the top cover can be easily removed, drilled, punched, or painted as needed. For example, an external monitor or other equipment can be directly fastened to the cover. There is even sufficient room behind the front faceplate to permit devices (e.g., connectors, switches, keypad, microterminal, LCD display, etc.) to be installed internally. Likewise, the rear faceplate can also accommodate connectors and other devices. Signal wiring from the panel is easily routed to the card cage and other internal circuitry. When using short I/O boards, the PC-Bus card-guide bracket (located behind the front panel) can be removed, freeing additional space.

The shielded card cage can house up to 10 3U-size Euro-Style termination panels, VME boards, or custom electronics. Seven different, optional, termination panels facilitate field-wiring and signal conditioning. The card cage is positioned so that available cables can be passed directly to an installed PCI input/output board. All cables are shielded to reduce noise pickup and radiation. Up to 160 channels can be accommodated with just internal termination panels. Each panel is securely held in place by finger-operated card locks. If not needed, the card cage can be removed, leaving its mounting pan. This pan is another ideal place for installing special equipment.

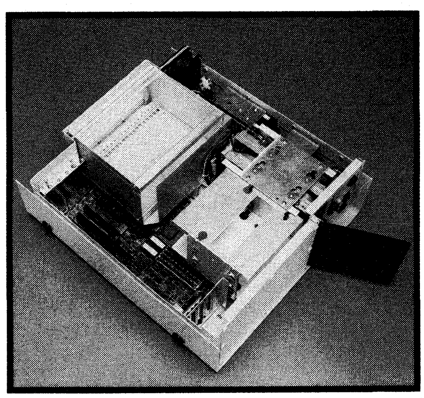
The parallel port connector, serial port connectors, and monitor connector are located on standard PC-slot brackets. Other connectors can be substituted as required by a specific application.

Additional Options

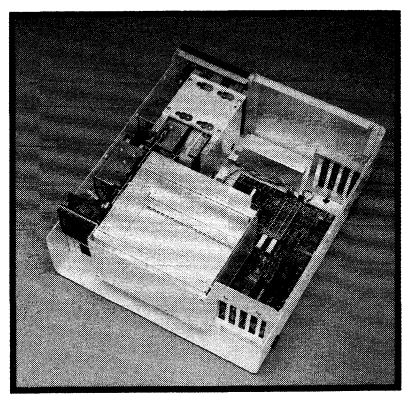
The PCI family includes many products designed to extend VIPc's capabilities. Each is available separately from Burr-Brown. They include I/O boards, carriers, and modules; termination panels; cables; an internal disk drive cage for installation of a third and fourth disk drive; rack-mount slides; and extensive software for a wide range of data acquisition, test, measurement, instrumentation, control, and analysis functions. Initial VIPc installations can be upgraded with a hard disk or monitor. The motherboard supports a coprocessor for faster math-intensive calculations and up to 4Mbytes of RAM.



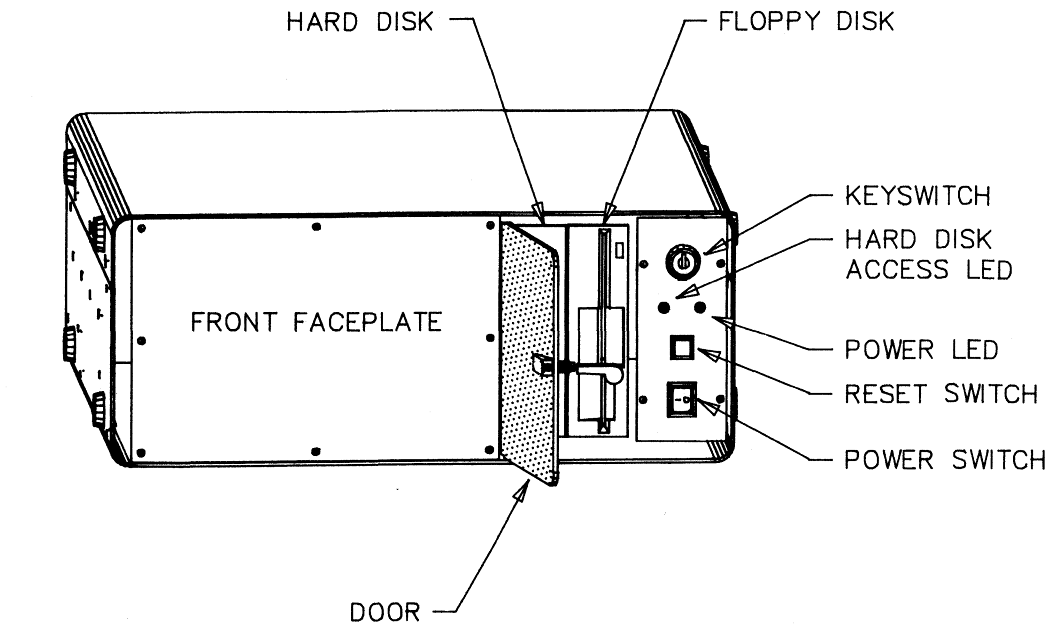
A custom application of VIPc with an I/O board, a microterminal, and Euro-Style termination panels installed. Note rear faceplate signal connectors.

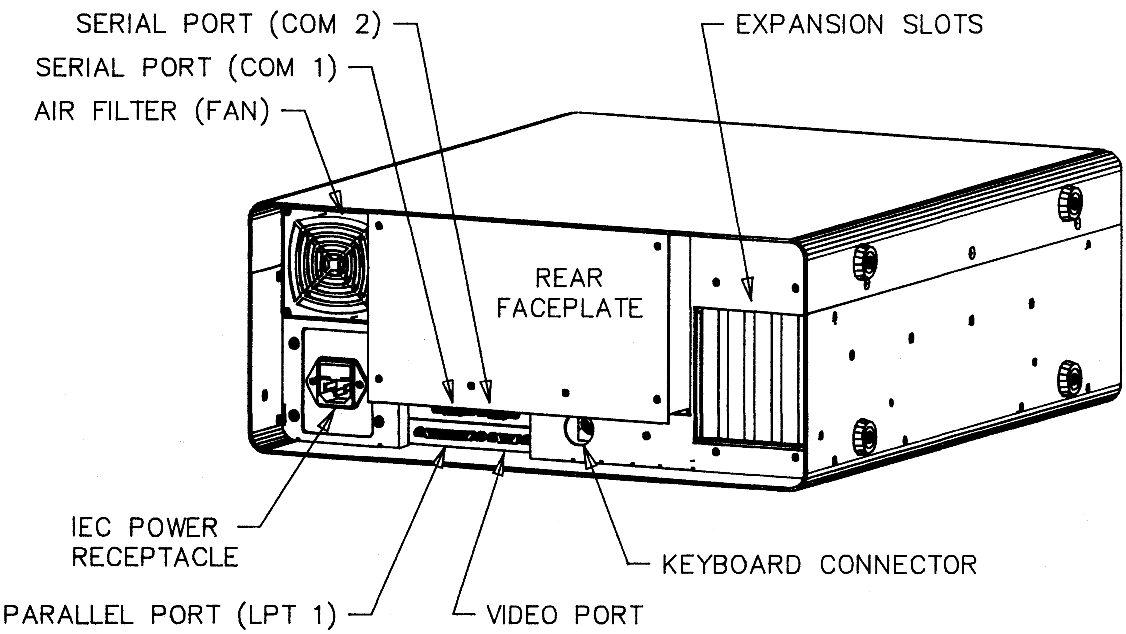


Front view showing "secondary" internal disk drive cage installed.

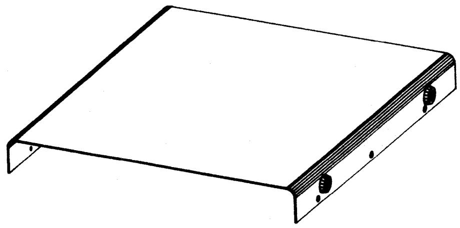


Rear view showing major user customizable cavities and panels: rear and front faceplates, Euro-Style card cage, I/O bus expansion space, and additional disk cage area.



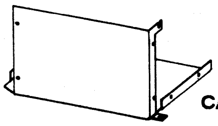


Front and Rear View of VIPc Showing Major Features.



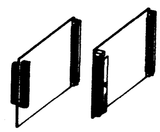
TOP COVER

Easily removed, can be customized to accept special application specific components (printer, display, etc.).



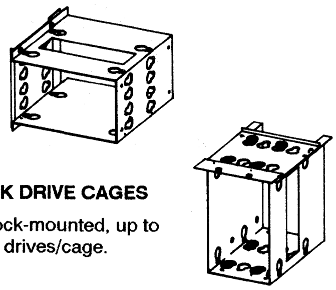
CARD CAGE MOUNTING PAN

Can be customized for other hardware mounting applications.



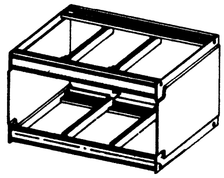
TERMINATION AND SIGNAL CONDITIONING PANELS

For analog, digital and counter/timer applications.
Space for user defined components and networks.



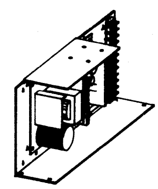
DISK DRIVE CAGES

Shock-mounted, up to two drives/cage.



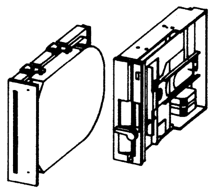
EURO-STYLE CARD CAGE

Provides internal mounting space for termination and signal conditioning panels.



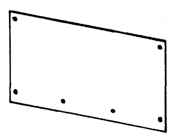
WORLDWIDE AC POWER SUPPLY

85 to 264 volt input.
Front panel switch and indicator.



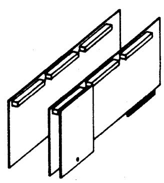
DISK DRIVE OPTIONS

Hard and floppy drives in several sizes.



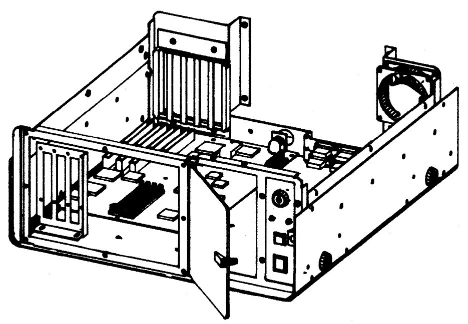
CUSTOMIZABLE PANEL

Rear faceplate is easily modified.
Mount switches, indicators, connectors, etc.



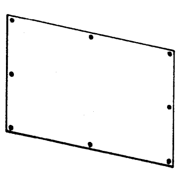
REAL-WORLD INPUT/OUTPUT

Analog, digital and counter/timer/generator interfaces are supported by the PCI-20000 Family of I/O boards, carriers and modules.



BASE UNIT—
PC/AT COMPATIBLE COMPUTER PLATFORM

RAM, graphics adaptor, communications ports, disk controller, 4 expansion slots, real-time clock and coprocessor socket are included.



CUSTOMIZABLE PANEL

Front faceplate is easily modified.
Mount keyboard, switches, indicators, connectors, etc.

The VIPc System.

TABLE 1. VIPc COMPATIBLE I/O PRODUCTS

FUNCTION	PCI MODEL NUMBERS[1]		
	BOARDS	CARRIERS[2]	MODULES
Analog Input General-purpose High-speed	PCI-20089W PCI-20091W	PCI-20098C	PCI-20002M PCI-20019M, PCI-20023M, PCI-20341M
Analog Input Expander			PCI-20031M
Analog Output 12-Bit 16-Bit	PCI-20093W		PCI-20003M PCI-20006M
Trigger/Alarm			PCI-20020M
Simultaneous Sample/Hold			PCI-20017M
Digital I/O	PCI-20087W	PCI-20001C, PCI-20041C, PCI-20098C	PCI-20004M
Counter/Timer		PCI-20098C	PCI-20007M
Intelligent Coprocessor *Smart* Carrier		PCI-20202C	PCI-20201M

Notes: (1) When part numbers are shown without "dash" numbers, all versions apply.
(2) Carriers can perform any function when the correct modules are installed. The model numbers shown in this column have the referenced on-board functions.

TERMINATION COMPONENTS

A wide variety of compatible termination panels and cables are available for use with VIPc. These Euro-Style panels install directly inside the integrated card cage. Up to 10 panels can fit. For guidelines on the space requirement of each panel, please refer to the PCI-20308H-1 data sheet. Please refer to the following table for additional general information.

EURO-STYLE TERMINATION PANEL COMPATIBILITY TABLE[1]

TERMINATION PANELS	TYPE	CABLES	CABLE LENGTH[4]	CARRIERS	MODULES	BOARDS[5]
PCI-20303T-1	Analog I/O	PCI-20310A-2 PCI-20310A-3	1.5 ft (0.46m) 3 ft (0.91m)	See Note 2	PCI-20002M, 3M, 6M, 17M, 19M, 20M, 21M, 23M, 31M, 341M	PCI-20089W, 91W, 93W
PCI-20303T-2	Thermocouple[3]	PCI-20310A-2 PCI-20310A-3	1.5 ft (0.46m) 3 ft (0.91m)	See Note 2	PCI-20002M, 31M	PCI-20089W
PCI-20304T-1	Analog In	PCI-20008A-2B PCI-20008A-3B	1.5 ft (0.46m) 3 ft (0.91m)	PCI-200098C[5]		
PCI-20304T-2	Thermocouple[3]	PCI-20008A-2B PCI-20008A-3B	1.5 ft (0.46m) 3 ft (0.91m)	PCI-200098C[5]		
PCI-20305T-1	Digital I/O	PCI-20311A-2 PCI-20311A-3	1.5 ft (0.46m) 3 ft (0.91m)	PCI-20001C-2A, PCI-40041C	PCI-20004M, PCI-20007M	PCI-20087W
PCI-20306T-1	Digital I/O	PCI-20009A-2B PCI-20009A-3B	1.5 ft (0.46m) 3 ft (0.91m)	PCI-20098C[5]		
PCI-20307T-1	Counter/Timer	Included	0.3 ft (0.09m)	PCI-20098C		
PCI-20324T-1	DI/O Signal Conditioner[7]	PCI-20311A-2 PCI-20311A-3	1.5 ft (0.48m) 3 ft (0.91m)	PCI-20001C-2A, PCI-200041C	PCI-20004M	PCI-20087W
PCI-20325T-1	DI/O Signal Conditioner[7]	PCI-20009A-2B PCI-20009A-3B	1.5 ft (0.46m) 3 ft (0.91m)	PCI-20098C[5]		
PCI-20326T-1	Expander[7]			See Note 6	See Note 6	See Note 6

Notes: (1) When part numbers are shown without "dash" numbers, all versions apply.
(2) The PCI-20303T-1 and PCI-20310A-1 can be used with any of the listed modules. (Modules are usually installed on a PCI carrier. Any carrier can be used.)
(3) Thermocouple panels include the required cold-junction compensation circuitry but can also be used for other analog applications.
(4) The proper cable length depends upon the hardware configuration. Contact your sales representative for additional information.
(5) In most applications involving the PCI-20098C-1 Carrier and the PCI-20089W-1, PCI-20091W-1 and PCI-20093W-1 Boards—3-foot (0.91m) long cables are recommended.
(6) The PCI-20326T-1 is an eight-channel expander that can be used with either the PCI-20324T-1 or PCI-20325T-1.
(7) The PCI-20324T-1, PCI-20325T-1, and PCI-20326T-1 utilize the PCI-1107 through PCI-1112 blocks.

PCI-2500-1: Numeric Keypad for Data Entry

The PCI-2500-1 is a low cost, compact, industrial data entry and display terminal intended as an interface to VIPc systems. It is ideal for simple keyboard entry, instrument user interface, process controllers, etc. The PCI-2500 mounts directly on the front of the VIPc.

The included mounting kit provides a cut-out front faceplate, mounting hardware, and a cable assembly for installing the PCI-2500 in VIPc.

The microterminal has six backlit programmable function keys. Space is provided to customize the keyboard and function keys with company logos and function labels.

A numeric keypad with six programmable function keys is provided for operator input. The keys are widely spaced for ease of entry. The silicone rubber keyboard provides environmental sealing with good tactile feedback. A unique characteristic of the keyboard is that each function key is backlit. The backlighting is under host-computer control to give maximum flexibility to the operator. The keyboard also features key-click and key-repeat functions. If an invalid key is pressed, the terminal responds with an audible tone.

The display is a 16-character LCD with large, easy-to-read characters. An 80-character display buffer with scroll keys allows the operator to slide the 16-character window across the 80-character line. The high-contrast display on the terminals provides sufficient alphanumeric display capability for most panel-mount applications.

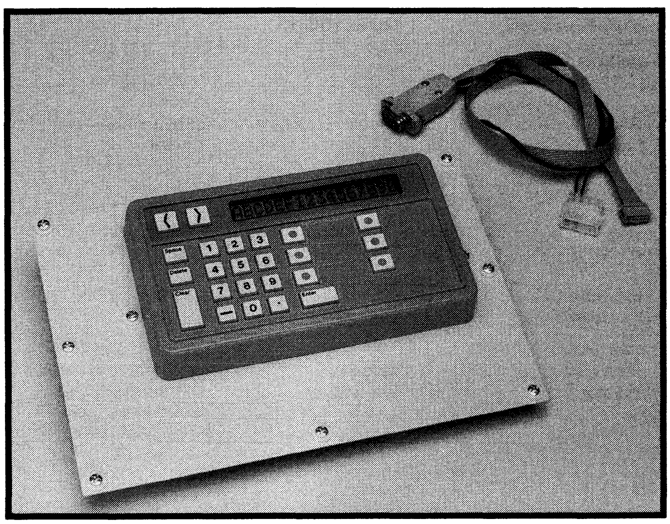
PCI-8500-1: Alpha Numeric Keyboard

The PCI-8500-1 is a versatile data entry and display terminal interface for VIPc systems. The compact size of the terminal allows it to be installed on the faceplate of VIPc. The included mounting kit provides a cut-out front faceplate, mounting hardware, and a cable assembly for installing the PCI-8500 in VIPc.The modular design of the PCI-8500 allows it to change and expand with your needs. Various input/output options are selected by easily installed modules that may be added or changed at any time. By using these modules, the terminal can accept magnetic stripe, laser scanner inputs, and a bar code wand or bar code slot.

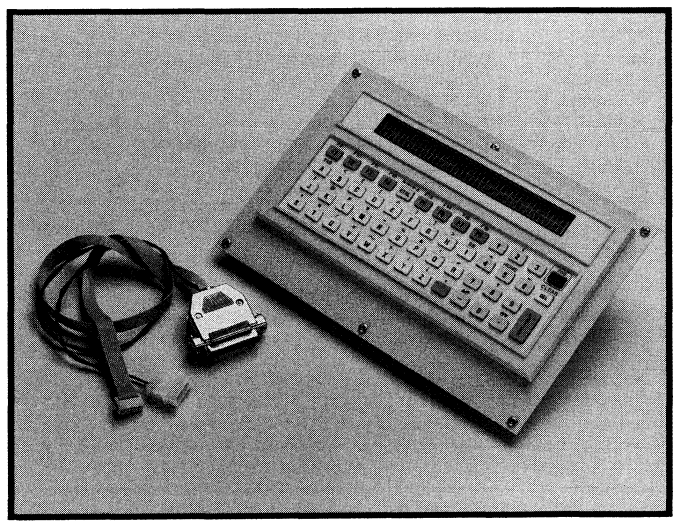
The PCI-8500 provides a standard, 51-key alphanumeric arrangement. Keyboard functions may be logically redefined (non-volatile) by the user, and keycaps may be easily arranged. The keyboard is easy to clean and resists dust and moisture.

Sixteen programmable function keys, combined with a completely redefinable keyboard, give the systems programmer control to create a simple and efficient operator interface. Two banks of function key memories provide a total of 32 function strings. Each can be up to 40 characters in length and may be stored in the terminals' non-volatile RAM. The application program may switch the terminal from one bank of functions to another, allowing keys to perform multiple functions.

The PCI-8500 features a 2-line by 40-character liquid crystal display (LCD). For ease of viewing in low light areas, the display is illuminated with a soft, blue electroluminescent backlight that may be controlled either from the keyboard or form the host computer. The viewing angle is adjustable from the keyboard.



PCI-2500-1 Numeric Keypad.



PCI-8500-1 Alphanumeric Keyboard.

STANDARD VIPc SYSTEMS INCLUDE:

- A 12.5MHZ, PC/XT/AT Compatible CPU
- Hard/Floppy Disk Controller
- EGA, CGA and Hercules Graphics Interface
- 2 Serial and 1 Parallel Port
- Coprocessor Socket
- International (Automatic) AC Power Supply
- 1.2MByte Floppy Disk Drive
- Keyboard (101 Key)
- 4 Expansion Slots for I/O or Other Purposes
- Internal, EMI-Shielded, Euro-Style Enclosure
- Filtered (Positive Pressure) Air Cooling
- Customizable Covers (Front, Rear and Top)

VIPc FEATURES BY MODEL NUMBER

PCI MODEL NUMBER	STANDARD FEATURES (LISTED ABOVE)	MONITOR	512K RAM	1M RAM	2M RAM	20MBYTE HARD DISK	40MBYTE HARD DISK	80287 COPROCESSOR	MS-DOS VER. 3.3
PCI-5001H-1	X	PCI-5010A-1	-	-	X	-	X	X	X
PCI-5001H-2	X	PCI-5010A-2	-	-	X	-	X	X	X
PCI-5002H-1	X	-	-	-	X	-	X	X	X
PCI-5003H-1	X	PCI-5010A-1	X	-	-	-	X	-	X
PCI-5003H-2	X	PCI-5010A-2	X	-	-	-	X	-	X
PCI-5004H-1	X	-	X	-	-	-	-	-	-
PCI-5016H-1	X	-	-	X	-	X	-	-	X
PCI-5017H-1	X	-	-	X	-	-	X	-	X

OPTIONAL ACCESSORIES

PCI MODEL NUMBER	DESCRIPTION
PCI-2500-1	Numeric keypad with mounting kit
PCI-8500-1	Alphanumeric keyboard with mounting kit
PCI-5005A-1	2Mbyte RAM expansion kit
PCI-5006A-1	80287-8 coprocessor
PCI-5007A-1	40Mbyte (28mS) Hard disk
PCI-5008A-1	Rack-mount hardware for VIPc base unit
PCI-5009A-1	Internal disk drive mounting cage
PCI-5010A-1	EGA/VGA monitor, tabletop, 100/110/120 VAC
PCI-5010A-2	EGA/VGA monitor, tabletop, 220/240 VAC
PCI-5012A-1	Vertical-mount base plate
PCI-5013A-1	Extra front face plate
PCI-5014A-1	Extra rear face plate
PCI-5015A-1	Front door without logos
PCI-5024A-1	3.5-inch floppy disk drive, 1.4MB
PCI-5027A-1	EGA monitor, industrial rack-mount, universal power supply
PCI-20000	Data acquisition products

Notes: Other combinations of standard features are available on special order in OEM quantities. Please contact your local Burr-Brown representative for additional information.

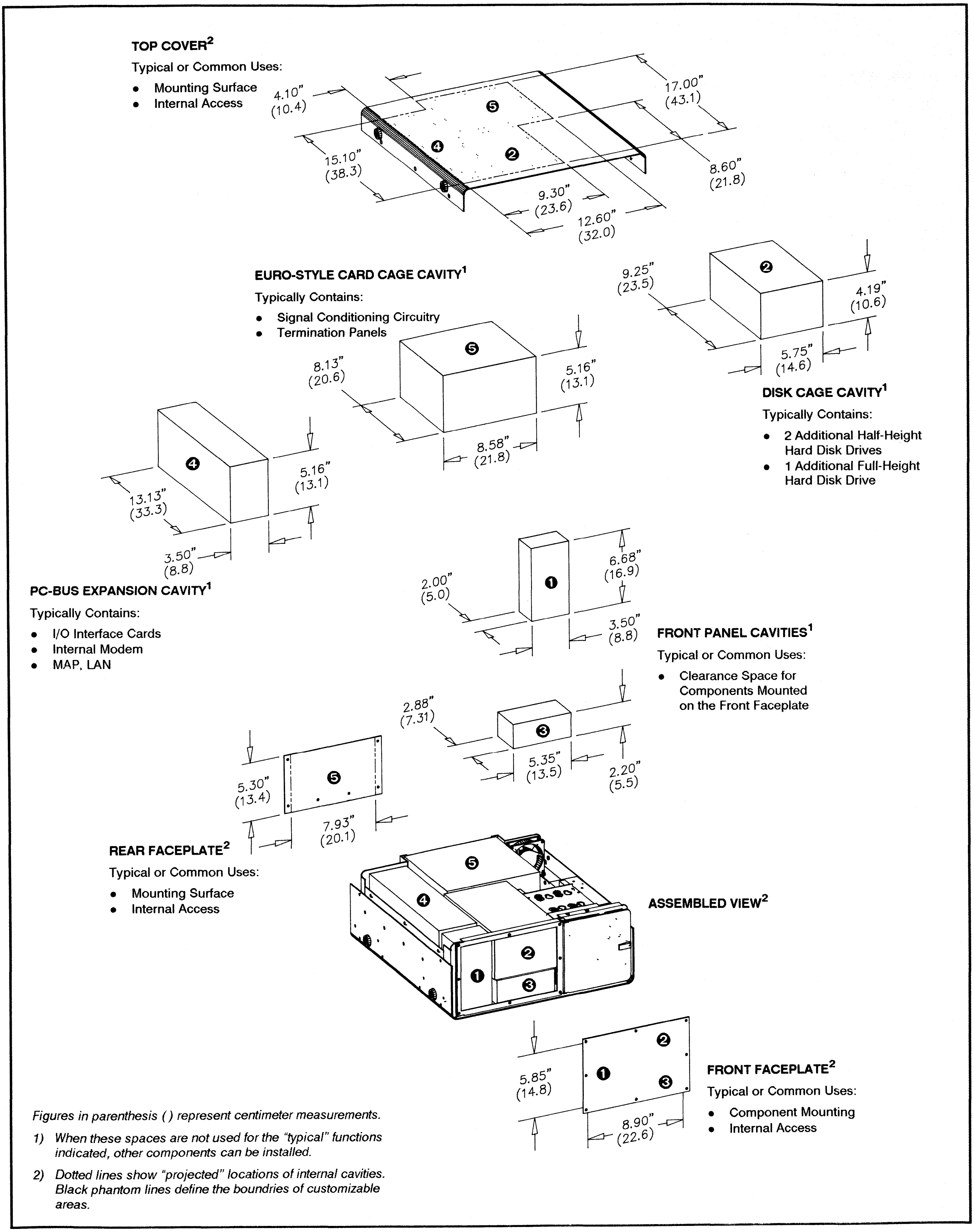
All VIPc systems are listed to UL478 and certified to CSA C22.2 No. 220 by Dash, Straus & Goodhue, Inc., and bear the mark DSG

In addition, all VIPc systems conform to the requirements of IEC950.

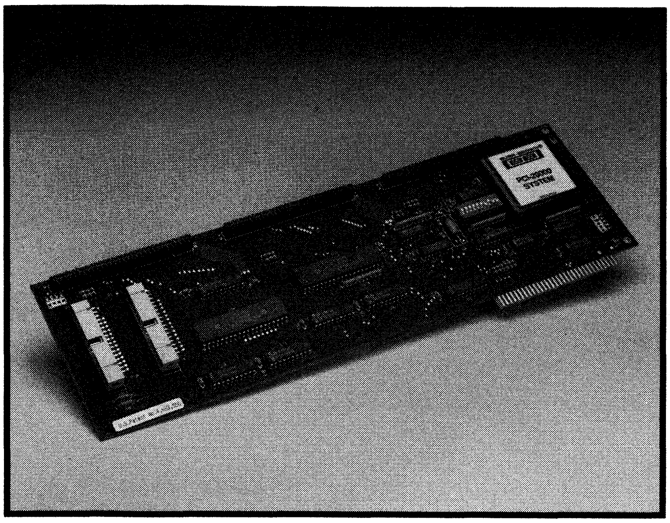
SPECIFICATIONS— VIPc SERIES

All specifications are typical at 25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Computer Resources		MS-DOS 3.3
CPU Speed	80286	12.5/6.25MHz
Coprocessor		80287-8
RAM	Expandable to 4MB	2Mbytes
BIOS		Phoenix
Disk Controller	2 Floppy & 2 hard drives	1
Floppy Disk Drive	5 1/4-inch	1.2MByte
Hard Disk	5 1/4-inch	40Mbyte, 28mS
Graphics Resolution	Color and monochrome	Hercules, CGA, EGA
Ports	Serial	2
	Parallel	1
Expansion Slots	Full size	3 16-Bit, 1 8-Bit
Keyboard	AT-Style,	101 Key
Power Supply		
Base Unit	110 Watts	85-264VAC, 47-440Hz
Monitor	Table-top model	90-130VAC, 50/60Hz 180-260VAC, 50Hz
	Rack-mount model	98-132VAC, 60Hz 196-264VAC, 50Hz
Base Unit		
Mounting Options		Rack, desk, wall, under shelf
Physical Size	Depth x Width x Height	19" x 17" x 7" (48cm x 43cm x 18cm)
Weight		30 lbs. (13.6kg)
Paint Color	Federal Standard 595A	Gray, #26559
Monitor	Tabletop model	13-inch, EGA
Temperature Range	Operating	0 to 50°C
Vibration While Operating	1 hard disk and 1 floppy disk 5-18Hz 30-500Hz	0.04 inches DA 1G
Shock While Operating	1 hard disk and 1 floppy disk 10mSec, 1/2-Sine	10G



User-definable Surfaces and Spaces.



BURR-BROWN®

PCI-20001C-2A

General-Purpose Carrier for PC Bus

FEATURES

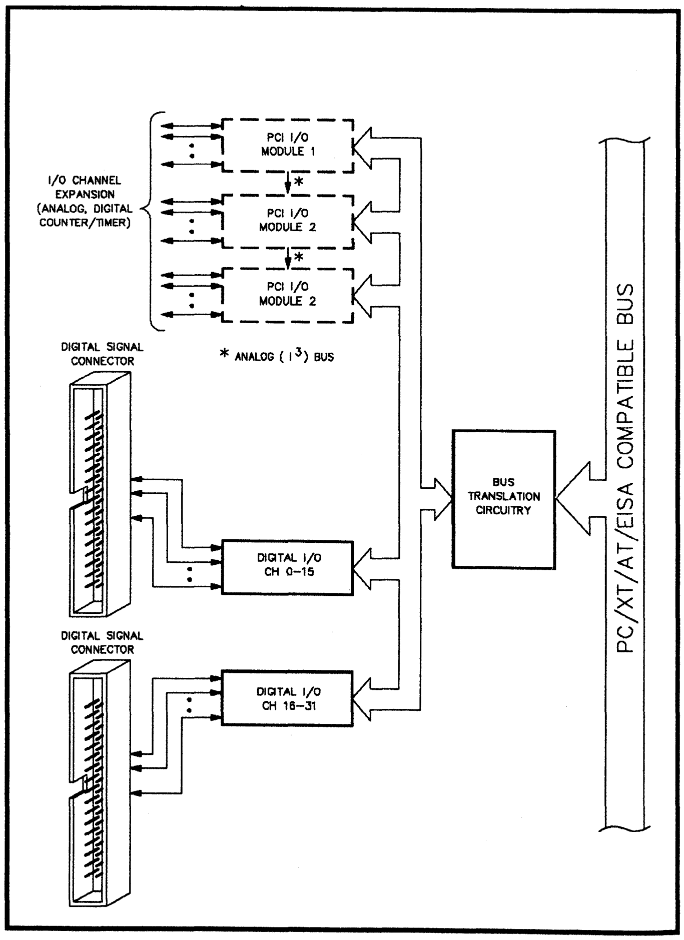
- Plugs into Internal Expansion Slot of Any PC-Compatible Computer: Burr-Brown VIPc; IBM PC/XT/AT/EISA; Compaq; etc.
- 32 Digital I/O Points Included, On-board
- Additional I/O Functionality Supported with Plug-in Modules
- Provisions for up to Three I/O Modules Per Carrier
- On-board I^3 Bus Allows Digital, Analog and Timing Signals to Be Passed Between Modules

DESCRIPTION

The PCI-20001C-2A Carrier is designed to interface directly with the PC's (conventional, IBM standard) internal bus through any available expansion slot. Major features of this carrier include the Intelligent Instrumentation Interface (I^3) Bus, its capacity for up to three I/O Modules, and 32 points of fully buffered digital I/O. The 32 points are arranged in four ports of 8 bits (bytes). Each port, under software control, can be configured for either input or output use. Field connections to these I/O points are made through two connectors on the carrier. Each connector supports two bytes. Ribbon cables are used to interconnect the carrier and the appropriate signal termination panels. This digital I/O capacity does not diminish any of the other functions, and it leaves all three module positions free for further expansion.

The I^3 bus supports digital, sync and analog signal communication. The sync lines make possible the coordination (timing) of various system elements. The differential analog daisy chain allows any module to condition its input signal and then pass the result to the next module. Bus translation circuitry links the PC bus to the I^3 bus. Logic for interrupt control, carrier identification and module selection is also included. All power is derived from the +5V, PC power supply. A DC/DC power converter on the carrier generates ±15V for use by the modules.

Several carriers can be installed in one PC, up to the limits on available expansion slots. However, the mechanical thickness of the carrier/module assembly and its power requirements can limit a practical installation to less than the number of slots. Each carrier is addressed into the memory map of the PC and requires 1Kbyte of space. DIP switches allow placing the carrier anywhere within the lower 1Mbyte of available memory address space.



PCI-20001C Carrier Block Diagram.

Of special significance is SYSCHECK PC, the system assurance utilities and diagnostics software package. This menu-driven product, shipped at no extra charge with each system, easily verifies proper installation and utilization of all PCI-PC system components. Not only does SYSCHECK PC greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK PC provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.

SPECIFICATIONS—PCI-20001C-2A

All specifications are typical at +25° C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility		All IBM-compatible PCs, including Burr-Brown VIPc, PC/XT/AT/EISA, etc.
Carrier Addressing		Memory mapped
Size	Boundary on any 1K increment	1Kbytes
I/O Configuration	Digital ports: programmable as input or output in groups of 8 channels	Three I^3 Bus sockets plus 32 digital I/O
Digital Inputs		
High-Level Voltage	Minimum	2V
Low-Level Voltage	Maximum	0.8V
I_{in}, High-Level	Maximum	20μA
I_{in}, Low-Level	Maximum	-0.2mA
Input Clamp Level		-1.5mV
Digital Outputs(1)		
High-Level Voltage	I_{out} = Max	2V
Low-Level Voltage	I_{out} = Max	0.5V
Current Source	V_{out} = Low	-15mA
Current Sink	V_{out} = High	24mA
Tri-State Current	V_{out} = 2.7V	10μA
	V_{out} = 0.4V	200μA
Digital I/O Speed	80286 @ 12MHz/80386 @ 16MHz	
QuickBASIC	Using PCI-20026S-1 drivers	7/10Kbytes/sec
C	Using PCI-20026S-2 drivers	7/11Kbytes/sec
TURBO PASCAL	Using PCI-20026S-3 drivers	5/8Kbytes/sec
Assembly Language	User Developed	160/280Kbytes/sec
Power Requirements	From PC's +15V supply	
	No load on internal supply[2]	560mA[2] max
	Full load on internal supply	4.12A max
Power Available to Modules	Internal +15V supply	150mA minimum[3]
	Internal -15V supply	150mA minimum[3]
	+5V Bus	Depends upon host
Physical	Expansion slot requirements	One to two slots[4]
Size	Length x Height	13.1" x 3.9"
		33.3cm x 9.9cm
Temperature Range	Board temperature	0 to +70° C

Notes: (1) All digital I/O ports are "Inputs" at power up.
(2) No modules are installed on the carrier.
(3) 150mA is a conservative rating. Typically 200mA is available, but this is not guaranteed.
(4) The width of an installed PCI-20001C-2 depends upon the I/O module configuration. With no modules, one slot is required—with three modules, two slots are required.

SOFTWARE COMPATIBILITY TABLE

(The PCI-20001C-2A can be used with the following software in conjunction with the listed hardware.)

PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER[2]	DMA SUPPORT	MODULES SUPPORTED[1]
PCI-20040S	LABTECH NOTEBOOK	Yes	Yes	No	PCI-20002M, 3M, 4M, 7M, 19M and 21M
PCI-20097S	LABTECH CONTROL	Yes	Yes	No	PCI-20002M, 3M, 4M, 7M, 19M and 21M
PCI-20068S	SNAPSHOT Series	Yes	Yes	No	PCI-20002M, 3M, 6M, 7M, 19M, 20M, 21M, 23M and 31M
PCI-20067S	DADiSP/PC	Yes	No	No	PCI-20002M, 19M, 23M, 31M and 341M
PCI-20210S	Hypersignal-Workstation	Yes	No	No	PCI-20002M, 19M, 23M, 31M and 341M
PCI-20026S	General-purpose drivers	No	Yes	No	All PCI I/O
PCI-20027S	High-performance drivers	No	Yes	No	PCI-20002M, 7M, 17M, 19M, 20M, 23M, 31M and 341M

Notes: (1) When a model number is shown without a "dash" number, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-20026S and PCI-20027S drivers).

HARDWARE COMPATIBILITY TABLES— MODULES

(The PCI-20001C-2A can be used in conjunction with the following hardware products.)

MODULE	FUNCTION	NUMBER OF CHANNELS	RESOLUTION	SPEED	CABLE	TERMINATION PANELS	ENCLOSURE
PCI-20002M-1	Analog Input	16/8[1]	12-bit	12,000Hz	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1 and PCI-20343A-1
PCI-20019M-1	Analog Input	8	12-bit	89,000Hz	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1 and PCI-20343A-1
PCI-20023M-1A	Analog Input	8	12-bit	180,000Hz	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1 and PCI-20343A-1
PCI-20341M-1	Analog Input	1/4[1]	16-bit	85,000Hz	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1 and PCI-20343A-1
PCI-20031M-1	Analog Expansion	32/16[1]		Limited by A/D	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1 and PCI-20343A-1
PCI-20017M-1	Simultaneous S/H	4/4[1]		6K Frames/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1 and PCI-20343A-1
PCI-20020M-1	Trigger/Alarm	1 or 2		20nS Scatter	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1 and PCI-20343A-1
PCI-20003M-2	Analog Output, V	2	12-bit	80,000 Pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1 and PCI-20343A-1
PCI-20003M-4	Analog Output, V/I	2	12-bit	40,000 Pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1 and PCI-20343A-1
PCI-20006M-2	Analog Output, V	2	16-bit	80,000 Pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1 and PCI-20343A-1
PCI-20021M-1B	Analog Output, V	8	12-bit	2,000 Pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1 and PCI-20343A-1
PCI-20004M-1	Digital I/O	32		280Kbytes/sec	PCI-20311A-1	PCI-20305T-1	PCI-20308H-1 and PCI-20343A-1
PCI-20004M-1	Digital I/O	32		280Kbytes/sec	PCI-20311A-1	PCI-20324T-1	PCI-20308H-1 and PCI-20343A-1
PCI-20007M-1	Counter/Timer	4/1[2]			PCI-20311A-1	PCI-20305T-1	PCI-20308H-1 and PCI-20343A-1

Notes: (1) Single-ended/Differential.
(2) Counters/Timers.

HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS

TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20305T-1	General-purpose	PCI-20311A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20025T-2	Customizer	PCI-20061A-1	PCI-20029A-1
PCI-20324T-1	Signal conditioner	PCI-20311A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20018T-1	Signal conditioner	PCI-20013A-1	PCI-20029A-1
PCI-20048T-1	Signal conditioner	PCI-20013A-1	PCI-20339A-1

For additional information, please refer to the configuration charts in the Summary Section.

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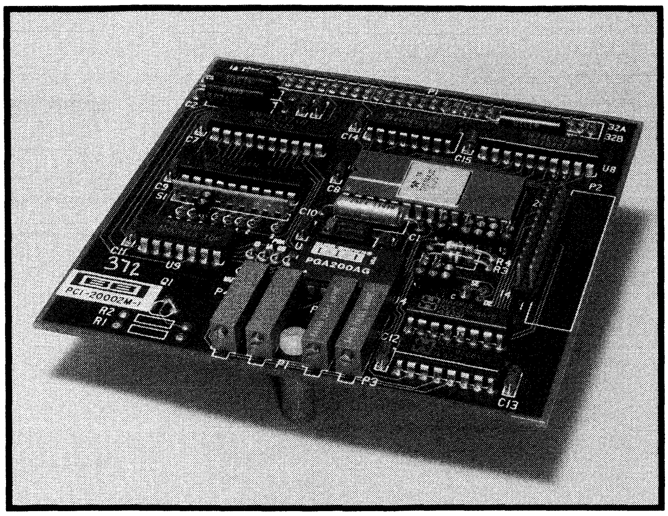


PCI-20002M-1

General-Purpose Analog Input Module

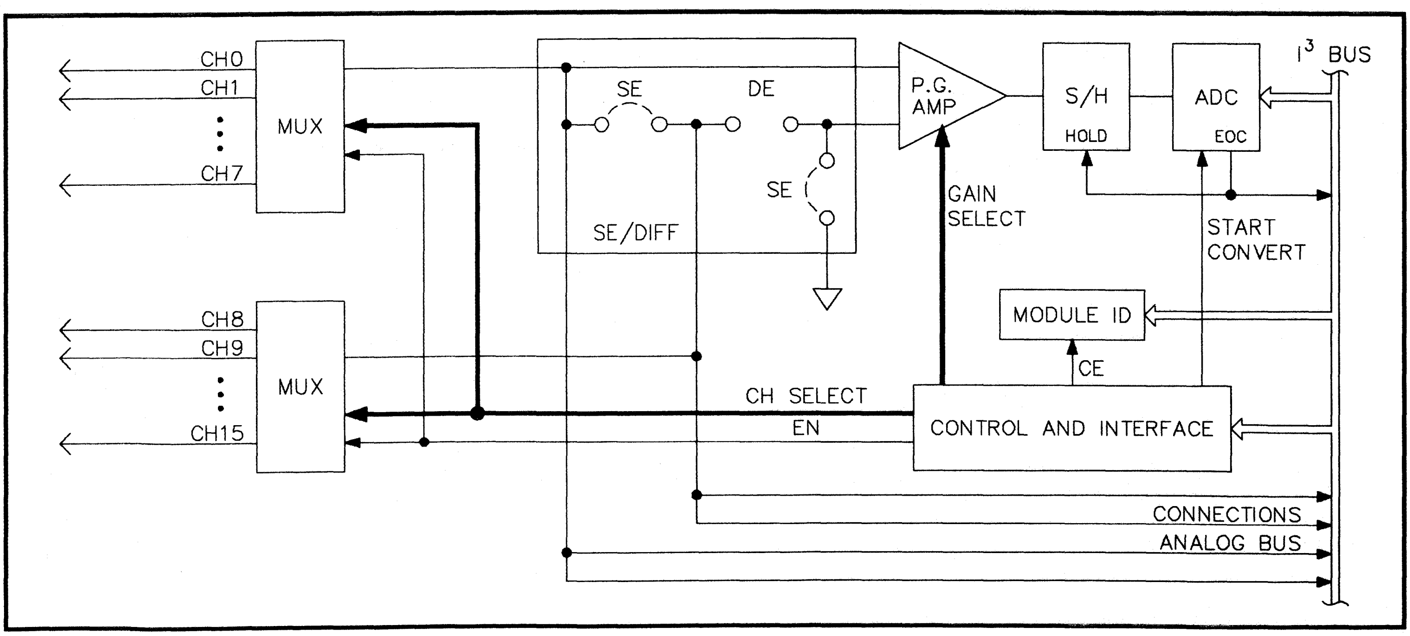
FEATURES

- 16 Single-Ended or 8 Differential Inputs
- 12-Bit Resolution
- Programmable Gains - 1, 10, 100, 1000
- 0.04% Linearity Error

DESCRIPTION

This module accepts a wide range of analog input signals and performs the A/D conversions necessary to make the data compatible with digital computers. Below is a functional block diagram of the module. Input multiplexers select any one of 16 single-ended input channels. Alternatively, the multiplexer (mux) can be jumper-programmed for eight differential channels. Additional input channels can be obtained by using the optional PCI-20031M-1 Expansion Module. Each expansion module adds 32 single-ended (or 16 differential) channels. A high-performance, differential input, programmable gain amplifier provides signal scaling and common-mode rejection. Gains of 1, 10, 100 and 1000 are available under software control. The 12-bit A/D converter can be set up for an input range of ±5V, 0 to 10V or ±10V full scale. This module synchronizes the start of a new A/D conversion to a software generated command. More precise timing is possible using the PCI-20019M-1A, PCI-20023M-1, PCI-20089W-1, PCI-20091W-1, or PCI-20098C-1. These products have facilities for hardware synchronization on either an internal crystal clock or an external signal. Input signals are usually connected to external termination panels and brought to the module via shielded ribbon cable.

The PCI-20033A-1 is a module extender that is designed to allow access to the calibration potentiometers on the PCI-20002M-1 Module. The extender fits between the connectors on the carrier and on the module. The PCI-20033A-1 can also be useful with other modules in system troubleshooting situations.



PCI-20002M-1 Module Block Diagram.

Of special significance is SYSCHECK PC, the system assurance utilities and diagnostics software package. This menu-driven product, shipped at no extra charge with each system, easily verifies proper installation and utilization of all PCI-PC system components. Not only does SYSCHECK PC greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK PC provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.

SPECIFICATIONS— PCI-20002M-1

All specifications are typical at +25° C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility		All I^3 Bus devices
I/O Configuration Number of Channels Resolution Code 	 Single-ended Differential Unipolar Bipolar	Analog input 16 8 12 bits Binary Offset binary
Input Stage Offset Voltage Offset Drift Common-Mode Rejection[1] Common-Mode Range (V_{cmr}) 	Programmable gain amplifier RTI:G = 1 G = 10 - 1k 60Hz, 100 Ohms unbalance, 10V range Gain = 1 Gain = 10 Gain = 100 Gain = 1000 $V_{cm} = V_{cmr} - (V_{diff} \times Gain/2)$	G = 1, 10, 100, 1000 Trimmable to zero 110ppm/°C 20ppm/°C 0.04LSB/volt (-80dB) 0.07LSB/volt (-95dB) 0.7LSB/volt (-95dB) 7.3LSB/volt (-95dB) 10V, DC + peak AC
Bias Current Offset Current		30nA 30nA
Linearity Error	G = 1, 10 G = 100 G = 1000	±0.04 (1.6LSB) ±0.05 (2LSB) ±0.065% (2.7LSB)
Gain Accuracy	Trimmable to zero	±0.5LSB
Source Impedance Input Impedance Crosstalk	Maximum recommended For 1LSB error @ 10kHz rate Channel-to-channel @ 1kHz, 1KΩ source impedance	 10K ohms 10G ohms at 40pF 0.2LSB (-90dB)
Input Range	Linear Without damage	±5, ±10, 0-10V 20V above supplies
Power Requirements[2]	+15V supply -15V supply +5V supply	32mA maximum 56mA maximum 200mA maximum
Size	Length x Height x Thickness	3.9" x 3.9" x 1.3" 9.9cm x 9.9cm x 3.3cm
Temperature Range	Module temperature	0 to +70°C

Notes: (1) For a single PCI-20002M-1 module without multiplexers connected through the I^3 Bus. Connections to the I^3 Bus can decrease CMR.
(2) If a module is powered from a PCI Carrier, the ±15V requirements are satisfied by the carrier's DC/DC converter, and the equivalent load on the computer's +5V supply will be 730mA, maximum. This takes into account the efficiency of the DC/DC converter.

SOFTWARE COMPATIBILITY TABLE

(The PCI-20002M-1 can be used with the following software in conjunction with the listed hardware.)

PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER[2]	DMA SUPPORT	CARRIERS[1]	EXPANSION MODULES[1]
PCI-20040S	LABTECH NOTEBOOK	Yes	Yes	No	PCI-20001C, PCI-20041C	PCI-20005M
PCI-20097S	LABTECH CONTROL	Yes	Yes	No	PCI-20001C, PCI-20041C	PCI-20005M
PCI-20068S	SNAP-Series	Yes	Yes	No	PCI-20001C, PCI-20041C	PCI-20031M
PCI-20068S	SNAP-Series	Yes	Yes	Yes	PCI-20041C-3A	PCI-20031M
PCI-20067S	DADiSP/PC	Yes	No	No	Not applicable	Not applicable
PCI-20210S	Hypersignal-Workstation	Yes	No	No	Not applicable	Not applicable
PCI-20026S	General-purpose drivers	No	Yes	No	PCI-20001C, PCI-20041C	PCI-20031M
PCI-20027S	High-performance drivers	No	Yes	No	PCI-20001C, PCI-20041C	PCI-20031M
PCI-20027S	High-performance drivers	No	Yes	Yes	PCI-20041C-3A	PCI-20031M
PCI-20096S	TURBO STREAM Drivers	No	Yes	Yes	PCI-20041C-3A	PCI-20031M
PCI-20203S	DSP Library Plus Series	No	Yes	Yes	PCI-20202C	

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-20026S and PCI-20027S drivers).

HARDWARE COMPATIBILITY TABLE— CARRIERS AND MODULES

(The PCI-20002M-1 can be used in conjunction with the following hardware products.)

				MAXIMUM NUMBER OF CHANNELS			
				WITH ONE PCI-20031M-1		WITH TWO PCI-20031M-1s	
PCI MODEL NUMBER	TYPE	DESCRIPTION	BUS	SOFTWARE SELECTION[1]	HARDWARE SELECTION[2]	SOFTWARE SELECTION[1]	HARDWARE SELECTION[2]
PCI-20001C-2A	Carrier	General-purpose	PC/XT/AT/EISA	48/24[3]	Not applicable	80/40[3]	Not applicable
PCI-20041C-2A	Carrier	High-performance	PC/XT/AT/EISA	48/24[3]	Not applicable	80/40[3]	Not applicable
PCI-20041C-3A	Carrier	High-performance	PC/XT/AT/EISA	48/24[3]	32/163	80/40[3]	64/32[3]
PCI-20202C-1, -2	Carrier	*Smart* processor	PC/XT/AT/EISA	48/24[3]	Not applicable	80/40[3]	Not applicable

Notes: (1) If the channel selection is made under software control.
(2) If the channel selection is made under hardware control (automatic channel sequencing). As an example, if used under DMA.
(3) Single-ended/differential.

HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS

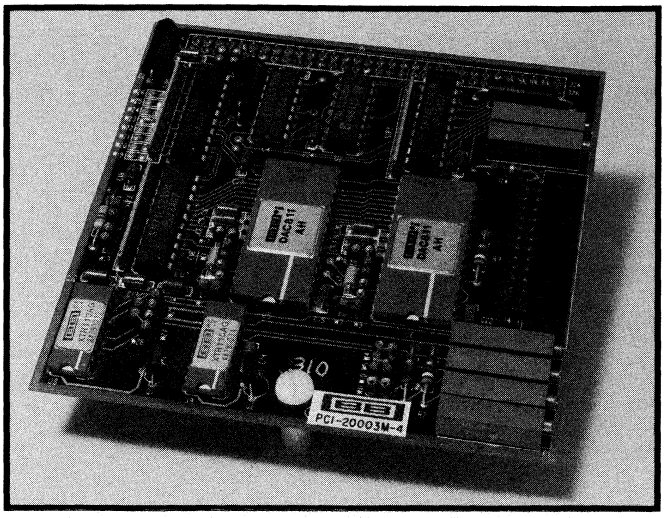
TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20303T-1	General-purpose	PCI-20310A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20303T-2	Thermocouple	PCI-20310A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20024T-2	Customizer	PCI-20015A-1	PCI-20029A-1
PCI-5B01-1	Signal conditioner	PCI-20015A-1	PCI-20339A-1
PCI-20042T-1	Signal conditioner	PCI-20012A-1	PCI-20029A-1
PCI-20044T-1	Signal conditioner	PCI-20012A-1	PCI-20029A-1

MAXIMUM SAMPLING SPEED FOR USER-WRITTEN SOFTWARE

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	80286 at 12MHz		80386 at 16MHz	
		PCI-20026S	PCI-20027S	PCI-20026S	PCI-20027S
QuickBASIC	Using PCI Software Drivers				
	G = 1, 10	3.3kHz	11kHz	4.1kHz	12kHz
	G = 100	2.1kHz	5.5kHz	2.5kHz	5.5kHz
	G = 1000	0.4kHz	0.8kHz	0.44kHz	0.8kHz
C	Using PCI Software Drivers				
	G = 1, 10	3.4kHz	11kHz	4.2kHz	12kHz
	G = 100	2.2kHz	5.5kHz	2.6kHz	5.5kHz
	G = 1000	0.4kHz	0.8kHz	0.44kHz	0.8kHz
TURBO PASCAL	Using PCI Software Drivers				
	G = 1, 10	2.9kHz	11kHz	3.7kHz	12kHz
	G = 100	1.9kHz	5.5kHz	2.3kHz	5.5kHz
	G = 1000	0.4kHz	0.8kHz	0.47kHz	0.8kHz
Assembly Language	User Developed Software				
	G = 1, 10	11kHz		12kHz	
	G = 100	5.5kHz		5.5kHz	
	G = 1000	0.8kHz		0.8kHz	

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20003M Series

12-Bit Analog Output Modules

FEATURES

- 12-Bit Resolution
- ±1/2LSB Linearity Error
- 3μs Settling Time
- Voltage and Current Outputs Available

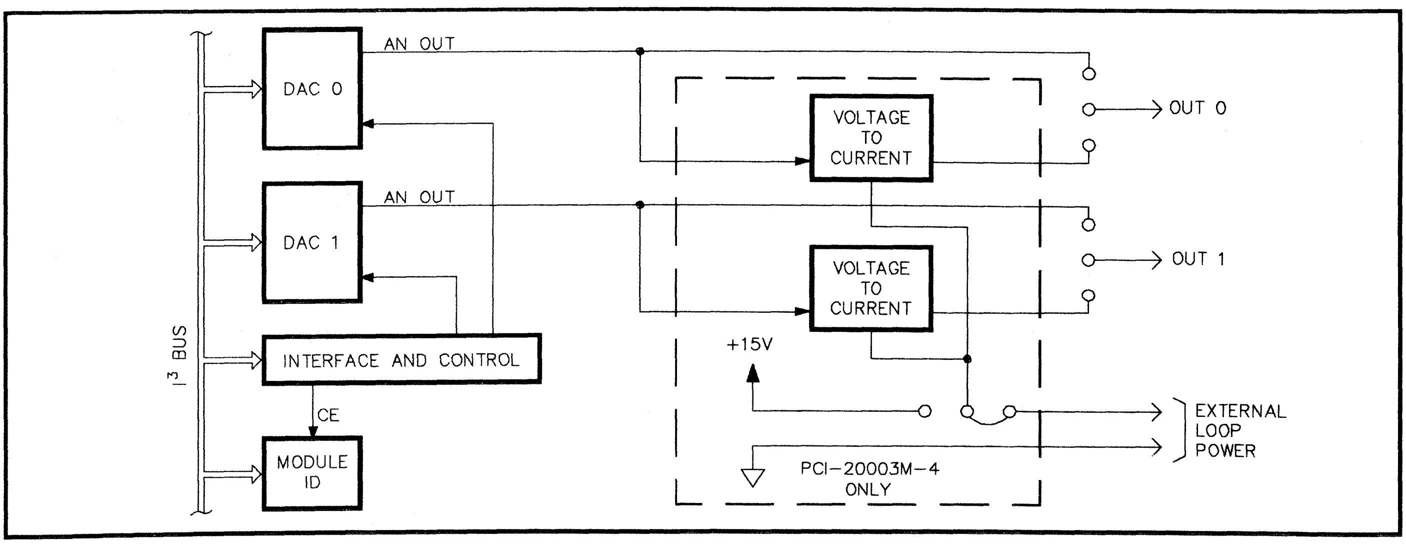
DESCRIPTION

The PCI-20003M-2 Module accepts digital code from the computer bus and generates analog output voltages in the range of ±10V. In addition to voltage outputs, the PCI-20003M-4 also has 4 to 20mA current outputs available. Below is a functional block diagram of the PCI-20003M-4. Both the PCI-20003M-2 and -4 modules contain 2 output channels with separate digital-to-analog converters (DACs).

All DACs have 12-bit resolution and can be jumper-programmed for ±5V, 0 to 10V and ±10V full-scale output. In addition, the current output model can be jumper-programmed for either 4 to 20mA or 5 to 25mA.

Output signals are usually connected to an external termination panel via shielded ribbon cable, where field connections can be easily accommodated.

Of special significance is SYSCHECK, the system assurance utilities and diagnostics software package. This menu-driven product, shipped at no extra charge with each system, easily verifies proper installation and utilization of all PCI system components. Not only does SYSCHECK greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.



PCI-20003M-4 Module Block Diagram.

SPECIFICATIONS— PCI-20003M-2, PCI-20003M-4

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility		I^3 Bus devices
Configuration		Analog output
	PCI-20003M-2	Voltage only
	PCI-20003M-4	Current or voltage
Range	Voltage output	±5V, ±10V, 0-10V
	Current output	4-20mA, 5-25mA
Number of Channels		2
Resolution		12-bit
Code	Unipolar	Binary
	Bipolar	Offset binary
Linearity Error	Voltage output, maximum	±0.5LSB
	Current output	±1.5LSB
Differential	Voltage output, maximum	±0.75LSB
Monotonicity	0 to +50°C	Fully monotonic
Gain Accuracy	Voltage output	Trimmable to zero
	Current output	0.6% FSR
Output Stage		
Current	Voltage output	±5mA
Impedance	Voltage output at DC	0.2Ω
Compliance	Current output	15V or loop supply
Settling Time	Voltage output, with 0.01%	
	20V step	4μs
	10V step	3μs
	Current output, within 0.1%	18μs
Slew Rate	Voltage output	8V/μs
	Current output	1mA/μs
Conversion Rate	Voltage output, assembly language	80K Points/sec
	Current output, assembly language	40K Points/sec
Output Rate (16MHz, 386)	Voltage output, QuickBASIC	10,000
	C	10,000
	TURBO PASCAL	8,000
	DMA (All languages)	74,000
Power Requirements	Voltage out or current out with external loop power	
	+15V supply	50mA max
	-15V supply	70mA[1] max
	+5V supply	180mA[2] max
	Current out with internal loop supply	
	+15V supply	100mA[1] max
	-15V supply	70mA[1] max
	+5V supply	180mA[3] max
	Two-channel current output	+13.5 to 35VG at 60mA
External Loop Power		
Size	Lenght x Height x Thickness	3.9″ x 3.9″ x 1.3″
		9.9cm x 9.9cm x 3.3cm
Temperature Range	Module temperature	0 to 70°C

Notes: (1) When more than two PCI-20003M Modules are installed on a single carrier, the required ±15V current may exceed that available. Typically, three modules operating in the voltage or Externally Powered Current Mode will work, but three modules are not guaranteed.
(2) If a module is powered from a PCI Carrier, the ±15V requirements are satisfied by the internal DC/DC converter, and the equivalent load on the computer's +5V supply will be 900mA, maximum. This takes into account the efficiency of the DC/DC converter.
(3) If a module is powered from a PCI Carrier, the ±15V requirements are satisfied by the internal DC/DC converter, and the equivalent load on the computer's +5V supply will be 12mA, maximum. This takes into account the efficiency of the DC/DC converter.

SOFTWARE COMPATIBILITY TABLE

(The PCI-20003M Series can be used with the following software in conjunction with the listed hardware.)

PCI MODEL NUMBER[3]	NAME	MENU-DRIVEN	H/W DRIVER[1]	DMA SUPPORT	CARRIERS SUPPORTED[3]
PCI-20040S-1	LABTECH NOTEBOOK	Yes	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20097S-1	LABTECH CONTROL	Yes	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20068S	SNAP-Series	Yes	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20210S-1	Hypersignal-Workstation	Yes	Yes	No	PCI-20202C
PCI-20026S	General-purpose drivers	No	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20027S	High-performance drivers	No	Yes	Yes	PCI-20041C-3A
PCI-20096S	TURBO STREAM Drivers	No	Yes	Yes	PCI-20041C-3A
PCI-20301S	ASYST Language	No	Yes	No	PCI-20098C
PCI-20203S	DSP Library Plus Series	No	Yes	Yes	PCI-20202C
PCI-20204S	DSP Software Development Pkg.	No	Yes[2]	Yes	PCI-20202C
PCI-703S	*MacAdapt*	Yes	Yes	No	PCI-701C
PCI-704S	*MacExpedite*	Yes	Yes	Yes	PCI-701C (with PCI-702M)
PCI-706S	Interface for LabVIEW 2	Yes	Yes	Yes	PCI-701C (with PCI-702M)

Notes: (1) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-20026S and PCI-20027S drivers).
(2) Drivers are supplied in the form of TMS Assembly source code.
(3) When model numbers are shown without "dash" numbers, all versions apply.

HARDWARE COMPATIBILITY TABLES— CARRIERS

(The PCI-20003M Series can be used in conjunction with the following hardware products.)

PCI MODEL NUMBER[1]	TYPE	DESCRIPTION	BUS
PCI-20001C-1, PCI-20001C-2	Carrier	General-purpose	PC/XT/AT/EISA
PCI-20041C-2, PCI-20041C-3	Carrier	High-performance	PC/XT/AT/EISA
PCI-20098C-1	Carrier	Multifunction	PC/XT/AT/EISA
PCI-20202C-1, PCI-20202C-2	Carrier	*Smart*	PC/XT/AT/EISA
PCI-701C	Carrier	Multifunction	Mac II NuBus

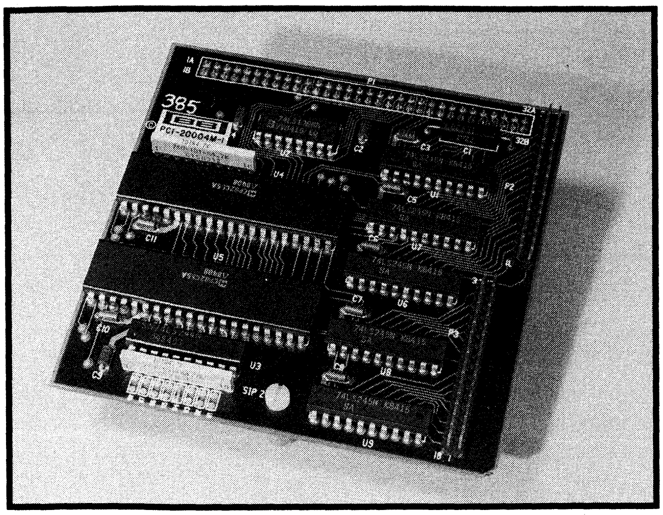
HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS

(The PCI-20003M Series can be used in conjunction with the following hardware products.)

TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20303T-1	General-purpose	PCI-20310A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20024T-2	Customizer	PCI-20015A-1	PCI-20029A-1
PCI-5B01-1	Signal conditioner[1]	PCI-20015A-1	PCI-20339A-1

Note: (1) The PCI-5B01-1 utilizes the PCI-5B Series of blocks.

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20004M-1

Digital Input/Output Module

FEATURES

- 32 Digital Input/Output Points
- TTL-Compatible Levels
- Buffered Outputs Both Source and Sink Current
- Directly Compatible With Industry Standard Opto-Isolators

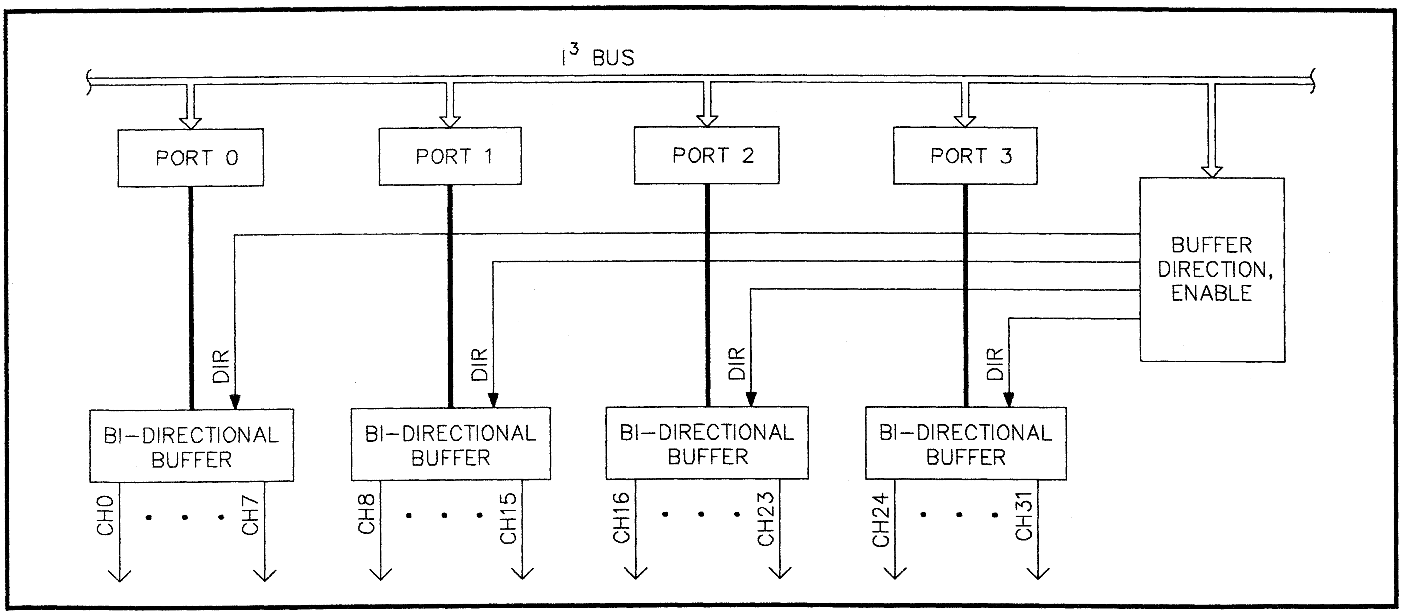
DESCRIPTION

This 32-point module functions with TTL-compatible digital signals. The 32 points are arranged in 4 ports of 8 bits each. Each port can, under software control, be selected for either input or output use. All lines are buffered to give full, bipolar, TTL drive capability. A block diagram is shown below.

The module can monitor or control devices having discrete on/off states such as relays, switches, lamps, etc. Through the use of opto-isolators (PCI-1100 Series), non TTL-signals can also be interfaced. For example, loads such as AC or DC motors can be readily switched and the presence of AC line voltage can be detected.

In addition to reading (or writing) bytes, software can extract individual bits or assemble words. In this way, logical combinations can be tested to determine alarm or control conditions.

The field I/O signals are usually connected to external termination panels and brought to the module via a ground-plane ribbon cable. Both conventional and opto-isolated termination panels are suitable for use with all PCI digital signals.



PCI-20004M-1 Digital I/O Functional Block Diagram.

Of special significance is SYSCHECK, the system assurance utilities and diagnostics software package. This menu-driven product, shipped at no extra charge with each system, easily verifies proper installation and utilization of all PCI system components. Not only does SYSCHECK greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.

SPECIFICATIONS— PCI-20004M-1

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility		All I^3 Bus devices
I/O Configuration	Software programmable as inputs or outputs in bytes	32 Digital I/O channels
Digital Inputs:		
High-Level Voltage	Minimum	2V
Low-Level Voltage	Maximum	0.8V
I_{in}, High-Level	Maximum	20μs
I_{in}, Low-Level	Maximum	-0.2mA
Input Clamp Level		-1.5V
Digital Outputs:[1]		
High-Level Voltage	I_{out} = Max	2V
Low-Level Voltage	I_{out} = Max	0.5V
Current Source	V_{out} = High	-15μA
Current Sink	V_{out} = Low	24μA
Tri-State Current	V_{out} = 2.7V	10μA
	V_{out} = 0.4V	200μA
Read/Write Rate		280Kbytes/sec
Power Requirements	+5V supply, quiescent	350mA max
Size	Length x Height x Thickness	3.9" x 3.9" x 1.3" 9.9cm x 9.9cm x 3.3cm
Temperature Range	Module temperature	0 to 70°C

Note: (1) All digital I/O ports are "inputs" at power-up.

SOFTWARE COMPATIBILITY TABLE

(The PCI-20004M-1 can be used with the following software in conjunction with the listed hardware.)

PCI MODEL NUMBER[1]	PRODUCT NAME	MENU-DRIVEN	H/W DRIVER[2]	DMA SUPPORT	CARRIERS SUPPORTED[1]
PCI-20040S	LABTECH NOTEBOOK	Yes	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20097S	LABTECH CONTROL	Yes	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20026S	General-purpose drivers	No	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20027S	High-performance drivers	No	Yes	Yes	PCI-20041C-3A
PCI-20096S	TURBO STREAM Drivers	No	Yes	Yes	PCI-20041C-3A
PCI-20204S	DSP Software Development Package	No	Yes[3]	Yes	PCI-20202C
PCI-703S	*MacAdapt*	Yes	Yes	No	PCI-701C
PCI-704S	*MacExpedite*	Yes	Yes	Yes	PCI-701C (with PCI-702M)
PCI-706S	Interface for LabVIEW 2	Yes	Yes	Yes	PCI-701C (with PCI-702M)

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-20026S and PCI-20027S drivers).
(3) Drivers are supplied in the form of TMS Assembly source code.

HARDWARE COMPATIBILITY TABLE— CARRIERS

(The PCI-20004M-1 can be used in conjunction with the following hardware products.)

PCI MODEL NUMBER[1]	TYPE	DESCRIPTION	BUS
PCI-20001C-1, PCI-20001C-2	Carrier	General-purpose	PC/XT/AT/EISA
PCI-20041C-2, PCI-20041C-3	Carrier	High-performance	PC/XT/AT/EISA
PCI-20098C-1	Carrier	Multifunction	PC/XT/AT/EISA
PCI-20202C-1, PCI-20202C-2	Carrier	*Smart* Processor	PC/XT/AT/EISA
PCI-701C	Carrier	Multifunction	Mac II NuBus

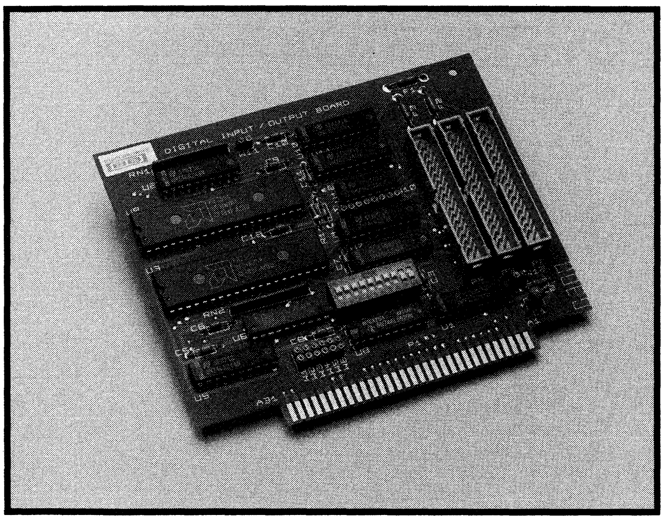
HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS

(The PCI-20004M-1 can be used in conjunction with the following hardware products.)

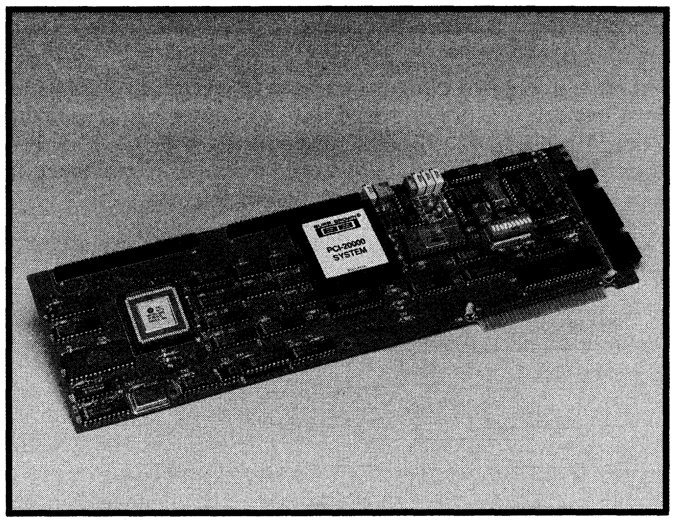
TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20305T-1	General-purpose	PCI-20311A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20025T-2	Customizer	PCI-20061A-1	PCI-20029A-1
PCI-20324T-1	Signal conditioner[1]	PCI-20311A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20018T-1	Signal conditioner[2]	PCI-20013A-1	PCI-20029A-1
PCI-20048T-1	Signal conditioner[2]	PCI-20013A-1	PCI-20339A-1

Notes: (1) The PCI-20324T-1 utilizes the PCI-1107 through PCI-1112 blocks.
(2) The PCI-20018T-1 and PCI-20048T-1 utilize the PCI-1101 through PCI-1106 blocks.

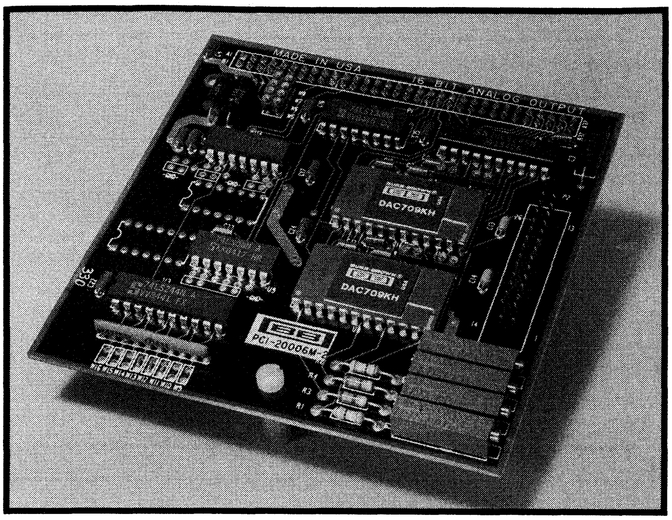
For additional information, please refer to the configuration charts in the Summary Section.



The PCI-20087W-1 Digital I/O Board Is an Ideal Alternative for Applications That Do Not Require the Flexibility of a Carrier-based System.



Each PCI-20004M-1 Adds 32 Channels of Digital I/O to a PCI Carrier (PCI-20001C-2, PCI-20041C-2, PCI-20041C-3, PCI-20098C-1, PCI-20202C-1, PCI-20202C-2 or PCI-701C).



BURR-BROWN®

PCI-20006M-2

16-Bit Analog Output Module

FEATURES

- Dual Channel
- 16-Bit Resolution (1 Part in 65K)
- ±0.003% Linearity Error
- 10V/μs Slew Rate
- Directly Plugs Into PCI Carriers

APPLICATIONS

- Waveform Generation
- Process Control
- Programmable Reference Voltage Source
- Automatic Test Systems

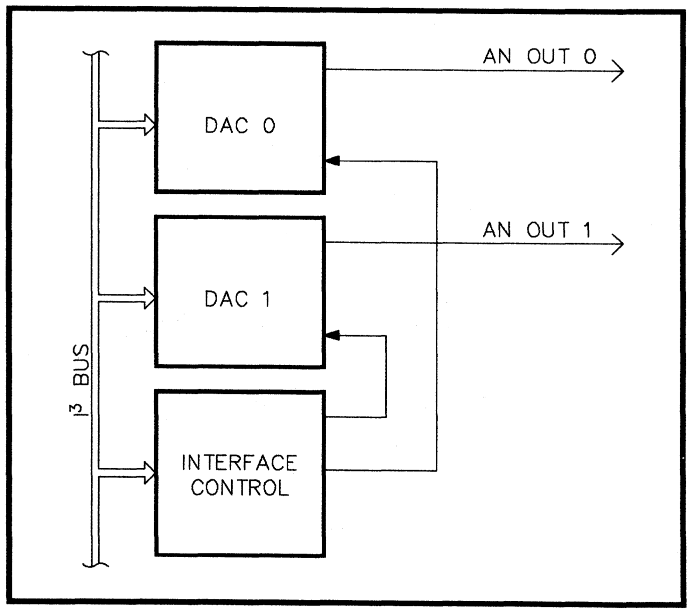
DESCRIPTION

The PCI-20006M-2 module accepts digital code from a computer and generates analog output voltages in the range of ±10V. Below is a functional block diagram of the PCI-20006M-2. The module contains two separate digital-to-analog converters (DACs). Both DACs have 16-bit resolution and can be jumper-programmed for ±5V, 0 to 10V and ±10V full-scale output.

This analog output module is ideal for signal generation and control applications requiring high resolution.

Output signals are usually connected to an external termination panel via shielded ribbon cable, where field connections can be easily accommodated.

Of special significance is SYSCHECK, the system assurance utilities and diagnostics software package. This menu-driven product, shipped at no extra charge with each system, easily verifies proper installation and utilization of all PCI system components. Not only does SYSCHECK greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.



Block Diagram of PCI-20006M-2 16-Bit Analog Output Module.

SPECIFICATIONS— PCI-20006M-2

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility		All I^3 Bus devices
Configuration Range Number of Channels Resolution Code	 Voltage output(1) Unipolar Bipolar	Analog output ±5V, ±10V, 0-10V Two 16-bit Binary Two's complement
Linearity Error Differential		±0.002% FSR ±0.003% FSR
Monotonicity	Over temperature range	14-Bits
Gain Accuracy		Adjustable to zero
Offset		Adjustable to zero
Output Stage: Current Impedance	 At DC	 ±5mA 0.15Ω
Settling Time	To 0.003% FSR, 20kΩ load, full scale step	8μs
Slew Rate		10V/μs
Conversion Rate	Assembly language	80K Points/sec
Output Rate (16MHz, 386)	Voltage output, QuickBASIC C TURBO PASCAL DMA (All languages)	10,000 10,000 8,000 74,000
Power Requirements	+15V supply -15V supply +5V supply	20mA max 60mA[2] max 240mA[3] max
Size	Length x Height x Thickness	3.9" x 3.9" x 1.3" (9.9cm x 9.9cm x 3.3cm)
Temperature Range	Module temperature	0 to +70°C

Notes: (1) When the system is first powered up, the outputs of this module are NOT in determined states until initialized by software. That is, the analog outputs could be any value consistent with the hardware jumpers installed.
(2) When more than two PCI-20006M-2 Modules are installed on a single carrier, the required ±15V current may exceed that available. Typically, three modules will work, but this is not guaranteed.
(3) If a module is powered from a PCI Carrier, the ±15V requirements are satisfied by the internal DC/DC converter, and the equivalent load on the computer's +5V supply will be 720mA, maximum. This takes into account the efficiency of the DC/DC converter.

SOFTWARE COMPATIBILITY TABLE

(The PCI-20006M-2 can be used with the following software in conjunction with the listed hardware.)

PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER[2]	DMA SUPPORT	CARRIERS SUPPORTED[1]
PCI-200068S	SNAP-Series	Yes	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20026S	General-purpose drivers	No	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20027S	High-performance drivers	No	Yes	Yes	PCI-20041C-3A
PCI-20096S	TURBO STREAM Drivers	No	Yes	Yes	PCI-20041C-3A
PCI-20301S	ASYST Language	No	Yes	No	PCI-20098C
PCI-20203S	DSP Library Plus Series	No	Yes	Yes	PCI-20202C
PCI-20204S	DSP Software Development Pkg.	No	Yes[3]	Yes	PCI-20202C
PCI-703S	*MacAdapt*	Yes	Yes	No	PCI-701C
PCI-704S	*MacExpedite*	Yes	Yes	Yes	PCI-701C (with PCI-702M)
PCI-706S	Interface for LabVIEW 2	Yes	Yes	Yes	PCI-701C (with PCI-702M)

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-20026S and PCI-20027S drivers).
(3) Drivers are supplied in the form of TMS Assembly source code.

HARDWARE COMPATIBILITY TABLE— CARRIERS

(The PCI-20006M-2 can be used in conjunction with the following hardware products.)

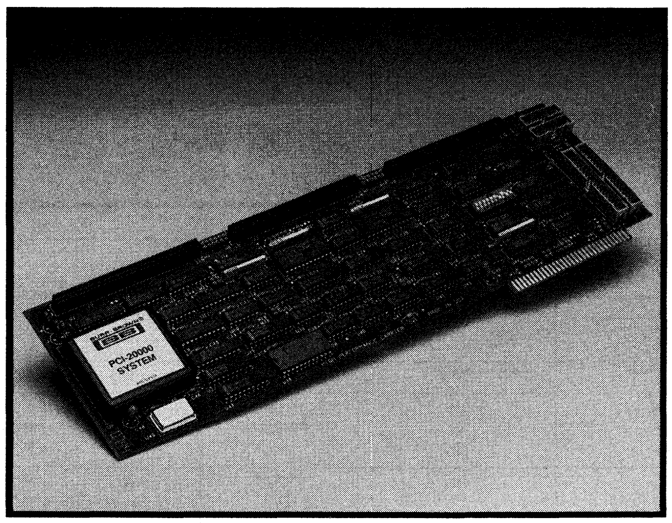
PCI MODEL NUMBER	TYPE	DESCRIPTION	BUS
PCI-20001C-2A	Carrier	General-purpose	PC/XT/AT/EISA
PCI-20041C-2A, PCI-20041C-3A	Carrier	High-performance	PC/XT/AT/EISA
PCI-20098C-1	Carrier	Multifunction	PC/XT/AT/EISA
PCI-20202C-1, PCI-20202C-2	Carrier	*Smart* processor	PC/XT/AT/EISA
PCI-701C	Carrier	Multifunction	Mac II NuBus

HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS

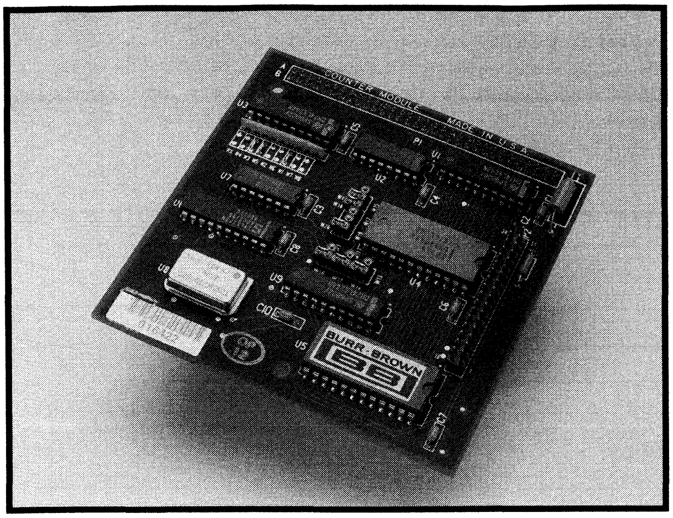
(The PCI-20006M-2 can be used in conjunction with the following hardware products.)

TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20303T-1	General Purpose	PCI-20310A-1	PCI-20308H-1, PCI-20343A-1
PCI-20024T-2	Customizer	PCI-20015A-1	PCI-20029A-1
PCI-5B01-1	Signal Conditioner[1]	PCI-20015A-1	PCI-20339A-1
Note: (1) The PCI-5B01-1 is used in conjuction with the PCI-5B39-02 block.			

For additional information, please refer to the configuration charts in the Summary Section.



The PCI-20006M-2 Adds 2 Channels of Analog Output to a PCI Carrier (PCI-20001C-2, PCI-20041C-2, PCI-20041C-3, PCI-20098C-1, PCI-20202C-1, PCI-20202C-2, or PCI-701C).



BURR-BROWN®

PCI-20007M-1

Counter/Timer/Pulse Generator Module

FEATURES

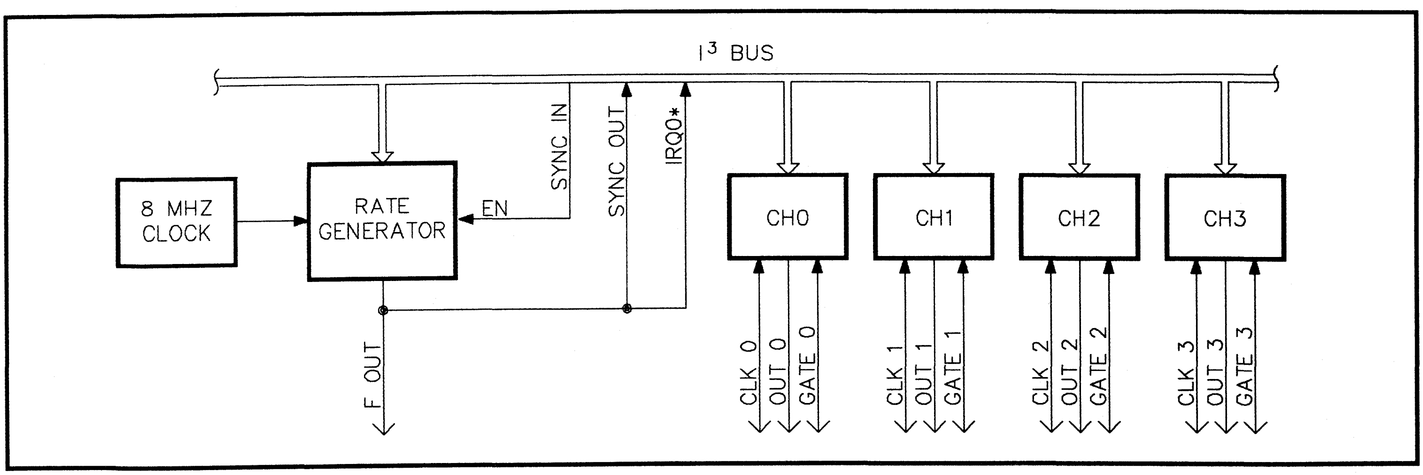
- Multifunctions
  - Timebase Generator
  - Pulse Generator
  - Event Counting, Accumulating and Decrementing
  - Frequency Measurement
- 125ns Resolution
- 0.01% Stability

DESCRIPTION

This multifunction module can perform a number of important time domain operations. A block diagram of the PCI-20007M-1 is shown below. Software control of the module provides an array of pulse-counting and generation capabilities. Based upon an accurate 8MHz crystal-controlled oscillator, the module is useful in many precision applications. These include timebase generation, event counting, accumulation and frequency measurement. The rate generator output can be linked to any other module through the I^3 Bus to perform sync or other functions.

In addition to a rate generator, the module has four independent counter/timer blocks. This allows several simultaneous tasks, including multiple input and pulse-generation functions.

All direct input and output signals are TTL compatible. Where other levels are encountered, some applications can utilize the PCI-1100 Series opto-isolators to provide logic-level conversion— for example: AC line voltage switching, or remote I/O situations where ground loop connections must be broken. Field I/O connections are usually made to external termination panels and brought to the module through ground-plane ribbon cable.



PCI-20007M-1 Module Block Diagram.

Of special significance is SYSCHECK PC, the system assurance utilities and diagnostics software package. This menu-driven product, shipped at no extra charge with each system, easily verifies proper installation and utilization of all PCI-PC system components. Not only does SYSCHECK PC greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK PC provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.

SPECIFICATIONS— PCI-20007M-1

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility		All I^3 Bus devices
I/O Configuration		4 Counters and 1 rate generator
Functions	Counters can be preset with a start value and reset when read	Count, accumulate, divide, measure frequency
Rate Generator	Pulse and square-wave outputs	
Counter Inputs		
High-Level Voltage	Minimum/Maximum	2V/5.5V
Low-Level Voltage	Minimum/Maximum	-0.5V/0.8V
I_{in}, High-Level		200μA
I_{in}, Low-Level		200μA
Range	16-bit counters	1 to 65,535
Sense	Pulse input	Low-high-low
Frequency	Maximum	8MHz
Counter Outputs(1)		
High-Level Voltage	I_{out} = Max, minimum	2.4V
Low-Level Voltage	I_{out} = Max, maximum	0.45V
Current Source	V_{out} = Low	2mA
Current Sink	V_{out} = High	-400μA
Rate Generator(1)		
High-Level Voltage	I_{out} = Max, minimum	3.4V
Low-Level Voltage	I_{out} = Max, maximum	0.5V
Current Source	V_{out} = Low	8mA
Current Sink	V_{out} = High	-400μA
Frequency	Basic Frequency	8MHz
Range	N_1 and N_2 are 16-bit integers	8MHz/ ($N_1 \cdot N_2$)
Accuracy	At +25°C	±0.008%
	Over Temp Range	±0.015%
Speed	Assembly language software	
	Read counter	230K reads/sec
	Read counter and reset	170K reads/sec
	C Language using PCI-20026S-2	
	Read counter	5300 reads/sec
Power Requirements	+5V supply	470mA max
Size	Length x Height x Thickness	3.9″ x 3.9″ x 1.3″ 9.9cm x 9.9cm x 3.3cm
Temperature Range	Module temperature	0 to 70°C

Note: (1) When the system is first powered up, the outputs of this module are NOT in a determined state until initialized by software. That is, the outputs could be "high" or "low".

SOFTWARE COMPATIBILITY TABLE

(The PCI-20007M-1 can be used with the following software in conjunction with the listed hardware.)

PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER[2]	DMA SUPPORT	CARRIERS SUPPORTED[1]
PCI-20040S	LABTECH NOTEBOOK	Yes	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20097S	LABTECH CONTROL	Yes	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20026S	General-purpose drivers	No	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20027S	High-performance drivers	No	Yes	Yes	PCI-20041C-3A
PCI-20096S	TURBO STREAM Drivers	No	Yes	Yes	PCI-20041C-3A
PCI-20204S	DSP Software Development Package	No	Yes[3]	Yes	PCI-20202C

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-20026S and PCI-20027S drivers).
(3) Drivers are supplied in the form of TMS Assembly source code.

HARDWARE COMPATIBILITY TABLE— CARRIERS

(The PCI-20007M-1 can be used in conjunction with the following hardware products.)

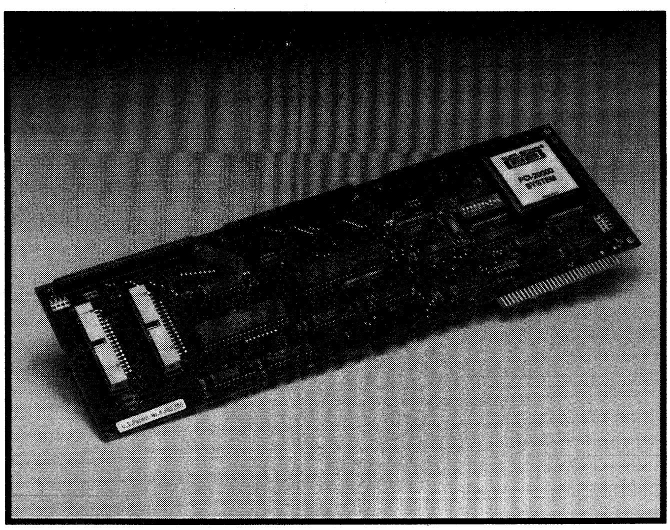
PCI MODEL NUMBER	TYPE	DESCRIPTION	BUS
PCI-20001C-2A	Carrier	General-purpose	PC/XT/AT/EISA
PCI-20041C-2A, PCI-20041C-3A	Carrier	High-performance	PC/XT/AT/EISA
PCI-20098C-1	Carrier	Multifunction	PC/XT/AT/EISA
PCI-20202C-1, PCI-20202C-2	Carrier	*Smart* processor	PC/XT/AT/EISA
PCI-701C	Carrier	Multifunction	Mac II NuBus

HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS

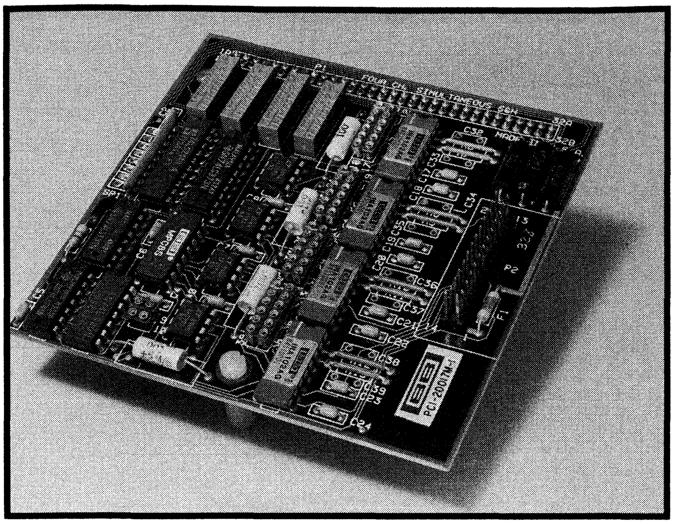
(The PCI-20007M-1 can be used in conjunction with the following hardware products.)

TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20305T-1	General-purpose	PCI-20311A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20025T-2	Customizer	PCI-20061A-1	PCI-20029A-1
PCI-20324T-1	Signal conditioner	PCI-20311A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20018T-1	Signal conditioner	PCI-20013A-1	PCI-20029A-1

For additional information, please refer to the configuration charts in the Summary Section.



The PCI-20007M-1 Adds Counter/Timer/Pulse Generator Capabilities to PCI Carriers (PCI-20001C-2, PCI-20041C-2, PCI-20041C-3, PCI-20098C-1, PCI-20202C-1, or PCI-20202C-2).



PCI-20017M-1

Simultaneous Sample/Hold Module

FEATURES

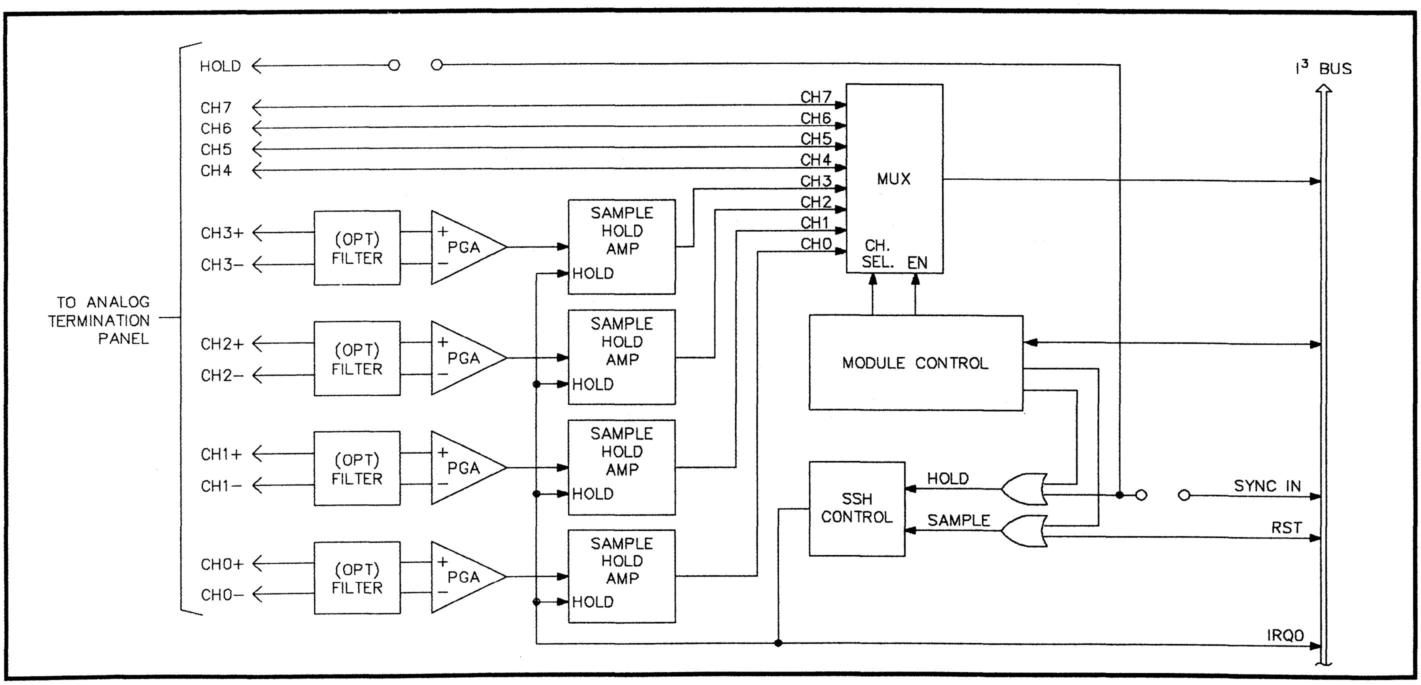
- Measures 4 Channels At The Same Time, Eliminating Time Skew Between Channels
- 20nS Channel-To-Channel Scatter
- Individual Programmable Gain Amplifiers For Each Input
- Compatible With PCI Analog Input Modules
- External Hold Input

DESCRIPTION

The PCI-20017M-1 is a four-channel simultaneous sample and hold amplifier module with built-in provisions for passive signal conditioning. A block diagram of the PCI-20017M-1 is shown below. Each of the four simultaneous channels contains a differential programmable gain amplifier. The sample/hold outputs are multiplexed (under software control) to the I^3 Bus where connections to an analog input module are made.

The simultaneous sample/hold module is useful in applications where time-skew among channels must be minimized. Since the module has an individual pre-amplifier and a sample/hold for each channel, all four inputs can be captured at the same time.

The module actually has eight inputs. The four other channels feed directly into the multiplexer without any signal processing. Thus, these additional inputs can be used to supplement the analog input channels on the A/D converter module.



PCI-20017M-1 Four-Channel Simultaneous Sample/Hold Module Block Diagram.

Of special significance is SYSCHECK, the system assurance utilities and diagnostics software package. This menu-driven product, shipped at no extra charge with each system, easily verifies proper installation and utilization of all PCI system components. Not only does SYSCHECK greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.

SPECIFICATIONS— PCI-20017M-1

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility		All I^3 Bus devices
I/O Configuration		Analog input
Number of Channels	Single-ended, straight through	4
	Differential, simultaneous	4
Input Stage$^{(1)}$	Jumper-programmable amplifier	G = 1, 10, 100, 1000
Offset Voltage		Trimmable to zero
Common-Mode Rejection	60Hz, 100Ω unbalanced	
	G = 1	70dB
	G = 10	80dB
	G = 100, 1000	90dB
Common-Mode Range	Linear response	10V (DC + peak AC)
	Without damage	15V
Bias Current		±50nA
Nonlinearity	G = 1, 10	±0.03%
	G = 100	±0.05%
	G = 1000	0.1%
Gain Error	G = 1, 10	0.1%
	G = 100	0.25%
	G = 1000	0.75%
Input Impedance		10GΩ at 20pF
Dynamic Response		
Slew Rate	G = 1 - 10	0.2V/μS
Frequency Response	Small signal	
	G = 1, ±1%	30kHz
	G = 10, ±1%	3kHz
	G = 100, ±1%	300Hz
	G = 1000, ±1%	30Hz
Settling Time	10V step, error<0.01%	
	G = 1	100μs
	G = 10, 100	130μs
	G = 1000	350μs
Sample/Holds		
Acquisition Time	Error<0.01%	6μs
Aperture Delay	Maximum	275ns
Aperture Jitter		20ns
Droop Rate		0.03mV/mS
	At 70°C	1mV/mS
Hold Step		10mV
Scan Time$^{(2)}$	Channel-to-channel, to 0.01%	
	PCI-20002M-1	35μs
	PCI-20019M-1A	15μs
Read Rate$^{(3)}$	Four-channel read including A/D conversions	41,000 channels/sec
Scatter$^{(4)}$	Channel-to-channel	20ns
Power Requirements$^{(5)}$	+15V supply	35mA max
	-15V supply	35mA max
	+5V supply	130mA max
Size	Length x Height x Thickness	3.9″ x 3.9″ x 1.3″ (9.9cm x 9.9cm x 3.3cm)
Temperature Range	Module temperature	0 to 70°C

Notes:
(1) This applies to the differential channels only.
(2) "Scan Time" is defined as the time required to select one of the four S/H channels and to read it with a given A/D converter.
(3) "Read Rate" is defined as the rate at which S/H channels can be read using the PCI-20026S/27S High Speed Read, expressed on a per-channel basis. It is assumed that all four channels hold desired data.
(4) "Scatter" is defined as the maximum differences in time required to capture all S/H channels. It is a measure of the system's "simultaneity". This is the key specification of a simultaneous S/H system.
(5) If a module is powered from a PCI Carrier, the ±15V requirements are satisfied by the carrier's DC/DC converter, and the equivalent load on the computer's +5V supply will be 550mA, maximum. This takes into account the efficiency of the DC/DC converter.

SOFTWARE COMPATIBILITY TABLE

(The PCI-20017M-1 can be used with the following software in conjunction with the listed hardware.)

PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER[2]	DMA SUPPORT	CARRIERS SUPPORTED[1]	A/D MODULES SUPPORTED[1]
PCI-20067S	DADiSP/PC	Yes	No	No	Not applicable	Not applicable
PCI-20204S	DSP Development Package	No	Yes[3]	Yes	PCI-20202C	PCI-20002M, 19M, 23M
PCI-20210S	Hypersignal-Workstation	Yes	No	No	Not applicable	Not applicable
PCI-20026S	General-purpose drivers	No	Yes	No	PCI-20001C, PCI-20041C	PCI-20002M, 19M, 23M
PCI-20026S	General-purpose drivers	No	Yes	No	PCI-20098C	
PCI-20027S	High-performance drivers	No	Yes	No	PCI-20001C, PCI-20041C	PCI-20002M, 19M, 23M
PCI-20027S	High-performance drivers	No	Yes	No	PCI-20098C	
PCI-703S	*MacAdapt*	Yes	Yes	No	PCI-701C	
PCI-706S	Interface for LabVIEW 2	Yes	Yes	No	PCI-701C	PCI-20023M

Notes: (1) When model number are shown without "dash" numbers, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-20026S and PCI-20027S drivers).
(3) Drivers are supplied in the form of TMS Assembly source code.

HARDWARE COMPATIBILITY TABLE— CARRIERS AND MODULES

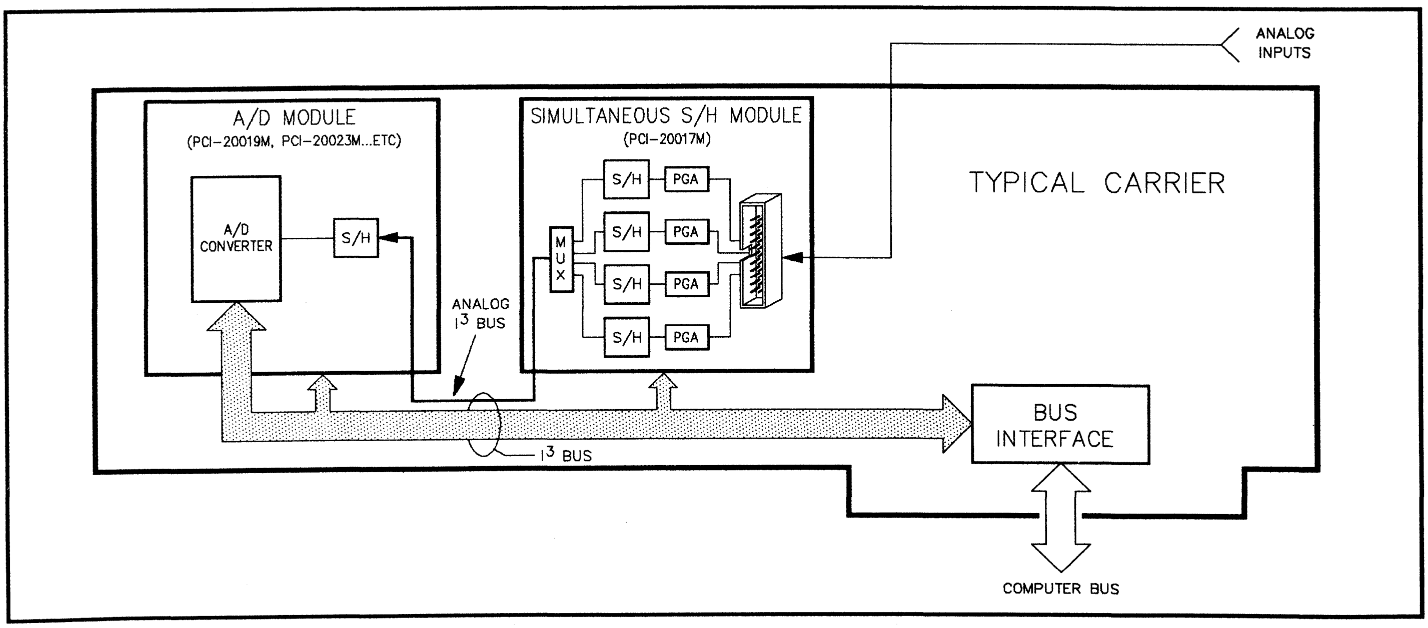
(The PCI-20017M-1 can be used in conjunction with the following hardware products.)

PCI MODEL NUMBER	TYPE	DESCRIPTION	BUS
PCI-20001C-2A	Carrier	General-purpose	PC/XT/AT/EISA
PCI-20041C-2A, PCI-20041C-3A	Carrier	High-performance	PC/XT/AT/EISA
PCI-20098C-1	Carrier	Multifunction	PC/XT/AT/EISA
PCI-20202C-1, PCI-20202C-2	Carrier	*Smart* processor	PC/XT/AT/EISA
PCI-701C	Carrier	Multifunction	Mac II NuBus
PCI-20002M-1	Module	Analog input, 12-bit, general-purpose	I^3
PCI-20019M-1A	Module	Analog input, 12-bit, high-speed	I^3
PCI-20023M-1	Module	Analog input, 12-bit, high-speed	I^3

HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS

(The PCI-20017M-1 can be used in conjunction with the following hardware products.)

TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20303T-1	General-purpose	PCI-20310A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20024T-2	Customizer	PCI-20015A-1	PCI-20029A-1



Modules Such as the Simultaneous Sample/Hold and the Analog Input Expander Interconnect Through the I^3 Bus to an Input Circuit Module Containing an A/D Converter. The Input Circuit Can Be in the Form of an On-board Feature (PCI-20098C-1, etc.) or a Separate Module (PCI-20019M-1A, PCI-20023M-1, etc.).

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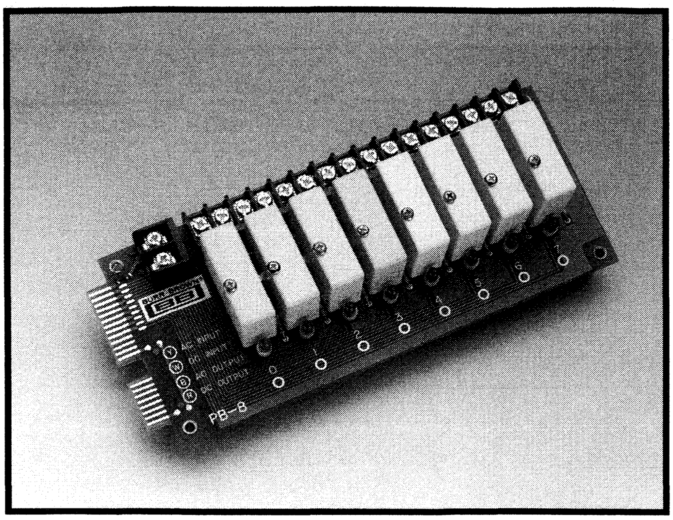


PCI-20018T-1

Isolated Digital Termination Panel

FEATURES

- 8-Channel Capacity
- Screw Terminals Provide For Easy Field Wiring Connections
- Can Be Used For Either Input Or Output Functions
- LEDs Indicate Channel Status
- Compatible With PCI-1100 Series Opto-Blocks
  - — Converts High-Level Signals To TTL
  - — Provides Isolation and Power Handling Capabilities
  - — Switches Up To 60VDC and 240VAC At 3A

DESCRIPTION

The PCI-20018T-1 is an eight-channel digital signal termination panel that accepts a separate PCI-1100 Series opto-block for each channel. This feature allows complete I/O flexibility. Various combinations of the different opto-blocks can be inter-mixed on one panel. However, all eight channels on this panel must contain only input or output blocks. Inputs and outputs cannot be mixed on this panel. Refer to the PCI-20048T-1 or PCI-20324T-1 for larger or mixed I/O applications.

The termination panel is divided into identical circuit patterns, each being associated with a plug-in opto-block and a set of two screw-terminals at the edge of the panel. Field connections are made to the panel via the screw-terminals. When used with a PCI board, carrier or module, the interconnecting cable brings +5V to the termination panel. Up to 250mA is available to power opto-blocks and the LED channel status indicators. Separate terminals are provided for the connection of an external power supply if this is desired. A 50-pin card-edge connector allows connection to other parts of the PCI system. This panel is compatible with the PCI-20013A Series cables.

The PCI-20013A Series cables are built with ground-plane type flat ribbon wire and are intended for either digital input or output use. Included in this category are counter/timer functions. The ground-plane minimizes cable inductance while reducing electrostatic and electromagnetic emissions. All ground-plane cables have the ground-plane connected at one end only to avoid ground loops.

The physical size of the PCI-20018T-1 panel is 8" x 3.5" x 2.1" (20.3cm x 8.9cm x 5.3cm). This height includes the height of the PCI-1100 series opto-blocks. The board itself is 1.4" (3.6cm) high. Up to four panels can be mounted in a PCI-20029A-1 enclosure. This enclosure can accommodate most combinations of both analog and digital panels in a table-top or 19-inch rack-mount configuration. The height and depth of the PCI-20029A-1 are 10.45 inches and 2.5 inches, respectively.

Various cable and connector manufacturers place marks or codes to indicate the location of wire or pin number 1. When using ANY PCI system, these codes or marks should be IGNORED. The correct wire and pin designations are described in the PCI user manuals. For those who wish to make their own cables, here are the mating connectors:

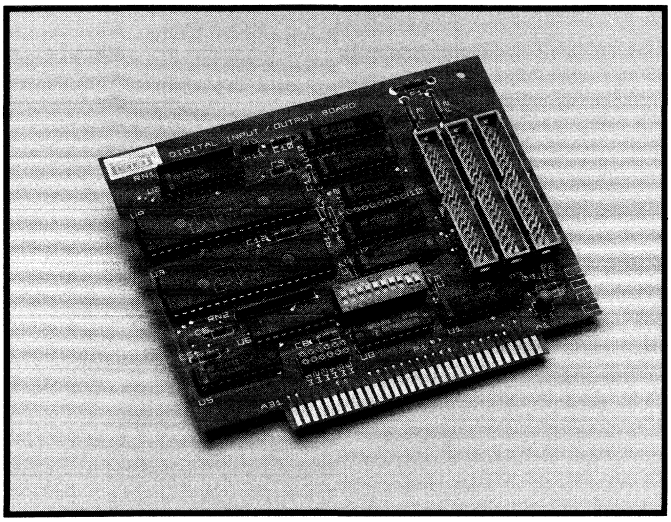
For Termination Panel	T&B Ansley #609-5015M
For Board, Carrier, or Module	T&B Ansley #609-3430

COMPATIBILITY TABLE— OPTICALLY ISOLATED TERMINATION PANELS

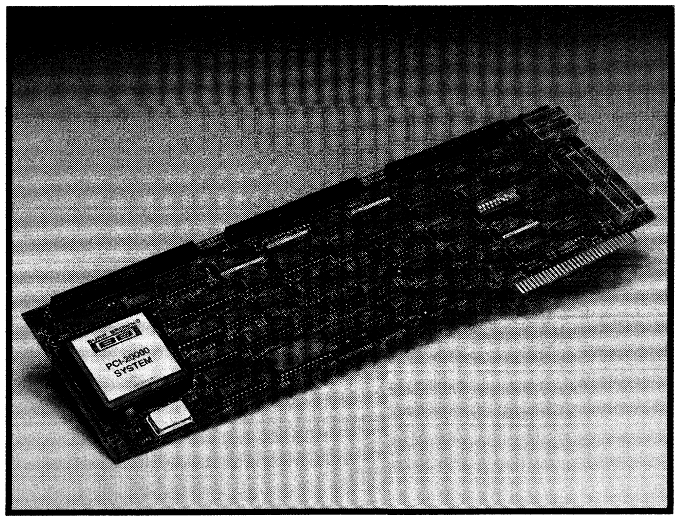
PCI MODEL NUMBER	TYPE[2]	NUMBER OF CHANNELS	DESCRIPTION	CARRIERS[1]	MODULES[1]	BOARDS
PCI-20013A-1	Cable	8	6-foot Ground Plane	PCI-20001C-2A, PCI-20041C	PCI-20004M, PCI-20007M	PCI-20087W-1
PCI-20013A-2	Cable	8	12-foot Ground Plane	PCI-20001C-2A, PCI-20041C	PCI-20004M, PCI-20007M	PCI-20087W-1
PCI-20029A-1	Enclosure	Up to 32	19-inch Rack/Table Mount			
PCI-1101	Block	1	AC/DC Input, 32V			
PCI-1102	Block	1	AC/DC Input, 120V			
PCI-1103	Block	1	DC Output, 60V			
PCI-1104	Block	1	AC Output, 120V			
PCI-1105	Block	1	AC/DC Input, 240V			
PCI-1106	Block	1	AC Output, 240V			

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) Up to eight blocks can plug into one PCI-20018T-1.

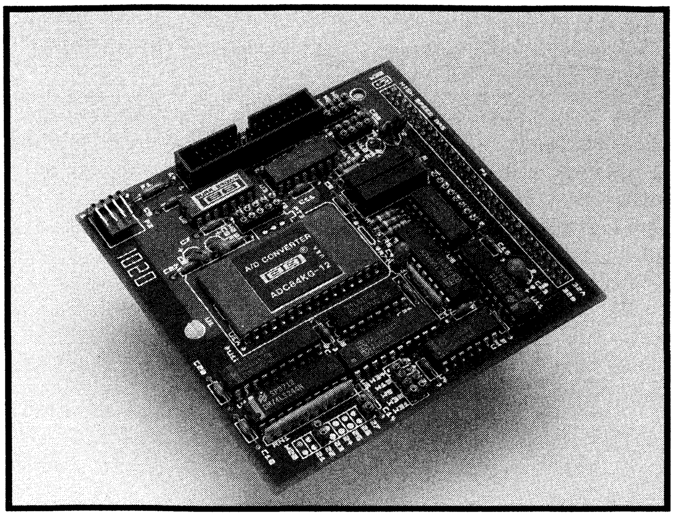
For additional information, please refer to the configuration charts in the Summary Section.



The PCI-20018T-1 Is Compatible with All PCI Products Having a Standard DI/O Connector (36-Pin). This Includes the PCI-20087W-1 Board.



The PCI-20018T-1 Is Also Compatible with the DI/O Ports on Many PCI Carriers. These Include the PCI-20001C-2, PCI-20041C-2, and PCI-20041C-3.



BURR-BROWN®

PCI-20019M-1A

High-Speed Analog Input Module

FEATURES

- Up To 89kHz Throughput Rate
- Eight-Channel Input
- Hardware and Software Trigger Capability
- Automatic Channel Advance

DESCRIPTION

The PCI-20019M-1A is a high-speed, 12-bit data acquisition module. Eight single-ended input channels are provided. This module is intended for high-level signals. The combination of a high-speed sample/hold and A/D converter provides for input sampling at up to 89,000 channels/second.

The full-scale input range can be jumper-selected for 0 to +5V, 0 to +10V, ±2.5V, ±5V or ±10V. Internal hardware can configure the module to automatically increment channels after each "start convert". This feature greatly reduces the computer's software burden and results in increased speed. Conversions may be started from either an internal or external signal, upon reading the previous conversion, or by software command.

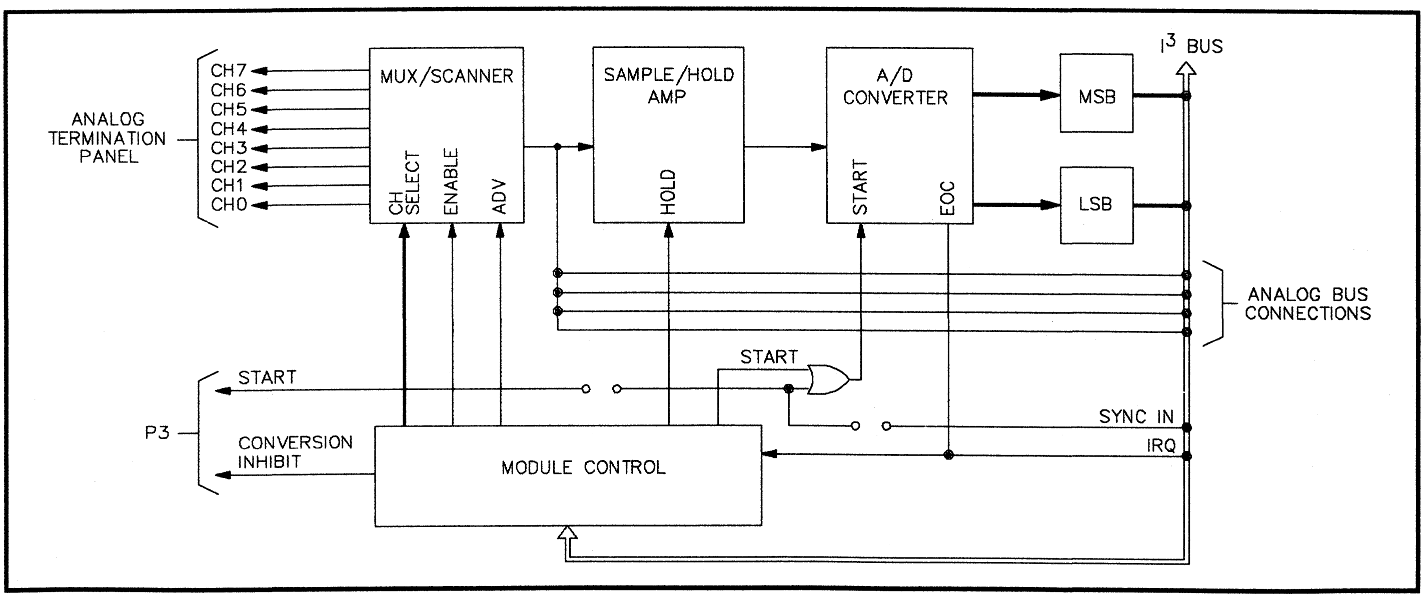
Additional input channels can be obtained by using the optional PCI-20031M-1 Expansion Module. Each expander adds 32 channels. The PCI-20019M-1A is also compatible with the PCI-20017M-1 Simultaneous Sample/Hold Module and with the PCI-20020M-1 Trigger/Alarm Module.

The Trigger/Alarm Module adds two unique functions when used in conjunction with a companion analog input product such as the PCI-20019M-1A Module:

a) Establishes a trigger on a given analog signal level and slope. The response time is within 3.5μS.

b) Ensures reliable analog triggering at high speeds.

The definition of high-speed depends upon the particular application and acquisition mode employed. An accurate timebase is usually used to pace the acquisition process. This start-convert signal (a



PCI-20019M-1A Module Block Diagram.

hardware pulse) can come from an external source or directly from an internal PCI Rate/Burst Generator. Each successive pulse will start a new conversion and advance the input multiplexer to the next channel to be read. In all cases it is very important that the first pulse does not reach the multiplexer (or multiplexers) until the system has had enough time to be initialized and is ready to read the A/D converter. If this rule is violated, "channel rotation" can occur. Channel rotation refers to the situation where the indicated channel and the recorded data are out of step (for example: the data for channels 2, 3, 4, 5, ... is reported as corresponding to channels 4, 5, 6, ...). The Trigger/Alarm Module is ideal for avoiding this state. By gating the pacing signal through the Trigger/Alarm Module it is easy to ensure the correct timing conditions.

"Capturing and Analyzing Transient Waveforms With A Personal Computer" is the title of an Applications Note that demonstrates the use of the Trigger/Alarm function with a high-speed analog input. This and other Application Notes can be found in Section 5 of this Handbook.

Of special significance is SYSCHECK PC, the system assurance utilities and diagnostics software package. This menu-driven product, shipped at no extra charge with each system, easily verifies proper installation and utilization of all PCI-PC system components. Not only does SYSCHECK PC greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK PC provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.

SOFTWARE COMPATIBILITY TABLE

(The PCI-20019M-1A can be used with the following software in conjunction with the listed hardware.)

PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER[2]	DMA SUPPORT	CARRIERS SUPPORTED[1]	EXPANSION MODULES SUPPORTED
PCI-20040S	LABTECH NOTEBOOK	Yes	Yes	No	PCI-20001C, PCI-20041C	
PCI-20097S	LABTECH CONTROL	Yes	Yes	No	PCI-20001C, PCI-20041C	
PCI-20068S	SNAP-Series	Yes	Yes	No	PCI-20001C, PCI-20041C	PCI-20031M-1
PCI-20068S	SNAP-Series	Yes	Yes	Yes	PCI-200041C-3	PCI-20031M-1
PCI-20067S	DADiSP/PC	Yes	No	No		
PCI-20210S	Hypersignal-Workstation	Yes	Yes	No	PCI-20202C	PCI-20031M-1
PCI-20026S	General-purpose drivers	No	Yes	No	PCI-20001C, PCI-20041C	PCI-20031M-1
PCI-20027S	High-performance drivers	No	Yes	No	PCI-20001C, PCI-20041C	PCI-20031M-1
PCI-20027S	High-performance drivers	No	Yes	Yes	PCI-20041C-3	PCI-20031M-1
PCI-20096S	TURBO STREAM Drivers	No	Yes	Yes	PCI-20041C-3	PCI-20031M-1
PCI-20203S	DSP Library Plus Series	No	Yes	Yes	PCI-20202C	
PCI-20204S	DSP Software Development Package	No	Yes[3]	Yes	PCI-20202C	PCI-20031M-1

Notes: (1) When model numbers are shown without dash" numbers, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If is does not, then the user must provide hardware control (for example, using PCI-20026S and PCI-20027S drivers).
(3) Drivers are supplied in the form of TMS Assembly source code.

HARDWARE COMPATIBILITY TABLE— CARRIERS

(The PCI-20019M-1A can be used in conjunction with the following hardware products.)

				MAXIMUM NUMBER OF CHANNELS			
				WITH ONE PCI-20031M		WITH TWO PCI-20031M-1s	
PCI MODEL NUMBER	TYPE	DESCRIPTION	BUS	SOFTWARE SELECTION[1]	HARDWARE SELECTION[2]	SOFTWARE SELECTION[1]	HARDWARE SELECTION[2]
PCI-20001C-2A	Carrier	General-purpose	PC/XT/AT	40	32	72	64
PCI-20041C-2A, PCI-20041C-3A	Carrier	High-performance	PC/XT/AT	40	32	72	64
PCI-20202C-1/-2	Carrier	*Smart* processor	PC/XT/AT	40	32	Not applicable	Not applicable

Notes: (1) If the channel selection is made under software control.
(2) If the channel selection is made under hardware control (automatic channel sequencing). As an example, if used under DMA.

HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS

(The PCI-20019M-1A can be used in conjunction with the following hardware products.)

TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20303T-1	General-purpose	PCI-20310A-1	PCI-20308H-1, PCI-20343A-1
PCI-20024T-2	Customizer	PCI-20015A-1	PCI-20029A-1
PCI-5B01-1	Signal conditioner	PCI-20015A-1	PCI-20339A-1
PCI-20042T-1	Signal conditioner	PCI-20012A-1	PCI-20029A-1
PCI-20044T-1	Signal conditioner	PCI-20012A-1	PCI-20029A-1

SPECIFICATIONS— PCI-20019M-1A

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility		All I^3 Bus devices
I/O Configuration		Analog input
Number of Channels	Single-ended	Eight
Input		
Offset Voltage		Trimmable to zero
Impedance		1MΩ at 35pf
Voltage Range	Linear	±10V
	Without damage	20V above supplies
Bias Curret		100nA
Noise		±1LSB
Crosstalk	Channel-to-channel @ 1kHz, 1KΩ source impedance	0.2LSb (-90dB)
A/D Converter		
Resolution		12-bit
Code	Unipolar	Complementary binary
	Bipolar	Complementary offset binary
Linearity Error		±0.5LSB
Gain Accuracy		Trimmable to zero
Ranges		0-5V, 0-10V, ±2.5V, ±5V, ±10V
Dynamic Response		
Mux Settling Time	Within 0.01%, maximum	3.5μs(1)
Conversion Time	A/D, maximum	10μs
Aperture Jitter	Sample to hold time uncertainty	0.3ns
Acquisition Time	S/H, maximum	1.5μs
Total Convert Time		11.25μs
Throughput Rate		89K samples/sec
Source Impedance, Maximum Recommended	PCI-20019M-1A alone at 89kHz	3K ohms
For 1 LSB Accuracy	PCI-20019M-1A plus PCI-20031M at 89kHz	1K ohms
Power Requirements[2]	+15V supply	65mA maximum
	-15V supply	50mA maximum
	+5V supply	385mA maximum
Physical	Length x Height x Thickness	3.9″ x 3.9″ x 1.3″ (9.9cm x 9.9cm x 3.3cm)
Temperature Range	Module temperature	0 to +70°C

Notes:
(1) Normaliy, mux settling time need not be added to the other components of "total convert time". The software can be arranged so that channel selection (mux transfer) takes place during the A/D conversion cycle (after the S/H captures the signal). The PCI-20026S/27S software drivers perform this task automatically.
(2) If a module is powered from a PCI Carrier, the ±15V requirements are satisfied by the carrier's DC/DC converter, and the equivalent load on the computer's +5V supply will be 1075mA, maximum. This takes into account the efficiency of the DC/DC converter.

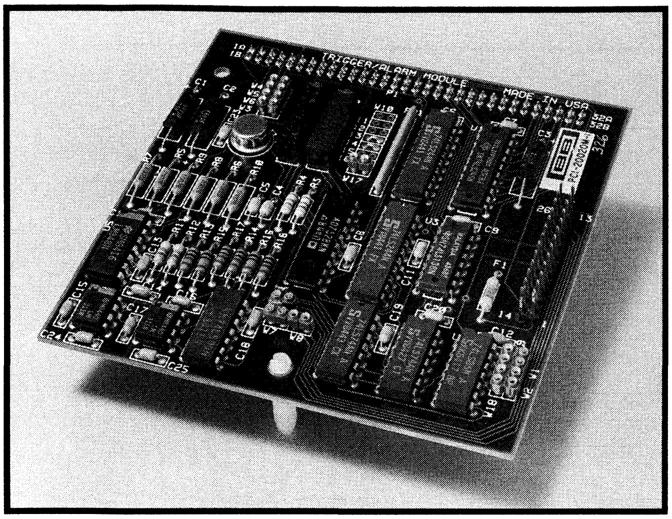
DYNAMIC PERFORMANCE— IN TYPICAL PC/XT/AT/EISA CARRIER-BASED INSTALLATION

All specifications are typical at +25°C unless otherwise noted.

CONDITIONS[2]	PC/XT/AT/EISA COMPATIBLE COMPUTERS	
	80286 AT 12MHz	**80386 AT 16MHz**
Installed on a PCI-20041C-3A Carrier		
PCI-20019M-1A alone, using DMA	89kHz	89kHz
Adding PCI-20031M-1 using DMA	89kHz	89kHz
Installed on any PCI PC/XT/AT/EISA Compatible Carrier[1]		
PCI-20019M-1A with PCI-20020M-1 without DMA	89kHz	89kHz
Adding PCI-20031M-1 and PCI-20020M-1 without DMA	89kHz	89kHz
Installed on any PCI PC/XT/AT/EISA Compatible Carrier[1]		
PCI-20019M-1A alone, without DMA, S/W pacer	55kHz	60kHz
Adding PCI-20031M-1, without DMA, S/W pacer	45kHz	50kHz

Notes:
(1) PC/XT/AT/EISA Compatible Carrier Families include: PCI-20001C, PCI-20041C and PCI-20098C.
(2) Data derived from measurements using PCI-20026S and PCI-20027S software in modes 3 or 4 as applicable.

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20020M-1

Trigger/Alarm Module

FEATURES

- Ensures Reliable Triggering At High Speeds
- Triggers On High, Low Or Window Comparisons
- Software Programmable Thresholds
- 3.5μsec Response Time (Max)

DESCRIPTION

The PCI-20020M-1 Trigger/Alarm Module adds two unique functions when used in conjunction with a companion analog input product (PCI-20098C-1 or PCI-701C Carriers and PCI-20019M-1A, PCI-20023M-1 or PCI-20341M-1 Modules):

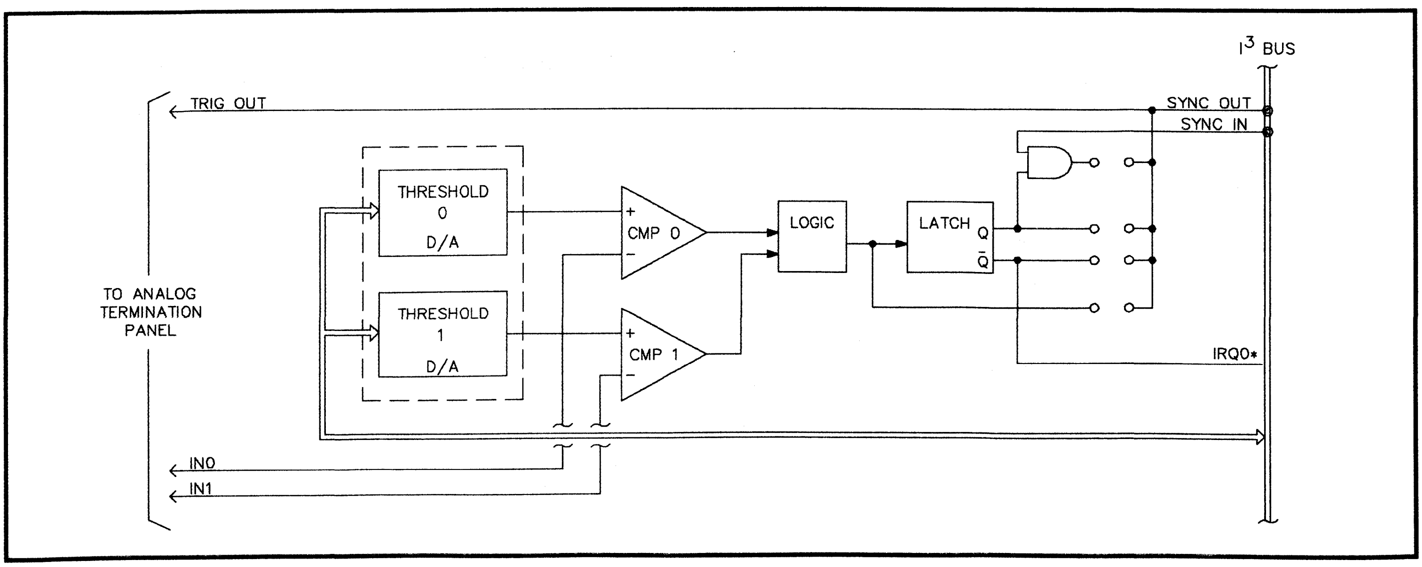
a) Establishes a trigger on a given analog signal level and slope. The response time is within 3.5μS.

b) Ensures reliable analog triggering at high speeds.

These features are well suited to oscilloscope, test and fault detection applications.

The definition of high speed depends upon the particular application and acquisition mode employed. An accurate timebase is usually used to pace the acquisition process. This start convert signal (a hardware pulse) can come from an external source or directly from an internal PCI Rate/Burst Generator. Each successive pulse will start a new conversion and advance the input multiplexer (or multiplexers) until the system has had enough time to be initialized and is ready to read the A/D converter. If this rule is violated, "channel rotation" can occur. Channel rotation refers to the situation where the indicated channel and the recorded data are out of step (for example: the data for channels 2, 3, 4, 5, ... is reported as corresponding to channels 4, 5, 6, ...). The Trigger/Alarm Module is ideal for avoiding this state. By gating the pacing signal through the Trigger/Alarm Module it is easy to ensure the correct timing conditions.

"Capturing and Analyzing Transient Waveforms With A Personal Computer" and "Synchronization and Triggering of Data Acquisition Processes" are the titles of Application Notes that



PCI-20020M-1 Module Block Diagram.

demonstrate the use of the trigger/alarm function. These and other Application Notes can be found in Section 5 of this Handbook.

The PCI-20020M-1 Trigger/Alarm module can monitor 1 or 2 analog channels and will generate a digital output when pre-programmed conditions are satisfied. A block diagram is shown below. Thresholds in the range of ±10V can be programmed with 8-bit (78mV) resolution. A trigger can be initiated on one of the following conditions:

Input BELOW limit,
Input ABOVE limit,
Input BETWEEN limits, or
Input OUTSIDE limits.

A pair of D/A converters and comparators are provided to perform the above functions. In the window modes (inputs Between or Outside), both comparators are connected to a single input. In all modes of operation the comparator outputs are combined with logic to produce a single output. The module can be programmed to trigger on true or false conditions. To minimize any oscillations or erroneous triggering, the comparators are designed with approximately 25mV of hysteresis. Both of the individual D/A converter and comparator outputs are available for external use.

Jumper options select the mode of operation, gating of the digital output and whether or not the output is latched. Once latched, the alarm indication will remain until cleared by software.

Of special significance is SYSCHECK, the system assurance utilities and diagnostics software package. This menu-driven product, shipped at no extra charge with each system, easily verifies proper installation and utilization of all PCI system components. Not only does SYSCHECK greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.

SPECIFICATIONS— PCI-20020M-1

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility		I^3 Bus devices
I/O Configuration	Analog or digital inputs	Trigger/alarm
Number of Channels	Level compare	2
	Window compare	1
Sync Output(1)	Jumper programmable	Follow/latched, gated sync in
Analog Outputs(1)		Both references and comparators
Comparators		2
Input Range	Linear	±10V
	Without damage	±15V
Bias Current		300na
Offset Voltage	Maximum	±7.5mV
Hysteresis		25mV
References	D/A converters	2
Resolution		8-bit
Step Size	Minimum increment	78.1mV
Code		Offset binary
Input Range	Maximum	-10V to 9.92V
Linearity		±1/2LSB
Response Time	Input to sync output, max	3.5μs
Power Requirements(2)	+15V supply	35mA max
	-15V supply	25mA max
	+5V supply	265mA max
Size	Length x Height x Thickness	3.9″ x 3.9″ x 1.3″ (9.9cm x 9.9cm x 3.3cm)
Temperature Range	Module temperature	0 to +70°C

Notes: (1) When the system is first powered up, the outputs of this module are NOT in determined states until initialized by software. That is, the analog outputs could be any value between ±10V, and the digital outputs could be either "high" or "low".
(2) If a module is powered from a PCI carrier, the ±15V requirements are satisfied by the internal DC/DC converter, and the equivalent load on the computer's +5V supply will be 625mA, maximum. This takes into account the efficiency of the DC/DC converter.

SOFTWARE COMPATIBILITY TABLE

(The PCI-20020M-1 can be used with the following software in conjunction with the listed hardware.)

PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER[2]	DMA SUPPORT	CARRIERS SUPPORTED[1]
PCI-20068S	SNAP-Series	Yes	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20068S	SNAP-Series	Yes	Yes	Yes	PCI-20041C, PCI-20098C
PCI-20026S	General-purpose drivers	No	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20027S	High-performance drivers	No	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20027S	High-performance drivers	No	Yes	Yes	PCI-20041C-3A, PCI-20098C
PCI-20096S	TURBO STREAM Drivers	No	Yes	Yes	PCI-20041C-3A, PCI-20098C
PCI-703S	*MacAdapt*	Yes	Yes	No	PCI-701C
PCI-704S	*MacExpedite*	Yes	Yes	Yes	PCI-701C (with PCI-702M)
PCI-706S	Interface to LabVIEW 2	Yes	Yes	Yes	PCI-701C (with PCI-702M)

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-20026S and PCI-20027S drivers).

HARDWARE COMPATIBILITY TABLE— CARRIERS AND MODULES

(The PCI-20020M-1 can be used in conjunction with the following hardware products.)

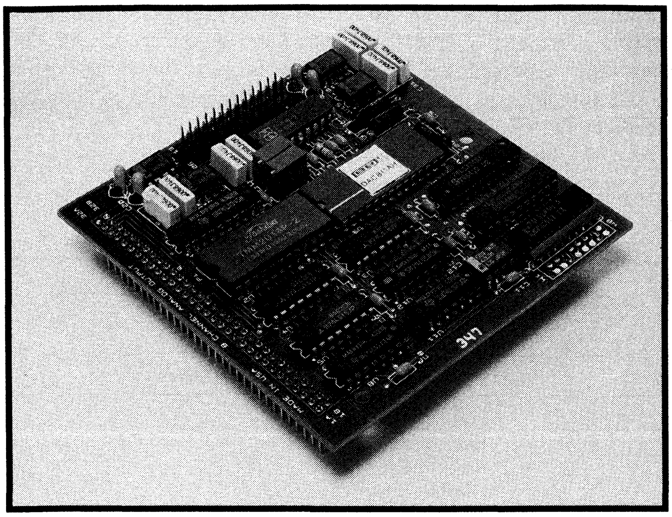
PCI MODEL NUMBER	TYPE	DESCRIPTION	BUS
PCI-20001C-2A	Carrier	General-purpose	PC/XT/AT/EISA
PCI-20041C-2A, PCI-20041C-3A	Carrier	High-performance	PC/XT/AT/EISA
PCI-20098C-1	Carrier	Multifunction	PC/XT/AT/EISA
PCI-20202C-1, PCI-20202C-2	Carrier	*Smart* processor	PC/XT/AT/EISA
PCI-701C	Carrier	Multifunction	Mac II NuBus
PCI-20019M-1A	Module	High-speed analog input	I[3]
PCI-20023M-1	Module	Very high-speed analog input	I[3]
PCI-20031M-1	Module	Analog expander	I[3]
PCI-20341M-1	Module	High-resolution analog input	I[3]

HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS

(The PCI-20020M-1 can be used in conjunction with the following hardware products.)

TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20303T-1	General-purpose	PCI-20310A-1	PCI-20308H-1, PCI-20343A-1
PCI-20024T-2	Customizer	PCI-20015A-1	PCI-20029A-1

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20021M-1B

8-Channel Analog Output Module

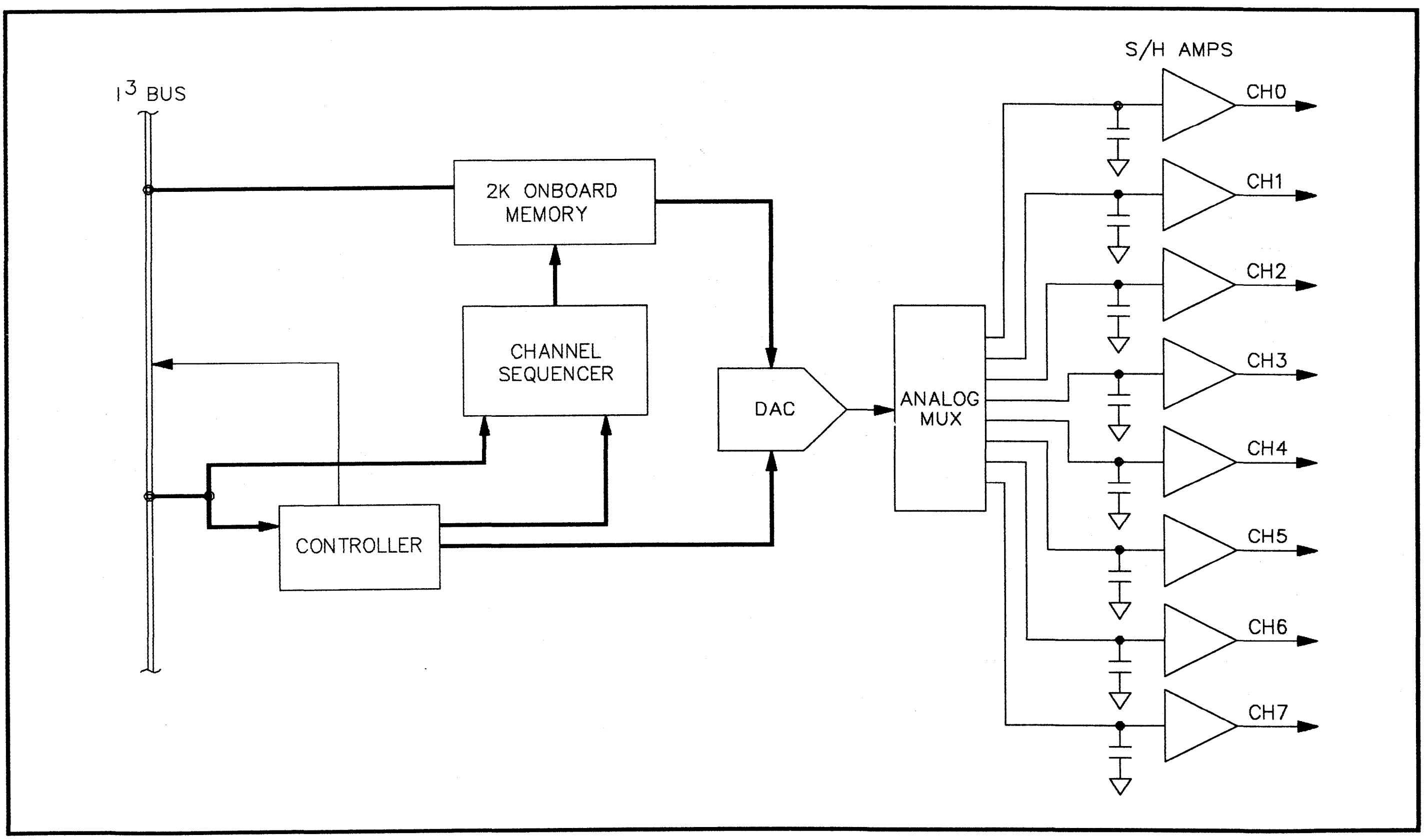
FEATURES

- 8 Channels
- 12-Bit Resolution
- 1/2LSB Linearity
- 500μs Settling Time

DESCRIPTION

The PCI-20021M-1B Analog Output Module generates eight 12-bit voltage outputs. Either a ±5V or a ±10V full-scale range can be selected by the user.

A multiplexed, dynamic refreshing technique is utilized. On-board memory holds the digital equivalents of the desired output voltages, which are consecutively read by a single digital-to-analog converter (D/A). The eight resulting analog signals are then multiplexed into separate sample/hold amplifiers. On-board circuitry automatically scans and converts the data to refresh the output channel values. Each channel can be addressed as if the module contained separate D/As.



PCI-20021M-1B Module Block Diagram.

Of special significance is SYSCHECK, the system assurance utilities and diagnostics software package. This menu-driven product, shipped at no extra charge with each system, easily verifies proper installation and utilization of all PCI system components. Not only does SYSCHECK greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.

SPECIFICATIONS— PCI-20021M-1B

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility		All I^3 Bus devices
Configuration Range **Number of Channels** **Resolution** **Code**	 Jumper selectable	Analog output ±5V, ±10V Eight 12-bit Offset binary
Linearity		±1/2LSB
Gain Accuracy		±1/2LSB
Offset		±2mV
Output Stage Current Impedance	 At 2kHz	 ±1mA 1Ω
Settling Time		500μs
Refresh Time	8-channel cycle	128μs
Conversion Rate		2kHz
Noise	DC to 10kHz, maximum	±1LSB
Feedthrough	Channel-to-channel	±1LSB
Power Requirements(1)	+15V supply -15V supply +5V supply	43mA max 50mA max 569mA max
Size	Length x Height x Thickness	3.9" x 3.9" x 1.3" (9.9cm x 9.9cm x 3.3cm)
Temperature Range	Module temperature	0 to +70°C

Note: (1) If a module is powered from a PCI Carrier, the ±15V requirements are satisfied by the carrier's DC/DC converter, and the equivalent load on the computer's +5V supply will be 1127mA, maximum. This takes into account the efficiency of the DC/DC converter.

SOFTWARE COMPATIBILITY TABLE

(The PCI-20021M-1B can be used with the following software in conjunction with the listed hardware.)

PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER	DMA SUPPORT	CARRIERS SUPPORTED[1]
PCI-20040S	LABTECH NOTEBOOK	Yes	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20097S	LABTECH CONTROL	Yes	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20068S	SNAP-Series	Yes	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20026S	General-purpose Drivers	No	Yes	No	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20027S	High-performance Drivers	No	Yes	Yes	PCI-20041C-3A
PCI-20096S	TURBO STREAM Drivers	No	Yes	Yes	PCI-20041C-3A
PCI-20204S	DSP Software Development Pkg.	No	Yes[2]	Yes	PCI-20202C
PCI-703S	*MacAdapt*	Yes	Yes	No	PCI-701C
PCI-704S	*MacExpedite*	Yes	Yes	Yes	PCI-701C (with PCI-702M)
PCI-706S	Interface to LabVIEW 2	Yes	Yes	Yes	PCI-701C (with PCI-702M)

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) Drivers are supplied in the form of TMS Assembly source code.

HARDWARE COMPATIBILITY TABLE— CARRIERS

(The PCI-20021M-1B can be used in conjunction with the following hardware products.)

PCI MODEL NUMBER	TYPE	DESCRIPTION	BUS
PCI-20001C-2A	Carrier	General-purpose	PC/XT/AT/EISA
PCI-20041C-2A, PCI-20041C-3A	Carrier	High-performance	PC/XT/AT/EISA
PCI-20098C-1	Carrier	Multifunction	PC/XT/AT/EISA
PCI-20202C-1, PCI-20202C-2	Carrier	*Smart* processor	PC/XT/AT/EISA
PCI-701C	Carrier	Multifunction	Mac II NuBus

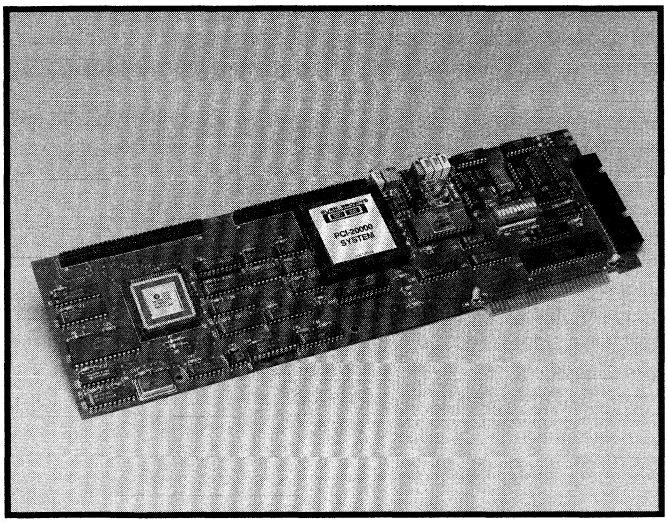
HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS

(The PCI-20021M-1B can be used in conjunction with the following hardware products.)

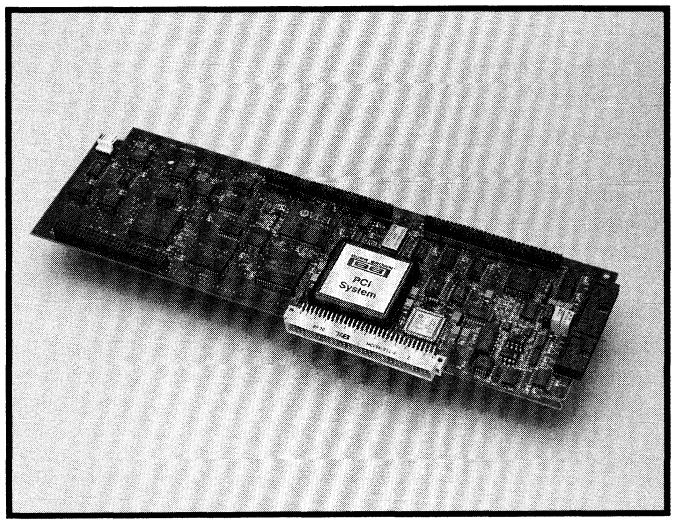
TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20303T-1	General-purpose	PCI-20310A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20024T-2	Customizer	PCI-20015A-1	PCI-20029A-1
PCI-5B01-1	Signal conditioner[1]	PCI-20015A-1	PCI-20339A-1

Note: (1) The PCI-5B01-1 is used in conjunction with PCI-5B39-02 blocks.

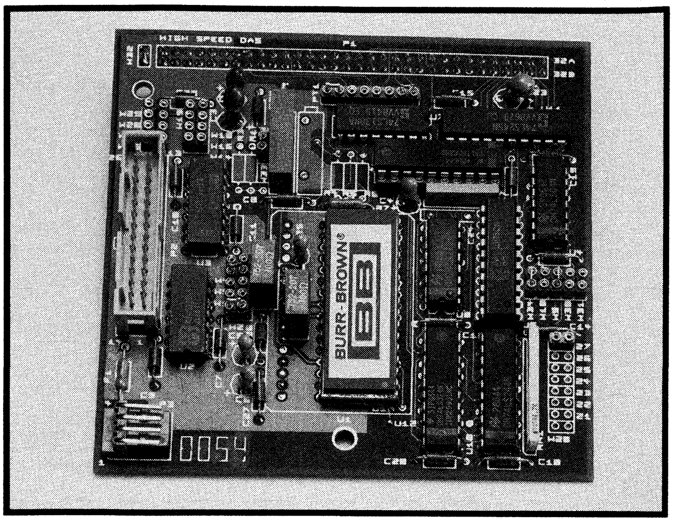
For additional information, please refer to the configuration charts in the Summary Section.



Each PCI-20021M-1B Can Add 8 Channels of Analog Output to Any of the PC-based Carriers (PCI-20001C-2, PCI-20041C-2, PCI-20041C-3, PCI-20098C-1, PCI-20202C-1, or PCI-20202C-2).



PCI-20021M-1B Can Also Be Used with the PCI-701C *NuCarrier* for the Mac II NuBus.



BURR-BROWN®

PCI-20023M-1

High-Speed Analog Input Module

FEATURES

- Up To 180kHz Throughput Rate
- Eight-Channel Input
- Hardware and Software Trigger Capability
- Automatic Channel Advance

DESCRIPTION

The PCI-20023M-1 is a high-speed, 12-bit data acquisition module. Eight single-ended input channels are provided. This module is intended for high-level signals. The combination of a high-speed sample/hold and A/D converter provides for input sampling up to 180,000 channels/second.

The full-scale input range can be jumper-selected for 0 to +10V, ±5V, or ±10V. Internal hardware can configure the module to automatically increment channels after each "start convert". This feature greatly reduces the computer's software burden and results in increased speed. Conversions may be started from either an internal or external signal, upon reading the previous conversion, or by software command.

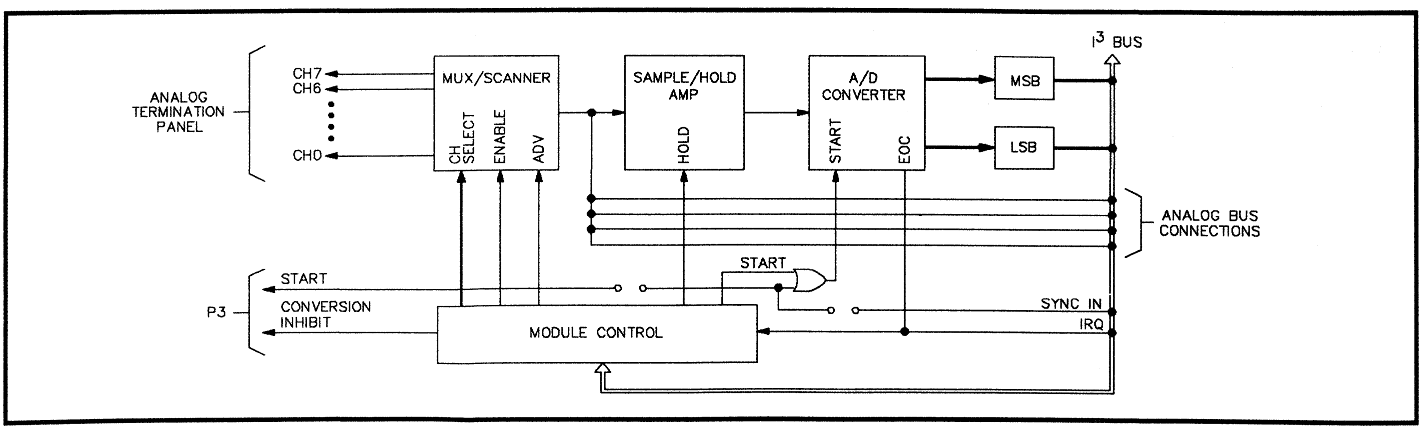
Additional input channels can be obtained by using the optional PCI-20031M-1 Expansion Module. Each expander adds 32 channels. The PCI-20023M-1 is also compatible with the PCI-20017M-1 Simultaneous Sample/Hold Module and with the PCI-20020M-1 Trigger/Alarm Module.

The Trigger/Alarm Module provides two unique functions when used in conjunction with a companion analog input product such as the PCI-20023M-1 Module:

a) Establishes start-of-conversion on a given analog signal level and slope within 3.5μsec.

b) Ensures reliable triggering at high speeds.

The definition of high speed depends upon the particular application and the acquisition mode employed. An accurate timebase is usually used to pace the acquisition process. This start-convert signal (a hardware pulse) can come from an external source or directly from an internal PCI Rate/Burst Generator. Each successive pulse will start a new conversion and advance the input multiplexer to the next channel to be read. In all cases it is very important that the first pulse does not reach the multiplexer (or multiplexers) until the system has had enough time to be initialized and is ready to read the A/D converter. If this rule is violated, "channel rotation" can occur. Channel rotation refers to the situation where the indicated channel and the recorded data are out of step (for example: the data for channels 2, 3, 4, 5, ... is reported as corresponding to channels 4, 5, 6, ...). The Trigger/Alarm Module is ideal for avoiding this state. By gating the pacing signal through the Trigger/Alarm Module it is easy to ensure the correct timing conditions.



Block Diagram of PCI-20023M-1 Module.

"Capturing and Analyzing Transient Waveforms With A Personal Computer" is the title of an Applications Note that demonstrates the use of the Trigger/Alarm function with a high-speed analog input. This and other Application Notes can be found in Section 5 of this Handbook.

Of special significance is SYSCHECK, the system assurance utilities and diagnostics software package. This menu-driven product, shipped at no extra charge with each system, easily verifies proper installation and utilization of all PCI system components. Not only does SYSCHECK greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.

SPECIFICATIONS— PCI-20023M-1

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility		I^3 Bus devices
I/O Configuration		Analog input
Number of Channels	Single-ended	Eight
Input		
Offset Voltage		Trimmable to zero
Impedance		1MΩ @ 35PF
Voltage Range	Linear	±10V
	Without damage	20V above supplies
Bias Current		100nA typ, 300nA max
Noise		±1LSB on 5V range
Crosstalk	Channel-to-channel @ 1kHz, 1KΩ source impedance	0.2LSB (-90dB)
A/D Converter		
Resolution		12-bit
Code	Unipolar	Binary
	Bipolar	Offset binary
Linearity Error		±0.5LSB
Gain Accuracy		Trimmable to zero ±1/2LSB
Ranges		0-10V, ±5V, ±10V
Dynamic Response		
Mux Settling Time	Within 0.01%, max	3.5μs(1)
Conversion Time	A/D, max	4μs
Aperture Jitter	Sample to hold time uncertain	0.3ns
Acquisition Time	S/H, max	1.5μs
Total Convert Time		5.5μs
Source Impedance, Maximum Recommended	PCI-20023M-1 alone at 180kHz	3k ohms
For 1LSB Accuracy	PCI-20023M-1 plus PCI-20031M-1 at 135kHz	100 ohms
Power Requirements[2]	+15V supply	42mA maximum
	-15V supply	52mA maximum
	+5V supply	685mA maximum
Size	Length x Height x Thickness	3.9" x 3.9" x 1.3" (9.9cm x 9.9cm x 3.3cm)
Temperature Range	Module temperature	0 to +70°C

Notes: (1) Normally, mux settling time need not be added to the other components of "total convert time". The software can be arranged so that channel selection (mux transfer) takes place during the A/D conversion cycle (after the S/H captures the signal). The PCI-20026/27S software drivers perform this task automatically.
(2) If a module is powered from a PCI carrier, the ±15V requirements are satisfied by the carrier's DC/DC converter, and the equivalent load on the computer's +5V supply will be 1250mA, maximum. This takes into account the efficiency of the DC/DC converter.

DYNAMIC PERFORMANCE— IN TYPICAL PC/XT/AT/EISA CARRIER-BASED INSTALLATION

All specifications are typical at 25°C unless otherwise noted.

CONDITIONS	PC/XT/AT/EISA COMPATIBLE COMPUTERS	
	80286 AT 12MHz	80386 AT 16MHz
Installed on a PCI-20041C-3A Carrier		
PCI-20023M-1 alone, using DMA	95kHz	100kHz
Adding PCI-20031M-1, using DMA	90kHz	90kHz
Installed on any PCI PC/XT/AT/EISA Compatible Carrier[1]		
PCI-20023M-1 with PCI-20020M-1, without DMA	145kHz	180kHz
Adding PCI-20031M-1 and PCI-20020M-1, without DMA	135kHz	135kHz
Installed on any PCI PC/XT/AT/EISA Compatible Carrier[1]		
PCI-20023M-1 alone, without DMA, S/W pacer	65kHz	87kHz
Adding PCI-20031M-1, without DMA, S/W pacer	65kHz	75kHz
Installed on a PCI-20202C-1 or PCI-20202C-2	200kHz	200kHz

Notes: (1) PC/XT/AT/EISA Compatible Carrier Families include: PCI-20001C, PCI-20041C and PCI-20098C.
(2) Data derived from measurements using PCI-20026S and PCI-20027S software in modes 3 or 4 as applicable.

SOFTWARE COMPATIBILITY TABLE

(The PCI-20023M-1 can be used with the following software in conjunction with the listed hardware.)

PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER[2]	DMA SUPPORT	CARRIERS SUPPORTED[1]	EXPANSION MODULES SUPPORTED
PCI-20068S	SNAP-Series	Yes	Yes	No	PCI-20001C, PCI-20041C	PCI-20031M-1
PCI-20068S	SNAP-Series	Yes	Yes	Yes	PCI-20041C-3A	PCI-20031M-1
PCI-20067S	DADiSP/PC	Yes	No	No	Not applicable	Not applicable
PCI-20210S	Hypersignal-Workstation	Yes	Yes	No	PCI-20202C	PCI-20031M-1
PCI-20026S	General-purpose Drivers	No	Yes	No	PCI-20001C, PCI-20041C	PCI-20031M-1
PCI-20027S	High-performance Drivers	No	Yes	No	PCI-20001C, PCI-20041C	PCI-20031M-1
PCI-20027S	High-performance Drivers	No	Yes	Yes	PCI-20041C-3A	PCI-20031M-1
PCI-20096S	TURBO STREAM Drivers	No	Yes	Yes	PCI-20041C-3A	PCI-20031M-1
PCI-20203S	DSP Library Plus Series	No	Yes	Yes	PCI-20202C	
PCI-20204S	DSP Software Development Package	No	Yes[3]	Yes	PCI-20202C	PCI-20031M-1
PCI-703S	*MacAdapt*	Yes	Yes	No	PCI-701C	PCI-20031M-1
PCI-704S	*MacExpedite*	Yes	Yes	Yes	PCI-701C (with PCI-702M)	PCI-20031M-1
PCI-706S	Interface to LabVIEW 2	Yes	Yes	Yes	PCI-701C (with PCI-702M)	PCI-20031M-1

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, you can use PCI-20026S and PCI-20027S drivers).
(3) Drivers are supplied in the form of TMS Assembly source code.

HARDWARE COMPATIBILITY TABLE— CARRIERS AND MODULES

(The PCI-20023M-1 can be used in conjunction with the following hardware products.)

				MAXIMUM NUMBER OF CHANNELS			
				WITH ONE PCI-20031M		WITH TWO PCI-20031Ms	
PCI MODEL NUMBER	TYPE	DESCRIPTION	BUS	SOFTWARE SELECTION[1]	HARDWARE SELECTION[2]	SOFTWARE SELECTION[1]	HARDWARE SELECTION[2]
PCI-20001C-2A	Carrier	General-purpose	PC/XT/AT/EISA	40	32	72	64
PCI-20041C-2A, PCI-20041C-3A	Carrier	High-performance	PC/XT/AT/EISA	40	32	72	64
PCI-20202C-1, PCI-20202C-2	Carrier	*Smart* processor	PC/XT/AT/EISA	40	32	Not applicable	Not applicable
PCI-701C	Carrier	Multifunction	Mac II NuBus	40	32	Not applicable	Not applicable

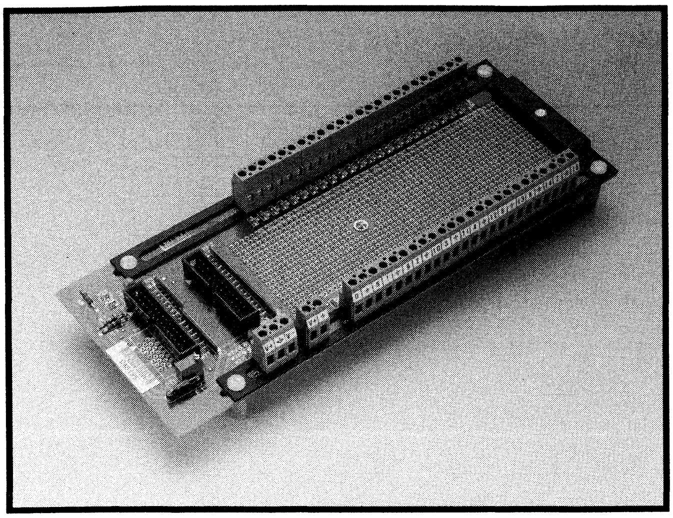
Notes: (1) If the channel selection is made under software control.
(2) If the channel selection is made under hardware control (automatic channel sequencing). As an example, if used under DMA.

HARDWARE COMPATIBILITY TABLE

(The PCI-20023M-1 can be used in conjunction with the following hardware products).

TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20303T-1	General-purpose	PCI-20310A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20024T-2	Customizer	PCI-20015A-1	PCI-20029A-1
PCI-5B01-1	Signal conditioner	PCI-20015A-1	PCI-20339A-1
PCI-20042T-1	Signal conditioner	PCI-20012A-1	PCI-20029A-1
PCI-20044T-1	Signal conditioner	PCI-20012A-1	PCI-20029A-1

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20024T Series

Analog Termination Panels *Customizer*

FEATURES

- Clamp-Type Screw Terminals For Field Wiring Connections
- Extensive Signal Conditioning Capabilities
- Thermocouple Cold-Junction Termperature Sensor

DESCRIPTION

The PCI family of analog signal termination components includes both passive and active units. Passive products are general purpose panels that are not shipped from the factory with amplifiers or isolators installed. However, it is possible, in some cases, for the user to install active circuits on passive panels. Passive panels and their complementary cables are described in this data sheet. Active units are found in the PCI-20042T-1 through PCI-20045T-1 and PCI-5B Series data sheets. The passive panels include two basic types: **Euro-Style** (for general applications) and **customizer.**

The **customizer**, PCI-20024T Series Termination Panels, can accommodate up to 32 channels of single-ended analog inputs or outputs, with signal conditioning available on each channel. Differential inputs may be connected by using single-ended channels in pairs, thus allowing up to 16 differential inputs per panel. A cold-junction compensation (CJC) temperature sensor is included on channel 4 for thermocouple applications. Up to 15 thermocouples can be supported on one PCI-20024T panel. Bias current return resistors are installed on all channels. Field connections are made to the panels via screw-terminal blocks. There are three screw terminals per pair of I/O channels. The center terminal is ground. In contrast to the other analog panels, the **customizers** have a completely general layout pattern. Virtually any kind of passive or active network can be added to each individual channel. Each group of 16 single-ended channels is interfaced to the PCI system with a separate ribbon cable connector (a total of two connectors). The PCI-20024T-1 and PCI-20024T-2 have different connector configurations. The PCI-20024T-1 model has two dissimilar connectors and is intended for use with multifunction products. One connector is a "high-density" type that mates with the PCI-20008A-1B cable and plugs into the multifunction board or carrier. The other is a standard 26-pin type that is intended for use with any other analog PCI board or module when mated with the PCI-20015A-1 cable. The PCI-20024T-2 model has two identical standard connectors and can be used with any analog I/O module or board except the on-board channels of the multifunction products. Please note that the standard connectors on the PCI-20024T-2 mate only with the PCI-20015A-1.

The CJC network on each of the panels described in this data sheet generates 1mV/°K, ± 1°K. The physical size of each panel is 9″ x 3.5″ x 1.6″ (22.9cm x 8.9cm x 4.1cm). Each panel type can be mounted in the PCI-20029A-1 enclosure. An enclosure has room for four panels in a tabletop or 19-inch, rack-mount configuration.

The PCI-20008A-1B and the PCI-20015A-1 are fully shielded flat ribbon cables. The PCI-20008A-1B is intended for use with the multifunction products' analog inputs. The PCI-20015A-1 can be used for either analog inputs or outputs. It is for use with the standard connectors on the PCI-20024T Series only. Shields are important to minimize both noise pickup and emission. Both the PCI-20008A-1B and the PCI-20015A-1 are 4 feet (1.2m) long. All shielded cables have the shield connected at one end only to avoid ground loops. The grounded end is clearly marked.

Various cable and connector manufacturers place marks or codes to indicate the locations of wire or pin number 1. When using ANY PCI System, these codes or marks should be IGNORED. The correct wire and pin designations are described in the PCI user manuals. For those who wish to make their own cables, here are the correct matting connectors for the termination panels:

PCI-20024T-1, High Density	Amphenol #845-C026S-ALA00
PCI-20024T-1, Standard	T&B Ansley #609-2630
PCI-20024T-2	T&B Ansley #609-2630

TERMINATION PANEL COMPATIBILITY TABLE— PCI-20024T-1[2], ANALOG I/O CUSTOMIZER

PCI MODEL NUMBER	TYPE	NUMBER OF CHANNELS	DESCRIPTION	CARRIERS	MODULES[1]	BOARDS[1]
PCI-20008A-1B **PCI-20015A-1**	Cable Cable	16/8[3] 16/8[3]	4-foot, high-density, shielded 4-foot, shielded	PCI-20098C-1, PCI-701C	PCI-20002M, 3M, 6M, 17M, 19M, 20M, 21M, 23M, 31M and 341M	PCI-601W, PCI-602W PCI-20089W, 91W and 93W
PCI-20029A-1	Enclosure	up to 128	19-inch rack/table mount			

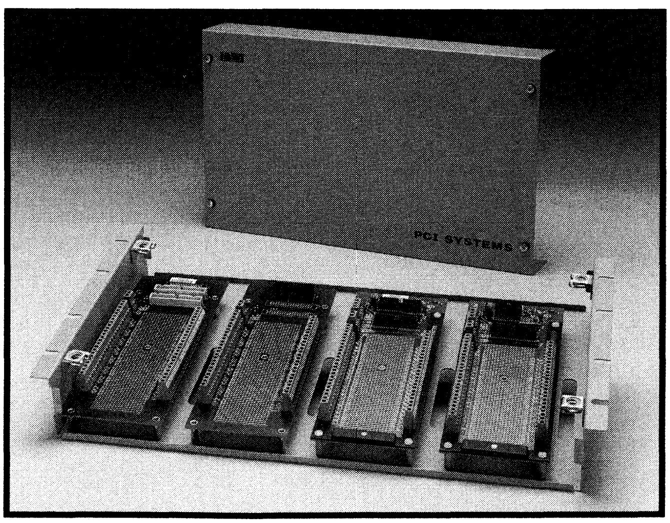
Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) The PCI-20024T-1 has both a high-density and normal-density connector on it, each accommodating up to 16 channels.
(3) Single-ended/differential.

TERMINATION PANEL COMPATIBILITY TABLE— PCI-20024T-2[2], ANALOG I/O CUSTOMIZER

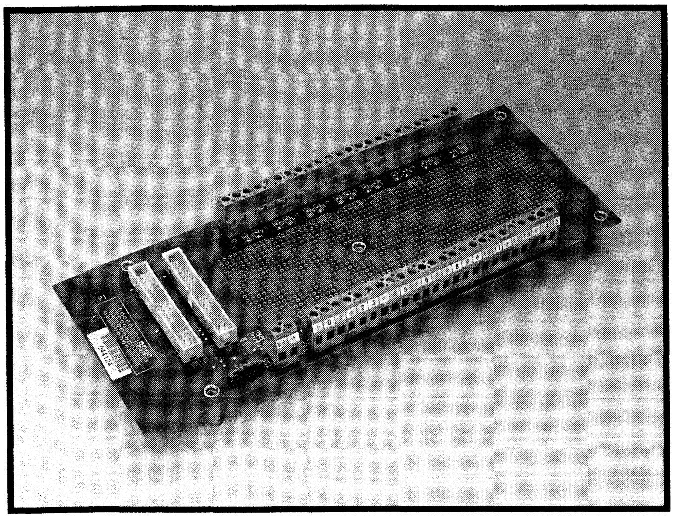
PCI MODEL NUMBER	TYPE	NUMBER OF CHANNELS	DESCRIPTION	CARRIERS	MODULES[1]	BOARDS[1]
PCI-20015A-1	Cable	16/8[3]	4-foot, shielded		PCI-20002M, 3M, 6M, 17M, 19M, 21M, 23M, 31M and 341M	PCI-20089W, 91W and 93W
PCI-20029A-1	Enclosure	Up to 128	19-inch rack/table mount			

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) The PCI-20024T-2 has two normal-density connectors on it, each accommodating up to 16 channels.
(3) Single-ended/differential.

For additional information, please refer to the configuration charts in the Summary Section.



PCI-20029A-1 with a PCI-20024T-1, PCI-20024T-2, PCI-20025T-1, and PCI-20025T-2.



BURR-BROWN®

PCI-20025T Series

Digital Termination Panels *Customizer*

FEATURES

- Clamp-Type Screw Terminals For Field Wiring Connections
- Extensive Signal Conditioning Capabilities
- Can Be User For Either Input Or Output Functions

DESCRIPTION

The PCI family of digital signal termination components includes both passive and active panels. Passive products are general-purpose panels that are not shipped from the factory with isolators, relays or logic circuits installed. However, it is possible, in some cases, for the user to install active circuits on passive panels. Passive panels and their complementary cables are described in this data sheet. Active units providing optical isolation and power handling capability are found in the PCI-20018T-1 and the PCI-20048T-1 data sheets. The passive panels include three basic types: **Euro-Style** (for general applications) **high-density** and **customizer.**

The **customizer**, PCI-20024T Series Termination Panels, can accommodate up to 32 channels of digital inputs or outputs, with signal conditioning available on each channel. Field connections are made to the panels via screw-terminal blocks. There is a ground terminal adjacent to each pair of inputs. In contrast to the other digital panels, the customizers have a completely general layout pattern. Virtually any kind of passive or active network can be added to each individual channel. The PCI-20025T-1 and PCI-20025T-2 have different connector configurations. The PCI-20025T-1 model has a "high-density" connector and is intended for use with multifunction products, digital I/O, counter/timers, and sync/control lines. This connector mates with the PCI-20009A-1B cable. The PCI-20025T-2 model has two standard connectors and can be used with any digital I/O modules or boards except the "on-board" channels of the multifunction products. The standard connectors mate with the PCI-20061A-1 or PCI-20036A-1 cables.

When used with a PCI board, carrier, or module, the interconnecting cable brings +5V to the termination panel. In most cases up to 240mA is available to power on-board functions (LEDs, pull-ups, etc.). A separate terminal block is also provided for the connection of an external power supply, if additional current or another voltage is required.

The physical size of each panel is 9″ x 3.5″ x 1.6″ (22.9cm x 8.9cm x 4.1cm). Each panel type can be mounted in the PCI-20029A-1 enclosure. An enclosure has room for four panels in a tabletop or 19-inch rack-mount configuration.

The PCI-20009A-1B, and the PCI-20061A-1 are built with "ground-plane" type flat ribbon cable. They are intended for both digital input and output use. Included in this category are counter/timer applications. PCI-20061A-1 mates with the PCI-20025T-2 and connects to any PCI digital board, carrier, or module (except the multifunction products). The ground-plane minimizes cable inductance while reducing electrostatic and electromagnetic emissions. The PCI-20009A-1B is 4 feet (1.2m) long while the PCI-20061A-1 is 6 feet (2m) long. All ground-plane cables have the ground plane connected at one end only to avoid ground loops. The grounded end is clearly marked.

The PCI-20036A-1 is NOT shielded but can be used for many digital I/O applications. It is a lower cost cable intended for applications where it is not critical to minimize noise or to preserve pulse shape. The PCI-20036A-1 is 4 feet (1.2m) long. It mates with only the PCI-20025T-2.

Various cable and connector manufacturers place marks or codes to indicate the location of wire or pin number 1. When using ANY PCI System, these codes or marks should be IGNORED. The correct wire and pin designations are described in the PCI user manuals. For those who wish to make their own cables, here are the correct mating connectors for the termination panels:

PCI-20025T-1	2 each Amphenol #845-C050- ALA00
PCI-20025T-2	T&B Ansley #609-3430

TERMINATION PANEL COMPATIBILITY TABLE— PCI-20025T-1, DIGITAL I/O CUSTOMIZER

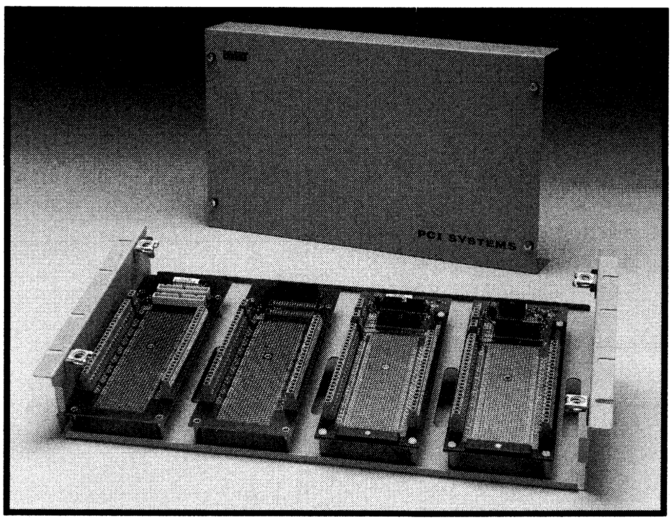
PCI MODEL NUMBER	TYPE	NUMBER OF CHANNELS	DESCRIPTION	CARRIERS	BOARDS
PCI-20009A-1B **PCI-20009A-2B** **PCI-20009A-3B**	Cable Cable Cable	16 16 16	4-foot, high-density, shielded 1.5-foot, high-density, shielded 3-foot, high-density, shielded	PCI-20098C-1, PCI-701C	PCI-601W, PCI-602W PCI-601W, PCI-602W PCI-601W, PCI-602W
PCI-20029A-1	Enclosure	Up to 128	19-inch rack/table mount		

TERMINATION PANEL COMPATIBILITY TABLE— PCI-20025T-2[2], DIGITAL I/O CUSTOMIZER

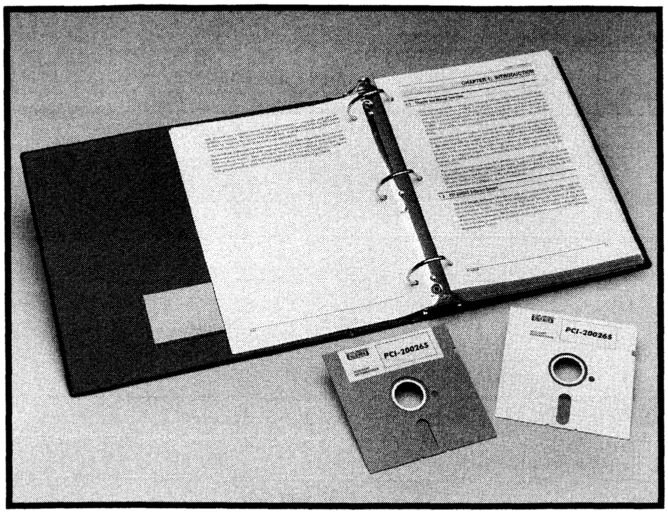
PCI MODEL NUMBER	TYPE	NUMBER OF CHANNELS	DESCRIPTION	CARRIERS[1]	MODULES[1]	BOARDS
PCI-20036A-1 **PCI-20061A-1**	Cable Cable	16 16	4-foot, unshielded 6-foot, shielded	PCI-20001C-2, PCI-20041C PCI-20001C-2, PCI-20041C	PCI-20004M, PCI-20007M PCI-20004M, PCI-20007M	PCI-20087W-1 PCI-20087W-1
PCI-20029A-1	Enclosure	Up to 128	19-inch rack/table mount			

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) The PCI-20025T-2 has two normal-density connectors on it, each accommodating up to 16 channels.

For additional information, please refer to the configuration charts in the Summary Section.



PCI-20029A-1 with a PCI-20024T-1, PCI-20024T-2, PCI-20025T-1, and PCI-20025T-2.



BURR-BROWN®

PCI-20026S Series

Language Support Software Drivers

FEATURES

- Interfaces to PCI PC-Based Hardware
- Compatible with PC/MS DOS, Version 2.0 or Higher
- Easy-to-use High-Level Commands for BASIC, C, and TURBO PASCAL
- Eliminates the Need for the Programmer to Be Familiar with the Details of the Hardware

DESCRIPTION

The PCI-20026S Series of software support packages are members of a family of memory-resident drivers. Each is designed to provide an uncomplicated, consistent and useful interface between several of the most popular high-level languages and the PCI PC-based hardware system. All goals are realized by buffering the programmer from the internal details by offering a set of commands to invoke the major hardware functions. Therefore, no detailed knowledge of the hardware is required. The PCI-20026S Series contains many general-purpose functions that operate in any compatible computer including the Burr-Brown VIPc and PC/XT/AT/EISA machines. The operating system can be PC or MS DOS, version 2.0 or higher. A summary of the available calls is found below. High speed, DMA, and direct-to/from-disk capabilities can be easily added by utilizing the family's companion products, the PCI-20027S and PCI-20096S Series.

BASIC, C, and TURBO PASCAL were selected because of their wide user base and general acceptance. Error checking is provided to help eliminate potential difficulties. Detailed sample programs are provided in each language, offering assistance to new users.

IBM BASIC A through version A3.10 is supported. Other true compatibles, such as Compaq BASIC and GWBASIC, can also be used.

Microsoft QuickBASIC Compiler version 4.5 is supported. Compiling BASIC code increases its execution speed about five times.

IBM BASIC Compiler is also supported, with some limitations.

Microsoft C Compiler version 4.0 through 6.0 and **Lattice C Compiler** thru version 3.0 are supported. **Borland TURBO C** version 2.0 is also supported.

Borland TURBO PASCAL through version 5.5 is supported.

Applications Example for PCI-20026S Series

The following are code segments showing how the PCI-20026S Series can read an analog input channel.

BASIC

```
"
"       'Include the Driver Interface Header
"       'Initialize the Hardware and Software
"
120     CHN=5         'Define Channel 5
130     GAIN = 10     'Define Gain=10 (for Channel 5)
140     ZERO = 0      'Autozero with respect to Channel 0
150     RANGE = 2     'Define that A/D is on Bipolar range
"
"       'Possible other tasks
"
230     CALL CNF.AI (CHN, GAIN, ZERO, RANGE) 'Configure Input
240     CALL READ.CH (AI, CHN, DATA) 'Read Analog Input
"
"
"       '"Process/Manipulate/Display Data"
"       'etc.
"       'etc.
        END
```

C

```
cnf_ai (chn, gain, zero, range);
data=read_ch (ai, chn);
```

TURBO PASCAL

```
Procedure CNfAI (CHn, Gain, Zero, Range);
Data:=ReadCh (AI, Chn);
```

SOFTWARE OPTIONS

PCI MODEL NUMBER	LANGUAGE	DISKETTE SIZE
PCI-20026S-1	BASIC	5 1/4 inch
PCI-20026S-2	C	5 1/4 inch
PCI-20026S-3	TURBO PASCAL	5 1/4 inch
PCI-20026S-4	Combination package[1]	5 1/4 inch
PCI-20026S-5	BASIC	3 1/2 inch
PCI-20026S-6	C	3 1/2 inch
PCI-20026S-7	TURBO PASCAL	3 1/2 inch
PCI-20026S-8	Combination package[1]	3 1/2 inch

Note: (1) The combination package includes all drivers for BASIC, C, and TURBO PASCAL

Command Summary— PCI-20026S Series

Utility Calls

ERR.SYS	Return the last error code
INIT	Initialize the system hardware
SETVEC	Set the dispatch vector
SYSINIT	Initialize the system hardware

Read Calls

READ.CH	Read any input channel
READ.CTS	Read a group of three counters simultaneously
READ.FRQ	Read the frequency of a TTL input
READ.LCH	Read input channel in long value format
READ.LS	Read signal from 32-Bit device
READ.SS	Read signal from 16-Bit device
READ.SSH	Read simultaneous sample/hold inputs
STAT.CNT	Read a counter value and status
STAT.HD	Query status of a handshake DI/O port

Write Calls

WRITE.CH	Write a value to any output channel
WRITE.GR	Write a group of analog outputs simultaneously

Configuration Calls

CNF.AI	Configure an analog input channel
CNF.BG	Configure burst generator
CNF.CNTR	Configure a counter channel
CNF.DI	Configure a digital input
CNF.DO	Configure a digital output
CNF.HDI	Configure handshake digital input
CNF.HDO	Configure handshake digital output
CNF.JMPS	Configure software jumpers
CNF.LCT	Configure 32-bit counter
CNF.LD	Configure 32-bit divider
CNF.RG	Configure a rate generator
CNF.RTD	Configure an RTD input
CNF.SCT	Configure 16-bit counter
CNF.SD	Configure 16-bit divider
CNF.TCPL	Configure a thermocouple input
CNF.TRIG	Configure a trigger/alarm module
CNF.VDCG	Configure variable-duty-cycle generator

Miscellaneous Calls

CVT.RTD	Linearize RTD data and return temperature
CVT.TCPL	Linearize and compensate thermocouple data
SOFT.INTR	Generate a software interrupt

COMPATIBILITY TABLE— CARRIERS

PCI MODEL NUMBER[1]	FUNCTION
PCI-20001C	General-purpose
PCI-20041C	High-performance
PCI-20098C	Multifunction

Note: (1) When model numbers are shown without "dash" numbers, all versions apply.

COMPATIBILITY TABLE— MODULES

PCI MODEL NUMBER	FUNCTION
PCI-20002M-1[1]	Analog input
PCI-20019M-1A[1]	Analog input
PCI-20023M-1[1]	Analog input
PCI-20341M-1[1]	Analog input
PCI-20031M-1	Analog expansion
PCI-20017M-1	Simultaneous sample/hold
PCI-20020M-1	Trigger/alarm
PCI-20003M-2	Analog output
PCI-20003M-4	Analog output
PCI-20006M-2	Analog output
PCI-20021M-1B	Analog output
PCI-20004M-1	Digital I/O
PCI-20007M-1[2]	Counter/timer

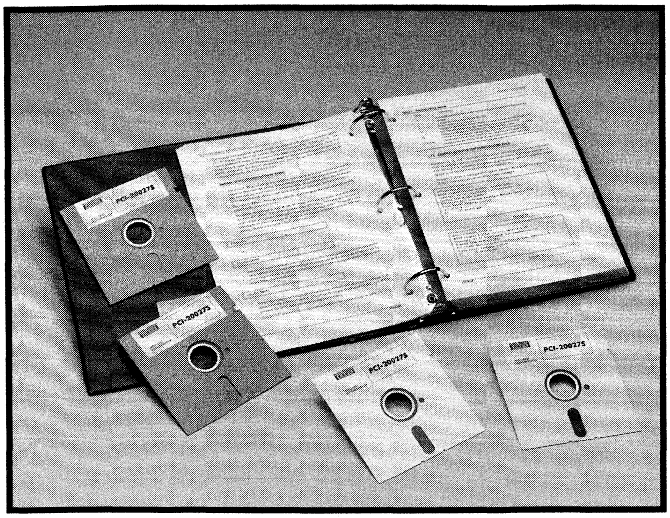
Notes: (1) This module is not supported on the PCI-20098C-1 carrier since analog inputs are already available on the PCI-20098C-1.
(2) When used with the PCI-20098C-1, the PCI-20026S software does not support the READ_FREQ command with the PCI-20007M-1 since the PCI-20098C-1 already supports frequency inputs.

COMPATIBILITY TABLE— BOARDS

PCI MODEL NUMBER[1]	FUNCTION
PCI-20087W	Digital I/O
PCI-20089W	Analog input
PCI-20091W	High-speed analog input
PCI-20093W	Analog output

Note: (1) When model numbers are shown without "dash" numbers, all versions apply.

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20027S Series

High-Performance, High-Speed Software Driver Extension

FEATURES

- Supports Data Files Up to the Limit of Available 640Kbytes RAM
- Supports Direct Memory Access (DMA)
  - — Up to 360Kbytes/sec I/O Transfers
  - — Analog, Digital, and Counter Data Can All Be Transferred Simultaneously
- Supports High-Speed Analog Data Acquisition
- Provides for Pre-Trigger and Post-Trigger Data Recording
- Has Easy-To-Use High-Level Commands for BASIC, C, and TURBO PASCAL

DESCRIPTION

The PCI-20027S Series are high-performance, memory-resident, software drivers. They provide easy-to-use direct memory access (DMA) and high-speed data acquisition capabilities. A list of the available commands is shown in the Command Summary Table. The PCI-20027S Series operates in conjunction with the PCI-20026S Series drivers. PCI-20027S is an add-on or extension to the PCI-20026S, and it cannot be used alone. Both driver sets are designed for IBM compatible personal computers, including the Burr-Brown VIPc and PC/XT/AT/EISA machines running PC or MS DOS, version 2.0 or higher. The drivers provide language interface support for PCI PC-based data acquisition, test, measurement and control hardware.

The PCI-20027S Series is a collection of high-level calls which can be invoked from BASIC, C, or TURBO PASCAL languages. The programmer does not need to have a detailed knowledge of the hardware to use these calls. All routines are internally written in assembly language to insure the highest possible speed and performance.

The DMA calls offered by the PCI-20027S Series allow analog, digital, and counter data transfers to occur simultaneously. The foreground/background feature allows the user to start a DMA process and, while DMA is operating, to perform whatever other functions are desired in the user's programming language. For example, DMA can be used to collect analog input data and to store it in memory in the background. At the same time the foreground program (under user software program control) can be performing display, analysis, or control functions. DMA transfers allow data buffers greater than 64Kbytes, up to the limit of the available 640Kbytes RAM (as recognized by DOS).

The PCI-20027S Series supports the maximum DMA speed possible with a PCI PC-based system.

The PCI-20027S Series also supports non-DMA high-speed data acquisition calls. They allow users to make "block-mode" readings and to specify the channels to be read, the sampling frequency, and the number of samples to be acquired. The sampling frequency can be provided by a hardware pacer clock, or it can come from an external source.

Other extremely important data acquisition, test, measurement, and control functions are supported. The multiple I/O function capability allows a user to read a variety of input types at the same time or generate a variety of output types at the same time. For instance, the user can read analog inputs, digital inputs, and counter inputs with the same DMA setup. In the same manner, the user can write analog outputs and digital outputs with one DMA setup. Often it is highly desirable to examine the data acquired just before and just after a specified trigger event. The PCI-20027S Series also supports this important pre-trigger/post-trigger function.

PCI-20027S Series Command Summary

Buffer Utilities

BUF.DEC	Decodes and returns data to a user's array
BUF.ENC	Encodes and writes data to a user's array
BUFLOC	Return address and pointers for a buffer
BUFSEEK	Moves location pointer within a data buffer
BUFSIZE	Sets up buffers and buffer sizes
CHGBUF	Selects active buffer

High-Speed Analog Acquistion Calls

CNF.HS	Configure a high-speed data acquistion
HS.RUN	Execute a high-speed data acquisition

DMA Acquisition Calls

CNF.DMA	Configure a DMA channel list
DMA.BUF	Assign a DMA buffer
DMA.RUN	Start a DMA data acquisition
DMA.STAT	Return the status of a DMA run
DMA.STOP	Stop a DMA operation
DMA.SWAP	Switch to another buffer

SOFTWARE OPTIONS

PCI MODEL NUMBER	LANGUAGE	DISKETTE SIZE
PCI-20027S-1	BASIC	5 1/4 inch
PCI-20027S-2	C	5 1/4 inch
PCI-20027S-3	TURBO PASCAL	5 1/4 inch
PCI-20027S-4	Combination package[1]	5 1/4 inch
PCI-20027S-5	BASIC	3 1/2 inch
PCI-20027S-6	C	3 1/2 inch
PCI-20027S-7	TURBO PASCAL	3 1/2 inch
PCI-20027S-8	Combination package[1]	3 1/2 inch

Note: (1) The comination packages include all drivers for BASIC, C, and TURBO PASCAL.

COMPATIBILITY TABLE— CARRIERS

(For high-speed analog acquisition routines)

PCI MODEL NUMBER	FUNCTION
PCI-20001C-2A	General-purpose
PCI-20041C-2A, PCI-20041C-3A	High-performance
PCI-20098C-1	Multifunction

COMPATIBILITY TABLE— MODULES

(For high-speed analog acquisition routines)

PCI MODEL NUMBER	FUNCTION
PCI-20002M-1[1]	Analog input
PCI-20019M-1A[1]	Analog input
PCI-20023M-1	Analog input
PCI-20341M-1	Analog input
PCI-20031M-1	Analog expansion
PCI-20017M-1	Simultaneous sample/hold
PCI-20020M-1	Trigger/alarm

Notes: (1) This module is not supported on the PCI-20098C-1 carrier since analog inputs are already available on the PCI-20098C-1.

COMPATIBILITY TABLE— BOARDS

(For high-speed analog acquisition routines)

PCI MODEL NUMBER	FUNCTION
PCI-20089W-1	Analog input
PCI-20091W-1	High-speed analog input

COMPATIBILITY TABLE— CARRIERS

(For direct memory access routines.)

PCI MODEL NUMBER	FUNCTION
PCI-20041C-3A	High-performance
PCI-20098C-1	Multifunction

COMPATIBILITY TABLE— MODULES

(For direct memory access routines.)

PCI MODEL NUMBER	FUNCTION
PCI-20002M-1[1]	Analog input
PCI-20019M-1A[1]	Analog input
PCI-20023M-1	Analog input
PCI-20341M-1	Analog input
PCI-20031M-1	Analog expansion
PCI-20020M-1	Trigger/alarm
PCI-20003M-2	Analog output
PCI-20003M-4	Analog output
PCI-20006M-2	Analog output
PCI-20021M-1B	Analog output
PCI-20004M-1	Digital I/O
PCI-20007M-1[2]	Counter/timer

Notes: (1) This module is not supported on the PCI-20098C-1 carrier since Analog Inputs are already available on the PCI-20098C-1.
(2) When used with the PCI-20098C-1, the PCI-20026S software does not support the READ_FREQ command with the PCI-20007M-1 since the PCI-20098C-1 already supports frequency inputs.

COMPATIBILITY TABLE— BOARDS

(For direct memory access routines.)

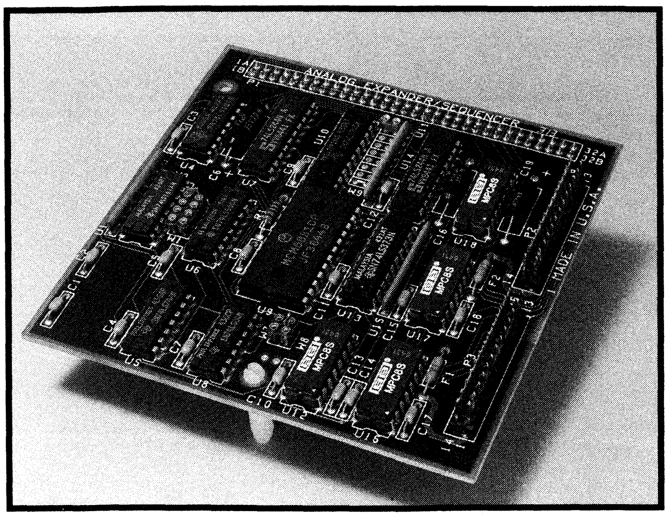
PCI MODEL NUMBER	FUNCTION
PCI-20091W-1	High-speed analog input

For additional information, please refer to the configuration charts in the Summary Section.

BURR-BROWN®

PCI-20031M-1

Analog Expander/ Sequencer Module



FEATURES

- Adds 32 Channels to Existing Analog Input Count
- Scan List Held in On-Board Memory
- Scan List Can Contain up to 128 Elements

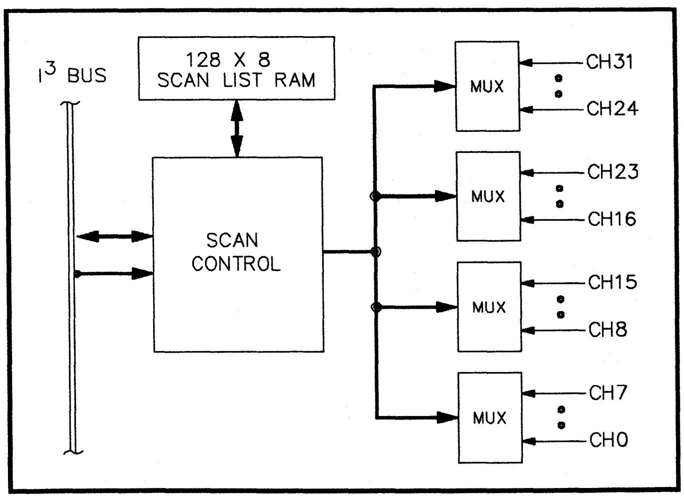
DESCRIPTION

The Analog Expander/Sequencer Module was designed to complement all analog input products in the PCI family by providing up to 32 additional multiplexed channels. The PCI-20031M-1 is compatible with the PCI-20002M-1, PCI-20019M-1A, PCI-20023M-1 and PCI-20341M-1 modules, as well as the analog inputs on the PCI-20098C-1 and PCI-701C Multifunction Carriers. Electrical connections between the output of the expander and the input to the analog input product (module or analog input section of the multifunction carrier) is automatically accomplished through the internal I^3 Bus. High-speed performance is enhanced by the use of on-board memory to store the desired scan list and the use of hardware to automatically advance through the scan list. This can be accomplished via a software, internal hardware, or external hardware signal (for example, each time an A/D conversion is initiated). This allows scanning to be accomplished without intervention from the host computer. The scan list can store up to 128 elements. The channel sequence specified in the scan list can be in any order desired and can include duplicate channels. Duplicate channels are extremely useful in cases where a given channel must be sampled at a higher frequency than others.

The PCI-20031M-1 supports both single-ended or differential inputs depending upon the configuration of the analog input device (module or analog input section of a multifunction carrier) that is connects with.

When used in the differential mode, 16 channels are supported. The total number of channels depends upon the analog input device it drives and the scan mode selected. In most cases, the PCI-20031M-1 channels are added to the original channels of the input device. However, in the hardware scan mode associated with the PCI-20019M-1A and PCI-20023M-1, the channels on the A/D module cannot be counted.

Of special significance is SYSCHECK, the system assurance utilities and diagnostics software package. This menu-driven product, shipped at no extra charge with each system, easily verifies proper installation and utilization of all PCI system components. Not only does SYSCHECK greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.



PCI-20031M-1 Module Block Diagram.

SPECIFICATIONS— PCI-20031M-1

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility		All I^3 Bus devices
I/O Configuration Number of Channels	 Single-ended Differential	Analog expander 32 16
Analog Signal Range	Linear operation Without damage	±10V 20V above supply
Input Capacitance(1)	Channel "on": Single-ended Differential Channel "off"	100pF 50pF 5pF
"On" Resistance **"Off" Isolation**	Maximum Frequency = 1kHz, R_S = 1kΩ	1.8kΩ 85dB
Input Leakage	"On" channel "Off" channel	0.1nA 0.03nA
Channel List Length	On-board RAM, advanced with sync input or S/W command	 128 channels
Power Requirements(2)	+15V supply -15V supply +5V supply	8mA max 4mA max 345mA max
Size	Length x Height x Thickness	3.9" x 3.9" x 1.3" (9.9cm x 9.9cm x 3.3cm)
Temperature Range	Module temperature	0 to +70°C

Notes: (1) For a single PCI-20031M-1 Module without regard to "loads" connected through the I^3 Bus. However, in the single-ended mode, it is assumed that all four mux outputs are connected together. In the differential mode, two mux outputs are connected together.
(2) If a module is powered from a PCI Carrier, the ±15V requirements are satisfied by the internal DC/DC converter, and the equivalent load on the computer's +5V supply will be 417mA, maximum. This takes into account the efficiency of the DC/DC converter.

SOFTWARE COMPATIBILITY TABLE

(The PCI-20031M-1 is a multiplexer module that is used to expand the number of analog input channels. The PCI-20031M-1 can be used with the following software in conjunction with the listed hardware.)

PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVERS[2]	DMA SUPPORT	CARRIERS SUPPORTED[1]	A/D MODULES SUPPORTED[1]
PCI-20040S	LABTECH NOTEBOOK	Yes	Yes	No	PCI-20098C	
PCI-20097S	LABTECH CONTROL	Yes	Yes	No	PCI-20098C	
PCI-20068S	SNAP-Series	Yes	Yes	No	PCI-20001C, 41C	PCI-20002M, 19M and 23M
PCI-20068S	SNAP-Series	Yes	Yes	Yes	PCI-20041C-3A	PCI-20002M, 19M and 23M
PCI-20068S	SNAP-Series	Yes	Yes	Yes	PCI-20098C	
PCI-20067S	DADiSP/PC	Yes	No	No	Not applicable	See note 4
PCI-20210S	Hypersignal-Workstation	Yes	No	No	Not applicable	See note 4
PCI-20210S	Hypersignal-Workstation	Yes	Yes	No	PCI-20202C	PCI-20019M and 23M
PCI-20026S	General-purpose Drivers	No	Yes	No	PCI-20001C, 41C	PCI-20002M, 19M, 23M and 341M
PCI-20026S	General-purpose Drivers	No	Yes	No	PCI-20098C	
PCI-20027S	High-performance Drivers	No	Yes	No	PCI-20001C, 41C	PCI-20002M, 19M, 23M and 341M
PCI-20027S	High-performance Drivers	No	Yes	Yes	PCI-20041C-3A	PCI-20002M, 19M, 23M and 341M
PCI-20027S	High-performance Drivers	No	Yes	Yes	PCI-20098C	
PCI-20096S	TURBO STREAM Drivers	No	Yes	Yes	PCI-20041C-3A	PCI-20002M, 19M, 23M and 341M
PCI-20096S	TURBO STREAM Drivers	No	Yes	Yes	PCI-20098C	
PCI-20301S	ASYST Series	No	Yes	Yes	PCI-20098C	
PCI-20204S	DSP Software Development Pkg.	No	Yes	Yes	PCI-20202C	PCI-20019M and 23M
PCI-703S	*MacAdapt*	Yes	Yes	No	PCI-701C	
PCI-704S	*MacExpedite*	Yes	Yes	Yes	PCI-701C, PCI-702M	
PCI-706S	Interface to LabVIEW 2	Yes	Yes	Yes	PCI-701C	PCI-20023M and 341M

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-20026S and PCI-20027S drivers).
(3) Drivers are supplied in the form of TMS Assembly source code.
(4) Post-process data collected with other hardware/software.

HARDWARE COMPATIBILITY TABLE— CARRIERS AND MODULES

(The PCI-20031M-1 is a multiplexer module that is used to expand the number of Analog Input Channels. The PCI-20031M-1 can be used with the listed hardware.)

				MAXIMUM NUMBER OF CHANNELS			
				WITH ONE PCI-20031M-1		WITH TWO PCI-20031M-1s	
PCI MODEL NUMBER[1]	TYPE	DESCRIPTION	BUS	SOFTWARE SELECTION[2]	HARDWARE SELECTION[3]	SOFTWARE SELECTION[2]	HARDWARE SELECTION[3]
PCI-20001C	Carrier	General-purpose	PC/XT/AT/EISA	See note 4	See note 4	See note 4	See note 4
PCI-20041C	Carrier	High-performance	PC/XT/AT/EISA	See note 4	See note 4	See note 4	See note 4
PCI-20098C	Carrier	Multifunction	PC/XT/AT/EISA	48/24[5]	48/24[5]	80/40[5]	80/40[5]
PCI-20202C	Carrier	*Smart* processor	PC/XT/AT/EISA	See note 4	See note 4	See note 4	See note 4
PCI-701C	Carrier	Multifunction	Mac II NuBus	48/24[5]	48/24[5]	80/40[5]	80/40[5]
PCI-20002M	Module	Analog input, 12-Bit, general-purpose	I^3	48/24[5]	Not applicable	80/40[5]	N/A
PCI-20019M	Module	Analog input, 12-Bit, 89kHz	I^3	40 SE	32 SE	72 SE	64 SE
PCI-20023M	Module	Analog input, 12-Bit, 180kHz	I^3	40 SE	32 SE	72 SE	64 SE
PCI-20341M	Module	Analog input, 16-Bit, 85K	I^3	20 Diff	20 Diff	36 Diff	36 Diff

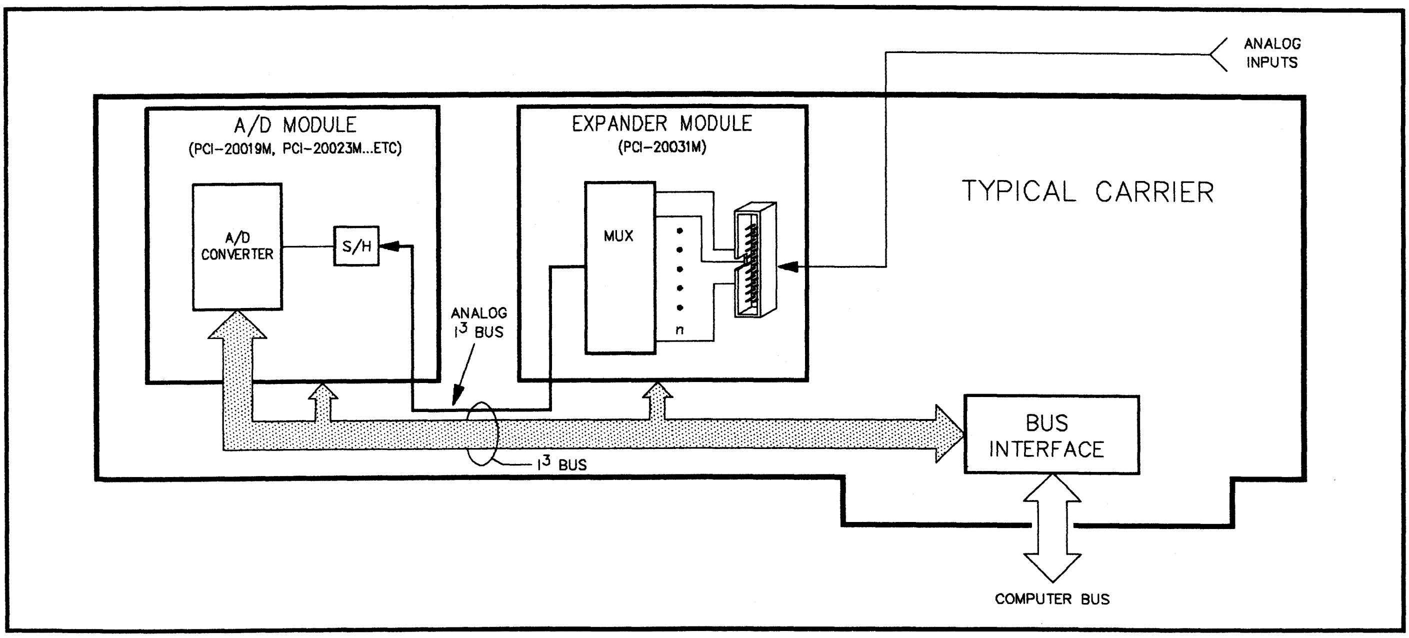
Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) If the channel selection is made under software control.
(3) If the channel selection is made under hardware control (automatic channel sequencing). As an example, if used under DMA.
(4) Determined by the analog input module
(5) Single-ended/differential.

HARDWARE COMPATIBIITY TABLE— TERMINATION PANEL

(The PCI-20031M-1 is a multiplexer module that is used to expand the number of analog input channel in a system.)

TERMINATION PANEL[1]	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20303T-1	General-purpose	PCI-20310A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20303T-2	Thermocouple[2]	PCI-20310A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20024T	Customizer[2]	PCI-20015A-1	PCI-20029A-1
PCI-5B01-1	Signal conditioner	PCI-20015A-1	PCI-20339A-1
PCI-20042T-1	Signal conditioner[2]	PCI-20012A-1	PCI-20029A-1
PCI-20044T-1	Signal conditioner[2]	PCI-20012A-1	PCI-20029A-1

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) One channel is required for CJC in thermocouple applications.



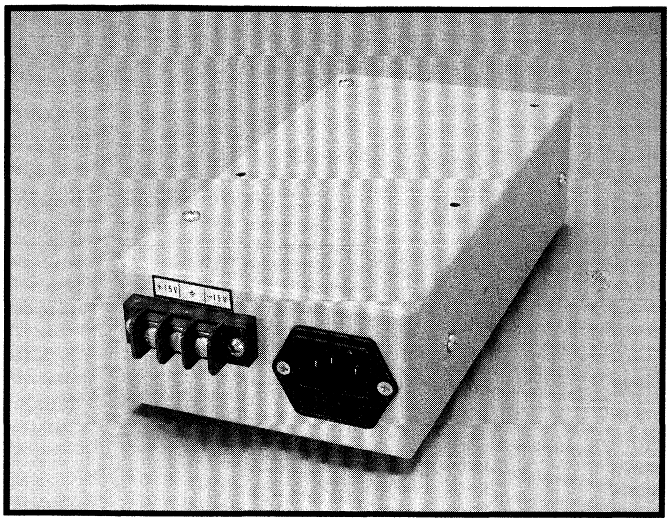
The Analog Outputs From the PCI-20031M-1 Are Connected Through the Internal I^3 Bus to the Analog Input Section of a Module or Multifunction Carrier.

For additional information, please refer to the configuration charts in the Summary Section.

BURR-BROWN®

PCI-20038A Series

±15 Volt DC Power Supply



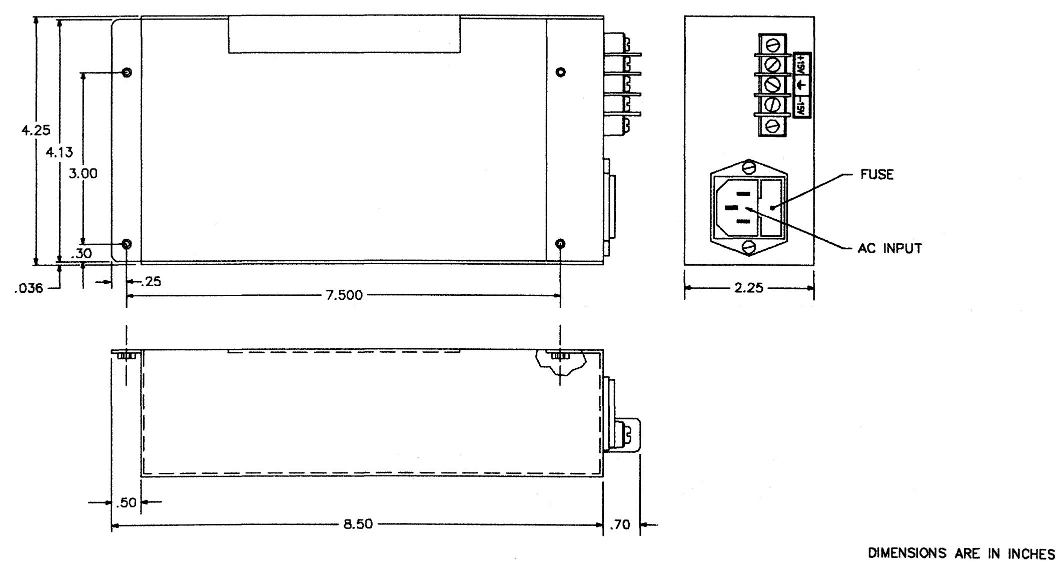
FEATURES

- ±15VDC at 0.8A
- ±0.05% Line and Load Regulation
- Short-circuit Protected
- Convenient Plug and Terminal Connections

DESCRIPTION

The PCI-20038A Series consists of general-purpose ±15VDC power supplies. They are available in 100, 115 and 240 AC line voltage models. Each has adjustable outputs (±5%) and is capable of delivering 800mA to its loads. Current limit/foldback protection is included. PCI-20038A-1 operates from 105 to 132VAC, while PCI-20038A-3 requires 209 to 264VAC. The PCI-20038A-4 requires 87 to 110VAC. All accept line frequencies between 47 and 63Hz. A continuous output current of 800mA is supported with less than 5mV peak-to-peak ripple and ±.05% load regulation. Line regulation is ±.05% for a 10% line change. The ambient operating temperature range is 0 to 50°C.

The supplies are completely enclosed in a metal case, offering both mechanical and electrical contact protection. While they can be used for almost any purpose, the PCI-20038A Series is primarily intended to power the PCI-20042T thru PCI-20045T Series of active signal conditioners. If desired, the supplies can be mounted either inside or on the rear of the PCI-20029A-1 Termination Panel Enclosure. The physical dimensions of the power supplies and the input and output connectors are shown below.



PCI-20038A Series ±15VDC Power Supply.

SPECIFICATIONS— PCI-20038A SERIES

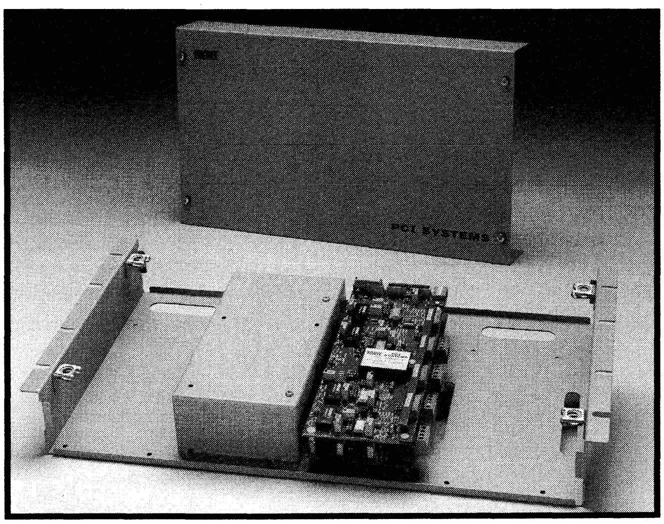
All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Output		
Voltage	Adjustment range, ±5%	±15V
Current	Short-circuit protected	800mA
Noise/Ripple	Peak-to-peak	5mV
Load Regulation		±0.05%
Line Regulation	For a 10% line change	±0.05%
Input Voltage Range	47-63Hz	
	PCI-20038A-1	105-132VAC
	PCI-20038A-3	209-264VAC
	PCI-20038A-4	87-110VAC
Temperature Range	Ambient	0 to 50°C
Size	Lenght x Width x Height	9.2" x 4.25" x 2.25" (23.35cm x 10.79cm x 5.71cm)

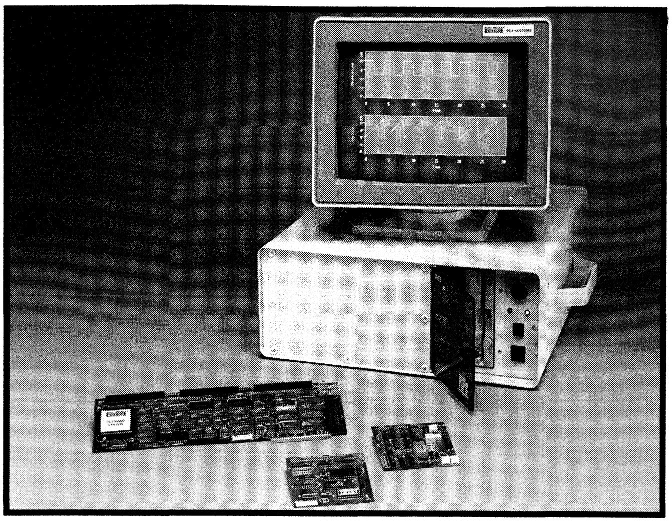
COMPATIBILITY TABLE— PCI-20038A SERIES

PCI MODEL NUMBER	PRODUCT TYPE	DESCRIPTION[2]	NUMBER OF CHANNELS[3]
PCI-20042T-1	Panel	Isolated conditioner	4
PCI-20043T-1	Panel	Isolated expander[1]	4
PCI-20044T-1	Panel	Signal conditioner	4
PCI-20045T-1	Panel	Expander[1]	4

Notes: (1) An inter-panel connection cable is provided with each expander panel.
(2) Isolated and non-isolated conditioner/expander panels can be interconnected to provide four isolated and four non-isolated channels via one cable connection to the data acquisition system.
(3) The number shown refers to each panel. The PCI-20038A Series is capable of powering up to 56 isolated or 160 non-isolated channels.



PCI-20038A-1 Installed in a PCI-20029A-1 with a PCI-20042T-1 and a PCI-20043T-1.



BURR-BROWN®

PCI-20040S-1

LABTECH NOTEBOOK Menu-Driven/Icon-Based Data Acquisition, Control, and Analysis Software

FEATURES

- Easy-To-Use, Menu-Driven/Icon-Based Interface
- Compatible with PCI Boards, Carriers, Modules, and IEEE-488 Interfaces
- Real-Time Data Acquisition
- Real-Time Process Control -- Open or Closed Loop
- Real-Time Analysis and Data Reduction
- Real-Time Graphics Display of Data
- Foreground/Background Operation under DOS

DESCRIPTION

The PCI-20040S-1 is the industry-standard LABTECH NOTEBOOK, designed for PCI products (see FIGURE 1). NOTEBOOK is compatible with most boards, carriers, modules and IEEE-488 devices within the PCI system. NOTEBOOK is an integrated, general-purpose software package for data acquisition, test, measurement, control, and analysis. Tasks are reduced to menu-driven or icon choices. As a result, minimum computer skills are required to perform complex operations. Voltage, current, thermocouple, RTD, pulse, frequency and digital input data can be recorded and displayed in real time, while open- and closed-loop (PID or on/off) outputs are supported. Hundreds of channels can be accommodated. NOTEBOOK runs on VIPc and other PC/XT/AT/EISA compatible platforms. IBM models 50, 60, 70 and 80 Micro Channel (PS/2) computers are also served. A separate version of LABTECH NOTEBOOK for PCI Mac II products will be available soon. Please contact your Burr-Brown representative for more information on availability. A key feature of NOTEBOOK is that it interfaces directly to real-world signals through PCI analog and digital I/O devices. This insulates the user from the need to program the data acquisition hardware.

LABTECH NOTEBOOK can replace handwritten notes, data logging and hand-keying of data. It can automate experiments, control test sequences, perform calculations, display results in a graphical format and generate reports. Because LABTECH NOTEBOOK is menu-driven/icon-based, it is extremely easy to learn and use. The conditions which define the current run are displayed on the screen and are readily modified. All of the conditions pertaining to a run can be easily saved or recalled as a group. LABTECH NOTEBOOK reduces complicated data acquisition and control procedures to single-button operations, so that repetitive tests and process-monitoring activities are greatly simplified.

Flexibility is another strength of LABTECH NOTEBOOK. Each channel can be set up with different characteristics. Sampling rates may vary from channel to channel and may also change at different times during a run. In addition to reading, analyzing and displaying data, NOTEBOOK can simultaneously record the data to disk for future use. Stored data can be "played back" as though it were being acquired in real time. This provides a facility for making comparisons with data previously acquired or with data that has been theoretically derived.

Channels can be used for purposes other than simple inputs or outputs. NOTEBOOK has the ability to derive channels from other channels. For example, channels can "operate" on others by calculating averages, derivatives, integrals, etc., in real time. The list of mathematical, logical, statistical and signal processing functions also includes: trigonometric, EXP, LN, LOG, OR, XOR, AND,

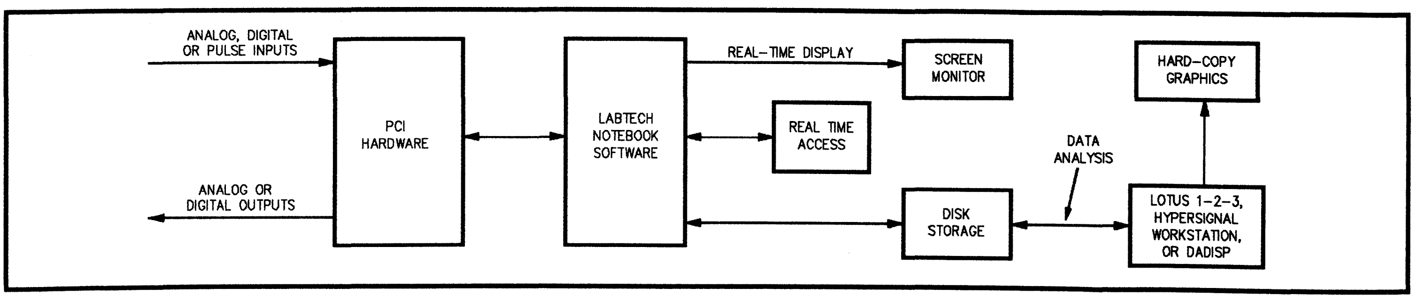


FIGURE 1. LABTECH NOTEBOOK Functional Diagram.

Filter, and FFT. These derived channels can also be used in determining triggers or as inputs to control loops.

Open- and closed-loop control algorithms are easily implemented. In open-loop mode, the user defines one period of any imaginable waveform and the signal is then clocked out automatically during the run. For closed-loop control, both proportional-integral-derivative (PID) and "bang-bang" (on/off) loops can be set up.

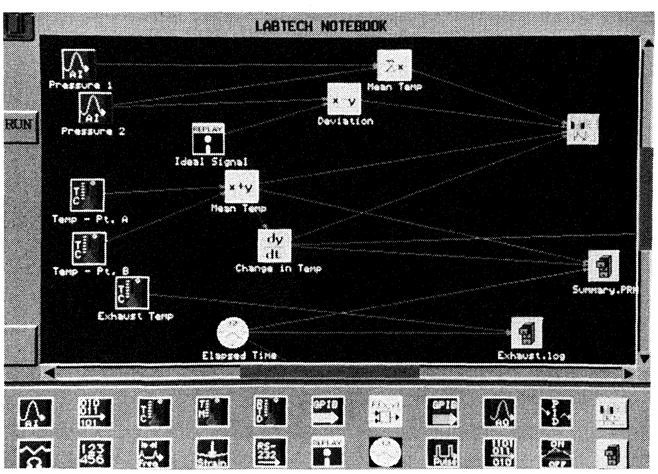
NOTEBOOK includes a powerful curve-fitting function. It uses an iterative routine to fit an arbitrarily complex model (up to ten parameters) to the collected data. This and other routines such as PID and thermocouple linearization will automatically take advantage of the PC's optional coprocessor if available. This offers 80-bit real number processing, reduces round-off error, and allows faster computation.

Additional functionality can be gained by combining NOTEBOOK with other analysis or spreadsheet programs. These can include DADiSP/PC, ASYST and Hypersignal-Workstation available from Burr-Brown, as well as Lotus 1-2-3 and TECH*GRAPH*PAD available elsewhere. LABTECH's data files can be automatically imported into one of these programs for further reduction or analysis. Some of the programs will also provide word processing or database capabilities. It is possible to build a "seamless" integration between LABTECH and these other programs, making it easy to go from acquisition to a final report without writing down or keying in a single piece of data.

Basic Operation

With LABTECH NOTEBOOK's menu-driven/icon-based interface, there are no commands for the user to remember. LABTECH NOTEBOOK includes a mouse-driven graphical interface called ICONview. ICONview allows setups to be visually created by interconnecting icons that represent I/O, file, and display functions. The unlimited "drawing board" size allows the configuration of setups with large numbers of channels and displays. The visual presentation of the system configuration shows the data flow between functions in a way that simplifies setup creation, verification and modification. ICONview works with ADJUST and the traditional menus to maximize productivity. If desired, a double-click of the mouse brings into view the underlying menu for the selected function.

Included are icons for all input and output functions, specialized channel types (such as calculated and time), data storage and display.



A Typical Iconic Interface Display.

The option menu displays a list of setup conditions on the left-hand side of the screen. The corresponding values for each of the setup conditions appear in the column to the right of the list. This is the basic format of all of NOTEBOOK's option menus. Changing any value is easy. Simply move the cursor (highlighted rectangle) up or down the entry column (using the cursor control keys) until the appropriate value is located. Type in the new value and press the Enter key.

Data Acquisition

LABTECH NOTEBOOK can perform data acquisition in either the normal or high-speed mode. In the normal mode, acquisitions may be performed at sampling rates from 0.001Hz to over 1kHz. In this mode, real-time display of data is available to the user (at reduced data rates), and data may also be permanently stored in user-defined files. In the high-speed mode, rates up to 80kHz can be obtained. In both cases the maximum speeds depend upon the particular PCI and computer hardware being used.

In the normal mode, each channel may have different setup conditions. That is, they may have different channel types, scale factors, sampling rates, etc. The time period for each channel may be divided into up to four stages, each stage having a different sampling rate, duration, and/or starting method. The series of stages may be repeated by setting an appropriate iteration count for the channel.

Any stage may be initiated in one of three ways:

— Normal starting, where a stage begins as soon as the previous stage ends (the first stage begins as soon as the run is initiated).

— Trigger starting, where a digital input or an analog level on any channel (or combination thereof) is received before the stage can begin.

— Time delay starting, where a stage begins only after a user-specified time has elapsed.

A stage may run until:

— A stated time period has elapsed, or

— An analog or digital trigger occurs.

The high-speed mode supports only analog inputs, and real-time display of the data is not available. Further, all channels must have identical setup conditions, and multiple stages and loops are not available. A high-speed run may be started using either the normal, trigger, or time-delay method. Data can be displayed after the run is complete.

Process Control

Both open- and closed-loop process control are available using LABTECH NOTEBOOK.

— When open-loop control is specified, the contents of a data file are sent, point-by-point, to the hardware interface at a rate determined by operator selection.

— With closed-loop analog control, the output is determined according to a PID equation. This equation provides an output signal which is a function of the input from an A/D channel and four PID variables, which must be specified during setup: loop gain, loop reset, loop rate, and loop set point.

— With closed-loop digital control, both on/off (bang-bang) and alarm controls are supported. The input signal is compared to upper and lower limits specified during setup, and the appropriate output is generated.

Calculated Channels

A unique channel type is provided to support user defined algebraic, calculus, trigonometric, statistical, and logical operations. Calculated channels, as they are called, accept one or two inputs (depending upon type) from other channels and produce a transformed output. Inputs can include live data, replayed data, time, or other calculated channels. Functions include: X+Y, X-Y, X*Y, X/Y, Sum(X..Y), X, X^2, Square Root, 1/X, ABSOLUTE VALUE, LN, LOG, EXP, SIN, COS, TAN, ARCSIN, ARCCOS, ARCTAN, dX/dt, Integral, MIN, MAX, LOWER LIMIT, UPPER LIMIT, AVERAGE, NOT, OR, AND, FFT, and FILTER. By stringing calculations together, it is possible to perform more complex transformations of the input data.

Data Storage

In the normal mode, how data is stored depends upon the mode selected. Data can be stored in RAM or continuously written to disk. In the high-speed mode data is always stored in RAM during the run. At the end of the run it is written to disk. Eight data storage modes are available, including ASCII and binary formats. The data storage mode determines the amount of space the data will require. Each data file may receive data from one or more data acquisition channels. NOTEBOOK also allows you to place header lines, names, and unit labels in data files. Data files from LABTECH NOTEBOOK may be imported directly into most analysis or spreadsheet programs. For example, external data manipulation, statistics and database management are all available with compatible file structures.

Real-time Display

The real-time display function is available during normal-mode data acquisition and control runs. FIGURE 2 shows an example of the display. As can be seen, the display is in the form of X-Y graphs, Y-time graphs, vertical bars, digital meters, and horizontal bars. Up to 50 signals can be displayed in up to 50 windows. The presentation and scaling of the displays are under the control of the user. Scrolling of the horizontal axis is provided in the Y-time mode. The sizing and positioning of windows is accomplished interactively. A mouse-driven function called "Adjust" is included that can create, delete, position, and stretch windows with ease. LABTECH supports most display standards, including CGA, EGA, VGA, and Hercules monochrome.

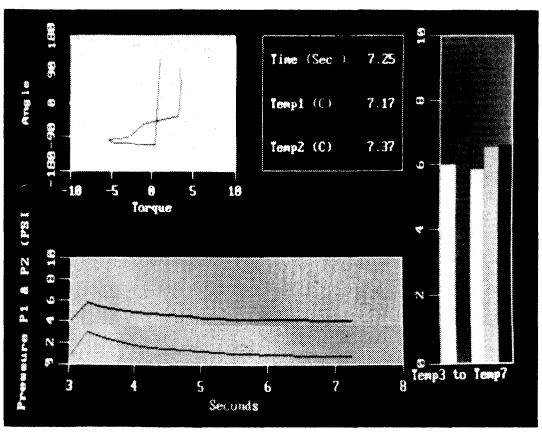


FIGURE 2. Real-Time Display.

Nonlinear Regression Analysis -- Curve-fit

NOTEBOOK offers a curve-fitting routine which enables you to fit an arbitrarily complex model to experimental data.

A mathematical model consisting of independent variables and parameters is entered by the user. Initial estimates for the parameters are also entered. Along with this equation, a data file with experimental data is provided.

The routine uses the model to calculate theoretical values for the data using the initial parameter estimates. The difference between experimental and theoretical data, the residual, is then calculated, and the squares of the residuals for every data point are summed. New values for the parameters are then chosen by the routine in an attempt to minimize this sum of the squared residuals (SSQR).

With the new choices for the parameters, theoretical values are again calculated, and a new set of residuals is found. Given the last value of SSQR and the new value, the routine can determine in which direction to vary the parameters so the SSQR will grow smaller. The process is repeated until the change in parameters between iterations is less than the specified parameter tolerance.

Full statistical data is presented on the quality of the fit, the accuracy of the fitted parameters, and inter-parameter correlation. A graph showing both the experimental and theoretical curves can be produced. An analysis of variance is also performed by the curve-fitting function. The output from this analysis consists of estimates of the parameter standard deviations and a parameter correlation matrix. These results allow the user to determine the quality of the fit to the theoretical model.

DOS System Utility

If at any time during a LABTECH NOTEBOOK session the user wishes to run a program under the DOS operating system, the DOS system utility may be selected from the menus. Scientific application programs, word processing programs, or specialized user-written programs may be executed using this function.

External Bus Support— RS-232 and IEEE-488 (GPIB)

In addition to communicating with PCI hardware installed within the PC, NOTEBOOK can also access external devices through standard RS-232 and GPIB ports. The interface to RS-232 is built into NOTEBOOK's channel setup menu and can be accessed through any available RS-232 port on your PC. A GPIB port can be added to your PC using PCI-800 Series products. These IEEE-488 interfaces are fully described in this Handbook. GPIB capabilities are added to NOTEBOOK with the PCI-20342S-1 Support Kit. This kit includes the required software supplement and complete documentation. Users can enter commands to control a GPIB instrument and then test those commands immediately. Therefore, users can interactively configure NOTEBOOK to control and collect data. Data can be read, displayed, filed to disk and used in calculations. Both GPIB and other PCI hardware interfaces can be used simultaneously.

Real-time Access

LABTECH NOTEBOOK has the unusual capability of operating as a real-time multitasking subsystem on a personal computer running under PC/MS-DOS. NOTEBOOK can operate in the background carrying out a complex schedule of data acquisition and control while the user at the console is running some other DOS application program. Normally, the two programs run independently -- they do not communicate with each other.

LABTECH Real Time Access (PCI-20065S-1) provides for interprogram communications. It allows the foreground application to access the real-time data being acquired simultaneously by NOTEBOOK. To the application program, that data looks as if it is coming from an ordinary DOS file or device. Virtually any existing application program that can access files can access data acquired in real time from analog or digital instrumentation. It need not have been specially written to work with the NOTEBOOK/Real Time Access. So, existing spreadsheets, statistical analysis programs, quality control programs, graphics programs and more can gain real-time data acquisition capabilities.

Foreground programs communicate with NOTEBOOK running in the background. They may access any or all of the data being acquired by NOTEBOOK data acquisition hardware drivers under control of the NOTEBOOK scheduler; or, the foreground programs may initiate data acquisition or process control events by themselves.

Access is via a DOS device driver, communicating with a "porthole" in NOTEBOOK's code. The driver creates a virtual real-time data acquisition and process control device appearing to the application program as an ordinary device or file. Therefore, the program can communicate to NOTEBOOK by sending commands using standard write statements in the language of the foreground program.

Reading is done in one of several modes. In one mode, all data accumulated in the buffer since the last read request is passed to the foreground program, assuring that no data will be skipped. In another mode, only the latest data point in the buffer is passed to the foreground program. Yet another command allows for the immediate collection of a new data point, regardless of when the last one was collected and put in the buffer. Reading can also be set to return with no data (if none has been collected since the last read command) or to wait for data to be entered in the buffer. This last feature provides a simple way for the foreground program to synchronize itself to the data acquisition rate.

Run-time Systems

Run-time systems allow the duplication of LABTECH NOTEBOOK applications around a facility. Run-time versions can execute any setup created with a full NOTEBOOK version, but they do not support making changes to the setups. Because the cost of a run-time system is about half of a complete version, a significant savings can be realized when replicating laboratory installations, production lines, etc. If necessary, setups can be altered using the main system.

The run-time package also allows tighter control over test procedures and conditions. Since it will only execute setups configured with the original system, operators can only run controlled setups. Run-time systems can thus be used by engineering departments and value-added resellers to configure turnkey applications. A Run-time system is the perfect solution when the integrity of a data acquisition and process control program must remain secure. Run-time copies of NOTEBOOK are available by ordering PCI-20316S-1.

Extended RAM Option

The PCI-20330S-1 Extended Memory Option allows NOTEBOOK'S setup files and data buffers to be stored outside of the normal 640Kbytes region of PC-DOS or MS-DOS. This allows more and larger setups while freeing lower memory space for Real Time Access and other foreground/background operations.

Termination Panel Compatibility

As a general rule, all termination panels are compatible with I/O hardware supported under LABTECH NOTEBOOK. However, due to the requirement for Cold-Junction Compensation (CJC) with thermocouples, not all termination panel configurations can be used. The Compatibility Table for Termination Panels defines the various thermocouple options. Please note that for all of the thermocouple channels on a given termination panel, one analog input channel is required to read the CJC on the termination panel -- except for PCI-5B applications.

SUPPORTED PCI HARDWARE

PCI MODEL NUMBER	TYPE	BUS SUPPORTED	FUNCTION[1]	CHANNELS[2]	MAX SPEED[3]	COMPATIBLE H/W PRODUCTS[5]
PCI-601W/602W	Board	Micro channel	Analog input Digital I/O Counter/timer Analog output	16/8[4] 16 2 2	70kHz 1800Hz 1800Hz 900Hz	(PCI-602W only)
PCI-20001C-2A	Carrier	PC/XT/AT/EISA	Digital I/O	32	1800Hz	PCI-20002M, 3M, 4M, 5M, 7M, 19M, 21M
PCI-20041C-2A/-3A	Carrier	PC/XT/AT/EISA	Digital I/O	32	1800Hz	PCI-20002M, 3M, 4M, 5M, 7M, 19M, 21M
PCI-20098C-1	Carrier	PC/XT/AT/EISA	Analog input Digital I/O Counter/timer	16/8[4] 16 2	32kHz 1800Hz 1800Hz	PCI-20003M, 4M, 21M, 31M-1
PCI-20002M-1	Module	I[3]	Analog input	16/84	25kHz	PCI-20001C, PCI-20005M, PCI-20041C
PCI-20003M-2/-3	Module	I[3]	Analog output	2	900Hz	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20004M-1	Module	I[3]	Digital I/O	32	1800Hz	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20005M-1	Module	I[3]	Analog expander	32/16[4]	25kHz	PCI-20001C, PCI-20002M, PCI-20041C
PCI-20007M-1	Module	I[3]	Counter/timer	4	1800Hz	PCI-20001C, PCI-20019M, PCI-20041C
PCI-20019M-1A	Module	I[3]	Analog input	8	80kHz	PCI-20001C, PCI-20007M, PCI-20041C
PCI-20021M-1B	Module	I[3]	Analog output	8	900Hz	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20031M-1	Module	I[3]	Analog expander	32/16[4]	1800Hz	PCI-20098C
PCI-20089W-1	Board	PC/XT/AT/EISA	Analog input	16/8[4]	25kHz	
PCI-20091W-1	Board	PC/XT/AT/EISA	Analog input	8	80kHz	
PCI-20093W-1	Board	PC/XT/AT/EISA	Analog output	8	900Hz	
PCI-5000 Series	Platform	PC/AT/EISA	All PCI-20000 H/W			
PCI-801K	Board	PC/XT/AT/EISA	IEEE-488 Port	1		
PCI-802K	Board	Micro channel	IEEE-488 Port	1		

Notes:
(1) The features listed for carriers can be greatly extended by using one or more compatible modules.
(2) The number of channels refer to a single unit. Multiple units can be used if needed.
(3) Refer to the Speed Benchmarks table below for additional information on performance.
(4) Single-ended/differential.
(5) When model numbers are shown without "dash" numbers, all versions apply.

COMPATIBILITY TABLE— TERMINATION PANELS FOR THERMOCOUPLE APPLICATIONS[1]

BOARD	CARRIER	A/D MODULE	FIRST EXPANSION MODULE	SECOND EXPANSION MODULE	TERMINATION PANEL	NUMBER OF THERMOCOUPLE CHANNELS
PCI-601W/PCI-602W					1 PCI-20024T-1	7
					1 PCI-5B01-1	16
PCI-20089W-1					1 PCI-20010T-2	7
					1 PCI-20042T-1 and 1 PCI-20043T-1	8
					1 PCI-20044T-1 and 1 PCI-20045T-1	8
					1 PCI-20057T-1	7
					1 PCI-5B01-1	16
	PCI-20001C or PCI-20041C	PCI-20002M-1			1 PCI-20010T-2	7
					1 PCI-20042T-1 and 1 PCI-20043T-1	8
					1 PCI-20044T-1 and 1 PCI-20045T-1	8
					1 PCI-20057T-1	7
					1 PCI-5B01-1	16
	PCI-20001C or PCI-20041C	PCI-20002M-1	PCI-20005M-1		3 PCI-20010T-2	21
					3 PCI-20042T-1 and 3 PCI-20043T-1	24
					3 PCI-20044T-1 and 3 PCI-20045T-1	24
					1 PCI-20057T-1	23
					3 PCI-5B01-1	48
	PCI-20001C or PCI-20041C	PCI-20002M-1	PCI-20005M-1	PCI-20005M-1	5 PCI-20010T-2	35
					5 PCI-20042T-1 and 5 PCI-20043T-1	40
					5 PCI-20044T-1 and 5 PCI-20045T-1	40
					2 PCI-20057T-1	38
					5 PCI-5B01-1	80
	PCI-20098C-1				1 PCI-20024T-1	7
					1 PCI-5B01-1	16
	PCI-20098C-1		PCI-20031M-1		1 PCI-20024T-1 and 1 PCI-20057T-1	22
					3 PCI-5B01-1	48
	PCI-20098C-1		PCI-20031M-1	PCI-20031M-1	5 PCI-20010T-2	35
					1 PCI-20024T-1 and 2 PCI-20057T-1	37
					5 PCI-20042T-1 and 5 PCI-20043T-1	40
					5 PCI-20044T-1 and 5 PCI-20045T-1	40
					5 PCI-5B01-1	80

Note: (1) When part numbers are shown without "dash" numbers, all version apply.

SPEED BENCHMARKS— PCI-20040S-1

(The specifications shown in this table are typical of what can be expected under the stated conditions.)

MODE	CONDITIONS	SPECIFICATIONS		
		8088 AT 4.7MHz	80286 AT 12MHz	80386 AT 16MHz
Normal, Analog In and Digital I/O	To RAM, no display or disk storage	300 Reads/sec	900 Reads/sec	1800 Reads/sec
	To disk, binary integer	150 Reads/sec	450 Reads/sec	900 Reads/sec
	To screen, with coprocessor	60 Reads/sec	180 Reads/sec	360 Reads/sec
	Without coprocessor	30 Reads/sec	90 Reads/sec	180 Reads/sec
	To disk and screen, with coprocessor	30 Reads/sec	90 Reads/sec	180 Reads/sec
	Without coprocessor	15 Reads/sec	45 Reads/sec	90 Reads/sec
Normal, Thermocouple and PID Loops	To RAM, no display or disk storage	67 Reads/sec	200 Reads/sec	400 Reads/sec
	To disk, binary integer	33 Reads/sec	100 Reads/sec	200 Reads/sec
	To screen, with coprocessor	13 Reads/sec	40 Reads/sec	80 Reads/sec
	Without coprocessor	7 Reads/sec	20 Reads/sec	60 Reads/sec
	To disk and screen, with coprocessor	7 Reads/sec	20 Reads/sec	60 Reads/sec
	Without coprocessor	4 Reads/sec	10 Reads/sec	30 Reads/sec
Normal, Analog Out	To RAM, no display or disk storage	150 Pts/sec	450 Pts/sec	900 Pts/sec
	To disk, binary integer	75 Pts/sec	225 Pts/sec	450 Pts/sec
	To screen, with coprocessor	30 Pts/sec	90 Pts/sec	180 Pts/sec
	Without coprocessor	15 Pts/sec	45 Pts/sec	90 Pts/sec
	To disk and screen, with coprocessor	15 Pts/sec	45 Pts/sec	90 Pts/sec
	Without coprocessor	7 Pts/sec	22 Pts/sec	45 Pts/sec
High-Speed				
PCI-20002M-1	To RAM only, clocked	4K Reads/sec	9K Reads/sec	9K Reads/sec
	Free running	16K Reads/sec	25K Reads/sec	25K Reads/sec
PCI-20019M-1A	To RAM only, (Requires PCI-20007M-1)	50K Reads/sec	80K Reads/sec	80K Reads/sec
PCI-20089W-1	To RAM only, clocked	4K Reads/sec	9K Reads/sec	9K Reads/sec
	Free running	16K Reads/sec	25K Reads/sec	25K Reads/sec
PCI-20091W-1	To RAM only	50K Reads/sec	80K Reads/sec	80K Reads/sec
PCI-20098C-1	Analog input to RAM	25K Reads/sec	32K Reads/sec	32K Reads/sec
PCI-601W/PCI-602W	Analog input to RAM	--	70K Reads/sec	70K Reads/sec

SPECIFICATIONS— PCI-20040S-1

PARAMETER	CONDITIONS	SPECIFICATION
Computer Platforms	PCI-20000 Series hardware PCI-600 Series hardware PCI-700 Series hardware	VIPc and other PC/XT/AT/EISA compatible machines PS/2 Micro channel compatible machines Contact Burr-Brown for availability
RS-232 Interface **IEEE-488 (GPIB) Interface**	Up to 8 ports supported Refer to PCI-800 Series for port hardware	Included Requires PCI-20342S-1 GPIB support kit
Data Acquisition Sampling Rate Input Types Starting Methods	See individual hardware speed guidelines above	 Up to 80kHz Analog, digital, pulse, frequency and thermocouple (Types B, E, J, K, R, S and T) Immediate, delayed, timed, triggered
Output (Signal Generation) Rate Process Control Modes Input Types Output Types	See individual hardware speed guidelines above	 Up to 900 Pts/sec Open loop and PID Analog, digital, pulse and frequency Analog and digital
Data Storage Types Modes		 RAM and disk ASCII real/integer, binary real/integer, ASCII, hex, binary
Real-Time Display Speed Types Number of Windows/Traces Graphics Modes	 Graphics adaptor required	 Up to 360 Pts/sec Y-Time, X-Y, bars, digital meters 50/50 CGA, EGA, VGA, high-resolution monochrome
PC Requirements[1] Platforms Drives Memory Coprocessor	MS-DOS or PC-DOS machines 8087, 80287, 80387	 PC/XT/AT/EISA or PS/2 compatibles[1] Hard Disk plus 3.5″ or 5.25″ floppy 640KB RAM[2] Automatically used if available

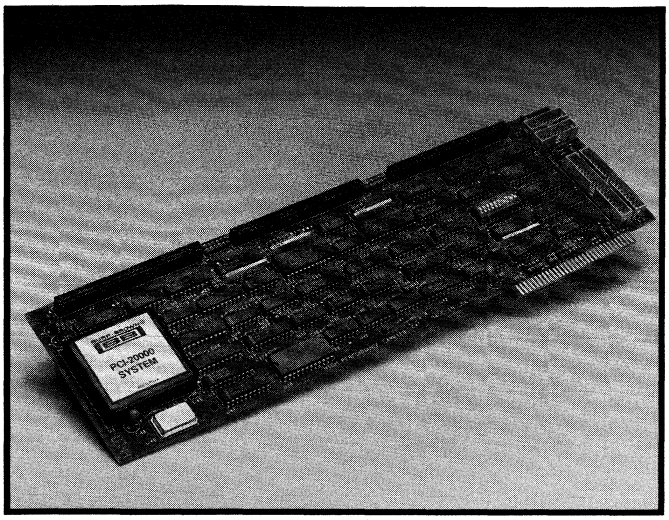
Notes: (1) Please contact your Burr-Brown representative for information on the availability of PCI-700 Series (Mac II) support.
(2) Extended RAM support is available with the PCI-20330S-1 extended memory option.

LABTECH NOTEBOOK— RELATED PRODUCTS

PRODUCT NAME	PCI MODEL NUMBER	DESCRIPTION
Real Time Access	PCI-20065S-1	Provides real-time communications between NOTEBOOK and most other software products
Run-Time System	PCI-20316S-1	Allows running duplicate NOTEBOOK systems at half the cost of a complete version
Extended Memory Support	PCI-20330S-1	Allows NOTEBOOK to use memory above 640KB, supporting larger/more setups and additional functionality
GPIB Support Kit	PCI-20342S-1	Adds an interface to standard IEEE-488 (GPIB) laboratory instruments
Hardware Interface	PCI-600 Series	Micro Channel (PS/2) compatible I/O products
Hardware Interface	PCI-700 Series[1]	Mac II NuBus compatible I/O products
Hardware Interface	PCI-800 Series	Interface products to add IEEE-488 (GPIB) ports to PC/XT/AT/EISA, Micro Channel and Mac II computers
Hardware Interface	PCI-5000 Series	VIPc Family of PC/XT/AT compatible computer platforms
Hardware Interface	PCI-20000 Series	PC/XT/AT/EISA compatible I/O products

Note: (1) Please contact your Burr-Brown representative for information on the availability of PCI-700 Series (Mac II) support.

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20041C Series

High-Performance Carriers for the PC Bus

FEATURES

- Unique DMA Technique Supports High-Speed Transfers of Analog, Digital and Counter Data Simultaneously
- Pre-Trigger and Post-Trigger Capture of Event Data
- Inter-Carrier Bus Allows Data Transfers Between Carriers
- DMA, Interrupt-Driven or Polled Modes of Operation
- Functionality Determined by up to Three Plug-In I/O Modules

DESCRIPTION

The PCI-20041C-2A and PCI-20041C-3A (DMA version) are carriers which interface directly with the internal bus of IBM-compatible PCs, including the Burr-Brown VIPc and other PC/XT/AT/EISA machines. Each carrier provides mounting space, power, and inter-module communications for three PCI I/O modules. Digital, sync, and analog signals may be passed between modules via the on-board Intelligent Instrumentation Interface (I^3) Bus. In addition, an inter-carrier communications port allows similar communications with up to 15 modules residing on multiple carriers. Thus, configurations can range from relatively simple systems with a small number of I/O points to sophisticated systems with several hundred I/O channels and high-speed capability.

The sync lines of the I^3 Bus make possible the coordination of multiple modules to perform various signal processing functions. The differential analog chain and the digital lines of this bus permit any module to condition its input signal and to pass the result to the next module. All power is derived from the +5V DC power supply of the PC. A DC/DC converter on the carrier generates regulated ±15V DC power for use by the modules.

Both the PCI-20041C-2A and PCI-20041C-3A Carriers have 32 points of fully buffered digital I/O capability. The 32 points are arranged in four groups (bytes) of eight bits. Each byte can, under software control, be configured for either input or output use. Field connections to these I/O points are made through two connectors on the carrier. Each connector supports two bytes. Ribbon cables are used to interconnect the carrier to optional signal termination panels. This digital I/O capacity does not diminish any of the other functions, and it leaves all three module positions free for further expansion.

Both carrier models also include an 8MHz programmable pacer clock for use in the timing of data acquisition and transfers of data to and from memory. Both the PCI-20041C-2A and the PCI-20041C-3A can operate in the programmed transfer mode using either polling or interrupt techniques. Each carrier supports a single interrupt to the host computer. The interrupt can be jumpered to levels 2 through 7.

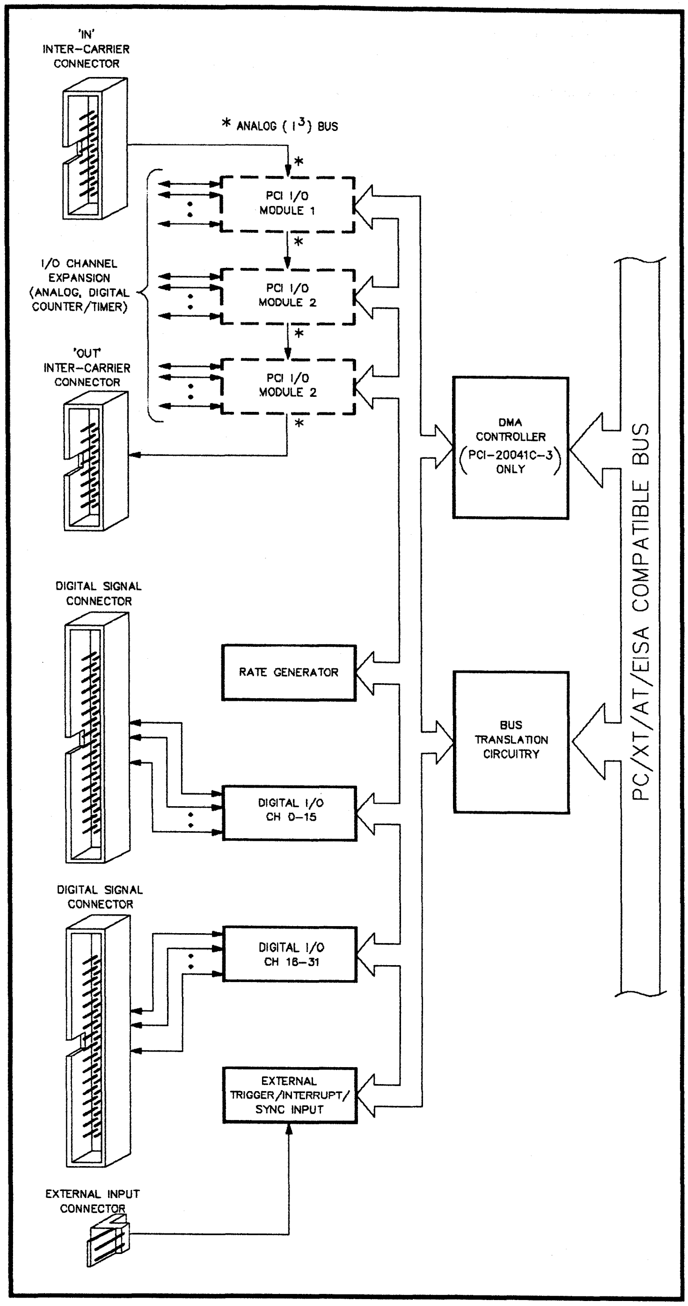
In addition to all of the above capabilities, a unique, patented DMA technique gives the PCI-20041C-3A Carrier the ability to make very high-speed transfers (up to 360Kbytes/sec) of input (or output) data to (or from) the memory of the PC. The DMA controller in the host computer is used in conjunction with a controller on the carrier to accomplish the transfer invisibly to the host computer. Data is transferred to or from the memory of the host PC in frames of up to 64Kbytes using DMA. For input transfers, frames of data from input modules on the I^3 Bus are stored to sequential locations in the host computer's memory. For output transfers, frames of data from specified sequential locations in the host computer's memory are transferred to specified output modules on the I^3 Bus. The frame map is stored in a block of memory on the carrier itself. This is a list of up to 64 I^3 Bus addresses which are to be in the frame, in the order in which they are to be read or written to. There is no need for the contents of this list of I^3 Bus addresses to be sequential. This allows the high-speed scanning of analog or digital inputs in any desired order simply by loading the desired sequence of I^3 Bus addresses into the frame map memory. Conversely, output DMA transfers may be made to any desired sequence of output devices on the I^3 Bus by specifying the appropriate frame map.

The inter-carrier communications port allows a designated carrier to operate as a master and to control DMA transfers from up to four other carriers, which operate as slaves. This is done by insertion of the appropriate jumpers on each carrier and by connecting the carriers together via inter-carrier ribbon cables. The PCI-20062A-1 is ideal for connecting two adjacent carriers. The PCI-20062A-2 is long enough to connect carriers that are separated by four slots. By chaining carriers together in this way, it is possible to make DMA transfers to or from up to 15 modules residing on the carriers. The maximum frame size is still 64 bytes. The sequence of module addresses is once again arbitrarily determined by the user to meet the requirements of the application.

DMA transfers may be initiated on command or on the occurrence of an event after delay. Transfers may be terminated on command, on the occurrence of an event after delay, or after transferring a specified number of frames of data. Transfers can be timed by the on-board pacer clock or by the occurrence of events. Transfers of data to a circular buffer can be used to give pre- and post-trigger information. This allows the analysis of conditions both before and after the occurrence of a random critical event.

Comprehensive documentation covers all aspects of installation, calibration and programming. Each carrier is shipped, at no extra charge, with Burr-Brown's innovative SYSCHECK PC, the system assurance utilities and diagnostics software package. This menu-driven product easily verifies proper installation and utilization of all PCI system components. Not only does SYSCHECK PC greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK PC provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.

When a PCI-20041C Series Carrier is used with plug-in I/O modules, the connecting cables should be routed through the unused PC expansion slot opening. A PCI-20028A-3 is available to support the I/O cables.



Block Diagram of the PCI-20041C Series Carrier.

SPECIFICATIONS— PCI-20041C-2A AND PCI-20041C-3A

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility		Burr-Brown VIPc and other PC/XT/AT/EISA compatibles
Carrier Addressing		Memory mapped
Size	Boundary on any 1K increment	1Kbyte
I/O Configuration		Three I^3 Bus sockets plus 32 digital I/O, programmable as In or Out in groups of 8-bits
Digital Inputs		
High-level Voltage	Minimum	2V
Low-level Voltage	Maximum	0.8V
I_{IN}, High-level	Maximum	70μA
I_{IN}, Low-level	Maximum	-0.25mA
Input Clamp Level		-1.5V
Digital Outputs[1]		
High-level Voltage	I_{out} = Max	2.4V
Low-level Voltage	I_{out} = Max	0.5V
Current Source	V_{out} = Low	-6mA
Current Sink	V_{out} = High	24mA
Tri-state Current	V_{out} = 2.7V	70μA
Tri-state Current	V_{out} = 0.4V	250μA
Digital I/O Speed	80286 @ 12MHz	
QuickBASIC	Using PCI-20026S-1 drivers	7Kbytes/sec
C	Using PCI-20026S-2 drivers	8Kbytes/sec
TURBO PASCAL	Using PCI-20026S-3 drivers	6Kbytes/sec
Assembly Language	User developed	160Kbytes/sec
	80386 @ 16MHz	
QuickBASIC	Using PCI-20026S-1 drivers	10Kbytes/sec
C	Using PCI-20026S-2 drivers	11Kbytes/sec
TURBO PASCAL	Using PCI-20026S-3 drivers	9Kbytes/sec
Assembly Language	User developed	280Kbytes/sec
Pacer Clock	Basic frequency	8MHz ±.01%
Output Frequency	N_1 and N_2 are user-programmable 16-bit integers	$8MHz/(N_1 \cdot N_2)$
Interrupts	Can be latched	
Levels	Jumper selectable	2 through 7
Sources	Via IRQ0*	Modules 1-3, pacer clock, external TTL
Sense		TTL high to low
DMA Transfers	PCI-20041C-3A only	
Data Types	Analog, digital, counter	Inputs or outputs
Speed	Maximum rate (2)	360Kbytes/sec
Transfer Modes	Linear or circular buffers	Start and stop on command or on event after Delay
Frame Size	Maximum number of addresses	64 Bytes
Block Size	Maximum data stored in RAM	64Kbytes
Current Requirements	From PC's +5V supply	
PCI-20041C-2A	No load on internal supply	1.7A[3] typcial, 2.7A[3] maximum
	Full load on internal supply	3.85A typcial, 4.85A maximum
PCI-20041C-3A	No load on internal supply	2.5A[3] typcial, 3.6A[3] maximum
	Full load on internal supply	4.65A typical, 5.75A maximum
Current Available to Modules	Internal +15V supply	150mA minimum[4]
	Internal -15V supply	150mA minimum[4]
	+5V Bus	Depends upon host
Physical	Expansion slot requirements	1 to 2 slots[5]
Size	Length x Height	13.1″ x 3.9″ (33.3cm x 9.9cm)
Temperature Range	Board temperature	0 to 70°C

SOFTWARE COMPATIBILITY TABLE— PCI-20041C SERIES

(The PCI-20041C Series can be used with the following software in conjunction with the listed hardware.)

PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER[2]	DMA OPERATION (PCI-20041C-3A ONLY)	MODULES SUPPORTED[1]
PCI-20040S	LABTECH NOTEBOOK	Yes	Yes	No	PCI-20002M, 3M, 4M, 7M, 19M and 21M
PCI-20097S	LABTECH CONTROL	Yes	Yes	No	PCI-20002M, 3M, 4M, 7M, 19M and 21M
PCI-20068S	SNAP-Series	Yes	Yes	Yes	PCI-20002M, 3M, 6M, 7M, 19M, 20M, 21M, 23M, 31M
PCI-20067S	DADiSP/PC	Yes	No	No	Post process data collected with other
PCI-20310S	Hypersignal-Workstation	Yes	No	No	hardware/software.
PCI-20026S	General-purpose Drivers	No	Yes	No	All PCI I/O modules
PCI-20027S	High-performance Drivers	No	Yes	No	PCI-20002M, 7M, 17M, 19M, 20M, 23M, 31M and 341M
PCI-20027S	High-performance Drivers	No	Yes	Yes	PCI-20002M, 3M, 4M, 6M, 7M, 19M, 20M, 21M, 23M, 31M and 341M
PCI-20096S	TURBO STREAM Drivers	No	Yes	Yes	PCI-20002M, 3M, 4M, 6M, 7M, 19M, 20M, 21M, 23M, 31M and 341M

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-20026S and PCI-20027S drivers).

HARDWARE COMPATIBILITY TABLE— MODULES

(The PCI-20041C Series can be used in conjunction with the following hardware products.)

PCI MODEL NUMBER	FUNCTION	NUMBER OF CHANNELS	RESOLUTION	SPEED	CABLE	TERMINATION PANEL	ENCLOSURE[1]
PCI-20002M-1	Analog input	16/8[2]	12-Bit	32,000Hz	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A
PCI-20019M-1A	Analog input	8	12-Bit	89,000Hz	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A
PCI-20023M-1	Analog input	8	12-Bit	180,000Hz	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A
PCI-20341M-1	Analog input	1/4[2]	12-Bit	100,000Hz	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A
PCI-20031M-1	Analog expansion	32/16[2]		Set by A/D	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A
PCI-20017M-1	Simultaneous S/H	4/4[2]		10K Frames/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A
PCI-20020M-1	Trigger/alarm	1		20ns scatter	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A
PCI-20003M-2	Analog output, V	2	12-Bit	80,000 Pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A
PCI-20003M-4	Analog output, V/I	2	12-Bit	40,000 Pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A
PCI-20006M-2	Analog output, V	2	16-Bit	80,000 Pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A
PCI-20021M-1B	Analog output, V	8	12-Bit	2,000 Pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A
PCI-20004M-1	Digital I/O	32		280Kbytes/sec	PCI-20311A-1	PCI-20305T-1	PCI-20308H-1, PCI-20343A
PCI-20007M-1	Counter/timer	4[3]			PCI-20311A-1	PCI-20324T-1	PCI-20308H-1, PCI-20343A

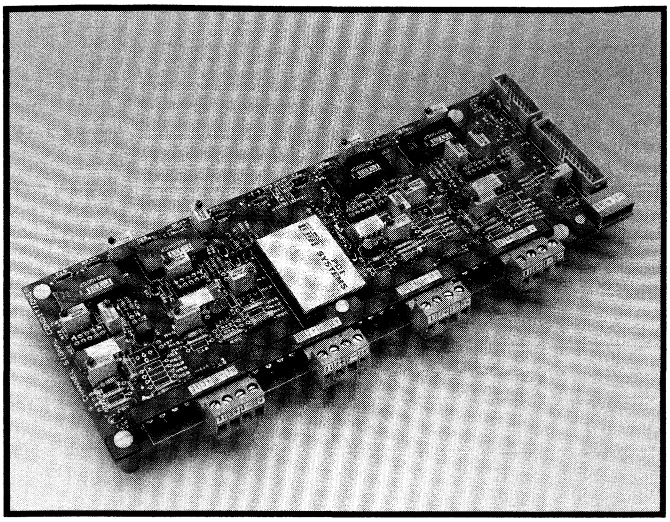
Notes: (1) When model numbers are shown wihtout "dash" numbers, all versions apply.
(2) Single-ended/differential.
(3) Counters/timers.

HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS

(The PCI-20041C Series can be used in conjunction with the following hardware products.)

TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20305T-1	General-purpose	PCI-20311A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20025T-2	Customizer	PCI-20061A-1	PCI-20029A-1
PCI-20324T-1	Signal conditioner	PCI-20311A-1	PCI-20308H-1
PCI-20018T-1	Signal conditioner	PCI-20013A-1	PCI-20029A-1
PCI-20048T-1	Signaı conditioner	PCI-20013A-1	PCI-20339A-1

For additional information, pleaser refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20042T-1

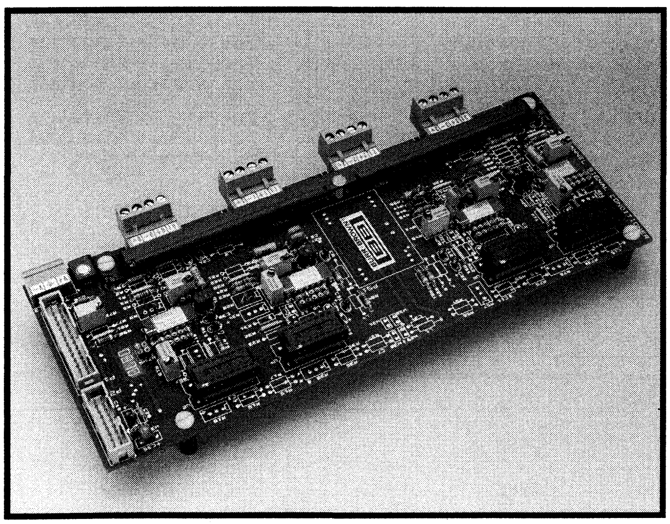
Isolated Signal Conditioner Termination Panel

FEATURES

- Input-to-Output and Channel-to-Channel Isolation (750V)
- Provisions for RTDs, Strain Gages, etc.
- Cold-junction Compensation for Thermocouples
- Differential Input Amplifier, Gain = 1, 10, 100, 1K
- Ideal for Ground Loop Interruption, Measuring Low-Level Signals Riding on Large Common-Mode Potentials, and Protection Against Power Line Contact

OVERVIEW

The PCI-20042T-1 is a four-channel active signal conditioner. All input channels are completely isolated from each other and from the main power supply ground. The number of channels can be expanded to eight. Isolation is rated for continuous operation at 750V. Each channel is tested at the factory to a 2500V specification. Applications for this panel include accurate measurements of low-level voltages in noisy environments, transducer signal conditioning, ground loop interruption, and thermocouple measurements.



BURR-BROWN®

PCI-20044T-1

Active Signal Conditioner Termination Panel

FEATURES

- Provisions for RTDs, Strain Gages, etc.
- Cold-Junction Compensation for Thermocouples
- Differential Input Amplifier, Gain = 1, 10, 100, 1K
- Ideal For Transducer Signal Conditioning, Biological and Physiological Measurements
- Four Channels, Expandable To Eight Channels

OVERVIEW

The PCI-20044T-1 is a four-channel active signal conditioner. It is similar to the PCI-20042T-1, but without isolation. The number of channels can be expanded to eight. Applications for this panel include signal scaling (amplification), filtering, and bridge conditioning. In addition to bridge completion capabilities, the panel includes a separate precision, excitation current source for each channel. Signals from thermocouples, strain gages, thermistors, RTDs, etc., can be mixed on the same panel.

The PCI-20042T-1 thru PCI-20045T-1 Series are each four-channel active signal conditioners. On the PCI-20042T-1 and PCI-20043T-1 all input channels are completely isolated from each other and from the main power supply ground. The PCI-20044T-1 and the PCI-20045T-1 are identical to the former units except that they are NOT isolated. The PCI-20042T-1 and the PCI-20044T-1 are base units, while the PCI-20043T-1 and the PCI-20045T-1 are designed to add channels. They are known as expanders. If needed, one expansion unit can be stacked below one base unit to provide an additional four channels. It is permissible to mix isolated and non-isolated units. Signals (after isolation, if available) from the lower panel connect to the upper panel through a short ribbon cable (included with the expansion unit). All eight signals are then available at a ribbon cable connector on the upper assembly (single-ended, referenced to output ground). The conditioned signals can be connected to the PCI System through the PCI-20012A Series Cables. PCI-20042T-1 thru PCI-20045T-1 can also be used with other, independent, measurement systems.

Each input channel is independently amplified by a true differential-input instrumentation amplifier. The low noise, excellent DC stability, and low nonlinearity preserve the integrity of low-level signals. The differential input of this amplifier provides excellent rejection of extraneous common-mode voltages that may exist with respect to the input reference (ground) points. These features can be critical in many applications. On the isolated panels, the individually amplified input signals are passed to separate high-performance isolation amplifiers, which translate the input signals so that they are referenced to the output ground. Any input common-mode voltages that exist with respect to output ground are rejected by the isolation barrier. This allows the interruption of ground loops that would otherwise lead to serious system errors. Isolation permits the measurement of small signals in the presence of large common-mode voltages, while protecting other connected instrumentation from such voltages.

These panels can accommodate input signals from transducers such as thermocouples, RTDs, and strain gages. In addition to amplification and isolation (on PCI-20042T-1 and PCI-20043T-1), the panels have provisions for specialized types of signal conditioning. An on-board cold-junction compensation network allows any mixture of thermocouple types. For bridge configurations, each channel includes a constant current source for bridge excitation and mounting locations for user-installed bridge-completion resistors. Other locations allow for user-installed components that permit the incorporation of one or two poles of filtering, voltage dividers, input protection, etc.

On-board calibration potentiometers allow the user to null input offsets and adjust gain and excitation currents if required.

Input power for each of the signal conditioning panels comes from an external ±15VDC supply. Both the PCI-20042T-1 and the PCI-20043T-1 include a DC-to-DC Converter (power supply) which provides isolated DC power for the four channels of amplification and signal conditioning on each panel.

The PCI-20038A Series power supply is recommended for powering the panels. Up to seven each of the PCI-20042T and PCI-20043T (56 isolated channels), or up to 20 each of the PCI-20044T-1 and PCI-20045T-1 (160 channels) can be powered by one supply.

Each panel measures 9″ x 3.85″ x 1.4″ (22.9cm x 8.9cm x 3.6cm). The PCI-20029A-1 enclosure is available to house these panels in a table-top or rack-mount configuration. Each enclosure will house up to 32 conditioned channels provided by four pairs of panels.

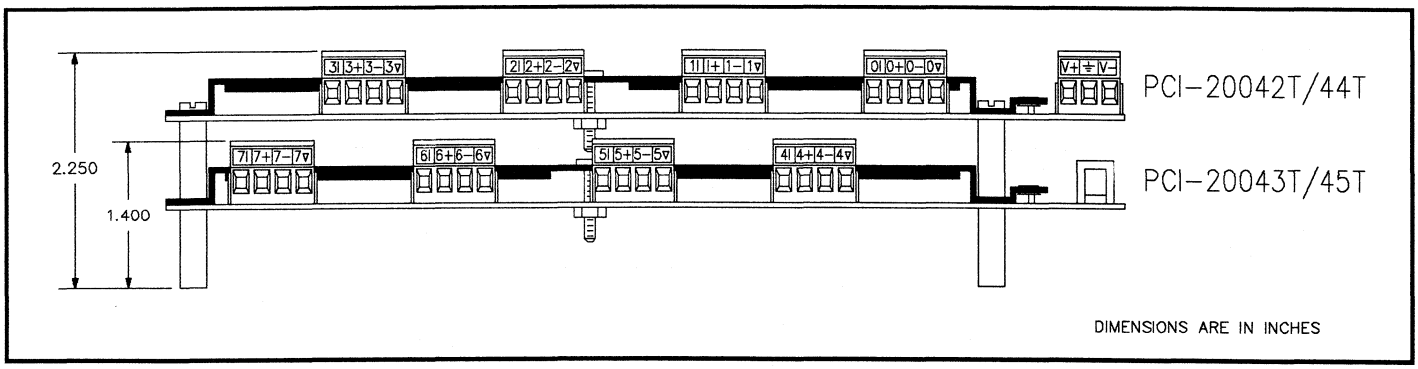


FIGURE 1. Base and Expander Unit Dimensions.

COMPATIBILITY TABLE— SIGNAL CONDITIONER SERIES

PCI MODEL NUMBER	PRODUCT TYPE	DESCRIPTION
PCI-20002M-1	Module	Analog input
PCI-20019M-1A	Module	Analog input
PCI-20023M-1	Module	Analog input
PCI-20031M-1	Module	Analog expander
PCI-20012A-1	Cable	6 feet long
PCI-20012A-2	Cable	12 feet long
PCI-20038A Series	Power supply	±15V, 800mA
PCI-20029A-1	Enclosure	19″ Rack mount or tabletop

SPECIFICATIONS—PCI-20042T-1, PCI-20043T-1, PCI-20044T-1 and PCI-20045T-1

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Number of Channels	Base or expansion unit	4
	Base plus expanion unit	8
Input Stage		
Gain	Jumper programmable[1]	G = 1, 10, 100, 1K
User,	Defined via R_G, G_A = 1 or 10	G = 1 to 1K
Equation(2)	Isolated	$1+[40K/(R_G+40)]\ G_A$
	Non-isolated	$1+[40K/(R_G+40)]$
Accuracy	Equation	±20%
Accuracy	Fixed gains	±0.05%
Linearity, Isolated	G = 1, 10	±0.083% FS
Non-isolated	G = 100	±0.083% FS
	G = 1000	±0.96% FS
	G = 1, 10	±0.05% FS
	G = 100	±0.15% FS
	G = 1000	±0.05% FS
Offset Voltage		±1mV
Drift, Isolated	RTI	1mV/°C max
Non-isolated		7μV/°C
Common-Mode, Rejection	60Hz, 1K unbalanced	
	G = 1	80dB
	G = 10 to 1000	96dB
Range	DC + peak AC	10V
Bias Current		6nA
Input Impedance		100Meg @ 15pF
Crosstalk	Channel-to-channel	-100dB
Output Stage		
Offset Voltage	RT0, Isolated models only	±1mV
Drift	RT0, Isolated models only	±0.5mV/°C
Current		1mA
Frequency Response	Full Scale, 1% flatness	
Bandwidth		
Isolated	G = 1, 10 100	100Hz
	G = 100	30Hz
Non-isolated	G = 1	30kHz
	G = 10	3kHz
	G = 100	300Hz
	G = 1000	30Hz
Slew Rate	10V Step	0.15V/μs
Settling Time		
Isolated	All gains	0.022s
Non-isolated	G = 1, 10	60μs
	G = 100	500μs
	G = 1000	4500μs
Isolation Ratings		
Voltage	Continuous, DC + peak AC	750V
	Test, 10 seconds	2500V
Leakage Current	240Vrms, 60Hz	1μA
Isolation Mode Rejection	60Hz, G = 1000	127dB
Excitation Current	For resistive loads	
Adjustment Range		1.1mA to 2mA
Factory Setting		1.4mA ±2μA
Compliance		14V
Cold-Junction Sensor	Thermocouple compensation	
Scale Factor		10mV/°K, ±1°K
Power Requirements	PCI-20042T-1, +15V	+100mA
	-15V	-10mA
	PCI-20043T-1, +15V	+10mA
	-15V	-100mA
	PCI-20044T-1, ±15V	±20mA
	PCI-20045T-1, ±15V	±20mA
Temperature Range	Board temperature	0 to 70°C

Notes: (1) Overall gains 1 to 1K are produced by combinations of first- and second-stage gain of 1, 10, 100, and 1 and 10 respectively.
(2) G_A is the second-stage gain (isolation amplifier).

For additional information, please refer to the configuration charts in the Summary Section.

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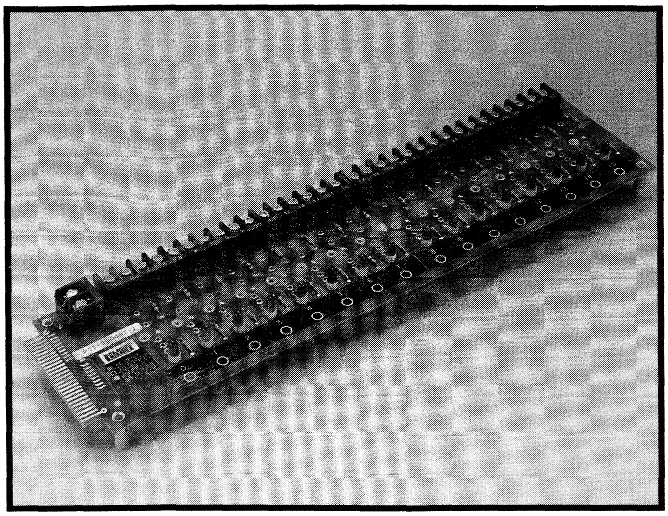


PCI-20048T-1

Isolated Digital Termination Panel

FEATURES

- 16-Channel Capacity
- Screw Terminals Provide for Easy Field Wiring Connections
- Can be Used for Either Input or Output Functions
- LEDs Indicate Channel Status
- Compatible with PCI-1100 Series Opto-Blocks
  - — Converts High-Level Signals to TTL
  - — Provides Isolation and Power Handling Capabilities
  - — Switches up to 60VDC and 240VAC at 3A

DESCRIPTION

The PCI-20048T-1 is a 16-channel digital signal termination panel that accepts a separate PCI-1100 Series opto-block for each channel. This feature allows complete I/O flexibility. Various combinations of the different opto blocks can be intermixed on one panel. However, each contiguous group of eight channels (starting with channel 0) must contain only input *or* output modules.

The termination panel is divided into identical circuit patterns, each being associated with a plug-in opto block and a set of two screw terminals at the edge of the panel. Field connections are made to the panel via the screw terminals. When used with a PCI board, carrier or module, the interconnecting cable brings ±5V to the termination panel. Up to 250mA is available to power on-board functions, including the LED channel status indicators. Separate terminals are provided for the connection of an external power supply if this is desired. A 50-pin card-edge connector allows connection to other parts of the PCI System. The panel is compatible with PCI-20013A Series Cables.

The PCI-20013A Series is built with ground-plane type flat ribbon wire and is intended for either digital input or output use. Included in this category are counter/timer functions. The ground-plane minimizes cable inductance while reducing electrostatic and electromagnetic emissions. The PCI-20013A-1 is 6 feet (2m) long, while the PCI-20013A-2 is 12 feet (4m) long. All ground-plane cables have the ground-plane connected at one end only to avoid ground loops.

The PCI-20048T-1 is 14″ x 3.5″ x 2.1″ (35.6cm x 8.9cm x 5.3cm), including the opto block height. One panel fits into a PCI- 20339A-1 19-inch, rack-mount enclosure. The height and depth of the PCI-20339A-1 are 3.5 inches and 3.7 inches, respectively.

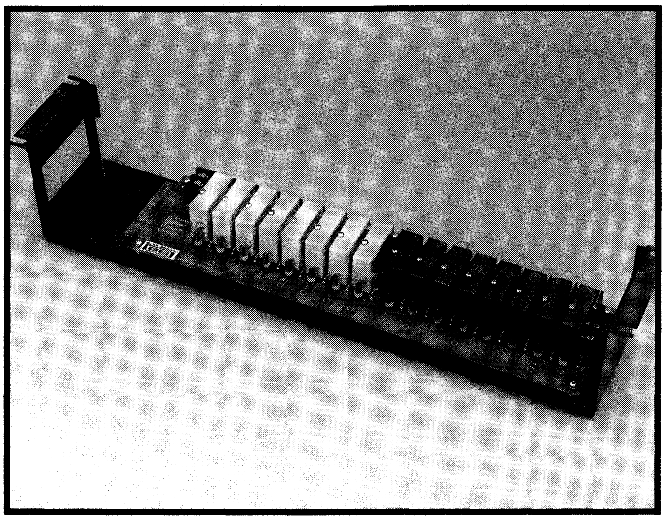
Various cable and connector manufacturers place marks or codes to indicate the location of wire or pin number 1. When using ANY PCI system, these codes or marks should be IGNORED. The correct wire and pin designations are described in the PCI user manuals. For those who wish to make their own cables, the mating connectors are listed below:

For Termination Panel	T&B Ansley #609-5015M
For Board, Carrier, or Module	T&B Ansley #609-3430

COMPATIBILITY TABLE— PCI-20048T-1

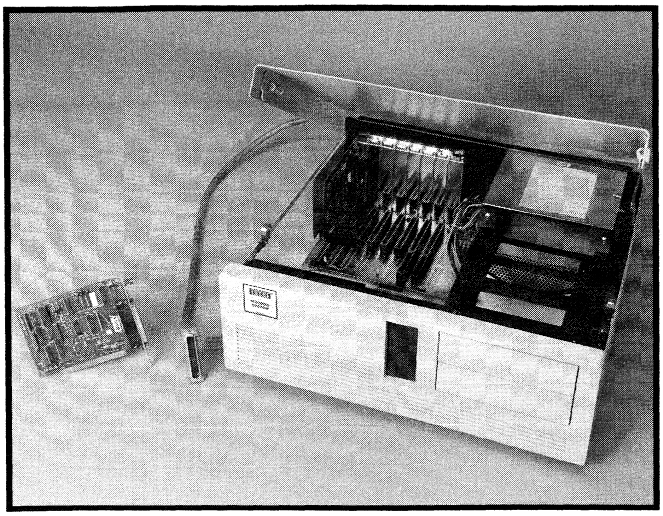
PCI MODEL NUMBER	TYPE	NUMBER OF CHANNELS	DESCRIPTION	CARRIERS[1]	MODULES[1]	BOARDS[1]
PCI-20013A-1	Cable	16	6-foot ground plane	PCI-20001C-2A, PCI-20041C	PCI-20004M, PCI-20007M	PCI-20087W
PCI-20013A-2	Cable	16	12-foot ground plane	PCI-20001C-2A, PCI-20041C	PCI-20004M, PCI-20007M	PCI-20087W
PCI-20339A-1	Enclosure	16	19-inch rack			
PCI-1101	Block	1	AC/DC input, 32V			
PCI-1102	Block	1	AC/DC input, 120V			
PCI-1103	Block	1	DC output, 60V			
PCI-1104	Block	1	AC output, 120V			
PCI-1105	Block	1	AC/DC input, 240V			
PCI-1106	Block	1	AC output, 240V			

Note: (1) When model numbers are shown without "dash" numbers, all versions apply.



The PCI-20048T-1 Accepts PCI-1101 Through PCI-1106 Signal Conditioning Blocks. The Panel Can Be Rack-mounted Using the PCI-20339A-1 Enclosure.

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20055H Series

Expansion Enclosures for the PC Bus

The PC Expander

FEATURES

- 7-Slot Capacity
- 200 Watt Internal Power Supply
- Bench-Top or In-Rack Installation
- Easy-Access Flip-Top Lid

DESCRIPTION

The PCI-20055H Series of Expansion Enclosures is designed to enhance the capabilities of any IBM compatible personal computer in data acquisition, test, measurement and control applications. These computers include the Burr-Brown VIPc and PC/XT/AT/EISA machines. As a system is expanded, it is possible to run out of expansion slots. Even with slots available, sufficient power for the add-in features may not be available. Most PCs have just a few available expansion slots for the installation of important add-in boards. The PC Expander extends the capability of the computer by adding up to seven additional expansion slots. This permits the construction of medium- to large-scale installations. Systems containing 300 to 600 channels are easily accommodated. In addition, multiple PC Expanders can be used when even larger configurations are required. As a general rule, up to four PC Expansion Boxes can be connected to one host computer. However, if DMA is to be used, we recommend that only two Expanders be *directly connected* to a given computer. Here are three examples of tested configuration options:

1) Non-DMA Modes of Operation. Four interface boards installed in one host computer, with one PC Expander connected to each (four total PC Expanders). Up to 2048 DI/O or 1280 analog input channels can be accommodated.

2) All Modes of Operation Including DMA. Two interface boards installed in one host computer, with one PC Expander connected to each (two total PC Expanders). Up to 1024 DI/O or 640 analog input channels can be accommodated.

3) All Modes of Operation Including DMA. One interface board is installed in the host computer. Three PC Expanders are daisy-chained together to the one computer. Up to 1152 DI/O or 720 analog input channels can be accommodated.

The convenient, flip-top lid provides easy access to the test and measurement system without disturbing the host computer. Both desktop and rack installations are supported by the attractive housing. The width of the enclosure is 17.4 inches (44 cm), allowing convenient tray mounting in a standard 19-inch rack. Only a half-size interface driver board (PCI-20063A-1) plugs into the host PC. While available separately, this board is required for operation of the PC Expander. Interface boards are sold individually so that one PC Expander-based system can be shared (only one is connected at a given time) by several computers (each with a PCI-20063A-1 installed). The PC Expander is easily connected and disconnected from the PC with a high-quality, round, shielded cable. The provided 3-foot (0.91M) cable has D-connectors on both ends. This length allows positioning the PC Expander on either side or above/below the host computer.

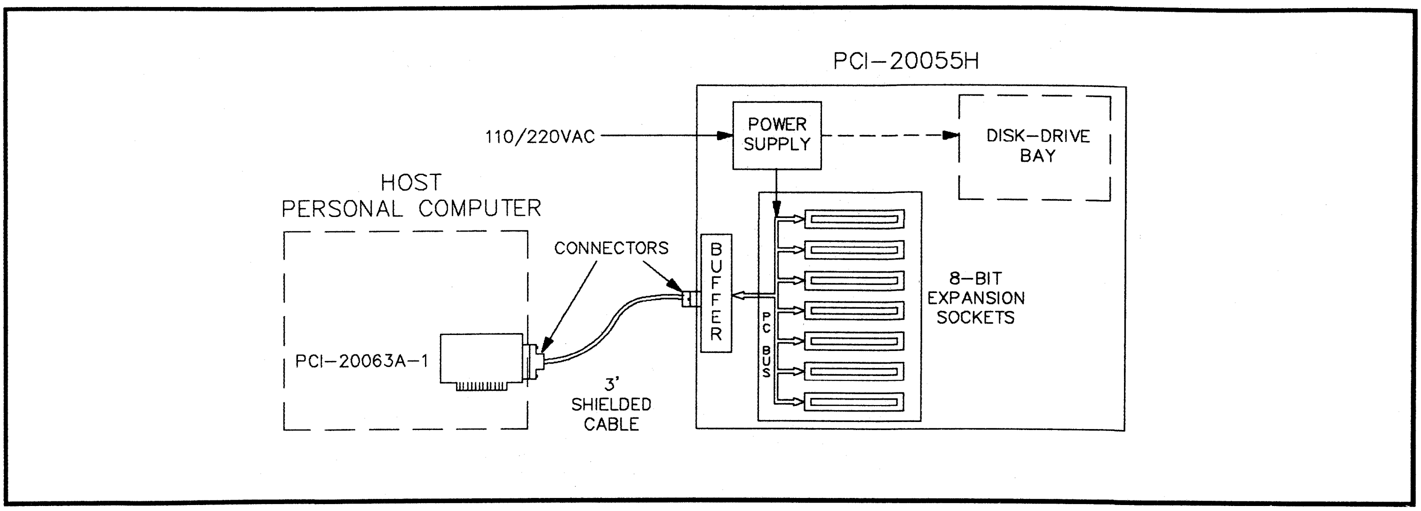
While designed specifically to support the Burr-Brown PCI System Series of data acquisition and control components, the PC Expander will also accept many other PC/XT type plug-in boards. This includes floppy and hard disk controllers as well as RAM expansion boards. The umbilical cable that interconnects the host PC and the PC Expander supports standard 8-bit transfers and is compatible with PC/AT/EISA type machines when only PC/XT type boards are installed in the PC Expander.

The PCI-20063A-1 PC Bus Host Interface Board plugs directly into an expansion slot in any VIPc or other PC/XT/AT/EISA compatible computers. These include the 386-type machines. In addition, the IBM PS/2 model 30 supports this and all other PCI System products. No jumpers or switches need to be set on the interface board, further simplifying installation.

The high speed of the interconnection hardware allows the PC Expander to be used with virtually all PC compatible machines with bus speeds up to 10MHz. It is important to note that most compatible computers with CPU speeds in excess of 8MHz divide the clock speed to 8MHz before connection to the expansion bus. This is done to maintain compatibility with the wide range of add-in boards available. Thus, most 80286 and 80386 computers running at 12, 16 and even 20MHz are compatible with the PC Expander.

A separate, internal power supply is included to energize all boards installed within the PC Expander. The AC input is *switch selectable* for use in most parts of the world. The PCI-20055H-3 is shipped with the switch set for 100/120VAC operation, while the PCI-20055H-4 is shipped in the 240VAC configuration. Two hundred watts of output power is available to satisfy all known applications. A fan assures adequate air flow for proper cooling. Mounting provisions for up to three half-height disk drives are also included.

A functional block diagram of the product is shown below.



Block Diagram of the PCI-20055H Series.

SPECIFICATIONS— PCI-20055H-3, PCI-20055H-4 and PCI-20063A-1

All specifications are typical at 25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility	See text above	Burr-Brown VIPc and other IBM PC/XT/AT/EISA compatibles
PC Bus Speed	Max recommended, see text	10MHz
Available Slots	PC/XT, 8-bit, full size	7
Slot Spacing		0.8" (2.03cm)
Power Supply, PCI-20055H Series	DC output, 200 watts total	
Output Current	+5V	20A
	-5V	0.5A
	+12V	8A
	-12V	0.5A
	Switchable	
AC Power Input	47 - 63Hz	300 watts max
	PCI-20055H-3	90 - 132VAC
Factory Setting	PCI-20055H-4	180 - 264VAC
Power Requirements		
PCI-20063A-1	From host PC, maximum	345mA
Physical Size	Width	17.4" (44cm)
Cover Closed	Depth, excluding cables	17" (43.2cm)
	Height, including feet	6.5" (16.5cm)
Enclosure Weight		28 lbs. (12.7 Kg)
Temperature Range	Internal	0 to 50°C

COMPATIBILITY TABLE— CARRIERS

PCI MODEL NUMBER[1,2]	FUNCTION
PCI-20001C	General-purpose
PCI-20041C	High-performance
PCI-20098C	Multifunction
PCI-20202C	*Smart* Processor

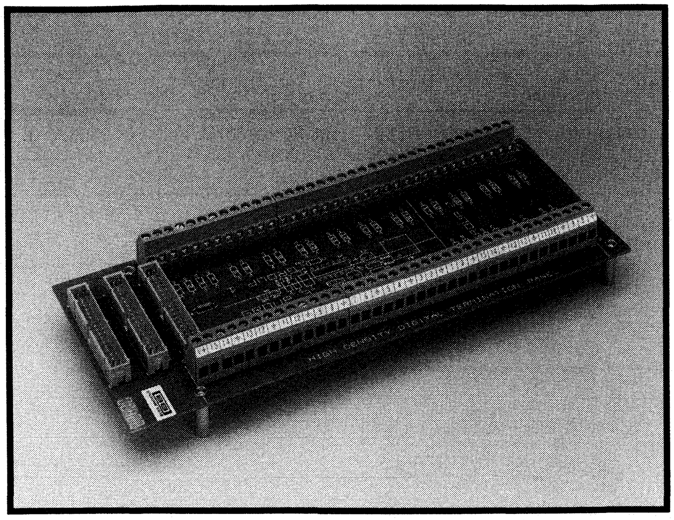
Note: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) Any modules can be used.

COMPATIBILITY TABLE— BOARDS

PCI MODEL NUMBER[1]	FUNCTION
PCI-20087W	Digital I/O
PCI-20089W	Analog input
PCI-20091W	High-speed analog input
PCI-20093W	Analog output

Note: (1) When model numbers are shown without "dash" numbers, all versions apply.

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20058T-1

High-Density Digital Termination Panel

FEATURES

- Clamp-type Screw Terminals for Field Wiring Connections
- Passive Signal Conditioning Capabilities
- Can be Used for Either Input or Output Functions

DESCRIPTION

The PCI family of digital signal termination components includes both *passive* and *active* panels. Passive products are general-purpose units that are not shipped from the factory with isolators, relays, or logic circuits installed. However, it is possible in some cases, for the user to install active circuits on passive panels. Passive panels and their complementary cables are described in this data sheet. Active units providing optical isolation and power handling capability are found in the PCI-20018T-1 and PCI-20048T-1 data sheets. The passive panels include three basic types: Euro-Style, high-density and customizer.

The high-density, PCI-20058T-1 Termination Panel can accommodate up to 48 channels of digital I/O, with signal conditioning available on each channel. Each group of 16 channels is interfaced to the DA&C system with a separate ribbon cable connector (a total of three connectors).

The termination panel layout is divided into groups of printed circuit patterns to support user-installed passive signal conditioning networks. Provisions are provided for logic pull-up and contact wetting. There are 16 network groups. In addition, the PCI-20058T-1 has space for the user to install components to create one input-contact debounce circuit. Each network/circuit is associated with a set of screw terminal blocks at the edge of the panel. Field connections are made to the panels via the screw terminal blocks. There is a ground terminal adjacent to each pair of inputs. The PCI-20058T-1 Panel is compatible with both the PCI-20036A-1 and PCI-20061A-1 Cables.

When used with a PCI board, carrier, or module, the interconnecting cable brings +5V to the termination panel. In most cases, up to 240mA is available to power on-board functions (LEDs, pull-ups, etc.). A separate terminal block is also provided for the connection of an external power supply, if additional current or another voltage is required.

The physical size of the panel is 9″ x 3.5″ x 1.6″ (22.9cm x 8.9cm x 4.1cm). It can be mounted in the PCI-20029A-1 Enclosure. An Enclosure has room for four panels in a tabletop or rack-mount configuration. Additional information can be found in the PCI-20029A-1 data sheet.

The PCI-20061A-1 is built with a ground-plane flat ribbon cable. It is intended for both digital input and output use. Included in this category are the counter/timer applications. The PCI-20061A-1 contains 34 wires. PCI-20061A-1 mates with the PCI-20058T-1 and connects to any PCI digital board, carrier, or module (except the multifunction units: PCI-20098C-1, PCI-601W/PCI-602W and PCI-701C). The ground-plane minimizes cable inductance while reducing electrostatic and electromagnetic emissions. PCI-20061A-1 is 6 feet (2m) long. All ground-plane cables have the ground plane connected at one end only to avoid ground loops. The grounded end is clearly marked.

The PCI-20036A-1 is NOT shielded but can be used for many digital I/O applications. It is a lower cost cable intended for applications where it is not critical to minimize noise or to preserve pulse shape. The PCI-20036A-1 is 4 feet (1.2m) long and has 34 wires.

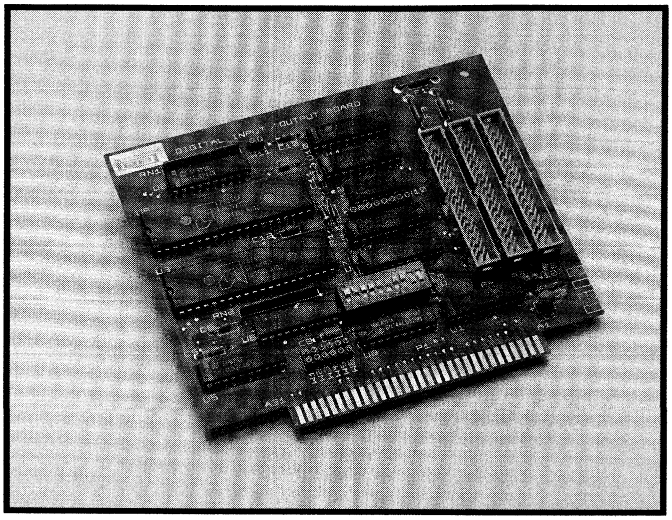
Various cable and connector manufacturers place marks or codes to indicate the location of wire or pin number 1. When using ANY PCI system, these codes or marks should be IGNORED. The correct wire and pin designations are described in the PCI user manuals. For those who wish to make their own cables, here are the correct mating connectors for the termination panels:

PCI-20058T-1	**T&B Ansley #609-3430**

COMPATIBILITY TABLE— PCI-20058T-1

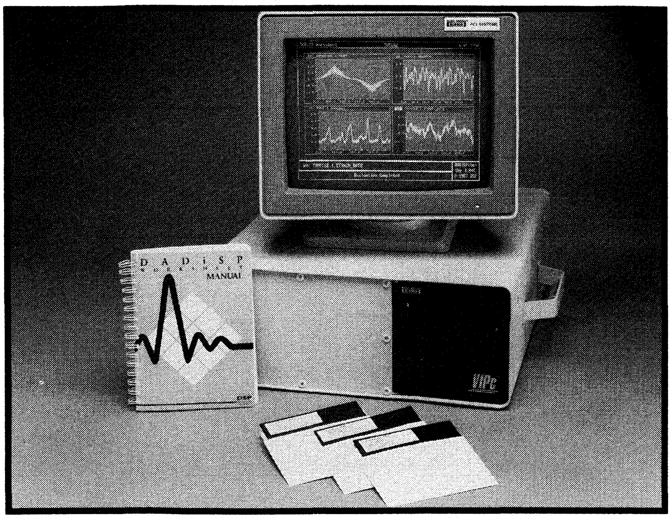
PCI MODEL NUMBER	TYPE	NUMBER OF CHANNELS	DESCRIPTION	CARRIERS[1]	MODULES[1]	BOARDS
PCI-20036A-1	Cable	16	4-foot, unshielded	PCI-20001C-2A, PCI-20041C	PCI-20004M, PCI-20007M	PCI-20087W-1
PCI-20061A-1	Cable	16	6-foot, shielded			
PCI-20029A-1	Enclosure	Up to 192	19-inch rack/table mount			

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) The PCI-20058T-1 can accommodate up to three cables, for a total of 48 channels.



The PCI-20058T-1 Termination Panel Is Ideal for Use with the PCI-20087W-1 Digital I/O Board. Either the PCI-20036A-1 or the PCI-20061A-1 Cables Can Be Used.

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20067S-1

DADiSP/PC Scientific Spreadsheet for Post-Acquisition Signal Analysis

FEATURES

- Analysis Capabilities
  - Waveform Generation
  - Signal Editing
  - Trigonometric Functions
  - Calculus Functions
  - Fourier Analysis
  - Frequency Domain Analysis
  - Statistical Analysis
- Graphics Capabilities
  - 1 to 64 Analysis Windows
  - Scroll, Zoom, Cursor

DESCRIPTION

DADiSP/PC provides menu-driven, post-acquisition data analysis and display. It does for science and engineering what financial spread-sheets have done for business. It eliminates the need to spend valuable time programming specialized routines. DADiSP/PC allows the user to set up a worksheet or analysis chain, simply by typing formulas.

The display contains windows analogous to cells in a financial spreadsheet -- except that a DADiSP/PC window manages an entire waveform. The user can define up to 64 of these windows in a given display. Every window acts as a processing step and displays a graph of the data transformed or generated by that step. Any change in the data in one window is automatically updated in all the other windows using that data.

Because DADiSP/PC pages the signal to disk as it is scrolled through a window, the software can handle signals of virtually any length. The program processes as much signal as the memory can handle, stores the processed data, calls up the next batch of signal data from the disk and continues until all of the signal data is processed. The user can zoom any window to full screen size for detailed manipulation and study. Pop-up boxes provide background information on a window and carry scientific units through compound calculations. Data is stored in individual DADiSP/PC files that permit individual users to keep their work separate from other users.

To analyze or manipulate data, the user simply types the appropriate command or formula into the desired window using any of more than 150 built-in functions. The functions include 42 trigonometric, calculus and common arithmetic operations; 14 Fourier analysis and related functions, such as fast Fourier transforms and complex algebra; ten statistical functions; 21 signal editing and peak analysis operations; and 32 functions for generating complex waveforms.

Special user-defined functions are easily generated by calling up a user macro table and typing in the desired formula for the macro. For example, an autocorrelation macro could be generated by using a number of the standard DADiSP/PC functions such as "convolute two signals". And, a chain of operations can be set up by typing in the formulas in consecutive windows -- with the results of each step displayed in sequence, window by window.

The DSP Pipeline function allows the running of external programs within the DADiSP/PC environment and the importing of new or modified data directly into a display. The pipeline adds flexibility to DADiSP/PC by dynamically linking the Worksheet environment to user-written or commercially available software.

DADiSP/PC supports a variety of printers for hardcopy output and can even send data files to external plotter drivers to customize graphs. DADiSP/PC can import and export data files in a variety of formats, including ASCII, Lotus PRN, byte, integer and floating point.

A demonstration disk is available that shows the major features of DADiSP. Please request PCI-20072S-1 to receive a free copy.

Summary of DADiSP/PC Functions

Waveform Generation

GSIN	Sine wave
GCOS	Cosine wave
GTAN	Tangent curve
GSINH	Hyperbolic sine
GCOSH	Hyperbolic cosine
GTANH	Hyperbolic tangent
GSQRWAVE	Square wave
GTRIWAVE	Triangle wave
GEXP	Exponentiation
GLOG	Log
GIN	Natural log
GLOG10	Log base 10
SGQRT	Square root

Peak Analysis, Signal Editing, and Related Operations

FMIN	Find minimum value
FMAX	Find maximum value
FPEAK	Find first peak
FVALL	Find first valley
FPEAKN	Find next peak
FVALLN	Find next valley
FPEAKP	Find previous peak
FVALLP	Find previous valley
EXTRACT	Extract part of a signal
CONCAT	Concatenate any number of signals
GETPT	Value of nth sample of the signal
MAX	Maximum value of the signal
MIN	Minimum value of the signal
SIGSIZE	Number of points in the signal

Trigonometric, Calculus, and Other Common Functions

SIN	Sine
COS	Cosine
TAN	Tangent
SINH	Hyperbolic sine
COSH	Hyperbolic cosine
TANH	Hyperbolic tangent
EXP	Exponentiation
LOG	Log
LN	Natural log
LOG10	Log base 10
SQRT	Square root
ABS	Absolute value
SINC	Sinc function (sin[x]/x)
DERIV	Derivative
INTEG	Integral
+	Addition
-	Subtraction
*	Multiplication
/	Division
^	Power

Fourier Analysis and Related Functions

DFT	Discrete Fourier transform
IDFT	Inverse discrete Fourier transform
FFTC	Fast Fourier transform (real/imaginary form)
IFFTC	Inverse Fourier transform (real/imaginary form)
REAL	Real part
IMAGINARY	Imaginary part
MAGNITUDE	Magnitude
ANGLE	Angle
POLAR	Convert to polar representation (magnitude/angle)
CARTESIAN	Convert to Cartesian representation (real/imaginary)
CONV	Convolute two signals

Statistical Functions

STATS	Mean and standard deviation
AMPDIST	Calculate amplitude distribution
MOVAVG	Calculate the moving average
LINREG	Linear regression of one signal
SUMS	Sum any number of signals
AVG	Average any number of signals

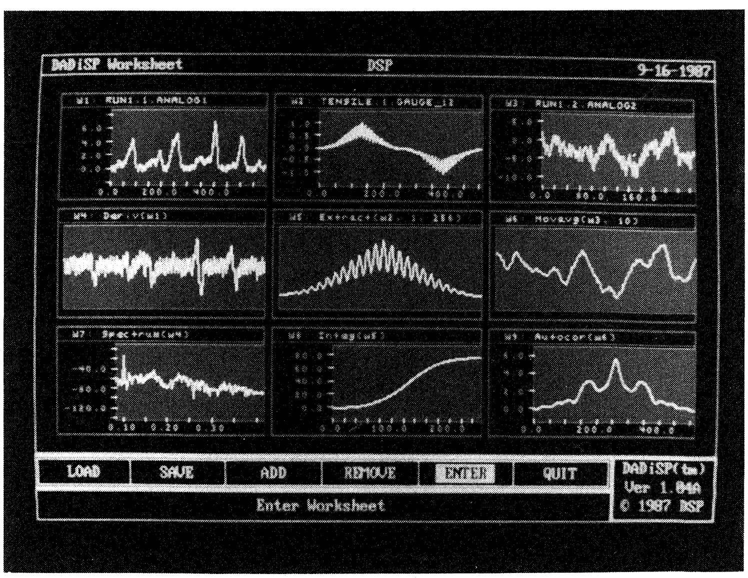
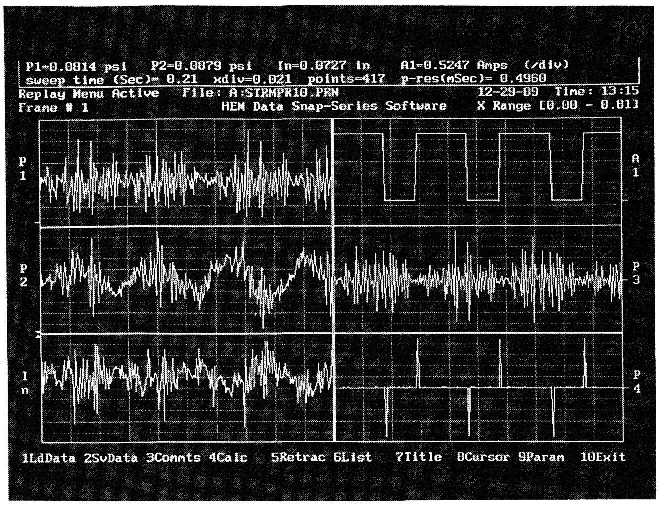


FIGURE 1. Typical Display.



BURR-BROWN®

PCI-20068S Series

SNAP-Series

Software for Data Acquisition, Analysis, Display and Waveform Generation

FEATURES

- Integrated Acquisition, Analysis, Display, Generation, Storage, Retrieval, and Hard-Copy Output
- Menu-driven, No Programming Required
- Supports the PCI Hardware System
  - Records Up to 80 Channels
  - Up to 180kHz Sample Rate
  - Pre-trigger Capability
- Displays Up To 100 Waveforms Concurrently, Including Over-plotting
- Simultaneously Generates and Acquires Data
- Magnifies Waveforms In Both Vertical and Horizontal Directions
- Dual Cursors Display Both Time and Voltage Values (In Engineering Units)
- Directs Output To Screen, Printer, and/or Disk
- Works With VIPc and Other PC/XT/AT/EISA Compatible PCs

APPLICATIONS

- Aerospace and Automotive Systems Evaluation
- Biomedical Signal Analysis
- Vibration Analysis
- Audio, Speech and Acoustics Analysis
- Geophysical/Seismic Evaluation
- Frequency Response Analysis
- Motion Studies
- Control System Analysis
- Electronic Product and Component Testing
- GO/NO-GO Testing

OVERVIEW

The SNAP-Series (PCI-20068S Series) is an integrated group of easy-to-use software products for recording, analyzing, displaying, and storing real-world signals. When used with PCI-20000 hardware products, your personal computer becomes a state-of-the-art measuring and analysis system. At this time, SNAP-Series works with 20 different PCI boards, carriers, and modules, for a total of 100 different configurations. All aspects of the PCI hardware's operation are included in the intuitive menu-driven interface. No previous computer or programming experience is required. To insure smooth operation, each keyboard entry is automatically checked for consistency using the industry-leading automatic parameter entry checking system (APECS). Instantaneous feedback is provided to guide proper parameter selection.

The SNAP-Series software currently consists of seven modular products. SNAPSHOT STORAGE SCOPE is the core product for the rest of the family. The relationship between the individual parts is described in FIGURE 1. Modularity enables the user to add the desired level of processing capabilities needed. By coupling the various SNAP-Series products together, comprehensive signal processing, generation and control functions are readily accomplished. This extension to the PCI product family can be used with Burr-Brown's VIPc, PC/XT/AT/EISA and other compatible computers.

The SNAP-Series of products include:
PCI-20068S-1, SNAPSHOT STORAGE SCOPE (Data Acquisition)
PCI-20068S-2, SNAP-CALC (Analysis/Signal Processing Software)
PCI-20068S-3, SNAP-FFT (Fast Fourier Transform)
PCI-20068S-4, SNAP-FILTER (Digital Filtering Software)
PCI-20068S-5, SNAP-ACTION (Decision Making Software)
PCI-20068S-7, SNAP-GENERATOR (Waveform Generator)
PCI-20068S-8, SNAP-STREAM (Continuous Storage to Disk).

SNAPSHOT STORAGE SCOPE (PCI-20068S-1) is an easy-to-use, menu-driven software product designed to emulate data acquisition and digital storage oscilloscope systems. Facilities for acquiring, graphing, manipulating, storing, and retrieving data are included. Sample rates up to 180,000 readings per second can be accomplished. Operation is simplified by a logical and convenient user interface. SNAPSHOT STORAGE SCOPE totally automates the operation of the PCI-20000 hardware system. Up to 80 analog inputs are supported in the single-ended mode (or 40 differential inputs). Unit conversion is readily accomplished. For example, raw data representing torque and RPM can be acquired and converted to

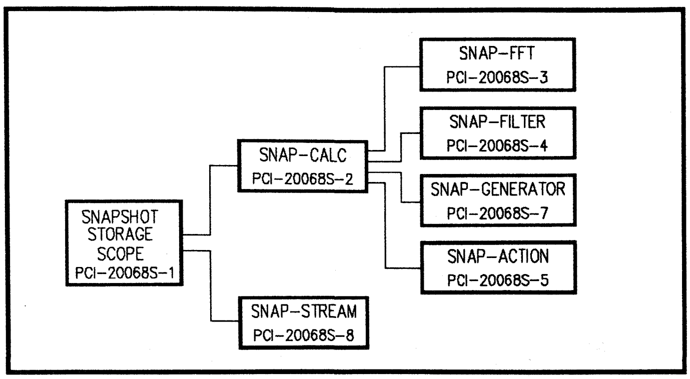


FIGURE 1. How the SNAP-Series Software Products Work Together. SNAP-Series Products Require the Indicated "companion" Products to Their Left in the Digram. For Example: the Use of SNAP-ACTION Requires both SNAP-CALC and SNAPSHOT STORAGE SCOPE.

proper units. In additon, horsepower could be computed and displayed along with the other parameters.

The start of the acquisition process can be internally or externally triggered on an analog or digital signal. Fast hardware trigger circuitry provides precisely timed acquistions and insures that no data points will be missed. It is of special significance that the acquisition and display of both pre- and post-trigger data are easily accomplished. An analog trigger can have a user-defined slope (+ or -) and amplitude (-10V to +10V). A digital trigger can be defined by a TTL signal. Test sequences include synchronized analog and digital outputs for control and excitation functions.

Acquired data is permanently stored in a user-defined disk file for future analysis. Depending upon the application, the user selects different storage criteria: store all acquired data, store upon operator command, and store by exception— based upon calculations and comparisons.

From 1 to 100 waveforms may displayed at the same time in different colors. Overplotting of successive frames and overplotting of channels is provided for better visual comparisons. Graphs are presented in a channel-versus-time (T-Y) or channel-versus-channel (X-Y) format or amplitude-versus-frequency (with SNAP-FFT). In the DMA mode, plots are updated on the screen in parallel with the acquisition. This provides a real-time "look" to the presentation for acquisitions longer than a few seconds.

Recorded data can be recalled from disk for further visual analysis aided by convenient cursor, offset, and zoom functions. Dual cursors provide quick and accurate readout of absolute or relative values of amplitude (engineering units) and time. Channel labels can be customized so that the waveforms are easily identified. User options are listed along the bottom line of the display. Minimal keystrokes are required to issue commands, specify parameters and select files. In addition to graphical displays, data can also be presented in tabular form to show long-term trends and precise amplitude levels.

SNAP-CALC (PCI-20068S-2) is an add-on to SNAPSHOT STORAGE SCOPE (PCI-20068S-1). This additional software enhances the basic analysis and signal processing capabilities. The seamless interface between acquisition and analysis tremendously simplifies the burden on the user to define the desired analysis. Complexities such as array sizes and stack locations are handled for you.

SNAP-CALC provides the unique ability to concurrently acquire and analyze data. Previously acquired data can also be analyzed as a post-process function or similar word. The user interface is consistent with the other SNAP-Series products and requires no programming except to define analysis equations.

SNAP-CALC supports a wide range of mathematical functions including algebraic, calculus, correlation, trigonometric, logic, and statistical. The user has the option of selecting three types of integration, differentiation, and trigonometric units.

Frequently used constants, functions, equations, and subroutines are stored as macros and recalled instantly whenever needed.

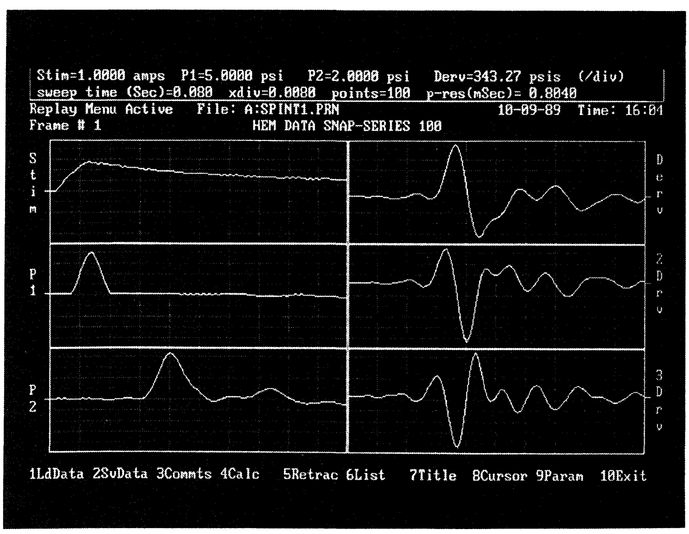


FIGURE 2. Screen Display of Plotted Data Provides Immediate Feedback Regarding Performance. The Display Identifies the Sensitivity of Each Channel in Engineering Units, Number of Points Collected, User-specified Title, Date and Time of the Test, Channel Labels, and Menu Options. Data Can Be Displayed in a Channel-vs-time or Channel-vs-channel Format. Up to Eight Channels Can Be Displayed on the Same Screen.

FIGURE 3. The Top Line Displays Five Equations Separated by Backslashes. The Upper Left Waveform Is the Original Acquired Waveform (channel 3); Lower Left Is the Derivative of Channel 3 Using the Two-point Method (stored as Result 0, R0); Upper Right Is the Product of Channel 3 and R0 (defined as R1); and Lower Right Is R0 Filtered Using a FIR Low-pass Filter with an Order of 20 and a Cut-off Frequency of 500Hz (Saved as R2). For Comparison, the Minimum Values of R0 and R2 Are Defined as S0 and S1.

reference. Menu parameters are saved for quick loading and setup of a new application.

Whenever new data is generated, resulting waveforms or single values are displayed. SNAP-CALC analyzes entire waveforms, portions of waveforms, or single data points.

Single-keystroke commands are defined alphabetically. The first letter of the corresponding operator is predominantly used, e.g., C for cosine, D for differentiation.

Equations are defined in a user-friendly, algebraic manner. For example:

('1^2 + '2^2 + '3^2) q = 'r0

calculates the square root of the sum of the squares of three channels and stores the resulting waveform as result 0.

'1 * '2d * #5 = 'r4

multiplies channel 1, the derivative of channel 2, and a conversion factor stored in Macro #5, and stores the answer as result 4.

'2R = 'S3

finds the root mean square (rms) value for waveform number 2 and stores it as a single value.

SNAP-FFT (PCI-20068S-3) is a frequency spectrum analysis software package designed to calculate and display Fast Fourier Transforms. SNAP-FFT is integrated into SNAPSHOT and SNAP-CALC. Therefore, time domain and frequency domain calculations are performed together and displayed together with the acquired data. SNAP-FFT converts the time domain data acquired with SNAPSHOT STORAGE SCOPE to the frequency domain. The amplitude and phase for 1 to 64 channels of data can be calculated.

There are over ten window types, including: rectangular (uniform); Hamming, Hann; force; exponential; Kaiser-Bessel; Parzen; triangular; sine third power; extended cosine bell; or cosine 4th power. Advanced processing functions include: power spectrum; correlation; convolution; impedance; transfer function; and coherance function. Complex math includes addition, subtraction, multiplication, division, complex conjugate, and transfers between rectangular and polar coordinates. SNAP-FFT is a software add-on to SNAP-CALC (PCI-20068S-2) and SNAPSHOT STORAGE SCOPE (PCI-20068S-1), both of which are required.

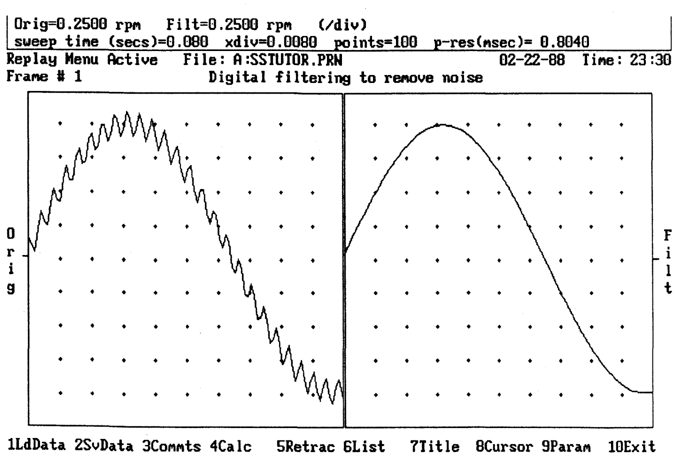


FIGURE 4. The Waveform on the Left Is a 3Hz Sine Wave with 60Hz Noise. The Waveform on the Right Shows the Result of Low-pass Digital Filtering with SNAP-FILTER.

SNAP-FILTER (PCI-20068S-4) adds digital filtering capabilities to the other data acquisition and analysis functions in the SNAP-Series. Its purpose is to remove unwanted frequencies from an acquired waveform. The user selectively removes desired frequency ranges and graphically views the results. Applications include signal-to-noise enhancement, attenuation of power line pickup, pass band limiting, and noise suppression. Figure 4 is a typical display showing both the input and output waveforms to a low-pass filter. Support for low-pass, high-pass, band-pass, and band-reject filters are included. Finite impulse response (FIR) designs, with linear phase response, preserves the time relationship between the signal's components. Infinite impulse response (IIR) designs emulate common analog filters with their very sharp attenuation. For smoothing noisy data, a low-pass, Hanning moving-average filter is available. Filters with up to 400 coefficients can be constructed.

The specification of a particular filter requires only a few key strokes. This includes the filter type and frequency range. Cut-in and cut-off frequencies are limited only by the data acquisition hardware's sampling rate as defined in the specification table. Advantages of digital filters over analog filters include higher noise immunity, accuracy independent of component tolerances, ease of tuning, and characteristics independent of time and temperature. An internal linear-regression routine easily fits data to a straight line. SNAP-FILTER is a software add-on to SNAP-CALC (PCI-20068S-2) and SNAPSHOT STORAGE SCOPE (PCI-20068S-1), both of which are required.

SNAP-ACTION (PCI-20068S-5) adds extensive decision-making capabilities to the other data acquisition and analysis functions in the SNAP-Series. Its purpose is to perform user-defined actions when specific test conditions occur. Applications include automated go/no-go testing, predicting and capturing failures, adaptive control, factory automation, quality control, and data recording by exception. SNAP-ACTION's conditional processing provides decision-making capability within equations by using IF...THEN...ELSE logic to automatically decide whether to take action based on analyzed data. The syntax of the IF...THEN...ELSE function is:

IF (condition) THEN (actions) ELSE (actions),

where conditions are relational comparisons that can be AND'ed or OR'ed together to provide a multitude of conditions. Logical operators include greater-than, less-than, equal-to, and not-equal-to comparisons. Comparisons are made between channels or with respect to constants, elapsed time, and statistical properties that summarize a waveform (such as its maximum, minimum, standard deviation, variance, or average). Elapsed time is defined in either seconds, minutes, or hours to record data at regular intervals. Actions include:

1) Setting analog and digital outputs
2) Pausing or aborting an acquisition
3) Assigning values to variables
4) Saving the current data frame to disk (recording "data by exception").

Data-by-exception stores the current frame (up to 32,768 points of data) to a disk file with the current date and time. The data may be replayed in SNAPSHOT. Only a few keystrokes are required to define criteria, make decisions, and automatically take user-defined actions. A multitude of conditions can be specified, and each condition can have a unique set of actions. A typical application is suggested in Figure 5. SNAP-ACTION is a software add-on to SNAP-CALC (PCI-20068S-2) and SNAPSHOT STORAGE SCOPE (PCI-20068S-1), both of which are required.

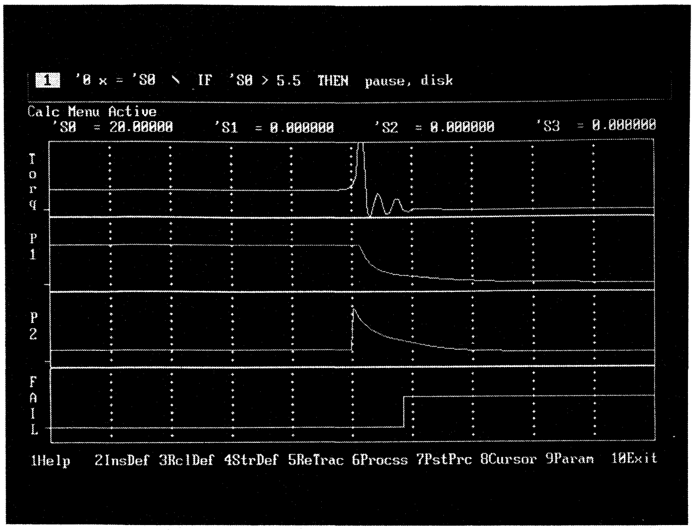


Figure 5. In This Example Peak Torque Is 20 ft-lb. This Exceeds the Set Limit of 5.5 ft-lb Indicating a System Failure. The Actions Taken Include Recording the Data to Both the Screen and Disk and Pausing the Acquisition Process.

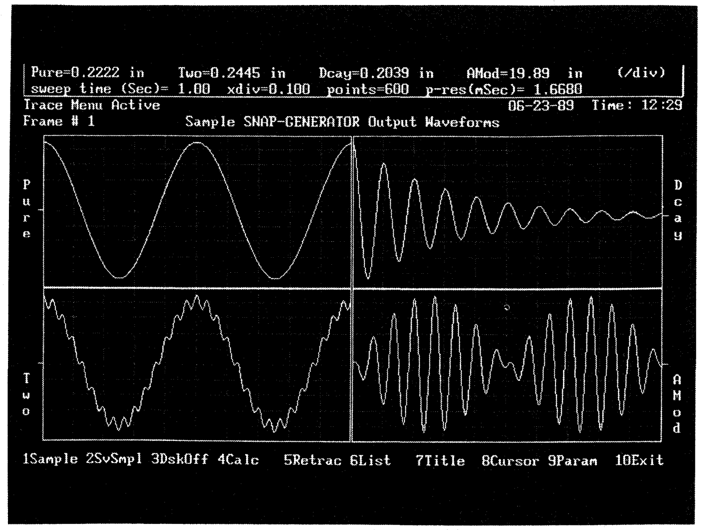


FIGURE 6. This SNAP-GENERATOR Photograph Shows Four Sample Output Waveforms: a Pure Sine Wave, a Higher Frequency Imposed on a Lower Frequency, an Exponentially Decaying Sine Wave, and an AM Modulated Waveform. The Waveforms Were All Mathematically Defined in SNAP-CALC.

SNAP-CALC (PCI-20068S-2) and SNAPSHOT STORAGE SCOPE (PCI-20068S-1), both of which are required.

SNAP-GENERATOR (PCI-20068S-7) adds signal-generation capabilities to the other data acquisition and analysis functions in the SNAP-Series. Its purpose is to generate user-defined waveforms to act as inputs or stimuli to drive a system under test. Applications include automated product evaluation, driving an X-Y plotter with stored data, biomedical pacing/stimulation, and product life testing. SNAP-GENERATOR works in conjunction with PCI analog output (D/A) modules (PCI-20003M-2/-4, PCI-20006M-2 and PCI-20021M-1B) to produce a wide range of both standard and arbitrary (custom) waveforms. Example waveforms are seen in Figure 6. Standard trigonometric waveforms with both linear and logarithmic sweeps can be generated. Such waveforms are useful for determining the transfer function and frequency response of systems.

Consistent with the other SNAP-Series products, SNAP-GENERATOR is completely menu-driven and requires no programming skills to operate. Custom signals are represented in a number of ways: by tabular inputs with up to 32K points per cycle, by mathematical expressions, by acquired data, and by modified (processed) acquired data. Besides specifying the shape of a waveform, the voltage level and DC offset (within the range of the D/A) is also defined. Waveforms can be set for continuous output, gated on for a specific time period, delayed from a trigger, or set to generate a predetermined number of cycles. Depending upon the PCI module selected, up to eight output signals can be simultaneously produced.

SNAP-GENERATOR must be used with the PCI-20041C-3A DMA carrier. Synchronous signal generation and input acquisition are supported. Normally, the repetition frequency for the inputs and outputs are equal. However, with the addition of a PCI-20007M-1 rate generator module, independent rates may be set. SNAP-GENERATOR is a high-performance, low-cost alternative to conventional laboratory instruments that are usually limited to a single output channel. SNAP-GENERATOR is a software add-on to SNAP-CALC (PCI-20068S-2) and SNAPSHOT STORAGE SCOPE (PCI-20068S-1), both of which are required.

SNAP-STREAM (PCI-20068S-8) is an add-on to SNAPSHOT STORAGE SCOPE (PCI-20068S-1). This software adds increased mass storage capabilities to the other data acquisition and analysis functions in the SNAP-Series. Its purpose is to provide for the *continuous* transfer of data to disk-storage type devices, including: RAM disk, hard disk, and floppy disk. Streaming eliminates time gaps and lost data points that often occur when acquiring large amounts of data at high speed. The amount of data that can be acquired is limited only by the available disk space. Transfer speeds of 50kHz to 100kHz have been achieved on a 286 computer and up to 180 kHz to a RAM disk on a 386 machine. The actual transfer rate in a specific application is highly dependent upon the particular data acquisition and computer hardware employed. An automatic function pre-tests the actual streaming parameters to ensure that the system will perform satisfactorily, avoiding overrun errors and lost data.

SNAP-STREAM is menu-driven and is very easy to use. No programming is required. Applications can include data logging, data archiving, event analysis, environmental monitoring, and product or process conformance testing. In order to support the highest possible data recording rate, SNAP-STREAM takes control of all computer resources during the data transfer process. Therefore, data analysis, display and other SNAP-Series functions are suspended until the streaming operation is complete. The full complement of SNAP-Series capabilities are available after the acquisition is complete (as a post-process). The entire data record (of any size) can be reviewed within SNAP-STREAM to provide an overview of the recorded event. Further detailed analysis, processing, and presentation can be accomplished by transferring the data into the SNAPSHOT environment.

PCI hardware provides a unique pre-trigger capability while streaming. The data file can contain up to 32,768 samples from before the trigger occurrance. Other features of SNAP-STREAM include a test of the available disk space and disk optimization for improved performance. A disk optimizer package is included. SNAP-STREAM is compatible with most PCI-20000 modules and the PCI-20041C-3A and PCI-20098C-1 DMA equipped carriers.

A demonstration disk is available that shows the major features of the SNAP Family of products. Please request PCI-20069S-1 to receive a free copy.

SPECIFICATIONS— SNAP SERIES PRODUCTS—PCI-20068S SERIES

All speed benchmarks are typical of what was measured in an 80286 computer (PC/AT) running at 12MHz, unless otherwise indicated.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility		
Computer		Burr-Brown VIPc, PC/XT/AT/EISA or compatibles
Memory (RAM)	Required	640Kbytes
Disk Drivers	Required	Hard disk or two floppy driver
Coprocessor		Recommended
Analog Input		80 channels maximum
Data Points	Maximum, total for all channels	32,768
Channels	PCI-20019M-1A/23M-1 (SE)	8
	with 2 PCI-20031M-1 (SE)	64
	PCI-20002M-1, PCI-20098C-1 (SE/Diff)	16/8
	with 2 PCI-20031M-1 (SE/Diff)	80/40
Signal Gain	PCI-20002M-1	1, 10, 100, 1000
	PCI-20019M-1A/23M-1	1
	PCI-20098C-1	1, 10, 100
Triggering	Free run or triggered analog, internal/external	Analog or digital
	Using PCI-20020M-1	Less than, greater than, and window
	Trigger level	± 70mV to ± 10V
	Response time	3.5μS
	Digital, external	TTL Levels
	Response time	
	1 of 8 bits	0.8μS
	External sync	0.5μS
Sweep Time	Minimum	10/sample rate
	Maximum	200 days
Display		
Channels		1 to 80
Total Waveforms		1 to 100
Interface	IBM or compatible	CGA, EGA, VGA, Hercules
Format		Cursor Readout, Plot, Tabular
Cursor	User-defined units	Absolute, relative
Data Storage	Data formats	ASCII, exponential hex, compacted hex, binary
Output Signals	Analog and digital	
Analog	Control and excitation Non-DMA	
Speed	PCI-20003M-2, PCI-20006M-2	3400/second
	PCI-20021M-1B	2000/second
	Waveform generation, requires PCI-20041C-3A	Using DMA
	PCI-20003M-2, PCI-20006M-2	30,000/second
	PCI-20021M-1B	2000/second
Channels	PCI-20003M-2, PCI-20006M-2	2
	PCI-20021M-1	8
	Control and excitation (8 TTL channels)	Non-DMA
Digital Speed	PCI-20001C-2A, PCI-20004M-1, PCI-20041C-2A, PCI-20041C-3A, or PCI-20098C-1	3400/second

ANALOG INPUT— DYNAMIC PERFORMANCE (READING/SECOND)— TYPICAL DATA

PARAMETER	CONDITIONS	SPECIFICATIONS	
		80286 COMPUTER @ 12MHz, MAX	**80386 COMPUTER @ 16MHz, MAX**
DMA	PCI-20002M-1, Single channel	32K/second	32K/second
	PCI-20002M-1, with PCI-20031M-1		
	G = 1, 100	12K/second	12K/second
	G = 100	8K/second	6K/second
	PCI-20019M-1A, PCI-20091W-1	89K/second	89K/second
	PCI-20023M-1	95K/second	180K/second
	PCI-20098C-1	32K/second	32K/second
Non-DMA	PCI-20002M-1, with PCI-20031M-1		
	G = 1, 100	10K/second	12K/second
	G = 100	6K/second	6K/second
	PCI-20019M-1A with PCI-20020M-1	89K/second	89K/second
	PCI-20023M-1 with PCI-20020M-1	145K/second	180K/second
	PCI-20089W-1	10K/second	12K/second
	PCI-20098C-1	32K/second	32K/second

SNAP-SERIES SELECTION GUIDE

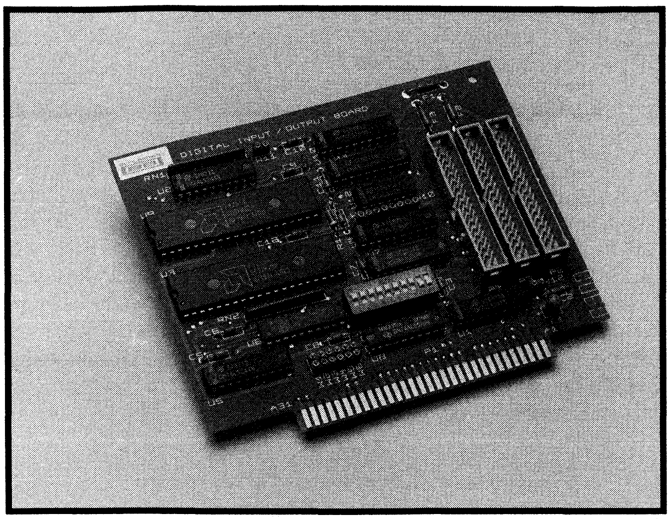
FOR/TO	SELECT	ORDER	DMA HARDWARE
High-speed acquisition and display trigger on an important event cursor readout of amplitude and time	SNAPSHOT STORAGE SCOPE	PCI-20068S-1	Optional
Collect more than 32K points continuously to disk	SNAP-STREAM(1)	PCI-20068S-1, PCI-20068S-8	Required (PCI-20041C-3A, PCI-20091W-1, PCI-20098C-1)
Data Analysis	SNAP-CALC	PCI-20068S-1, PCI-20068S-2	Optional
Remove specific frequencies from the data	SNAP-FILTER	PCI-20068S-1, PCI-20068S-2, PCI-20068S-4	Optional
Monitor a test and take action based upon results. **Record data upon exception** **Generate an output upon exception**	SNAP-ACTION	PCI-20068S-1, PCI-20068S-2 PCI-20068S-5)	Optional
Analyze data in the frequency domain **Compute an FFT or transfer function**	SNAP-FFT	PCI-20068S-1, PCI-20068S-2 PCI-20068S-3	Optional
Generate a waveform (stimulus)	SNAP-GENERATOR	PCI-20068S-1, PCI-20068S-2, PCI-20068S-7	Required (PCI-20041C-3A)

Notes: (1) Recording data using SNAP-STREAM uses all of the available computer resources. Therefore, display, analysis, and signal generation cannot occur concurrently with streaming to disk.

HARDWARE COMPATIBILITY TABLE

BOARDS/ CARRIERS	DMA/ OPTION	ANALOG INPUT/ EXPANDERS[3]	ANALOG TRIGGER	DIGITAL TRIGGER	RATE GENERATOR	ANALOG OUTPUT
PCI-20001C-2A	No	PCI-20002M-1/ PCI-20031M-1 PCI-20019M-1A/ PCI-20031M-1 PCI-20023M-1/ PCI-20031M-1	PCI-20020M-1 & software	Yes	PCI-20007M-1	PCI-20003M-2, 3M-4, 6M-2, 21M-1B
PCI-20041C-2A	No	PCI-20002M-1/ PCI-20031M-1 PCI-20019M-1A/ PCI-20031M-1 PCI-20023M-1/ PCI-20031M-1	PCI-20020M-1 & software	Yes	On Carrier	PCI-20003M-2, 3M-4, 6M-2, 21M-1B
PCI-20041C-3A	Yes	PCI-20002M-1/ PCI-20031M-1 PCI-20019M-1A/ PCI-20031M-1 PCI-20023M-1/ PCI-20031M-1	PCI-20020M-1 & software	Yes	PCI-20007M-1[1]	PCI-20003M-2, 3M-4, 6M-2, 21M-1B
PCI-20098C-1	Yes[2]	On Carrier/ PCI-20031M-1	PCI-20020M-1 & software	Yes	On Carrier	PCI-20003M-2, 3M-4, 6M-2, 21M-1B
PCI-20089W-1	No	On Board/None	Software	Yes	On Board	None
PCI-20091W-1	Yes	One Board/None	Software	Yes	On Board	None

Notes:
1) The PCI-20041C-3A has an on-board rate generator. A second rate generator, the PCI-20007M-1, is only required when it is desired to simultaneously generate an analog output waveform and do an analog input acquisition at *different* clock rates.
2) The PCI-200098C-1 supports DMA transfers for analog inputs only. Therefore, the simultaneous analog acquisition/waveform generation mode is not available.
3) When using the PCI-20001C-2A or PCI-20041C-2A carriers, you can choose from three different analog input modules. To add additional channels, use the expander module indicated.



BURR-BROWN®

PCI-20087W-1

Digital I/O Board for the PC Bus

FEATURES

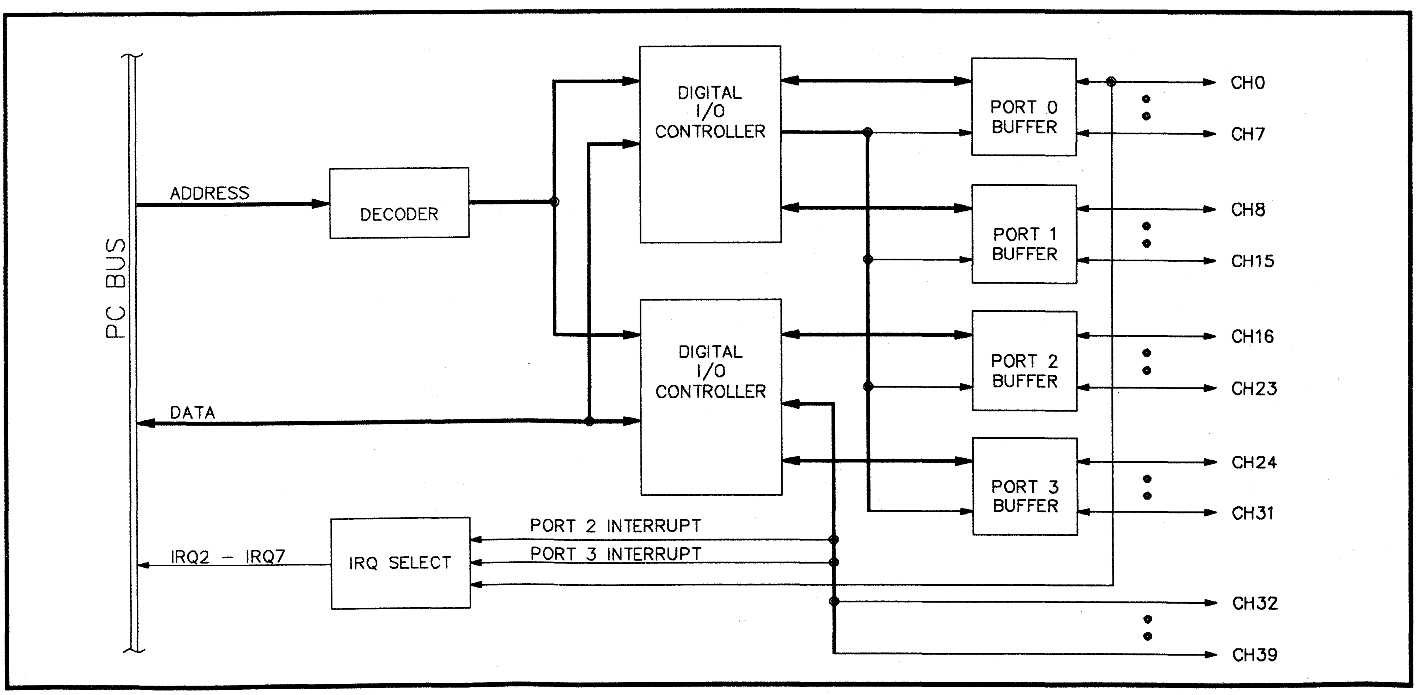
- 40 Digital I/O Channels with TTL Compatible Levels
- Software Programmable for Inputs/Outputs
- QuickBASIC Language Software Drivers Included
- Synchronization/Handshaking Capability

DESCRIPTION

The PCI-20087W-1 Digital Input/Output Board plugs directly into an expansion slot of Burr-Brown's VIPc or any other PC/XT/AT/EISA compatible machine.

Forty channels of TTL compatible signals are accommodated in five groups of eight bits each. Each 8-bit port can be independently software programmed for use as either an input or output port. Data transfer on two of these ports can be synchronized to external hardware events. This is accomplished by utilizing the channels in the fifth port as handshake control lines. All ports are initialized as inputs at power-on.

The PCI-20087W-1 is also equipped to generate interrupts to the PC upon receipt of various hardware signals. These include a high or low I/O transition on channel 0(bit 0) and a request from either handshake port. An interrupt can be directed to the PC via interrupt lines 2 thru 7.



Block Diagram of the PCI-20087W-1 Digital I/O Board.

Because of its small size, the PCI-20087W-1 can be installed in the "short" slot of computers such as the IBM PC/XT. Signal connections are made to the board through standard ribbon-cable connectors. The PCI-20087W-1 is compatible with PCI digital termination components. The PCI-20036A-1 is a low-cost cable for digital applications. This 4-foot (1.2m) long, unshielded cable is intended for use with the PCI-20058T-1and PCI-20025T-2 Termination Panels.

To utilize all of the available channels on the PCI-20087W-1, three cables are required— one cable for each group of two bytes (16 channels). Because the PCI-20058T-1 accommodates up to 48 channels, it is ideally suited for use with the PCI-20087W-1. Optical isolation can be added to selected ports by using the optional PCI-20018T-1, PCI-20048T-1, or PCI-20324T Series panels. Different isolation blocks are available which can be installed on the signal conditioning panels to determine the individual channel's I/O capabilities.

QuickBASIC language software support drivers are included with the hardware. Optional software drivers for other BASICs, C or TURBO PASCAL are available.

Comprehensive documentation is included covering all aspects of installation, calibration and programming. Each board is shipped, at no extra charge, with Burr-Brown's innovative SYSCHECK PC, the system assurance utilities and diagnostics software package. This menu-driven product easily verifies proper installation and utilization of all PCI System components. Not only does SYSCHECK PC greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK PC provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.

SPECIFICATIONS—PCI-20087W-1

All specifications are typical at 25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Software Drivers	Interface language included with board	QuickBASIC
Functions Supported		PCI-20088S-1
	Channels 0-39	Read/Write
I/O Configuration	Each port is programmable as either input or outputs	40 channels total
Number of Ports	8 bits each	5
Digital I/O	Fully buffered	32 channels
I/O or Handshake	Nonbuffered	8 channels
I/O Cable Connector	Mating cable connector (T&B Ansley or equivalent)	#609-3430
Input Characteristics		
High-Level Voltage	Minimum	2V
Low-Level Voltage	Maximum	0.8V
I_{in}, High-Level	Maximum	20μA
I_{in}, Low-Level	Maximum	200μA
Output Characteristics		
Buffered Ports	Initialized as inputs	
High-Level Voltage	I_{out} = Max	2V
Low-Level Voltage	I_{out} = Max	0.8V
Current Source	V_{out} = Low	15mA
Current Sink	V_{out} = High	24mA
Tri-State Current	V_{out} = 2.7V	20μA
Tri-State Current	V_{out} = 0.4V	200μA
Output Characteristics		
Nonbuffered Ports	Initialized as inputs	
High-Level Voltage	I_{out} = Max	2.4V
Low-Level Voltage	I_{out} = Max	0.45V
Current Source	V_{out} = Low	200μA
Current Sink	V_{out} = High	1.7mA
Tri-State Current	V_{out} = 2.7V	10μA
Tri-State Current	V_{out} = 0.4V	10μA
Digital I/O Speed	80286 @ 12MHz	
QuickBASIC	Using PCI-20026S-1 Driver	7Kbytes/sec
C	Using PCI-20026S-2 Driver	8Kbytes/sec
TURBO PASCAL	Using PCI-20026S-3 Driver	6Kbytes/sec
Assembly Language	User developed	160Kbytes/sec
	80386 @ 16MHz	
QuickBASIC	Using PCI-20026S-1 Driver	10Kbytes/sec
C	Using PCI-20026S-2 Driver	11Kbytes/sec
TURBO PASCAL	Using PCI-20026S-3 Driver	9Kbytes/sec
Assembly Language	User developed	280Kbytes/sec
Power Requirements	+5V supply	425mA maximum
Physical Size	Length x Height (one slot)	5.0" x 4.2" (12.7cm x 7cm)
Temperature Range	Board temperature	0 to 70°C

SOFTWARE COMPATIBILITY TABLE

(The PCI-20087W-1 can be used with the following software).

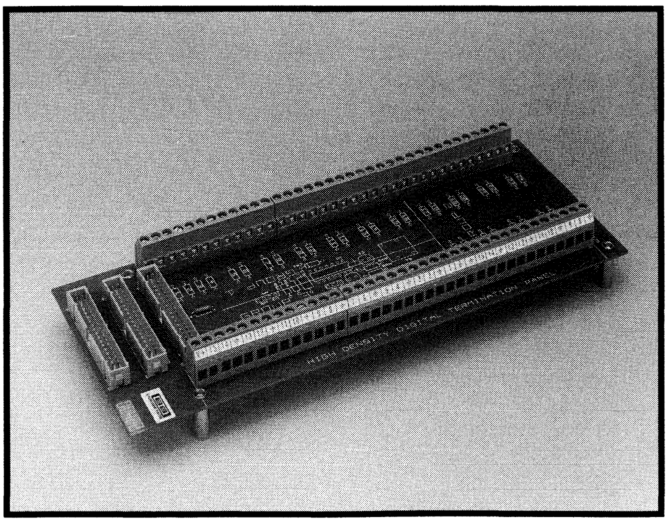
PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER
PCI-20040S-1	LABTECH NOTEBOOK	Yes	Yes
PCI-20097S-1	LABTECH CONTROL	Yes	Yes
PCI-20026S	General-purpose Drivers[2]	No	Yes
PCI-20088S-1	QuickBASIC Drivers (Included)	No	Yes
PCI-20348S-1	Easyest	Yes	Yes

Notes: (1) When model numbers are shown without "dash" number, all versions apply.
(2) Available for BASIC, C, and TURBO PASCAL.

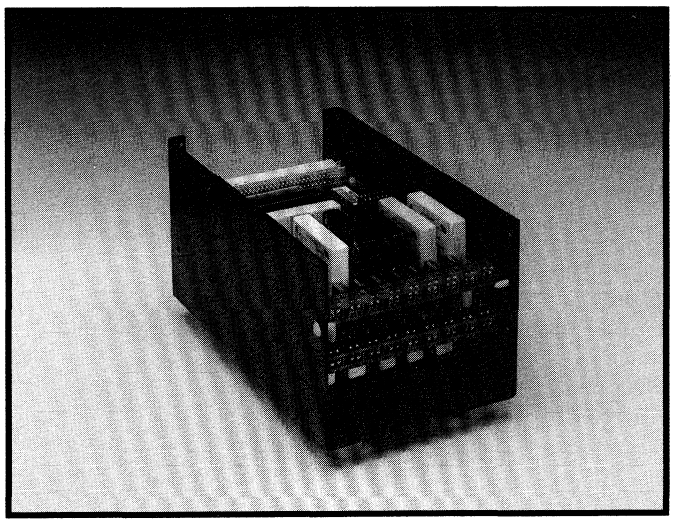
HARDWARE COMPATIBILITY TABLE—TERMINATION PANELS

(The PCI-20087W-1 can be used in conjunction with the following hardware products.)

TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20305T-1	General-purpose	PCI-20311A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20025T-2	Customizer	PCI-20061A-1, PCI-20036A-1	PCI-20029A-1
PCI-20324T-1	Signal conditioner	PCI-20311A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20018T-1	Signal conditioner	PCI-20013A-1	PCI-20029A-1
PCI-20048T-1	Signal conditioner	PCI-20013A-1	PCI-20339A-1

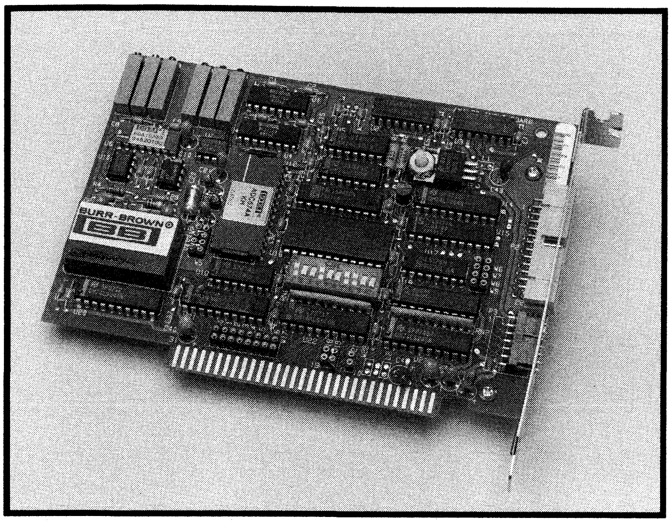


PCI-20058T-1 Along with PCI-20036A-1 Cables Are Ideal for Connecting Field Signals to the PCI-20087W-1.



A Complete Family of Euro-Style Termination Components Is Also Available.

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20089W-1

Analog Input Board for PC Bus

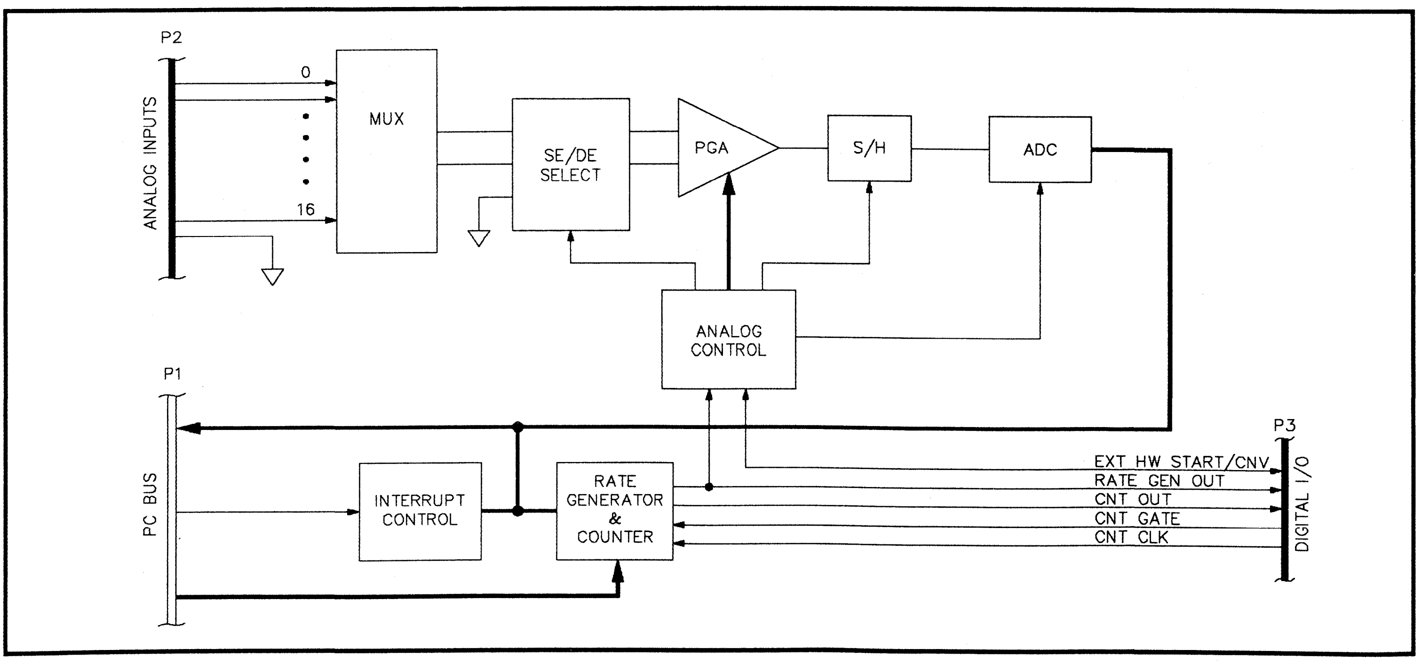
FEATURES

- 16/8 Analog Input Channels
  - — Single-Ended/Differential
  - — 12-Bit Resolution
  - — Programmable Gain Amplifier, Gain = 1, 10, 100
  - — Start-Convert Via Software, Internal Rate Generator or External Hardware Signal
- Independent Counter Channel
- Interfaces to PC Interrupt Levels 2 thru 7
- QuickBASIC Language Software Drivers are Included

DESCRIPTION

The PCI-20089W-1 is a high-performance analog input subsystem with an internal timebase generator and auxiliary pulse counter. Typical applications for this product include data acquisition, process monitoring, and test systems. A wide variety of voltage and current signals can be accepted from thermocouples, RTDs, strain gages, load cells, and optical/magnetic pickups, etc. The board plugs directly into an expansion slot of most PCs. These include Burr-Brown's VIPc and other PC/XT/AT/EISA machines. A functional block diagram of the product is shown below.

The PCI-20089W-1 performs the necessary analog-to-digital (A/D) conversions required to make analog input data compatible with your personal computer. The input multiplexer can select from among 16 single-ended or 8 differential channels. Signal scaling and common-mode rejection are provided by a high-performance, differential input, programmable gain amplifier. Gains of 1, 10 and 100 are available under software control. The 12-bit A/D converter can be configured for input ranges of ±5, 0 to 10 or ±10 volts full scale. A standard 26-pin connector is provided for analog input signal



Block Diagram of the PCI-20089W-1 Analog Input Board.

connections. Optional ribbon cables and termination panels are available to help facilitate external connections.

The digital section of the board contains a programmable rate generator and a general-purpose counter. The rate generator is very useful for establishing an accurate and dependable timebase for data acquisition. Two 16-bit, divide by "n", counters scale the computer's crystal clock to the desired frequency. Clock rates in the range of 0.01Hz to 1MHz can be selected. Some PC manufacturers include a feature that causes the computer's bus clock to dynamically change frequency. The frequency is dependent upon whether the CPU is servicing its own internal resources or devices attached to the expansion bus. Because the PCI-20089W-1 derives its rate generator (for timing the acquisition speed) from the PC's clock, this switched mode of operation is unacceptable. Fortunately, most computers with this characteristic can be set to run in the conventional, fixed-frequency mode. The PCI-20089W-1 operates correctly in VIPc computer platforms when used in the 6.25MHz mode. SYSCHECK PC software included with the PCI-20089W-1 will automatically detect this condition if it exists. An additional, independent counter is provided for general-purpose applications. The maximum input clock rate for this counter is 8MHz. Typical operations include event counting as well as speed and frequency measurement. Separate CLOCK, GATE and OUTPUT connections are available for maximum utility. To insure that the digital signals do not contaminate (degrade) the analog inputs, a separate connector is provided for these functions. A mating cable connector is included.

A family of QuickBASIC language software support drivers is included with the hardware. The current version of this software supports a wide range of functions including: System Initialization, Channel Configuration, Analog Read, High-Speed Analog Block Read, Set Rate Generator, Read Counter and Read Frequency. Optional software drivers are available offering additional functions and support for other programming languages. These include the PCI-20026S and PCI-20027S families, which offer extended capabilities for BASIC, C and TURBO PASCAL.

Comprehensive documentation is included covering all aspects of installation, calibration and programming. Each board is shipped, at no extra charge, with Burr-Brown's innovative SYSCHECK PC, the system assurance utilities and diagnostics software package. This menu-driven product easily verifies proper installation and utilization of all PCI System components. Not only does SYSCHECK PC greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK PC provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.

SOFTWARE COMPATIBILITY TABLE

(The PCI-20089W-1 can be used with the following software.)

PCi MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER[2]
PCI-20040S-1	LABTECH NOTEBOOK	Yes	Yes
PCI-20097S-1	LABTECH CONTROL	Yes	Yes
PCI-20068S	SNAP-Series	Yes	Yes
PCI-20067S-1	DADiSP/PC	Yes	No
PCI-20210S-1	Hypersignal-Workstation	Yes	No
PCI-20026S	General-purpose Drivers[3]	No	Yes
PCI-20027S	High-performance Drivers	No	Yes
PCI-20090S-1	QuickBASIC Drivers (Included)	No	Yes

Notes:
(1) When model numbers are shown without "dash" number, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-20026S and PCI-20027S drivers).
(3) Available for BASIC, C, and TURBO PASCAL.

HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS

(The PCI-20089W-1 can be used in conjunction with the following hardware products.)

TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20303T-1	General-purpose	PCI-20310A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20303T-2	Thermocouple	PCI-20310A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20024T-2	Customizer	PCI-20015A-1	PCI-20029A-1
PCI-5B01-1	Signal conditioner	PCI-20015A-1	PCI-20339A-1
PCI-20042T-1	Signal conditioner	PCI-20012A-1	PCI-20029A-1
PCI-20044T-1	Signal conditioner	PCI-20012A-1	PCI-20029A-1

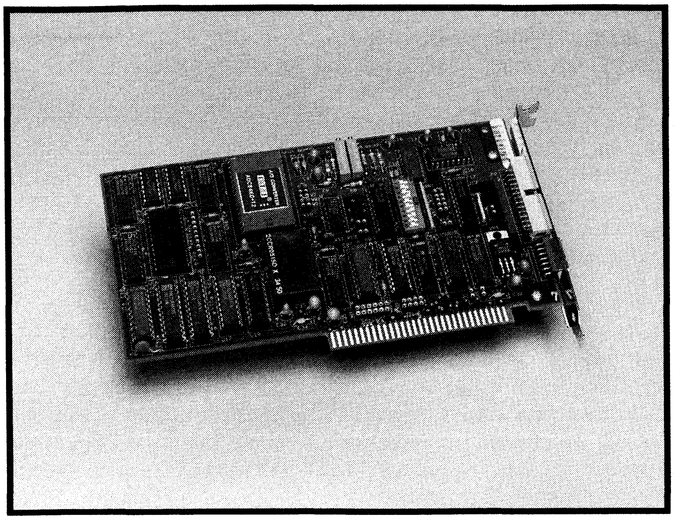
For additional information, please refer to the configuration charts in the Summary Section.

SPECIFICATIONS - PCI-20089W-1

All specifications are typical at 25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Board Level	Plugs inside IBM compatible PCs	Burr-Brown's VIPc and PC/XT/AT/EISA, etc.
Functions		Analog Input, Pulse Counter and Rate Generator
Addressing	Memory mapped, switchable	1Kbyte required
Physical Size	Length x Height (one slot)	5.8" x 4.2" (14.7cm x 10.7cm)
Temperature Range	Board temperature	0 to 70°C
I/O Interface	Mating cable connectors	
Analog Input	T&B Ansley or equivalent	#609-2630
Digital I/O	Method Elec. #1300-107-422	Included
Power Requirements	From PC supply, +5V	2A
	Quiescent (add load), +12V	5mA
Analog Input		
Number of Channels	Single-ended	16
	Differential	8
Signal Range	Linear operation	±10V maximum
	Without damage, Power on	±35V
	Power off	±20V
Offset Voltage	Trimmable to zero	±0.5LSB
Common Mode Range(1)	$V_{cm} = CM_{range} - (V_{diff} \cdot Gain)$	±12V
Rejection Error	60Hz, 100 ohm imbalance, 10V range	
	Gain = 1	0.04dB (-80dB)
	Gain = 10	0.07dB (-95dB)
Bia Current	Gain = 100	0.73dB (-95dB)
Input Impedance		500 pA
Source Impedance		10^{11} @ 60pF
Max Recommended	For 1LSB error	
	At 32kHz sample rate	7.5K ohms
	At 26kHz sample rate	10K ohms
Crosstalk	Channel-to-channel @ 1KHz, 1KΩ source impedance	0.2LSB (-90dB)
Nonlinearity	Gain = 1, 10	0.5LSB
	Gain = 100	1.0LSB
Gain, Ranges	Software programmable	1, 10, 100
Inaccuracy	Trimmable to 0%	±0.5LSB
A/D Converter		
Resolution	(1 part in 4096)	12-bit
Code	Unipolar	Binary
	Bipolar	Offset Binary
Ranges	Jumper selectable	±5, ±10, 0-10V FS
PC Interrupts	PC levels 2 thru 7	End of conversion or rate generator
Dynamic Performance	12-bit accuracy	
Total Throughput	IBM PC/AT	32kHz
Mux Settling Time		5μs maximum
S/H Capture Time		6μs maximum
A/D Conversion Tiem		25μs maximum
PGA Settling Time	10-volt step, Gain = 1, 10	18μs
	Gain = 100	24μs
Rate Generator	(Timebase generator)	1 channel
Output Frequency	Software programmable	TTL pulse output
Equation	F_{clock} = Computer clock at bus connector	$F_{clock}/(2 \cdot N_1 \cdot N_2)$
Frequency Range	Based upon a 6MHz computer clock frequency	0.011Hz to 750kHz
Counter	General-purpose	1 Channel
Functions		Count, divide by N (pulse or squarewave out), one-shot, Interrupt on terminal count, Strobe
Count Capacity	16-bit	65,536
Software Drivers	Interface language	QuickBASIC
	Included with board	PCI-20090S-1
Functions Supported		Analog input, counter rate generator
Speed	With supplied software	
Analog Read	READ.CH in PC/AT (12MHz)	3300 channels/second
Block Read	In PC/AT (16MHz)	4100 channels/second
Read Counter	RUN.HS in PC/AT (12MHz)	32,000 channels/second
	In PC/AT (16MHz)	32,000 channels/second
	READ.CH in PC/AT (12MHz)	4500 reads/second
	In PC/AT (16MHz)	5300 reads/second

Notes: (1) The allowable common-mode voltage (V_{cm}) is a function of the applied differential voltage (V_{diff}) multiplied by the gain selected. The specified common-mode range (CM_{range}) is diminished by the applied differential voltage ($V_{cm} = CM_{range} - (V_{diff} \cdot Gain)$).



BURR-BROWN®

PCI-20091W-1

High-Speed Analog Input Board for the PC Bus

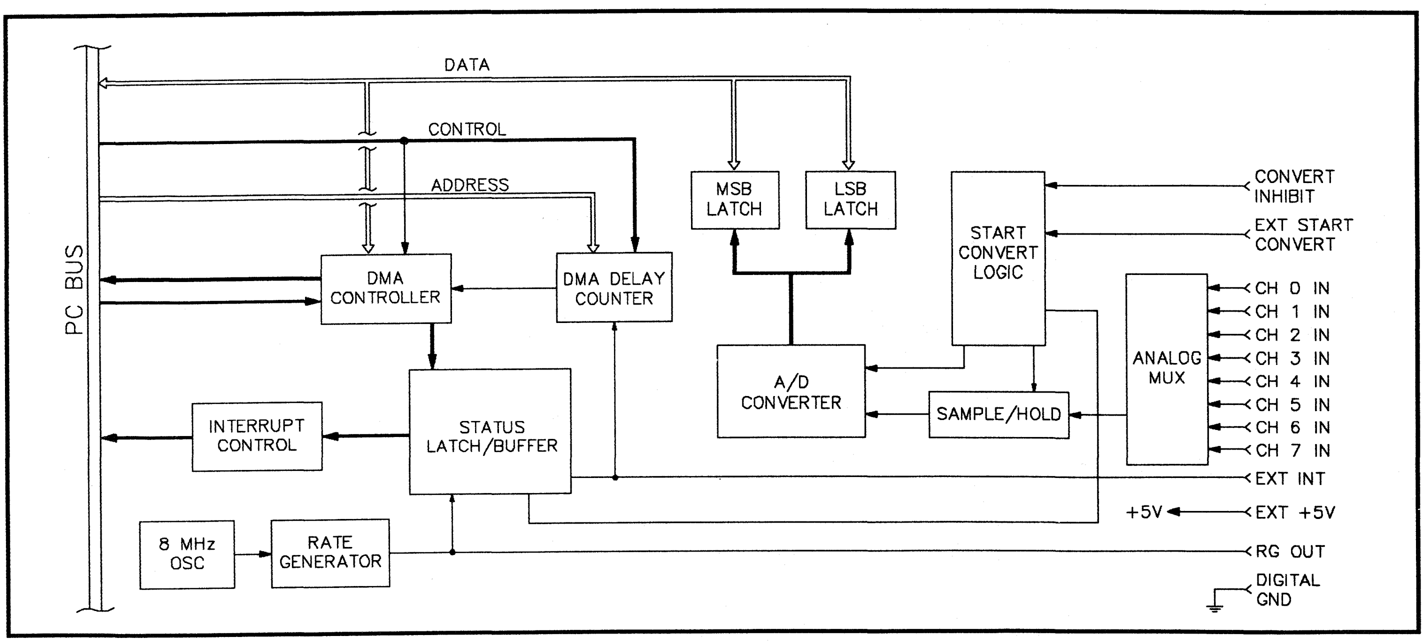
FEATURES

- 8 Analog Input Channel, Single-Ended
  - Up to 89kHz Sample Rate
  - Program and DMA Support
  - Automatic Channel Advance
  - 12-Bit Resolution
  - Start-Convert Via Software, Internal Rate Generator or External Hardware Signal
- QuickBASIC Language Software Drivers are Included

DESCRIPTION

The PCI-20091W-1 is a high-speed analog input subsystem featuring Direct Memory Access (DMA) and an internal timebase generator. This board is intended for high-level signals. Applications for the PCI-20091W-1 include data acquisition, transient capture, audio evaluation, and vibration analysis. The unit plugs directly into an expansion slot of most PCs. These include the Burr-Brown VIPc and other PC/XT/AT/EISA machines. A functional block diagram of the product is shown below.

The PCI-20091W-1 performs the required analog-to-digital (A/D) conversions necessary to make the input data compatible with your personal computer. The combination of an auto-sequencing multiplexer and a high-speed sample/hold and A/D converter allows input sampling speeds at up to 89,000 channels/second. The multiplexer can select from among 8 different single-ended input channels. Resolution of the A/D converter is 12 bits. To enhance resolution, five full-scale input ranges are available: ±2.5, ±5, ±10, 0 to 5, and 0 to 10 volts. Direct memory access is supported by two unique modes of operation: Start-On-Command, Stop-On-Terminal



Block Diagram of the PCI-20091W-1 Analog Input Board.

Count and Start-On-Command, Stop-On-Trigger with delay. The second method permits the capture of pre-trigger information. Data is stored continuously in a circular buffer until an external TTL command triggers the stop sequence. The user can define the number of new readings to be taken (Delay) after the trigger.

A standard 26-pin connector is provided for analog input signal connections. Optional ribbon cables and termination panels are available to facilitate external connections.

The digital section of the PCI-20091W-1 contains the channel sequencing and control circuitry and a programmable rate generator (RG). The RG is very useful for establishing an accurate and dependable timebase for data acquisition. Two 16-bit, divide by "n", counters scale an 8MHz crystal clock to the desired frequency. Clock rates in the range of 0.01Hz to 1MHz can be selected. Both software and hardware control over programmed and DMA acquisition are supported. In the hardware modes, connections are provided for either internal (RG) or external start. The board can generate an interrupt to the PC on end of conversion. Interrupt levels 2 through 7 are supported. To insure that the digital signals (start convert, conversion inhibit, external interrupt, and RG) do not contaminate (degrade) the analog inputs, a separate connector is provided for these functions.

For ease-of-use, a set of QuickBASIC language software support drivers is included with the hardware. The current version of this software supports a wide range of functions, including System Initialization, Channel Configuration, Analog Read, High-speed Analog Block Read, DMA Read and Set Rate Generator. Optional software drivers offer additional functions and support for other programming languages. These include the PCI-20026S family, along with the PCI-20027S family, which offer extended capabilities for BASIC, C and TURBO PASCAL. The SNAP-Series (PCI-20068S) provides a comprehensive, menu-driven interface that requires no programming. This software is ideal for acquisition, analysis and graphics display.

Excellent documentation is included covering all aspects of installation, calibration, and programming. Each board is shipped, at no extra charge, with Burr-Brown's innovative SYSCHECK PC, the system assurance utilities and diagnostics software package. This menu-driven product easily verifies proper installation and utilization of all PCI-20000 system components. Not only does SYSCHECK PC greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK PC provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.

SOFTWARE COMPATIBILITY TABLE— PCI-20091W-1

(The PCI-20091W-1 can be used with the following software.)

PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER[2]	DMA SUPPORT
PCI-20068S	SNAP-Series	Yes	Yes	Yes
PCI-20067S-1	DADiSP/PC	Yes	No	No
PCI-20210S-1	Hypersignal-Workstation	Yes	No	No
PCI-20026S	General-purpose Drivers[3]	No	Yes	No
PCI-20027S	High-Performance Drivers[3]	No	Yes	Yes
PCI-20096S	TURBO STREAM Drivers[3]	No	Yes	Yes
PCI-20092S-1	QuickBASIC Drivers (Included)	No	Yes	Yes

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-20026S and PCI-20027S drivers).
(3) Available for BASIC, C and TURBO PASCAL.

HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS

(The PCI-20091W-1 can be used in conjunction with the following hardware products.)

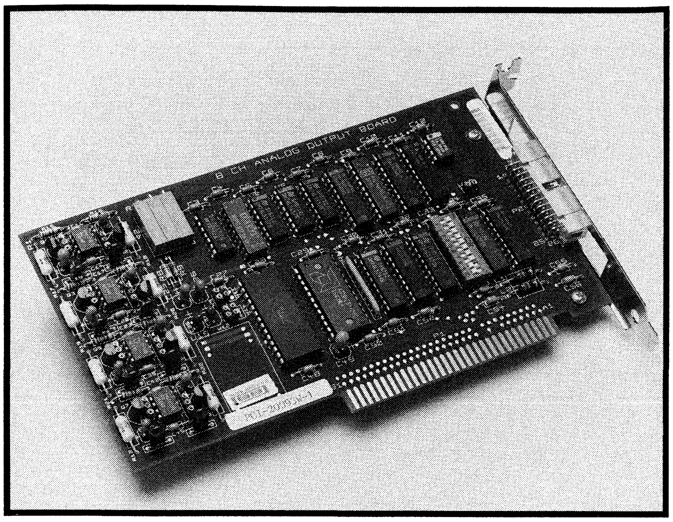
TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20303T-1	General-purpose	PCI-20310A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20024T-2	Customizer	PCI-20015A-1	PCI-20029A-1
PCI-5B01-1	Signal conditioner	PCI-20015A-1	PCI-20339A-1
PCI-20042T-1	Signal conditioner	PCI-20012A-1	PCI-20029A-1
PCI-20044T-1	Signal conditioner	PCI-20012A-1	PCI-20029A-1

For additional information, please refer to the configuration charts in the Summary Section.

SPECIFICATIONS—PCI-20091W-1

All specifications are typical at 25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Board Level	Plugs inside IBM compatible PCs	Burr-Brown VIPc and other PC/XT/AT/EISA machines
Functions		Analog input and rate generator
Addressing	Memory mapped, switchable	1KBytes required
Physical Size	Length x Height (one slot)	7.5" x 4.2" (19cm x 10.7cm)
Temperature Range	Board temperature	0 to 70°C
I/O Interface	Mating cable connectors	
Analog Input	T&B Ansley or equivalent	#609-2630
Digital I/O	Methode Elec. #1300-107-422	Included
Power Requirements	+5V supply from PC	2 Amps maximum
Analog Inputs		
Input Stage		
Number of Channels	Single-ended	8
Input Multiplexer	Software channel select mode	Any 1 of 8
	Auto channel scan mode	"n" thru 7
Signal Range		±10V maximum
Offset Voltage	Trimmable to zero	±1LSB
Bias Current	0 to 70°C	100nA
Input Impedance		1 Meg @ 35pf
Source Impedance	For 1LSB error	
Max Recommended	At 89kHz sample rate	3K Ohm
Crosstalk	Channel-to-channel @ 1kHz, 1KΩ source impedance	0.2LSB (-90dB)
A/D Converter		
Resolution	(1 part in 4096)	12-bit
Code	Unipolar	Complementary binary
	Bipolar	Complementary offset binary
Ranges	Jumper selectable	±2.5, ±5, ±10, 0-5, 0-10V FS
Dynamic Performance	12-bit accuracy	
Total Throughput	Hardware performance	89,000 channels/second
Mux Settling Time		3.5μsec maximum
S/H Capture Time		1.5μsec maximum
A/D Conversion Time		10μsec maximum
Rate Generator	(Timebase generator)	
Output Frequency	Software programmable	TTL pulse output
Equation		8MHz/($n_1 \cdot n_2$)
Frequency Range		0.002Hz to 2MHz
Output Voltage Levels		TTL
Output Current	Capability, Sink	8mA
	Source	400μA
PC Interrupts	TTL high/low transition	DMA terminal count
Levels 2 thru 7		External input
Software Drivers	Interface language	QuickBASIC
	Included with board	PCI-20092S-1
Functions Supported		Analog input (program and DMA), rate generator
Speed	With supplied software in a PC/XT/AT (12MHz)	
Software Channel Selection	READ.CH	5700 channels/second
Hardware Scan	RUN.HS	55,000 channels/second
DMA Control	DMA.RUN	89,000 channels/second



BURR-BROWN®

PCI-20093W-1

8-Channel Analog Output Board for the PC Bus

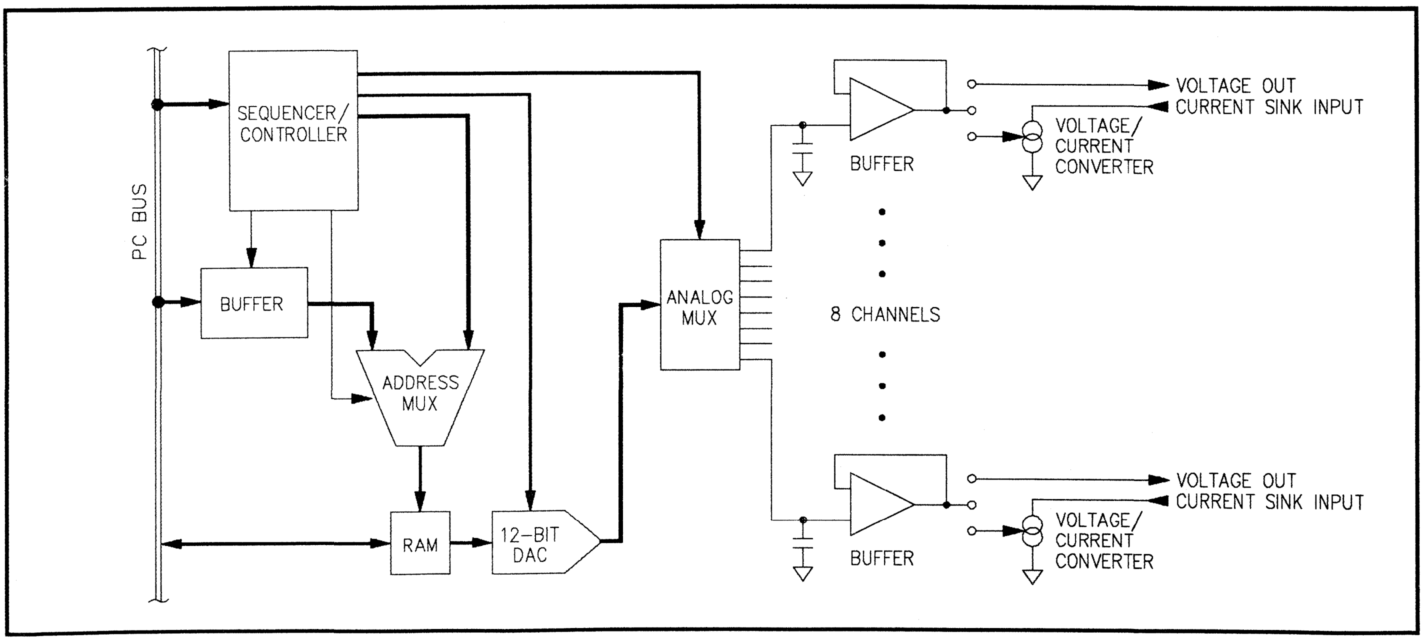
FEATURES

- 8 Analog Output Channels
  - Voltage & Current Outputs
  - 12-Bit Resolution
- QuickBASIC Language Software Drivers are Included

DESCRIPTION

The PCI-20093W-1 is an analog subsystem featuring eight channels of voltage or current output. This board is intended for a wide range of applications, including waveform generation, simulators, controllers, display drivers, and test systems. The PCI-20093W-1 plugs directly into an expansion slot of most PCs. These include the Burr-Brown VIPc and other PC/XT/AT/EISA machines. A functional block diagram of the product is shown below.

The PCI-20093W-1 accepts programmed digital instructions from your personal computer and performs the digital-to-analog (D/A) conversions necessary to generate corresponding analog output levels for external use. To reduce cost and size, one D/A converter is shared by eight channels. High performance is insured by the use of a proprietary, multiplexed, dynamic refreshing technique. This method provides "glitch-free" updates to all eight channels within 256 μsec (3900 times/sec). Data is stored in onboard RAM, allowing the system to operate as though eight independent converters exist. The 12-bit D/A converter can be configured for output ranges of ±2.5, ±5 and 0-5 volts full scale. When set to the 0-5V range, each channel can be optionally jumpered for 0-20 mA operation. Through software, an offset can be implemented to generate 4-20 mA. A standard 26-pin connector is provided for external connections.



Block Diagram of PCI-20093W-1 Analog Output Board.

Comprehensive documentation is included covering all aspects of installation, calibration and programming. For ease of use, a set of QuickBASIC language software support drivers is included with the hardware. The current version of this software supports: System Initialization and Channel Write. Optional software drivers are available, offering additional functions and support for other programming languages. These include the PCI-20026S family, which offers extended capabilities for BASIC, C, and TURBO PASCAL. Also available are menu-driven software products that require no programming. These include LABTECH NOTEBOOK (PCI-20040S-1) and the SNAP-Series (PCI-20068S).

Optional ribbon cables and termination panels are available to help facilitate external connections. In addition to convenient screw terminal connections, the panels provide a place for the user to install separate signal conditioning components for each channel. Provisions for filters, voltage divides and protection networks are included.

Each board is shipped, at no extra charge, with Burr-Brown's innovative SYSCHECK PC, the system assurance utilities and diagnostics software package. This menu-driven product easily verifies proper installation and utilization of all PCI System components. Not only does SYSCHECK PC greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK PC provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.

SOFTWARE COMPATIBILITY TABLE— PCI-20093W-1

(The PCI-20093W-1 can be used with the following software.)

PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER
PCI-20040S-1	LABTECH NOTEBOOK	Yes	Yes
PCI-20097S-1	LABTECH CONTROL	Yes	Yes
PCI-20026S	General-purpose Drivers[2]	No	Yes
PCI-20094S-1	QuickBASIC Drivers (Included)	No	Yes

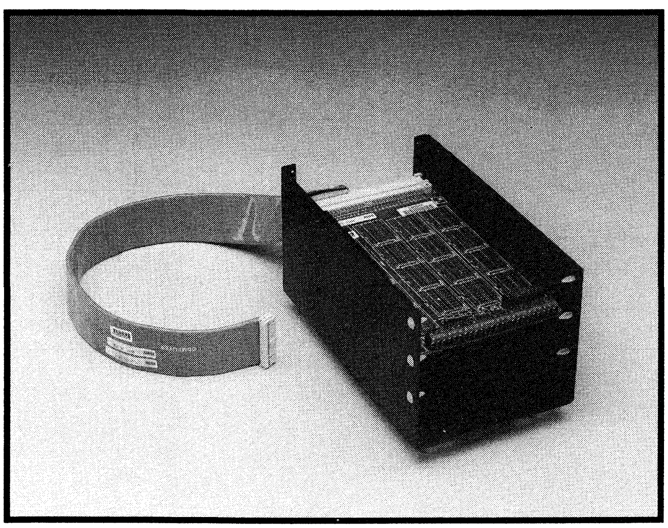
Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) Available for BASIC, C, and TURBO PASCAL.

HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS

(The PCI-20093W-1 can be used in conjunction with the following hardware products.)

TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20303T-1	General-purpose	PCI-20310A-1	PCI-20308H-1 and PCI-20343A-1
PCI-20024T-2	Customizer	PCI-20015A-1	PCI-20029A-1
PCI-5B01-1	Signal conditioner	PCI-20015A-1	PCI-20339A-1

For additional information, please refer to the configuration charts in the Summary Section.



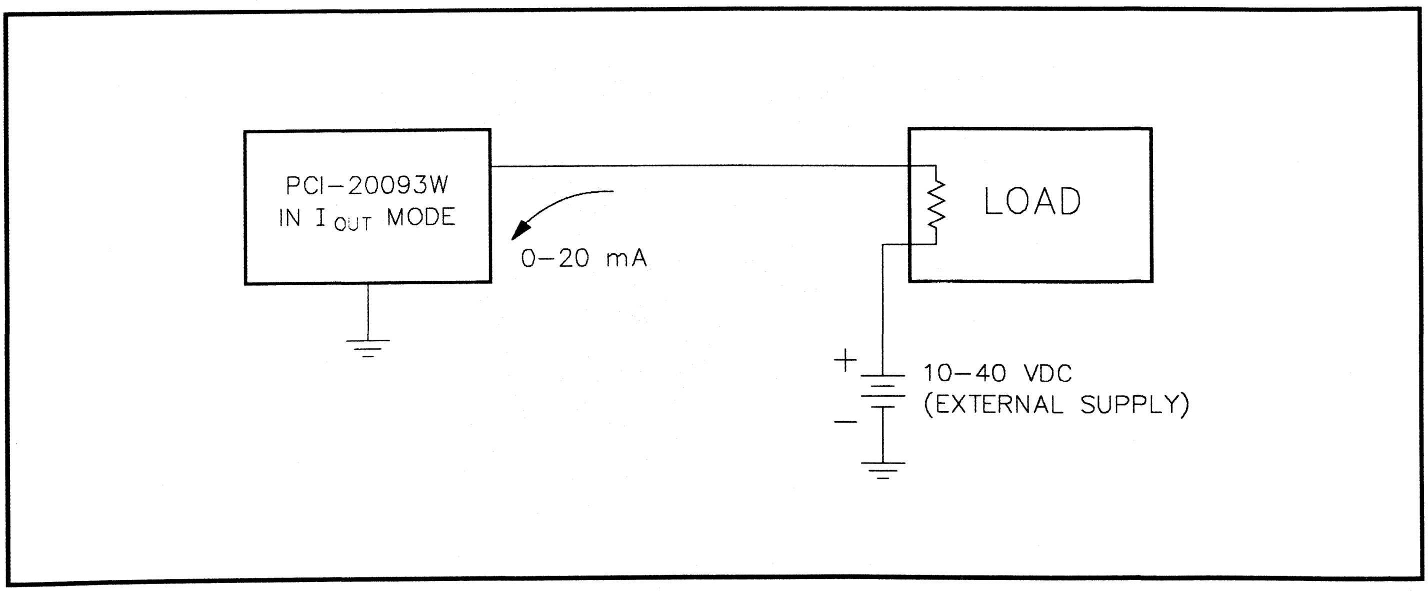
A Complete Family of Euro-Style Termination Components Are Available.

SPECIFICATIONS—PCI-20093W-1

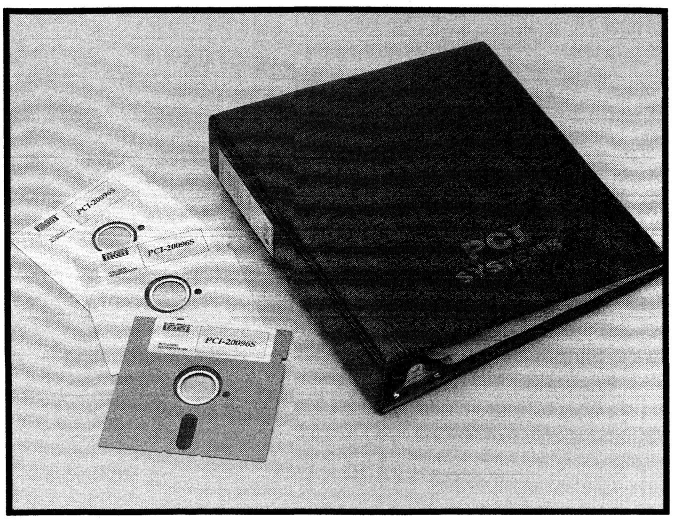
All specifications are typical at 25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Board Level	Plugs inside IBM compatible PCs	Burr Brown VIPc, and other PC/XT/AT/EISA machines
Function		Analog output
Addressing	Memory-mapped, switchable	1Kbyte required
Physical Size	Length x Height (one slot)	7.2" x 4.2" (18.3cm x 10.7cm)
Temperature Range	Board temperature	0 to 70°C
I/O Interface	Mating cable connectors T&B Ansley or equivalent	#609-2630
Power Requirements	From PC supply, +5V	570mA maximum
	+12V	50mA maximum
Configuration		
Ranges	Voltage or current output (jumper selectable)	±2.5V, ±5V, 0-5V or 0-20mA
Number of Channels		8
Resolution	(1 part in 4096)	12 bits
Code	Unipolar	Binary
	Bipolar	Offset binary
Accuracy		±1/2LSB
Gain		±1LSB
Over Temperature	10-volt range	±1/2LSB
Linearity	Voltage ranges	±1LSB
	Current range	±1LSB
Offset Voltage	Voltage and current ranges	±1LSB
Noise	DC to 10kHz, maximum	±1LSB
Crosstalk	Channel-to-channel	±1LSB
Output Stage		
Output State[1]	At power up	Zero
Output Current	Voltage mode	±1mA
	Current mode	20mA (sink)
Output Impedance	Voltage mode @ 2kHz	1 ohm
	Current mode	30 Megohm
Voltage Compliance	Current mode	40V max[(2)]
Dynamic Performance		
Total Throughput[3]	8-channel frames	31,200 outputs/second
Update Rate[3]	Per channel	3900 output/second
Settling Time	To 12-bit accuracy	256 μsec
Software Drivers	Interface language included with board	QuickBASIC
Functions Supported	WRITE.CH	Analog output
Speed[3]		3900 outputs/sec

Notes:
(1) When the system is first powered up, the outputs of this board are originally set to zero volts (or zero current) until reinitialized by software.
(2) When operating in the current output mode, the minimum allowable external loop-supply voltage depends upon the external load resistance as follows: V_{min} - 5.2 +.02 R_L.
(3) Refers to "changes in the output" or "new output" per second.



The PCI-20093W-1 Operates in the Current Sink Mode.



BURR-BROWN®

PCI-20096S Series

TURBO STREAM Direct-To/From-Disk Software Drivers

FEATURES

- Up to 191 Kbytes/Second Transfer Rate to Hard Disk
- Acquire Data to Disk Directly from Analog/ Digital/Counter Hardware
- Writes Data Directly to RAM, Floppy and Hard Disks
- Data Files Can Be As Big As Available Disk
- Interfaces to BASIC, C, TURBO PASCAL
- Easy-To-Use, High-Level Commands
- Eliminates the Need for the Programmer to be Familiar with the Details of the Hardware

DESCRIPTION

TURBO STREAM, the PCI-20096S Series of direct-to/from-disk software products, is designed to provide an uncomplicated and useful interface between the PCI System and all forms of mass storage in your PC. These drivers maintain high performance while avoiding the complexities of assembly language. All goals are realized by offering the programmer a set of commands to invoke desired functions. This effectively buffers the user from the internal details of the hardware. Direct memory access (DMA) techniques are used to maximize speed. In addition to storing data to disk, data files can be read from disk to any PCI output device (analog or digital). Speeds up to 191Kbytes/second are readily accomplished on some machines. A speed test utility call is provided to help measure performance for a specific configuration.

TURBO STREAM is an extension to the PCI family of modular software products. This software module is intended to be used in conjunction with the PCI-20026S Series and the PCI-20027S Series of software products (both are required). TURBO STREAM gives the programmer the ability to conveniently utilize all available storage media. This includes hard disks, floppy disks and RAM disks. The size of a data file is limited only by the size of accessible media. IBM or Microsoft DOS, version 3.0 or greater, is also required.

The most widely used software language families are supported. These include BASIC, C and TURBO PASCAL. Error checking is provided to help eliminate difficulties. Tutorial material, including detailed sample programs in each language, offers assistance to new users.

BASIC—IBM BASICA, through version A3.10, is supported. Other compatibles, such as COMPAQ BASIC and GWBASIC, can also be used.

Microsoft QuickBASIC, compiler, version 4.5 is supported.

IBM BASIC COMPILER, thru version 2.00 is supported, with some limitations.

C—MICROSOFT and **LATTICE C COMPILER**s, thru version 3.00, are supported. Microsoft versions 4.0 through 6.0 are also supported, as is **BORLAND TURBO C** version 2.0

TURBO PASCAL—BORLAND TURBO PASCAL, through version 5.5, is supported.

SOFTWARE OPTIONS

PCI MODEL NUMBER	LANGUAGE	DISKETTE SIZE
PCI-20096S-1	BASIC	5 1/4 inches
PCI-20096S-2	C	5 1/4 inches
PCI-20096S-3	TURBO PASCAL	5 1/4 inches
PCI-20096S-4	BASIC	3 1/2 inches
PCI-20096S-5	C	3 1/2 inches
PCI-20096S-6	TURBO PASCAL	3 1/2 inches

Command Summary— PCI-20096S Series

Configuration Calls

CNF.DTD	Configure Direct-to-Disk

Read/Write Calls

DTD.RUN	Conducts the Disk Read/Write operation

Utility Calls

DTD.SEEK	Locates a given data record
DTD.XFER	Moves data segments between files and memory
DTD.TIMER	Determines the approximate maximum throughput rate

SPECIFICATIONS— PCI-20096S SERIES SOFTWARE LIBRARIES, TYPICAL DATA

PARAMETER	CONDITIONS	SPECIFICATION
Language Interfaces	Microsoft QuickBASIC Microsoft C Borland TURBO PASCAL	PCI-20096S-1 PCI-20096S-2 PCI-20096S-3
Speed Benchmarks Inputs(1)	IBM PC, 4.77MHz *Standard* 286, 6MHz[2] *Standard* 286, 8MHz[2] *Standard* 286, 8MHz[3] *Standard* 286, 8MHz[4] *Standard* 386, 16MHz[2]	60Kbytes/second 121Kbytes/second 132Kbytes/second 191Kbytes/second 180Kbytes/second 141Mbytes/second
Outputs(1)	IBM PC/AT, 8MHz *Standard* 286, 8MHz[2] *Standard* 286, 8MHz[4]	162Kbytes/second 136Kbytes/second 180Kbytes/second
Requirements		
Computer	IBM PC compatible	Burr-Brown VIPc and other PC/XT/AT/EISA machines
Operating System	IBM or Microsoft	DOS 3.0 or greater
Related Software		PCI-20026S Series PCI-20027S Series

Notes: (1) Performance is shown in bytes/second. Please note that analog data transfers require more than one byte. Analog inputs require two bytes while analog outputs require three bytes.
(2) With Miniscribe 6053 43Mbyte hard disk.
(3) With Miniscribe 3650 65Mbyte hard disk and ADAPTEK ACB 2372 controller.
(4) To extended memory RAM disk.

COMPATIBILITY TABLE— CARRIERS

(For Direct-to/from-Disk Routines.)

PCI MODEL NUMBER	FUNCTION
PCI-20041C-3A	High-performance
PCI-20098C-1	Multifunction

COMPATIBILITY TABLE— BOARDS

(For Direct-to-Disk Routines.)

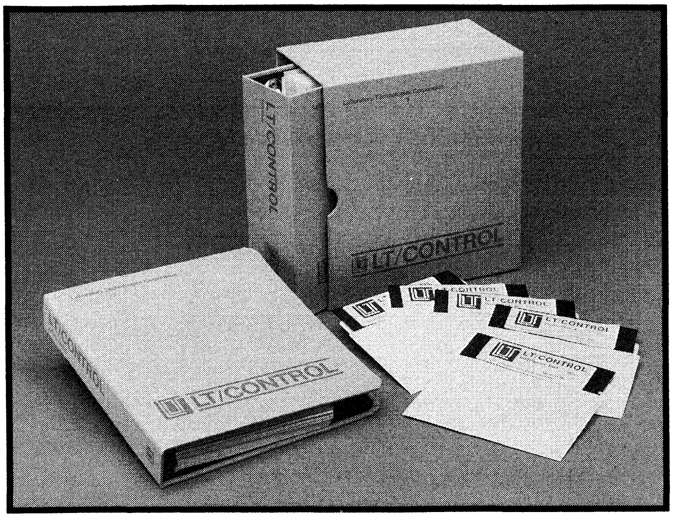
PCI MODEL NUMBER	FUNCTION
PCI-20091W-1	High-speed Analog Input

COMPATIBILITY TABLE— MODULES

(For Direct-to/from-Disk Routines using the PCI-20041C-3A Carrier.)

PCI MODEL NUMBER	FUNCTION
PCI-20002M-1	Analog input
PCI-20019M-1A	Analog input
PCI-20023M-1	Analog input
PCI-20341M-1	Analog input
PCI-20031M-1	Analog expansion
PCI-20020M-1	Trigger/Alarm
PCI-20003M-2, PCI-20003M-4	Analog output
PCI-20006M-2	Analog output
PCI-20021M-1B	Analog output
PCI-20004M-1	Digital I/O
PCI-20007M-1	Counter/Timer

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20097S-1

LABTECH CONTROL

Integrated Industrial Monitoring and Control Software

FEATURES

- Process Control (With Multilevel Password Security)
  - — Easy-To-Use, Menu-Driven/Icon-Based Interface
  - — Compatible with PCI Boards, Carriers, Modules, and IEEE-488 Interfaces
  - — PID, On-Off (Bang-Bang), Cascade
  - — On-Line Process Tuning
  - — Built-In Network Compatibility
- Real-Time Display
  - — User-Definable, Animated Process Diagrams
  - — Library of ISA Symbols Included
  - — Trendline, T vs Y, X vs Y, Horizontal and Vertical Bar Graphs, Digital Meters, Etc.
  - — Up to 50 Windows/Screen, 50 Trend Lines/Screen and 16 Colors/Window
  - — Up to 64 Display Screens
- Process Monitoring
  - — Up to 600 Functional Blocks: Analog, Digital, Thermocouple, Counter, Frequency, Calculated Channels, Etc.
- Data Logging
  - — Extensive Trigger Capabilities
  - — Alarm on Hi-Hi, High, Low or Lo-Lo
  - — Alarm on Data Input, Calculated Value, or Time-of-Day
  - — Logs Continuously or in Response to Event/Alarm Triggers or User Input
- On-Line Analysis
  - — Calculation Functions Including Arithmetic, Exponential, Trigonometric, Calculus, Statistical, and Logical
  - — Data Transformations Include Polynomial, FFT, Digital Filter, BCD to Decimal, and Thermocouple Linearization
  - — Easily Interfaced to Spreadsheet Programs

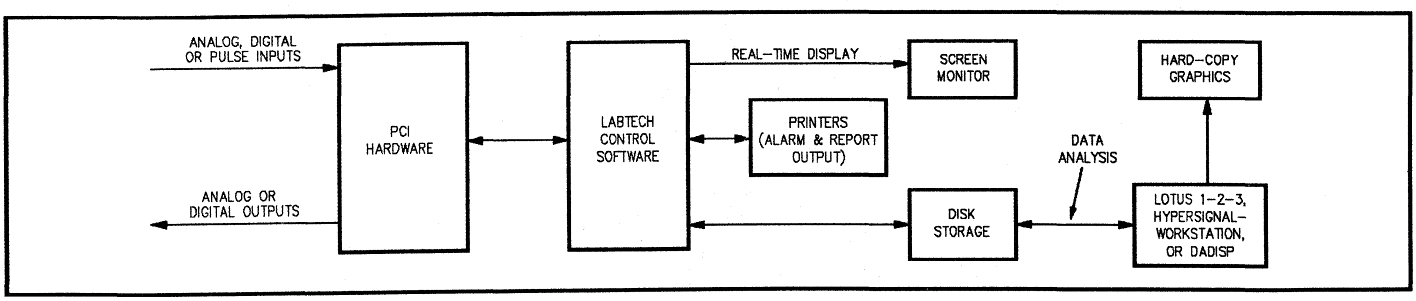


FIGURE 1. LABTECH CONTROL Functional Diagram.

DESCRIPTION

The PCI-20097S-1 is the industry-standard LABTECH CONTROL, optimized for use with PCI products (see FIGURE 1). CONTROL is a superset of the popular LABTECH NOTEBOOK that provides comprehensive industrial process control capabilities. It integrates process monitoring, data acquisition, output, test, measurement, analysis, and display. CONTROL is compatible with most boards, carriers, modules and IEEE-488 devices within the PCI hardware system. The user interface is designed so that no programming is required. All features are selected with easy-to-use icons and menus (see FIGURE 2). As a result, minimum computer skills are required to perform complex operations.

A wide variety of process signals are supported, including those from analog transducers (voltage or current) and discrete, pulse and frequency devices. Both open-loop and closed-loop (PID) control algorithms are included. Each loop can be independently switched on- or off-line and tuned without disturbing the remaining system. Hundreds of channels can be accommodated.

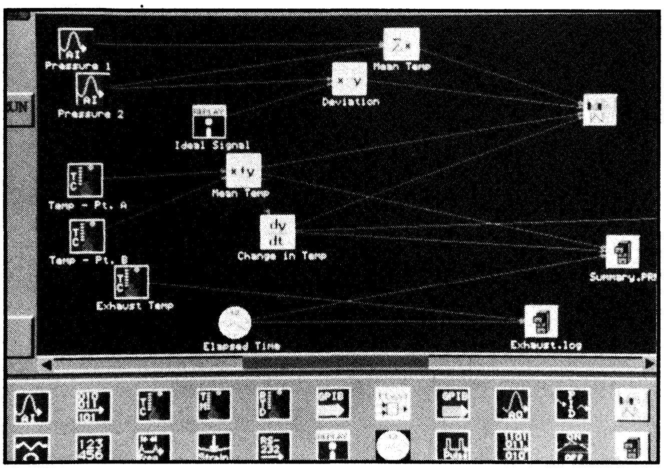


FIGURE 2. A Typical Iconic Interface Display.

Custom, color graphic "flow diagrams" provide display of real-time and trend information to the operator (see FIGURE 3). Animation features can provide immediate visual feedback (e.g., the tank is filling, the door is open, etc.). Alarms can be set to call the operator's attention, or they can automatically trigger any desired action. Data can be stored on floppy or hard disk or written to a printer to provide historical records.

CONTROL runs on VIPc and other PC/XT/AT/EISA compatible platforms. IBM models 50, 60, 70 and 80 Micro Channel (PS/2) computers are also served. A separate version of LABTECH CONTROL for PCI Macintosh II products will be available soon. Please contact your Burr-Brown representative for more information on availability. The fact that CONTROL interfaces directly to real-world signals through PCI analog and digital I/O devices insulates the user from the need to program the data acquisition hardware.

LABTECH CONTROL supports expanded memory. Available memory beyond the traditional 640Kbyte limit can be used to store setup structures (channel configurations, etc.) and to house data buffers. This feature not only allows larger and more numerous setups, but it also frees DOS memory for other applications (e.g., terminate-and-stay-resident programs).

LABTECH CONTROL is ideal for many real-world process control tasks in manufacturing and laboratory environments. It can automate experiments, control test sequences, perform calculations, display results in a graphical format and generate reports. Applications include: **direct machine control**, **supervisory control**, **process monitoring**, **data logging**, **statistical process control**, **pilot plant production**, and **sequencing control**. CONTROL is in use in **petrochemical**, **pharmaceutical**, **wave soldering**, **automotive**

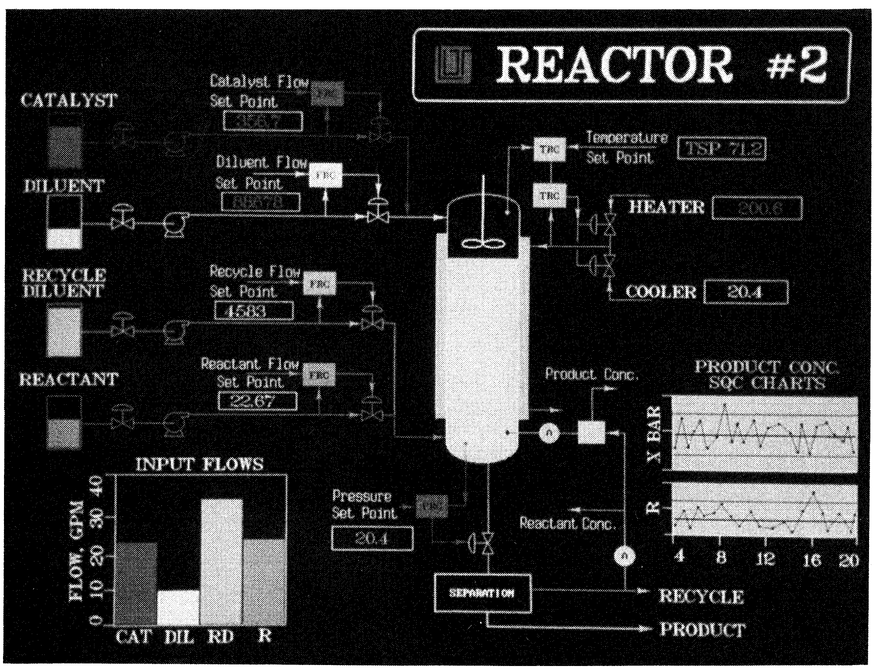


FIGURE 3. An Example of a Process Flow Diagram Using the Built-In ISA Symbol Library.

machining, **food processing**, **water treatment**, and **plastics extrusion** operations. Because LABTECH CONTROL is menu-driven/icon-based, it is extremely easy to learn and use. The conditions which define the current run are displayed on the screen and are readily modified. All of the conditions pertaining to a run can be easily saved or recalled as a group. LABTECH CONTROL reduces complicated procedures to single-button operations.

Flexibility is another strength of LABTECH CONTROL. Each channel can be set up with different characteristics. Sampling rates may vary from channel to channel and may also change at different times during a run. In addition to reading, analyzing and displaying data, CONTROL can simultaneously record the data to disk for future use. Stored data can be played back as though it were being acquired in real time. This provides a facility for making comparisons with data previously acquired or with data that has been theoretically derived. These on-line capabilities are ideal for statistical process control.

Channels can be used for purposes other than simple inputs or outputs. CONTROL has the ability to derive channels from other channels. For example, channels can "operate" on others by calculating averages, derivatives, integrals, etc., in real time. The list of mathematical, logical, statistical and signal processing functions also includes: trigonometric, EXP, LN, LOG, OR, XOR, AND, Filter, and FFT. These derived channels can also be used in determining triggers or as inputs to control loops.

Open- and closed-loop control algorithms are easily implemented. In the open-loop mode, the user defines one period of any imaginable waveform, and the signal is then clocked out automatically during the run. For closed-loop control, both proportional-integral-derivative (PID) and "bang-bang" (on/off) loops can be set up.

CONTROL includes a powerful curve-fitting function. It uses an iterative routine to fit an arbitrarily complex model (up to ten parameters) to the collected data. This and other routines such as PID and thermocouple linearization will automatically take advantage of the PC's optional coprocessor if available. This offers 80-bit real number processing, reduces round-off error, and allows faster computation.

Basic Operation

With LABTECH CONTROL's menu-driven/icon-based interface, there are no commands for the user to remember. LABTECH CONTROL includes a mouse-driven graphical interface called ICONview. ICONview allows setups to be visually created by interconnecting icons that represent I/O, file, and display functions. The unlimited drawing board size allows the configuration of setups with large numbers of channels and displays. The visual presentation of the system configuration shows the data flow between functions in a way that simplifies setup creation, verification and modification. ICONview works with ADJUST and the traditional menus to maximize productivity. If desired, a double-click of the mouse brings into view the underlying menu for the selected function. Icons are included for all input and output functions, specialized channel types (such as calculated and time channels), data storage and display.

The option menu displays a list of setup conditions on the left- hand side of the screen. The corresponding values for each of the setup conditions appear in the column to the right of the list. This is the basic format of all of CONTROL's option menus. Changing any value is easy. Simply move the cursor (highlighted rectangle) up or down the entry column (using the cursor control keys) until the appropriate value is located. Type in the new value and press the Enter key.

Process Control

Both open- and closed-loop process control are available using LABTECH CONTROL. When open-loop control is specified, the contents of a data file are sent, point-by-point, to the hardware interface at a rate determined by operator selection. With closed-loop analog control, the output is determined according to a PID equation. This equation provides an output signal which is a function of the input from an A/D channel and four PID variables, which can be modified during a run: loop gain, loop reset, loop rate, and loop set point. Tuning a given loop does not disturb other operations. Cascade control is also supported. With closed-loop digital control, both on/off (bang-bang) and alarm controls are supported. The input signal is compared to upper and lower limits specified during setup, and the appropriate output is generated.

Data Acquisition

LABTECH CONTROL can perform data acquisition in either a normal or high-speed mode. In the normal mode, acquisitions may be performed at sampling rates from 0.001Hz to over 1kHz. In this mode, real-time display of data is available to the user (at reduced data rates), and data may also be permanently stored in user-defined files. In the high-speed mode, rates up to 80kHz can be obtained. In both cases the maximum speeds depend upon the particular PCI and computer hardware being used. Please refer to the SPEED BENCHMARK table.

In the normal mode, each channel may have different setup conditions. That is, they may have different channel types, scale factors, sampling rates, etc. In addition, the time period for each channel may be divided into up to four stages, each stage having a different sampling rate, duration, and/or starting method. The series of stages may be repeated by setting an appropriate iteration count for the channel.

Any stage may be initiated in one of three ways:

— Normal starting, where a stage begins as soon as the previous stage ends (the first stage begins as soon as the run is initiated).

— Trigger starting, where a digital input or an analog level on any channel (or combination thereof) is received before the stage can begin.

— Time delay starting, where a stage begins only after a user-specified time has elapsed.

A stage may run until:

— A stated time period has elapsed, or

— An analog or digital trigger occurs.

The high-speed mode supports only analog inputs, and real-time display of the data is not available. Further, all channels must have identical setup conditions, and multiple stages and loops are not available. A high-speed run may be started using either the normal, trigger, or time-delay method. Data can be displayed after the run is complete.

Calculated Channels

A unique channel type is provided to support user-defined algebraic, calculus, trigonometric, statistical, and logical operations. Calculated channels, as they are called, accept one or two inputs (depending upon type) from other channels and produce a transformed output. Inputs can include live data, replayed data, time, or other calculated channels. Functions include: X+Y, X-Y, X*Y, X/Y, Sum(X..Y), X, X^2, Square Root, 1/X, ABSOLUTE VALUE, LN, LOG, EXP, SIN, COS, TAN, ARCSIN, ARCCOS, ARCTAN, dX/dt, Integral, MIN,

MAX, LOWER LIMIT, UPPER LIMIT, AVERAGE, NOT, OR, AND, FFT, and FILTER. By stringing calculations together, it is possible to perform more complex transformations of the input data.

Data Storage

In the normal mode, how data is stored depends upon the mode selected. Data can be stored in RAM or continuously written to disk. In the high-speed mode data is always stored in RAM during the run. At the end of the run it is written to disk. Eight data storage modes are available, including ASCII and binary formats. The data storage mode determines the amount of space the data will require. Each data file may receive data from one or more data acquisition channels. CONTROL also allows you to place header lines, names, and unit labels in data files. Data files from LABTECH CONTROL may be imported directly into most analysis or spreadsheet programs. For example, external data manipulation, statistics and database management are all available with compatible file structures.

Real-Time Display

The real-time display function is available during normal-mode data acquisition and control runs. FIGURE 4 shows an example of display. As can be seen, the display is in the form of X-Y graphs, Y-time graphs, vertical bars, digital meters, and horizontal bars. Up to 50 signals can be displayed in up to 50 windows. The presentation and scaling of the displays are under the control of the user. Scrolling of the horizontal axis is provided in the Y-time mode. The sizing and positioning of windows is accomplished interactively. A mouse-driven function called ADJUST is included that can create, delete, position, and stretch windows with ease. LABTECH supports high-resolution display standards including EGA and VGA.

Network Capabilities

LABTECH CONTROL can run on any PC (node) in a network. A separate copy of CONTROL (full or Run-Time system) is needed for each PC on the network that will be running CONTROL. Data can be stored on any hard disk in the network, including a file server.

Any station can read real-time data as it is collected on another PC. The data can be manipulated, displayed, and used as inputs for a control loop. Therefore, the data being read by one station on a plant floor can be used to determine control outputs for another node. These features can be used to set up a central monitoring and control location. All control operations can be reviewed from this station and adjustments to individual setpoints can be made. The operator can quickly switch between display screens (up to 64) showing the desired remote activity. The maximum transfer rate between network nodes is about once per second for each channel.

External Bus Support— RS-232 and IEEE-488 (GPIB)

In addition to communicating with PCI hardware installed within the PC, CONTROL can also access external devices through standard RS-232 and GPIB ports. The interface to RS-232 is built into CONTROL's channel setup menu and can be accessed through any available RS-232 port on your PC. A GPIB port can be added to your PC using PCI-800 Series products. These IEEE-488 interfaces are fully described in this Handbook. GPIB capabilities are added to CONTROL with the PCI-20342S-1 Support Kit. This kit includes the required software supplement and complete documentation. Users can enter commands to control a GPIB instrument and then test those commands immediately. Therefore, users can interactively configure CONTROL to control and collect data. Data can be read, displayed, filed to disk and used in calculations. Both GPIB and other PCI hardware interfaces can be used simultaneously.

Real-Time Access

LABTECH CONTROL has the unusual capability of operating as a real-time multitasking subsystem. CONTROL can operate in the background, carrying out a complex schedule of control and monitoring functions while the user at the console is tuning a loop, analyzing data or running some other DOS application program. A real-time-access feature even provides for inter-program communications. This allows a foreground application to access the real-time data being acquired simultaneously by CONTROL. To the application program, that data looks as if it is coming from an ordinary DOS file or device. Virtually any existing application program that can access files is compatible. It need not have been specially written to work with the CONTROL. So, existing spreadsheets, statistical analysis programs, quality control programs, graphics programs and more can gain real-time data acquisition capabilities.

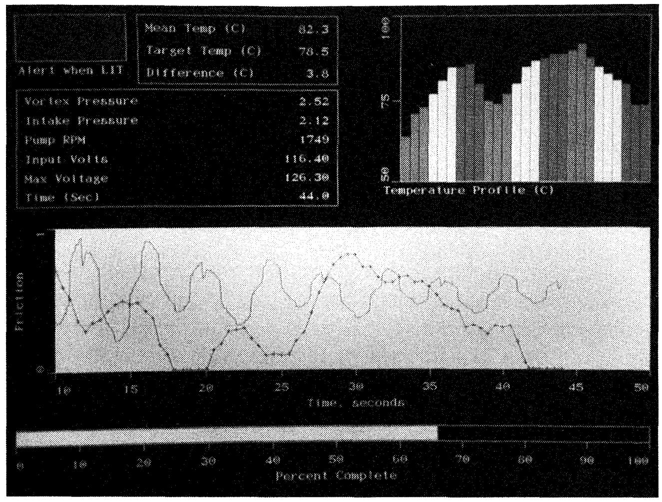


FIGURE 4. An Example of a Real-Time Screen, Including Amplitude vs Time Plots, Bar Graphs, and Digital Display.

Reading is done in one of several modes. In one mode, all data accumulated in the buffer since the last read request is passed to the foreground program, assuring that no data will be skipped. In another mode, only the latest data point in the buffer is passed to the foreground program. Yet another command allows for the immediate collection of a new data point, regardless of when the last one was collected and put in the buffer. Reading can also be set to return with no data (if none has been collected since the last read command) or to wait for data to be entered in the buffer. This last feature provides a simple way for the foreground program to synchronize itself to the data acquisition rate.

Run-Time Systems

Run-time systems allow the duplication of LABTECH CONTROL applications around a facility. Run-time versions can execute any setup created with a full CONTROL version, but they do not support making changes to the setups. Because the cost of a run-time system is about half of a complete version, a significant savings can be realized when replicating production lines, etc. If necessary, setups can be altered using the main system.

The run-time package also allows tighter control over test procedures and conditions. Since it will only execute setups configured with the original system, operators can only run controlled setups. Run-time systems can thus be used by engineering departments and value-added resellers to configure turnkey applications. A run-time system is the perfect solution when the integrity of a data acquisition and process control program must remain secure. Run-time copies of CONTROL are available by ordering PCI-20318S-1.

Termination Panel Compatibility

As a general rule, all termination panels are compatible with I/O hardware supported under LABTECH CONTROL. However, due to the requirement for Cold-Junction Compensation (CJC) with thermocouples, not all termination panel configurations can be used. The Compatibility Table for Termination Panels defines the various thermocouple options. Please note that for all of the thermocouple channels on a given termination panel, one analog input channel is required to read the CJC on the termination panel -- except for PCI-5B applications.

SUPPORT PCI HARDWARE

PCI MODEL NUMBER	TYPE	BUS SUPPORTED	FUNCTION[1]	CHANNELS[2]	MAX SPEED[3]	COMPATIBLE H/W PRODUCTS[5]
PCI-601W/602W	Board	Micro Channel	Analog input	16/8[4]	70kHz	
			Digital I/O	16	1800Hz	
			Counter/timer	2	1800Hz	
			Analog output	2	900Hz	(PCI-602W only)
PCI-20001C-2A	Carrier	PC/XT/AT/EISA	Digital I/O	32	1800Hz	PCI-20002M, 3M, 4M, 5M, 7M, 19M, 21M
PCI-20041C-2A/-3A	Carrier	PC/XT/AT/EISA	Digital I/O	32	1800Hz	PCI-20002M, 3M, 4M, 5M, 7M, 19M, 21M
PCI-20098C-1	Carrier	PC/XT/AT/EISA	Analong input	16/8[4]	32kHz	PCI-20003M, 4M, 21M, 31M-1
			Digital I/O	16	1800Hz	
			Counter/timer	2	1800Hz	
PCI-20002M-1	Module	I[3]	Analog input	16/8[4]	25kHz	PCI-20001C, PCI-20005M, PCI-20041C
PCI-20003M-2/-3	Module	I[3]	Analog output	2	900Hz	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20004M-1	Module	I[3]	Digital I/O	32	1800Hz	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20005M-1	Module	I[3]	Analog expander	32/16[4]	25kHz	PCI-20001C, PCI-20002M, PCI-20041C
PCI-20007M-1	Module	I[3]	Counter/timer	4	1800Hz	PCI-20001C, PCI-20019M, PCI-20041C
PCI-20019M-1A	Module	I[3]	Analong input	8	80kHz	PCI-20001C, PCI-20007M, PCI-20041C
PCI-20021M-1B	Module	I[3]	Analog output	8	900Hz	PCI-20001C, PCI-20041C, PCI-20098C
PCI-20031M-1	Module	I[3]	Analog expander	32/16[4]	1800Hz	PCI-20098C
PCI-20089W-1	Board	PC/XT/AT/EISA	Analog input	16/8[4]	25kHz	
PCI-20091W-1	Board	PC/XT/AT/EISA	Analog input	8	80kHz	
PCI-20093W-1	Board	PC/XT/AT/EISA	Analog output	8	900Hz	
PCI-5000 Series	Platform	PC/AT/EISA	All PCI-20000 H/W			
PCI-801K	Board	PC/XT/AT/EISA	IEEE-488 Port	1		
PCI-802K	Board	Micro Channel	IEEE-488 Port	1		

Notes:
(1) The features listed for carriers can be greatly extended by using one or more compatible modules.
(2) The number of channels refer to a single unit. Multiple units can be used if needed.
(3) Refer to the Speed Benchmarks table below for additional information on performance.
(4) Single-ended/differential.
(5) When model numbers are shown without "dash" numbers, all versions apply.

COMPATIBILITY TABLE— TERMINATION PANELS FOR THERMOCOUPLE APPLICATIONS[1]

BOARD	CARRIER	A/D MODULE	FIRST EXPANSION MODULE	SECOND EXPANSION MODULE	TERMINATION PANEL	NUMBER OF THERMOCOUPLE CHANNELS
PCI-601W/PCI-602W					1 PCI-20024T-1	7
					1 PCI-5B01-1	16
					1 PCI-20010T-2	7
PCI-20089W-1					1 PCI-20042T-1 and 1 PCI-20043T-1	8
					1 PCI-20044T-1 and 1 PCI-20045T-1	8
					1 PCI-20057T-1	7
					1 PCI-5B01-1	16
	PCI-20001C or PCI-20041C	PCI-20002M-1			1 PCI-20010T-2	7
					1 PCI-20042T-1 and 1 PCI-20043T-1	8
					1 PCI-20044T-1 and 1 PCI-20045T-1	8
					1 PCI-20057T-1	7
					1 PCI-5B01-1	16
	PCI-20001C or PCI-20041C	PCI-20002M-1	PCI-20005M-1		3 PCI-20010T-2	21
					3 PCI-20042T-1 and 3 PCI-20043T-1	24
					3 PCI-20044T-1 and 3 PCI-20045T-1	24
					1 PCI-20057T-1	23
					3 PCI-5B01-1	48
	PCI-20001C or PCI-20041C	PCI-20002M-1	PCI-20005M-1	PCI-20005M-1	5 PCI-20010T-2	35
					5 PCI-20042T-1 and 5 PCI-20043T-1	40
					5 PCI-20044T-1 and 5 PCI-20045T-1	40
					2 PCI-20057T-1	38
					5 PCI-5B01-1	80
	PCI-20098C-1				1 PCI-20024T-1	7
					1 PCI-5B01-1	16
	PCI-20098C-1		PCI-20031M-1		1 PCI-20024T-1 and 1 PCI-20057T-1	22
					3 PCI-5B01-1	48
	PCI-20098C-1		PCI-20031M-1	PCI-20031M-1	5 PCI-20010T-2	35
					1 PCI-20024T-1 and 2 PCI-20057T-1	37
					5 PCI-20042T-1 and 5 PCI-20043T-1	40
					5 PCI-20044T-1 and 5 PCI-20045T-1	40
					5 PCI-5B01-1	80

Note: (1) When part numbers are shown without "dash" number, all versions apply.

For additional information, please refer to the configuration charts in the Summary Section.

SPEED BENCHMARKS— PCI-20097S-1

(The specifications shown in this table are typical of what can be expected under the stated conditions.)

MODE	CONDITIONS	SPECIFICATIONS 8088 AT 4.7MHz	80286 AT 12MHz	80386 AT 16MHz
Normal, Analog In and Digital I/O	To RAM, no display or disk storage	300 Reads/sec	900 Reads/sec	1800 Reads/sec
	To disk, binary integer	150 Read/sec	450 Reads/sec	900 Reads/sec
	To screen, with coprocessor	60 Reads/sec	180 Reads/sec	360 Reads/sec
	Without coprocessor	30 Reads/sec	90 Reads/sec	180 Reads/sec
	To disk and screen, with coprocessor	30 Reads/sec	90 Reads/sec	180 Reads/sec
	Without coprocessor	15 Reads/sec	45 Reads/sec	90 Reads/sec
Normal, Thermocouple and PID Loops	To RAM, no display or disk storage	67 Reads/sec	200 Reads/sec	400 Reads/sec
	To disk, binary integer	33 Reads/sec	100 Reads/sec	200 Reads/sec
	To screen, with coprocessor	13 Reads/sec	40 Reads/sec	80 Reads/sec
	Without coprocessor	7 Read/sec	20 Reads/sec	60 Reads/sec
	To disk and screen, with coprocessor	7 Reads/sec	20 Reads/sec	60 Reads/sec
	Without coprocessor	4 Reads/sec	10 Reads/sec	30 Reads/sec
Normal, Analog Out	To RAM, no display or disk storage	150 Pts/sec	450 Pts/sec	900 Pts/sec
	To disk, binary integer	75 Pts/sec	225 Pts/sec	450 Pts/sec
	To screen, with coprocessor	30 Pts/sec	90 Pts/sec	180 Pts/sec
	Without coprocessor	15 Pts/sec	45 Pts/sec	90 Pts/sec
	To disk and screen, with coprocessor	15 Pts/sec	45 Pts/sec	90 Pts/sec
	Without coprocessor	7 Pts/sec	22 Pts/sec	45 Pts/sec
High-Speed				
PCI-20002M-1	To RAM only, clocked	4K Reads/sec	9K Reads/sec	9K Reads/sec
	Free running	16K Reads/sec	25K Reads/sec	25K Reads/sec
PCI-20019M-1A	To RAM only, (required PCI-20007M-1)	50K Reads/sec	80K Reads/sec	80K Reads/sec
PCI-20089W-1	To RAM only, clocked	4K Reads/sec	9K Reads/sec	9K Reads/sec
	Free running	16K Reads/sec	25K Reads/sec	25K Reads/sec
PCI-20091W-1	To RAM only	50K Reads/sec	80K Reads/sec	80K Reads/sec
PCI-20098C-1	Analog input to RAM	25K Reads/sec	32K Reads/sec	32K Reads/sec
PCI-601W/PCI-602W	Analog input to RAM	--	70K Reads/sec	70K Reads/sec

SPECIFICATIONS— PCI-20097S-1

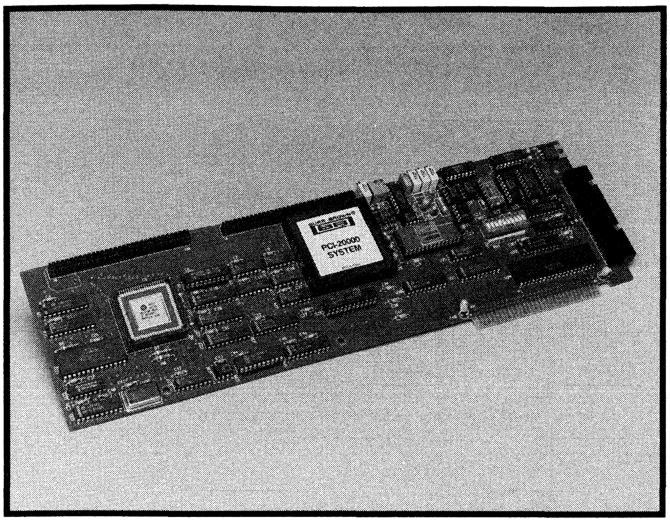
PARAMETER	CONDITIONS	SPECIFICATION
Computer Platforms	PCI-20000 Series hardware PCI-600 Series hardware PCI-700 Series hardware	VIPc and other PC/XT/AT/EISA compatible machines PS/2 Micro Channel compatible machines Contact Burr-Brown for availability
RS-232 Interface **IEEE-488 (GPIB) Interface**	Up to 8 ports supported Refer to PCI-800 Series for port hardware	Included Requires PCI-20342S-1 GPIB support kit
Data Acquisition Sampling Rate Input Types Starting Methods	See individual hardware speed guidelines above	 Up to 80kHz Analog, digital, pulse, frequency and thermocouple (Types B, E, J, K, R, S and T), calculated Immediate, delayed, timed, triggered
Output (Signal Generation) Rate Process Control Modes Input Types Output Types	See individual hardware speed guidelines above	 Up to 900 Pts/sec Open loop and PID Analog, digital, pulse and frequency Analog and digital
Data Storage Types Modes		 RAM and disk ASCII real/integer, binary real/integer, ASCII, hex, binary
Real-Time Display Speed Types Number of Windows/Traces Graphics Modes	 Graphics adaptor required	 Up to 360 Pts/sec Y-Time, X-Y, bars, digital meters 50/50 EGA, VGA, or 8514A
PC Requirements[1] Platforms Drives Memory Coprocesor Mouse	MS-DOS or PC-DOS machines 8087, 80287, 80387	 PC/XT/AT/EISA or PS/2 compatibles[1] Hard disk plus 3.5″ or 5.25″ floppy 640KB RAM Automatically used if available Mouse Systems or Microsoft

Notes: (1) Please contact your Burr-Brown representative for information on the availability of PCI-700 Series (Mac II) support.

LABTECH NOTEBOOK— RELATED PRODUCTS

PRODUCT NAME	PCI MODEL NUMBER	DESCRIPTION
Run-Time System	PCI-20318S-1	Allows running duplicate CONTROL systems at half the cost of a complete version
GPIB Support Kit	PCI-20342S-1	Adds an interface to standard IEEE-488 (GPIB) laboratory instruments
Hardware Interface	PCI-600 Series	Micro Channel (PS/2) compatible I/O products
Hardware Interface	PCI-700 Series[1]	Mac II NuBus compatible I/O products
Hardware Interface	PCI-800 Series	Interface products to add IEEE-488 (GPIB) ports to PC/XT/AT/EISA, Micro Channel and Mac II computers
Hardware Interface	PCI-5000 Series	VIPc Family of PC/XT/AT compatible computer platforms
Hardware Interface	PCI-20000 Series	PC/XT/AT/EISA compatible I/O products

Note: (1) Please contact your Burr-Brown representative for information on the availability of PCI-700 Series (Mac II) support.



BURR-BROWN®

PCI-20098C-1

Multifunction Carrier for the PC Bus

FEATURES

- All Functions Software Programmable, No Jumpers Needed
- 16 / 8 Analog Input Channels
  - — Single-Ended/Differential
  - — Expandable to 80/40 Channels with PCI Modules
  - — 12-Bit Resolution
  - — Programmable Gain = 1, 10, 100
  - — Up to 32kHz Sample Rate
  - — DMA, Interrupt-Driven or Polled Modes
- Internal Timebase/Burst/Rate Generator
- 2 Independent Counter Channels
  - — 16/32-Bit Operation
  - — Event Counter and Divider
  - — Read Frequency, Period, and Pulsewidth
  - — Variable-Duty-Cycle Generator
- 16 Channels of Digital I/O
- Compatible with All PCI I/O Modules

DESCRIPTION

The PCI-20098C-1 is a Multifunction Carrier that supports a wide range of analog and digital I/O functions. The carrier interfaces directly to the internal bus of any IBM compatible computer. These include the Burr-Brown VIPc and other PC/XT/AT/EISA machines. In addition to its on-board I/O capabilities, each carrier has provisions for expansion through the use of PCI modules. This family of modules supports analog input expansion, analog outputs, digital I/O, counters, trigger/alarm, and simultaneous sample and hold functions. Typical applications for this product include data acquisition, process control, and test systems. Compatibility is insured for a wide variety of analog voltages and currents (thermocouples, RTDs, strain gages, load cells, etc.), as well as digital and pulse signals (switch closures, optical/magnetic pickups, etc.). All options and functions on the board are under software control. No jumpers are required. A functional block diagram of the product is shown below.

The PCI-20098C-1 performs the necessary signal interface functions required to make input/output data compatible with your personal computer. This includes analog-to-digital (A/D) conversion. The on-board analog input multiplexer can select from among 16 single-ended or 8 differential channels. This channel count can be expanded in 32-channel increments to a total of 80 channels using optional Expander Modules. Signal scaling and common-mode rejection are provided by a high-performance, differential input, programmable gain amplifier. Gains of 1, 10, and 100 are available. The 12-bit A/D converter can be configured for input ranges of ± 5, 0 to 10, or ±10 volts full scale. In normal operation, the user has program control over every aspect of the data collection process. For each channel, the gain, A/D range, and the choice of single-ended or differential input are all programmable. A hardware channel scanner enhances high-speed and DMA performance. Not only can channels be scanned in any sequence, but each channel can have independent gain settings.

When the multifunction carrier is used with plug-in I/O modules, the connecting cables should be routed through the unused PC expansion slot opening. A PCI-20028A-3 strain-relief bracket is available to support the I/O cables.

The digital section of the carrier contains 16 channels of digital I/O, a programmable burst/rate generator, and 2 general-purpose counters. The crystal-controlled burst/rate generator is very useful for establishing an accurate and dependable timebase for data acquisition. In addition to generating continuous clock rates in the range of 0.002Hz to 2MHz, the user can program bursts of pulses. Using this feature, the desired number of pulses can be generated with a specified pulse spacing and an independent repetition rate. This innovation makes it easy to perform a maximum-speed acquisition of a group of channels (in order to minimize time skew between channels) while the group is sampled at a slower rate that is independent of the channel-to-channel timing.

The two 16-bit counters can be used separately or in combination to form a 32-bit counter. Typical operations include event counting and dividing as well as speed, frequency, pulsewidth, and period measurement. Also, the counters can be configured to produce a variable-duty-cycle generator. The counter's separate clock, gate and output connections have independent, fully programmable, active-high/low states. Input clock rates up to 16MHz are supported. Counter inputs include Schmitt triggers to support slowly changing signals.

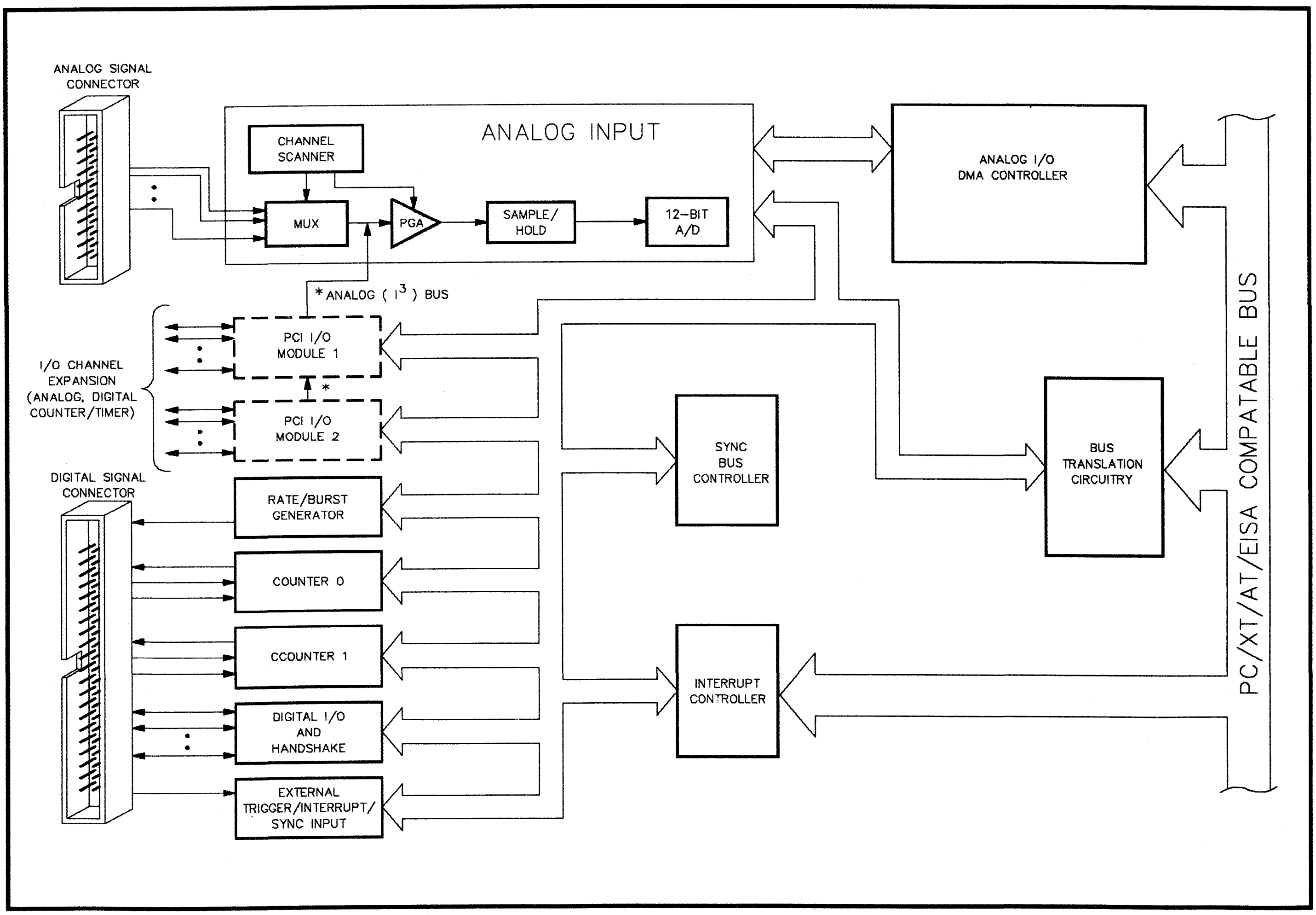
The 16 channels of TTL compatible digital I/O are arranged in two byte-size ports (8 channels each) that can be programmed for either input or output use. In addition, all outputs are buffered, and full handshake and interrupt capabilities are supported.

Separate bulkhead connectors are provided for both the analog and the digital signals. This is to insure that digital signals do not contaminate (degrade) the analog inputs. Optional ribbon cables and termination panels are available to help facilitate external connections.

Optional software drivers are available offering a wide range of capabilities for several programming languages. These include the PCI-20026S family, along with the PCI-20027S and the PCI-20096S families, which offer extended capabilities for BASIC, C, TURBO PASCAL, and Assembler.

Comprehensive documentation covers all aspects of installation, calibration, and programming. Each Carrier is shipped, at no extra charge, with Burr-Brown's innovative SYSCHECK PC, the system assurance utilities and diagnostics software package. This menu-driven product easily verifies proper installation and utilization of all PCI system components. Not only does SYSCHECK PC greatly reduce the time required to confirm appropriate operation, but it also provides a permanent resource for test and calibration. In addition, SYSCHECK PC provides non-programmers with a fundamental way of exercising the input/output capabilities of the system. This can be useful as both a product tutorial and in performing modest test and simulation functions.

High-level, menu-driven application software provides extensive features without programming. These programs include LABTECH NOTEBOOK, LABTECH CONTROL, Easyest, and the SNAP-Series.



Block Diagram of the PCI-20098C-1 Multifunction Carrier.

SPECIFICATIONS—PCI-20098C-1

All specifications are typical at 25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility	DMA and program control	All IBM compatible PCs, including Burr-Brown VIPc and other PC/XT/AT/EISA machines
Carrier Addressing, Size		Memory mapped, 1Kbytes
I/O Configuration	Compatible with all input/output modules	Two I^3 Bus sockets plus 16 DI/O, 16/8 Ain (SE/Diff), two counters, 1 rate generator
Analog Input	Expandable with modules	Fully programmable
Number of Channels	Single-ended/differential	16/8
Signal Range	Linear operation	±10V maximum
	Without damage, Power on	±35V
	Power off	±20V
Offset Voltage	Trimmable to zero	±0.5LSB
Common Mode Range	$V_{cm} = CM_{range} - (V_{diff} \cdot Gain)$	±12V
Rejection Error	60Hz, 100 ohm imbalance	
	Gain = 1	0.2LSB (-80dB)
	Gain = 10	0.4LSB (-95dB)
	Gain = 100	3.6LSB (-95dB)
Bias Current		500pA
Input Impedance		10^{11} @ 75pF
Source Impedance	For ≤1 LSB error	
Maximum Recommneded	At 32kHz sample rate	7.5K ohms
	At 26kHz sample rate	10K ohms
Crosstalk	Channel-to-channel @ 1kHz, 1KΩ source impedance	0.2LSB (-90dB)
Nonlinearity	Gain = 1, 10	0.5LSB
	Gain = 100	1LSB
Gain, Selections	Software programmable	1, 10, 100
Inaccuracy	Trimmable to 0%	±0.5LSB
A/D Converter		Fully programmable
Resolution	(1 part in 4096)	12-bit
Code	Unipolar	Binary
	Bipolar	Offset binary
Ranges		±5, ±10, 0-10V FS
Dynamic Performance	12-bit accuracy	
Total Throughput	80286 at 12MHz/6MHz	32kHz/28kHz
Mux Settling Time		5μsec maximum
S/H Capture Time		6μsec maximum
A/D Conversion Time		25μsec maximum
PGA Settling Time	10-volt step, gain = 1, 10	15μsec
	Gain = 100	20μsec
Digital I/O(1)		Fully programmable
Number of Ports	8 channels each	2
Modes		Normal I/O, strobed
Digital Inputs		
High-Level Voltage	Minimum	2.0V
Low-Level Voltage	Maximum	0.8V
I_{in}, High-Level	Maximum	20μa
I_{in}, Low-Level	Maximum	-0.2mA
Digital Outputs(2)		
High-Level Voltage	I_{out} = Max	2.0V
Low-Level Voltage	I_{out} = Max	0.5V
Current Source	V_{out} = Low	-15mA
Current Sink	V_{out} = High	24mA
Rate Generator	Fully Programmable	
Output Frequency		0.002Hz to 2MHz
Resolution		125nS
Stability	Crystal Clock	±0.01%
Output Modes		Continuous and burst
Counters	Fully Programmable	Configurable as one 32-bit or two 16-bit
Number		16MHz
Clock Speed	Maximum	Event counter; divider; frequency, period, and pulsewidth measurement; variable-duty-cycle generator
Functions		
Interrupts	Latched	Fully programmable
PC Level		2 thru 7
Sources		Modules 1, 2
		Rate generator, external TTL, end of conversion, and end of measurement
Power Requirements	From PC's +5V supply	
	No modules installed	1.45A
		1.70A maximum
	Two modules installed	2.5A

...Continued

SPECIFICATIONS— PCI-20098C-1 (CONTINUED)

PARAMETER	CONDITIONS	SPECIFICATION
Power Available to Modules	Internal +15V supply Internal -15V supply +5V Bus	120mA Minimum 120mA Minimum Depends upon host
Physical Size	Expansion slot requirements Length x Height	1 to 2 slots$^{(3)}$ 13.35" x 3.9" (33.9cm x 9.9cm)
Connectors (Mating)	Mounted on bulkhead Analog Digital	 Amphenol #845C026SALA00 Amphenol #845C050SALA00
Temperature Range	Board temperature	0 to 70°C

Notes: (1) All digital I/O points are programmable as either inputs or outputs in byte-size groups (8 channels each).
(2) All digital I/O ports are inputs at power up.
(3) The width of the PCI-20098C-1 depends upon the combination of I/O and other expansion boards installed in the PC. With no modules, one slot is required. In most cases, when two modules are installed, two slots are required.

SOFTWARE COMPATIBILITY TABLE

(The PCI-20098C-1 can be used with the following software in conjuction with the listed hardware.)

PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER[2]	DMA SUPPORT	HARDWARE SUPPORTED[1]
PCI-20040S-1	LABTECH NOTEBOOK	Yes	Yes	No	PCI-20003M, 4M, 7M, 21M and 31M Modules
PCI-20097S-1	LABTECH CONTROL	Yes	Yes	No	PCI-20003M, 4M, 7M 21M and 31M Modules
PCI-20068S	SNAP-Series	Yes	Yes	Yes	PCI-20003M, 6M, 20M, 21M and 31M Modules
PCI-20067S-1	DADiSP/PC	Yes	No	No	N/A
PCI-20210S-1	Hypersignal-Workstation	Yes	No	No	N/A
PCI-20026S	General-purpose Drivers	No	Yes	No	All PCI I/O Modules
PCI-20027S	High-performance Drivers	No	Yes	Yes	PCI-20020M and PCI-20031M Modules
PCI-20096S	TURBO STREAM Drivers	No	Yes	Yes	PCI-20020M and PCI-20031M Modules
PCI-20301S-1	ASYST Series	No	Yes	Yes	PCI-20003M, PCI-20006M and PCI-20031M Modules
PCI-20348S-1	Easyest	Yes	Yes	Yes	PCI-20003M and PCI-20006M Modules

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-20026S and PCI-20027S drivers).

HARDWARE COMPATIBILITY TABLE— MODULES

(The PCI-20098C-1 can be used in conjunction with the following hardware products.)

PCI MODEL NUMBER	FUNCTION	NUMBER OF CHANNELS	RESOLUTION	SPEED	CABLE	TERMINATION PANEL	ENCLOSURE[1]
PCI-20031M-1	Analog Expansion	32/16[2]			PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, 343A
PCI-20017M-1	Simultaneous S/H	4/4[2]			PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, 343A
PCI-20020M-1	Trigger/Alarm	1			PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, 343A
PCI-20003M-2	Analog Output	2	12-bit	80,000 pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, 343A
PCI-20003M-4	Analog Output	2	12-bit	80,000 pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, 343A
PCI-20006M-2	Analog Output	2	16-bit	80,000 pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, 343A
PCI-20021M-1B	Analog Output	8	12-bit	2,000 pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1. 343A
PCI-20004M-1	Digital I/O	32			PCI-20311A-1	PCI-20305T-1	PCI-20308H-1, 343A
PCI-20007M-1	Counter/Timer	4/1[3]			PCI-20311A-1	PCI-20305T-1	PCI-20308H-1, 343A

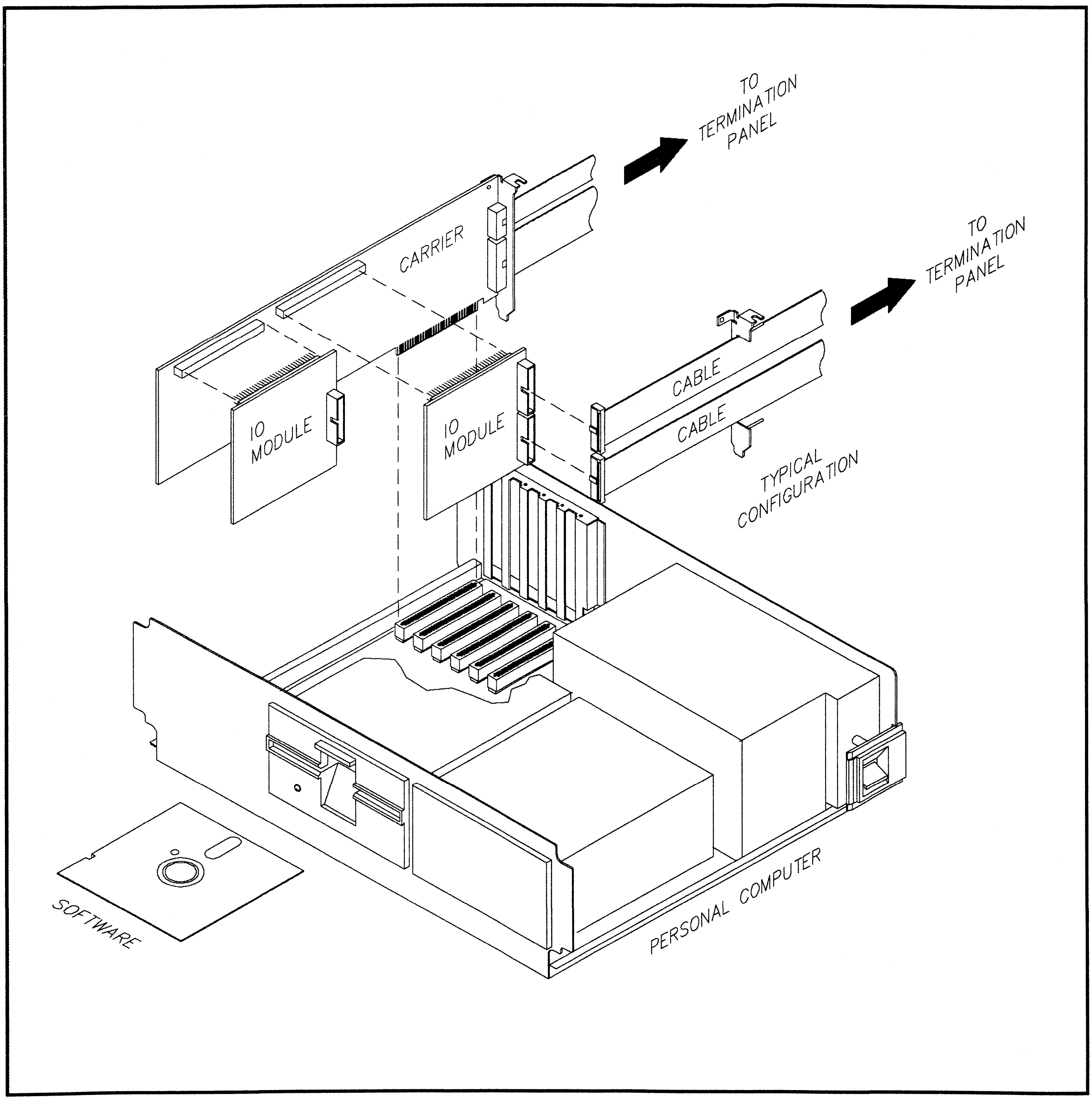
Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) Single-ended/Differential
(3) Counters/Timers

For additional information, please refer to the configuration charts in the Summary Section.

HARDWARE COMPATIBILITY TABLE—TERMINATION PANELS

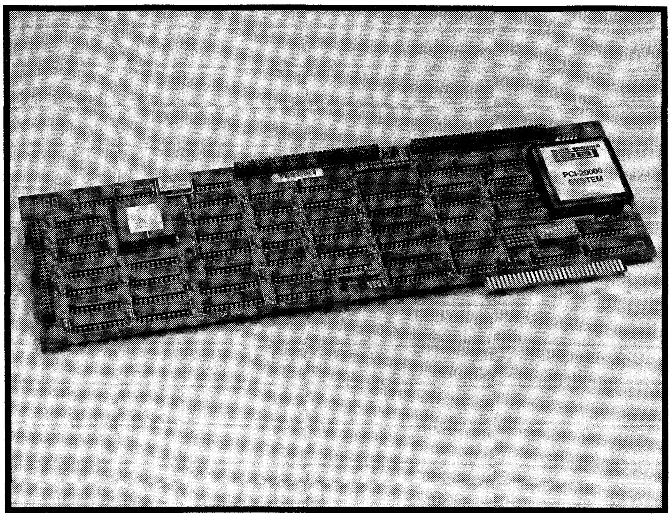
(The PCI-20098C-1 can be used in conjunction with the following hardware products.)

TERMINATION PANELS	I/O TYPE	CABLE	PANEL FUNCTION	ENCLOSURE
PCI-20304T-1 PCI-20304T-2 PCI-20024T-1 PCI-5B01-1	Analog Input	PCI-20008A-1B PCI-20008A-1B PCI-20008A-1B PCI-20008A-1B	General-purpose Thermocouple Customizer Signal conditioner	PCI-20308H-1 and PCI-20343A-1 PCI-20308H-1 and PCI-20343A-1 PCI-20029A-1 PCI-20339A-1
PCI-20306T-1 PCI-20025T-1 PCI-20325T-1	Digital I/O, Counters, Burst Generator	PCI-20009A-1B PCI-20009A-1B PCI-20009A-1B	General-purpose Customizer Signal conditioner	PCI-20308H-1 and PCI-20343A-1 PCI-20029A-1 PCI-20308H-1 and PCI-20343A-1



How the Multifunction Carrier Fits Into a PC System.

BURR-BROWN®



PCI-20202C Series
Smart Carriers for the PC Bus

DATA PROFESSIONAL Products

FEATURES

- Multi-Channel, High-Speed Analog Input and Output Capabilities Via the PCI Family of I/O Modules
- Based upon the Industry-Standard TMS320C25 Processor, Offering:
  - Up to 10 MIPS (100nS Instruction Cycle)
  - Comprehensive Software Support
- Both 28MHz and 40MHz Models Available
- Up to 96KWords of Internal High-Speed Memory, Zero-Wait-State
- DMA Interface to Host PC at 400Kbytes/Sec
- Internal Timebase / Rate Generator
- Programmable from High-Level Languages. Extensive Subroutine Libraries and Hardware Drivers Available

APPLICATIONS

- Data Acquisition & Control
- Transient Analysis
- Digital Filtering
- Automotive Testing & Simulation
- High-speed Machine Control
- Biomedical Signal Analysis
- Vibration Analysis

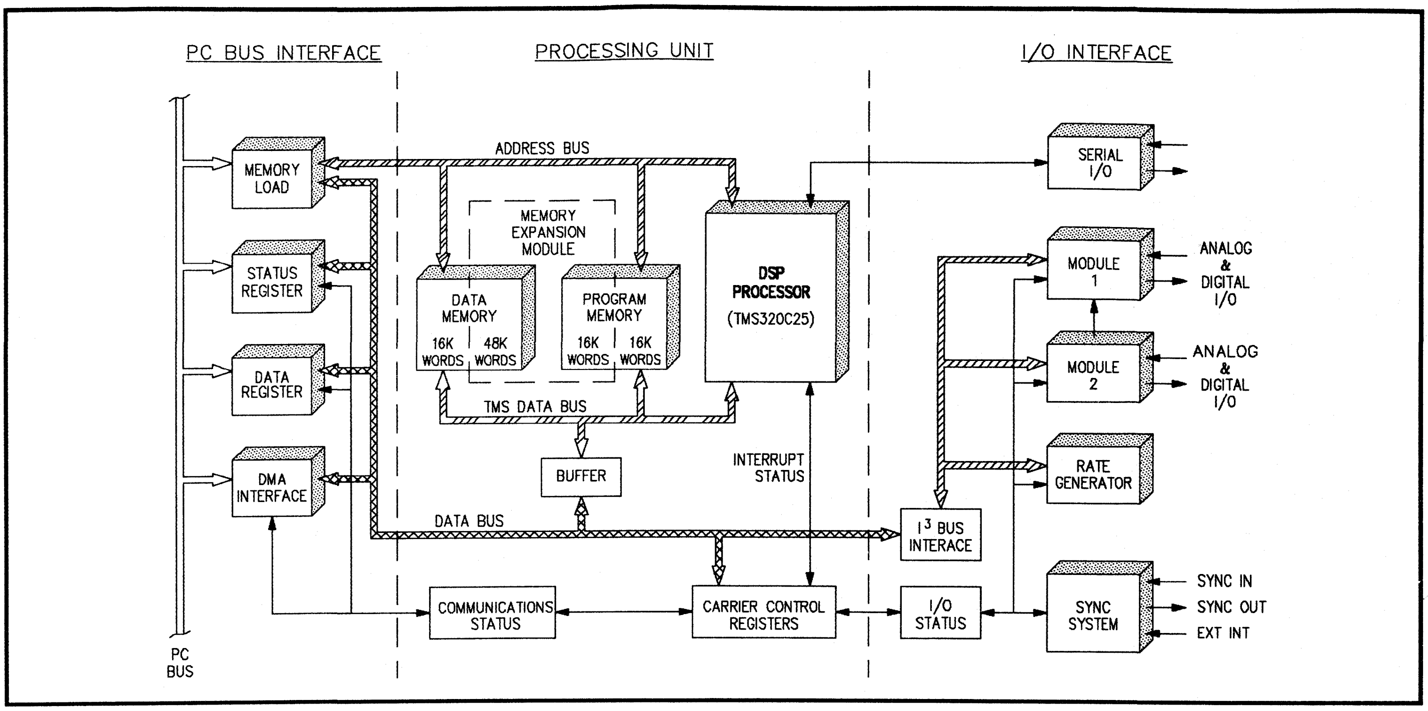
Complete systems including the PCI-20202C Series are available. See PCI-20207K Series.

DESCRIPTION

The PCI-20202C Series are high-performance *Smart* Carriers designed for the PC Bus. This includes the Burr-Brown VIPc and other PC/XT/AT/EISA machines. It is now possible, at low cost, to utilize real-time data acquisition and digital signal processing (DSP) techniques in a wide variety of applications. These *Smart* Carriers are based upon the highly regarded Texas Instruments TMS320C25 processor. TMS320s are the most widely used, tested and supported processors available. By using this high-performance signal processor, we are able to process data at rates 20 to 200 times faster than by using the PC alone. Furthermore, true background processing capability is provided. When used as an attached processor, both the control of the input/output process (i.e., analog-to-digital and digital-to-analog conversion) and the desired mathematical analysis (i.e., window, FFT, filter, etc.) can be performed independently of the host PC.

The PCI-20202C Series Carriers are available in two versions. Running at 28MHz, the PCI-20202C-1 is optimized for high performance at the lowest possible cost. Its 140nS instruction cycle achieves 7MIPS (Million Instructions Per Second). The PCI-20202C-2 runs at 40MHz. The result is state-of-the- art 10MIPS operation. Both *Smart* Carriers utilize a zero-wait-state memory design insuring the maximum data transfer rate.

The personal computer contributes the human interface and supervisory functions. For example, the PC downloads programs to the TMS processor, exchanges control parameters, permanently stores data, and displays results. When used as a coprocessor, the *Smart* Carrier can transfer a data array from the host computer's memory, process the data, and return the result to the PC's memory using direct memory access (DMA). Applying high-speed data acquisition, control or DSP techniques has never been easier. The modular hardware supports analog inputs, analog outputs, digital inputs, digital outputs, counters and timers. With appropriate modules, up to 64 digital I/O, 40 analog inputs of 16 analog outputs can be accommodated on a single board. Powerful software is available to suit a range of applications and user experience levels. Complete data acquisition, waveform generation, analysis, display, storage and report generation are all easy to accomplish with Hypersignal-Workstation Software (PCI-20210S-1). For basic spectrum analysis our exclusive DSPview is menu-driven and ready-to-run. For other applications, complete programming tools are available. These include a comprehensive library of input/output, processing and analysis algorithms that are compatible with popular high-level languages including BASIC, C, TURBO PASCAL and FORTRAN. To program unique or special algorithms there are



Block Diagram of the *DATA PROFESSIONAL* Carrier.

facilities for generating optimized assembly language code. The Software Compatibility Table summarizes the available software support.

DSP or other multiply/accumulate intensive algorithms can greatly benefit from the Carrier's high-speed capabilities. As an example, here are representative execution speeds using the PCI-20202C-2 (80MHz) *Smart* Carrier:

FFT	64 point	1.3 mSec
	256 point	2.5 mSec
	1024 point	20 mSec
FIR Filter	(80 Taps)	8 μSec

The Carrier plugs directly into an expansion slot of any IBM compatible PC. Each Carrier can accept up to three plug-in modules. Two module locations are for input/output functions, while the third is for RAM expansion. The RAM modules from the PCI-20201M Series add 64K words of memory. The PCI-20201M-1 contains 55nS memory to run at 28MHz on the PCI- 20202C-1 Carrier. The PCI-20201M-2 contains 25nS memory to run at 40MHz on the PCI-20202C-2 Carrier. A family of 12 different I/O modules is now available to support a wide variety of real-world signals. Of particular interest are the analog input and output modules that provide up to 16-bit data conversions at rates up to 200kHz. Optional termination panels and ribbon cables are available to help facilitate external connections.

In addition to the many input/output modules and signal termination components outlined, other accessory products are offered to further enhance the utility of the PCI system. If desired, more than one PCI-20202C can be installed in the same computer. A functional block diagram of the PCI-20202C is shown above.

The cables coming from the I/O modules should be routed through the unused PC expansion slot. A PCI-20028A-3 strain-relief bracket can be used to support the I/O cables.

Comprehensive documentation is provided for both the *Smart* Carriers and the I/O modules, covering all aspects of installation, programming and calibration (I/O modules only). No calibration is ever required for the *Smart* Carrier. While complete hardware documentation permits the programmer to communicate at the register level (directly to the individual hardware functions), high-level programming support is also available, if desired. In addition, one of the major advantages of selecting a DSP product based upon the Texas Instruments TMS320C25 processor is the extensive array of available software.

The major building blocks of the *Smart* Carrier include:

— Digital Signal Processing Unit, TMS320C25

— High-speed data and program memory, with zero wait states

— Memory Up/Down Load circuitry

— Communications interface to the host PC

— DMA interface between the *Smart* Carrier and host PC

— High-speed serial I/O interface

— Analog/digital I/O module positions

— Rate generator, synchronization and interrupt system

The carrier itself includes 16K words of program memory, along with 16K words of data memory. While this is adequate for most applications, the optional expansion module increases the data memory to the full 64K words allowed by the TMS processor. At the same time, program memory is extended to 32K words. All memory is accessed with zero wait states. An up/down load feature allows the PC to read or write to this memory directly.

The *Smart* Carriers can use the entire memory of the PC for data storage through a high-speed DMA interface. This allows for uninterrupted data acquisition up to the limit of available RAM (16Mbyte in PC/AT and 1Mbyte in PC/XT computers). Data archiving applications requiring mass memory can also utilize floppy and hard disks. Data is then accessible for a wide range of post-process analysis and display operations.

Coordinated processing is enhanced by the internal, Intelligent Instrumentation Interface (I^3) Bus. This bus supports both analog and digital data flow between module positions, permitting synchronization and triggering of operations on selected events. Data transfers between the modules and the Digital Signal Processing Unit (DSPU) can be synchronized with interrupts, programmed I/O, and a hardware-implemented, wait-mode I/O which automatically synchronizes the processor to the incoming data by inserting wait cycles as needed.

The Rate Generator is very useful for establishing an accurate and dependable timebase for data acquisition. Two 16-bit, divide by N counters are used to scale the crystal clock frequency to a desired frequency. Clock rates in the range of 0.002Hz to 2MHz can be programmed.

While a full range of analog and digital I/O is supported by the PCI family of modules, provisions for other interfaces are also provided. A high-speed serial port gives the user access to the TMS processor. This can be useful when communicating with a codec, with a serial A/D, or with another *Smart* Carrier for multiprocessor applications. Also, an external trigger input is available for synchronization purposes. All necessary signals are available on a convenient connector. Both 8-bit and 16-bit communications are supported.

The functions of the TMS320C25 processor are controlled through 16 I/O ports on the Carrier. These ports also control any external, real world, input/output signals connected to optional I/O Modules. One or two standard PCI modules can be plugged into the available I^3 bus module positions. Any of the modules in the comprehensive PCI line can be used.

Included with every system is a menu-driven software package which automatically tests the key functions of the carrier.

An advanced communications channel connects the *Smart* Carrier's processing unit (DSPU) to the PC. This allows the DSPU and the host processor to perform independent tasks simultaneously, while providing an effective synchronization mechanism. Furthermore, background routines can be activated on both processors via interrupts. For example, this permits the PC to perform operations such as screen updates without interrupting the data collection process. New control parameters can be fed to the DSPU without disturbing the program currently running. The communications between the DSPU and the host PC are controlled by three registers:

— The Control and Status Register (CSR)

— The Interprocessor Communications Register (ICM)

— Load Program Address Register (LPA)

SPECIFICATIONS—PCI-20202C SERIES AND PCI-20201M SERIES

All specifications are typical at 25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Board Level		
Compatibility	IBM compatible computers	Burr-Brown VIPc and other PC/XT/AT/EISA machines
Functions		I/O and DSP
Addressing	I/O mapped, switchable	8 bytes
Physical Size	Carrier without modules	One slot
	Smart Carrier with modules	Two slots
Temperature Range	Board temperature	0 to 55°C
Power Requirements	From PC supply, +5V	
	Carrier and memory module	3 amps
	Including A_{in} and A_{out}	4.6 amps
DSP Processor	Texas Instruments	TMS320C25
Speed	PCI-20202C-1	
	Clock speed	28MHz
	Time/Instruction cycle	142nSec
	Instructions/second	7 million
	PCI-20202C-2	
	Clock speed	40MHz
	Time/Instruction cycle	100nSec
	Instructions/second	10 million
	Zero-wait-state memory	
	On-carrier, program space	16K words
	Data space	16K words
	Including expansion module	PCI-20202M-1 and PCI-20202M-2
	Program space	32K words
	Data space	64K words
Memory Expansion	In the host PC	Speed set by PC
External	RAM	All available RAM
	Disk	All available disk
DMA Speed	To/From host PC RAM	400Kbytes/second
Serial I/O Port	Buffered TMS320C25 port	
Speed	PCI-20202C-1	3.5Mbaud
	PCI-20202C-2	5Mbaud
External Inputs	Interrupt to TMS	TTL, deglitched
	Clock inputs	To any module

Software Support

The PCI-20202C Series *Smart* Carriers are supported by an extensive set of software products. These packages were designed specifically for these carriers to aid the user in the complete software development cycle. The wide range of tools provides significant capabilities for all application and user levels. Please refer to the software selection guide below. The types of products include:

— **Hypersignal-Workstation**, a comprehensive acquisition, playback, analysis, display and report generation package. No programming is required to use this completely menu-driven software. All hardware control and DSP analysis functions are built-in. The package is ideal for scientists, engineers, physicians and other researchers.

— **DSPview**, a menu-driven instrument package, requiring no programming. For basic spectrum analysis.

— **DSP Library Plus**, which permits extensive analog I/O and analysis while using only high-level programming languages.

— **Software Development Pak** for custom TMS code generation.

— Family of **Hardware Drivers** to greatly ease the custom development process. They provide the communcations between the host PC and the *Smart* Carrier.

SOFTWARE SELECTION GUIDE

IF YOU WANT TO DO:			SELECT:	
NO PROGRAMMING	HIGH-LEVEL PROGRAMMING	TMS320 PROGRAMMING	PRODUCT NAME	PCI NUMBER
	Use	Also Suggested	DSP Library Plus (Includes Drivers)	PCI-20203S Series
		Use	Software Development Pak	PCI-20204S-1
Use			DSPview, FFT Analysis	PCI-20205S-1
		Use	Drivers	PCI-20206S Series
		Use	Macro Assembler	PCI-20208S-1
Use			Hypersignal-Workstation	PCI-20210S-1
Post Analysis Only			DADiSP PC (H/W Control Not Included)	PCI-20067S-1

SOFTWARE COMPATIBILITY TABLE

(The PCI-20202C Series can be used with the following software in conjunction with the listed hardware.)

PCI MODEL NUMBER	NAME	MENU-DRIVEN	H/W DRIVER[2]	MODULES SUPPORTED[1]
PCI-20210S-1	Hypersignal-Workstation	Yes	Yes	PCI-20003M, 19M, 23M and 31M
PCI-20203S Series	DSP Library Plus Series	No	Yes	PCI-20002M, 3M, 6M, 19M, 23M and 202M
PCI-20204S-1	DSP Software Development Pkg.	No	Yes[3]	PCI-20003M, 4M, 6M, 7M, 17M, 19M 21M, 23M and 31M
PCI-20205S-1	DSPview	Yes	Yes	PCI-20019M and 23M
PCI-20206S Series	DSP Hardware Drivers Series	No	No	
PCI-20208S-1	Microsoft Macro Assembler	No	No	
PCI-20067S-1	DADiSP PC	Yes	No	

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-20203S DSP Library Plus).
(3) Drivers are supplied in the form of TMS Assembly source code.

HARDWARE COMPATIBILITY TABLE— MODULES

(The PCI-20202C Series can be used in conjunction with the following modules.)

PCI MODEL NUMBER	FUNCTION	NUMBER OF CHANNELS	RESOLUTION	SPEED	CABLE	TERMINATION PANELS	ENCLOSURE
PCI-20002M-1	Analog Input	16/8[2]	12-bit	32,000Hz	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20019M-1A	Analog Input	8	12-bit	89,000Hz	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20023M-1	Analog Input	8	12-bit	180,000Hz	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20341M-1	Analog Input	1/4[2]	16-bit	85,000Hz	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20031M-1	Analog Expansion	32/16[2]			PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20017M-1	Simultaneous S/H	4/4[2]			PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20020M-1	Trigger/Alarm	1			PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20003M-2	Analog Output, V	2	12-bit	80,000 pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20003M-4	Analog Output, V/I	2	12-bit	40,000 pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20006M-2	Analog Output, V	2	16-bit	80,000 pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20021M-1B	Analog Output, V	8	12-bit	2,000 pts/sec	PCI-20310A-1	PCI-20303T-1	PCI-20308H-1, PCI-20343A-1
PCI-20004M-1	Digital I/O	32			PCI-20311A-1	PCI-20305T-1	PCI-20308H-1, PCI-20343A-1
PCI-20007M-1	Counter/Timer	4			PCI-20311A-1	PCI-20305T-1	PCI-20308H-1, PCI-20343A-1
PCI-20201M-1/-2	Memory Expansion						

Notes: (1) Drivers are supplied in the form of TMS Assembly source codes.
(2) Single-ended/Differential

For additional information, please refer to the configuration charts in the Summary Section.

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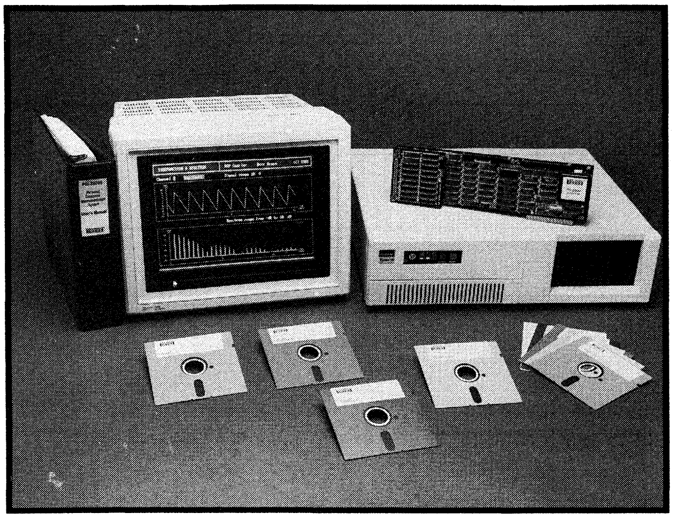


PCI-20203S Series

DSP Library Plus

High-Level Language Interface

FEATURES

- Supports:
  - — Analog Inputs and Outputs
  - — Vector Operations
  - — Trigonometric Functions
  - — Autocorrelation and Crosscorrelation
  - — Filtering
  - — Window Functions
  - — Fourier Transforms
  - — Interpolation and Decimation
- High-Level Language Interface for BASIC, C, TURBO PASCAL, and FORTRAN
- No TMS320 Assembly Language Programming Required

DESCRIPTION

DSP Library Plus is an extensive collection of subroutines for data acquisition and digital signal processing applications. Designed to run on the PCI-20202C Series *Smart* Carriers, this software offers unprecedented ease of use and speed of operation. DSP algorithms in this library will run from 20 to 200 times faster than conventional algorithms running on the PC alone.

The library consists of three major parts:

— TMS Assembly Code to operate the hardware

— A language-dependent Header File

— A high-level language interface

The first part is a program that resides within RAM on the *Smart* Carrier. This code (written in TMS320 assembly language) is executed directly by the TMS320C25 processor. It performs all of the signal processing computations at very high speed. Control of the analog input and output operations (A/D and D/A) is also performed at this level. TABLE 1 lists the input/output modules currently supported by the library. The second portion of the library consists of a software module that is included at the beginning of the application program. This code allows users to communicate with the system from the familiar environment of their favorite high-level language. Interfaces for BASIC, C, TURBO PASCAL, and FORTRAN are available. The third portion of the library resides within the host PC's RAM. It is this code that links the PC to the *Smart* Carrier. Running under the MS DOS operating system, this code insures compatibility for all IBM PCs and true compatibles. All data conversions and computations are invoked through standard subroutine calls. Communication between the application program and the memory-resident functions are through a user-defined interrupt dispatch vector. The code to read this vector is included within a supplied header file. There is no TMS assembly code to write, and a detailed understanding of the hardware is not required. Library calls can be concatenated to avoid intermediate data transfers between the *Smart* Carrier and the host PC. This minimizes overhead and optimizes the speed of applications requiring multiple operations. A diagram illustrating the functional structure of DSP Library Plus is shown in FIGURE 1. DSP Library Plus includes the drivers found in PCI-20206S. Additional drivers are not required. FIGURE 2 shows an example of high-level programming using DSP Library Plus.

DSP Library Plus can fit within 12KWords of the *Smart* Carrier's program memory. An additional version containing a very fast 256-point FFT routine, is also included and requires 29KWords of program memory. Memory expansion is available using the PCI-20201M Series Modules.

The DSP Library Plus structure enables the user to add his own application-specific subroutines to be executed by the *Smart* Carrier. Complete software development tools are available in the DSP Software Development Package (PCI-20204S-1).

TABLE 1. A SUMMARY OF PCI INPUT/OUTPUT MODULES SUPPORTED BY DSP LIBRARY PLUS

MODEL NUMBER	DESCRIPTION
PCI-20002M-1	Analog input, 12-bit resolution, single-ended/differential, programmable gain
PCI-20003M-2	Analog output, 12-bit resolution, 2 channels (V_{out})
PCI-20003M-4	Analog output, 12-bit resolution, 2 channels (V_{out} or I_{out})
PCI-20006M-2	Analog output, 16-bit resolution, 2 channels (V_{out})
PCI-20019M-1A	High-speed analog input, 12-bit resolution, single-ended
PCI-20023M-1	Very high-speed analog input, 12-bit resolution, single-ended

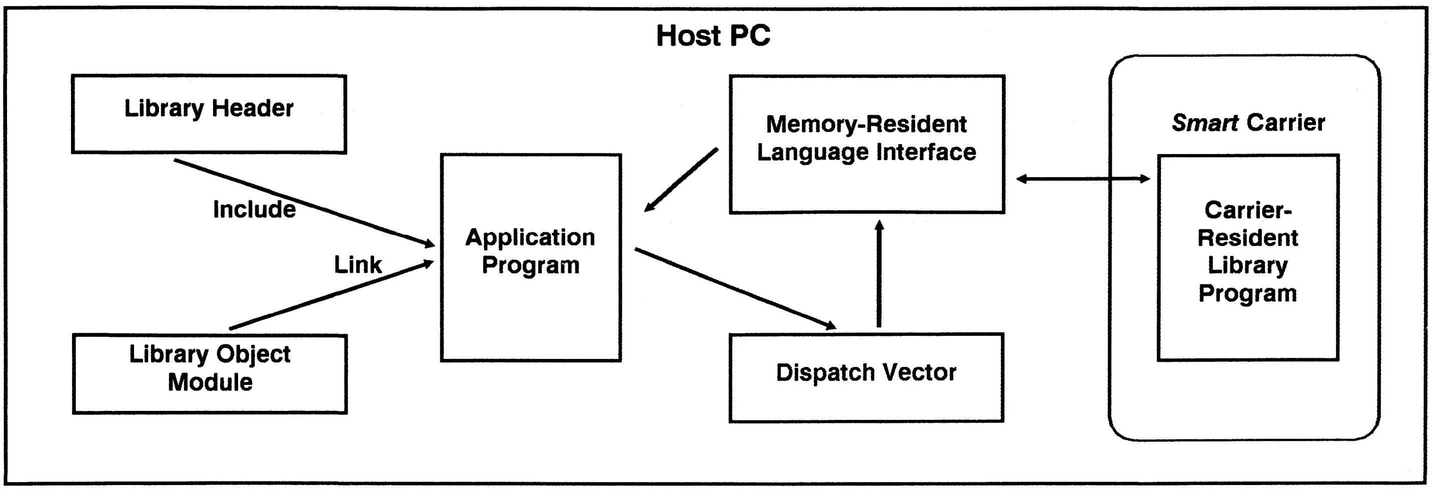


FIGURE 1. The Structure of DSP Library Plus.

TABLE 2. SUMMARY OF DSP LIBRARY PLUS FUNCTIONS

A/D and D/A Conversion Functions Supported:

DAOUT	Wait Mode D/A Conversion
STRTDA	Background D/A Conversion
ADIN	Wait Mode A/D Conversion
STRTAD	Background A/D Conversion

Data Transfer Functions Supported:

PCDMAW	Data Transfer to the *Smart* Carrier
PCDMAR	Data Transfer from the *Smart* Carrier

Vector Operations Supported:

VMOV	Vector Move
VABS	Vector Absolute Value
VSUM	Vector Sum
VADD	Vector Addition
VSUB	Vector Subtraction
VMUL	Vector Multiplication
VDIV	Vector Division
VMAX	Maximum of a Vector

Correlation Functions Supported:

ACFS	Autocorrelation Function
CCFS	Crosscorrelation Function

Weighting Functions Supported:

HAMW	Hamming Window
HANW	Hanning Window
BINW	Binary Window
TRIANG	Triangular Window

Trigonometric Functions Supported:

DSPSIN	Sine
DSPLIN	LOGe
DSPCOS	Cosine
DSPLOG	Log_{10}
DSPPWR	$Log(Re_2+Im_2)$
DSPMAG	$SQRT(Re_2+Im_2)$

Filter Functions Supported:

FIR	Linear-phase Filter Design Program
IIR	Recursive Filter Design Program
FIRLOD	Loads FIR Filter Coefficients into *Smart* Carrier
IIR_LOD	Loads IIR Filter Coefficients into *Smart* Carrier
FIRFIL	Filtering of Data Sequence with FIR Filter
IIRFIL	Filtering of Data Sequence with IIR Filter
RAVEG	Running Average

Fourier Transform Functions Supported:

FF64	Radix-2 FFT of 64 complex or 128 real values
FF128	Radix-2 FFT of 128 complex or 256 real values
FF256	Radix-2 FFT of 256 complex or 512 real values
FF512	Radix-2FFT of 512 complex or 1024 real values
FF1024	Radix-2 FFT of 1024 complex or 2048 real values
FF2048	Radix-2 FFT of 2048 complex or 4096 real values
FF4096	Radix-2 FFT of 4096 complex or 8192 real values

Interpolation and Decimation Functions Supported:

DOWN	Filtering and Down-sampling
IPOL	Filtering and Interpolation
ISPLIN	Spline-interpolation

```
{ ACQUIRE 1024 ANALOG DATA, COMPUTE THE LOGARITHMIC SPECTRUM
   AND TRANSFER THE DATA TO THE HOST}
{$I c:\dspusl\dspdr_tp.hdr }
{$I c:\dspusl\dsplb_tp.hdr }
VAR
   PSPec: array[0..511] of integer;
   TimeF: array[0..1023] of integer;
   Time, AcqLen: array [0..1] of integer;
   LunIt, Len, Ier, IMod, Dummy, Trig, I: Integer;
   Chan, Gain, ScanMode: Integer;
BEGIN
   LunIt:=0;
   {------------RESTART THE DSP CARRIER------------------}
   PCRES(LunIt)
   PCGO(LunIt);

   {SET THE A/D CONVERTER TO DESIRED VALUES--
     SAMPLING FREQUENCY: 10kHz, CHANNEL: 0,
     WITHOUT SCAN, GAIN:1}
   Time[1]:=0;
   Time[0]:=1000;
   Chan:=0;
   Gain:=1;
   ScanMode:=0;
   SETAD(LunIt, Time[0], Chan, Gain, ScanMode, Ier);
   if (Ier <> 0) then
     Writeln('error in SETAD:',Ier);

   {---ACQUIRE 1024 ANALOG DATA, NO TRIGGER,---}
   {DATA TO STAY IN DSP CARRIER LOCAL MEMORY
     AND TO BE TRANSFERRED TO HOST FOR
       PRINTOUT}
   AcqLen[1]:=0;
   AcqLen[0]:=1024;
   IMod:=1;
   Trig:=0;
   ADIN(LunIt, TimeF[0], Acqlen[0], IMod, Trig, 0, 0, Ier);

   {-----WEIGHT DATA WITH HANNING WINDOW-----}
   {DATA INPUT AND OUTPUT LOCAL TO CARRIER}
   Len:=1024;
   IMod:=2;
   HANW(LunIt, Dummy, Dummy, Len, IMod, Ier);

   {-----PERFORM AN FFT OF 1024 REAL VALUED DATA-----}
   {DATA INPUT AND OUTPUT LOCAL TO THE CARRIER}
   IMod:=2;
   FF512(LunIt, Dummy, Dummy, 1, 1, 1, IMod, Ier);

   {-CALCULATE THE LOGARITHMIC POWER SPECTRUM-}
   {SEND THE DATA BACK TO THE HOST}
   IMod:=1;
   DSPPWR(LunIt, Dummy, PSpec[0], Len, IMod, Ier);

   {-------------PRINT OUT THE POWER SPECTRUM--------------}
   Writeln ('Logarithmic Power Spectrum:');
   for I:=0 to 512 do
      Writeln ('Component',I,': ', PSpec[I]);
end.
```

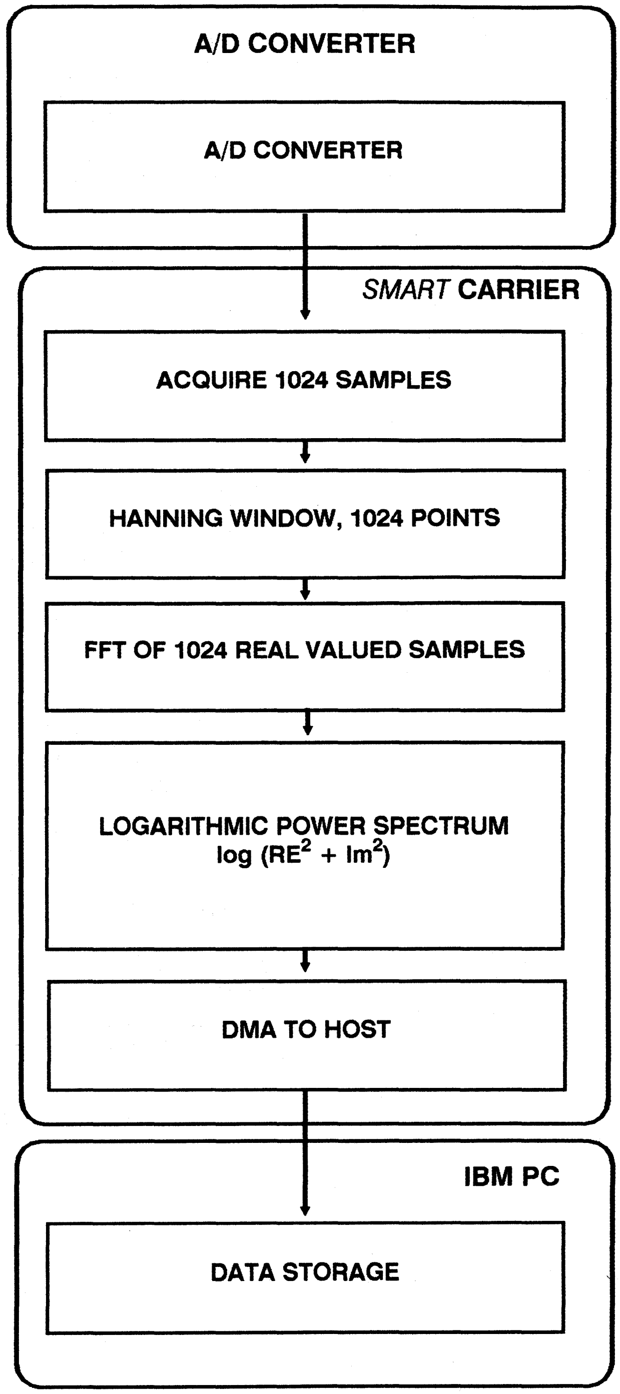
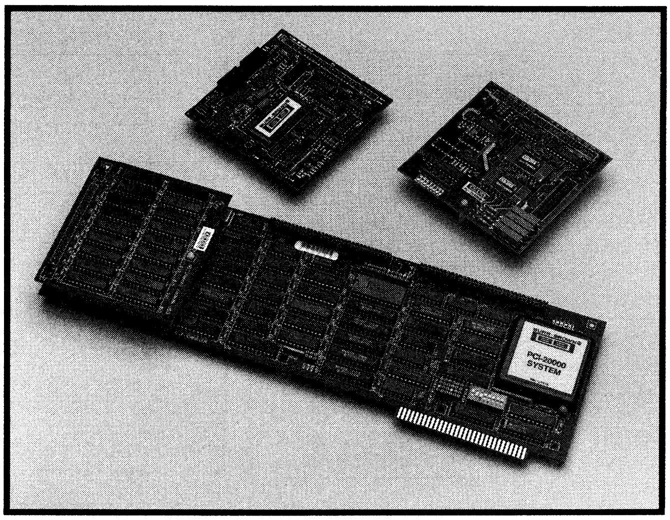


FIGURE 2. An Example of High-level Programming Using the *DSP Library Plus.*

SPECIFICATIONS— PCI-20203S SERIES SOFTWARE LIBRARIES

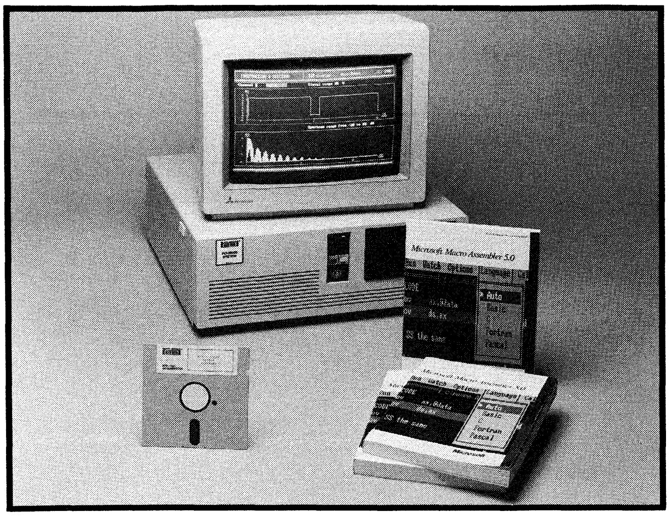
All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Language Interfaces	BASICA/GWBASIC/IBM Compiled BASIC	PCI-20203S-1
	Microsoft C	PCI-20203S-2
	Borland TURBO PASCAL	PCI-20203S-3
	Microsoft FORTRAN	PCI-20203S-4
	All Four Languages	PCI-20203S-5
Speed Benchmarks	PCI-20202C-2 (40MHz)	
Looped Algorithms	FFT of 64 Complex Values	1.3mS
	FFT of 128 Complex Values	2.3mS
	FFT of 256 Complex Values	4.6mS
	FFT of 512 Complex Values	9.4mS
	FFT of 1024 Complex Values	20mS
Straight Line Algorithm	FFT of 256 Complex Values (Requires Memory Expansion)	2.5mS
Memory Requirements	*Smart* Carrier program memory	
Complete Library	Including:	
	Looped FFT algorithms	12K words
	Straight line FFT algorithm	29K words



A PCI-20202C Series *Smart* Carrier with a Few of Many Possible I/O Module Options.

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20204S-1

DSP Software Development Package

FEATURES

- Compatible With The PCI-20202C Series *Smart* Carrier
- Supports TMS320 Program Generation, Test, and Optimization

APPLICATIONS

- Custom Algorithm Development and Evaluation
- Digital Filtering
- Data Acquisition and Control
- Vibration Analysis
- Audio Synthesis
- Pattern Recognition
- Process Control

DESCRIPTION

The PCI-20204S-1 DSP Software Development Package provides full program development capabilities for the industry-standard signal processor, the Texas Instruments TMS320C25. A Crossassembler, Disassembler, and Monitor/Debugger are provided. To further ease the software development process, the DSP Software Development Package is fully compatible with the PCI-20206S Series of DSP Carrier Drivers.

The crossassembler consists of a set of macro definitions for the Microsoft Macro Assembler (available separately from Burr-Brown as the PCI-20208S-1). The advantages of using this macro assembler are the full use of the extensive macro facility and use of the standard MS DOS linker to link modules that were assembled separately. The crossassembler can be used on all IBM PC compatible machines running under the MS DOS operating system. Programs for the *Smart* Carrier can be written with a standard text editor such as WordStar or WordPerfect. The recognized TMS320 mnemonic opcodes and the operand syntax conform with the definitions in the Texas Instruments TMS320C25 User's Guide. A utility is included to load the assembled and linked program into the Smart Carrier (PCI-20202C Series).

Once the code is written, assembled and linked into a TMS-executable file by the cross assembler, the Monitor/Debugger can be used to interactively test and debug it. All of the carrier's resources— including program memory, data memory, TMS processor registers, and carrier control registers— can be interactively displayed or modified.

The Monitor/Debugger includes facilities for loading the program onto the carrier, single-stepping, and setting or clearing of breakpoints. Up to 10 breakpoints can be set. Breakpoints can be activated immediately or after a preprogrammed number of occurrences.

A separate disassembler is also provided with the package. This program will disassemble code residing on the carrier. Output can be sent directly to the screen or to a file. In the screen option, two windows are provided. The user can select any section of the code to appear in either window.

Example and demonstration programs are included in the complete manuals to assist users.

A library of TMS Assembler programs are provided for a number of important input/output functions. These programs are documented in the user manual. The complete code is also provided on disk. A description of the routines is shown below.

Summary of Assembler and Disassembler Commands and Function

AORG	Absolute Origin Directive
.WORD	Define a Word in Program Memory
.dbas	Define Data Address
.TDATA	Assigns a name to the value of a data location counter
.debug	Invokes Debug option
DIS	Start Disassembling
QUIT	Return to DOS
START	Defines the Start Address of the code to be disassembled
END	Defines the End Address of the code to be disassembled
FILE	Name of the file where code is written to

Summary of Monitor/Debugger Commands and Functions

DPB	Dump Program Memory
DDM	Dump Data Memory
DIR	Display Internal Registers
DER	Display External Registers
MPM	Modify Program Memory
IPM	Initialize Program Memory
MDM	Modify Data Memory
CDM	Clear Data Memory
FDM	Fill Data Memory
MIR	Modify Internal Registers
MER	Modify External Registers
FDD	Find Value in Data RAM
FDP	Find Value in Program RAM
CEI	Clear External Interrupt
WPO	Write to Port
RPO	Read Port
SBP	Set Breakpoints
DBP	Display Breakpoints
CBP	Clear Breakpoints
EXE	Execute Program
RUN	Run Program
SST	Single Step
BSE	Number Base Selection
HLP	Help Information
END	End Monitor
STA	Start Program
SNP	Snapshot (execute breakpoints with set number of loops)

Summary of Included TMS Routines

PCI-20003M-2 and PCI-20003M-4 Routines

DAB3	Output a sample from a data buffer to a PCI-20003M-2 and PCI-20003M-4
DAM3	Output a sample from a memory location to a PCI-20003M-2 and PCI-20003M-4

PCI-20004M-1 Routines

CnfDio	Configure all four DIO ports on a PCI-20004M-1
RDCh0	Read a byte from DIO 0
RDCh1	Read a byte from DIO1
RDCh2	Read a byte from DIO 2
RDCh3	Read a byte from DIO 3
WDCh0	Write a byte to DIO 0
WDCh1	Write a byte to DIO 1
WDCh2	Write a byte to DIO 2
WDCh3	Write a byte to DIO 3

PCI-20006M-2 Routines

DAB6	Output a sample from a data buffer to a PCI-20006M-2
DAM6	Output a sample from a memory location to a PCI-20006M-2

PCI-20007M-1 Routines

RGInit	Program rate generator mode and frequency
RGEn	Enable the rate generator
RGDis	Disable the rate generator
SetCtr	Program mode and count of a counter
EnCtr	Enable a counter
DisCtr	Disable a counter
RdCtr	Read a counter

PCI-20017M-1 Routines

SSH19M	Acquire four samples into four memory locations using the PCI-20019M-1A
SSH19B	Acquire four samples into a memory buffer using the PCI-20019M-1A
SSH23M	Acquire four samples into four memory locations using the PCI-20023M-1
SSH23B	Acquire four samples into a memory buffer using the PCI-20023M-1
Hld17M	Put the PCI-20017M-1 into Hold Mode, and start a conversion
Sam17M	Put the PCI-20017M-1 into Sample Mode

PCI-20019M-1A Routines

ADB19	Acquire a sample from a PCI-20019M-1A into a buffer
ADM19	Acquire a sample from a PCI-20019M-1A into a memory location

PCI-20021M-1B Routines

SetFrame	Outputs a new frame number to the PCI-20021M-1B
IncFrame	Increments the PCI-20021M-1B frame number
Init21	Initialize the PCI-20021M-1B
Out210	Output a value to Channel 0
Out211	Output a value to Channel 1
Out212	Output a value to Channel 2
Out213	Output a value to Channel 3
Out214	Output a value to Channel 4
Out215	Output a value to Channel 5
Out216	Output a value to Channel 6
Out217	Output a value to Channel 7
Out21	Load a value into PCI-20021M-1B frame memory
Out821	Load values for 8 channels into PCI-20021M-1B frame memory

PCI-20023M-1 Routines

ADB23	Acquire a sample from a PCI-20023M-1 into a buffer
ADM23	Acquire a sample from a PCI-20023M-1 into a memory location

PCI-20031M-1 Routines

Init31	Initialize the PCI-20031M-1

Pacer Clock Routines

PacEn	Enable the Pacer Clock
PacDis	Disable the Pacer Clock
Pacer	Program the Pacer Frequency

ICM Communications Routines

GetCmd	Get a command from the ICM, decode and execute it
OutICM	Send a single value out to the ICM
InICM	Read a single value in from the ICM

DMA Communications Routines

DMAOUT	Output a value to the host using DMA

SPECIFICATIONS—PCI-20204S-1

PARAMETER	CONDITIONS	SPECIFICATION
Compatible Hardware *Smart* Carrier Memory Expansion Input/Output	Data acquisition and control TMS320C25 board Modules Modules	Burr-Brown PCI-20202C-1 and PCI-20202C-2 PCI-20201M-1 and PCI-20201M-2 All PCI
Computer Requirements Operating System	IBM PC compatible	Burr-Brown VIPc and PC/XT/AT/EISA compatibles MS/PC DOS
Software Function Crossassembler Disassembler Monitor/Debugger **Macro Assembler**	 Requires macro assembler Microsoft	 PCI-20204S-1 PCI-20208S-1
DSP Carrier Driver	Provides high-level control and communcation capability	PCI-20206S Series

PCI-20204S-1 Helps Produce Custom Algorithms for the *DATA PROFESSIONAL* Family of *Smart* Hardware..

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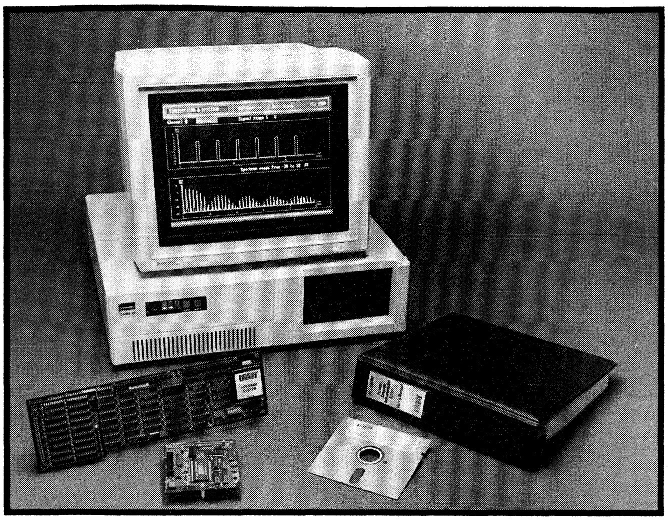


PCI-20205S-1

DSPview Analyzer Software

FEATURES

- Completely Menu-Driven
- Controls the A/D Conversion Process
- Performs FFT Spectral Analysis
- Displays Both the Time Signal and its Spectrum
- Displays the Power Spectrum in a Waterfall Format
- High-Resolution Graphics Display

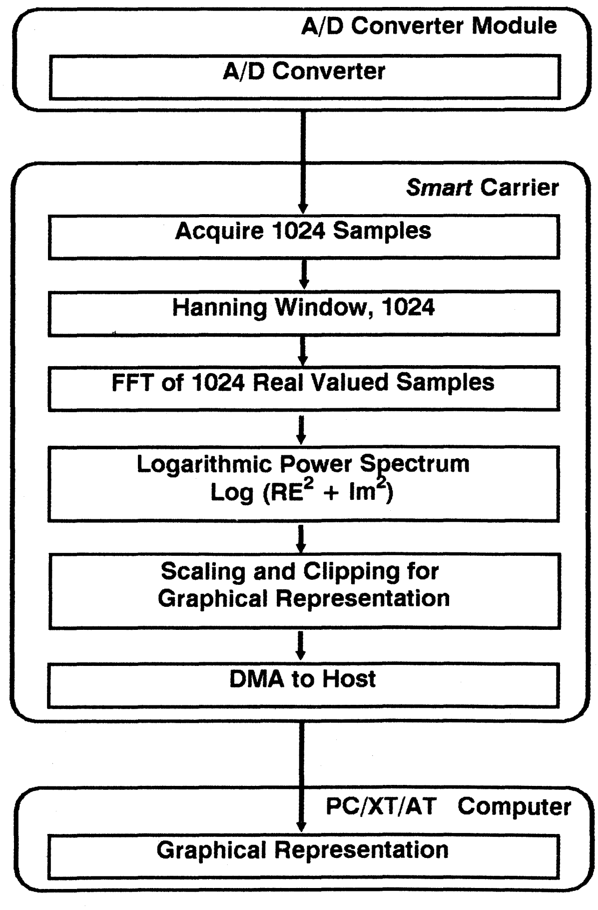
APPLICATIONS

- Perform Spectral Analysis in:
  - — Audio System Assessment
  - — Biomedical Signal Analysis
  - — Machine Health Monitoring
  - — Vibration Analysis
  - — Power Utility Load Evaluation
- Teaching and Experimentation in Schools, Laboratories, Industry
- Develop Familiarity With DSP Techniques

DESCRIPTION

DSPview is a signal analysis utility that demonstrates the capabilities of the *Smart* Carrier in data acquisition and spectrum analysis applications. Actual data collection is performed using the PCI-20202C Series *Smart* Carriers and any one of the available analog input modules (PCI-20002M-1, PCI-20019M-1 or PCI-20023M-1). Analog data are acquired in real time and passed through an FFT transformation. The input signal and the spectrum are displayed in several different forms, including waterfall diagrams. With DSPview, several measurement tasks can be carried out, including the measurement of harmonic distortion and resonance analysis. The digital signal processing portion of DSPview is built entirely from a subset of the routines found in the Burr-Brown DSP Library Plus (PCI-20203S Series).

A complete, descriptive, user manual is included with DSPview. The flow diagram below illustrates how DSPview implements the data collection, analysis and display functions.

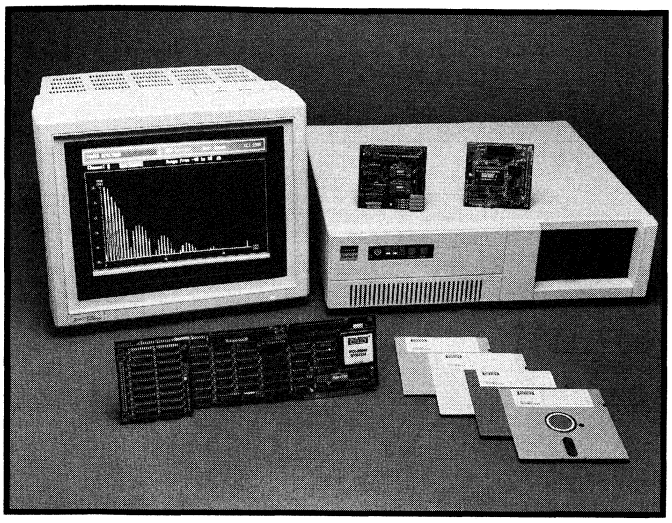


Flow Diagram of FFT Analysis.

SPECIFICATIONS— PCI-20205S-1

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Hardware Requirements	Burr-Brown	PCI System
Smart Carrier	Memory expansion not required	PCI-20202C-1 and PCI-20202C-2
Analog Input Module		PCI-20002M-1 or PCI-20019M-1A or PCI-20023M-1
Computer Requirements	Hard disk recommended	
Type	IBM PC compatible	Burr-Brown VIPc and other PC/XT/AT/EISA machines
Graphics Adapter		EGA
Monitor	User-selectable colors	Color or monochrome
Analog Inputs		
Active Channels	Select from channels 0-7	1
Acquisition Speed	Selectable	1kHz to 180kHz
Functions		All Menu-driven
FFT Analyzer	Set up A/D converter	
	Display time function	
	Display power spectrum	
	One-shot waterfall diagram	
	Running waterfall diagram	
Dynamic Range		72dB
Display	Time function	In volts
	Power spectrum	In dBs



BURR-BROWN®

PCI-20206S Series

DSP Carrier Drivers Software

FEATURES

- Compatible with the PCI-20202C Series *Smart* Carrier
- Provides a High-Level Language Interface to the Hardware from: BASIC, C, TURBO PASCAL and FORTRAN
- Supports all Control and Communications Functions, Including DMA

APPLICATIONS

- Development of Custom DSP Applications
  - — Digital Filtering
  - — Data Acquisition and Control
  - — Vibration Analysis
  - — Audio Synthesis
  - — Machine Health Monitoring
  - — Process Control

DESCRIPTION

The PCI-20206S Series of DSP Carrier Drivers give the user a simple and consistent method of communicating with the *Smart* Carrier from a high-level language program. These drivers are useful for those who have created their own TMS320C25 programs using the PCI-20204S Software Development Pak. They provide an easy method of loading programs onto the carrier, starting and stopping program execution, passing parameters to and from the Carrier's TMS program, and transferring data between the PC and the Carrier. The drivers act to minimize the need for a detailed knowledge of the *Smart* Carrier. This is accomplished by a family of mnemonic commands that translate the desired functions into the required hardware register statements. There are routines to handle almost every form of communications and control that is needed while using the *Smart* Carrier. Use of the drivers also reduces the chance of making errors in control or communications protocol. Several of the most popular high-level languages are supported, including BASIC, C, TURBO PASCAL and FORTRAN.

The drivers themselves are memory resident routines that are normally loaded when the computer boots up. The user's application program can call the necessary drivers as needed. Header files, which are provided for each language, serve to direct a given call statement to the appropriate memory address. Calls are made through a user-defined interrupt dispatch vector. This permits the use of multiple interface languages at the same time. In addition, several *Smart* Carriers can be installed in the same computer.

Example code is included in the complete User Manual. Comprehensive error flagging is incorporated and the error codes are generally self-explanatory.

Summary of Initialization Functions

PCINIT	Initialize a carrier unit
PC_OPT	Set system OPTIONS
PC_ERR	Find the last ERROR that occurred
PCRES	Put the carrier into the RESET mode
PCHOLD	Put the carrier into the HOLD mode
PCGO	Put the carrier into the RUN mode
PCBACK	READ an array from memory
LOADF	LOAD a program onto the carrier
PC_MEM	Check for the MEMORY expansion module
PCPACV	Get PACER clock values
PC_VEC	Set dispatch VECTOR
PCLOAD	WRITE an array to memory

Summary of DMA Routines

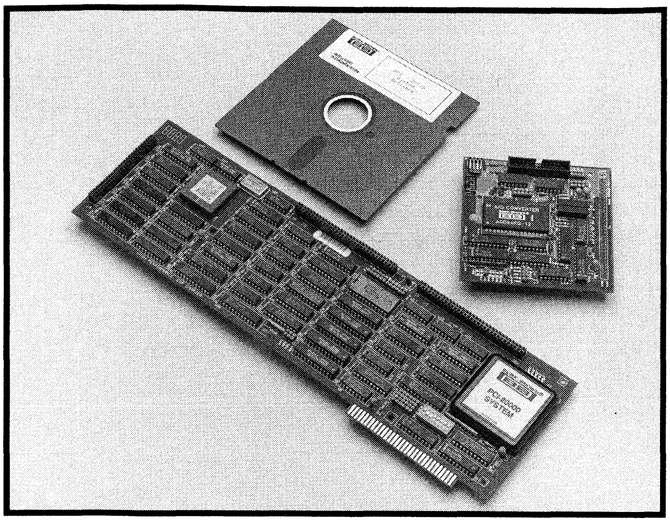
PCRDMA	Start wait-mode DMA, carrier to host
PCWDMA	Start wait-mode DMA, host to carrier
PMARGO	Start background DMA, carrier to host
DMAWGO	Start background DMA, host to carrier
DMACHK	Check status of background DMA
DMASTP	Stop background DMA in progress
DMACON	Setup host DMA controller chip
PASPAR	Do handshake required for DMA start

Summary of Communcation Functions

PCRDW	Wait/Read the word in the ICM register
PCRDWB	Wait/Read array from the ICM register
PCWRW	Wait/Write a word to the ICM register
PCWRWB	Wait/Write an array to the ICM register
ICMIN	Has the carrier written a word to the ICM register?
PCSOUT	Set STAT OUT bit in the CSR register
PCRDCS	READ the CSR register
PCWRCS	WRITE to the CSR register
PCRDIC	Immediate Read of the ICM register
ICMOUT	Is the ICM register available to be written to?
PCWRIC	Immediate Write to the ICM register
ISTAT	Test STAT IN from the carrier
PCWRLP	WRITE to the LPA register

SPECIFICATIONS— PCI-20206S SERIES

PARAMETER	CONDITIONS	SPECIFICATION
Language Interfaces	BASICA/GW BASIC/IBM Compiled BASIC Microsoft C Borland TURBO PASCAL Microsoft FORTRAN	PCI-20206S-1 PCI-20206S-2 PCI-20206S-3 PCI-20206S-4
Compatible Hardware *Smart* Carriers Memory Expansion	Data acquisition and control TMS320C25 board Modules	Burr-Brown PCI-20202C-1 and PCI-20202C-2 PCI-20201M-1 and PCI-20201M-2
Computer Requirements Operating System	IBM PC compatible	Burr-Brown VIPc and PC/XT/AT/EISA compatibles MS/PC DOS



BURR-BROWN®

PCI-20207K Series

Digital Signal Processing Systems for the PC Bus

FEATURES

- DSP Paks Include:
  - *Smart* Carrier
  - Analog Input Module
  - Menu-Driven Software
- Compatible With VIPc and Other PC/XT/AT Computers
- Multi-Channel, High-Speed Analog Input and Output Capabilities Via the PCI Family of I/O Modules

APPLICATIONS

- Fast Fourier Transforms
- Transient Analysis
- Biomedical Signal Analysis
- Spectral Analysis
- Vibration Analysis
- Digital Filtering
- Data Acquisition

DESCRIPTION

The PCI-20207K Series are high-performance Digital Signal Processing packages (DSP Paks). They contain the PCI-20202C Series *Smart* Carriers and selected PCI analog input modules. The PCI-20207K Series is summarized in the table below. DSP Paks are designed for the PC bus and are compatible with the Burr-Brown VIPc and other PC/XT/AT/EISA machines. With these products it is now possible, at low cost, to utilize real-time DSP techniques in a wide variety of applications. Optional termination panels and ribbon cables are available to help facilitate external connections.

The *Smart* Carrier is based upon the highly regarded Texas Instruments TMS320C25 processor. TMS320s are the most widely used, tested and supported processors available. By using this high-performance signal processor, data can be processed 20 to 200 times faster than using the PC alone.

PCI-20207K-1, PCI-20207K-2 and PCI-20207K-3 include DSPview. DSPview (PCI-20205S-1) is an FFT analyzer software package. It provides an introduction to typical applications and capabilities. Because it is menu-driven, DSPview brings a working demonstration of the system's key components to all users. Useful instruments include:

— Display of a time signal and its spectrum

— Display of a power spectrum in a one-shot waterfall format

— Display of a power spectrum in a running waterfall format

PCI-20207K-4 includes Hypersignal-Workstation Software (PCI-20210S-1). The extensive menu-driven facilities allow any scientist, engineer, physician, or other researcher the ability to acquire, display, modify, generate and output intricate signals (waveforms).

Comprehensive documentation is provided for both the *Smart* Carrier and the I/O modules covering all aspects of installation and programming. A special menu-driven software package automatically tests the key functions of the carrier.

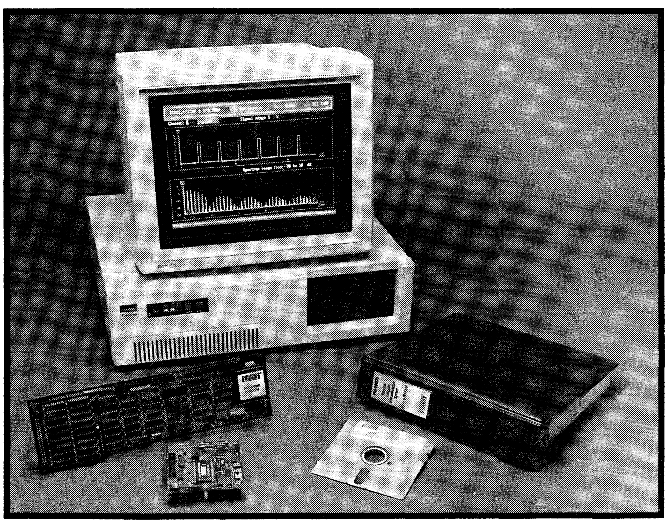
ThE PCI-20207K SERIES— DSP PAKS

DSP PAK	CARRIER	CLOCK RATE	ANALOG MODULE	MAX SAMPLE RATE	SOFTWARE INCLUDED
PCI-20207K-1	PCI-20202C-1	28MHz	PCI-20019M-1A	89kHz	PCI-20205S-1 DSPview
PCI-20207K-2	PCI-20202C-1	28MHz	PCI-20023M-1	150kHz	PCI-20205S-1 DSPview
PCI-20207K-3	PCI-20202C-2	40MHz	PCI-20023M-1	180kHz	PCI-20205S-1 DSPview
PCI-20207K-4	PCI-20202C-1	28MHz	PCI-20019M-1A	89kHz	PCI-20210S-1 Hypersignal-Workstation

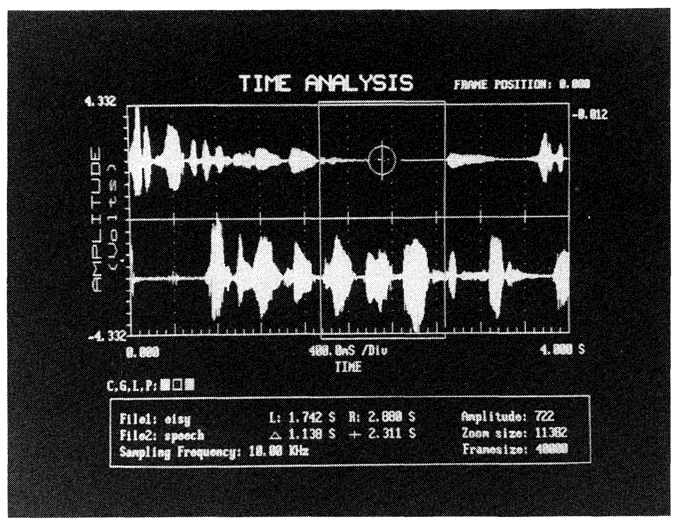
SPECIFICATIONS— PCI-20207K SERIES, DSP PAKS

All specifications are typical at 25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Board Level		
Compatibility	IBM PC compatible	Burr-Brown VIPc and other PC/XT/AT/EISA machines
Functions		I/O and digital signal processing
Addressing	I/O mapped, switchable	8 bytes
Physical Size	*Smart* Carrier with modules	Two slots
Temperature Range	Board temperature	0 to 55°C
Power Requirements	From PC supply, +5V	3.8 amps
DSP Processor	Texas Instruments	TMS320C25
Speed	PCI-20207K-1, PCI-20207K-2 and PCI-20207K-4	
	Clock speed	28MHz
	Time/Instruction cycle	142nSec
	Instructions/Second	7 million
	PCI-20207K-3	
	Clock speed	40MHz
	Time/Instruction cycle	100nSec
	Instructions/Second	10 million
Analog Inputs		
Number of Channels		8
Resolution		12-bit
Acquisition Speed	Using included software	
	PCI-20207K-1/PCI-20207K-4 (PCI-20019M-1)	Up to 89kHz
	PCI-20207K-2 (PCI-20023M-1)	Up to 150kHz
	PCI-20207K-3 (PCI-20023M-1)	Up to 180kHz

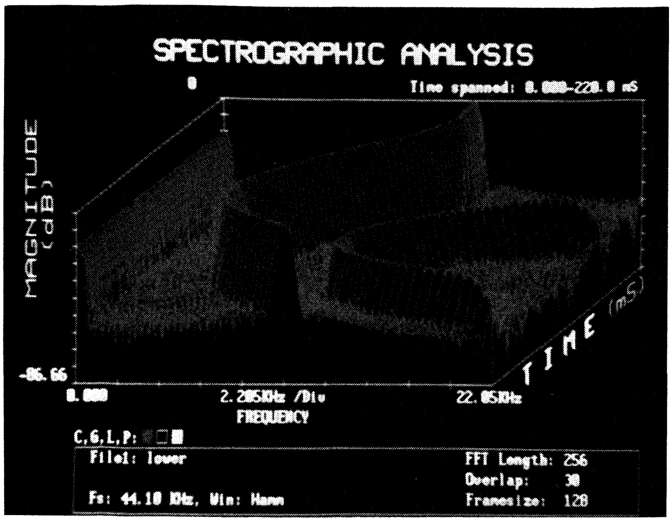


DSPview Software Provides Easy-to-use Spectrum Analysis Capabilities.



Hypersignal-Workstation Software Includes the Most Extensive DSP Capabilities.

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20210S-1 Software

Hypersignal-Workstation DSP Software

FEATURES

- Completely Menu-Driven, No Programming Required
- Continuous Acquisition and Playback: Sample Rates Up to 55kHz to Hard Disk, 89kHz to RAM Disk, Up to 32 Input Channels
- Continuous Playback (D/A Output) From Time and Frequency Domain Displays
- Difference Equations: Provide For Complete Math, Signal Arithmetic and Signal Manipulation Capabilities--Operates on Entire Waveforms--Can Generate Arbitrary Waveforms
- High-Speed FFT Processing (1024 Point, 50mS To Disk)
- Wide Range of Display Formats
  - — Dual-Channel Digital Oscilloscope
  - — Real-Time Spectrum Analyzer
  - — 2-D and 3-D Spectrographic
  - — Unwrapped Phase, Group Delay, Linear/Log and Pole-zero
- Convolution, Correlation and Autocorrelation
- Classical and Arbitrary FIR/IIR Filter Design
- Signal Editing--Cut and Paste Capability
- On-Line Context Dependent Help Facility
- Compatible With *DATA PROFESSIONAL* Analog I/O Hardware
- Publication Quality Output to Most Printers

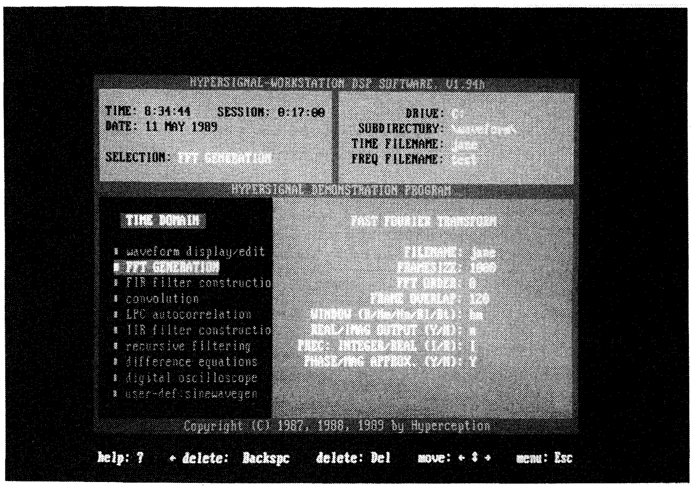
APPLICATIONS

- Data Acquisition
- Speech Analysis
- Spectral Analysis
- Fast Fourier Transforms
- Transient Analysis
- Digital Filtering
- Automotive Testing and Simulation
- Biomedical Signal Analysis
- Vibration Analysis
- Automatic Test Equipment
- Waveform Generation
- Communications Channel Evaluation

DESCRIPTION

Hypersignal-Workstation provides a new level of support for digital signal processing (DSP) applications. The extensive menu-driven facilities allow any scientist, engineer, physician, or other researcher the ability to acquire, analyze, display, modify, generate, and output intricate signals (waveforms). This software complements the growing family of low-cost *DATA PROFESSIONAL* data acquisition hardware for IBM compatible PCs. Control of all analog input and output hardware functions is fully integrated with the software's comprehensive signal manipulation and presentation capabilities. In addition, data files from other sources can also be imported for analysis and display purposes. Graphical tools are included to ensure fast and accurate results without resorting to complex computer programming. Time- and frequency-domain analysis is aided by sophisticated mathematical capabilities and filter design algorithms. Difference equation support offers unmatched flexibility in both analysis and signal generation. For all of its power, Hypersignal-Workstation is very easy to use. The logical and intuitive user interface is backed-up with a comprehensive, on-screen, context-sensitive help facility.

The *DATA PROFESSIONAL* hardware family is based upon a *Smart* Carrier (motherboard) that plugs directly into an available expansion slot in your PC. Two standard PCI input/output modules can be installed on the carrier to support the acquisition and output of fast analog signals. The Carrier supplies both the computer interface logic and the circuitry for FFT (and iFFT) execution acceleration. The system is designed for real-world applications and provides both high-speed and I/O configuration flexibility. Up to 32 inputs can be supported in complex monitoring and analysis situations with throughput rates up to 89kHz. The carrier's on-board TMS320C25 processor greatly reduces the time required to execute FFT functions. For example, the total time required to process 1024 points of data, including all disk I/O, is only 50 milliseconds. In addition to the carriers and modules listed in the Specification Table, a complete family of termination panels and cables is also available to facilitate interconnection and signal conditioning requirements. A DSP Pak (PCI-20207K-4) is offered that includes a *Smart* Carrier (PCI-20202C-1), a high-speed analog input module (PCI-20019M-1A), and the Hypersignal-Workstation Software (PCI-20210S-1).



Easy-to-use Menu-driven Operation

The user interface consists of a series of two-level, menu-driven screens. Major operations are organized into time-domain, frequency-domain, and utility categories. Together, they contain over 25 integrated functions. To simplify use, data flow between time- and frequency-domain files is automatic. The entering of waveform filenames is assisted by the display of pop-up directories. Further, the user environment which includes current files, display parameters, menu states, and data fields is saved between sessions, expediting operations.

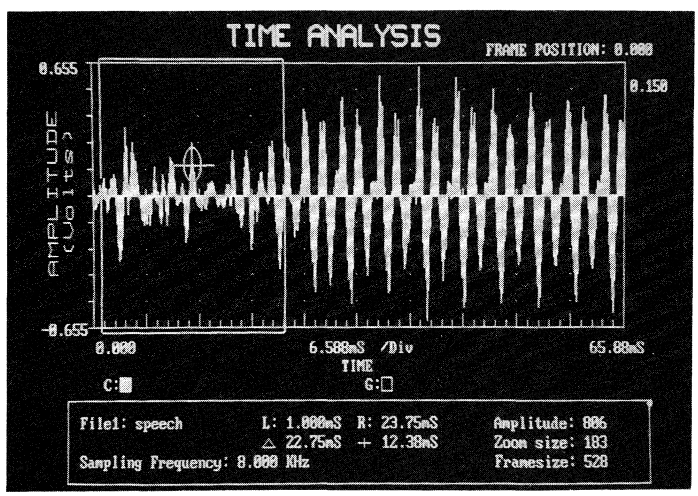
More than 100 graphics adaptors and monitor combinations are supported, including monochrome, CGA, EGA and VGA. Everything is provided for both time- and frequency-domain display. Input data can come from a disk (or RAM) file, or it can be read directly from the *DATA PROFESSIONAL* acquisition hardware. Time-domain modes include both general oscilloscope and detailed waveform analysis support. The digital oscilloscope has a dual-trace display and is useful for quickly identifying input signals. A freeze function permits screen print-outs and waveform capture to a disk file. The full-featured waveform mode offers: up to 32-channel acquisition; selectable trigger level; variable timebase; user-definable scaling; labels and units; editing; and selective playback to D/A output. Provisions for filtering, FFT, convolution, autocorrelation, and other mathematical transformations are included. The results of any waveform manipulations can be recorded, displayed, and played back upon command. The frequency domain features a real-time spectrum analyzer, 3-D spectrogram (waterfall with adjustable viewing angle), magnitude, phase/group delay, and pole/zero (for filters) displays. Of special interest is the 2-D spectrogram which presents frequency, time and amplitude in a single plane. Color is used to depict the third dimension (amplitude). This type of display finds wide application in speech analysis and includes zoom, pan, random-access, and selective D/A playback commands.

Any size waveform can be recorded, analyzed, displayed and played back (up to 536 Mega-samples). Very large data files are automatically adjusted for display purposes, while the integrity of the original data is preserved. It is a simple matter to pan through the data looking for a particular event. Detail can be seen by zooming in on a region of interest. Again, data content is automatically adjusted to maintain maximum resolution consistent with the span selected. Time/frequency and amplitude are digitally displayed and correspond to a crosshair position set by either cursor keys or a mouse. The time difference between two points is also available. All, or any segment of the data file, can be defined for playback through a PCI analog output module (PCI-20003M-2).

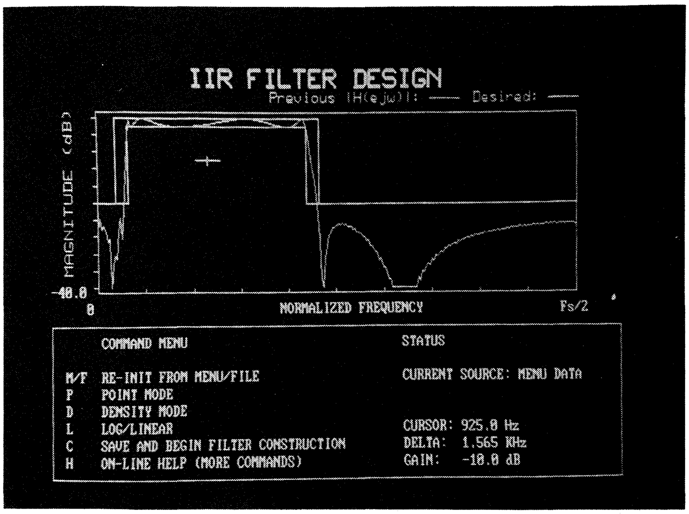
An extensive mathematics capability known as difference equations supports waveform analysis and generation. A free-form equation input format makes it easy to combine or modify waveforms. Signal arithmetic and transcendental functions, exponentiation, signal calculus and recursion are allowed. Standard DSP input notation is used throughout (i.e., U[n] for unit step, etc.). Output data files can be exported to other systems and software routines, or they can be fed through *DATA PROFESSIONAL* output hardware to directly generate test signals.

Digital filter design and subsequent waveform processing are an integral part of the menu structure. Both FIR (Kaiser window, differentiator, Hilbert transformer and arbitrary Parks-McClellan) and IIR (Classical and Steiglitz arbitrary) designs are supported. Low-pass, high-pass, and multi-band-pass designs are readily produced. The results of the design can be graphically compared to the input parameters. Filter coefficients are immediately available for processing. In addition, source code can be generated for transfer to other high-speed processors such as the TMS320C25 on the PCI-20202C Series Carriers. Analysis and display also encompasses pole/zero (S-plane and Z-plane) capabilities.

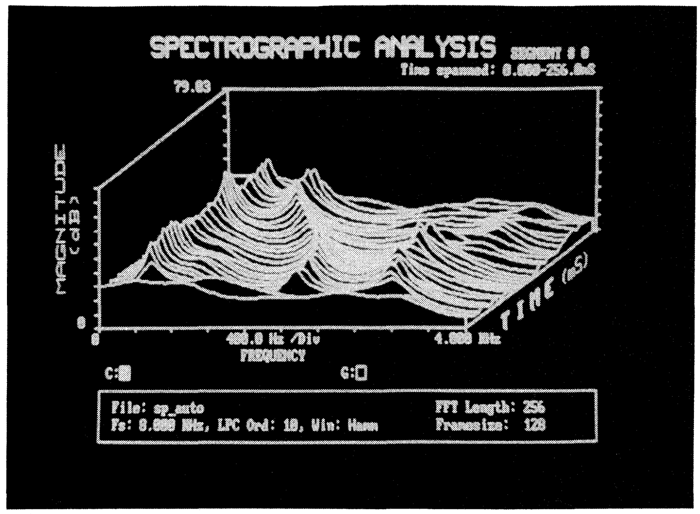
Hypersignal-Workstation and the *DATA PROFESSIONAL* hardware each come with a complete, illustrated user manual. A free demonstration disk is available that shows the major features of Hypersignal-Workstation. Please request PCI-20211S-1.



Example of Time Analysis



Example of IIR Filter Design Showing a Comparison



Example of Spectra Analysis

SPECIFICATIONS— HYPERSIGNAL-WORKSTATION PRODUCTS

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Computer Requirements	IBM PC compatible, DOS 2.0 or greater	Burr-Brown VIPc and other PC/XT/AT/EISA machines
	Minimum RAM	384Kbytes
	Disk drives	1.2Mbytes floppy and a hard disk
	Graphics card	Most mono, CGA, EGA, VGA
Supported I/O Hardware	Carriers	PCI-20202C-1 and PCI-20202C-2
	Input modules	PCI-20019M-1A and PCI-20023M-1
	Input multiplexer	PCI-20031M-1
	Output module	PCI-20003M-2
DSP Pak	PCI-20207K-4	
Included Hardware	Carrier	PCI-20202C-1
	Analog input module	PCI-20019M-1A
Included Software	Hypersignal-Workstation	PCI-20210S-1
Speed Benchmarks	*DATA PROFESSIONAL* Series	PC/AT, 80386 @ 25MHz
Complex FFT	1024 pt, written to disk	20 frames/second
Analog Inputs		
Number of Channels	PCI-20019M-1A, PCI-20023M-1	Up to 8
	with PCI-20031M-1	Up to 32
Acquisition Speed	To hard disk	Up to 55kHz
	To RAM disk	Up to 89kHz
Resolution		12-bit
Analog Outputs	PCI-20003M-2 module	
Number of Channels		1
Acquistion Speed		Up to 55kHz
Resolution		12-bit
Data Capacity	Waveform size, maximum	536 Mega-samples
	IIR Filter order, maximum	
	Bandpass/bandstop	40
	Lowpass/highpass	20
	FIR filter order, maximum	
	Kaiser window	2049
	Parks-McClellan	257
	Autocorrelation order, maximum	31
	FFT size, max	4096

DIRECT HARDWARE COMPATIBILITY TABLE

(Hypersignal-Workstation controls the I/O process)

PCI MODEL NUMBER	BUS COMPATIBILITY[1]	TYPE	DESCRIPTION	CHANNELS
PCI-20202C-1	PC	Carrier	*Smart* processor	
PCI-20202C-2	PC	Carrier	*Smart* processor	
PCI-20207K-4	PC	DSP Pak	Hardware/Software Combination	8 A_{in}
PCI-20019M-1A	I^3	Module	Analog input	8 A_{in}
PCI-20023M-1	I^3	Module	Analog input	8 A_{in}
PCI-20031M-1	I^3	Module	Channel expander	Adds 32 A_{in}
PCI-20003M-2	I^3	Module	Analog output	2 A_{out}

Notes: (1) I^3 Bus products are compatible with all PCI Carriers. They are also ideal as building block components in OEM applications. "PC" implies VIPc and other PC/XT/AT/EISA compatible computers.

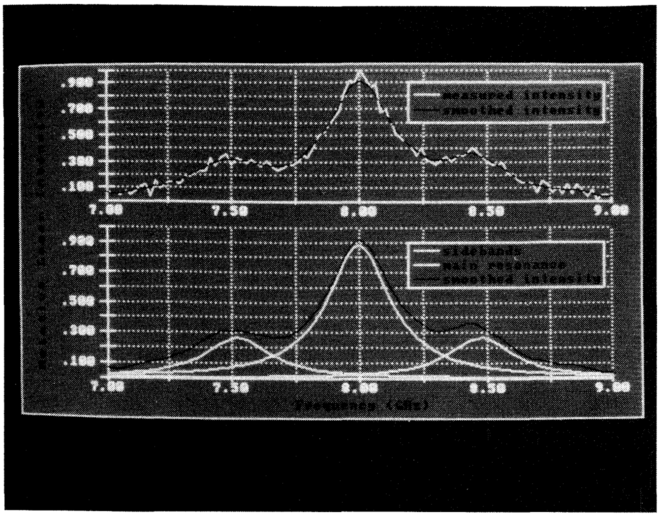
HARDWARE COMPATIBILITY TABLE— FOR POST-PROCESSING APPLICATIONS

(Hypersignal-Workstation does not control the I/O process)

PCI MODEL NUMBER	BUS COMPATIBILITY[1]	TYPE	DESCRIPTION	A/D RESOLUTION	CHANNELS[2]	SAMPLE RATE[3]
PCI-601W/PCI-602W	MCA	Board	Multifunction	12-bit	16/8	70kHz
PCI-20089W-1	PC	Board	Analog input	12-bit	16/8	32kHz
PCI-20091W-1	PC	Board	Analog input	12-bit	8/0	89kHz
PCI-20001C-2	PC	Carrier	General-purpose	Not applicable	Not applicable	Not applicable
PCI-20041C Series	PC	Carrier	High-performance	Not applicable	Not applicable	Not applicable
PCI-20098C-1	PC	Carrier	Multifunction	12-bit	16/8	32kHz
PCI-20002M-1	I^3	Module	Analog input	12-bit	16/8	13kHz
PCI-20341M-1	I^3	Module	Analog input	16-bit	1/4	89kHz

Notes: (1) I^3 Bus products are compatible with all PCI Carriers. They are also ideal as building block components in OEM applications. "PC" implies VIPc and other PC/XT/AT/EISA compatible computers. "MCA" stands for Micro Channel computers.
(2) Single-ended/differential.
(3) Maximum sample rate in a 12MHz PC/AT compatible computer.

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20301S Series

ASYST Language Interface

FEATURES

- Designed for Scientific Programming
- Supports Real-Time Data Collection and Analysis
- Interfaces with the PCI Hardware System
- High-Level Math, Analysis, & Transformation Calls
- High-Level Calls for Graphics Display
- Built-In Text and Array Editors

APPLICATIONS

- Data Acquisition and Monitoring
- Process and Experiment Control
- Automatic Test Equipment
- Spectrum and Signal Analysis
- Statistical Analysis
- Technical Report Generation

DESCRIPTION

ASYST is an integrated, high-level programming language intended primarily for scientific and engineering applications. The language is a close relative of FORTH, which was originally developed for astronomical and optical research. Many powerful instructions (words) have been added to the original product to increase programming efficiency and versatility. Individual words perform tasks that are the equivalent of whole programs in most other languages. Hundreds of these high-level commands are provided for functions such as FFT, curve fitting, matrix inversion, integration, ANOVA, automatic graphics plotting, etc. ASYST utilizes the computer's math coprocessor (8087/80287/80387) for enhanced speed performance. The popular "calculator-type" stack orientation and reverse Polish notation is employed. Stack operands can contain complete arrays. ASYST provides the PC programmer with power and speed usually associated with mini- and mainframe computers. For example, a 1024-point FFT takes about 2 seconds. This is comparable to minicomputers costing four times the price. Real-time data can be collected from laboratory instruments, sensors and transducers. ASYST interfaces to real-world signals through PCI hardware. This modular system includes analog input, analog output, digital I/O, and counter/timer (including frequency, pulsewidth, and period measurements) capabilities. Up to 80 analog input channels can be read with one board. The PCI products supported at this time are listed below. Complete specifications for all PCI carriers and modules can be found in this Handbook.

Data from any source can be processed and displayed, while outputs are generated to produce stimulus or feedback control signals. An on-line help system operates interactively to provide quick reference information. The "word guessing" feature suggests a list of possible words when an incorrect entry is made. Programs and data can utilize LIM expanded memory up to the 8Mbyte limit. Data inputs from the PCI System can be written direct-to-disk at rates up to 45kHz. For flexibility, the software is offered in three modules (volumes), each supporting unique capabilities. They include:

Module 1 -- System/Graphics/Statistics
Module 2 -- Advanced Analysis, PCI-20301S-1
Module 3 -- Data Acquisition Interface, PCI-20301S-3
Module 4 -- GPIB, IEEE-488 Support, PCI-20301S-5

Module 1. This volume contains the ASYST language shell. It provides basic programming capabilities, including: control structures (logic), graphics, arithmetic, standard statistics, array operations, and RS-232 support. Control structures can include: if..then...else; begin...until; begin...while...repeat; case...of...endcase; and do...loop. Comparisons can involve =, <, >, ≤, ≥, <>, not, and, or, and xor. Two full-screen editors are built into the system. One is for entering and modifying text, and the other is for manipulating arrays. Special routines are included for string conversions, input/output file manipulations, and gamma, bessel and error functions.

Data types encompass single- or double-precision real, integer, or complex values; strings; and named scalars or arrays. Automatic or user-controlled conversions are available when using mixed data types. *Arrays* may have up to 16 dimensions and may be as large as

64Kbytes each. Array functions support sub-arrays, reversal of indices, transposition of dimension, lesser dimension subsets, individual elements, catenation, lamination, auto-entry of array data, scrolling, format control of array data display, generalized inner and outer products, and matrix multiplication.

Standard *arithmetic* operations include +, -, *, /, **, min, max, neg, abs, inv, sqrt, ln, exp, conj, sin, cos, tan, sec, csc, cot, sinh, cosh, tanh, sech, csch, coth, asin, acos, atan, asec, acsc, acot, asinh, acosh, atanh, asech, acsch, and acoth. All operators work directly (without loops) on all elements of an array. Mixed expressions of arrays and scalars or arrays of different dimensions are permitted.

Statistical functions provide mean, variance, mode, median, moments, standard deviation, cumulative distributions, random number generation, as well as Gaussian, Chi-square, and Student-T distributions.

High-resolution *graphics* can be displayed on IBM-type EGA or Hercules monitors and can be output to several types of printers and plotters. High-level features support automatic line graphs, scatter plots, bar and pie charts, and plotting with error bars. Options include: color graphics; superposition of plots; multiple graphics windows; polar plots; autoscaling and data fitting; linear or logarithmic display along either axis; strip chart recorder emulation; and replotting data subsets with a single keystroke. On-screen graphic cursors, controlled by the arrow keys, are also included. FIGURES 1 and 2 suggest some of ASYST's graphics capabilities.

Module 2. Module 2 is an extension to the data reduction and analysis capabilities offered in Module 1. However, in all cases Module 1 and Module 2 must be used together. Major additions include: polynomial mathematics and evaluation; advanced graphics; vectors and matrices; solutions to simultaneous equations; eigenvalues and eigenvectors; curve fitting; non-linear regression; advanced statistics; and transforms.

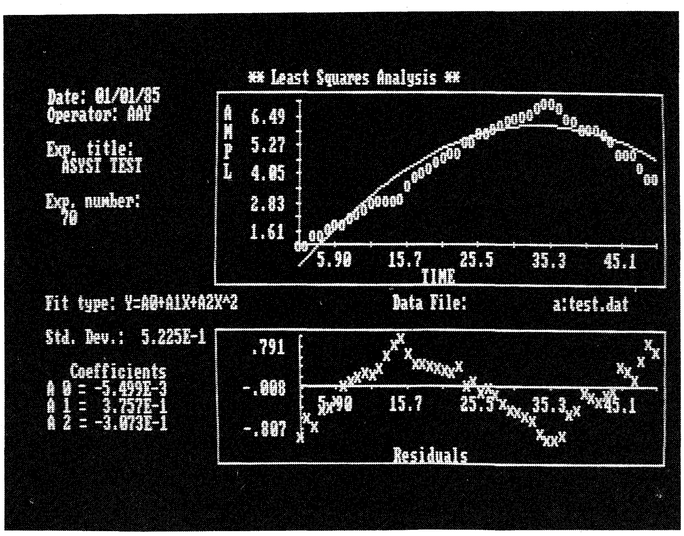


FIGURE 1.

Polynomial operations involve multiplication, synthetic division, integration, differentiation, shifting, and root extraction. Added to the *graphics* capabilities are axonometric and contour plots, as well as plotting with hidden lines removed. Treatment of *vectors and matrices* is broadened with matrix inversion, QR factorization, Gram-Schmidt orthogonalization, and determinants. Also included are functions for *ANOVA*, data smoothing, peak detection, integration, differentiation, *convolution, filtering*, least squares polynomial curve fitting, non-linear *curve fitting*, multiple regression, and several *FFT-related algorithms*.

Module 3. Module 3 is an extension to Modules 1 and 2. It furnishes a high-level software interface to the PCI-20000 hardware. The hardware, in turn, provides the actual input/output path to the real-world signals. A comprehensive group of words (calls) provides a clear and consistent bridge to the PCI system. As a result, a detailed knowledge of the hardware is not required to invoke extensive data collection, output, and control operations.

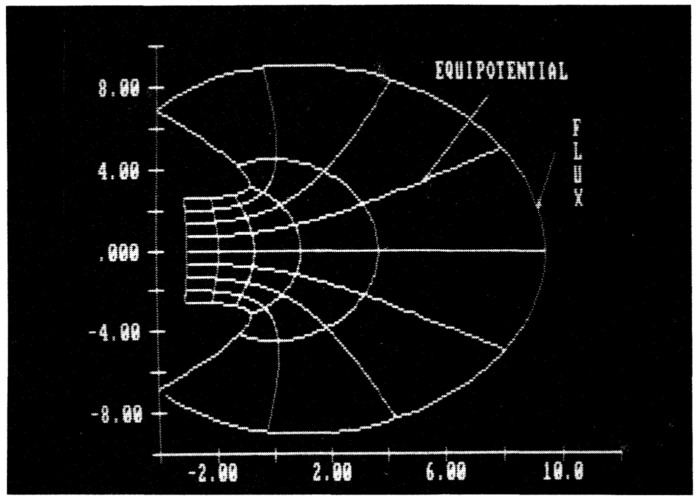


FIGURE 2.

PCI hardware accepts a wide range of signals, including voltage, current, resistance, on/off, and frequency. These can represent speed, distance, time, weight, strain, temperature, open/closed, motion, direction, pressure, flow, and pH, etc. Because each application is different, Burr-Brown offers many configuration options with its modular hardware system. The multifunction carrier supports the most widely used set of I/O types. Built into the carrier are analog input, digital I/O, and counter/timer/burst generator functions. Additional I/O types, channels, and features can be easily added by using the two plug-in module positions. Optional modules can provide both analog outputs, and analog input channel expansion. Those PCI hardware products currently supported by ASYST are summarized in the chart below.

Module 4. Module 4 is an extension to modules 1 and 2. It provides a high-level software interface to the standard GPIB, IEEE-488 communications bus. Complete support for the PCI-802W and PCI-804W are included. This capability extends ASYST to include data transfers to and from most laboratory instruments: digital multimeters, oscilloscopes, test chambers, signal generators, etc. Synchronous and asynchronous operations plus DMA acquisitions are supported. Up to 15 separate devices can be controlled by the host PC.

SUMMARY - ASYST is a high-level scientific programming language designed to give researchers and engineers an integrated data acquisition, analysis, and graphics output environment. Depending upon the application, the software modules can be used in various combinations. Modules 1 and 2 can be used together without Module 3 to provide general programming capabilities. While data acquisition is not included in these volumes, analysis can be conducted on internal (stored) data. Communications with the outside world is provided by Module 3. Module 3 links the ASYST programming language to the PCI-20000 hardware to facilitate input, output, and control. Module 4 is used with Modules 1 and 2 to provide an interface to standard IEEE-488 (GPIB) instruments.

PCI HARDWARE SUPPORTED BY ASYST

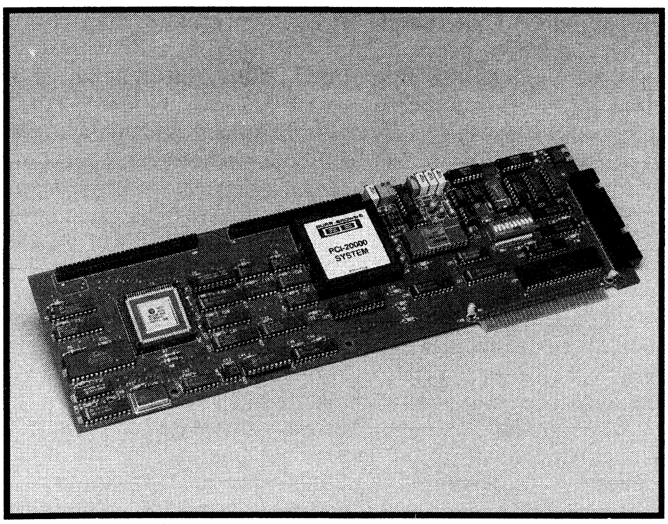
PRODUCT	TYPE	ANALOG INPUT[1]	ANALOG OUTPUT	DIGITAL I/O	RATE GENERATOR	NOTES
PCI-20098C-1	Multifunction Carrier	8/16 Ch	--	16 Ch	1	Single-ended/differential PGA=1, 10, 100; DMA
PCI-20003M-2	Analog Output Module	--	2 Ch	--	--	12-bit, ±10V
PCI-20003M-4	Analog Output Module	--	2 Ch	--	--	12-bit, ±10V or 4-20mA
PCI-20006M-2	Analog Output Module	--	2 Ch	--	--	16-bit, ±10V
PCI-20031M-1	Analog Expander Module	16/32 Ch	--	--	--	Up to 48 Ain Channels
PCI-802W **PCI-804W**	GPIB/PC Interface GPIB/ Interface Micro Channel					

Note: (1) Differential/Single-ended

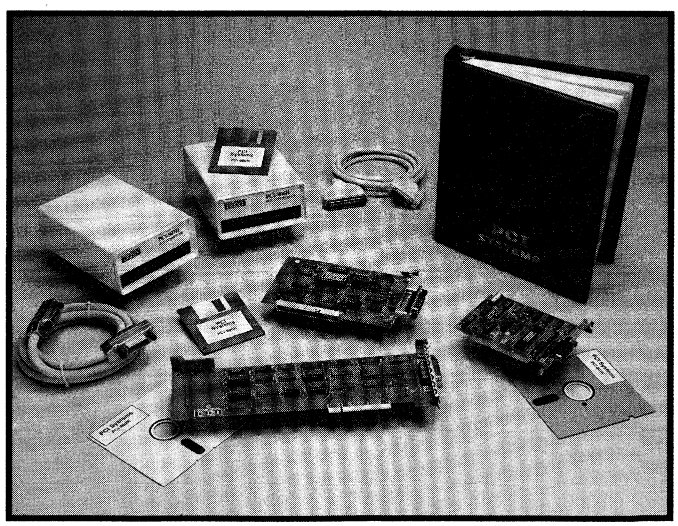
HOW TO ORDER ASYST

Most users of ASYST are interfacing to the PCI-20098C Multifunction Carrier. This requires Module 3 in addition to Modules 1 and 2. These three modules are available under one PCI part number. GPIB users can order Module 4 separately. Both the PCI-20098C-1 Multifunction Carrier (using Module 3) and the PCI-802W/PCI-804W GPIB Interface Boards (using Module 4) can be used at the same time. A demonstration disk is available that shows the major features of the ASYST language. Please request PCI-20328S-1 to receive a free copy.

PCI MODEL NUMBER	ASYST MODULES	DESCRIPTION
PCI-20301S-1	1 and 2	Language Support Shell
PCI-20301S-3	3	PCI-20000 Hardware Interface
PCI-20301S-4	1, 2 and 3	Combination Package
PCI-20301S-5	4	GPIB (IEEE-488) Hardware Interface

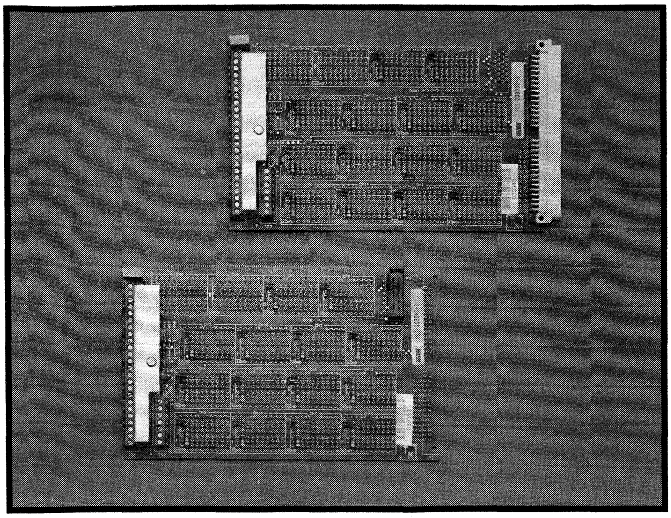


ASYST Software Has Built-in Calls to Control the PCI-20098C-1 Carrier and Several I/O Modules.



PCI-800 Series GPIB (IEEE-488) Interface Boards Are Available to Control External Instruments.

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20303T thru PCI-20307T

Euro-Style Termination Panels

FEATURES

- Euro-Style Design and Size
- High Channel Density (Channels/Unit Volume)
- Extensive, Signal Conditioning Capabilities
- Thermocouple, Cold-Junction Monitor Models
- Panels Can Be Used for Either Input or Output Signals
- Compatible With All PCI Systems

DESCRIPTION

Burr-Brown's Euro-Style Termination System complements the growing family of PCI data acquisition, test, measurement and control (DA&C) products. This group supports all of Burr-Brown's PC compatible I/O boards. The Euro Series consists of plug-in termination panels, a card cage, cables, and mounting accessories. Termination panels are available to mate with each PCI carrier, module and board, including the multifunction carriers (PCI-20098C-1 for the PC/XT/AT/EISA, the PCI-601W/602W for the PS/2, and the PCI-701C for the Mac II computer). While Burr-Brown's Euro products offer many new features, backward compatibility with existing carriers and modules is maintained. Improvements include enhanced signal conditioning capabilities, an increase in the number of channels per-unit-rack volume, and simplified installation and wiring connections. An individual, customizable, circuit board section is provided for each channel to accommodate the installation of components for signal conditioning purposes. These can include anti-alias filtering, voltage division, current-to-voltage conversion, surge protection, buffer/amplification, bridge completion, etc. However, on-board wiring is optional and is not always necessary. The panels are shipped from the factory with jumpers installed to route all external connections straight-through to the I/O boards. In general, each panel can support up to 16 channels. In differential input (analog) applications, a panel's input lines are employed in pairs, thus supporting up to 8 channels. Compression screw terminals are utilized to ensure reliable connections while protecting the field wires and making installation easy to accomplish. In addition to each pair of I/O terminals on the analog panels, an extra, programmable terminal is also provided. These can be individually jumpered to +V, ground or any other user-defined point. This feature is very useful in applications involving shields, external excitation, lead wire compensation, etc. Each digital I/O point has its own ground terminal. All panels also have separate terminal connections for an external power supply (+V) if needed.

The termination panels and card cage conform to the Euro-standard 3U size and are compatible with many existing components. The wide variety of panels makes them ideal for interfacing most analog and digital inputs/outputs signals. Provisions for thermocouples and for high-density connectors are included.

Burr-Brown's Euro components are suitable for end-user, OEM, VAR, and system integrator projects. They can be used in conjunction with PCI or other data collection and control products. There are a total of seven Euro-Style panels. Of these, four panels are optimized for analog applications, while the others are intended for digital functions. Two of the analog panels have high-density connectors (PCI-20304T-1, -2) for use with the multifunction carriers. These models can simultaneously accommodate both the analog inputs and outputs of the PCI-602W. The additional analog panels (PCI-20303T-1, -2) support the modules and boards of the PCI-20000 system. For thermocouple measurements the PCI-20303T-2 and PCI-20304T-2 panels include the necessary cold-junction compensation (CJC) circuitry. The CJC function is optionally activated with jumpers. When CJC is selected, one differential channel (Channel 0) is utilized for this purpose.

Digital applications involving conventional or high-density connectors are accommodated by the PCI-20305T-1 and PCI-20306T-1, respectively. When the PCI-20306T-1 is used with a multifunction carrier, the 16 terminals/signal conditioning spaces can be shared between digital I/O, handshaking, counter, burst generator, and external interrupt functions. To utilize all of these functions simultaneously, a special panel known as the PCI-20307T-1 can be used to add additional channels to the PCI-20306T-1. The PCI-20307T-1 includes a short umbilical cable which interconnects to the PCI-20306T-1 in an adjacent mounting slot.

The PCI-20308H-1 is a standard 3U-size card cage constructed from lightweight extruded aluminum. It is designed for installation in either a tabletop or 19-inch rack mount configuration. When not needed, the rack-mount ears can be detached. Termination panels are easily installed and removed. They slide along card guides that insure alignment with the mating connector at the rear of the cage. Depending upon the height of optional components that may be installed on the termination panels, up to 20 panels can fit into one card cage. This accommodates up to 320 channels in a single, 5.25 inch (13.3 cm) high, rack space. Panels are securely held in place by individual, finger operated, card locks. Included with the PCI-20308H-1 is hardware for five panels (5 pairs of card guides, 5 card locks, and 15 cable/connector mounting screws). Additional mounting hardware is available in the PCI-20309A-1 Termination Panel Mounting Kit. Each kit includes 5 pairs of card guides, 5 card locks, and 15 cable/connector mounting screws.

Signal connections between a given termination panel and an I/O port (on a carrier, module, or board) are accomplished with an easy to use ribbon cable. Twelve different cables are available for different functions and applications. Please see TABLE 1 for compatibility information. All cables are shielded to reduce noise pickup and radiation. The shield is connected only at the computer end to avoid ground loops. This end is clearly marked. In addition to using keyed connectors on both ends of the cables, a distinctive key is used on each type of panel/cable group to minimize the possibility of mixed assemblies (e.g., a digital panel connected to an analog cable). Lengths vary from 1.5 feet (46 cm) to 6.6 feet (2 M), depending upon the model number. See the Specification Table (TABLE 2) for more details.

TABLE 1. EURO-STYLE TERMINATION PANEL COMPATIBILITY TABLE

TERMINATION PANELS	TYPE	CABLE[1]	CARRIERS[1]	MODULES[1]	BOARDS[1]
PCI-20303T-1	Analog I/O	PCI-20310A	See Note (2)	PCI-20002M, PCI-20003M, PCI-20006M, PCI-20017M, PCI-20019M, PCI-20020M, PCI-20021M, PCI-20023M and PCI-20031M	PCI-20089W, PCI-20091W and PCI-20093W
PCI-20303T-2	Thermocouple[(3)]	PCI-20310A	See Note (2)	PCI-20002M and PCI-20031M	PCI-20089W
PCI-20304T-1	Analog I/O	PCI-20008A	PCI-20098C and PCI-701C		PCI-601W and PCI-602W
PCI-20304T-2	Thermocouple[(3)]	PCI-20008A	PCI-20098C and PCI-701C		PCI-601W and PCI-602W
PCI-20305T-1	Digital I/O	PCI-20311A	PCI-20001C-2A and PCI-20041C	PCI-20004M and PCI-20007M	PCI-20087W
PCI-20306T-1	Digital I/O	PCI-20009A	PCI-20098C and PCI-701C		PCI-601W and PCI-602W
PCI-20307T-1	Counter/Timer	Included	PCI-20098C and PCI-701C		PCI-601W and PCI-602W

Notes: (1) When part numbers are shown without "dash" numbers, all versions apply.
(2) The PCI-20303T-1 and PCI-20310A-1 can be used with any of the listed modules. (Modules are usually installed on a PCI Carrier. Any Carrier can be used.)
(3) Thermocouple panels include the required cold-junction compensation circuitry but can also be used for other analog applications.

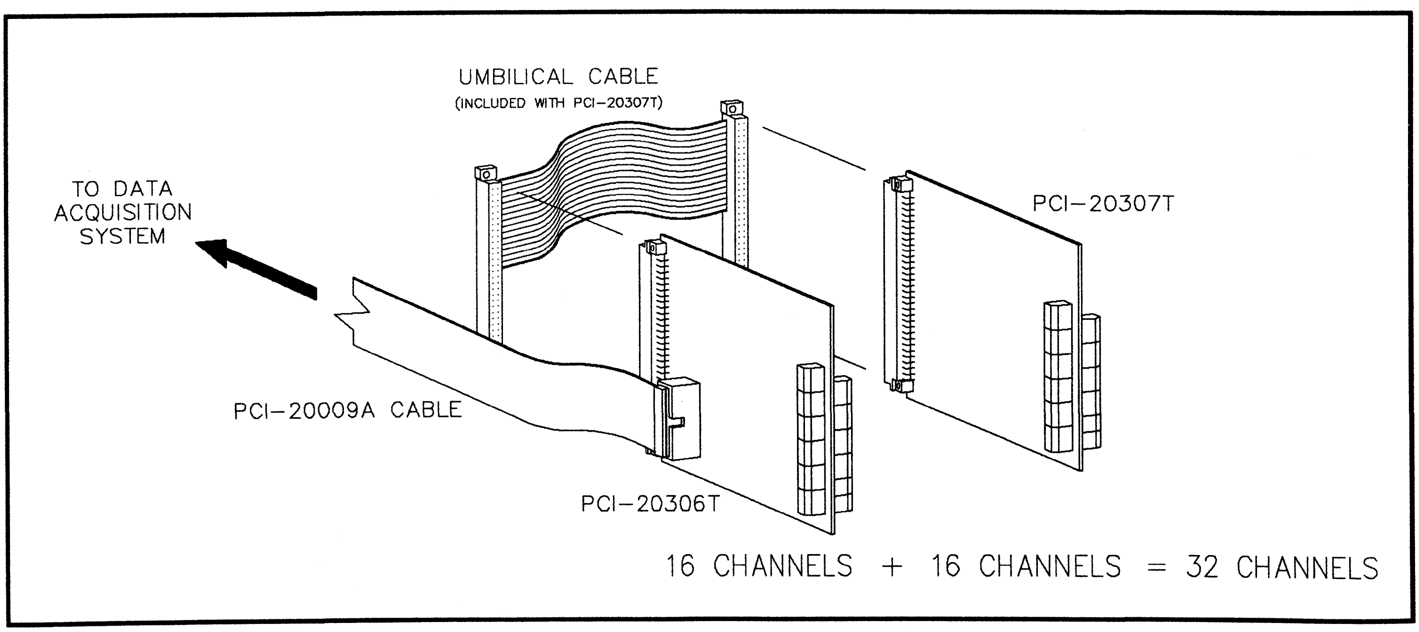
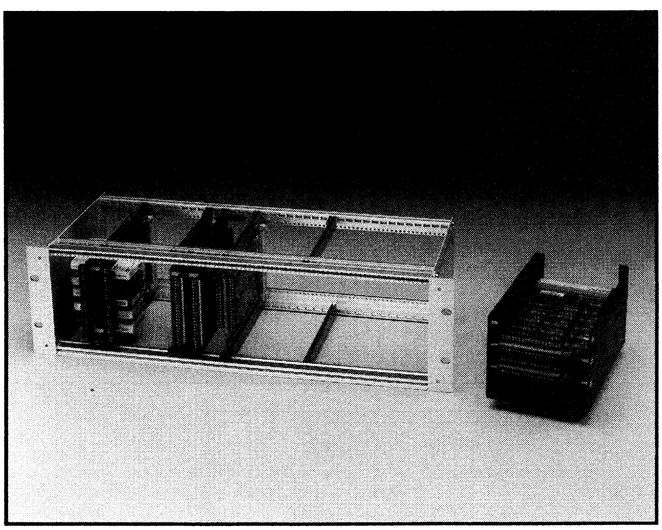


Diagram of PCI-20306T-1 and PCI-20307T-1 Interconnection

TABLE 2. SPECIFICATIONS—EURO-STYLE TERMINATION COMPONENTS

PARAMETER	CONDITIONS	SPECIFICATION
Panels		
Number of Channels[1]	PCI-20303T-1, Inputs	16 Single-ended/8 differential
	PCI-20303T-2, Thermocouples	7 Differential, 1 CJC
	PCI-20304T-1, Inputs	16 Single-ended/8 differential
	Outputs	2
	PCI-20304T-2, Thermocouples	7 Differential, 1 CJC
	Outputs	2
	PCI-20305T-1, DI/O	16
	PCI-20306T-1, DI/O	16
	PCI-20307T-1, Pulse signals	16 Expansion
Cold Junction Compensation	PCI-20303T-2 and PCI-20304T-2	1mV/°K, ±1°K
Temperature Range	Board	0-70°C
Size	Euro-standard	100mm x 160mm
Weight		75 grams
Mating Connectors	Mass termination type	Manufacturer's Part Number
PCI-20303T-1	64-pin	3553-0001[2]
PCI-20303T-2	64-pin	3553-0001[2]
PCI-20304T-1	26-pin high-density	845C026SALA00[3]
PCI-20304T-2	26-pin high-density	845C026SALA00[3]
PCI-20305T-1	64-pin	3553-001[2]
PCI-20306T-1	50-pin high-density	845C050SALA00[3]
PCI-20307T-1	64-pin	3553-0001[2]
Cables, Length	PCI-20008A-1	4 feet (1.2m)
	PCI-20008A-2[4]	1.5 feet (0.46m)
	PCI-20008A-3	3 feet (0.91m)
	PCI-20009A-1	4 feet (1.2m)
	PCI-20009A-2[4]	1.5 feet (0.46m)
	PCI-20009A-3	3 feet (0.91m)
	PCI-20310A-1	6.6 feet (2m)
	PCI-20310A-2[4]	1.5 feet (0.46m)
	PCI-20310A-3	3 feet (0.91m)
	PCI-20311A-1	6.6 feet (2m)
	PCI-20311A-2[4]	1.5 feet (0.46m)
	PCI-20311A-3	3 feet (0.91m)
Card Cage, PCI-20308H-1	Standard 3U Size	19-inch width
Size (without rack mount ears)	Length x Depth x Height	17.25" x 7.25" x 5.25" (43.8cm x 18.4cm x 13.3cm)
Weight		2.4 lb (1.1kg)

Notes: (1) The number of channels shown is the maximum available on the panel. The number of active channels may be further limited by the available channels on one connector of the attached carrier, module, or board.
(2) Manufactured by 3M Corporation.
(3) Manufactured by Amphenol Corporation
(4) 1.5 feet. (0.46m) cables are primarily intended for use with Burr-Brown VIPc Systems.



PCI-20308H-1 Card Cage and PCI-20343A-1 Tabletop Enclosure.

COMPATIBILITY TABLE— PCI-20303T-1, ANALOG I/O GENERAL PURPOSE

PCI MODEL NUMBER	TYPE	NUMBER OF CHANNELS	DESCRIPTION	MODULES[1]	BOARDS[1]
PCI-20310A-1	Cable	16/8[2]	2 meters, shielded	PCI-20002M, 3M, 6M, 17M, 19M, 20M, 21M, 23M, 31M and 341M	PCI-20089W, 91W and 93W
PCI-20310A-2	Cable	16/8[2]	1.5 feet, shielded	PCI-20002M, 3M, 6M, 17M, 19M, 20M, 21M, 23M, 31M and 341M	PCI-20089W, 91W and 93W
PCI-20310A-3	Cable	16/8[2]	3 feet, shielded	PCI-20002M, 3M, 6M, 17M, 19M, 20M, 21M, 23M, 31M and 341M	PCI-20089W, 91W and 93W
PCI-20308H-1 PCI-20343A-1	Enclosure Enclosure	Up to 48	19-inch rack/table-mount Tabletop		

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) Single-ended/Differential

COMPATIBILITY TABLE— PCI-20303T-2[2], THERMOCOUPLE

PCI MODEL NUMBER	TYPE	NUMBER OF CHANNELS	DESCRIPTION	MODULES[1]	BOARDS[1]
PCI-20310A-1	Cable	8	2 meters, shielded	PCI-20002M, 31M and 341M	PCI-20089W
PCI-20310A-2	Cable	8	1.5 feet, shielded	PCI-20002M, 31M and 341M	PCI-20089W
PCI-20310A-3	Cable	8	3 feet, shielded	PCI-20002M, 31M and 341M	PCI-20089W
PCI-20308H-1 PCI-20343A-1	Enclosure Enclosure	Up to 48	19-inch rack/table-mount Tabletop		

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) Thermocouple panels include the required cold-junction compensation circuitry but can also be used for other analog applications.

COMPATIBILITY TABLE— PCI-20304T-1, ANALOG I/O GENERAL PURPOSE

PCI MODEL NUMBER	TYPE	NUMBER OF CHANNELS	DESCRIPTION	CARRIERS[1]	BOARDS[1]
PCI-20008A-1	Cable	16/8[2]	4-foot, high-density, shielded	PCI-20098C and PCI-701C	PCI-601W and PCI-602W
PCI-20008A-2	Cable	16/8[2]	1.5-foot, high-density, shielded	PCI-20098C and PCI-701C	PCI-601W and PCI-602W
PCI-20008A-3	Cable	16/8[2]	3-foot, high-density, shielded	PCI-20098C and PCI-701C	PCI-601W and PCI-602W
PCI-20308H-1 PCI-20343A-1	Enclosure Enclosure	Up to 48	19-inch rack/table-mount Tabletop		

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) Single-ended/Differential

COMPATIBILITY TABLE—PCI-20304T-2[2], THERMOCOUPLE

PCI MODEL NUMBER	TYPE	NUMBER OF CHANNELS	DESCRIPTION	CARRIERS[1]	BOARDS[1]
PCI-20008A-1	Cable	8	4-foot, high-density, shielded	PCI-20098C and PCI-701C	PCI-601W and PCI-602W
PCI-20008A-2	Cable	8	1.5-foot, high-density, shielded	PCI-20098C and PCI-701C	PCI-601W and PCI-602W
PCI-20008A-3	Cable	8	3-foot, high-density, shielded	PCI-20098C and PCI-701C	PCI-601W and PCI-602W
PCI-20308H-1 PCI-20343A-1	Enclosure Enclosure	Up to 24	19-inch rack/table-mount Tabletop		

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) Thermocouple panels include the required cold-junction compensation circuitry but can also be used for other analog applications.

COMPATIBILITY TABLE— PCI-20305T-1, DIGITAL I/O GENERAL PURPOSE

PCI MODEL NUMBER	TYPE	NUMBER OF CHANNELS	DESCRIPTION	CARRIERS[1]	MODULES[1]	BOARDS[1]
PCI-20311A-1	Cable	16	2 meters, ground plane	PCI-20001C-2A, PCI-20041C	PCI-20004M, PCI-20007M	PCI-20087W
PCI-20311A-2	Cable	16	1.5-foot, shielded	PCI-20001C-2A, PCI-20041C	PCI-20004M, PCI-20007M	PCI-20087W
PCI-20311A-3	Cable	16	3-foot, shielded	PCI-20001C-2A,PCI-20041C	PCI-20004M, PCI-20007M	PCI-20087W
PCI-20308H-1	Enclosure		19-inch rack/table-mount			
PCI-20343A-1	Enclosure	Up to 48	Tabletop			

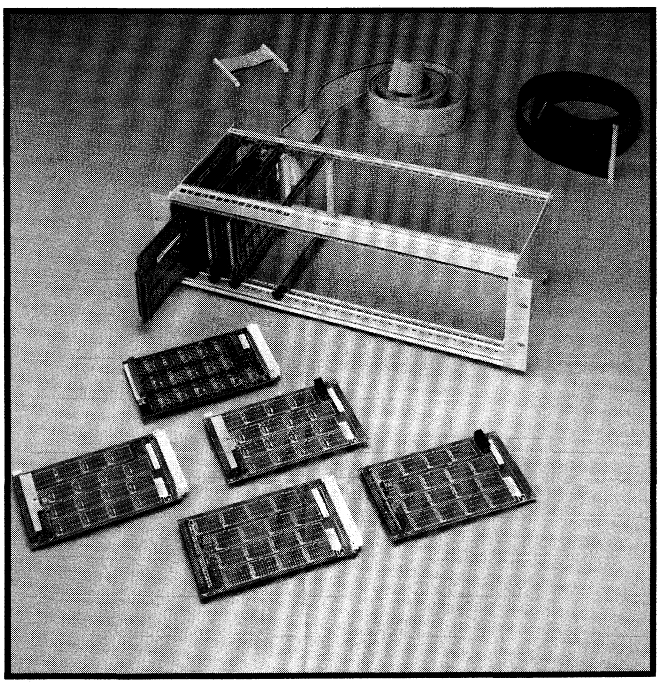
Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.

COMPATIBILITY TABLE— PCI-20306T-1, DIGITAL I/O GENERAL PURPOSE

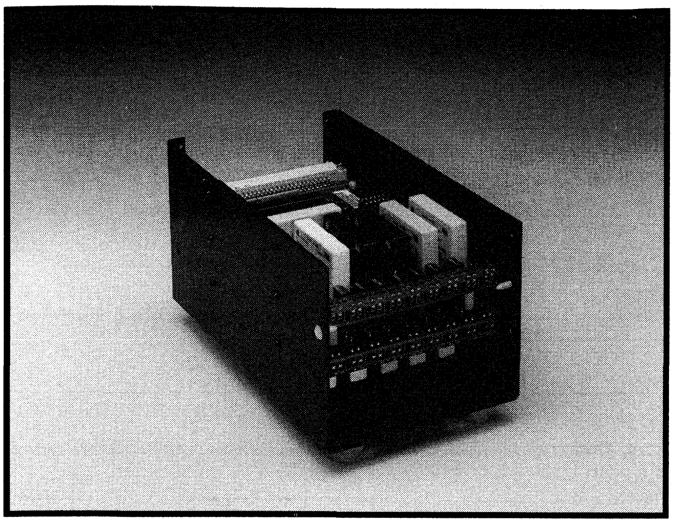
PCI MODEL NUMBER	TYPE	NUMBER OF CHANNELS	DESCRIPTION	CARRIERS[1]	BOARDS[1]
PCI-20009A-1	Cable	16	4-foot, high-density, shielded	PCI-20098C, PCI-701C	PCI-601W and PCI-602W
PCI-20009A-2	Cable	16	1.5-foot, high-density, shielded	PCI-20098C, PCI-701C	PCI-601W and PCI-602W
PCI-20009A-3	Cable	16	3-foot, high-density, shielded	PCI-20098C, PCI-701C	PCI-601W and PCI-602W
PCI-20307T-1	Expander	16	Adds other digital signals[2]		
PCI-20308H-1	Enclosure		19-inch rack/table-mount		
PCI-20343A-1	Enclosure	Up to 48	Tabletop		

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) The PCI-20307T-1 allows access to counters, rate generators and handshake lines, if available on the hardware.

For additional information, please refer to the configuration charts in the Summary Section.



A Complete Family of Euro-Style Termination Components Are Available.



BURR-BROWN®

PCI-20308H-1
PCI-20343A-1

Euro-Style Card Cages

FEATURES

- Popular Euro-Style Design
- Rack-Mount or Tabletop Use
- Holds Up To 20 3U-Size Panels.
- Lightweight Aluminum

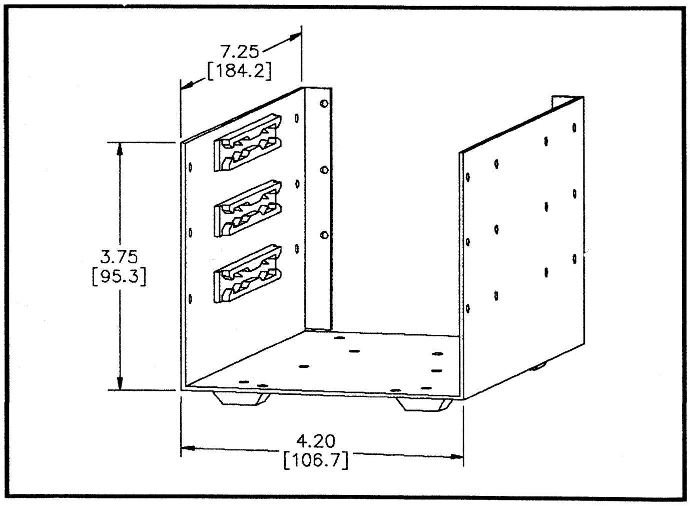
DESCRIPTION

PCI-20308H-1 is a Euro-Style card cage that accepts 3U-size boards. These include standard PCI termination panels and signal conditioners. Up to 20 panels can be accommodated in one cage, supporting as many as 320 I/O channels. The cage is constructed from lightweight anodized aluminum. It is designed for installation in either a tabletop or 19-inch, rack-mount configuration. Only 5.25 inches (13.4 cm) of rack height is required. Detachable brackets accommodate large bench-top applications. For applications requiring a few (1-3) termination panels, the PCI-20343A-1 is recommended. This enclosure is ideal for use in both tabletop and surface mount configurations.

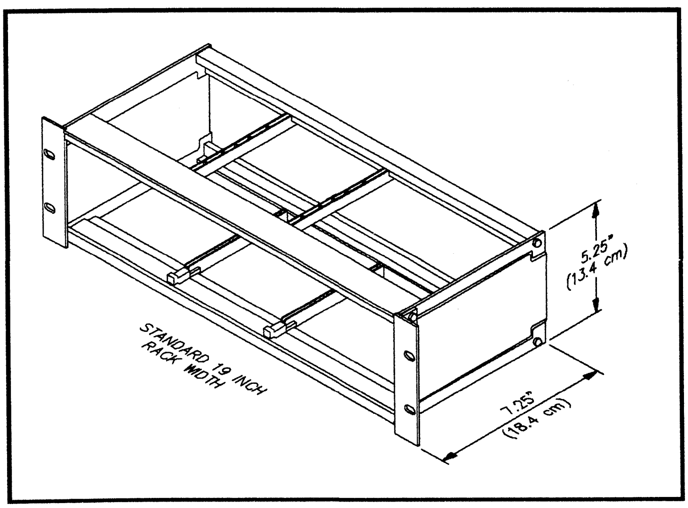
Panels are easily installed and removed. Each has individual card guides to ensure physical alignment with the mating connectors, which usually attach to the rear of the cage. Separate card locks are also included. The cage is shipped with 5 pairs of card guides, 5 card locks, and 15 cable/connector mounting screws. Additional mounting hardware for 5 more cards is available by ordering the PCI-20309A-1 Mounting Kit.

A total of 41 cm is available within the PCI-20308H-1 for mounting panels. Space requirements for a given termination panel are shown below. The figures given are for estimation purposes. The exact cage capacity depends upon the actual combination of panels installed.

A wide variety of panels and cables are available to satisfy all analog, digital, and counter/timer/generator applications. Each panel is designed to accept user-defined signal conditioning components. These can include voltage dividers, amplifiers, surge protectors, filters, relays, indicators, etc.



PCI-20343A-1 Enclosure for Up To 3 Termination Panels.



PCI-20308H-1 Card Cage for Up To 20 Termination Panels.

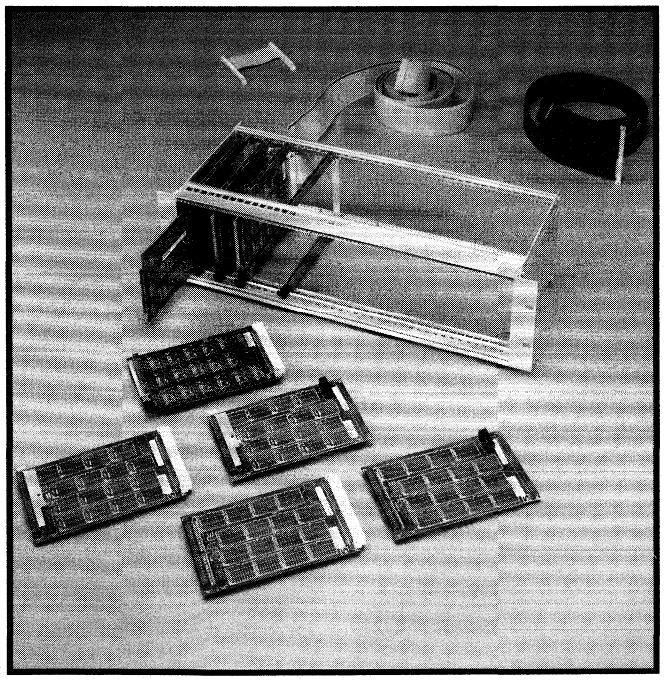
COMPATIBILITY TABLE

TERMINATION PANELS	FUNCTION	SPACE REQUIREMENT[1]	CABLE	CABLE MOUNTING
PCI-20303T-1	Analog I/O	2cm	PCI-20310A-1	See Note 2
PCI-20303T-2	Thermocouple	2cm	PCI-20310A-	See Note 2
PCI-20304T-1	Analog I/O	3cm	PCI-20008A-1	See Note 3
PCI-20304T-2	Thermocouple	3cm	PCI-20008A-1	See Note 3
PCI-20305T-1	Digital I/O	3cm	PCI-20311A-1	See Note 2
PCI-20306T-1	Digital I/O	3cm	PCI-20009A-1	See Note 3
PCI-20307T-1	Counter/Timer	3cm	Included	See Note 2
PCI-20324T-1	Opto-Isolated Digital I/O	4cm	PCI-20311A-1	See Note 2
PCI-20325T-1	Opto-Isolated Digital I/O	4cm	PCI-20009A-1	See Note 3
PCI-20324T-1 plus PCI-20326T-1	Opto-Isolated Digital I/O	7cm	PCI-20311A-1	See Note 2
PCI-20325T-1 plus PCI-20326T-1	Opto-Isolated Digital I/O	7cm	PCI-20009A-1	See Note 3

Notes: (1) A total of 41cm is available within the PCI-20308H-1. Space requirements for a given termination panel are provided for estimation purposes. Examples of the maximum number of panels (of a given type) which will fit within one rack as shown below:

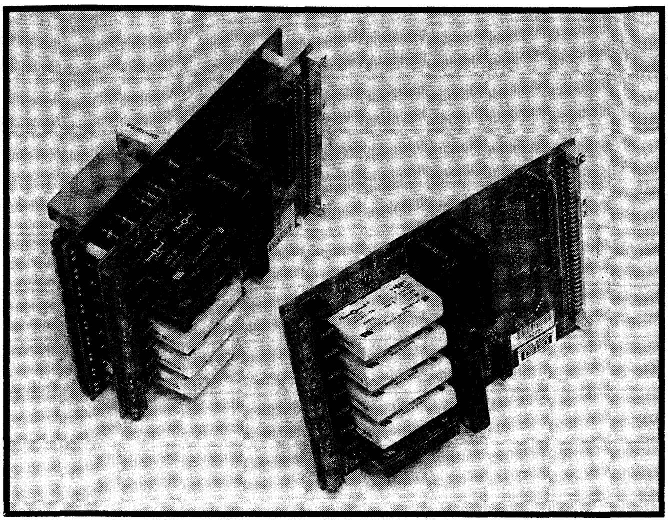
PCI-20303T-1 or PCI-20303T-2	20 units
PCI-20304T-1 or PCI-20304T-2	13 units
PCI-20324T-1	10 units
PCI-20325T-1 plus PCI-20326T-1	5 units

(2) These cable have a connector which can be screwed to the rear of the card cage. The termination panel plugs in to this connector.
(3) These cables plug into a connector on the surface of the termination panel. The connector does not attach to the card cage.



A Complete Family of Euro-Style Termination Components Are Available.

For additional information, please refer to the configuration charts in the Summary Section.



BURR-BROWN®

PCI-20324T-1 thru PCI-20326T-1

Euro-Style Optically Isolated Digital Termination System

FEATURES

- Euro-Style Design and Size
- Output Blocks Switch Up To 60VDC or 240VAC at 3A
- Provides Isolation and Power-Handling Capabilities
- Screw Terminals for Field Wiring Connections
- Panels Can Be Used for Either Input or Output Functions
- Input Opto-Isolator Blocks Convert Wide Range of Voltages to TTL Levels

DESCRIPTION

The PCI-20324/5/6 Series of termination panels and its companion PCI-1100 Series Opto-isolator blocks are an extension of Burr-Brown's Euro-Style Termination System. Like Burr-Brown's other Euro products, these digital termination panels are compatible with all PCI carrier, module, and board products. They provide enhanced signal conditioning capabilities, increase I/O channel capacity per unit-rack-volume by decreasing space requirements, and simplify installation.

The Optically Isolated Digital Termination System includes:

— PCI-20324T-1 and PCI-20325T-1 Termination Panels

— PCI-20326T-1 Termination Panel Expander

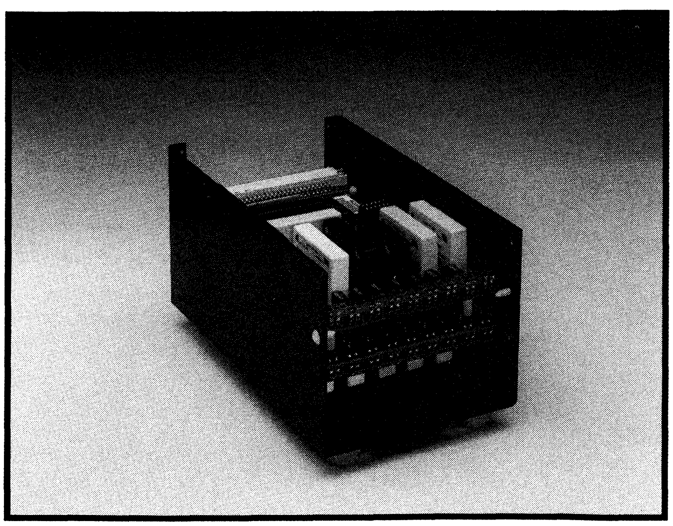
— PCI-1107 through -1112 Opto-Isolator I/O Modules

The PCI-20324T-1 Termination Panel supports up to 8 digital I/O channels; that number can be increased to 16 channels with the PCI-20326T-1 Termination Panel Expander, which is piggy-backed to the base panel via an inter-board connector. The PCI-20324T-1 can be used in conjunction with all products having standard 34-pin connectors (PCI-20001C-2A, PCI-20004M-1, PCI-20007M-1, PCI-20041C-2A, PCI-20041C-3A, and PCI-20087W-1).

The PCI-20325T-1 Termination Panel supports up to eight digital I/O channels for DA&C systems using the new high-density connector (multifunction products: PCI-20098C-1, PCI-601W, PCI-602W and PCI-701C). Its channel capacity can also be increased to 16 via the PCI-20326T-1 Expander.

Handshake, counter I/O, rate/burst generator, or external interrupt signals from multifunction carriers or boards can be accessed and isolated by using the PCI-20327A-1 Digital Transition Cable to connect an additional set of PCI-20324T-1 and PCI-20326T-1 Termination Panels to the PCI-20325T-1. If the handshake signals do not need to be isolated, the PCI-20307T-1 Digital Euro-Style Termination Panel Expander can be used as a bridge to the optically isolated panel(s). As FIGURE 1 suggests, a variety of isolated and partially isolated configurations are possible with the Euro-Style Optically Isolated Digital Termination System.

The PCI-1107/1112 Series opto-isolators sense voltage levels and control load switching. The slim-line modules, which are meant to be used with the Euro-Style Termination System, plug directly into the panels (one per channel) and are available in six versions to satisfy a variety of application requirements.



PCI-20343A with PCI-20324T and PCI-20326T Installed.

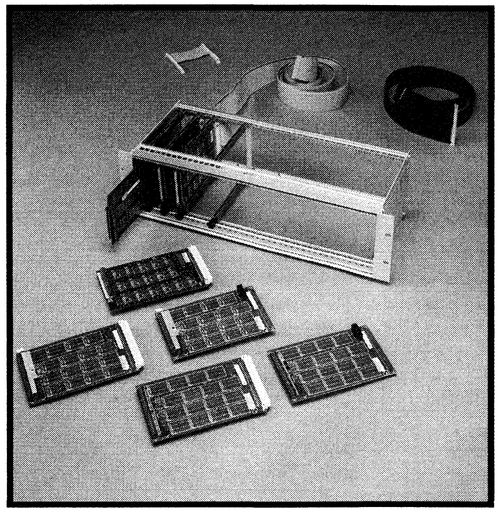
The PCI-1107, PCI-1108, and PCI-1111 input blocks accept both AC and DC voltages and provide a TTL output to drive a standard PCI digital input. Outputs can be switched by the PCI-1109, PCI-1110, and PCI-1112 modules, which convert TTL outputs from the PCI system to switch higher voltage (and current) loads. The DC-output module (PCI-1109) presents an open collector NPN transistor to the load. The AC output modules contain zero-crossing circuitry and switch their loads with triacs. Remember that the digital I/O on all PCI products is programmable (as either inputs or outputs) in byte-size groups. Therefore, care must be taken to configure each panel with either input *or* output blocks (not both).

Field connections are made to the panel via screw-terminal blocks. Normally, +5V is supplied by the PCI board, carrier, or module to power the opto modules. Up to 250mA is available for this function. When more power is required, a separate terminal block is available for the connection of an external power supply.

The termination panels and expander conform to the Euro-standard 3U-size and can be mounted in the PCI-20308H-1 Euro-Style Card Cage, the VIPc Embedded Computer Platform, or the PCI-20343A-1 Tabletop Enclosure. The PCI-20308H-1 card cage can be installed in tabletop or 19-inch, rack-mount configurations. Termination panels slide into card guides that insure alignment with the mating connector at the rear of the cage.

Connection between a termination panel and an I/O port on a board, carrier, or module is made by a special ground-plane ribbon cable. The PCI-20311A-1 cable connects the PCI-20324T-1 Termination Panel to compatible PCI carriers, boards, and modules with standard 34-pin connectors. The PCI-20009A high-density cable connects the PCI-20325T-1 Termination Panel to the multifunction carriers and boards. See the individual PCI-20324T-1 and PCI-20325T-1 compatibility tables for cable specifications.

Note that the rear connector on the PCI-20325T-1 is used for channel expansion *beyond* 16 channels. In these applications, connections are made to either the PCI-20307T-1 (non-isolated) or the PCI-20324T-1 (isolated) panels. The PCI-20307T-1 comes with the necessary umbilical cable. The connection to the PCI-20324T-1 requires the PCI-20327A-1 transition cable, which can be ordered separately.



A Complete Family of Euro-Style Termination Components Are Available.

SPECIFICATIONS— EURO-STYLE OPTICALLY ISOLATED DIGITAL SYSTEM COMPONENTS

PARAMETER	CONDITIONS	SPECIFICATION
Panels		
Number of Channels	PCI-20324T-1, DI/O	8
	PCI-20325T-1, DI/O	8
	PCI-20326T-1, DI/O	8 Expansion
Temperature Range	Board	0-70°C
Size	Euro-standard	100mm x 160mm
Width	Termination panel (opto-isolators installed)	4.0 cm
	2 Termination panels (opto-isolators installed)	7.2 cm
Weight		82 grams
Cables, Length	PCI-20009A-1B	4 feet (1.2m)
	PCI-20311A-1	6.6 feet (2m)

EURO-STYLE OPTICALLY ISOLATED TERMINATION PANEL COMPATIBILITY

TERMINATION PANELS	TYPE	CABLE[1]	CARRIERS	MODULES	BOARDS
PCI-20324T-1	Digital I/O	PCI-20311A	PCI-20001C-2A PCI-20041C-2A, PCI-20041C-3A	PCI-20004M-1 PCI-20007M-1	PCI-20087W-1
PCI-20325T-1	Digital I/O	PCI-20009A	PCI-20098C-1 and PCI-701C		PCI-601W and PCI-602W
PCI-20326T-1	Digital I/O	None required	See note (2)		See Note (2)

Notes: (1) When part numbers are shown without "dash" numbers, all versions apply.
(2) The PCI-20326T-1 is an expander panel that can be used with either the PCI-20324T-1 or PCI-20325T-1. Therefore, the PCI-20326T-1 is compatible with all of the listed carriers, modules and boards.

COMPATIBILITY TABLE— PCI-20324T-1, DIGITAL I/O CONDITIONER

PCI MODEL NUMBER	TYPE	NUMBER OF CHANNELS	DESCRIPTION	CARRIERS[1]	MODULES[1]	BOARDS
PCI-20311A-1	Cable	8	2 meters, ground plane	PCI-20001C-2, PCI-20041C	PCI-20004M, PCI-20007M	PCI-20087W-1
PCI-20311A-2	Cable	8	1.5 feet, shielded	PCI-20001C-2, PCI-20041C	PCI-20004M, PCI-20007M	PCI-20087W-1
PCI-20311A-3	Cable	8	3 feet, shielded	PCI-20001C-2, PCI-20041C	PCI-20004M, PCI-20007M	PCI-20087W-1
PCI-20326T-1	Expander	8	Adds 8 more digital I/O			
PCI-20308H-1	Enclosure		19-inch rack/table-mount			
PCI-20343A-1	Enclosure	Up to 16	Tabletop use			
PCI-1107	Block	1	AC/DC Input, 32V			
PCI-1108	Block	1	AC/DC Input, 115V			
PCI-1109	Block	1	DC Output, 60V			
PCI-1110	Block	1	AC Output, 115V			
PCI-1111	Block	1	AC/DC Input, 240V			
PCI-1112	Block	1	AC Output, 240V			

Note: (1) When model numbers are shown without "dash" numbers, all versions apply.

COMPATIBILITY TABLE— PCI-20325T-1, DIGITAL I/O CONDITIONER

PCI MODEL NUMBER	TYPE	NUMBER OF CHANNELS	DESCRIPTION	CARRIERS[1]	BOARDS
PCI-20009A-1	Cable	8	2 meters, ground plane	PCI-20001C-2, PCI-20041C	PCI-20087W-1
PCI-20009A-2	Cable	8	1.5 feet, shielded	PCI-20001C-2, PCI-20041C	PCI-20087W-1
PCI-20009A-3	Cable	8	3 feet, shielded	PCI-20001C-2, PCI-20041C	PCI-20087W-1
PCI-20327A-1	Cable	8	Interconnects a PCI-20324T-1 to a PCI-20325T-1 when more than 16 listed channels are required.		
PCI-20326T-1	Expander	8	Adds 8 more digital I/O		
PCI-20307T-1	Expander	8	Adds other digital signals[2]		
PCI-20308H-1	Enclosure		19-inch rack/table-mount		
PCI-20343A-1	Enclosure	Up to 16	Tabletop use		
PCI-1107	Block	1	AC/DC Input, 32V		
PCI-1108	Block	1	AC/DC Input, 115V		
PCI-1109	Block	1	DC Output, 60V		
PCI-1110	Block	1	AC Output, 115V		
PCI-1111	Block	1	AC/DC Input, 240V		
PCI-1112	Block	1	AC Output, 240V		

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) The PCI-20307T-1 allows access to counters, rate generators and handshake lines, if available on the hardware.

For additional information, please refer to the configuration charts in the Summary Section.

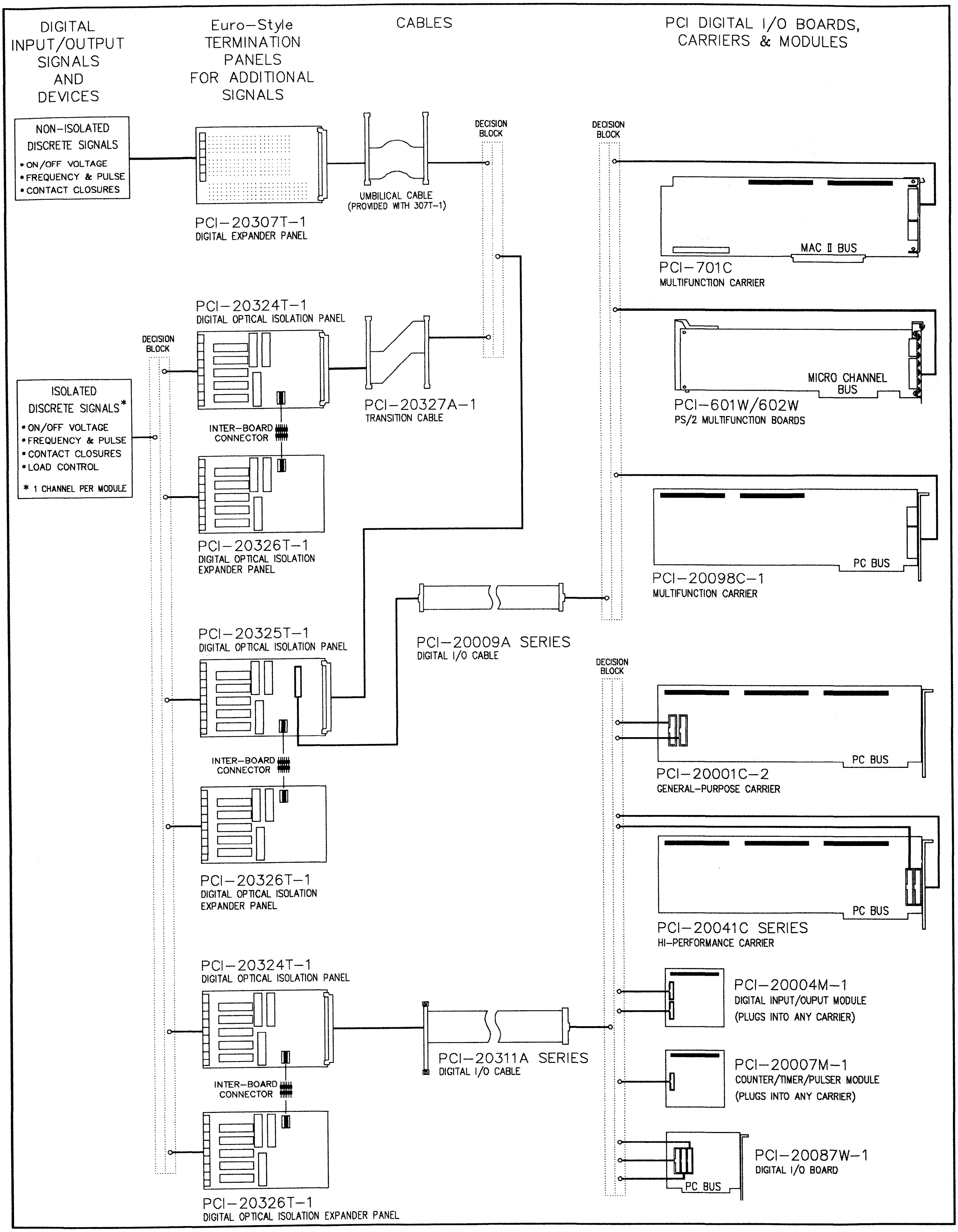
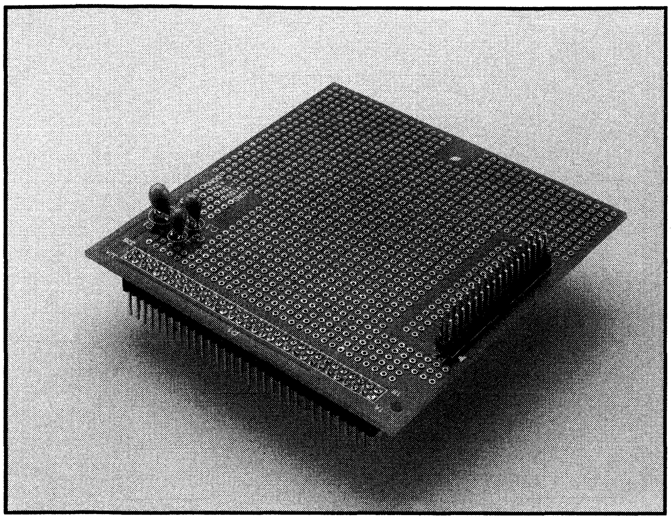


FIGURE 1. Compatibility Options for the PCI-20324T-1, PCI-20325T-1 and PCI-20326T-1 Termination Panels.



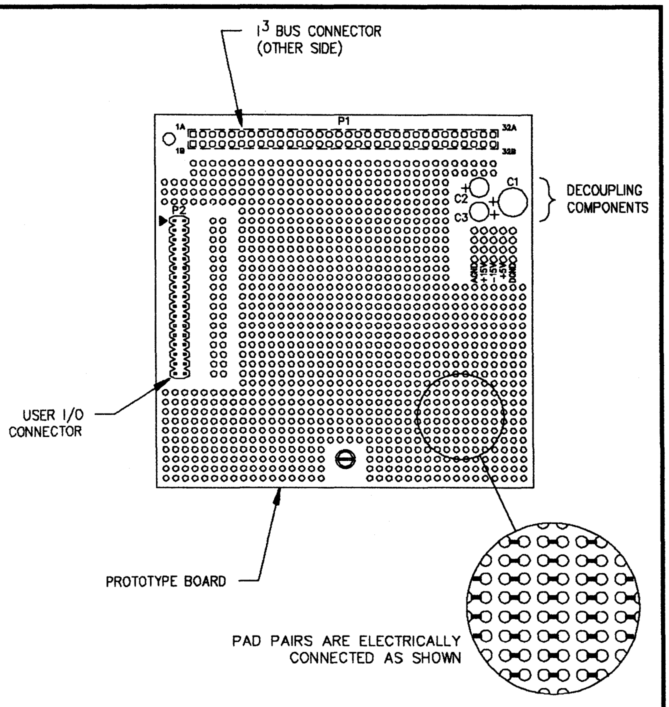
BURR-BROWN®

PCI-20329M-1

Prototype Module

FEATURES

- Provides A Platform For User-Defined Custom Circuitry
  - — Signal Conditioning
  - — Filtering
  - — Carrier Bus Expansion
- Compatible With All PCI Carrier-Based Products
- Supports Both Analog and Digital I/O Applications



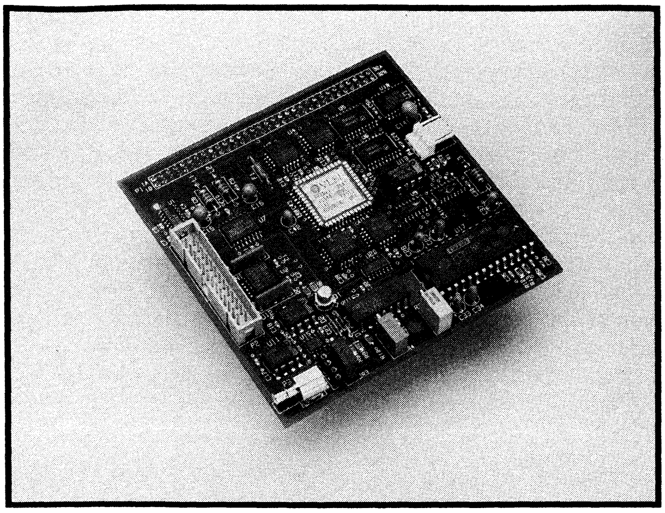
DESCRIPTION

The PCI-20329M-1 Prototype Module is designed for users who wish to interface their own circuitry to the Intelligent Instrumentation Interface (I^3) Bus.

Approximately three quarters of the module's surface area consists, of pairs of 0.1 inch plated-through holes, to accommodate the user's circuitry. This hole pattern is particularly useful for mounting and connecting IC's. Decoupling capacitors are provided for the 15V and 5V lines as they enter the module from the I^3 Bus. Two rows of pads are located along the left edge of the module for mounting connectors with up to 34 pins. This is suitable for both analog and digital I/O applications. A 64-pin connector is also provided for the I^3 Bus connections.

Documentation provided with the Prototype Module describes in detail the pinout and function for each I^3 Bus line. Suggestions for bus interfacing and programming are also included.

This product is intended to facilitate the integration of user- designed custom circuitry into a PCI System application. This prototype module is sold without any warranty of its suitability for a particular application. In purchasing this product, the user accepts total responsibility for its selection and eventual use. The user should understand that in providing this module, Burr-Brown does not accept any obligation to furnish technical assistance relating to custom implementations utilizing the PCI-20329M-1.



BURR-BROWN®

PCI-20341M-1

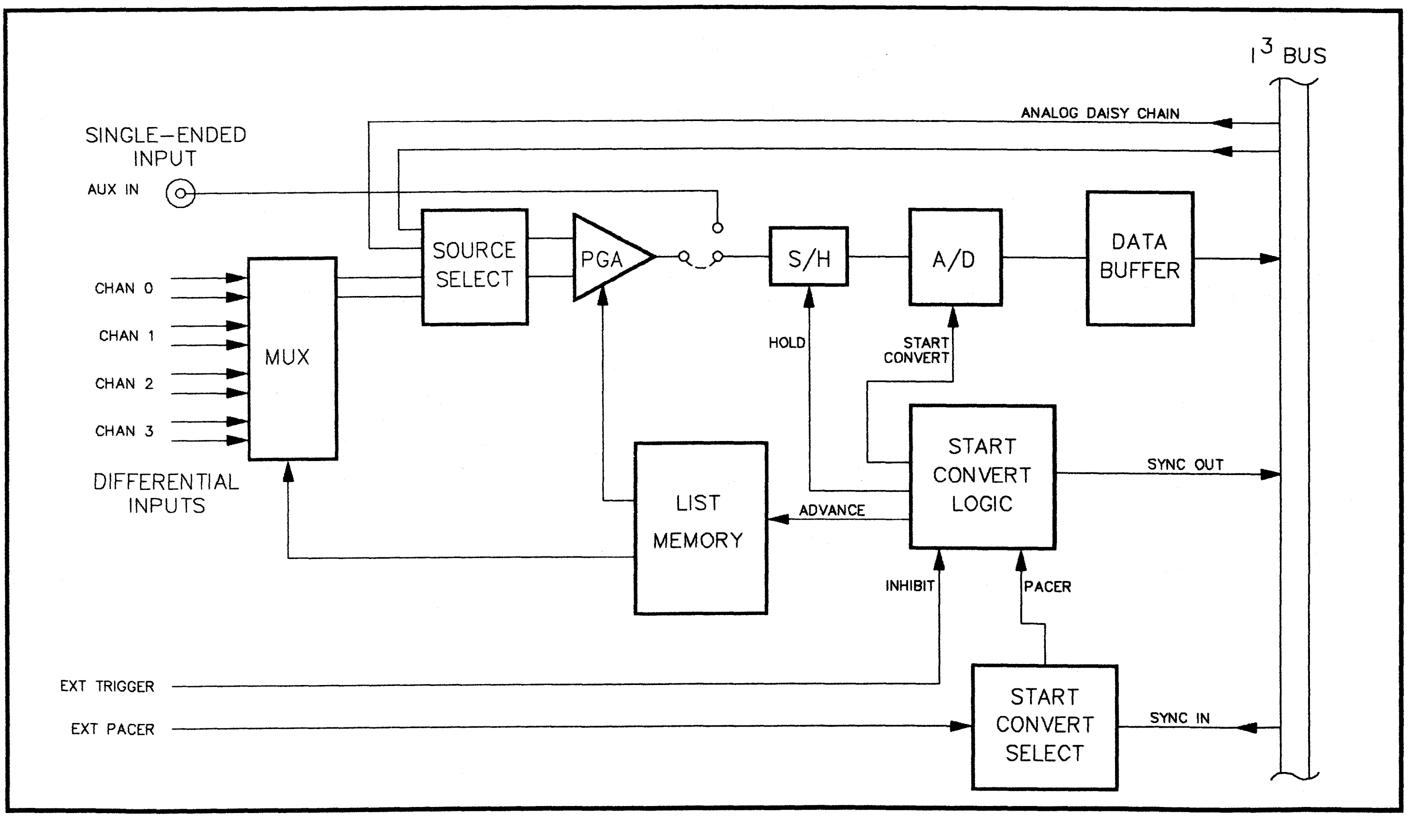
High-Resolution Analog Input Module

FEATURES

- Up To 85kHz Throughput Rate
- 4 Differential Inputs
- Hardware Captures Pre-Trigger Data
- Hardware and Software Acquisition Pacing Capability
- Automatic Channel Advance
- 16-Bit Resolution

DESCRIPTION

The PCI-20341M-1 is a high-speed, 16-bit data acquisition module with four differential inputs or one single-ended input. The differential inputs pass through a programmable gain amplifier (PGA) with gains of 1, 10, 100, and 200. Internal RAM stores a user-defined channel list that can contain the order in which channels should be read along with their corresponding gains. Internal hardware can configure the module to automatically increment channels after each conversion has started. This feature greatly reduces the computer's software burden and results in increased speed. Conversions may be started with an external hardware signal or by software command. The single-ended input is routed through



PCI-20341M-1 Module Block Diagram.

a separate coaxial connector that is further optimized for high-speed by bypassing the PGA.

The high-speed sample/hold and A/D converter provide for input sampling at up to 85,000 channels/second. The full-scale input range of the module is ±5V.

Additional differential input channels can be added with the optional PCI-20031M-1 Expansion (Multiplexer) Module. Each Expander adds 16 differential channels. This yields 20 or 36 total inputs when used with one or two multiplexers. Special internal hardware supports a channel scan list and triggering with delay. All channels can be read in any order with individual gains. The delay capability allows continuous high-speed acquisition into a circular data buffer of user-definable length. Data recording is stopped after "n" (delay) samples by an external digital trigger. This results in a waveform capture that includes both pre- and post-trigger data.

The PCI-20341M-1 is also compatible with the PCI-20020M-1 Trigger/Alarm Module. The Trigger/Alarm Module adds analog trigger capability with programmable level and slope. The response time is only 3.5μsec. This ensures reliable analog triggering at high speed. The definition of high speed depends upon the particular application and the acquisition mode employed. An accurate hardware timebase is usually used to pace the acquisition process. This start convert signal can come from an external source or from a rate/burst generator on a PCI carrier or on another module. Each successive pulse will start a new conversion and advance the input multiplexer to the next channel to be read. In all cases it is very important that the first pulse does not reach the multiplexer (or multiplexers) until the system has had enough time to be initialized and is ready to read the A/D converter. If this rule is violated "channel rotation" can occur. Channel rotation refers to the situation where the indicated channel and the recorded data are out of step (for example: the data for channels 2, 3, 4, 5 ... is reported as corresponding to channels 4, 5, 6, ...). The Trigger/Alarm Module is ideal for avoiding this state. By gating the pacing signal through the Trigger/Alarm Module it is easy to ensure the correct timing conditions.

"Capturing And Analyzing Transient Waveforms With A Personal Computer" is the title of an Applications Note that demonstrates the use of the Trigger/Alarm function with a high-speed analog input. This and other Application Notes can be found in Section 5 of this Handbook.

DYNAMIC PERFORMANCE— IN TYPICAL PC/XT/AT CARRIER-BASED INSTALLATIONS

All specifications are typical at +25°C unless otherwise noted.

CONDITIONS	PC/XT/AT/EISA COMPATIBLE COMPUTERS	
	80286 AT 12MHz	80386 AT 16 MHz
Installed on a PCI-20041C-3A Carrier		
PCI-20341M-1 alone, using DMA	85kHz	85kHz
Adding PCI-20031M-1, using DMA	85kHz	85kHz
Installed on any PCI PC/XT/AT/EISA Compatible Carrier[1]		
PCI-20341M-1 with PCI-20020M-1, without DMA	55kHz	60kHz
Adding PCI-20031M-1 and PCI-20020M-1, without DMA	45kHz	50kHz
Note: (1) PC/XT/AT/EISA Compatible Carrier Families include: PCI-20001C, PCI-20041C and PCI-20098C.		

DYNAMIC PERFORMANCE— IN TYPICAL Mac II NuBus CARRIER-BASED INSTALLATIONS

All specifications are typical at +25°C unless otherwise noted.

CONDITIONS	Mac II COMPATIBLE COMPUTERS	
	68030 AT 16MHz	68030 AT 25MHz
Installed on a PCI-701C Carrier With or Without PCI-702M Bus Master Module		
PCI-20341M-1 alone, using DMA	85kHz	85kHz
Adding PCI-20031M-1, using DMA	85kHz	85kHz
PCI-20341M-1 with PCI-20020M-1, with DMA	85kHz	85kHz
PCI-20341M-1 with PCI-20020M-1, without DMA	85kHz	85kHz
PCI-20341M-1 with PCI-20031M-1 without DMA	85kHz	85kHz

SPECIFICATIONS—PCI-20341M-1

All specification are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Compatibility		All I^3 Bus devices
I/O Configuration		Analog input
Number of Channels	Single-ended	1
	Differential	4
Input		
Voltage Gain	Single-ended	1
	Differential	1, 10, 100, 200
Offset Voltage		Trimmable to zero
Common-Mode Rejection[3]	60Hz, 100 Ohms unbalance	
	G = 1	0.1LSB/V (-96dB)
	G = 10	1LSB/V (-96dB)
	G = 100	10LSB/V (-96dB)
	G = 200	10LSB/V (-102dB)
Common-Mode Range (V_{cmr})	$V_{cm} = V_{cmr} - (V_{diff} \cdot Gain)/2$	10V, DC plus peak AC
Impedance	Single-ended	3k Ohm at 40pF
	Differential	10^{12} Ohm at 50pF
Source Impedance (Maximum Recommended)	PCI-20341M-1 (differential) alone at 85kHz	5KΩ
Voltage Range	Linear operation	±5V
	Without damage	20V above supplies (±35V)
Bias Current	Differential inputs	0.5nA
	Single-ended input	±325nA
Noise	RMS, G=1, 10k samples	±2LSB
Crosstalk	Channel-to-channel @ 1kHz, 1KΩ source impedance	2LSB/Volt
A/D Converter		
Resolution		16-Bit
Monotonicity		14-Bit
Code		2's compliment
Linearity Error		0.003%
Gain Accuracy		0.01%
Range		±5V
Dynamic Respone		
Mux Settling Time	Within 0.01%	3.5μs[1]
PGA Settling Time	G = 1, 10	10μs
	G = 100	20μs
	G = 200	40μs
Conversion Time	A/D maximum	10μs
Aperture Time		25ns
Acquisition Time	S/H, maximum	1μs
Total Conversion Time[1]	G = 1	12μs
Throughput Rate	G = 1	85k channels/sec
Power Requirements[2]	+15V supply	50mA maximum
	- 15V supply	50mA maximum
	+5V supply	360mA maximum
Physcial	Length x Height x Thickness	3.9" x 3.9" x 1.3" (9.9cm x 9.9cm x 3.3cm)
Temperature Range	Module temperature	0 to +70°C

Notes:
(1) Normally, mux settling time need not be added to the other components of "total convert time". The software can be arranged so that channel selection (mux transfer) takes place during the A/D conversion cycle (after the S/H captures the signal). PCI software drivers perform this task automatically.
(2) If the module is powered from a PCI Carrier, the ±15V requirements are satisfied by the internal DC/DC converter, and the equivalent load on the computer's +5V supply will be 960mA, maximum. This takes into account the efficiency of the DC/DC converter.
(3) For a single PCI-20341M-1 module without multiplexers connected through the I^3 Bus. Connections to the Bus can reduce CMR.

SOFTWARE COMPATIBILITY TABLE

(The PCI-20341M-1 can be used with the following software in conjunction with the listed hardware.)

PCI MODEL NUMBER[1]	NAME	MENU-DRIVEN	H/W DRIVER[2]	DMA SUPPORT	CARRIERS SUPPORTED[1]	EXPANSION MODULES SUPPORTED
PCI-20067S-1	DADiSP/PC	Yes	No	No	Not applicable	Not applicable
PCI-20210S-1	Hypersignal-Workstation	Yes	No	No	Not applicable	Not applicable
PCI-20026S	General-purpose Drivers	No	Yes	No	PCI-20001C, PCI-20041C	PCI-20031M-1
PCI-20027S	High-performance Drivers	No	Yes	No	PCI-20001C, PCI-20041C	PCI-20031M-1
PCI-20027S	High-performance Drivers	No	Yes	Yes	PCI-20041C-3A	PCI-20031M-1
PCI-20096S	TURBO STREAM Drivers	No	Yes	Yes	PCI-20041C-3A	PCI-20031M-1
PCI-703S	*MacAdapt*	No	Yes	No	PCI-701C	PCI-20031M-1
PCI-704S	*MacExpedite*	No	Yes	Yes	PCI-701C (with PCI-702M)	PCI-20031M-1
PCI-706S	Interface to LabVIEW 2	No	Yes	Yes	PCI-701C	PCI-20031M-1

Notes: (1) When model numbers are shown without "dash" numbers, all versions apply.
(2) This heading indicates if the software includes control for the hardware listed. If it does not, then the user must provide hardware control (for example, using PCI-20026S and PCI-20027S Drivers.)

HARDWARE COMPATIBIILITY TABLE— CARRIERS AND MODULES

(The PCI-20341M-1 can be used in conjunction with the following hardware products.)

PCI MODEL NUMBER	TYPE	DESCRIPTION	BUS	MAXIMUM NUMBER OF CHANNELS	
				WITH ONE PCI-20031M-1[1]	WITH TWO PCI-20031M-1s[1]
PCI-20001C-2A	Carrier	General-purpose	PC/XT/AT/EISA	20	36
PCI-20041C-2A, PCI-20041C-3A	Carrier	High-performance	PC/XT/AT/EISA	20	36
PCI-20098C-1	Carrier	Multifunction	PC/XT/AT/EISA	20	Not applicable
PCI-20202C-1, PCI-20202C-2	Carrier	*Smart* Processor	PC/XT/AT	20	36
PCI-701C	Carrier	Multifunction	Mac II NuBus	20	Not applicable

Notes: (1) All inputs are differential.

HARDWARE COMPATIBILITY TABLE— TERMINATION PANELS

(The PCI-20341M-1 can be used in conjunction with the following hardware products.)

TERMINATION PANELS	PANEL FUNCTION	CABLE	ENCLOSURE
PCI-20303T-1	General-purpose	PCI-20310A-1	PCI-20308H-1, PCI-20343A-1
PCI-20024T-1	Customizer	PCI-20015A-1	PCI-20029A-1

For additional information, please refer to the configuration charts in the Summary Section.

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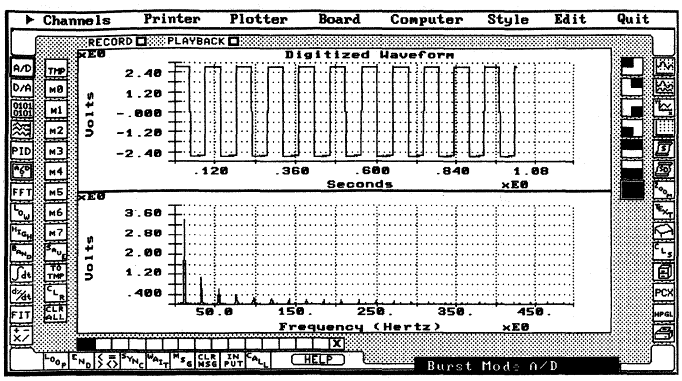

PCI-20348S

EASYEST Icon-driven Analysis and Display Software

FEATURES

- Intuitive Point and Click Iconic Interface
- High-Speed Analog Signal Acquisition
- Continuous Recording to Disk
- Analog Output and Digital I/O Capabilities
- Open- and Closed-Loop (PID) Control
- Extensive Analysis Capabilities, Including Filtering
- Auto-Scaled Graphic Displays
- Strip Chart Recorder
- Internal and External Triggering
- Works with the PCI-20098C-1 Carrier, Several I/O Modules and the PCI-20087W-1

DESCRIPTION

Easyest *is* the easiest and fastest way to perform data acquisition, control, analysis, and graphic display functions on a PC/XT/AT/EISA based system. The software is designed for immediate practical use. It is ideal for engineers, researchers, students, technicians or anyone involved with data manipulation. All of Easyest's capabilities are immediately accessible from the main menu, which appears when you load the program. The mouse-driven user interface is intuitive and completely interactive. Incoming data as well as all operations (functions) are described by icons. The functional groups consist of acquisition, analysis, display, programming (sequence automation), and input/output. A summary of the individual functions is found in TABLE 1. When required, parameters are supplied through drop-down dialog boxes. As a result, keyboard entries are kept to a minimum. On-screen, context-sensitive help defines all icons and functions.

In addition to the interactive mode, which is excellent for exploring incoming data, there is a full-featured sequence mode. The sequence mode allows the automation of complex operations. Programming comes naturally! Simply perform the desired steps interactively, and Easyest memorizes the action. Sequences can include: analog acquisition; analog output; reading digital status; writing a digital pattern; triggering, looping, branching, delay, and conditional control structures; linear and polynomial conversion; filtering; algebraic, trigonometric, calculus, and statistical analysis; auto-scaled graphics plots and tabular display.

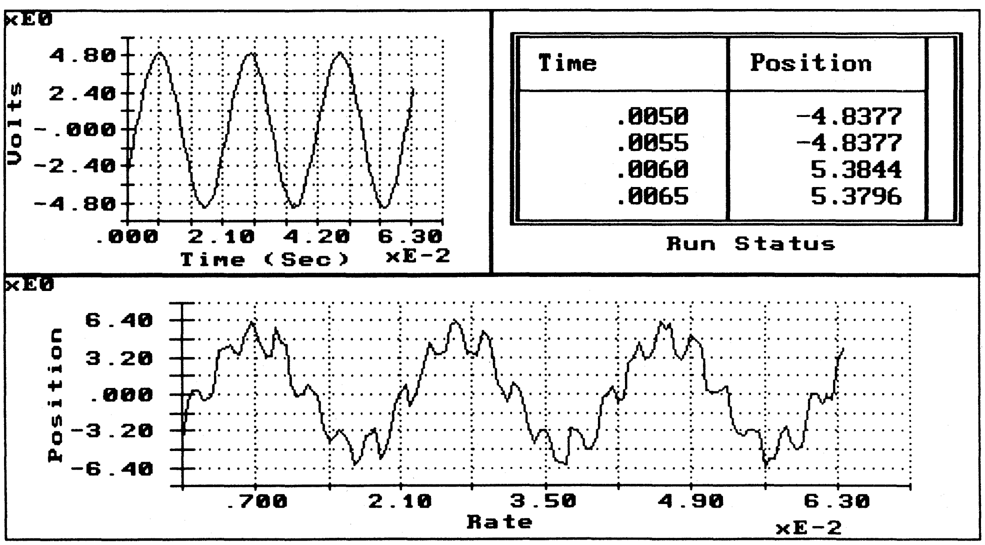

FIGURE 1. A Typical Full-Screen Display.

TABLE 1. EASYEST FUNCTIONS

FUNCTION NAME	DESCRIPTION
Acquisition	Hardware control with a wide range of trigger options
A/D Acquisition	Analog input on 1 to 8 channels, burst mode— up to 1024 points to RAM buffer
D/A Output	Analog output on 1 to 4 channels— single point or from RAM buffer
Digital I/O	Read or set digital levels— up to 8 inputs and 8 outputs
Strip Chart Recorder	Continuous real-time display and file storage for 1 to 8 analog input channels
PID Control	Closed-loop control on up to 4 channels— real-time display and tuning
A/D To File	Acquires 1 to 8 analog inputs directly to disk— up to 8Mbytes
Analysis	Data manipulation and engineering unit conversion
FFT	Frequency analysis, phase and magnitude or power spectrum, several window options
Low Pass Filter	Time domain filter (Blackman window) with user-specified cutoff frequency
High Pass Filter	Time domain filter (Blackman window) with user-specified cutoff frequency
Band Pass Filter	Time domain filter (Blackman window) with user-specified cutoff frequencies
Integrate	Running or total area using 1/3 Simpson's rule
Differentiate	First order derivative (rate of change)
Curve Fit	Performs a linear or polynomial curve fit up to fifth order
Arithmetic Operators	Performs unary, binary, trigonometric, and array creation operations
Display	Graphic (in a choice of 15 colors) or numeric— up to four windows
Draw Graph	Auto-scaled plot of data in a buffer vs. time (or frequency)
Overlay Graph	Adds additional traces to existing axes (choice of color)
XY Graph	Auto-scaled plot of data in one buffer vs. another
Axis Plot	Draws a set of axes with user-defined horizontal and vertical ranges
Scroll From Memory	Allows a close look at data with zoom capabilities
Scroll From Disk	Allows a close look at data files created with the analog input functions
Zoom In On Data	Operates on last data plotted— zoom and digital readout capabilities
Graph Labels	Adds up to 8 labels to existing display before printing— control over position
Input/Output	
Create Data Table	Displays data in table format
Clear Screen	Clears the current graph area
File Operators	Reads or writes data files to or from buffers
Create PCX File	Writes pixel information from the screen to a PCX file
Plotter Output	Generates plotter output using HPGL commands
Screen Print	Prints a screen dump of the current graph area
Programming	Automates measurement, analysis, and display operations
Begin Loop	Defines the beginning of a repetitive loop
End Loop	Defines the end of a loop— can include conditional statements
Comparison Operations	Performs <, >, =, <=, >=, and <> functions on selected data or user values
Set Loop Timing	Forces the loop execution time to a specified value— provides synchronization
Insert Pause	Interrupts sequence until defined time or keystroke appears
Display Message	Displays up to five lines of text and the data value in a specified buffer
Clear Message	Clears current message
Input Value	Stores a specified value into a specified buffer
Call Another Routine	Adds a previously recorded sequence to the current sequence during playback

Single-ended or differential inputs are supported, using the PCI-20098C-1 Multifunction Carrier. All of the carrier's functions are completely software programmable, so no jumpers are involved. Functions include: 8 analog inputs, 8 digital inputs, and 8 digital outputs. Analog acquisition with a throughput rate of 32KHz is supported. Up to 1024 samples of each channel can be recorded into separate RAM buffers. Alternatively, up to a total of 8Mbytes (4 mega-samples) can be continuously acquired to hard disk. In the Strip Chart Recorder mode 1 to 8 channels can be displayed in real time with file storage capability. Analog outputs are supported when the PCI-20003M Series or PCI-20006M Series Modules are installed on the Carrier. The modules can be used alone or in pairs to yield up to four 12- or 16-bit outputs. Open-loop outputs can consist of a burst of points read from a buffer (up to 1024 points) or a specified single point.

The strip chart option also works with the closed-loop PID mode to display both the controlled output and the set-point data. This aids loop tuning. All loop parameters (P,I,D, and set-point) can be adjusted in real-time. Up to four PID loops can run together if data is not displayed. The update rate can be programmed between 0.01 and 5Hz per loop. Up to 8 digital inputs can be read (a single read) to determine status or trigger conditions. The inputs can be logically compared to other data. In addition to digital triggering, analog acquisition can be started by a keystroke, a timed delay, an external input, or an analog input. The user can select either rising or falling edge for digital triggers. Analog triggers can be programmed from -10 to +10 volts. Up to 8 digital output points can be set to start other equipment, sound alarms, etc.

The data from analog input channels can be displayed directly in volts, or it can be converted to engineering units. Each channel can be individually scaled with the PCI-20098C-1's programmable gain amplifier (gain = 1, 10, or 100). In addition, up to a fifth order polynomial can be used for unit conversion (e.g., volts to pressure). Several graphs and tables can be displayed at the same time. Combinations of up to four windows can be created using the quarter-, half-, and full-screen icons. Creating an auto-scaled plot of the desired data is as easy as a single mouse click! Notes and legends can be added to the display before printing. A wide range of dot matrix and laser printers can be used. All plotters accepting the Hewlett-Packard Graphics Language are supported.

Easyest has extensive analysis and graphics capabilities. Linear and fifth order polynomial curve fits can be computed and used for input data unit conversion. Low, high, and bandpass filtering is provided in the time domain. This is internally accomplished by convolving a Blackman window with the data. The user can select the cutoff frequency(s). Frequency analysis supports FFT (phase and magnitude) and power spectrum with a choice of Hanning, Hamming, rectangular, and Blackman windows. The DC component of the input signal can be included or rejected. Standard mathematical functions include +, -, /, *, LN, LOG, COS, TAN, SQRT, MAX, MIN, MEAN, and Y^n. Waveform analysis includes running and total area integration as well as first order differentiation. Linear least-squares curve fitting (1^{st} to 5^{th} order polynomial) displays goodness-of-fit parameters. A range of plot types allow auto-scaled and user-defined axes for Y-versus-time and Y-versus-X presentations. Multiple traces can be overlayed on one set of axes using different colors, line types, and symbols. Tabular and single-point data can be combined with the graphical information into one display. Scroll and zoom functions easily show desired details.

In addition to the hardware interfaces described above (PCI-20098C-1, PCI-20003M Series, and PCI-20006M Series), Easyest also supports the PCI-20087W-1 Digital I/O Board. Using the PCI- 20087W-1, Easyest can read the status of 8 bits (1 byte) upon command. It can also set (write) 8 bits to control external equipment. These features are useful in low-cost digital test, sequencing, and control applications.

Easyest operates as a code generator for the ASYST programming language. The setups you create with Easyest's iconic interface are directly transferable to ASYST. Therefore, investment protection is assured. If future needs require extended capabilities, an upward compatible path to the unlimited power of ASYST is available.

TABLE 2. SPECIFICATIONS— EASYEST

All specifications are typical at +25°C unless otherwise noted.

PARAMETER	CONDITIONS	SPECIFICATION
Requirements	Computer RAM memory Coprocessor Disk drives Graphics Mouse DOS	All PC/XT/AT/EISA or compatibles 640Kbytes 8087, 80287, or 80387 Hard disk and floppy drive EGA or VGA adaptor and monitor Microsoft compatible 3.0 or above (4.0 without user shell)
Input/Output Hardware	Burr-Brown	PCI-20098C-1 Multifunction Carrier PCI-20003M Series Analog Output Module PCI-20006M Series Analog Output Moduel PCI-20087W-1 Digital I/O Board
Optional Equipment	Printers Plotters	Any of 90 supported printers Any HPGL compatible plotter
Analog Input	Channels Acquisition speed to buffer Maximum buffer size Continous to disk speed Maximum file size Strip chart display Triggering	8 single-ended or differential 32kHz throughput 1024 points per channel 32kHz throughput 8Mbytes (4 mega-samples) 100Hz per channel Keystroke, timed, analog level, digital, and external
Analog Output	Channels Modes Output speed Triggering	Up to 4 Single point and buffered 20,000 points per second Keystroke, timed, digital, and external
Digital Input	Channels[1] Without external triggering With external triggering Mode Signal levels Triggering	 8 points (1 Byte) 4 points Single read with bit masking TTL[2] Keystroke, timed, digital, and external
Digital Output	Channels Mode Signal levels Triggering	8 points (1 Byte) Single write with bit masking TTL[2] Keystroke, timed, digital, and external
Closed-Loop Control, PID	Channels Display Speed Triggering	Up to 4 Strip chart with real-time tuning 0.01 to 5Hz per channel Keystroke, timed, digital, and external

Notes: (1) External triggering is supported for analog input, analog output, digital input, and digital output. Four of the available digital input points are reserved for this function whenever external triggering is selected during setup.
(2) Other signal levels can be accommodated by using appropriate signal conditioning. Please refer to the Tutorial Section of this handbook for more information.

TABLE 3a. I/O HARDWARE COMPATIBILITY— CARRIERS AND MODULES

PCI MODEL NUMBER	BUS COMPATIBILITY	PRODUCT TYPE	DESCRIPTION	RESOLUTION	CHANNELS[1]	SAMPLE RATE
PCI-20098C-1	PC	Carrier	Multifunction	12-bit	8/16	32kHz
PCI-20003M-2	I^3	Module	Analog output	12-bit	2	20k points/sec
PCI-20006M-2	I^3	Module	Analog output	16-bit	2	20k points/sec
PCI-20087W-1	PC	Board	Digital I/O		8in, 8out	Single read/write

Note: (1) Single-ended/differential.

TABLE 3b. I/O HARDWARE COMPATIBILITY— TERMINATION COMPONENTS

PCI MODEL NUMBER	FUNCTION	USED WITH	DESCRIPTION
PCI-20304T-1	Panel, analog input	PCI-20098C-1	Euro-Style termination panel
PCI-5B01-1	Panel, analog input	PCI-20098C-1	Signal conditioning (isolation) panel
PCI-20008A-1B	Cable, analog input	PCI-20304T-1, PCI-5B01-1	Shielded cable, 4 feet (1.2m) long
PCI-5B30 Series	Analog input block	PCI-5B01-1	Voltage signal conditioner
PCI-5B31 Series	Analog input block	PCI-5B01-1	Voltage signal conditioner
PCI-5B39 Series	Analog input block	PCI-5B01-1	Thermocouple signal conditioner
PCI-20303T-1	Panel, analog output	PCI-20003M-2, PCI-20003M-4, PCI-20006M-2	Euro-Style termination panel
PCI-5B01-1	Panel, analog output	PCI-20003M-2, PCI-20003M-4, PCI-20006M-2	Signal conditioning (isolation) panel
PCI-20310A-1	Cable, analog output	PCI-20303T-1	Shielded cable, 6.6 feet (2m) long
PCI-20015A-1	Cable, analog output	PCI-5B01-1	Shielded cable, 4 feet (1.2m) long
PCI-5B39-02	Analog output block	PCI-5B01-1	Signal conditioner
PCI-20305T-1	Panel, digital I/O	PCI-20087W-1	Euro-Style termination panel
PCI-20306T-1	Panel, digital I/O	PCI-20098C-1	Euro-Style termination panel
PCI-20324T-1	Panel, digital I/O	PCI-20087W-1	Euro-Style signal conditioning panel
PCI-20325T-1	Panel, digital I/O	PCI-20098C-1	Euro-Style signal conditioning panel
PCI-20009A-1B	Cable, digital I/O	PCI-20306T-1, PCI-20325T1	Shielded cable, 4 feet (1.2m) long
PCI-20311A-1	Cable, digital I/O	PCI-20305T-1, PCI-20324T-1	Shielded cable, 6.6 feet (2m) long
PCI-1100 Series	Digital I/O block	PCI-20324T-1, PCI-20325T-1	Signal conditioner
PCI-20339A-1	Rack-mount enclosure	PCI-5B01-1	Holds 1 panel
PCI-20343A-1	Tabletop enclosure	All Euro-Style panels	Holds up to 3 panels

For additional information, please refer to the configuration charts in the Summary Section.

PCI PRODUCTS BY TYPE

(See complete Subject Index for additional assistance)

FIXED-FUNCTION BOARDS

CARRIERS

ANALOG INPUT MODULES

ANALOG OUTPUT MODULES

DIGITAL I/O MODULES

SPECIAL-PURPOSE MODULES

ACCESSORIES

INTERFACE PRODUCTS

SOFTWARE

TERMINATION PANELS

SIGNAL CONDITIONING BLOCKS

SYSTEMS

DATA ACQUISITION AND CONTROL TUTORIAL

Most people would agree that the digital computer has had an enormous influence on the course of measurement, control, analysis, and presentation techniques. In large part, this is due to the proliferation of the modern personal computer. For all of the PC's strengths, however, it is not the "answer". Rather, it is one of our tools. Making the most of this tool (technology) requires an understanding of the computer's characteristics, capabilities, strengths, AND limitations. Perhaps the most significant limitations are related to the *signals* that the computer must process. Most real-world signals cannot be directly connected to the PC. The electrical equivalents of temperature, pressure, speed, flow, and open/closed (for example) are not necessarily compatible with the narrow requirements of the PC. How, then, do signals get in and out of the PC? Also, keep in mind that old, but true, computer adage — "garbage in -- garbage out." The best signal converters and fancy computers cannot eliminate the devastating effects of corrupted inputs.

This section of the PCI Handbook presents background information on many of the most common topics relating to data acquisition and control. Of these, no topic is more important than signal conditioning. Signal conditioning can include isolation, buffering, shielding, filtering, linearization, bridge completion, excitation, surge protection, amplification, and attenuation, as well as cold-junction compensation. Understanding how and when to employ these techniques is essential to obtaining reliable (accurate and repeatable) measurements. Please note that the requirement for signal conditioning is not unique to computerized systems. All test, measurement, and control procedures are dependent upon *meaningful* signals.

TABLE OF CONTENTS

Data Acquisition and Control: An Overview

The term *data acquisition and control* (DA&C) can mean different things to each of us. Observing a voltmeter and manually recording its reading certainly constitutes data acquisition. Furthermore, when we turn the dimmer knob on a room lamp, we achieve control. These are, of course, very simple examples. Think about the number of DA&C actions taken by each of us at work, in industry, in driving a car, in everyday life.

Simply stated, data acquisition is the collecting of information that describes a given situation. The data typically reflects what was happening when a given condition was satisfied. Usually, this condition is defined by a uniform timebase, but it could be controlled by any event. "Real-time" systems are characterized by their ability to perform a given data acquisition and/or control task within an appropriate time window. How fast such a system must respond depends upon the speed and accuracy requirements of that given application.

For every data acquisition or control system, no matter how slow it may be, there is an application sufficiently slow that, for that application, the system is real-time.

Control implies the generation of an output signal in response to input data. Control can be "open loop" or "closed loop". Turning off the heat at 4:00 p.m. is an example of open-loop control, while turning off the heat because it is too hot represents closed-loop control.

Data is collected by technicians, engineers, physicists, chemists or others involved in research, test, development, production, quality control, management, process control, etc. Industries involved include: electrical, electronics, steel, mechanical, chemical, oil, food, energy, genetics, medical, and paper. Data can be collected by anyone, anywhere, to deduce trends, establish alarms, make decisions, and control operations.

We have been data takers since the beginning of time. We have sensed our environment and learned to take beneficial action. We read thermometers, voltmeters, scales and oscilloscopes. We record the data, analyze it, use it, and communicate it. However, methods are changing. Now the emphasis is on getting machines to meet many of our data acquisition and control needs. The unselfish motive is productivity. Speed, accuracy, dependability, reliability and cost are related factors.

In the past, when process monitoring was the principal task, an automatic data logger was the accepted form of automation. Data loggers include strip chart recorders, printers, and tape recorders. When monitoring alone was not enough, programmable controllers were often matched to the requirements of the job. However, in an increasing number of applications, data loggers and programmable controllers could not do everything that was desired. This was due, in part, to the narrow range of functions supported by their hardware and software. In contrast, today's state-of-the-art systems, offering a full range of capabilities, are based upon our most effective productivity machine— the modern digital computer.

FIGURE 4-1 depicts the components of a data acquisition and control system. The computer not only provides the analysis and decision-making capability, but also controls the active signal-conditioning and data-conversion functions. A given system might not include all of the elements shown in FIGURE 4-1. In this handbook, all further references to data acquisition or control apply to those applications in which a computer plays an important role.

Modern computers offer high speed, flexibility, adaptability, consistency, reliability and mass memory. These features provide extensive capabilities for mathematics, analysis, storage, display, report generation, control and communications. However, most real-world signals (temperature, pressure, flow, speed, intensity, position, etc.) cannot be read directly by digital computers. These parameters are represented by analog signals distinguished by their continuum of levels. However, computers can recognize only digital (off or on) levels. Therefore, a translation-type product is required.

The Link—Data acquisition and control products translate real-world signals into a format that digital computers can accept. DA&C systems can also regenerate analog and other signals from computer instructions. In this way DA&C systems bridge the gap between the digital computer and the real world.

The personal computer (PC), in contrast to other forms of computers, is the fastest growing engine for new DA&C system designs. Many of the reasons for this trend will be explored later.

The PC has already made significant inroads into many important application areas. These include:

— Laboratory data collection and automation

— Medical instrumentation and patient monitoring

— Automatic test equipment (ATE) for incoming inspection, life test, burn-in, production test, and final test

— Industrial monitoring and control

— Environmental and utility management

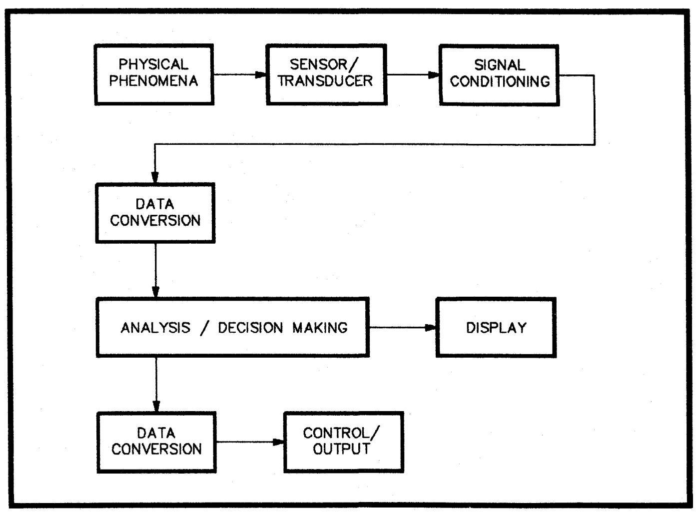

FIGURE 4-1. Data Acquisition and Control Flow Diagram.

Different Types of Systems and How They Connect to the Personal Computer

An important part of any data acquisition system is its host computer. There are two possible ways for the DA&C hardware to interface with the computer: direct connection to the PC bus (internal bus products) or connection via a standard communication channel such as RS-232, RS-422 or IEEE-488 (external bus products). Each method has its advantages and disadvantages.

Throughout this section, the term "system" will be used in several ways. A system can include everything that is required to perform the complete data acquisition task, including the host computer. The term "system" can also be used to describe a group of circuit elements. Perhaps this should more accurately be called a subsystem.

External Bus Products— There are several advantages associated with external bus products (using RS-232, etc.).

— Virtually any size system can be configured

— The DA&C system can be placed remotely from the host computer (and thus close to the field signals)

— The DA&C system can off-load some of the data-collecting tasks from the host computer

— The DA&C system can be interfaced to virtually any type of computer

FIGURE 4-2 shows a simplified block diagram of an external bus system. Communications through RS-232, RS-422 or IEEE-488 requires the data acquisition system to have its own internal microprocessor. This local microcomputer also facilitates remote operation and helps reduce the load on the host PC. Systems of this type reside in their own enclosures. These enclosures, or "boxes", provide space not only for the microcomputer, but also for the power supplies and the analog and digital input/output hardware. In most cases the I/O functions are grouped by type on individual plug-in boards. This allows both the selection of I/O types and a choice of the number of channels to be supported. To facilitate very large point-count systems, add-on expansion enclosures are also available.

The ability to have remote (distant from the host computer) DA&C boxes allows the construction of distributed systems. Thus, a large number of parameters can be monitored or controlled even though they physically originate far from each other and far from the host PC. For example, the data from many different production lines, each with separate DA&C subsystems, can be interconnected via RS-422. This allows monitoring by a single PC, which could be in a supervisor's office located in another building several thousand feet (or hundreds of meters) away. This type of capability can greatly improve productivity and reduce overall system cost.

Internal Bus Products— The main advantages of making direct connection to the PC bus include:

— High speed

— Low cost

— Smaller size

Cost is reduced with this kind of DA&C system because it does not require its own separate enclosure or power supply. Power is obtained from the PC. When the data acquisition hardware resides inside the host computer, important advantages in both size and space utilization are obtained. High speed is achieved by eliminating the relatively slow, external, communications-channel protocol. As an example, the data acquisition rate using RS-232 communications at 9600 baud is limited to about 20 analog readings per second. In contrast, some direct PC bus products can take data faster than 1 million samples per second. FIGURE 4-2 shows a simplified block diagram of an internal bus system.

Three major types of internal bus (PC bus) products exist, distinguished by the way in which the Input/Output channels are configured. All are board-level systems that make direct connection to the computer expansion bus, yielding the speed and cost advantages mentioned above. Some boards have a *fixed* arrangement of analog and digital inputs/outputs. This means that whatever configuration one buys, that's what he has regardless of future needs. Limitations of this type of system include lack of channel expansion capability and the inability to add functions not originally purchased. However, cost is usually lowest. In contrast, *modular* systems allow the user to select, even in the field, the quantity and configuration of the I/O functions desired. This feature is provided by a family of function modules. Thus, modular, board-level systems share some of the positive features of the box systems. These include expandability and user selection of I/O functions. Fixed products include single-function and general-purpose configurations. The focused, single-function boards are often effective in small applications or in well-defined instances where the board is embedded in a larger end product (such as an OEM product).

Often, general-purpose fixed I/O configurations require significant compromise. Either the number of channels desired cannot be obtained, or the user must purchase functions not required. With the great diversity of uses, it is inevitable that a mismatch between the available I/O and the actual requirements will exist. Some fixed-configuration products allow for selected types of channel expansion via external add-on boards or boxes. When cost, space, and ease of use are considered, this type of product is less attractive than

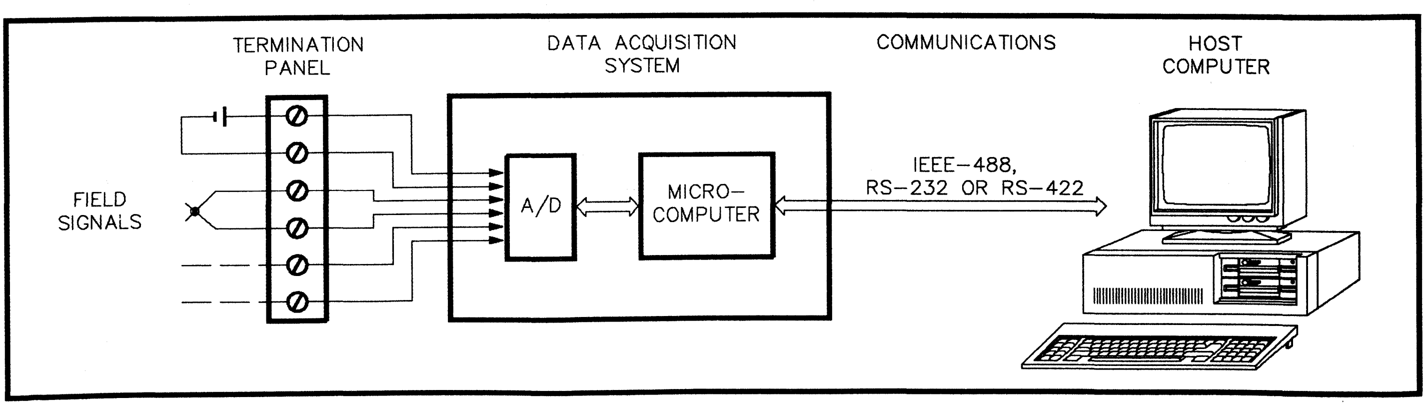

FIGURE 4-2. An External Bus Data Acquisition and Control System Block Diagram.

systems that can meet all I/O requirements inside the host computer. Modular board-level systems are far more effective in this regard and are readily tailored for specific applications. The PCI system includes products that represent the state-of-the-art in both modular and focused plug-in board systems for the PC bus. Detailed information and specifications on the PCI system are included in this handbook.

FIGURE 4-4 is a photograph showing a *fixed-configuration* I/O board alongside a *modular* type of I/O product.

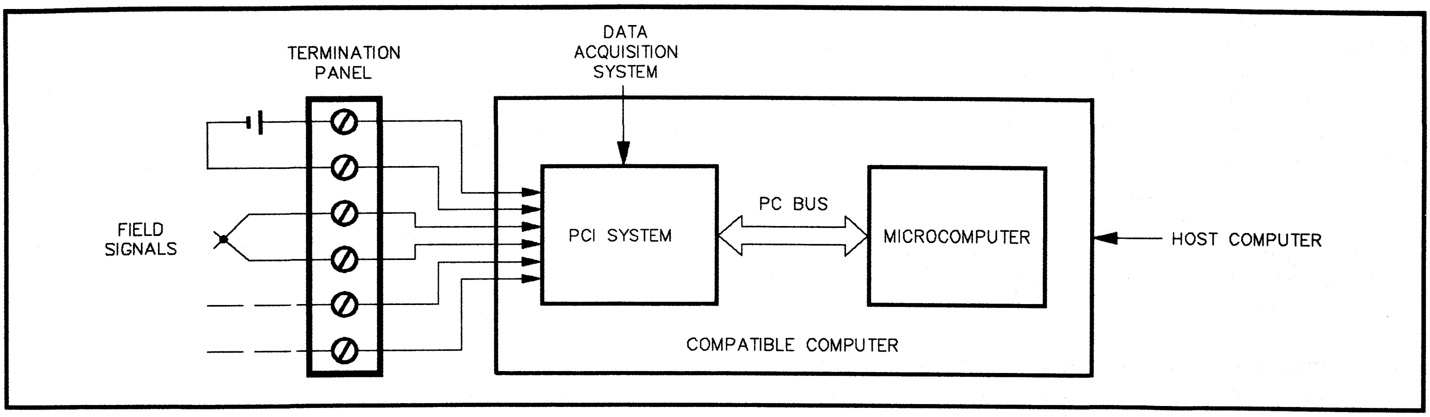

FIGURE 4-3. Internal PC Bus System.

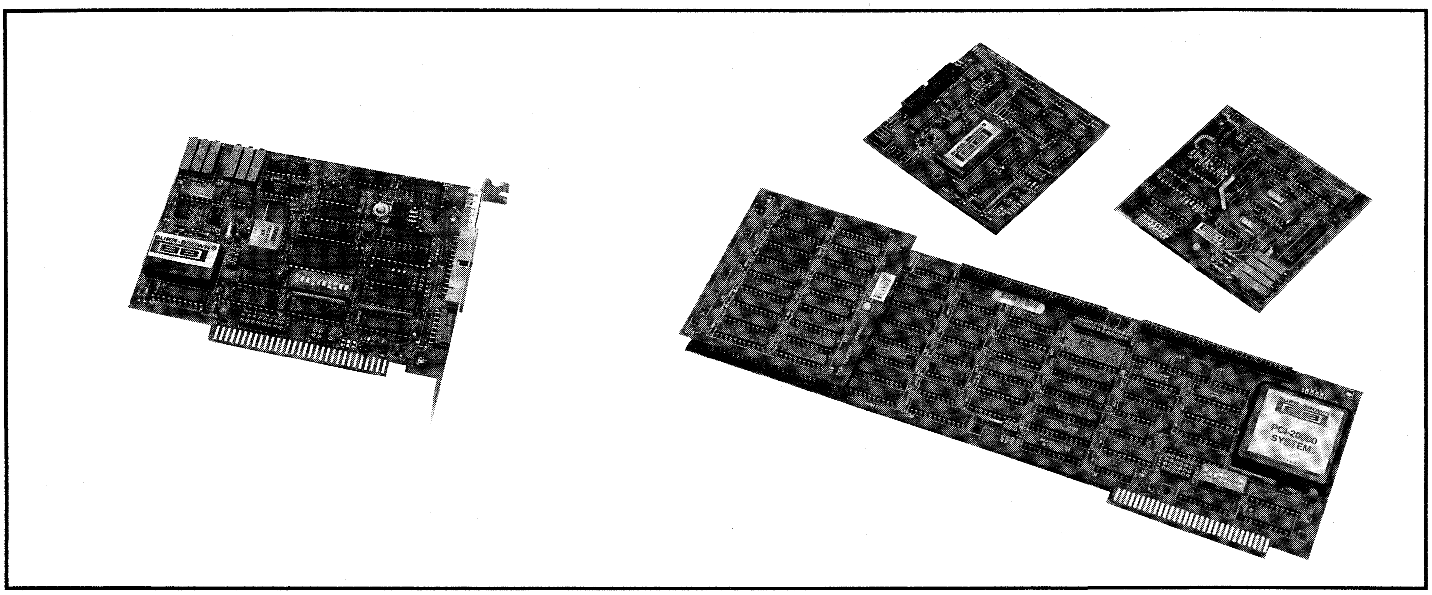

FIGURE 4-4. Comparison of a Fixed-Configuration I/O Board with a Modular System (The Left Board Is a Fixed Configuration; The Boards on the Right Are Components of the Modular System).

Personal Computers in Data Acquisition and Control

Historically, industrial and scientific data acquisition and control (DA&C) tasks were implemented with large mainframe or minicomputer systems. Typically, these were powerful 16-bit machines that ran in time-sharing or multitasking modes. Their complexity and expense dictated that they be configured as centralized utilities shared by many users and applications. Small or remote jobs were often relegated to manual, or at best, simple electronic data-logging techniques. These tasks could not justify the capital expense or manpower overhead of computerization. Thus, these smaller tasks could not benefit from the flexibility and power of a computerized solution.

The advent of the modern personal computer (PC) makes it possible for virtually everyone to take advantage of the flexibility, power and efficiency of computerized data acquisition and control. PCs offer high performance and low cost along with an ease-of-use that is unprecedented. Thanks to a significant degree of standardization among PC and DA&C manufacturers, a large family of hardware/software tools and application packages has evolved. The result is that an individual engineer or scientist can now implement a custom DA&C system within a fraction of the time and expense formerly required. It is now practical to tailor highly efficient solutions to unique applications. Furthermore, personal computers invite innovation. This type of innovation has revolutionized the office and is now revolutionizing factories, production lines, testing, and laboratories. FIGURE 4-5 shows the relationship between the DA&C system and its host computer.

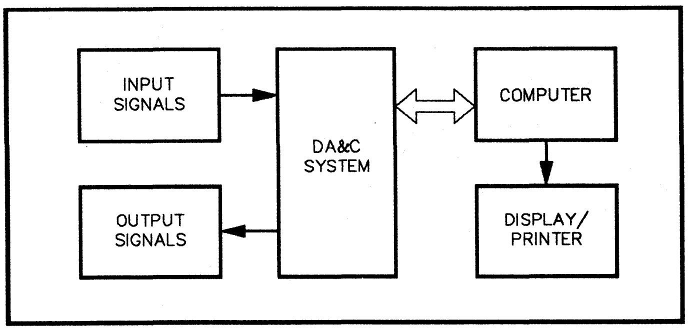

FIGURE 4-5. A Computerized Data Acquisition & Control System.

Because of the obvious advantages of personal computers, along with their increasingly widespread usage, we will assume the use of a PC in this handbook.

In scientific, technical, and industrial environments, the popularity of IBM's personal computers have made them a de facto standard. The PC/XT/AT bus architectures used in these computers have also become industry standards and have been incorporated in a vast array of IBM PC *work-alikes*. Some of these compatible PC models offer advantages in features, performance, and/or cost.

In addition, PC systems based on several other types of bus architectures are being used with increasing frequency in data acquisition applications. These alternate bus architectures include: Micro Channel (used in IBM's PS/2 Series), NuBus (used in Apple's Macintosh II), and Extended Industry Standard Arichitecture (EISA). EISA-based PCs are being manufactured by Compaq and Hewlett-Packard, among others.

In the context of DA&C applications, "true" IBM PC compatibility includes both hardware and software requirements. Only those computers that can run, without modification, the same software written for the IBM PC are compatible with it. Likewise, a compatible machine must accept the same range of add-on (or add-in) boards that plug directly inside the IBM PC.

Inside the IBM PC

The PC consists of a system unit (microprocessor, memory, power supply, etc.), a keyboard, and one or more output devices such as monitors, printers and plotters. The system unit is usually housed in an enclosure, separate from other major components such as the monitor. An exception to this rule would be portable PCs, which integrate all devices into an easy-to-carry case (example: Compaq portables).

"Lap-top" and other miniature computers are usually not included in the true PC-compatible category, because they lack expansion slots. This definition could be debated, because some small computers do offer external expansion capabilities.

An expansion slot is a physical and electrical space set aside for the connection of accessory hardware items to the PC. Electrical connection is made directly to the internal microcomputer bus. These accessory items usually take the form of a plug-in, printed-circuit board (i.e., a graphics interface, a memory expansion module or a data acquisition device).

Plug-in boards can be designed to be addressed by the microcomputer in two different ways, either as I/O ports or as memory locations. There are advantages to both systems. However, memory addressing offers a higher level of performance that includes improved speed, extended address space, and the full use of the processor's instruction set.

Some of the computer I/O and memory addresses are reserved by the computer manufacturers for standard functions (i.e. graphics cards, RS-232 ports, memory, disk controllers, etc.). Most other types of plug-in boards are equipped with a bank of switches that allows the user to select an appropriate address location. Included at the end of this handbook section is a "map" that identifies both the I/O and the memory address allocations for the most common PCs. Thus, if you know your computer's hardware configuration, using the map will make the selection of additional available address locations easy.

PCs employ several distinct memory types: RAM, ROM, floppy disk and hard disk. Other memory technologies include magnetic tape, optical disk, and bubble. RAM and ROM are semiconductor devices offering a very high-speed operation. Random-access memory (RAM) has both read and write capabilities that can be accessed by the microcomputer. Read-only memory (ROM), on the other hand, contains a fixed set of information that can only be read by the microcomputer. The microcomputer itself is often referred to as the central processing unit (CPU).

The name RAM is somewhat of a misnomer, because both RAM and ROM along with many other memory types are random-access. ROM is pre-programmed at the factory to contain the most fundamental CPU operating instructions. This includes the code required to start or to "boot" the computer, which is in a special ROM called the BIOS (basic input/output system). All other active program information is contained in RAM. The amount of RAM that can be used is determined by the particular microprocessor chip used and the available software. The 20-bit address bus of the 8088 limits memory locations to about 1Mbyte. The 80286 has a 24-bit bus which can address about 16Mbytes. RAM is normally termed "volatile", because in most systems its data will be destroyed if power is lost. Permanent storage of data and programs is usually provided by the disk drives.

Most people who use computers will not wish to "talk" directly with the CPU, BIOS or the disk drives because of the complexities involved. Extensive interface software has been developed to bring the power of the PC within easy reach of non-specialists. This software is known as the operating system. The most widely used operating system is PC-DOS (disk operating system) or MS-DOS. Other operating systems include Unix and OS/2.

Even among compatible PCs, the effectiveness of the expansion slots varies considerably. The main considerations include: the number of available slots, the length of the slots, and the power supply available. Because of their mechanical design, some computer types make it easier than others to insert boards into expansion slots.

The speed at which a PC can process instructions (i.e. run a program) is dependent upon many factors. Some ingredients are under the programmer's control. Choice of language and the efficiency of the resulting code are significant. Software efficiency refers, in part, to how many machine cycles are required to execute the desired instructions. A "tight" program requires the fewest number of machine cycles and is thus very efficient, from a time standpoint.

Other factors are related to the PC's electrical design. Selection of the microprocessor chip, additional logic, circuit configuration and clock frequency are all important.

The clock frequency sets the speed of the microprocessor, but not necessarily its execution efficiency. For a given clock frequency one microprocessor can do more work than another. The 8088 and 80286 are both 16-bit chips. However, the 8088's bus can transfer only 8 bits at a time, compared to 16-bits for the 80286. If all other factors are equal, this results in a speed advantage approaching 2:1. Normally, the 8088 is clocked at 4.77MHz. 80286 machines are available with speeds of 6 to 25MHz. Still other characteristics of the 80286 contribute to improved efficiency.

In contrast to the many benefits of the 80286 machines, there is at least one important drawback. In presently available 80286 computers, the configuration of the direct memory access (DMA) circuitry is not optimized for DA&C. This can result in DMA transfers which are slower than expected (by as much as 2:1).

Computers using the new 80386 processor are also readily available. This chip further increases speed and the amount of addressable RAM. 80386 machines running at 33MHz are offered by several companies.

Regardless of the computer's CPU speed, most machines limit their expansion bus speed to 8-10MHz. This helps insure compatibility with older add-in products. The net effect of this is that while faster machines will process acquired data in proportionately less time, they will usually not be able to acquire data at a faster rate.

The IBM PC "memory map" presented in FIGURE 4-6 has been compiled from many sources, including extensive practical experience. It is significant that the region of the PC's memory map that is of most interest to DA&C users is that area with the least available information. "User areas" are open for many potential applications. As such, there is always the possibility of an address conflict. It is very important that only one device (graphics, PCI I/O board, etc.) be set to the same address.

Alternative PCI System Address Location shown in FIGURE 4-6:

1) PC/XT only
2) Without LIM Board
3) PC or AT (not XT)
4) Usually open
5) Without EGA
6) Without EGA
7) AT, without 128K expansion board

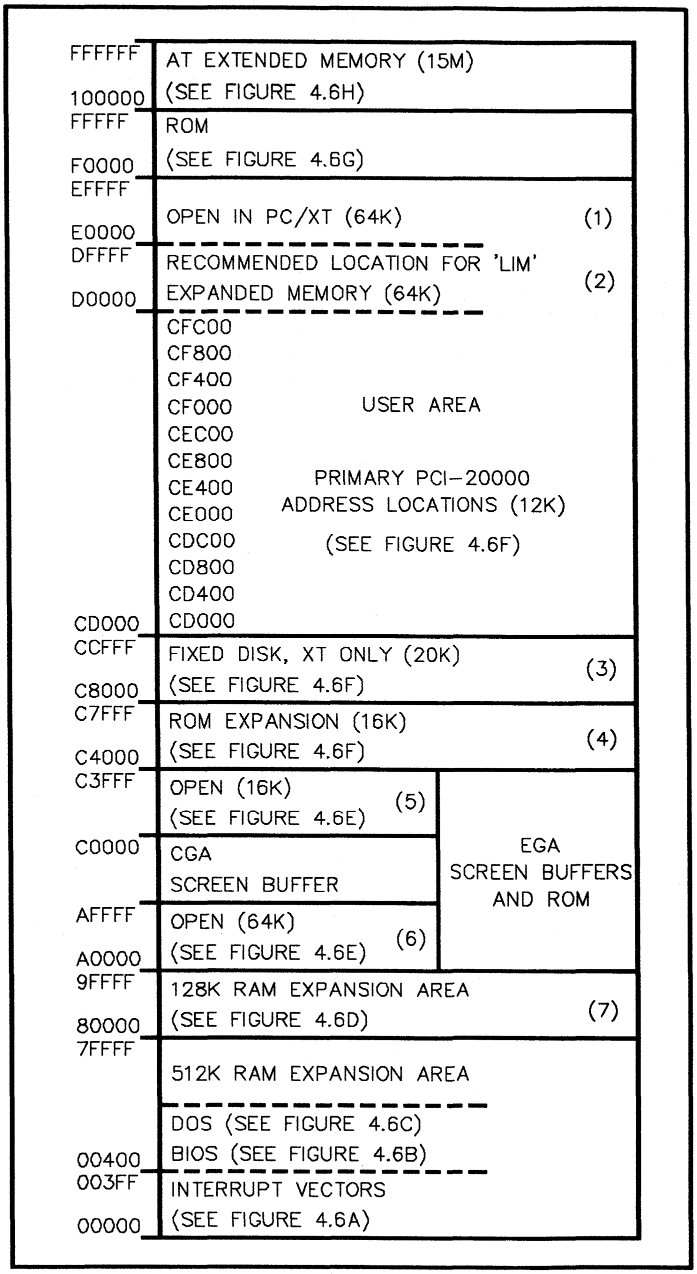

FIGURE 4-6. Memory Map for Most PC/XT/AT Type Computers.

00000-00003	=	Interrupt 0, divide-by-zero error.
00004-00007	=	Interrupt 1, single-step operation.
00008-000B	=	Interrupt 2, non-maskable interrupt.
0000C-0000F	=	Interrupt 3, break-point.
00010-00013	=	Interrupt 4, arithmetic overflow.
00014-00017	=	Interrupt 5, BIOS print-screen routine.
00018-0001B	=	Interrupt 6, reserved.
0001C-0001F	=	Interrupt 7, reserved.
00020-00023	=	Interrupt 8, hardware timer 18.2Hz
00024-00027	=	Interrupt 9, keyboard.
00028-0002B	=	Interrupt A, reserved.
0002C-0002F	=	Interrupt B, communications.
00030-00033	=	Interrupt C, communications.
00034-00037	=	Interrupt D, alternate printer.
00038-0003B	=	Interrupt E, floppy disk atten signal.
0003C-0003F	=	Interrupt F, printer control.
00040-00043	=	Interrupt 10, invokes BIOS video I/O service routines.
00044-00047	=	Interrupt 11, invokes BIOS equipment configuration check.
00048-0004B	=	Interrupt 12, invokes BIOS memory-size check.
0004C-0004F	=	Interrupt 13, invokes BIOS disk I/O service routines.
00050-00053	=	Interrupt 14, invokes BIOS RS-232 I/O routines.
00054-00057	=	Interrupt 15, invokes BIOS cassette I/O, extended AT service routines.
00058-0005B	=	Interrupt 16, invokes BIOS keyboard I/O routine.
0005C-0005F	=	Interrupt 17, invokes BIOS printer I/O.
00060-00063	=	Interrupt 18, ROM BASIC.
00064-00067	=	Interrupt 19, invokes BIOS boot-strap start-up routine.
00068-0006B	=	Interrupt 1A, invokes BIOS time-of-day routines.
0006C-0006F	=	Interrupt 1B, BIOS ctrl-break control.
00070-00073	=	Interrupt 1C, generate timer clock tick.
00074-00077	=	Interrupt 1D, video initialization control param pointer.
00078-0007B	=	Interrupt 1E, disk parameter table pointer.
0007C-0007F	=	Interrupt 1F, graphics character table pointer.
00080-00083	=	Interrupt 20, invokes DOS program termination.
00084-00087	=	Interrupt 21, invokes all DOS function calls.
00088-0008B	=	Interrupt 22, user-created, DOS-controlled interrupt routine invoked at program end.
0008C-0008F	=	Interrupt 23, user-created, DOS-controlled interrupt routine invokes on keyboard break.
00090-00093	=	Interrupt 24, user-created, DOS-controlled interrupt routine invoked at critical error.
00094-00097	=	Interrupt 25, invokes DOS absolute disk read service.
00098-0009B	=	Interrupt 26, invokes DOS absolute disk write service.
0009C-0009F	=	Interrupt 27, ends program and keeps program in memory under DOS.
000A0-000FF	=	Interrupts 28 thorugh 3F, reserved.
00100-00103	=	Interrupt 40, disk I/O (XT).
00104-00107	=	Interrupt 41, fixed disk parameters (XT).
00108-00123	=	Interrupt 42 through 48, reserved.
00124-00127	=	Interrupt 49, keyboard supplement translation table pointer.
00128-0017F	=	Interrupts 49 through 5F, reserved.
00180-0019F	=	Interrupts 60 through 67, user-defined interrupts.

PCI-20026S Series can be programmed to use any one of the interrupts in the range of 60 thru 67. Some programming language editors/compilers use interrupt vector 60.

001A0-001FF	=	Interrupts 68 through 7F, not used.
00200-00217	=	Interrupts 80 through 85, reserved for BASIC.
00218-003C3	=	Interrupts 86 through F0, BASIC interpreter.
003C4-003FF	=	Interrupts F1 through FF, not used.

FIGURE 4-6a. Interrupt Vectors.

00400-00401	=	Address of RS-232 adapter 1.
00402-00403	=	Address of RS-232 adapter 2.
00404-00405	=	Address of RS-232 adapter 3.
00406-00407	=	Address of RS-232 adapter 4.
00408-00409	=	Address of printer adapter 1.
0040A-0040B	=	Address of printer adapter 2.
0040C-0040D	=	Address of printer adapter 3.
00040E-0040F	=	Address of printer adapter 4.
00410-00411	=	Equipment flag.
00412	=	Manufacturing test indicator.
00413-00414	=	Useable memory size in Kbytes.
00415-00416	=	Memory in I/O channel for 64K--planar PC.
00417-00418	=	Keyboard status bits.
00419	=	Alternate keyboard numeric input (future use).
0041A-0041B	=	Keyboard buffer head pointer.
0041C-0041D	=	Keyboard buffer tail pointer.
0041E-0043D	=	Keyboard buffer.
0043E	=	Floppy disk seek status.
0043F	=	Floppy disk motor status.
00440	=	Floppy disk motor timeout.
00441	=	Floppy disk status.
00442-00448	=	Floppy disk controller status bytes.
00449	=	CRT mode code.
0044A-0044B	=	CRT column screen width.
0044C-0044D	=	CRT regeneration buffer length.
0044E-0044F	=	Starting address in regeneration buffer.
00450-00451	=	Cursor position for CRT page 1.
00452-00453	=	Cursor position for CRT page 2.
00454-00455	=	Cursor position for CRT page 3.
00456-00457	=	Cursor position for CRT page 4.
00458-00459	=	Cursor position for CRT page 5.
0045A-0045B	=	Cursor position for CRT page 6.
0045C-0045D	=	Cursor position for CRT page 7.
0045E-0045F	=	Cursor position for CRT page 8.
00460-00461	=	Cursor mode.
00462	=	Active page number.
00463-00464	=	Address of current display adapter.
00465	=	CRT mode.
00466	=	Palette setting.
00467-00468	=	Time count.
00469-0046A	=	CRC register.
0046B	=	Last input value.
0046C-0046D	=	Low word of timer count.
0046E-0046F	=	High word of timer count.
00470	=	Timer rollover.
00471	=	Break indicator.
00472-00473	=	Reboot (Ctrl-Alt-Del) indicator.
00474-00477	=	Fixed disk data area (XT).
00478	=	Printer 1 timeout (XT).
00479	=	Printer 2 timeout (XT).
0047A	=	Printer 3 timeout (XT).
0047B	=	Printer 4 timeout (XT).
0047C	=	RS-232 card 1 timeout (XT).
0047D	=	R-232 card 2 timeout (XT).
0047E	=	RS-232 card 3 timeout (XT).
00480-00483	=	Additional keyboard buffer pointers (XT).
00484-004A8	=	EGA BIOS buffer.
00484	=	Number of character rows.
00485	=	Bytes-per-character.
00487	=	Status byte.
00488	=	Feature bits, DIP switches.
00490-004CF	=	Used by MODE.COM.
004A8	=	Pointer save.
004D0-004EF	=	Reserved.
004F0-004FF	=	Intra-application communication area.

FIGURE 4-6b. BIOS Data Area.

00500	=	Print screen status.
00504	=	Single-drive status (drive A or B).
00510-00511	=	BASIC's default data segment pointer.
00512-00513	=	IP for BASIC's timer interrupt vector.
00514-00515	=	CS for BASIC's timer interrupt vector.
00516-00517	=	IP for BASIC's ctrl-break interrupt.
00518-88519	=	CS for BASIC's ctrl-break interrupt.
0051A-0051B	=	IP for BASIC's fatal-error interrupt.
0051C-0051D	=	CS for BASIC's fatal-error interrupt.
00600-XXXXX	=	DOS and "other things".

FIGURE 4-6c. DOS and BASIC Data Area.

7FFFF	=	Top of 512K.
80000-9FFFF	=	AT, 128K RAM expansion area.*
9FFFF	=	Top of 640K, end of memory expansion area.

**Suggested memory location for installation of PCI-20000 products.*

FIGURE 4-6d. RAM Expansion Area.

A0000-AFFFF	=	Enhanced Graphics Adapter (EGA) screen buffers.*
B0000-B7FFF	=	Monochrome adapter or EGA.
B0000-B0FFF	=	Monochrome screen buffer.
B1000-B7FFF	=	Reserved for screen buffers.
B8000-BFFFF	=	Color/graphics adapter (CGA) or EGA.
B8000-BBFFF	=	CGA buffer.
BC000-BFFFF	=	CGA/EGA screen buffers.
C0000-C3FFF	=	EGA BIOS.*

**Suggested memory location for installation of PCI-20000 products.*

FIGURE 4-6e. CRT Screen Buffers.

C4000-C7FFF	=	ROM expansion area.*
C8000-CCFFF	=	Fixed disk control (XT).*
CD000-CFFFF	=	User PROM, memory-mapped I/O.*
D0000-DFFFF	=	User PROM, recommended "LIM" location.*
E0000-EFFFF	=	ROM expansion area, optional I/O for PC/XT.*

**Suggested memory location for installation of PCI-20000 products.*

FIGURE 4-6f. User Area.

F0000-FDFFF	=	ROM BASIC.
FE000-FFFD9	=	BIOS.
FFFF0-FFFF4	=	First code executed after power-on.
FFFF5-FFFFC	=	BIOS release date.
FFFFE-FFFFF	=	Machine ID.

FIGURE 4-6g. ROM.

100000-FFFFFF	=	I/O channel memory (PC/AT extended memory, 15Mb maximum).

FIGURE 4-6h. PC/AT Extended Memory.

000-00F	=	DMA controller (8237A).
020-021	=	Interrupt controller (8259A).
040-043	=	Timer (8253).
060-063	=	PPI (8255A).
080-083	=	DMA page register (74LS612).
0A0	=	NMI mask register.
200-20F	=	Joystick (game controller).
210-217	=	Expansion unit.
2F8-2FF	=	Serial port (secondary).
300-31F	=	Prototype card.
320-32F	=	Fixed disk.
378-37F	=	Parallel printer (primary).
380-38F	=	SDLC.
3B0-3BF	=	Monochrome adapter/printer.
3D0-3D7	=	Color/graphic adapter.
3F0-3F7	=	Diskette controller.
3F8-3FF	=	Serial port (primary).

FIGURE 4-7. IBM PC/XT I/O Map.

000-01F	=	DMA controller (8237A-5).
020-03F	=	Interrupt controller (8259A).
040-05F	=	Timer (8254).
060-06F	=	Keyboard (8042).
070-07F	=	NMI mask register, real-time clock.
080-09F	=	DMA page register (74LS612).
0A0-0BF	=	Interrupt controller 2 (8259A).
0C0-0DF	=	DMA controller 2 (8237A).
0F0-0FF	=	Math coprocessor.
1F0-1F8	=	Fixed disk.
200-207	=	Joystick (game controller).
258-25F	=	Intel "Above Board".
278-27F	=	Parallel printer (secondary).
300-31F	=	Protoptype card.
060-36F	=	Reserved.
378-37F	=	Parallel printer (primary).
080-38F	=	SDLC or bisynchronous communications (secondary).
3A0-3AF	=	Bisynchronous communications (primary).
3B0-3BF	=	Monochrome adapter/printer.
3C0-3CF	=	EGA, reserved.
3D0-3DF	=	Color/graphics adapter.
3F0-3F7	=	Diskette controller.
3F8-3FF	=	Serial port (primary).

FIGURE 4-8. IBM PC/AT I/O Map.

Data Conversion Principles

As discussed earlier, digital computers, powerful as they are, speak a very limited "language". Most real-world signals are not in a format (for example: amplitude, level, timing) that can be directly accepted by the computer. It is the data acquisition system that performs the translation function. Internal to the data acquisition unit, there is a variety of data acquisition components that facilitate the translation operations. These include: analog-to-digital (A/D) converters, multiplexers, sample/holds, amplifiers, counter/timers and other, more specialized, functions.

Perhaps the most important feature of a data acquisition product is that it brings together these sophisticated functions in a compatible, integrated system. Given the companion software that is available, the user can take advantage of the latest technology without being intimately familiar with the internal details. When selecting a system, however, it is useful to have a basic understanding of data acquisition principles.

Analog Input Systems

The fundamental function of an analog input system is to convert the analog signals into a corresponding digital format. It is the "analog-to-digital converter" (A/D) that transforms the original analog information into computer-readable data (digital, binary code). In addition to the A/D, several other components may be required to obtain optimum performance. These can include: an amplifier, a sample/hold, a multiplexer and signal conditioning elements.

Analog-to-Digital Converters - A significant number of different types of A/D converters exists today. Among these, a few stand out as the most widely used: successive approximation, integrating, and parallel (flash) converters. While flash converters are the fastest, they are also the most expensive. Complexity generally limits these devices to low-resolution (8 bits or less) applications. Most data acquisition tasks usually require a minimum of 12-bit resolution. It is predictable that higher resolution converters are not only more expensive, but they are usually slower. Therefore, it makes sense to carefully consider the application requirements before making a resolution decision.

A good starting point is the input sensor or transducer. Some sensors have very wide dynamic ranges. Dynamic range is the span, or difference, between the maximum full scale signal level and the lowest detectable signal. There is not necessarily a good correlation between sensor accuracy and dynamic range. For example, a 0.5% accurate transducer can have a dynamic range of more than 80dB. This requires a system with at least 12-bit resolution. To maintain maximum dynamic range, some applications may require 14-bit to 16-bit resolution. Amplifying a low-level signal by 10 or 100 increases the effective resolution by more than 3 and 6 bits respectively. Starting with a 12-bit converter, this results in 15 to 18 bits of dynamic range.

A 12-bit system provides a resolution of one part in 4096 (2^{12}) or approximately 0.025% of full scale. 16 bits corresponds to one part in 65,536 (2^{16}) or approximately 0.0015% of full scale. Therefore, resolution not only determines dynamic range; it also limits overall system accuracy. On the other hand, increasing a system's resolution cannot benefit its accuracy if other components such as the amplifier or sample/hold are the limiting factor.

When an input signal change is smaller than the system's minimum resolution, then that event will go undetected. For instance, when using a 12-bit A/D converter (without any pre-amplification), any signal change that does not exceed 2.44 millivolts on the 10 volt range will not be seen by the data acquisition system. In contrast, if the signal is first amplified by 1000 before conversion, the resolution could be increased to 2.44 **microvolts** (in the absence of noise).

For speeds above 100 samples/second the successive approximation converter is most popular. In fact, speeds above 100K samples/second are attainable. Binary weighted "guesses" are compared to the actual input signal until a match is achieved. It is essential that the input signal remain constant during the course of the successive comparisons or very significant errors can result. This requires the use of a sample/hold circuit, as described below.

When high speed is not required, an "integrating" A/D converter can give 12-, 14- or even 16-bit resolution at low cost. Sampling speed is typically on the order of 3 to 50 conversions per second. As the name implies, this converter averages any input signal variations during the conversion cycle. This feature inherently filters input noise. Linearity and overall accuracy are generally better than in the other A/D converters.

Accuracy is an important measure of an analog input system. It defines the total error in any particular reading. For example, a data acquisition system which is specified as accurate to 0.05% of full scale on the 10 volt range, would exhibit a worst-case error of 5 millivolts (10V · 0.0005). If the system is specified as 0.1% accurate on the ±10 millivolt range (for example the A/D on the ±10V range and the PGA in a gain of 1K) the system would exhibit a worst-case error of 20 microvolts referred to the input (20mV · 0.001). In assessing the value of a data acquisition system, the accuracy specification requires careful scrutiny. Be sure the accuracy is specified for the input range of interest.

Amplifiers - Analog input signals can vary in amplitude over a very wide range. The A/D converter, however, requires a high-level signal in order to perform at its best. In many systems an amplifier is provided to boost possible low-level signals to the desired amplitude. Ideally, the input amplifier will have several gain choices available, all under software control. This device is usually called a programmable gain amplifier (PGA). However, cost and performance trade-offs sometimes dictate that the gain of the amplifier should be manually adjusted. Manual adjustment refers to the selection of a resistor or a jumper.

A simple analog input stage is shown in FIGURE 4-9. Remember, the amplifier shown in this diagram may not be required in every application. As shown, this circuit can accommodate only one input channel. One way of measuring several channels would be to duplicate the A/D converter and amplifier for each input signal. However, there is a less expensive way described below.

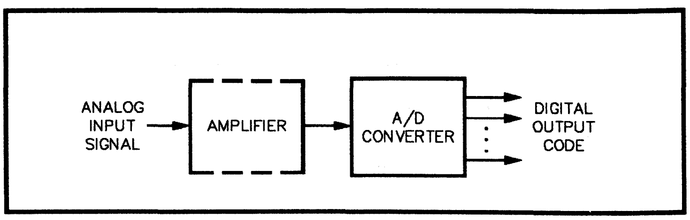

FIGURE 4-9. An Analog Input Channel.

Multiplexers - The multiplexer (Mux) shown in FIGURE 4-10 is simply a switch arrangement that allows many input channels to be serviced by one amplifier and A/D. Software can control these switches to select any one channel for processing at a given time. This approach offers considerable cost savings over separate amplifiers and A/Ds. Since the amplifier and A/D are being shared, the speed of analog acquisition will be reduced. To a first approximation, the rated speed of the amplifier and A/D will be divided by the number of input channels serviced. Throughput rate is often defined as the per-channel speed multiplied by the number of channels.

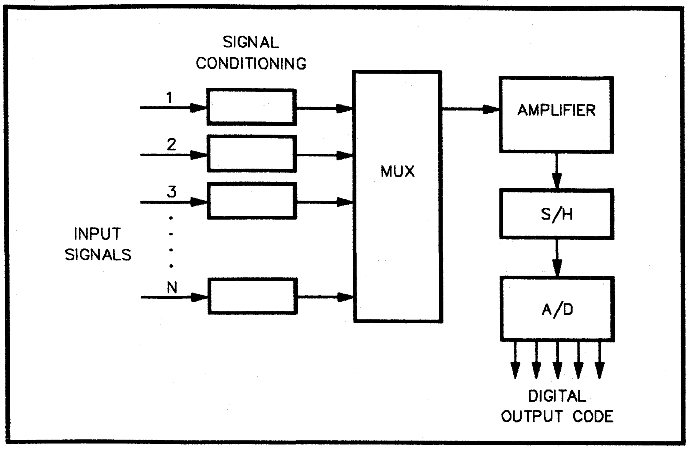

FIGURE 4-10. A Complete Analog Input Subsystem.

Sample/Hold - In general, an analog input signal can change with time. That is, the input could be an AC signal whose amplitude varies continuously. Successive approximation A/D converters require that the input amplitude not change during the conversion cycle. The function of the sample/hold (S/H) is to grab the present value of the signal just before the beginning of an A/D conversion. This level is held constant, despite a changing input, until the A/D conversion is complete. This feature allows the accurate conversion of high-frequency signals.

Time Multiplexing - The system described in Figure 4-10 shares the amplifier, S/H and A/D converter among the various input channels. The user selects the desired sample rate to fit the given application. If each channel is to be read "R" times per second, then the Mux must scan at "n" times this rate (where "n" is the number of channels to be read). Clearly, the S/H and A/D must be fast enough to allow a complete conversion in less than $1/(R \cdot n)$ seconds.

We must be careful not to be misled by the speed specifications of the individual components in the system. *Conversion time* defines only the speed of the A/D converter, which is only part of the total time required to measure a given channel. In order to understand the true speed of a system we must know either the per-channel sample rate or throughput rate, and the conditions under which it was specified (for example, throughput is a strong function of the amplifier gain).

Ideally, all of the input channels will be read at the same time, every 1/R seconds. However, time multiplexing inherently generates a "skew" or time difference between each channel's reading. If the Mux, S/H and A/D combinations are fast enough, then it may appear that the channels are being read at the same instant. Some applications are very sensitive to time skew, such as the measurement of instantaneous electrical power $(I \cdot V)$ or relative position of mechanical components. Given the fastest A/D converters available, there are still many applications that cannot tolerate the time difference between readings resulting from sequential readings. In critical applications the technique of *simultaneous sample and hold* can further reduce time skew by a factor of 100 to 1000 times.

The simultaneous sample/hold architecture is ideal for applications in which the phase and time relationships of multiple input channels are critical to the given investigation. For example, if the system in FIGURE 4-10 were sequentially scanning four analog inputs at a throughput of 89K samples/second, the time elapsing between conversions would be 11.25 microseconds. About 45 microseconds will be required to digitize all four channels. This represents a 162-degree phase shift between the first and fourth channels at a 10kHz signal frequency ($45\mu s/100\mu s \cdot 360$ deg). In contrast, the simultaneous sample/hold system in FIGURE 4-11 can capture all four channels within about 10 nanoseconds of each other, representing a phase shift of less than 0.04 degrees at 10kHz.

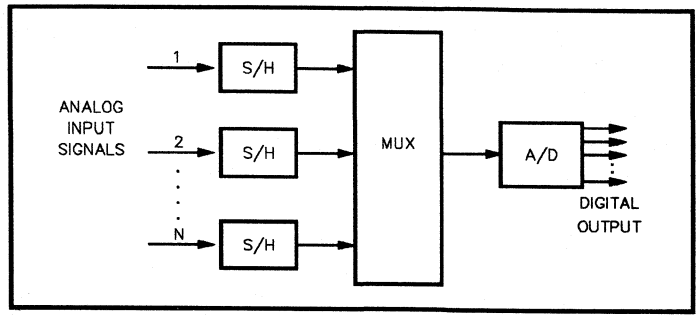

FIGURE 4-11. Simultaneous Sample/Hold Systems.

In addition to phase and time relationships, this technique is particularly useful for applications in which cross-correlation functions must be calculated. Prime examples include: speech research, materials and structural dynamics testing, three-phase electrical power measurements, geophysical signal analysis, and automatic test equipment (ATE) on production lines.

Signal Conditioning - Even with the high-quality components mentioned above, it may be desirable to pre-process the input signals. This task is called signal conditioning and is often divided into two categories. *Active* signal conditioning can include amplification and isolation, while *passive* signal conditioning includes voltage division, surge suppression, current-to-voltage conversion and filtering.

The maximum signal amplitude that can be applied to an amplifier or A/D converter is usually +/-10 volts. Resistive dividers can be used to scale virtually any voltage level down to this acceptable range. Thus, monitoring 48 volts or 480 volts is entirely practical. It is important to consider that the multiplexer and other electronic components can be permanently damaged if signals above 15 volts make direct connection to these devices. The addition of clamping devices such as zeners or MOVs to the signal conditioning network can insure protection against possible input faults or surges.

It is sometimes desirable to preamplify low-level signals (1mV to 1V) outside the main DA&C enclosure to maintain maximum signal-to-noise ratio. One form of this kind of signal conditioning is the *two-wire transmitter*. Transmitters not only amplify the input signal but can also provide isolation, linearization, cold-junction compensation and conversion to a high-level current (typically 4 to 20 milliamps). Current transmission allows signals to be sent up to several thousand feet (1500 meters) without significant loss of accuracy. While voltage signals are rapidly attenuated by the resistance of the connecting wires, current signals are not. In a current loop, the voltage drop due to wire resistance is compensated for by the compliance of the current source. That is, the voltage across the current source automatically adjusts to maintain the desired current level.

When signals are represented by currents, it is a simple matter to convert them to voltage signals with a resistor. Values of 250 to 500 ohms are most common (producing 5- to 10-volt signals, for 4 to 20mA currents).

Of all the signal conditioning categories, filtering is the most widely needed, most widely used, and most widely misunderstood. Simply stated, filtering is used to separate desired signals from undesired signals. Undesired signals include: noise, AC line frequency pick-up, radio/TV station interference, and signal frequencies above 1/2 the sampling frequency. Generally, a low-pass filter is employed to control these unwanted sources of error, by excluding the portion of the frequency spectrum where desired signals do not exist. When input signal frequency components above 1/2 the sampling frequency are allowed at the input to the A/D converter, a phenomenon known as "aliasing" occurs. This results in the generation of spurious signals within the frequency range of interest that cannot be distinguished from real information. Hence, serious errors in the interpretation of the data can occur. This discussion of signal conditioning is intended only to suggest the need for this type of consideration. More detail will be offered in the Signal Conditioning Section.

Single-Ended vs Differential Signals - Analog signals can be configured as either single-ended or differential inputs. Single-ended inputs all share a common return or ground line. Only the high ends of the signals are connected through the multiplexer to the amplifier. The low ends of the signals return to the amplifier through the system ground connections. That is, both the signal source and the input to the amplifier are referenced to ground. This arrangement works fine as long as the ground potential difference is very small. Problems arise when there is a large difference in ground potentials. This causes extraneous currents to flow (a ground loop) which can generate errors. The main advantage of single-ended inputs is the low per-channel cost. Only one multiplexer switch is required to handle each input channel.

A differential arrangement allows both the non-inverting (+) and the inverting (-) inputs of the amplifier to make connections to both ends of the actual signal source. In this way, any ground-loop-induced voltage appears as a common-mode signal and is rejected by the differential properties of the amplifier. While differential connections can greatly reduce the effects of ground loops, they require two multiplexer switches per channel. Thus, a 32-channel, single-ended system can handle only 16 differential inputs. In addition, while a simple op-amp can be used for single-ended inputs, an instrumentation type amplifier is required for differential inputs.

In some applications the so-called "pseudo-differential" connection can be employed. This is actually a single-ended connection in which one of the inputs is connected to the common ground return point of the input signals. Thus, this channel measures the ground-loop-induced voltage, which can then be corrected for in the software. This technique is useful when all of the input signals are referenced to the same ground potential.

Instrumentation Amplifiers (IA) - As suggested above, the instrumentation amplifier is a differential input gain block that presents a very high impedance at both the + and - input terminals. The common-mode rejection characteristics attenuate the effects of ground loops, AC power line pick-up and noise-induced error signals. Thus, the IA is especially useful for measuring low-level signals. When the IA has software-programmable gain, it is known as a PGIA (programmable gain instrumentation amplifier). Because virtually all programmable gain amplifiers in DA&C systems are IAs, we simply refer to PGIAs as PGAs.

Ideally, the input impedance, common-mode rejection and bandwidth of amplifiers would be infinite. In addition, input current and offset voltage would be zero. This implies that the measuring circuit does not influence the signal source. However, real amplifiers do have finite input impedance and input current characteristics as well as offset voltage (Vos). Offset voltage refers to the amplifier's output voltage when zero input is applied (inputs are shorted). Actually, Vos is the input voltage that must be applied to the +/- input of the amplifier to make the output voltage zero. Offset voltage is due to small mismatches in the characteristics of components in the amplifier's input stages. While most amplifiers have provisions for trimming the offset to zero, this is not done without sacrificing other parameters. For example, trimming Vos often generates an additional amount of offset drift (Vos change with temperature) and other non-ideal effects. Vos can be compensated for in the software. The PCI System has built-in provisions for offset correction.

In most cases it is the input current that is potentially most troublesome. Two terms are used to describe input current: bias current (Ib) and offset current (Ios). Bias current refers to the current flowing into (or out of) either the + or the - terminal of the amplifier. Offset current is the difference between the + and - bias currents. In principle, the distinction is important because Ios can be much smaller than Ib. These non-ideal currents interact with the signal source impedance to produce an additional offset voltage term. When the source impedance is balanced (that is, equal at both + and - inputs) it is only Ios that generates an error.

It is essential that an external conductive path exists between the input terminals of the amplifier and its power supply ground. In addition, the resistance of this path must be small enough so that the resulting offset voltage (Ib · Rs) does not interfere with the amplifier's performance. In the extreme case where the inputs are left floating (no external return resistance), the amplifier is likely to reside in a nonlinear or otherwise unusable state. As a general rule, single-ended inputs do not require attention to the bias current return resistance. This is because one side of the input is directly connected to ground and the other input has a return path through the signal source. In contrast, differential connections almost always require the user to provide an external return resistance path. Normally the DA&C system's termination panels have provisions for these resistors. Typically, values of 10K or 100KΩ are used.

Common-Mode Rejection (What It Means)

The ability of a differential-input amplifier to discriminate between a normal-mode (the desired input signal) and a common-mode (undesired) signal is expressed as its common-mode rejection ratio (CMRR in dBs). For a given amplifier, the ratio of its common-mode gain (G_{cm}) to its differential gain (G_{diff}) is:

$$\text{CMRR} = [20 \cdot \text{LOG}_{10}(G_{cm}/G_{diff})]\ \text{dB}$$

Common-mode gain is determined by measuring the change in output (ΔV_{out}) that results from a change in common-mode input voltage (ΔV_{cm}):

$$G_{cm} = \Delta V_{out}/\Delta V_{cm}$$

Substituting this gain relationship into the CMRR equation yields:

$$\Delta V_{out}\ (\text{Due to a } \Delta V_{cm}) = \Delta V_{cm} \cdot G_{diff} \cdot 10^{(-\text{CMRR}/20)}$$

As a general rule, the CMRR of an input amplifier improves as its closed loop gain increases. However, the actual change in output voltage, as shown in the ΔV_{out} equation above, increases with differential gain (G_{diff}). This is important in data acquisition systems because more is involved than just an input amplifier.

In a complete data acquisition system the output signal (data) from the input amplifier (including any errors due to the finite CMRR) makes its way to the analog-to-digital (A/D) converter. The A/D cannot discriminate between the "true" and "error" portions of its input signal. Only the relationship between the magnitude of the error and the sensitivity of the A/D (an LSB) are significant. If the error exceeds an LSB, the A/D responds. Therefore, it is often desirable to express common-mode error in terms of LSBs. This is done by dividing the common-mode error voltage (ΔV_{out}) by the sensitivity of the A/D (1LSB on the given range). Sensitivity is equal to the converter's full-scale range (FSR) divided by its resolution (number of steps).

$$\text{Error}_{cm}\text{ (in LSBs)} = \frac{\Delta V_{cm} \cdot G_{diff} \cdot 10^{(-CMRR/20)}}{\text{FSR/Resolution}}$$

The following table shows the relationship between common-mode error expressed in dBs and LSBs for a hypothetical input system. A 12-bit A/D on a 10-volt range (0 to 10V or ±5V) is assumed in this comparison. A 10-volt common-mode signal is applied to the shorted (connected together) input terminals of the system. Dividing the common-mode error (in LSBs) by the common-mode voltage yields a direct (useful) figure of merit for the complete data acquisition system, **not just the input amplifier.**

SIGNAL GAIN	CMRR	ERROR$_{CM}$, ABSOLUTE	ERROR$_{CM}$/V$_{CM}$
1	80dB	0.4LSB	0.04LSB/Volt
10	90dB	1.3LSB	0.13LSB/Volt
100	100dB	4.1LSB	0.41LSB/Volt
1000	110dB	13LSB	1.3LSB/Volt

Note that an increase (improvement) in CMRR at a given gain improves the system's performance. However, the (relatively small) increase in CMRR, as a result of increasing gain, actually results in a decrease in the system's overall accuracy.

Analog Outputs

In many applications analog output signals are required. These signals are used to drive chart recorders, to provide feedback in closed-loop control, and to initiate a variety of other tasks. Common analog output ranges include ±5V, ±10V, 0-10V and 4-20mA.

When operating in the voltage output mode, most D/A converters can supply up to 5 or 10mA of load current. However, some multiple output systems have ratings as low as 1mA. This is not usually a limitation, because the majority of these applications call for driving high impedances. When large loads such as positioners, valves, lamps and motors are to be controlled, power amplifiers or current boosters are required. Most DA&C systems do not include high-power analog drivers within the standard configuration.

Digital Inputs and Outputs

Most data acquisition systems are able to accept and generate TTL level signals (0 to 5 volts). However, applications often require an interface for other discrete voltage levels. Higher voltage and current outputs are also required to control devices such as solenoids, motors and relays.

Many types of standard signal termination panels are available to facilitate the connection of the field wires to the DA&C system. These termination panels have provisions for screw terminal connections, signal conditioning, channel status indicators (LEDs), voltage dividers and isolators. Thus, the monitoring and control of high DC levels, along with AC line voltage circuits, are readily accomplished.

These features will be described in more detail in the Signal Conditioning Section of this handbook.

Pulse and Frequency Inputs and Outputs - A variety of counting, timing and frequency measuring applications exists. Other applications require that devices be turned on and off for precise time periods. All of these functions can be provided by *counter/timer* (C/T) circuits. The system's counter/timers are optimized for pulse applications including frequency measurement and timebase generation. Counters are characterized by the number of input events that can be accumulated and by their maximum input frequency. Most systems employ 16-bit counters that can accumulate pulses at frequencies up to 8 megahertz. Up to 65,536 (2^{16}) events can be accumulated before the counter overflows. The counters are all independent of each other and can be used to count events, measure frequency or act as frequency dividers. The pulse generators (rate generators) are software programmable over a very wide range of frequencies and duty cycles. A rate generator is often used to provide the precise timebase required for accurate data acquisition.

The digital counters available in most DA&C systems accept TTL level signals and can be used to accumulate the number of input pulses. Counting can be started from a defined initial value and the counter can be configured to automatically reset to this value after it has been read. Internally, the counter actually decrements or subtracts a count for each input pulse. However, software can easily interpret the counter's data as a sum or difference from an arbitrary starting point. When a 16-bit counter exceeds 65,535 or the initial count value (whichever is smaller), an overflow occurs and generates a digital output. This signal can be used to activate external events. Of great significance is that the next input pulses simply cause the counter to decrement from 65,535. Thus, if overflows are detected and accounted for, total counts of any size can be accumulated in the software.

Frequency measurements using counters can be accomplished in different ways, depending upon the application. When the unknown frequency is a TTL signal, it can be applied directly to the counter circuit. Analog signals with an amplitude of at least 100mV can be converted to TTL levels with the PCI system's Trigger/Alarm Module (PCI-20020M-1). Voltage dividers using resistors and/or zener diodes or opto-isolators can be used to scale down high-level signals. When using any kind of signal conditioning before the counter input, consideration should be given to possible resulting speed limitations.

Two distinct options exist for measuring high or low frequencies. The first method counts a known clock generator for the period of the unknown input signal. This provides high resolution for low-frequency signals, while minimizing the time required for the measurement. Generally this is used for frequencies below 10Hz. The second method counts cycles of the unknown input signal for a fixed time interval. The advantage of this technique is that it allows measurements beyond 8MHz. It is easy to implement an auto-ranging software algorithm that optimizes resolution over a very wide frequency range.

Software Techniques

The previous personal computer section briefly discussed the role of DOS and other operating systems. Everyone knows that a computer is made to perform a useful task by programming it with a series of instructions. At the chip level, the system can respond only to the most primitive digital commands: an input is High or Low (On or Off, I or O). Semiconductor circuits do not understand "Add", "Multiply", "Read" or "Print". They can understand that a given voltage is, or is not, present at an input. So ultimately, all communication with a computer is in terms of digital ones and zeros. In the beginning, only this "machine language" existed. Programming was slow, error prone, difficult to maintain, and— approached only by specialists.

The invention of *compilers* changed everything for the better. A compiler accepts (understands) alphanumeric inputs and translates them into machine-readable code. Sensible combinations of alphanumeric inputs (acronyms or other recognizable words) are defined to be equivalent to a pattern of digital inputs. Thus, the compiler (an intermediate program) provides a more practical human interface. Assembly language is the first step above machine code. An *assembler* is a low-level compiler that converts assembly language into machine code. The resulting code works with the computer's operating system to further simplify a specific programming task. For most, Assembly language is not simple. It is, however, much more manageable than machine code.

What else can be done to improve the situation? Languages such as BASIC can now come into play. These "high-level" languages perform still more complex operations while presenting an additional degree of recognizable English (still dominated by jargon and special syntax, however). Each of the many high-level languages has been fine-tuned to excel in particular areas. BASIC is best known for the ease with which it can be learned and used. Other languages (C, PASCAL, etc.) are recognized for their execution speed and program maintainability.

As was explained earlier, the use of a high-level language requires that a compiler be used to translate the written program into machine code. Compiled languages are converted before run-time and executed in that form (e.g., C and PASCAL). The entire program must be debugged as a whole. "Interpreted" languages are incrementally compiled (e.g., BASIC). That is, as *each line* of the original code is read, it is then converted and executed. This permits a single program line to be written and tested independently.

One sometimes gets the feeling that the differences between computer languages are smaller than they are made out to be.

Imagine asking an international gathering to select the best, single, spoken language for all to use! Similar disagreements about the best computer language also exist.

Software makes the computer-based data acquisition and control system operational. A low-cost, powerful hardware system is of little value without appropriate software.

Personal computer-based data acquisition systems have been designed so that users have the opportunity to write specialized programs for data acquisition, storage, display, logging, and control in high-level languages. When software is provided with a data acquisition system, it should make these tasks as simple as possible for the user.

Three classes of software are generally available for PC-based DA&C systems: tutorial and program development tools, function subroutine libraries, and complete "turn-key", menu-driven application packages.

Program development tools and function libraries are packages designed to allow users to write their own unique application software. They usually include "drivers" that provide the interface to the I/O hardware. These packages make it very easy to write programs in high-level languages such as BASIC, C, TURBO PASCAL and ASYST. This type of programming is very flexible and is useful for general purposes.

Complete application packages are designed to get the system going immediately, usually with no programming required. However, some of these packages offer users the facilities to enhance or modify the software to meet their own needs. Normally, this type of product is directed at a specific type of application. As a result, these packages are often quite structured and less flexible than are the other classes of software.

Third-party software is that vast collection of "generic" software products designed by independent companies to serve hardware built by others. Some well-known products include LABTECH NOTEBOOK, Hypersignal-Workstation and SNAP-Series. These and many other software packages provide data collection, analysis, plotting, and control capabilities. In the Product Selection Guide section of this handbook are several examples of third-party software being used with PCI products.

Many, if not most, data acquisition and control applications depend upon the timely execution of read/write operations. When speed and/or timing are critical, three techniques for software control should be considered: polling, interrupts and direct memory access (DMA).

As would be expected, each has its special merits and requirements. Polling is the simplest method for detecting a unique condition and then taking action. This involves a software loop that contains all of the required measurement, analysis, decision-making algorithms and planned actions. The data acquisition program periodically tests the system's clock or external trigger input to sense a transition. Whenever a transition occurs, the program then samples each of the inputs and stores their values in a buffer. A buffer is simply a storage location that contains the values representing the specified inputs at a given time. The buffer can be stored in RAM, disk or other types of memory. Each time the program senses a clock "tick", the inputs are scanned and converted, and a new value is added to the buffer. In this mode, the PC/AT can support a data acquisition rate of about 180kHz, depending upon the CPU clock rate. On the other hand, the design of the PC is such that potentially significant variations (or jitter) in timing can occur. In the IBM PC, jitter of approximately 12 microseconds is not uncommon. In addition, the PC is continuously busy when the polling loop is operational, and hence no other tasks can be serviced. When an application cannot tolerate these characteristics, interrupt techniques may be indicated.

Interrupts do provide a means of tightly controlling the timing of events, while allowing the processing of more than one task. Multitasking systems are also known as "foreground/background" systems. One way of putting data acquisition in the background is to relegate it to an interrupt routine. The clock or external timing signal, rather than being polled continuously, is used to generate an interrupt to the computer. Whenever the interrupt occurs, the computer suspends current activity and executes an "interrupt service routine". The interrupt service routine in this case might be a short program which acquires one frame of data and stores it in a buffer. The computer can perform other operations in the foreground while collecting data in the background. Whenever a clock tick or external interrupt occurs, the computer will automatically stop the foreground processing, acquire the data, and then resume where it left off.

The reaction speed of the interrupt system is much slower than that of a well-written polling loop. This results because the interrupt mechanism in most computers involves a significant amount of software overhead. Speed, for an IBM PC, is about 4kHz in the interrupt mode. Also, the software complexity of interrupts can be significant. In most cases the programmer must be prepared to write assembly language code. In contrast, most polled systems can be written in a high- level language. Interrupts are useful in situations where the acquisition rate is slow, timing accuracy is not a priority, and background operation is important. When the amount of time required to service an interrupt is small, compared to the rate at which the interrupts can occur, then this technique yields excellent results. These factors should make it clear that careful thought is warranted before making a polling/interrupt question.

DMA is a hardware technique that often allows the highest speed transfer of data, to or from random access memory (RAM). Given the potentially more expensive hardware, DMA can provide the means to read or write data at precise times without significantly restricting the microprocessor's tasks. For example, the PCI System, under DMA control, can read or write any combination of analog, digital or counter/timer data to or from RAM at a maximum rate of 360Kbytes/second. This is accomplished by taking minimal time from the other tasks of the microprocessor. The amount of time required to respond to a DMA request is very small compared to the time required to service an interrupt. This makes the goal of high-speed foreground/background operation possible.

Field Signals and Transducers

A good DA&C system does everything practical to simplify the handling of a wide variety of field signals. However, it is helpful for the user to have a basic knowledge of the types of signals that the system may be called upon to read or generate. This section reviews what the most common signals consist of, and shows how the DA&C system deals with them.

Transducers - Whatever the phenomena detected or the device controlled, transducers play a vital role in the DA&C system. It is the transducer that makes the transition between the physical and the electrical world. Remember that data acquisition and control can involve both input and output signals. Input signals can represent force, temperature, flow, displacement, count, speed, level, pH, light intensity, etc. Output signals can control valves, relays, lamps, horns, motors, etc. The electrical equivalents produced by input transducers are most commonly in the form of voltage, current, charge, resistance or capacitance. As shown later, the process of signal conditioning will further convert these basic signals into voltage signals. This is important because the major interior blocks of the DA&C system can only deal with voltage signals.

Signal Types - It is necessary to further define three types of voltage signals: analog, digital and pulse. While all signals are assumed to be changing with time, analog signals are the only ones to have information contained in their incremental variations in amplitude. The pulse signals referred to here are similar to the digital signals in many respects. Both digital and pulse signals are of uniform amplitude and are represented by only two possible values (high and low). Typically, these high and low levels are approximately 5 and 0 volts, respectively (TTL levels). The actual allowable ranges for TTL signals are:

low level = 0V to 0.8V
high level = 2.0V to 5.0V

However, other levels including 110 or 220 VAC (line voltage) can be accommodated.

So, with analog it is important *how high* the signal is, while with digital it matters only *if* the signal is high or low (on or off, true or false). The distinction between digital and pulse signals lies in the information conveyed and the type of data acquisition hardware utilized. Digital signals are sometimes called "discrete" signals. A given digital bit is one channel of the DA&C system's digital port. While all digital signals have the potential to be changing states at high speed, information is usually contained in the static state of a bit or group of bits at a given time. In contrast, pulse information is usually contained in the number of state transitions that have occurred or in the rate at which the state transitions are occurring (pulses/second). Refer to FIGURE 4-12 for a look at the differences between analog and digital signals.

Analog signals will be transformed into a digital representation (binary number) by the system's analog-to-digital converter (A/D). When analog outputs are required, they will be generated by the system's digital-to-analog converters (D/A). Analog inputs usually come from some type of preamplifier where the primary sensor signal has been conditioned and amplified for presentation to the data acquisition system. Most preconditioned signals are of a relatively high amplitude, in the range of ±1 to ±10 Volts. However, many primary sensors, such as thermocouples, photovoltaic cells, piezoelectric sensors and biomedical sensors produce small signals that may have a full scale range of only 10 millivolts. A quality data acquisition system must handle both high- and low-level signals with equal ease and accuracy.

Thermocouples - The thermocouple (TC) is so widely used for temperature measurement in industry and science, that it will be given special treatment. Physically, a TC is a junction of two dissimilar metals. This junction produces a thermal EMF (voltage) proportional to the temperature of the junction (Seebeck effect). Temperatures of -200°C to +4000°C can be measured. The output voltage is usually in the range of -10 to +50 millivolts and has an average sensitivity of 10 to 50 microvolts/°C, depending upon the TC used. Many thermocouple types, using different combinations of metal alloys, are in wide use. For convenience, alphabetic letter designations have been given to the most common.

These include:

J	Iron-Constantan	(Fe-C)
K	Chrome-Alumel	(Ch-Al)
T	Copper-Constantan	(Cu-C)

Tungsten, rhodium and platinum are also popular metals, particularly at very high temperatures.

While TCs are both low in cost and very rugged, they are not without their limitations and applications problems. Accuracy is generally limited to 1-3% due to material and manufacturing variations. In addition, response time is slow (on the order of several seconds), and both nonlinearity and compensation must be made for multiple junction phenomena.

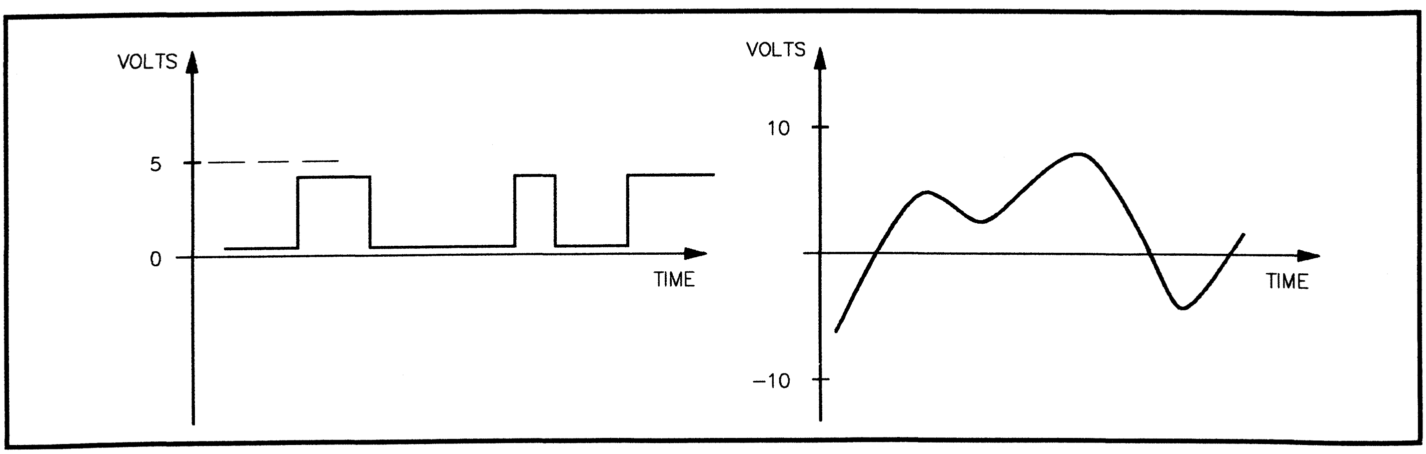

FIGURE 4-12. Digital and Analog Signals.

The Law of the Junction - A single thermocouple junction generates a voltage proportional to temperature:

Equation: $1\ V = k\ (t)$,

where "k" is the Seebeck coefficient, defining a particular metal-to-metal junction and "t" is in degrees Kelvin.

Seebeck voltage cannot be measured. When connecting the TC to a measuring system, the connection directly leads themselves create a new thermoelectric circuit. As an example, consider connecting a voltmeter to a copper-constantan (Type T) thermocouple as in FIGURE 4-13.

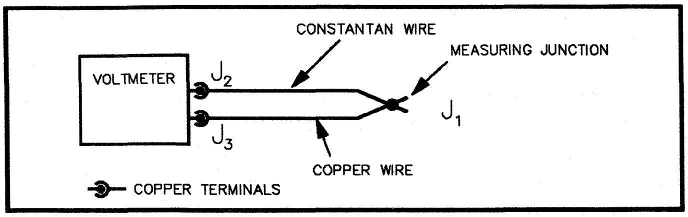

FIGURE 4-13. The Thermocouple Measurement Problem— Extra Junctions.

It is desired that the voltmeter read only V_1 (of J_1), but the act of connecting the voltmeter creates two more metallic junctions: J_2 and J_3. Since J_3 is a copper-to-copper junction, it creates no thermal EMF (V_3=0) but J_2 is a copper-to-constantan junction which will add an EMF (V_2) in opposition to V_1. As a result the voltmeter reading, V_v, will be proportional to the temperature difference between J_1 and J_2. This means that determining the temperature at J_1 requires a knowledge of the temperature at J_2.

One way to establish the temperature of J_2 is to physically put the junction into an ice bath, forcing its temperature to 0°C. This defines J_2 as a Reference Junction (t_2 - t_{ref}), and therefore:

Equation 2: $V_v = (V_1 - V_{ref}) = k\ (t_1 - t_{ref})$

Note that even under these conditions (see Equation 1), V_{ref} is not 0 volts. The Seebeck relationship is based upon the Kelvin (absolute zero) scale. It is also important to remember that k is highly nonlinear with respect to temperature. However, tables have been compiled that yield not only V_{ref} at any temperature, but more directly, V_v when t_{ref} is 0°C. These tables take variations in k into account and can provide t_1 directly in terms of V_v, assuming that t_{ref} is at 0°C. Note that both the measuring and reference junctions are both Copper-Constantan.

The copper-constantan TC used in this example is a special case because the copper wire is the same metal as the voltmeter terminals. It is interesting to look at a more general example using iron-constantan (Type J). The iron wire increases the number of dissimilar metal junctions in the circuit, as J_3 becomes a Cu-Fe thermocouple junction. However, it can be shown that if the Cu-Fe and the Cu-C junctions (at the termination panel) are at the same temperature, the resulting EMF is equivalent to a single Fe-C junction. This allows the use of Equation 2, noting that both the measuring and reference junctions are of the same materials (Fe-C, in this case). Again, it is very important that both "parasitic" junctions be held at the same reference temperature. This can be aided by making all connections on an isothermal (same temperature) block.

Clearly, the requirement of an ice bath is undesirable for many practical reasons. Taking the analysis to the next logical step, Equation 2 shows that t_{ref} need not be at any special temperature. It is only required that the reference temperature be accurately known. If the temperature of the isothermal block (the reference junction) can be measured independently, this information can be used to compute the unknown temperature, t_1.

Devices like thermistors, RTDs, and semiconductor sensors can provide a way to measure the absolute temperature of the reference junction. Therefore, under computer control:

1) Measure t_{ref} and compute the equivalent TC voltages for the parasitic junctions (V_{ref}).
2) Measure V_v and subtract V_{ref} to find V_1.
3) Convert V_1 to the desired temperature t_1.

This procedure is known as software "cold-junction" compensation, because it relies upon the computer to account for the effects of the reference junction.

If a device that measures absolute temperature (such as RTDs, thermistors and IC sensors) is already available, why bother with a thermocouple that requires cold-junction compensation? First, thermocouples can be used over a very wide range of temperatures, while the other devices are useful over a more limited range. Secondly, they are much more rugged than the competitive devices, as evidenced by the fact that thermocouples are often welded to a metal part or clamped under a screw. Thirdly, they can be constructed in the desired lengths in the field, either by soldering or welding. Fourth, a singe reference sensor can be used to compensate many thermocouples. In short, thermocouples are the lowest cost, most versatile temperature transducer available. Since the DA&C system can perform the entire task of cold-junction compensation and voltage-to-temperature conversion, using a thermocouple becomes as easy as connecting a pair of wires.

When selecting a thermocouple, the following factors should be taken into account:

Type J **Lowest cost**, Highest sensitivity, Moderate accuracy. Should not be used above 760°C because of severe decalibration.

Type K Moderate cost, Moderate sensitivity, Low accuracy, **High temperature range**. Can be used to 1372°C due to its high resistance to oxidation.

Type T Moderate cost, Moderate sensitivity, High accuracy. **Very useful at low temperatures**. Because one lead is copper, cold-junction compensation is not required when making differential temperature measurements with two back-to-back TCs.

For J, K and T type thermocouples, the red colored lead is always the negative terminal.

Thermistors - The thermistor is a metal oxide or semiconductor device that changes resistance with temperature. While positive temperature coefficient devices are available, most units exhibit a negative slope. This temperature coefficient can be as large as several percent per degree Celsius. This makes it possible to resolve smaller changes than with other devices (0.01°C). The accuracy of thermistors is typically 10 times better than that of thermocouples, yielding ±0.1°C under some conditions. Only the platinum RTD has better accuracy. The physically small size and high nominal resistance are significant advantages. Small size yields a fast response, while the high resistance makes any error, due to lead-wire resistance, small.

Along with the high sensitivity goes a high degree of nonlinearity. However, several manufacturers offer devices that have excellent conformance to published tables. While an individual unit exhibits a third-order logarithmic relationship, combinations of positive and negative slope devices can be made to have highly linear relationships. These units can be used from -50 to +100°C. In addition to the limited temperature range, attention must be given to the fragile nature of these devices. Careful mounting and handling must be used to avoid accuracy-destroying stress or catastrophic crushing.

Since it is basically a resistor, a thermistor can be read in several ways. These include current excitation (read a voltage) and voltage excitation (a voltage divider is formed with a fixed resistor). In either case, current must be passed through the measuring device. This will generate internal power dissipation that can produce an error-causing temperature rise. As a general rule, the self-heat error associated with this device can be estimated by dividing the proposed internal power dissipation by 8 milliwatts (yielding rise in °C). This rule applies to small bead thermistors in a conductive environment (like oil or water).

In all cases, excitation levels must be held to a very low level to achieve high accuracy.

Resistance Temperature Detectors (RTDs) - As thermistors, RTDs exhibit a changing resistance with temperature. Several different metals can be used to produce RTDs, but for a number of reasons, platinum has proven to be the most widely used. One notable exception to this rule is tungsten, which does find applications at very high temperatures. RTDs always have a positive temperature coefficient, with a small nonlinearity. For accurate measurements a third-order polynomial correction should be applied. Many data acquisition systems provide this built-in linearization capability.

Most RTDs are of either wire-wound or metal-film designs. The film design offers faster response time, lower cost and higher resistance values than the wire-wound types. The more massive wire-wound designs are more stable with time. High resistance is desirable because of the potential for lead-wire induced errors. However, even the so-called high resistance units require careful attention to lead-wire effects. Because of the excitation current required to produce a measurable signal, self-heating can also be a factor. However, the dissipation constant of an RTD is about ten times that of a thermistor. In this case, an estimate of the temperature rise (in °C) can be found by dividing the internal power dissipation by 80 milliwatts. Again, this is a general rule that applies to small RTDs in a conductive fluid like oil or water.

Most platinum RTDs are built with 100 or 200 ohm elements. 100-ohm metal-film devices seem to be the most popular. These units have sensitivities of about +0.4 ohms°C. The combination of low sensor resistance and low sensitivity suggests the use of a bridge type of measuring configuration.

Solid State Temperature Sensors - These devices are derived from modern silicon integrated circuit technology, and are often referred to as Si sensors. They consist of electronic circuits that exploit the temperature characteristics of active semiconductor junctions. Versions are available with either current or voltage outputs. In both cases the outputs are directly proportional to temperature. Not only is the output linear but it is of a relatively high level, making the interpretation very easy. The most common type generates 1 microamp per degree Kelvin (298 microamps at 25°C). This can be externally converted to a voltage by using a known resistor. The usable temperature range is -50 to +150°C. The stability and accuracy of these devices are good enough to provide readings within ±0.5°C. It is easy to obtain 0.1°C resolution.

Strain, Pressure, Force, Position, Displacement and Level - These and many other types of transducers are often characterized by their responses to physical movement. Crystal and resistive strain gauges, linear voltage displacement transducers (LVDTs), slidewires (resistive potentiometers), and capacitive sensors are among the most common. While each of these sensors is based upon very different principles, the ultimate output signals are ordinary voltages, currents or impedances. These signals are directly or indirectly represented by analog voltage levels. Hence, the techniques described in this handbook can be applied to these types of transducers. Sensors that require external excitation present an accuracy dilemma. Invariably, higher excitation levels yield greater transducer output. However, this also leads to internal power dissipation that can cause errors even in mechanical devices. An optimum excitation level exists for each type of device. If additional information about a specific transducer is desired, reference to the manufacturer's data sheet or to one of the available texts is suggested.

Flow, Speed and Count - Flow and speed can be measured in several ways. These include resistive, piezoelectric and thermal techniques. As discussed previously, these methods ultimately generate analog voltage signals. Transducers such as shaft encoders, paddle wheels (turbine), and both optical and magnetic pickups typically have digital or pulse outputs. The desired speed, rate or number of events can be determined by using digital counting or frequency measurement techniques. The methods for acquiring analog, pulse and frequency signals are covered elsewhere in this handbook.

Light Intensity and Chemical Action - These parameters are often encountered in density, spectroscopy and pH measurements. The transducers are characterized as having a very high output impedance. The light-activated devices typically are modeled as current sources, while the chemical devices look like voltage sources with high series resistance. In most cases, the raw signals from these types of transducers cannot be directly processed by standard DA&C systems. Even the excellent characteristics of the modern PGAs discussed earlier are inadequate in these specialized applications. However, many transducer manufacturers include the necessary preprocessing as an integral part of their product. When they do, the signals are then high-level voltages or currents which can be read as outlined elsewhere in this handbook.

Low-level currents are often preprocessed with an FET input op-amp operating as a current-to-voltage converter (transimpedance amplifier). As suggested earlier, all amplifiers have finite input bias currents that can produce errors. FET input amplifiers have bias currents that are often below 1 picoamp (10 to 100 femtoamp units are available), which makes them useful for the majority of practical applications.

High impedance voltage sources are also preamplified with FET input amplifiers. In this case the op-amp is configured as a non-inverting voltage amplifier. This can yield input impedances on the order of 10^{14} ohms, which satisfies most high impedance transducer applications.

Detailed information about selecting and applying FET amplifiers can be found in the Burr-Brown components data book, as well as in several Burr-Brown textbooks and application notes.

Resistance - Resistance signals arrive at the data acquisition system from primary sensors such as strain gages and RTDs. A resistance sensor is usually measured as part of a Wheatstone "bridge" circuit. A bridge is a symmetrical, four-element circuit that enhances the system's ability to detect small changes in the sensor. The sensor can occupy 1, 2 or 4 arms of the bridge, with any remaining arms being filled with fixed resistors. A differential voltage signal is developed across the arms of the bridge when the sensing resistors vary from their nominal values as a result of temperature or strain.

Transducer excitation, as well as provisions for the insertion of bridge-completion components, can be provided on signal *termination panels*. While both voltage and current excitation can be

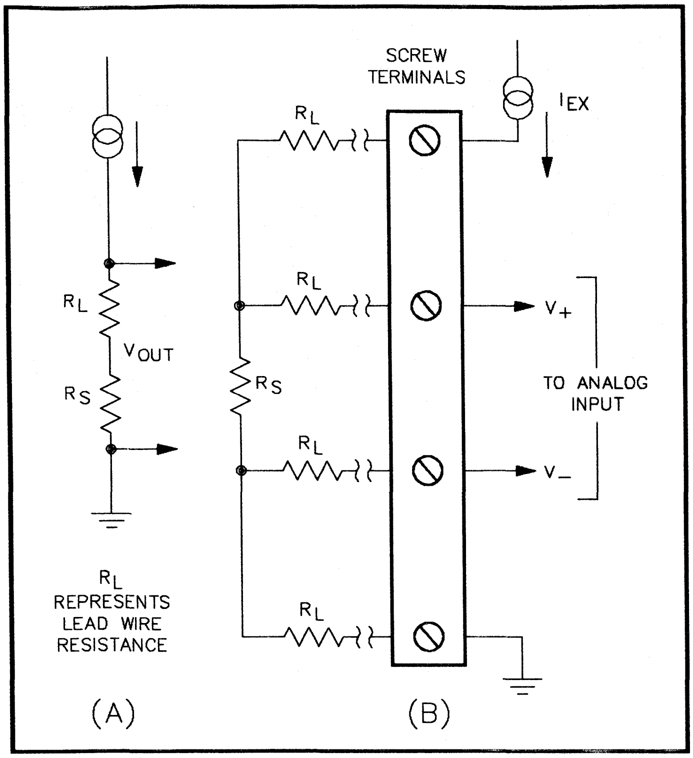

FIGURE 4-14. Measuring a Resistive Device.

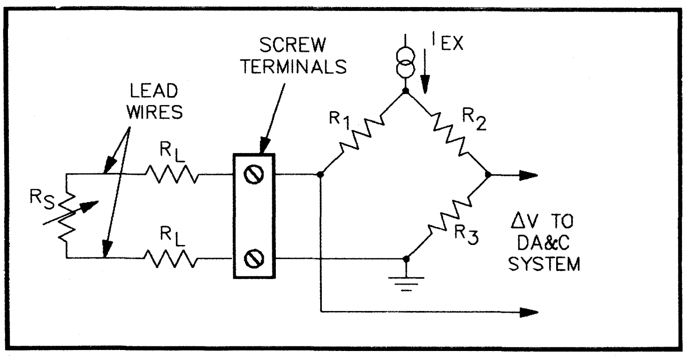

FIGURE 4-15. A Two-Wire Bridge Configuration.

used, current excitation is generally more desirable. This is because current excitation provides a more linear output response, making the data interpretation easier. The PCI System provides adjustable current sources that can be optimized for the type of transducer being measured.

The diagrams included here show some of the more common configurations for resistive bridge elements. Bridge-completion resistors should be of very high precision (typically 0.05%). Stability is actually the most important characteristic of the bridge-completion elements. Initial inaccuracies can be calibrated out, but instability always appears as an error. More information about bridge circuits and their transfer functions can be found in the Burr-Brown textbook series.

Transducers, such as strain gauges and RTDs, have relatively low sensitivity. That is, the change in resistance is small for a given change in the input parameter. Simply measuring the change in voltage (due to a current excitation) across the device is difficult. Not only is the change in voltage small, but it is "riding" on the device's quiescent (IR) voltage. The quiescent voltage greatly limits the amplification that can be used to amplify the voltage change. Let us explore this concept in more detail. Fundamentally, a DA&C system can measure only voltage. Fortunately, as has been suggested, all other types of signals can be transformed into voltages. To convert a changing resistance, we need only to "excite" it with a current. The voltage across the resistance is then (I · R). FIGURE 4-14 (A) shows the basic idea.

A real application might involve a 100-ohm platinum RTD. To control internal self-heating, the excitation level is usually limited to 2mA. Given that the sensitivity of this type of device is about +0.4 ohms/°C, the output will be about 0.8mV/°C. This is indeed a small signal that will require amplification. It would be useful to multiply the signal by 100 to 1000 times to make best use of the A/D's full-scale range (typically, 5 or 10V). However, the quiescent voltage across the RTD is (2mA · 100 ohms) = 0.2V. This limits the maximum gain to 10. Thus, in a 12-bit system, the smallest detectable temperature change is about 0.5°C. In contrast, the bridge circuits shown balance out the fixed or quiescent voltage drop, allowing greater magnification of the difference signal. This allows the detection of changes as small as 0.005°C.

The effects of lead-wire resistance should also be considered. The output voltage is proportional to the sum of the RTD resistance and the connecting wire resistance (R_L). In many applications this "wire error" can be very significant. FIGURE 4-14 (B) suggests a solution. This is the so-called Kelvin or four-terminal connection. Wire resistance cannot be eliminated, but this measurement technique greatly reduces the effects. The idea is to connect two wires to each end of the measuring device. One lead carries the excitation current and the other senses the terminal voltage. Current in the sense or measurement lead is very small and can be assumed to be zero. This is because the DA&C system has a very high input impedance. Thus, no voltage drop occurs in the sensing lines. Note that under these conditions the drops in the excitation lines are not in the measurement circuit.

The most common resistive sensors are of the one- and four-element types. Both the two-wire and three-wire bridge configurations are intended to monitor single-element transducers. These are transducers that are represented by a single resistor that is exposed to, and is sensitive to, the measured parameter. In the four-element circuit, all four of the resistors react to the measured parameter. As might be expected, this configuration offers four times the sensitivity of a single-element bridge. In addition, the four-element bridge offers the most linear response.

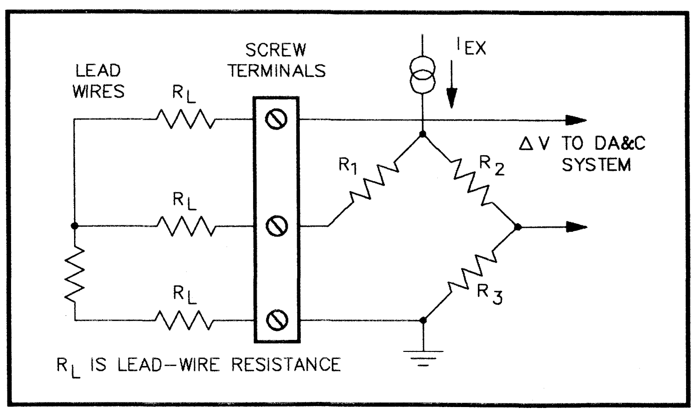

FIGURE 4-16. A Three-Wire Bridge Configuration.

The two-wire bridge is very simple but has the potential to be adversely affected by the series resistance of the connecting wires. As can be seen in FIGURE 4-15, the lead-wire resistance is indistinguishable from the transducer's resistance. Hence, this circuit is not usually employed in precision applications.

While the three-wire bridge requires an additional wire to be run to the sensor, several very important advantages are gained. If we make the reasonable assumption that the two wires bringing current to the sensor are of the same material and length, many of the potential error terms cancel. In FIGURE 4-16, it can be visualized that one lead resistance is in the top arm of the bridge while the other lead resistance is in the lower arm. The result is that most of the lead-wire effects are cancelled. However, when long leads (generally, over 10 feet) are used or the highest possible precision is desired, software correction of the lead effects can be employed. The resistance of the sense wire is of little significance because the current that flows in this lead is very small. Owing to the lead-wire error cancellation and the available computational power of the PC, this configuration is ideal for most DA&C applications.

FIGURE 4-17 shows a four-element bridge circuit. Here, the connecting lead wires do not introduce any significant error terms. Both of the power supply connecting wires are in series with a current source and hence do not affect the excitation level. A complete bridge does not have any connecting wires in a series with the individual sensing resistors. As suggested above, this circuit has the highest sensitivity and the best linearity, and it does not require bridge-completion resistors. Unfortunately, the complex manufacturing process for this type of sensor does result in relatively high cost.

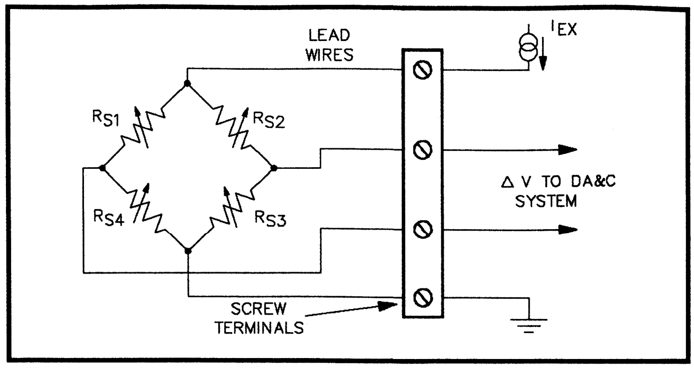

FIGURE 4-17. A Four-Wire/Element Bridge Configuration.

Wiring and Noise Considerations

It is a fact that signals entering a data acquisition system will include unwanted noise. Whether this noise is troublesome depends upon the signal-to-noise ratio and the specific application. In general, it is desirable to minimize noise to achieve high accuracy. Digital signals are relatively immune to noise because of their discrete (and high-level) nature. In contrast, analog signals are directly influenced by relatively low-level disturbances. The major noise transfer mechanisms include conductive, inductive (magnetic), and capacitive coupling. For example:

— The switching of high-current loads in nearby wiring can induce noise signals by magnetic coupling (transformer action).

— Signal wires running close to AC power cables can pick up 50/60Hz noise by capacitive coupling.

— Allowing more than one power or signal return path can produce ground loops that inject errors by conduction.

Conduction involves current flow through ohmic paths (direct contact), rather than inductance or capacitance.

Interference via capacitive or magnetic mechanisms usually requires that the disturbing source be close to the affected circuit. At high frequencies, however, radiated emissions (electromagnetic signals) can be propagated over long distances.

In all cases, the noise level induced will depend upon several user-influenced factors.

— Signal source *output impedance* (the input impedance to the data acquisition system).

— Signal source *load impedance* (the input impedance to the data acquisition system).

— Lead-wire: length, shielding and grounding.

— Proximity to noise source(s).

— Signal and noise amplitude.

Transducers that can be modeled by a current source are inherently less sensitive to magnetically induced noise pickup than are voltage-driven devices. An error voltage coupled magnetically into the connecting wires appears in series with the signal source. This has the effect of modulating the voltage across the transducer. However, if the transducer approaches ideal current-source characteristics, no significant change in the signal current will result.

When the transducer appears as a voltage source (regardless of impedance), the magnetically induced errors add directly to the signal source without attenuation.

Errors also are caused by capacitive coupling in both current and voltage transducer circuits. With capacitive coupling, a voltage divider is formed by the coupling capacitor and the load impedance. The error signal induced is proportional to $2\pi f \cdot RC$, where R is the load resistor, C is the coupling capacitance and f is the interfering frequency. Clearly, the smaller the capacitance (or frequency), the smaller is the induced error voltage. However, reducing the resistance only improves voltage-type transducer circuits.

Example:

Assume that the interfering signal is a 110VAC, 60Hz power line, the equivalent coupling capacitance is 100pF and the terminating resistance is 250Ω (typical for a 4-20mA current loop). The resulting induced error voltage will be about 1mV, which is less than 1LSB in a 12-bit, 10V system.

If the load impedance were 100KΩ, as it could be in a voltage input application, the induced error could be much larger. The equivalent R seen by the interfering source depends upon not only the load impedance but also the source impedance and the distributed nature of the connecting wires. Under worst-case conditions, where the wire inductance separates the load and source impedances, the induced error could be as large as 0.4V. This represents about an 8% full-scale error.

Even though current-type signals are usually converted to a voltage at the input to the data acquisition system, with a low-value resistor, this does not improve noise performance. This is because both the noise and transducer signals are proportional to the same load impedance.

It should be pointed out that this example does not take advantage of— or benefit from —shielding, grounding and filtering techniques.

Most noise problems can be solved by close attention to a few grounding and shielding principles:

— Do not confuse the definitions of ground and return paths. (ground = safety, return = current carrying).

— Minimize wiring inductance.

— Minimize ground currents.

— Limit antennas.

— Maintain balanced networks where possible.

This sounds simple enough, but what is involved?

To begin with, redefine some common terms. A ground is NOT a signal or power supply return path. A ground wire connects equipment to earth for safety reasons, to prevent accidental contact with dangerous voltages. Ground lines do not normally carry current. Return lines are an active part of a circuit, carrying power or signal currents. This is depicted in FIGURE 4-18. Care should be taken to distinguish between grounds and returns and to avoid more than one connection between the two.

To be effective, return paths should have the lowest possible impedance. Someone once said that the shortest distance between two points is a straight line. But, in geography it's not true, and it's not generally true in electronics either. Current does not take the shortest path, rather it takes the path of least resistance (really, of least impedance). Return impedance is usually dominated by the path inductance. Wiring inductance is proportional to the area inside the loop formed by the current-carrying path. Therefore, impedance is minimized by providing a return path that matches or overlaps the forward signal path. Note that this may not be the shortest or most direct route. This concept is fundamental to insuring proper system interconnections.

Three different grounding and connection techniques are suggested in FIGURE 4-19. The circuit in FIGURE 4-19a allows the signal return line to be grounded at each chassis. This may look like a good idea from a safety standpoint. However, if a difference in potential exists between the two grounds, a ground current must flow. This current, multiplied by the wire impedance, results in an error voltage, e_e. Thus, the voltage applied to the amplifier is not V_1, but $V_1 + e_e$. This may be acceptable in those applications where the signal voltage is much greater than the difference in the ground potentials.

When the signal level is small and a significant difference in ground potentials exists, the connection in FIGURE 4-19b is more desirable. Note that the return wire is not grounded at the amplifier and ground current cannot flow in the signal wires. Any difference in ground potential appears, to the amplifier, as a common-mode voltage

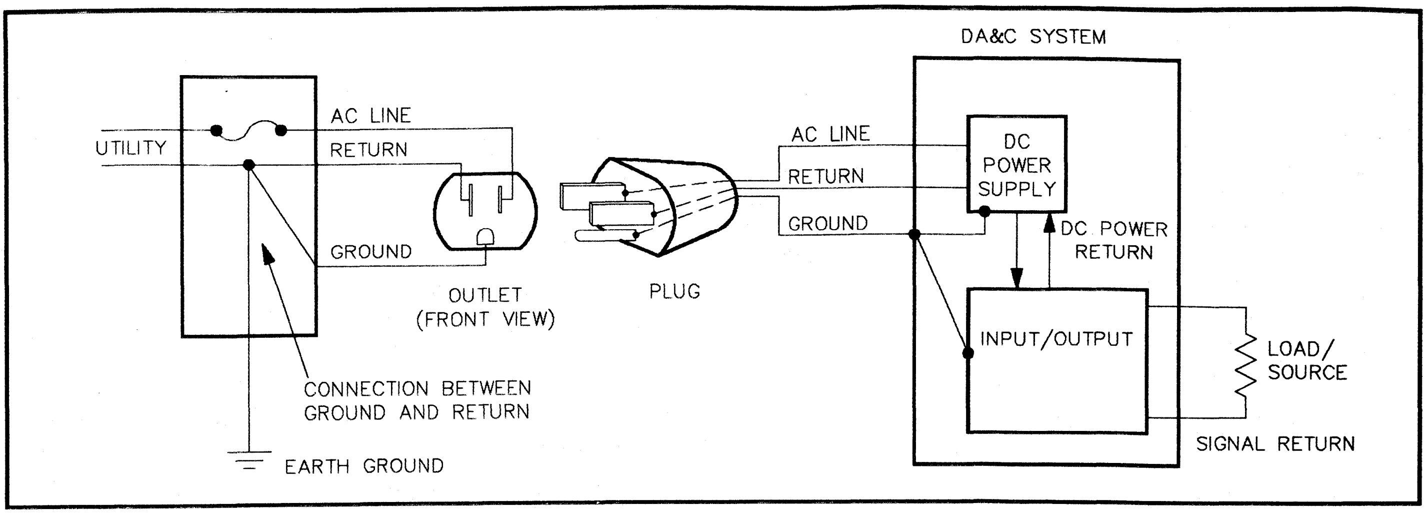

FIGURE 4-18. The Differences Between Ground and Return Conductors.

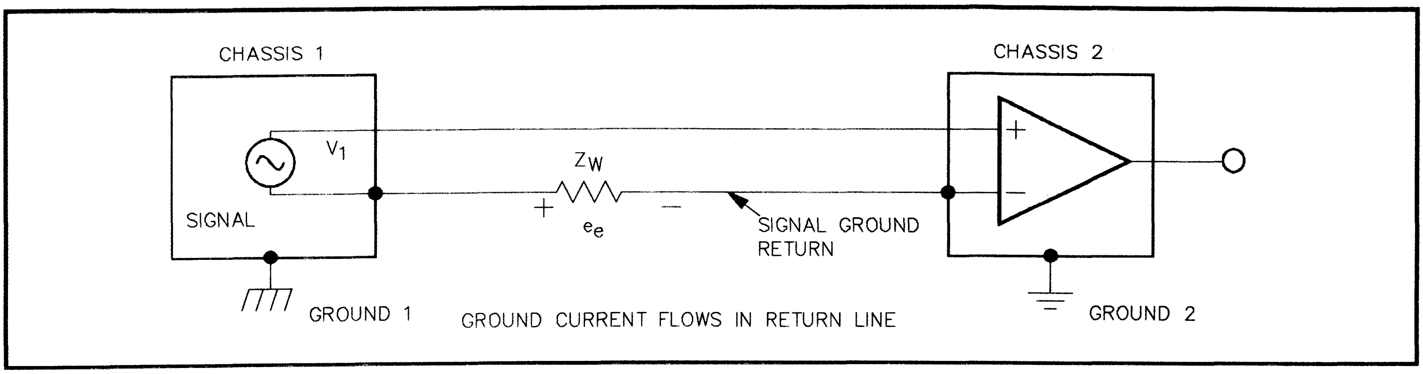

FIGURE 4-19a. A Single-Ended Connection.

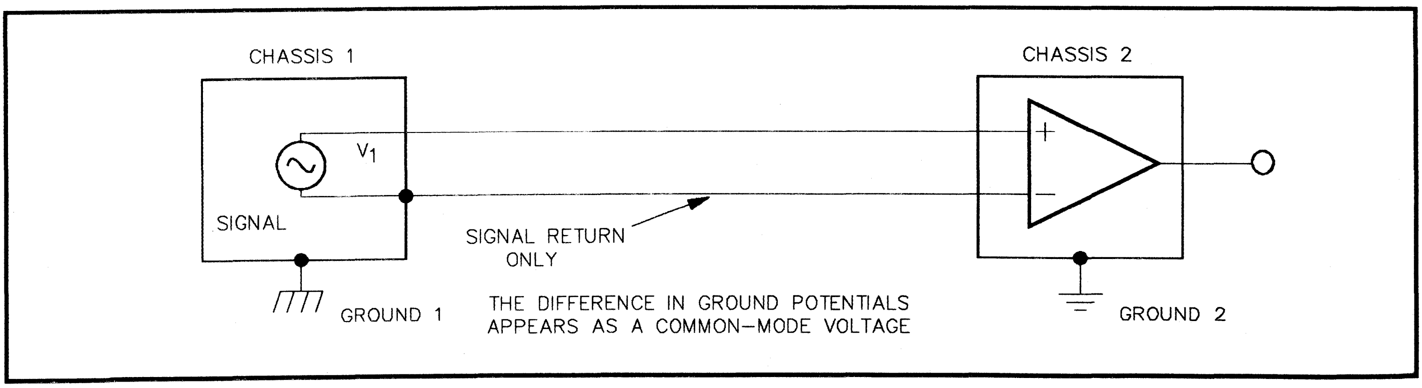

FIGURE 4-19b. A Differential Connection.

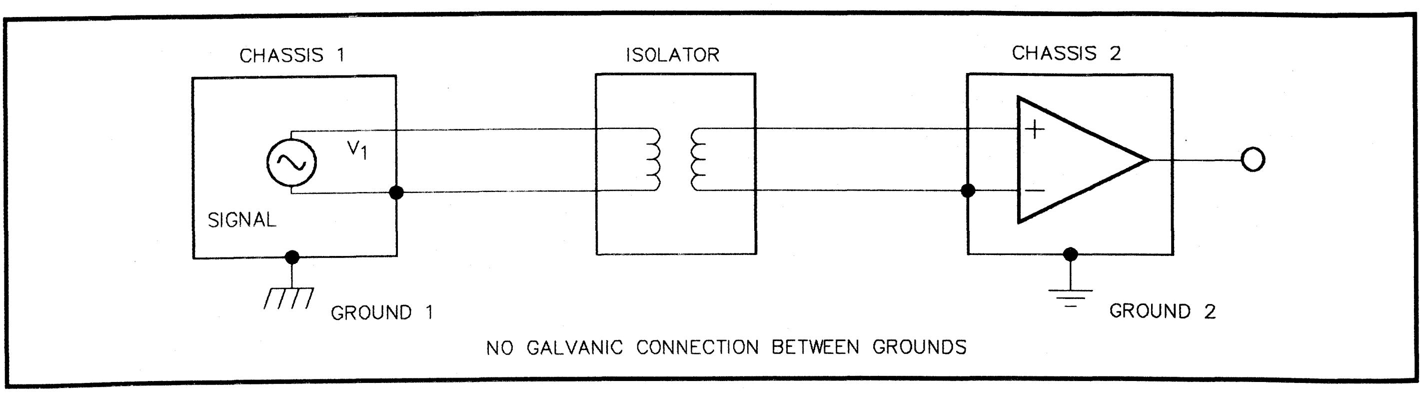

FIGURE 4-19c. An Isolated Connection.

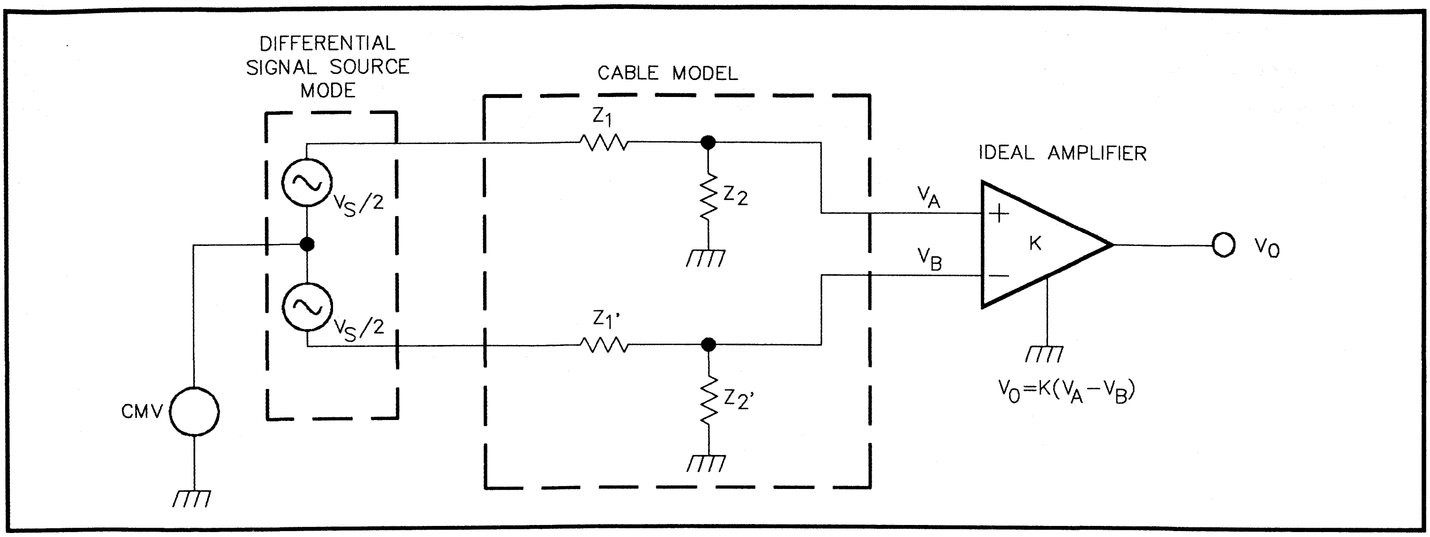

FIGURE 4-20. Influence of Cable Connectors on Common-Mode Signal Performance.

(CMV). In most circuits the effects of CMV are very small, as long as the signal voltage plus CMV is less than 10V (10V is the linear range for most amplifiers). Additional information about common-mode rejection and single-ended versus differential amplifiers can be found in the handbook section "Data Conversion Principles".

If cost is not a limitation, FIGURE 4-19c offers the highest performance under all conditions. Injecting an isolator into the signal path faithfully conveys V_1 to the amplifier while interrupting all direct paths. In this configuration multiple ground connections can be tolerated along with several hundred volts between the input and output circuits. Additional information on both analog and digital isolators can be found in the handbook section on signal conditioning. Related product data sheets are included in the PCI System configuration and data sheets section.

Cable Types - What kind of wire should be used to interconnect a system? We must first emphasize that a single piece of wire is not generally useful. Circuits consist of complete paths, so we will refer to pairs of wires in this discussion. Basically, four kinds of wire are fundamental: the plain pair, shielded pair, twisted pair and coaxial cable. All the the coaxial (coax) wires are said to be balanced. Coax differs from the others in that the return line surrounds the central conductor. Technically, we should not call the outer conductor a shield because it carries signal current. It is significant that the forward and return path conductors do not have exactly the same characteristics. In contrast, a shielded pair is surrounded by a separate conductor (properly called a shield) that does not carry signal current.

FIGURE 4-20 suggests a simple model for a differential signal connection. The attributes of the signal source have been split to model the influence of a common-mode voltage (CMV). Focus on the effect of forward and return path symmetry in the cable. Assuming that the amplifier is perfect, it will respond only to the difference between V_A and V_B. A technique called superposition allows us to analyze each half of the cable model separately and then to add the results. Z_1 is usually dominated by series inductance, while Z_2 is dominated by parallel capacitance. In any case, Z_1 and Z_2 form a voltage divider. If the dividers in both legs of the cable are identical, V_A - V_B will not be influenced by CMV. If, however, the capacitance represented by Z_2 is different in the two paths, a differential voltage will result and the amplifier will be unable to distinguish the resulting CM error from a change in V_S.

Coax offers a very different capacitance between each of its conductors and ground. Not only does the outer conductor surround the inner, but it is also connected to ground. Thus, coax is intended for single-ended applications only. Note that even perfectly balanced cables can still attenuate differential signals.

Sometimes even a single-ended source is best measured with a differential amplifier. Refer again to FIGURE 4-19b. To maintain a high rejection of any ground difference potential, balanced cables are required.

One method of reducing errors, due to capacitive coupling, is to employ a "shield". Generally, there is little that can be done to reduce the actual capacitance (wire length and physical location are factors, however). Nevertheless, placing a conductive material (at ground potential) between the signal wires and the interference source is very useful. The shield blocks the interfering current and directs it to the ground. Depending upon how complete the shield is, attenuations of more than 60dB are attainable. When using shielded wire, it is very important to connect only one end of the shield to ground. The connection should be made at the DA&C-system end of the cable (input amplifier, etc.). Connecting both ends of the shield can generate significant error by inducing ground-loop currents.

A shield can work in three different ways:

— *Bypassing* capacitively coupled electric fields

— *Absorbing* magnetic fields

— *Reflecting* radiated electromagnetic fields.

Another approach is to use twisted pairs. Twisted-pair cables offer several advantages. Twisting of the wires insures a homogenous distribution of capacitances. Both capacitances to ground and to extraneous sources are balanced. This is effective in reducing capacitive coupling while maintaining high common- mode rejection. From the perspective of both capacitive and magnetic interference, errors are induced equally into both wires. The result is a significant error cancellation.

The use of shielded and/or twisted-pair wire is suggested whenever low-level signals are involved. With low impedance sensors, the largest gage-connecting wires that are practical should be used to reduce lead-wire resistance effects. On the other hand, large connecting wires that are physically near thermal sensing elements tend to carry heat away from the source, generating measurement

OBSERVATION	SUSPECT	POSSIBLE SOLUTION	NOTES
Noise a Function of Cable Location	Capacitive coupling Inductive coupling	Use shielded or twisted pair. Reduce loop area, use twisted pair or metal shield.	A B
Average Value of Noise is not Zero Is Zero	Conductive paths or ground loops Capacitive coupling	Faulty cable or other leakage. Eliminate multiple ground connections. Use shielded or twisted pair.	C A
Shield Inserted Ground Significant Ground Insignificant	 Capacitive coupling Inductive coupling	 Use shielded or twisted pair. Reduce loop area, use twisted pair or metal shield.	 A B
Increasing Load Reduces Error Increases Error	 Capacitive coupling Inductive coupling	 Use shielded or twisted pair. Reduce loop area, use twisted pair or metal shield.	 A B
Dominant Feature: Low Frequency High Frequency	 60Hz AC line, motor, etc. Electromagnetic radiation	(1) Use shielded or twisted pair (2) Reduce loop area; use twisted pair or metal shield (3) Faulty cable or other leakage; eliminate multiple ground connections. Complete shield.	 D
Noise a Function of Cable Movement	Triboelectric effect	Rigid or lubricated cable.	
Note is "White" or 1/f	Electronic amp, etc.	Not a cable problem.	

Notes: (A) Connect shield to noise-return point and check for floating shields.
(B) Nonferrous shields are good only at high frequencies. Use MuMetal shields at low frequencies.
(C) Could be capacitive coupling with parasitic rectification, e.g., nonlinear effects.
(D) Look for circuit element whose size is on the order of the noise wavelength (antennas). Openings or cracks in the chassis or shields with a dimension bigger than the noise wavelength/20 should be eliminated.

FIGURE 4-21. Troubleshooting Guide for Noise.

errors. This is known as thermal shunting, and it can be very significant in some applications.

The previous discussion concentrated on cables making single interconnections. Multi-conductor cables, for connecting several circuits, are also available in similar forms (e.g., twisted pairs, shielded pairs, etc.). Both round and flat (ribbon) cables are widely used. Because of the close proximity of the different pairs in a multi-conductor cable, they are more susceptible to "crosstalk". Crosstalk is interference caused by the inadvertent coupling of internal signals via capacitive or inductive means.

Again, twisted pairs are very effective. Other methods include connecting alternate wires as return lines, running a ground plane under the conductors or using a full shield around the cable.

Still another noise source, not yet mentioned, is that of triboelectric induction. This refers to the generation of noise voltage due to friction. All commonly used insulators can produce a static discharge when moved across a dissimilar material. Fortunately, the effect is very slight in most cases. However, it should not be ignored as a possible source of noise when motion of the cables or vibration of the system is involved. Special low-noise cables are available that employ graphite lubricants between the inner surfaces to reduce friction.

The key to designing low-noise circuits is recognizing potential interference sources and taking appropriate preventive measures. FIGURE 4-21 can be useful when troubleshooting an existing system.

After proper wiring, shielding and grounding techniques have been applied, input filtering can be used to further improve the signal-to-noise ratio. However, filtering should never be relied upon as a fix for improper wiring or installation.

Cable Length Guidelines - What is the maximum allowable cable length? There is no direct answer to this question. The number of factors relating to this subject are overwhelming. Signal source type, signal level, cable type, noise source type(s), noise intensity, distance between the cable and the noise source(s), noise frequency, signal frequency range and required accuracy are just some of the variables to consider. However, experience has given us a feel for what often works. For example:

Analog, Current Source Signals -

Given: 4-20mA signal, shielded wire, bandwidth limited to 10Hz, accuracy required is 0.5%, "average" industrial noise levels.

Cable lengths of 1000 to 5000 feet (300 to 1500 meters) have been used successfully.

Analog, Voltage Source Signals -

± 1 to ± 10 volt signal, shielded wire, bandwidth limited to 10Hz, accuracy required is 0.5%. "average" industrial noise levels.

Cable lengths of 50 to 300 feet (15 to 90 meters) have been used successfully.

Analog, Voltage Source Signals -

Given: 10mV to 1volt signal, shielded wire, bandwidth limited to 10Hz, accuracy required is 0.5%. "average" industrial noise levels.

Cable lengths of 5 to 100 feet (1.5 to 30 meters) have been used successfully.

Digital, TTL Signals -

Ground-plane type cable, "average" industrial noise levels.

Cable lengths of 10 to 100 feet (3 to 30 meters) have been used successfully.

Ground-plane cable reduces signal reflections, ringing and RFI. Special termination networks may be required to maintain signal integrity and minimize RFI. If "squaring circuits" (e.g., Schmitt triggers) are used to restore the attenuated high-frequency signals, improved performance can be realized.

Remember, this information is offered as typical of what might be encountered. The actual length allowed in a particular application could be quite different.

The following relationships are offered as an aid to visualizing the influence of the most significant factors determining cable length. These relationships show **how** the various parameters affect cable length. These relationships are **not equations**, and will not allow the calculation of cable length.

For Current Source Signals:

Allowable length is proportional to

$$\frac{I_s\, D_n\, C_f}{f_n\, A\; N_i}$$

For Voltage Source Signals:

Allowable length is proportional to

$$\frac{V_s\, D_n\, C_f}{f_n\, A\, N_i\, R_L}$$

Where:

I_s or V_s	equals the signal level,
C_f	equals the coupling factor which is inversely proportional to the effectiveness of any shielding or twisting of the wires.
D_n	equals the distance to the noise source,
f_n	equals the noise frequency,
A	equals the required accuracy,
N_i	equals the noise source intensity, and
R_L	equals the equivalent resistance to ground at the signal input.

Signal Conditioning

We are all familiar with the old cliche "a chain is only as strong as its weakest link." As suggested in FIGURE 4-1, a DA&C system is made up of several links. It is common to partition the system at the transducer/signal conditioning interface. That is, the transducer is considered to be the signal source. Because signal conditioning affects the quality of the input signal, the ultimate performance of the system can be greatly influenced by the type of conditioning employed. Signal conditioning can include current-to-voltage conversion, scaling, filtering, isolation and amplification. Optimum signal conditioning is important to maintain the highest overall accuracy. Signal conditioning can be physically installed at a number of locations, including the signal source, the termination panel, or the data acquisition board (at the amplifier input or A/D). Usually it is most convenient and hence most common to use the termination panel. A large variety of standard PCI signal-conditioning termination panels are available. Both "passive" and "active" panels support a wide range of digital and analog applications. All panels provide for field wiring connections through convenient screw terminals. Passive panels are designed to allow installation of active or passive termination circuits, should they be required by the application. The active panels also provide for filtering, programmable differential amplification, bridge completion, bridge excitation, cold-junction compensation and optical isolation. FIGURE 4-22 suggests two of the many termination panel styles. Shielded ribbon cables are used to bring the termination panel's input/output signals to the data acquisition electronics (board, module, or carrier).

Input Buffering - The input characteristics (bias current, impedance, offset voltage, bandwidth, slew rate, etc.) of the DA&C system place limits on the range of signals that can be accurately measured. Some transducers, including piezoelectric and pH, exhibit a very high output impedance. Under these conditions, direct connection to the DA&C system (normally presenting a moderate input impedance) can result in measurement errors. These applications require that a special, high-input impedance amplifier be incorporated to buffer the connection between the signal and the actual measuring device. FIGURE 4-23 suggests a type of buffer circuit that can be used.

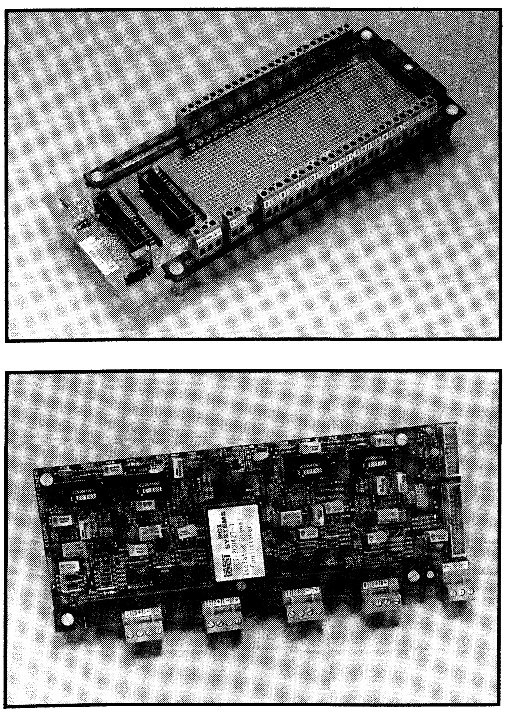

FIGURE 4-22. Passive and Active Panels.

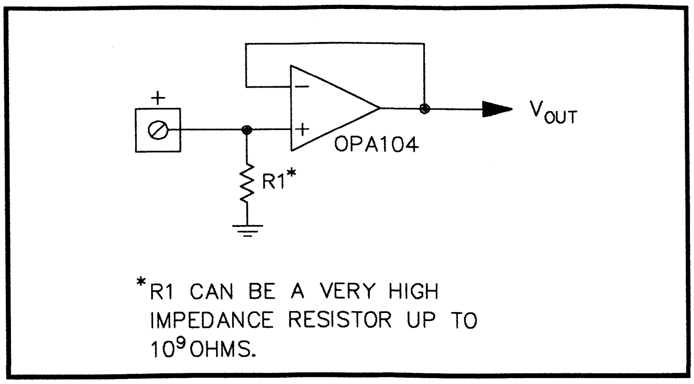

FIGURE 4-23. A Very High-input Impedance Buffer Circuit.

Current Conversion - The need to measure input current is quite common in DA&C systems. The outputs from remote sensors are often converted to high-level, 4 to 20mA signals at the source. This task is easily accomplished with a wide variety of *transmitters*. At the measurement system, current is easily converted back to a voltage with a simple resistor. See FIGURE 4-24. Values of 250 to 500 ohms are often used to provide voltage ranges of 1-5 volts and 2-10 volts, respectively, for a 4-20mA signal. The largest resistor that does not cause an over-range condition should be employed. This insures the maximum resolution. Stability of the resistor is essential; however, the exact value is not important. Most systems have software provisions for calibrating the measurement sensitivity of each channel at the time of installation. Low-cost, 0.1% metal-film resistors are usually adequate.

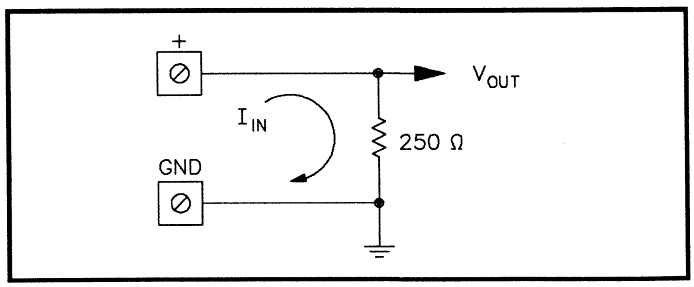

FIGURE 4-24. 4-20mA Input Conversion Circuit (Single-ended).

The technique of using only a resistor to convert from current to voltage does have limitations. If, for example, we wish to measure a 1μA level, a resistor of approximately, 5Meg ohms will be required. Unfortunately, the use of high-value resistors leads to potentially large errors due to noise and "measuring system loading". The input stage to the DA&C system always includes a device that presents a small but finite current (input bias current) that must be absorbed by the signal source. This bias current (typically around 10nA) also flows through the conversion resistor and is indistinguishable from the signal current. Therefore, when very low currents must be measured, a different technique is employed. FIGURE 4-25 suggests an active circuit that utilizes a precision FET-input amplifier to minimize the bias current problem. Both the simple resistor and FET amplifier circuits require the same resistor value for a given current level. However, in the latter circuit the DA&C system's bias current is supplied by the amplifier and does not effect the measurement accuracy. A wide range of low bias current amplifiers are available for special applications. With the amplifier shown, currents as low as 10pA can be read reliably.

Analog Signal Scaling - A/D converters are designed to operate with high-level input signals. Common A/D ranges include 0-10, ±5, and ±10 volts. When an input signal is below 1 volt, resolution, noise and

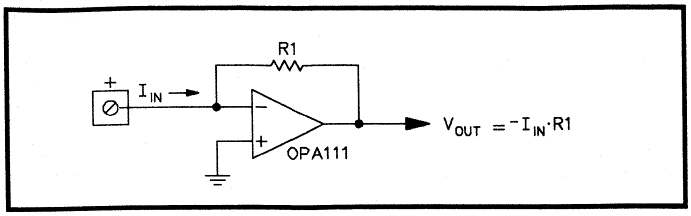

FIGURE 4-25. A Current-to-voltage Converter Circuit Suitable for Very Low Current Levels.

accuracy are degraded. Under these circumstances it is often appropriate to amplify the signal before the A/D converter. Some A/D boards, carriers, and modules have amplifiers built-in. With a gain of 1000, signals as small as 1mV can be accurately processed. When on-board amplifiers are not available or additional gain is required, active termination panels or signal conditioning blocks can be employed. Two types of panels are applicable, one with amplifiers installed at the factory and one that allows the user to install almost any type of circuit desired.

In addition to an input signal being too small, it is possible that it might be too large. Remember that most converters accept a maximum of 10 volts at their input. Signals to measure might be 12, 48 or 100 volts. Fortunately, it is a simple matter to reduce high levels with a resistive voltage divider network. FIGURE 4-26 is appropriate for most analog signals. In selecting R_1 and R_2, there are practical factors to consider. Making R_1 large can introduce limitations on signal bandwidth, due to the low-pass filter produced by R_1 and the parasitic capacitance (C_p) in parallel with R_2. In some applications the network bandwidth can be extended by placing a capacitor (C_s) across R_1. The value should be selected to make the time constant $R_1 \cdot C_s$ equal to $R_2 \cdot C_p$. In addition, the equation assumes that the source (signal) impedance is very low compared to the series combination of R_1 and R_2 ($R_1 + R_2$). From this perspective, R_1 and R_2 should be as large as possible.

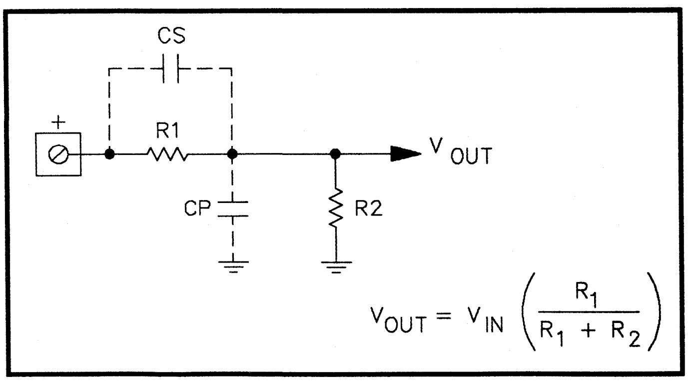

FIGURE 4-26. Resistive Voltage Divider To Reduce Large Analog Input Signals to Below 10 Volts.

Low-Pass Filtering - By averaging a series of incoming data points, we may effectively increase the signal-to-noise ratio. Given the speed and math capabilities of modern computers, averaging is readily employed. Averaging will be most effective in reducing the effects of random, non-periodic noise. It is less effective in dealing with 50/60Hz or other periodic noise sources. It is important to remember that all noise filtering techniques, whether implemented in hardware or software, are designed to filter specific types of noise. PCI Signal Termination Panels have provisions for the user to install a variety of filters. The most common types are represented by the one- and two-pole passive filters shown in FIGURE 4-27. FIGURE 4-27b is an example of an effective, single-ended, double-pole circuit to attenuate 50/60Hz noise. The filter has a -6dB cutoff at about 1Hz while attenuating 60Hz about 52dB (380 times).

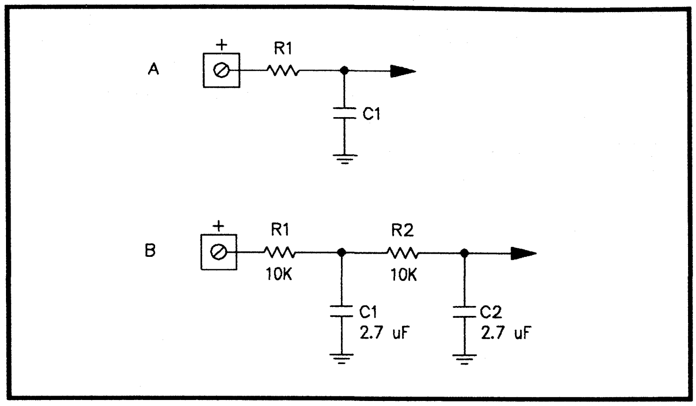

FIGURE 4-27. One- and Two-pole Low-pass Filters.

FIGURE 4-28 suggests a differential, two-pole, low-pass filter. In contrast to the circuits in FIGURE 4-27, this can be used in balanced applications. Note that any mismatch of the attenuation in the top and bottom path will result in a degradation of the system common-mode rejection ratio, CMRR. Therefore, the resistors and capacitors should be carefully matched to each other. If it is given that all of the resistors and capacitors are of equal values, the pole position (f_1) for this *differential* two-section filter is:

$$f_1 = 0.03/(R \cdot C)$$

and the approximate attenuation ratio ($r = V_{in}/V_{out}$), at a given frequency (f_x), is:

$$r = \left[\frac{f_x \cdot R \cdot C}{.088} + 1\right]^2$$

and also,

$$r = \left[\frac{.3 f_x}{f_1} + 1\right]^2$$

$$dB = 20 \log (r)$$

The equations for a *single-ended*, single-pole filter are:

$$f_1 = \frac{.159}{R \cdot C}, \quad r = \frac{f_x \cdot R \cdot C}{.159} + 1$$

and also, $$r = \frac{f_x}{f_1} + 1$$

The above equations assume that the source impedance is much less than R and that the load impedance is much larger than R.

For filter applications, monolithic ceramic-type capacitors have been found to be very useful. They possess very high density (small in size for a given capacitance), have low leakage and are non-polarized. Values up to 4.7μF at 50V are commonly available from Sprague, Centralab and others.

Filters have special significance in computerized DA&C systems beyond noise reduction. Such systems generally employ sampled-data techniques. This implies that while data is recorded on a regular basis, it is not taken continuously. That is, there are gaps of time between the data points. Thus, when the data is interpreted, certain assumptions must be made about what the data is doing between the known points. In most cases it is assumed that the gaps contain information that falls on a straight line drawn between the known data points. This is known as linear interpolation. When this type of presumption is not sufficiently accurate, the logical recourse is to increase the sampling rate. This makes the gaps smaller by adding additional "real" data points. Nyquist has provided us with a firm theoretical foundation upon which to deal with sampled data. In the simplest of terms, he states that a signal must be sampled at a minimum of two times the highest input frequency present in the input signal.

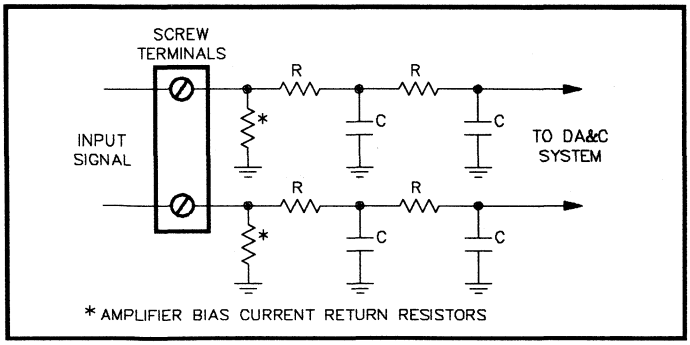

FIGURE 4-28. A Two-pole, Differential, Low-pass Filter.

With pulse waveforms there can easily be very significant harmonics far beyond the repetition rate. Frequencies out to $1/t_r$ are often important (t_r is the pulse rise time). The danger of under-sampling is that erroneous conclusions can be drawn about the input signal. It is not simply a matter of overlooking something, but of reaching totally wrong conclusions about the basic makeup of the data. See FIGURE 4-29 for an example. Note that sampling a pure sine wave (containing only the fundamental frequency) at a rate in violation of the Nyquist criterion leads to meaningless results. In this example, it suggests the presence of a totally nonexistent signal. This phenomenon is known as "aliasing".

Given that there are practical limits to the maximum sampling rate, another action must be taken to insure that the input signal does cause a violation of the Nyquist criterion. This involves the use of an input filter (anti-aliasing filter) to limit high frequencies. In the ideal case, this filter would have infinite rejection beyond the cutoff frequency. This would allow the filter to be set at exactly one half the sampling rate, providing maximum bandwidth without danger of aliasing. Because perfect filters are not available, an appropriate compromise must be made between the allowed system bandwidth and sampling speed. The required accuracy for a given system will greatly influence the necessary bandwidth reduction. In applications using simple passive filters, the sampling frequency might have to be 5 to 10 times the filter corner frequency (the signal bandwidth). Using high-order active filters might require a bandwidth reduction of only two or three.

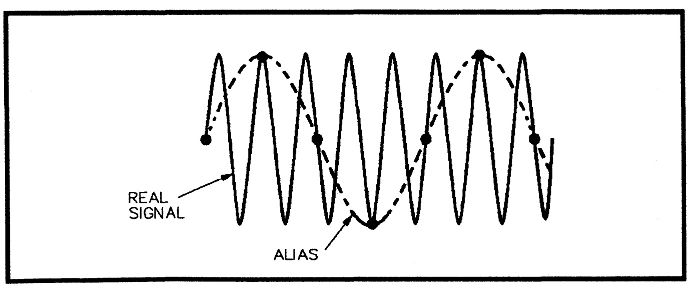

FIGURE 4-29. Aliasing Because of an Insufficient Sampling Rate.

High-order active filters are very desirable in anti-aliasing applications. While offering excellent performance, they are physically large and expensive compared to simpler filters. Complete, ninth-order elliptic designs are available in a number of configurations. This type of filter has very steep roll-off (attenuation) while maintaining nearly constant gain in the pass-band (±0.2dB is common). In selecting elliptic filters you must be sure to choose a unit that has a stop-band attenuation greater than the resolution of the system's A/D converter. For example, a 12-bit converter has a resolution of one part in 4096. This corresponds to a dynamic range of 72dB. Therefore, the filter used should attenuate all undesired frequencies by more than 72dB. Fixed-frequency filter modules, as well as switch- and software-programmable units, can be purchased from various manufacturers, including Frequency Devices in Haverhill, MA. Several of the modular elliptic filters can be installed directly on the PCI-20024T Series and PCI-5B01-1 Termination Panels. Also available from Frequency Devices is a line of modular elliptic filters which will plug directly into the PCI-5B01-1 Analog I/O Termination Panel.

Many (perhaps most) applications can be satisfied by low-cost, one- or two-pole passive filters. In low or moderate bandwidth applications, simple filters can be used in conjunction with "over-sampling". Over-sampling involves reading the input at a sufficiently high rate to account for the non-ideal filter characteristics. Depending upon the termination panel selected, accommodations for one-, two- or three-pole filters can be provided.

In summary, filtering is intended to attenuate unavoidable noise and to limit bandwidth to comply with the Nyquist sampling theorem (the maximum signal frequency must be limited to half of the sampling frequency). It must always be remembered that filtering is not intended as a substitute for proper wiring and shielding techniques.

Analog Isolation - Analog isolation as well as digital isolation can be used to protect people and equipment from contact with high voltages. Other applications include the breaking of ground loops or the removal of large common-mode signals. For example, if a thermocouple is connected to a motor armature, it could be at 240V above ground. However, the TC output voltage might be only 30mV. The 30mV (the actual signal) is a differential signal because it is applied to the + and - inputs of the data acquisition channel. On the other hand, the 240V signal appears not as a differential signal, but as a signal common to both + and - inputs. Common-mode voltages are referenced to the power supply ground. Standard analog input channels can only accept up to a 10V common-mode signal while remaining linear. Voltages above 30V are likely to damage the input components. In the thermocouple example above, an analog isolator would separate the desired differential signal from the unwanted common-mode voltage.

Three major types of analog isolators are in wide use today: capacitively-coupled, transformer-coupled, and optically-coupled. The so-called flying capacitor isolator is widely used because of its low cost. However, its mechanical relay design causes the system to be slow and to have a poor mean-time-to-failure. As the cost of alternative methods declines, the trend is for mechanical systems to give way to electronic solutions. Transformer-coupled devices offer the highest level of electrical performance available today. Unfortunately, the high isolation voltage and high accuracy are associated with very high cost. In some application areas, such as medical patient monitoring, this cost is well-justified. Generally, in the commercial/industrial world, the lower-cost optical isolators are more appropriate.

For use in DA&C systems, optical isolators offer high performance at moderate cost. This type of technology provides a wide range of isolation features. It is desirable to keep all potentially high voltage signals outside the personal computer. For this reason, both digital and analog isolation should be provided on external termination panels. In addition to isolation, analog panels should also provide differential input gain stages, bridge-completion and excitation circuitry, as well as passive signal conditioning capabilities. Provisions for thermocouples, RTDs, strain gages and pressure transducers are also included in better systems.

More information on analog isolators can be found by referring to the PCI-20042T and PCI-5B Series in this handbook. The PCI-5B Series Blocks provide integrated filtering solutions in easily-installed block-type packages. These products (with compatible backplanes and accessories) allow users to satisfy individual channel requirements simply by installing the type of block required for the signal- or transducer-type connected to the channel.

Surge Protection - When a system can be subjected to unintentional high-voltage inputs, it is required that protection be provided to avoid possible destruction of the equipment. High-voltage inputs can be induced from: lightning, magnetic fields, static electricity, and accidental contact with power lines, to name just a few sources.

FIGURE 4-30 suggests two different protection networks. Both circuits offer transient (short duration) as well as steady state protection. Circuit A can tolerate continuous inputs of up to 45 volts. When the overload disappears, the signal path automatically returns to normal. The Circuit B protects against continuous overloads of up to 280 volts (limited by physical distances on the termination panel). However, sustained overloads to this circuit will cause the fuse to open (protecting the protection circuit). A disadvantage of this network is that the fuse must be replaced before the signal path is again active.

The resistor (or fuse in circuit B) and MOV forms a voltage clamp to insure that transients will not get to the inputs of the DA&C system. MOVs are *metal oxide varistors*. They are semiconductor devices that can react very quickly to absorb high energy spikes. Good results have been recorded with the General Industries SCL15C TransZorb MOV. Consideration should be given to the possible leakage current of the MOVs. If the series R is large, the leakage could appear as a significant temperature-dependent error voltage (IR). In the circuits shown, the resulting error will be insignificant (less than 1LSB).

The capacitors help to suppress high-frequency transients. In some applications they must be rated for high voltage because transients in power stations or other noisy environments can exceed 1000V. The values should be as large as physically possible, and these capacitors should be positioned as close as possible to the signal entry point of the system. Capacitors with low series impedance (low "ESR") at high frequencies should be selected. This requirement eliminates

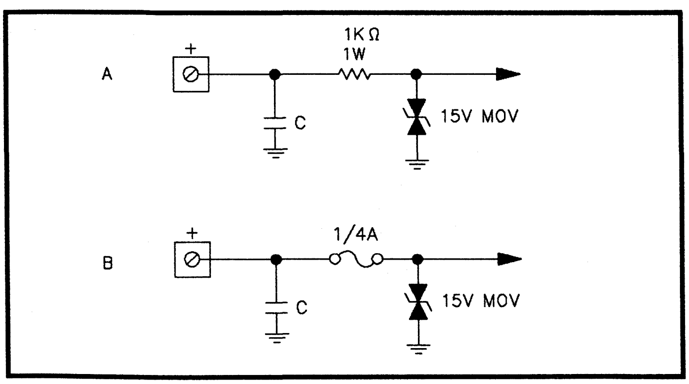

FIGURE 4-30. Representative Input Protection Networks.

electrolytic-type capacitors. If the input signal can change polarity, polarized capacitors must be avoided.

Thermocouples - Thermocouples were discussed in a previous section. However, because they produce low-level (-10mV to +50mV) differential signals, they deserve special attention. In addition to the filtering and surge protection techniques described above, FIGURE 4-31 shows how to implement open thermocouple detection. This can be important in both monitoring and control applications. Particularly at high temperature, thermocouples are subject to mechanical fatigue leading to broken wires. Unfortunately, an open thermocouple results in a measurement of zero volts (not including cold-junction compensation) which could represent a legitimate temperature. Including R1 and R2 in the signal conditioning circuit eliminates this ambiguity. R2 (10K ohms), connected to the positive input terminal, provides the bias current return path required in all differential applications. A similar resistor is not required on the negative terminal because its bias current can flow through the low impedance of the thermocouple, to R2, and on to ground. The addition of R1 (10Meg ohms connected to +V) produces a small current that has negligible effect on a normal measurement. However, if the thermocouple should break, the negative terminal is forced to +V, simulating a negative full-scale signal (usually representing a -50mV input). This voltage is outside of the expected range and can thus be identified by software as an open thermocouple.

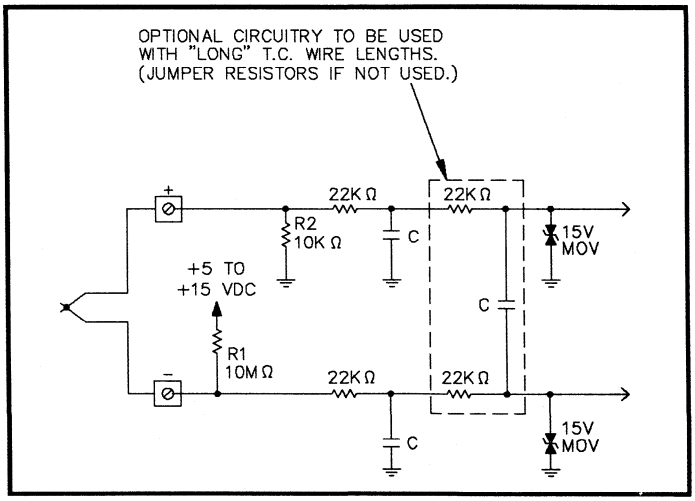

FIGURE 4-31. Complete Thermocouple Signal Conditioning.

Digital Signal Scaling - For large digital signals the circuit in FIGURE 4-32 can be used to produce TTL-compatible levels. It is generally true that most digital acquisition products require fast input level transitions to insure reliable operation. Usually, transitions faster than 10μS are adequate. The 10pF capacitor in FIGURE 4-32 is included to help preserve the high-frequency components present in the input signal. However, if a given input is not fast enough, it can be made TTL-compatible with the Schmitt trigger circuit shown in FIGURE 4-33. These networks are compatible with all PCI digital and counter input products.

Digital Isolation - When driving heavier loads than a TTL output is rated for, digital isolation modules can be used. These devices convert a standard TTL input via power transistors or triacs to switch high voltage/high current, AC or DC signals. Optical isolation provides high-voltage separation between the load and the DA&C system, without using mechanical relays. Other modules are designed to monitor digital input signals while breaking the galvanic connection between the signal source and the measuring equipment. The modules not only isolate but also convert the inputs to standard TTL

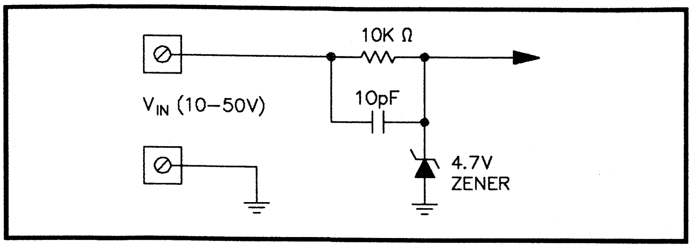

FIGURE 4-32. Circuit To Convert Large Digital Signals to TTL-Compatible Levels.

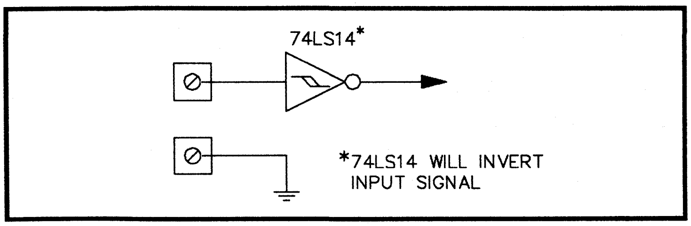

FIGURE 4-33. Schmitt Trigger Circuit to "Speed-up" Slow Input Signals. The Input Levels Must Be TTL Compatible.

levels that can be read by the DA&C system's digital input channels. Isolation is useful for safety, equipment protection and ground-loop interruption. Each module supports a single channel, allowing the flexibility to mix the various types when configuring a system. Special termination panels are available that accommodate either 8 or 16 isolated blocks.

There are 12 optically isolated PCI blocks in four basic groups: AC input, AC output, DC input, and DC output. The AC models are intended to monitor and control 120V and 240V power lines. Line voltage inputs can be directly connected to these devices. Actually, DC input models can accommodate almost any AC or DC input level with the choice of an appropriate series resistor. The DC output devices are rated for up to 60V. Both the AC and DC models can switch loads up to 3A. More information on this family of opto-isolators is available by referring to the PCI-1100 Series in this handbook.

Contact Sensing - When interfacing to relay or switch contacts, a "pull-up" current must be provided. The pull-up current converts the opening and closing of the contacts to TTL levels. Because all metal surfaces tend to oxidize with time, poor relay contacts can result. This oxidation can be cleaned away by passing a minimum current through the relay contacts. Both level generation and contact wetting can be accomplished by connecting resistors between the input lines and the +5V power supply. This can be implemented on the signal termination panel as shown in FIGURE 4-34. A value of 250 ohms for R_1 will provide 20mA of wetting current, which is usually enough to keep most contacts free of oxide build-up. R2 and C1 function as a debounce filter to reduce erroneous inputs due to the mechanical bouncing of the contacts. When the switch is open, the system sees +5V. When the switch is closed, the input is 0V. This satisfies the TTL requirements of the system.

Relay Driving - FIGURE 4-35 shows how a TTL output is connected to drive an external relay coil. The diode, D1, protects the internal circuit against the inductive "kickback" from the relay coil. Without the diode, the resulting high-voltage spikes will damage the digital port. Note that the direction or polarity of the diode must be as shown in the diagram. Protection diodes must be able to respond very quickly and be able to safely absorb the coil's energy. Most standard "switching" diodes fill these needs.

When large relays, contactors, solenoids or motors are involved, an additional driver or intermediate switching network can be employed.

Motor Control - Many different types of motors are in common use today. When it comes to controlling these devices, specialized circuits are often required. Some applications, however, require only on-off operations. These can simply be driven by digital output ports, usually through optical isolators (loads up to 3 amps) or with various types of contactors (relays).

In general, when variable speed is desired, either analog or digital outputs from the DA&C system are used to manipulate the motor through an external controller. A wide range of both AC and DC controllers is available from KB Electronics (Brooklyn, NY) and others.

Stepper-type motors are of particular interest in robotics, process control, instrumentation and manufacturing. They allow precise control of rotation, angular position, speed and direction. While several different types of stepping motors exist, the permanent-magnet design is perhaps the most common. The permanent magnets are attached to the rotor of the motor. Four separate windings are arranged around the stator. By pulsing DC current into the windings in a particular sequence, forces are generated to produce rotation. To continue rotation, current is switched to successive windings. When no coils are energized, the shaft is held in its last position by the magnets. In some applications these motors can be driven directly (via opto relays) by one of the DA&C system's digital output ports. The user provides the required software to produce the desired pulses in proper sequence. The software burden can be reduced by driving the motor with a specially designed interface device. These units accept a few digital input lines representing the desired speed, rotation, direction and acceleration, etc. A full range of both motors and interfaces is available from companies such as Airpak Corporation (Cheshire, CT), Superior Electric (Bristol, CT) and others.

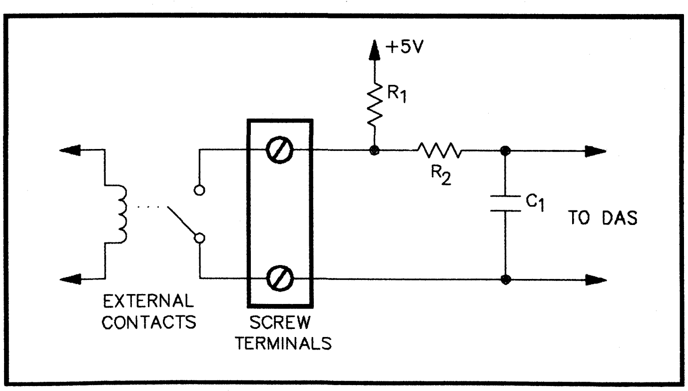

FIGURE 4-34. Contact Sensing and Wetting.

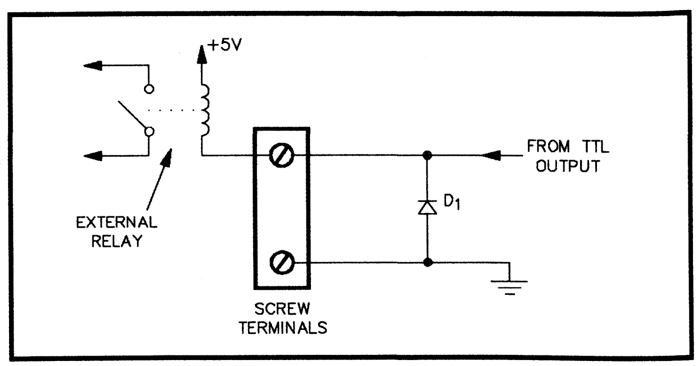

FIGURE 4-35. Relay Driving Circuit.

APPLICATION NOTES

This section includes a collection of articles that address a number of important data acquisition and control principles and techniques. The fundamentals presented in earlier sections are linked to practical applications. In this way, the interrelationship between the PC platform, the PCI data acquisition hardware, and the controlling software is demonstrated. Burr-Brown has extensive experience in most areas of PC-based data acquisition, test, measurement, and control applications. The notes published here represent just a sample of what is available. If you have a particular requirement, please contact your local Burr-Brown representative (or the factory directly) for additional assistance.

In some cases it is appropriate to first have a basic knowledge of the specific hardware and/or software items before studying these notes. Additional information and specifications can be found in the product data sheets in Section 3.

TABLE OF CONTENTS

Interrupt-Driven Data Acquisition with the PCI System

Many computer-based data acquisition applications can benefit from the use of interrupts. Interrupts provide immediate communication from the data acquisition hardware to the computer. They can be used to synchronize data acquisition with external events, to provide prompt response to alarm conditions, and to improve system performance. The PCI System is designed to make it easy to connect appropriate interrupt signals.

This Application Note is designed to provide an understanding of:

— How microprocessor interrupts work

— How interrupts are implemented on the IBM PC and compatibles

— How to determine which data acquisition applications are good interrupt applications

— How to design software to support interrupts

Descriptions of sample data acquisition systems using interrupts are included, along with listings of sample interrupt handler routines. Examples show how to program the PC's interrupt controller and how to make use of the IBM PC system clock for data acquisition.

In order to use interrupts effectively, you must follow these steps:

— Analyze your system to determine whether interrupts are, in fact, necessary, and which signals should be used to generate interrupts

— Connect the selected signals to the computer's interrupt system

— Write software which will enable the computer to respond to interrupts and to handle the interrupts when they occur

What Are Interrupts?

A microprocessor runs programs by executing **machine instructions** which it reads from memory. Ordinarily, the processor executes instructions sequentially, in the order in which they appear in memory. A special processor register, the **instruction pointer**, keeps track of the next instruction to be executed. Certain instructions, namely **jump** instructions, and certain input signals, namely **interrupts**, cause the processor to start taking instructions from a different area of memory.

A **call** instruction is a special type of jump used to execute subprograms. Before jumping to the new program location, the processor saves the instruction pointer in a block of memory called the **stack**. Another processor register, the **stack pointer**, keeps track of the "top" of the stack. The processor stack is like a stack of plates. Items are added to and removed from the top of the stack. The last item put on the stack will be the first one removed. The call instruction **pushes** the instruction pointer onto the stack. This stores the instruction pointer on top of the stack and updates the stack pointer to show the next location as the top of the stack. The last instruction in a subprogram is a **return** instruction, which **pops** the instruction pointer off the stack. The stack is restored to its condition prior to the call, and the processor continues executing the instructions following the original call instruction.

An interrupt is a special input signal to a microprocessor. When a transition (usually high-to-low) occurs on the interrupt line, the processor latches the interrupt state and finishes the instruction it is currently executing. If interrupts are **enabled**, the processor then saves the instruction pointer and a word describing its current state on the stack, provides an **interrupt acknowledge** signal, and starts executing a special **interrupt handler** routine. The last instruction of an interrupt handler is an **interrupt return** instruction, which is similar to a return instruction. The original instruction pointer and state of the processor are restored, and the processor resumes executing instructions following the one that was interrupted.

Interrupts can be inhibited during part of a program by executing a **disable interrupt** instruction. If the processor receives an interrupt when interrupts are disabled, it will not respond until it encounters an **enable interrupt** instruction. If an interrupt is pending when an enable interrupt instruction is executed, the processor will then acknowledge the interrupt and execute the interrupt handler routine.

Communicating with External Devices

In order for the computer to be useful, the processor must be able to communicate with the outside world. It does this through the keyboard, CRT, disk drives, printer, data acquisition system, and other **peripheral devices**. The processor communicates with the peripherals by reading data from them or writing data to them. Many microprocessors have separate address spaces for **input** and **output (I/O)** and **memory**. A peripheral device can be designed to occupy either I/O addresses or memory addresses. I/O addresses are accessed through **input** and **output** instructions; memory addresses are accessed through **memory load** and **memory store** instructions.

The processor's communication with peripherals is complicated by the fact that the programmer usually can't predict exactly what a peripheral will be doing when the processor reaches a particular place in a program. If the processor attempts to read data from a device when the device hasn't yet supplied the data, the result will be meaningless. If the processor doesn't read the data soon enough, the device may have already supplied new data, or the data may no longer be valid. For example, if two keys were depressed since the last time the keyboard was checked, information about the first key would be replaced by information about the second. Similarly, if the processor attempts to write data to a device that is not ready, the device won't respond as expected.

In order to synchronize communication between the processor and its peripherals, there are two techniques that can be used:

The processor can **poll** a device, periodically reading a status register to determine whether the device requires attention.

The device can be set up to **interrupt** the processor when it needs service. Both of these methods have advantages and disadvantages which must be weighed for each application.

Polling

The processor polls the device periodically by reading one or more **status registers**, memory or I/O locations whose values allow the processor to determine whether the device needs attention. If the device does need attention, an appropriate subroutine is called. Otherwise, the processor may continue to poll peripheral devices or it may perform other tasks. A program using polling is usually designed with a single loop containing instructions that poll peripherals and perform all other tasks. A program that handles peripheral devices by polling can be written in any programming language, using ordinary programming skills.

Although polling is very simple, this method has disadvantages. The processor must always be able to execute the entire loop fast enough to be able to keep up with the demands of the peripherals. A loop which is fast enough most of the time may occasionally fail if too many tasks must be performed on any one pass through the loop. For example, if the processor polls several peripherals, they may occasionally all require service. As more complexity is added to a developing program, a polling loop that originally worked well can become too long. Furthermore, if accurately timed operations must be performed, as is common in data acquisition, a long polling loop may not allow the timing source to be checked often enough to insure adequate accuracy.

Interrupts

With this technique, peripherals signal the processor when they require attention by generating interrupts. Prompt attention to all peripherals is insured as long as demands on the system are reasonable, and the programmer does not need to intersperse polling operations with other program tasks. This method is particularly well suited to an application which requires accurate timing of data acquisition while the processor is performing other operations. Interrupts are also useful if several peripherals requiring service at different rates are used.

In order to make use of interrupts a programmer must write an interrupt handler routine. The addresses of this routine must be placed in a special location in memory, the **interrupt vector table**, so that they can be executed when an interrupt occurs. This usually requires some knowledge of assembly language. (Some high-level languages provide interrupt handling capability with routines to perform absolute memory reads and writes, input and output operations, and interrupt routine entry and exit sequences.) The program flow depends on the occurrence of interrupts and is no longer obvious to the reader of a program listing. Mistakes in handling a computer's interrupt system can result in catastrophic program failures, which makes programs utilizing interrupts especially difficult to debug.

Buffered I/O

A very robust programming technique uses **buffered I/O**, which combines the advantages of polling and interrupts. This technique is particularly useful for applications such as control loops or real-time displays, in which the program must process data as it is being acquired.

An application program using buffered input is written as a polling loop in which the processor waits for data, processes the data, and returns to wait for more data. An interrupt handler routine responds to interrupts to read the data and store it in a **circular buffer**, which is a short array for temporary data storage. The interrupt handler maintains an **insertion counter** to indicate the next position in the buffer which it updates each time data is stored in the buffer. When the counter reaches the end of the array, it is set back to the beginning of the array, completing the circle. A second **removal counter** is maintained by a polling procedure which is called by the application program to read the data buffer. The polling procedure compares the two counters. If their values are different, new data exists at the position of the removal counter. The polling procedure updates the counter and returns the new data to the application program. If no new data exists, the polling procedure can be designed to wait for data or to return to the application program with an indication of no data.

If a suitable data acquisition rate is used, the buffer should never contain more than a few entries. However, the interrupt handler must compare the removal counter with the updated insertion counter to detect a possible buffer overflow. If this has happened, the polling procedure should return an error value to the application program.

Buffered output can be handled similarly. The application program passes data to the polling procedure. The data is stored in a circular buffer if there is room for it and rejected otherwise. In this case the polling procedure updates the insertion counter, and the interrupt handler updates the removal counter. If data must be updated at regular intervals, as in the case of waveform generation, the buffer must not be allowed to become empty. If the data is being sent to a printer or similar device, the interrupt handler may simply disable the interrupt if the buffer becomes empty.

Choosing the Optimum Strategy

It must be emphasized that using interrupts is not always preferable to polling, and that polling can provide significantly better performance than interrupts for some applications.

The best strategy for high performance (high data acquisition rates) is to use polling and provide a **tight loop** (written in assembly language or machine language) which continuously monitors a status register until the desired condition is satisfied. Interrupts must be disabled during execution of a tight loop, or its purpose may be defeated by the occurance of a non-related interrupt (DOS real-time clock, for example). The peripheral is then serviced, and the processor returns to the tight loop. Unlike the general polling loop described above, this loop performs no other operations (except possibly to exit the routine after enough cycles have elapsed!).

If precise timing of data acquisition or data output is of primary consideration, and if the timing uncertainty due to a tight polling loop is unacceptable, then timing should be controlled by an external timing source. For example, analog data acquisitions might be triggered by the falling edge of a square-wave pulse train produced by a programmable counter or a frequency generator. The end-of-convert signal from the converter would then be used to signal the processor to read the converted data. Either interrupts or polling could be used, depending on other requirements of the system.

Interrupts are a good way to control data acquisition when the acquisition rate is slow enough that there is a significant amount of time available between interrupts. Interrupts can provide a significant advantage over polling if the program must handle more than one device, or if the program must perform other tasks while acquiring data. Most interrupt applications are best handled using buffered I/O.

Examples

It is worthwhile thinking through most applications before deciding to use interrupts, to see if polling could do the job. In many cases there is little or no improvement gained by using interrupts, and polling should be used because of its simplicity and ease of implementation.

An example of a good polling application is a program which must take data very rapidly. A higher sampling rate can be achieved by polling a timing source rather than using the host computer's internal timer. This is because of the **interrupt overhead**. When an interrupt is detected, the contents of all the processor's flags and registers must be saved on the stack. When returning from the interrupt handler, these flags and registers are restored. These operations take much longer than a polling loop, which reads and tests a status register until a condition is satisfied. The processor can respond to a timing signal with greater accuracy when a polling loop is used rather than interrupts. This is because the processor must complete the current instruction before acknowledging an interrupt, and the time required to execute an instruction varies widely.

On the other hand, a program taking data several times per second can make good use of interrupts from the timing source. For such low sampling rates, small variations in the processor's response time to the timing signal are unimportant. Another good application for interrupts is data acquisition with a slow analog-to-digital converter, using a signal from the converter to interrupt the processor when the conversion is complete. (An integrating converter might require 300mSec for a conversion. The use of interrupts allows the processor to perform other tasks, such as logging data to disk, performing control functions, or updating a display, while it waits for the peripheral.

Most applications fall somewhere between these extremes. Suppose, for example, that data is to be taken at 20kHz or that you are using a converter with an expected conversion time of 50μs. Before deciding whether to use polling or interrupts, you must estimate the interrupt overhead, which depends on the processor and clock speed your computer uses. It may seem wasteful to have the processor "spinning its wheels" in a polling loop for 50μs, but depending on the interrupt overhead, you may find that it is not possible to improve performance. An example of an interrupt overhead estimate appears later in this Application Note. The practical limit for sampling rates using interrupts on the IBM PC/XT/AT/EISA may range from a few samples per second to a few thousand samples per second, depending on the data acquisition process, other tasks the system must perform, and the programming language used.

8088/8086 Family Processors and the IBM PC

The discussion above is applicable to most modern microprocessors, with minor variations in terminology. We can apply this discussion to the IBM PC/XT/AT/EISA and compatible computers with a few qualifications.[1]

The 8086 family microprocessors have 16-bit registers (including instruction pointer and stack pointer registers), but they can address 20 address bits, which requires 1 Mbyte of memory. A complete address is specified by combining the contents of a **segment register** with an **offset register**:

Address = 16 * **Segment + Offset**

The processor has four segment registers, the **Code Segment** (CS), **Stack Segment** (SS), **Data Segment** (DS), and **Extra Segment** (ES).

The "instruction pointer" described is actually formed by combining the IP (instruction pointer) register with the CS register.

The IBM PC and compatible computers make use of an **interrupt controller** chip (Intel 8259A[2]) to provide eight different **vectored, prioritized** interrupts.[3,4] The interrupt controller automatically identifies the source of the interrupt. Because the interrupts are prioritized, high-priority events can interrupt the servicing of low-priority interrupts. Any of the eight interrupts can be inhibited, independent of the processor's interrupt enable and disable capabilities.

When a high-to-low transition occurs on one of the eight interrupt lines, and that interrupt channel is not inhibited, the controller produces a high-to-low transition on its output line. When the processor responds with the interrupt acknowledge signal, the controller causes the processor to execute a special **software interrupt** instruction. Whenever the controller generates an interrupt, interrupts with lower priority (higher number) are automatically inhibited until the controller is cleared by the processor. The new interrupt condition is latched by the controller, but it is not passed to the processor until servicing of the higher priority interrupt is complete. Higher priority interrupts can interrupt a lower priority interrupt handler if the program issues an enable interrupt instruction. The low-priority interrupt routine is put on hold until the high-priority interrupt has been serviced.

The eight hardware interrupt inputs are "mapped" by the controller to software interrupts 8 through 15. A software interrupt instruction appears in assembly language as:

INT n

where **n** is a number from 0 to 255. When an **INT n** instruction is executed, the processor saves the program location (IP and CS) and status and jumps to an interrupt handler whose **address** (offset and segment) is stored at memory location 4*n. For example, **INT 8** would cause the 2-byte word beginning at location 32 (20H) to be loaded into the IP register and the next word (location 34, or 22H) to be loaded into the CS register. The next instruction to be executed will be at this address.

A hardware interrupt can be simulated by putting an appropriate **INTn** instruction in a program. Other software interrupts, which don't correspond to hardware interrupts, are used by the operating system or other programs which are loaded independently but which must be able to communicate with each other. The operating system and its extensions require different amounts of memory depending on the system configuration; so, there is no way to predict the exact memory location at which a program will be loaded. It is important to have **absolute** memory locations that can be used for communication between programs. Some of these locations may be used to store information other than the addresses of interrupt handlers. For example, an **interrupt vector** might contain the address of a data table, or it might be used as a "mailbox" to store other information to be passed between programs.

Connecting the PCI-20000 Interrupt Signal

The IBM PC/XT/AT/EISA interrupt controller has eight interrupt inputs, IRQ0 through IRQ7, which are mapped by the controller to software interrupts **INT 8** through **INT 15**. IRQ0 and IRQ1 are used for system timer and keyboard interrupts. These signals are always generated by circuitry on the computer system board. The other six interrupts are connected to pins in the PC's expansion box, the slot where expansion boards are plugged in. The PC/XT/AT/EISA design reserves most of these interrupts for particular peripherals, but, if those devices aren't present, the interrupts can be used for other purposes. PCI Series Carriers permit any of these six interrupts to be selected by placing an appropriate jumper.[1] Of course, no more than one of these jumpers should be in place, and any conflict with other devices should be avoided.

IBM's interrupt signals are assigned as follows:[3,4]

PC/XT/AT/EISA I/O Channel Interrupt Signals

Interrupt	**IBM Assignment**
IRQ2	Reserved
IRQ3	COM2 (second serial I/O port)
IRQ4	COM1 (first serial I/O port)
IRQ5	Fixed disk
IRQ6	Diskette
IRQ7	Printer

The PC/AT has an additional interrupt controller whose interrupts are mapped to INT 71H through INT 77H.[6] The output signal from the second controller goes to IRQ2, which is replaced in the first I/O Channel connector by IRQ9. The operating system calls the code set up for IRQ2 when an interrupt occurs on IRQ9, so that hardware and software designed for the PC will also work on the AT. However, the AT's reset and power-on sequence checks for activity on IRQ9 in order to detect special peripherals. If you use the IRQ2 jumper to select IRQ9 on the AT you must insure that your hardware will never generate interrupts during a reset or power-on, or your computer will be unable to boot. In fact, it's a bad idea to allow any peripherals to generate interrupts during the computer startup.

In addition to selecting the PC interrupt number your system will use, you must install jumpers to connect signals from the I/O Modules to the interrupt line. Before installing these jumpers, be sure that the corresponding module provides appropriate interrupt signals and that your program requires a signal from that module. You may find it helpful to study the examples in the section on Sample Systems. Don't install more module interrupt jumpers than you need, since you will just make it more difficult and time-consuming for your interrupt routine to determine the source of the interrupt.

Handling Interrupts in Software

Although your application programs will be mainly written in a high-level language, you will probably have to write at least part of your interrupt handler routines in assembly language or machine language. If you have never programmed in assembly language for the IBM PC/XT/AT/EISA, start by writing some practice routines which perform simple tasks, such as adding two numbers and returning the sum to a calling program. This will allow you to become familiar with the 8088/8086 instruction set, the assembler, and the assembly language interface used by your high- level language.

Some programming languages, such as TURBO PASCAL[7], make use of **in-line machine language** or **in-line assembly language**. These features allow you to intersperse machine instructions with high- level programming statements. If you will be using in-line code to handle interrupts with a high-level language, you should write some similar practice programs before you begin to program interrupt handler routines.

In order to make use of interrupts, you must provide an interrupt handler to perform whatever tasks you require when an interrupt occurs. DOS provides routines to store and retrieve interrupt handler addresses (vectors) through the DOS Function Call INT 21H. For details, you should consult the DOS Technical Reference Manual[8] or the Microsoft MS-DOS Programmer's Reference Manual.[9] If you prefer, you can read and write the interrupt vectors, accessing Segment 0 directly, but you should do this with the processor interrupts disabled.

The interrupt handler must save any registers it uses and set up the segment registers that it will require. The interrupt handler may read and write any memory or I/O location. The interrupt handler should not try to perform any I/O that requires calls to DOS. This normally includes screen output or printer output, keyboard input, and file I/O. All registers must be restored and the interrupt controller cleared before the interrupt return is performed.

After the address of the interrupt handler has been stored, the interrupt controller must be commanded to permit interrupts on the selected channel. At the end of the program, that channel's interrupts must again be inhibited. It's a good idea to make sure the interrupt controller will be re-programmed to its initial state— even if the user exits the program by typing CTRL-Break. You can do this by replacing the DOS CTRL-Break function, which is called by INT 23H, with your own "clean-up" routine.

The PC operating system does not provide any routines for programming the interrupt controller. The interrupt controller is programmed using the 8086 Family's **IN** and **OUT** instructions. On IBM PC/XT/AT/EISAs and most compatibles, the interrupt controller occupies I/O addresses 20H and 21H. The interrupt enable mask is read from or written to I/O location 21H. Bit values of 0 in the mask correspond to interrupt channels that are enabled. The following sequence would enable interrupts on IRQ2 without changing the state of any other interrupts:

```
IN      AL,21H          ;read original mask
MOV     OLD_MASK,AL     ;save mask so it can be restored
AND     AL,OFBH         ;set bit 2 to 0
OUT     21H, AL         ;write new mask
```

To restore the original controller mask:

```
MOV     AL,OLD_MASK     ;get original mask
OUT     21H,AL          ;write to controller
```

The interrupt controller must be cleared at the end of the interrupt handler routine. Unless this is done, no further interrupts of equal or lower priority will occur. The following sequence clears the controller:

```
MOV     AL,20H          ;this byte is the end-of- interrupt
                        ; command
OUT     20H,AL          ;clear the controller
```

Using the System Clock for Data Acquisition

Many data acquisition applications have relatively low speed requirements and can be adequately timed by the IBM PC's internal system clock. This clock is based on interrupts at approximately 18.2 Hz from an Intel 8253 timer. If you can make use of interrupts at this speed for your application, there are two simple ways to use the internal system clock. With either of these methods, the PC system clock continues to function; so, you don't have to worry about maintaining the time-of-day clock, clearing the interrupt controller, or other "housekeeping" tasks performed by the system clock interrupt handler.

Using **INT 1CH**

This is the interrupt number recommended by IBM for installing a timer interrupt handler. The DOS timer interrupt handler always calls the user's timer interrupt handler, **INT 1CH**, before performing an interrupt return. To install your timer interrupt handler routine, retrieve the current interrupt vector for **INT 1CH** and save it. Replace it with the address of your interrupt handler. Your interrupt handler must save all registers used, restore them at the end, and exit with an interrupt return instruction.

Using **INT 8**

This interrupt can provide a more accurate time base than using **INT 1CH**, since your interrupt handler will execute before the DOS routine, which can take varying lengths of time. To replace the DOS **INT 8** interrupt handler with your routine, retrieve the current interrupt vector for **INT 8** and save it. Replace it with the address of your interrupt handler. Your interrupt handler must save all registers used and restore them at the end. Instead of exiting with an interrupt return, however, you will exit with a **FAR JUMP** to the original **INT 8** vector.

Regardless of which of these methods you use, you must be sure to restore the interrupt vector to its original value at the end of the program.

Reprogramming the System Clock

If your application requires interrupts faster than 18.2 Hz, you can still use the system timer. However, you must re-program the counter and restore it when your program finishes. The system timer is Counter 0 of an Intel 8253[2], which occupies I/O addresses 40H through 43H on IBM PC/XT/AT/EISAs and compatibles. The following sequence will program the counter to interrupt at a new rate:

```
MOV     AL,36H          ;set Mode 3, 16-bits, binary
OUT     43H,AL          ;write control register
MOV     AX,TMR_CNT      ;load new count value
OUT     40H,AL          ;write low-order byte
MOV     AL,AH
OUT     40H,AL          ;write high-order btye
```

The following sequence will restore the counter to its original interrupt rate:

```
MOV     AL,36H          ;set Mode 3, 16-bits, binary
OUT     43H,AL          ;write control register
XOR     AL,AL           ;count value 0 (same as 65,536)
OUT     40H,AL          ;write low-order byte
OUT     40H,AL          ;write high-order byte
```

You can determine the value to load into the count register with, **TMR_CNT**, as follows:

TMR_CNT = TI * F0

F0 is the frequency in Hz of the input signal to the 8253, which is 1.19318MHz on the IBM PC and most compatibles. TI is the time interval you want between interrupts. For example, to generate interrupts every 10mSec,

TMR_CNT $= (10 * 10^{-3}) * (1.19318 * 10^{6})$
$= 11{,}932$ (approximately)

The count you program must be less than or equal to 65,536 (0 corresponds to 65,536). If you require a larger value, divide that value by a number large enough that the result is less han 65,536. Call this number NDIV. Your interrupt handler must then maintain a counter in a memory location which is initially loaded with NDIV and is decremented by 1 on each interrupt. When this counter reaches 0, the interrupt handler should reload it with NDIV and call the data acquisition routine.

For example, to perform data acquisitions every second,

TMR_CNT $= 1 * (1.19318 * 10^{6})$
$= 20 * 59{,}659$

You would set NDIV to 20 and replace TMR_CNT with 59,659.

If you want to maintain the time-of-day clock and the computer's other housekeeping tasks, you must arrange to call the original **INT 8** routine at the right frequency. You can do this by maintaining a counter in a memory location. On each interrupt, the interrupt handler adds the value TMR_CNT to this location. When the result overflows (the addition produces a carry), the system timer interrupt handler should be called. (This procedure results in an average clock frequency the same as that of the original clock, but the rate is not exactly constant.)

The symbols **NDIV_CT** and **SYST_CT** refer to memory locations which are allocated in the data segment (not shown). The symbols **NDIV** and **TMR_CT** may refer to memory locations in the data segment, or they may be constants.

The following sequence might form the skeleton of a timer interrupt handler.

```
;These variables must be stored in the code segment:
PC+INT8     LABEL       DWORD           ;storage for original interrupt
PC_OFF8     DW          ?               ; offset
PC_SEG8     DW          ?               ; and segment
PSEG        DW          ?               ;storage for data segment value
;--------------------------------------------------------------------------------
MY_INT8:    PUSH        DS              ;save data segment
            PUSH        AX              ;save accumulator
            ...                         ;save other registers as needed
            MOV         AX,CS:DSEG      ;load DS with correct value
            MOV         DS,AX           ; (saved in code segment)
;This section of code is required for counts greater than 65536:
            DEC         NDIV_CT         ;decrement NDIV counter
            JNZ         NOT_ZRO
            MOV         AX,NIDV         ;reload NDIV counter
            MOV         NDIV_CT,AX
;--------------------------------------------------------------------------------
;This section of code is always required:
            CALL ACQUIRE                ;call data acquisition routine
;--------------------------------------------------------------------------------
;This section of code is required whenever the timer has been re-programmed:
NOT_ZRO:    MOV         AX,TMR_CNT      ;update dummy system timer
            ADD         SYST_CT,AX      ;ADD sets carry flag on overflow
                                        ;restore all saved registers
            POP         AX              ;POP doesn't affect flags (in
            POP         DS              ; particular, the carry flag)
            JNC         NOT_CYF         ;skip if timer didn't overflow
            JMP         CS:PC_INT8      ;jump to original routine
                                        ; address (saved in code segment)
NOT_CYF:    IRET                        ;return from interrupt
;--------------------------------------------------------------------------------
```

;This above would be replaced by this section of code if the timer is not
; re-programmed:

```
                ...                         ;restore all saved registers
                POP         AX
                POP         DS
                JMP         CS:PC+INT8      ;jump to original routine
;-------------------------------------------------------------------------------
```

SAMPLE PCI-20000 SYSTEMS USING INTERRUPTS

;Interrupt entry sequence:

```
                                            ;51 cycles to respond to INT n
MY_INT8         PUSH        DS              ;10     save registers
                PUSH        ES              ;10
                PUSH        DI              ;10
                PUSH        AX              ;10
                MOV         AX,DSEG         ;4      load segment registers
                MOV         ES,AX           ;2
                MOV         AX,0C000H       ;4      DS addresses the PCI-20000
                MOV         DS,AX           ;2      carrier segment
                MOV         DI,BUFR_PTR     ;14     load buffer pointer
                                            ;127    total cycles for entry
```

;Data acquisition sequence:

```
                MOV         AX,CNVT_DAT     ;16     read converter
                STOSW                       ;14     store data in memory and
                                            ;       increment pointer
                CMP         DI,END_BUFR     ;15     check for end of buffer
                JZ          END_PRC         ;4      quit if end of buffer
                                            ;49     cycles data acquisition
```

;Interrupt return sequence:

```
                MOV         BUFR_PTR,DI     ;15     store buffer pointer
                MOV         AL,20H          ;4      clear interrupt
                OUT         20H,AL          ;10
                POP         AX              ;8      restore registers
                POP         DI              ;8
                POP         ES              ;8
                POP         DS              ;8
                IRET                        ;32     return
                                            ;93     total cycles for exit
END_PRC:        ...                         ;       quit at end of buffer
```

;Setup sequence (performed once):

```
MY_POLL:        MOV         DI,BEG_BUFR     ;lead buffer pointer
                MOV         CX,BUFR_CNT     ;load buffer length
                MOV         DL,MASK         ;get mask for status register
                PUSH        DS              ;load segment registers
                POP         ES
                MOV         AX,0C000H       ;DS addresses the PCI-20000
                MOV         DS,AX           ; carrier segment
```

;Data acquisition sequence:

```
POL_LP:         TEST        STATUS,DL       ;17     test data ready
                JNZ         POL_LP          ;4-16
                                            ;21 cycles loop overhead (min)
                                            ;33 cycles for additional pass
                MOV         AX,CNVT_DAT     ;16 read converter
                STOSW                       ;11 store data in memory
                                            ; and increment pointer
                LOOP        POL_LP          ;17 continue
                                            ;44 cycles data acquisition
END_PRC:        ...                         ;quit at end of buffer
```

Sample PCI Systems Using Interrupts

Below are examples of PCI Systems which might be used for interrupt-controlled data acquisition. Each example includes a brief description of the hardware configuration and the function of the software.

Example 1. Use a PCI-20020M-1 Trigger/Alarm Module to generate an alarm interrupt.

Connect the PCI-20020M-1 *IRQ0 to the interrupt line. When an interrupt occurs, your software will respond to the alarm. The alarm response might include recording the alarm activity or activation of other equipment. The example interrupt handler routine which appears in LISTING #1 at the end of this Application Note could be used as a model for the interrupt handler.

This is a good example of an application in which interrupts give better performance than polling. Alarms, by definition, occur at unpredictable times. Interrupts allow the processor to perform other tasks and still respond quickly to an alarm.

Example 2. Use the rate generator on a PCI-20007M-1 Counter/Timer/Rate Generator Module to time data acquisition using any combination of I/O Modules.

Connect the PCI-20007M-1 *IRQ0 signal to the interrupt line. Program the Rate Generator to produce an output signal of the desired frequency.[5] When an interrupt occurs, your software will perform the desired data acquisition sequence.

The Turbo Pascal sample program shown in LISTING #2 at the end of this Application Note is designed for this system. The program uses a 3000Hz interrupt signal generated by a PCI-20007M-1 module to time the acquisition of analog data using a PCI-20002M-1 module. While the data acquisition process is occurring the program also graphs the data being acquired. The use of the interrupt handler to acquire the analog data not only allows the program to do two processes at once but ensures that the acquisition progresses at a well-defined rate. Using this method, data acquisition and graphing occur simultaneously without interfering with each other.

Example 3. Use the rate generator on a PCI-20007M-1 Counter/Timer/Rate Generator Module to control data acquisition from a PCI-20019M-1A High Speed Analog Input Module.

Connect the PCI-20007M SYNC OUT signal to SYNC IN of the PCI-20019M-1A. Connect the PCI-20019M-1A *IRQ0 signal to the interrupt line. You can optionally configure the input module for automatic channel advance. When an interrupt occurs, your software will read the converted data from the PCI-20019M-1A. This is a good example of an application in which either polling or interrupts could be used, depending on speed requirements and other program tasks.

Timing Comparisons of Interrupts and Polling

The time required to execute a data acquisition sequence may affect the rate at which data are acquired, and it may determine whether interrupts or polling are to be used to control data acquisition. Routine MY_INT8 on the previous page shows sequences to support the data acquisition system of Example 3 using interrupts and polling. We will use this example to estimate the time required for a minimum data acquisition process and to compare the processor overhead required to service an interrupt. The number of 8086 processor cycles required for each instruction is shown in the comment field.[1]

The total number of cycles of interrupt overhead is 220, corresponding to about 46μsec for a 4.77MHz processor clock. The instruction cycle counts shown are for an 8086 processor. These do not give a precise estimate of the actual time required. The 8088 processor used in the PC/XT and compatibles requires more cycles because of its 8-bit bus. Some time is gained by the processor's "pre-fetch queue" which allows it to read the next program instructions during idle bus cycles, and the memory refresh circuitry competes with the processor for bus access. The actual overhead of this example is close to 55μsec for an PC/XT. (This corrected estimate is based on timing tests of similar code on an PC/XT.)

Compare the interrupt routine above with this polling routine which performs the same function:

The total loop overhead is 21 cycles minimum, and the data acquisition time is approximately the same as in the interrupt. Clearly, data could be taken more rapidly using polling than using interrupts. Furthermore, the accuracy with which the processor can respond to a signal is limited only by the polling loop time of 33 cycles. An interrupt response is limited by the cycle time of the interrupted instruction. Typical instructions that access memory require 10-30 cycles, but a multiply or divide instruction might require over 100 cycles. Of course, for maximum timing accuracy, either application would be run with other interrupts masked or disabled. This polling loop is not very versatile; the computer is completely tied up while data is taken. For relatively slow sampling rates, the interrupt overhead becomes negligible, and the interrupt technique allows the processor to perform other tasks.

These sample code sequences contain a few symbols that are not defined above. Instruction timing depends on whether symbols used in **MOV** instructions refer to constants or to memory locations. The symbol **DSEG** is the default data segment value, a constant. The symbol CNVT_DAT refers to the memory location of an A/D converter data register. The symbols **BUFR_PTR, BEG_BUFR, END_BUFR,** AND **BUFR_CNT** refer to memory storage locations in the default data segment.

The examples show two different ways of keeping track of the data count and the location in which the data is to be stored. Assembly language code to set up all the buffer variables might appear as follows, where **BUFR_LEN** is a constant.

```
BUFR_PTR     DW     OFFSET BUFFER
BEG_BUFR     DW     OFFSET BUFFER
END_BUFR     DW     OFFSET BUFFER +
                      BUFR_LEN*2
BUFR_CNT     DW     BUFR_LEN
BUFFER       DW     BUFR_LEN
```

Sample Listings

Listings of two interrupt handling systems are given in this section. These listings, along with the examples and discussions above, can be used as a reference for designing an interrupt handling system to suit your application. The first listing contains several assembly language subroutines which can be adapted for use with any compiled language that produces object files (*.OBJ) that are combined by the linker, LINK.EXE. The second listing is a complete program in TURBO PASCAL, in which in-line machine code is used to provide the interrupt handling functions that are not available in TURBO PASCAL.

LISTING #1 contains sample interrupt handler routines written in assembly language, which can be assembled by the Macro Assembler and linked with your other program modules by LINK.EXE. The routines must be adapted to interface properly to your compiler. (They were tested with a program compiled by Microsoft C, Version 2.04.) Note that other compilers or version numbers may require changes to this code. Please refer to your compiler manual for guidance.

The documentation for your compiler will explain how to interface assembly language modules with compiled programs. You must make sure that the routines treat the registers and stack properly and that the names of the routines are compatible with your language's naming conventions. The SEGMENT and GROUP declarations[10] must be changed to match the segment and group names used by your compiler. The PROC declarations may need to be changed from NEAR to FAR.

If you use interpreted BASIC, you cannot directly use a file generated by an assembler. You must decide how you will load machine language routines so that BASIC can access them. You might read in the machine instructions from a file or store them in DATA statements in your program. The instructions must be POKEd into memory before the routines can be called. Using machine language subroutines is described in the IBM BASIC manual.[11]

Listing 1 contains the following routines:

SET_INT saves the original values of the interrupt vectors for **INT 8** (timer), INT 0AH (IRQ2), and INT 23H (control-break exit function) and sets up a new control-break exit routine.

CLR_INT restores all interrupt routines and re-programs the 8259A interrupt controller and the 8253 timer chips, which may have been altered by the program.

MY_CTBK is the control-break exit routine set up by **SET_INT**.

This routine insures that the interrupt routines and peripheral chips will be restored even if the user types control-break to exit the program. It calls **CLR_INT**, then jumps to the original control-break exit routine.

SET_IRQ2 sets up an interrupt handler for IRQ2 and programs the interrupt controller to enable IRQ2.

MY_IRQ2 is the interrupt handler set up by **SET_IRQ2**. It clears the interrupt controller and calls a user-supplied routine to acquire data or perform other functions.

SET_TIM sets up an interrupt handler for the system timer interrupt and re-programs the system timer to interrupt at a new rate.

MY_TIM is the interrupt handler set up by **SET_TIM**. It calls a user-supplied routine to acquire data or perform other functions. It maintains the system time-of-day clock by calling the system timer interrupt handler at the proper rate.

LISTING #2 shows a complete program, **INTERDMO.PAS**, which includes an interrupt handler routine. This program is written in TURBO PASCAL[7], which has provisions for writing in-line machine code.

```
LISTING #1                          TITLE   Sample Interrupt Handlers
                                    .RADIX 16
;****************************************************************************************************************
;   IR2_DAT and TIM_DAT
;
;   These are external procedures to acquire data or perform other desired functions.  They are called from the interrupt handlers
;   for IRQ2 and the timer interrupt (IRQ0), respectively.  Because MS-DOS and PC-DOS are not re-entrant, there are
;   limitations on what there routines can do.
;
;   IR2_DAT and TIM_DAT should NOT perform I/O using standard DOS console I/O, printer I/O, or disk I/O routines.
;   This includes most I/O library functions provided with compiled languages such as C and PASCAL.
;
;   Many compilers generate code to perform "stack checking" at the beginning of each subroutine (Microsoft compilers do
;   this).  You should DISABLE this feature when you compile the routines IR2_DAT and TIM_DAT, especially if your program
;   will perform console, printer, or disk I/O while data acquisition is taking place.  Your compiler manual should explain how to
;   disable stack checking.
;
;   You should initialize data buffers and other variables used by the IR2_DAT and TIM_DAT before calling SET_IR2 or
;   SET_TIM.
;
;****************************************************************************************************************
;   Language Interface
;
;   In order to combine this module with object modules produced by a compiler, the following SEGMENT and GROUP declarations must
;   correspond to the requirements of the compiler.  The segment or group name (depending on the compiler requirements) must also
;   appear in the OFFSET expressions that appear in the program.  Some compilers alter the names of global (public and external) symbols.
;   The names declared PUBLIC and EXTRN in this file must match the names the compiler puts in the OBJ files.  If your linker is
;   case-sensitive, the names must also be in the correct case.  You must refer to your compiler documentation for the correct SEGMENT
;   and GROUP declarations and for the correct form of global names.
;
;   The variable ERR_FL, which must be accessible by the calling program, is declared external.  The calling program must contain a
;   global 2-byte integer variable ERR_FL which is located in the default data segment.
;
;   The external routines IR2_DAT and TIM_DAT are expected to preserve DS, SS, and BP.  The interrupt handlers preserve all
;   registers.  All other routines preserve DS, ES, SS, and BP.  Some languages may require other registers to be preserved.
;
;****************************************************************************************************************
;   IBM PC AT
;
;   If you are using an IBM PC AT or equivalent computer, you should make the following modifications to this module:  Immediately
;   following EACH "IN" or "OUT" assembly instruction, add the following
;
;                       jmp  $+2
;
;   This insures that the I/O chip has adequate time between successive accesses.
pgroup          GROUP           prog
prog            SEGMENT         PUBLIC                  'PROG'
                ASSUME          cs:prog

INT_0A          DD              ?                       ;storage for original interrupt vectors
INT_08          DD              ?
INT_23          DD              ?
D_SEG           DW              ?                       ;storage for default data segment
TIMER           DW              0                       ;count register
INIT_FL         DB              0                       ;setup flag
OLD_MSK         DB              ?                       ;original interrupt controller mask
BUSY_2          DB              0                       ;IRQ2 re-entry flag
;****************************************************************************************************************
;   SET_INT
;
;   This routine is intended to be called near the beginning of a program.  It preserves the original contents of the interrupt vectors for
;   IRQ0 (timer, INT 8) and IRQ2 (data acquisition, INT OAH, which will be changed, as well as the original contents of the 8259
;   interrupt enable mask.  A flag, INIT_FL, is checked to prevent the setup procedure from being executed twice.
;
;   The routines SET_TIM and SET_IRQ2, which set up new interrupt handler routines, check INIT_FL and call SET_INT if necessary.
                PUBLIC          SET_INT
SET_INT         PROC            NEAR

                push            bp                      ;save BP
                mov             bp,sp
                sub             sp,2                    ;allocate space for one temporary word
                cmp             cs:INIT_FL,0
```

```
                jz      setup
                jmp     set_ex
setup:          mov     [bp-2],ds                       ;save DS in temporary
                inc     cs:INIT_FL
                mov     cs:D_SEG,ds                     ;save DS value in code area
                xor     ax,ax                           ;zero AX
                mov     ds,ax                           ;address Segment 0 with DS
;  ***************  The following is required if the timer interrupt is used.
                mov     ax,ds:(8*4)
                mov     dx,ds:(8*4+2)
                mov     WORD PTR cs:INT_08,ax           ;save original interrupt vectors
                mov     WORD PTR cs:INT_08+2,dx
;  ***************  The following is required if either the timer or IRQ2 is used.
                mov     ax,ds:(0a*4)
                mov     dx,ds:(0a*4+2)
                mov     WORD PTR cs:INT_0A,ax
                mov     WORD PTR cs:INT_0A+2,dx
                in      al,21                           ;save original interrupt
                mov     cs:OLD_MSK, al                  ; mask
;  ***************  The following is required if either the timer or IRQ2 is used.
                mov     ax,ds:(23*4)
                mov     dx,ds:(23*4+2)
                mov     WORD PTR cs:INT_23,ax
                mov     WORD PTR cs:INT_23+2,dx
;  ***************  Interrupts must be disabled to change interrupt vectors.
                cli                                     ;replace CTRL-BRK with local routine
                mov     WORD PTR ds:(23*4), OFFSET pgroup:MY_CTBK
                mov     ds:(23*4+2),cs                  ;CS contains MY-CTBK
                sti                                     ; address MY_CTBK

                mov     ds,[bp-2]                       ;restore DS
set_ex:         mov     sp,bp
                pop     bp                              ;restore BP
                ret
SET_INT         ENDP
;*****************************************************************************************************************
;  CLR_INT
;
;  This routine must be called prior to the end of the program. It restores the original contents of the interrupt vectors preserved by
;  SET_INT. The flag INIT_FL is checked and the routine is bypassed if SET_INT was never called. CLR_INT is called from
;  MY_CTBK if the user types a CTRL-BREAK.

                PUBLIC  CLR_INT
CLR_INT         PROC    NEAR
                push    bp                              ;save BP
                mov     bp,sp
                sub     sp,2                            ;allocate space for one temporary word
                cmp     cs:INIT_FL,0
                jz      clr_ex
                mov     [bp-2],ds                       ;save DS in temporary
                xor     ax,ax                           ;address Segment 0 with DS
                mov     ds,ax
                cli
;  ***************  Interrupts must be disabled to change interrupt vectors or to reprogram the timer.
;  ***************  The following is required if the timer interrupt is used.
                mov     al,36                           ;output timer control word
                out     43,al
                xor     ax,ax                           ;initialize time count to zero
                out     40,al
                mov     al,ah
                out     40,al
                mov     ax,WORD PTR cs:INT_08           ;restore original interrupt vectors
                mov     dx,WORD PTR cs:INT_08+2
                mov     ds:(8*4),ax
                mov     ds:(8*4+2),dx
```

```
;    ***************   The following is required if IRQ2 is used
                  mov          al,cs:OLD_MSK                ;restore interrupt mask
                  out          21,al
                  mov          ax,WORD PTR cs:INT_0A
                  mov          dx,WORD PTR cs:INT_0A+2
                  mov          ds:(0a*4),ax
                  mov          ds:(0a*4+2),dx
;    ***************   The following is required if either the timer or IRQ2 is used.
                  mov          ax,WORD PTR cs:INT_23
                  mov          dx,WORD PTR cs:INT_23+2
                  mov          ds:(23*4),ax
                  mov          ds:(23*4+2),dx
                  sti
                  mov          ds:,[bp-2]                   ;restore DS
                  mov          cs:INIT_FL,0                 ;clear flag
clr_ex            mov          sp,bp
                  pop          bp                           ;restore BP
                  ret
CLR_INT           ENDP
;*************************************************************************************************************************
;    MY_CTBK
;
;    This routine replaces the usual INT 23 "interrupt handler", which is called if a CTRL_BREAK is pressed during execution of the
;    program. It ensures that the interrupt routines will be restored properly and that the interrupt controller and timer chips will be
;    correctly reprogrammed.
                  PUBLIC       MY_CTBK
MY_CTBK           PROC         NEAR
                  push         ax                           ;save all registers
                  push         bx
                  push         cx
                  push         dx
                  push         si
                  push         di
                  push         es
                  push         ds
                  mov          ds,cs:D_SEG                  ;load data segment
                  call         CLR_INT                      ;restore interrupts
                  pop          ds                           ;restore registers
                  pop          es
                  pop          di
                  pop          si
                  pop          dx
                  pop          cx
                  pop          bx
                  pop          ax
                  jmp          cs:INTT+23                   ;call regular INT 23 routine
MY_CTBK ENDP
;*************************************************************************************************************************
;    SET_IRQ2
;
;    This routine calls SET_INT to preserve the initial interrupt routine addresses, if necessary. It sets up a special interrupt routine
;    for IRQ2 and enables interrupts from IRQ2 by reprogramming the interrupt controller.
                  PUBLIC       SET_IRQ2
SET_IRQ2          PROC         NEAR
                  push         bp                           ;save BP
                  mov          bp,sp
                  sub          sp,2                         ;allocate space for one temporary word
                  cmp          cs:INIT_FL,0
                  jnz          enable
                  call         SET_INT                      ;make sure SET_INT is called
enable:           mov          [bp-2],ds                    ;save DS in temporary
                  xor          ax,ax                        ;address Segment 0 with
                  mov          ds,az                        ; DS
;    ***************   Interrupt must be disabled to change interrupt vectors.
                  cli                                       ;set up IRQ2 routine
                  mov          WORD PTR ds:(0a*4),OFFSET pgroup:MY_IRQ2
                  mov          ds:(0a*4+2),cs               ;CS contains segment to address MY_IRQ2
                  in           al,21                        ;set interrupt mask
                  and          al,0fbh
                  out          21,al
                  sti
```

```
         mov      ds,[bp-2]        ;restore DS
         mov      sp,bp
         pop      bp               ;restore BP
         ret
SET_IRQ2 ENDP
;***************************************************************************************************************
;  MY_IRQ2
;
;  This is the interrupt handler for IRQ2. It is written as a skeleton which calls the actual data acquisition routine, IR2_DAT. (The routine
;  IR2_DAT is not provided in this example.) Since all registers are saved, IR2_DAT may be written in a high-level language.
;
;  In order to detect a too-rapid data acquisition situatin, interrupts are re-enabled immediately and the interrupt controller is cleared. A
;  flay is set to prevent re-entry in case one interrupt is not finished before another occurs.  If the routine is re-entered, it increments an
;  error counter, ERR_FL, and immediately returns. The calling program should check the error counter as an indication of bad data.
         PUBLIC   MY_IRQ2
MY_IRQ2  PROC     FAR
         push     ax               ;save AX and DS
         push     ds
         mov      ds,cs:D_SEG      ;set up program data segment
         cmp      cs:BUSY_2,0      ;test for multiple entry
         mov      al,20            ;write EOI to 8259 to allow interrupt at this
         out      20,al            ; level
         jz       ir2_ok
         inc      ds:ERR_FL        ;set flag
         jmp      SHORT ir2_ex
ir2_ok:  mov      cs:BUSY_2,1      ;set busy flag
;  ***************  Interrupts enabled after testing and setting BUSY_2.
         sti
         push     bx               ;save all other registers
         push     cx
         push     dx
         push     si
         push     di
         push     bp
         push     es
         mov      ex,cs:D_SEG      ;set up extra segment
         mov      bp,sp            ;save SP in BP
         call     IR2_DAT          ;call data acquisition routine
         mov      sp,bp            ;restore SP
         pop      es               ;restore all registers
         pop      bp
         pop      di
         pop      si
         pop      dx
         pop      cx
         pop      bx
;  ***************  Routine must end with interrupts disabled.  No interrupts can be allowed after BUSY_2 is cleared.
         cli
         mov      cs:BUSY_2,0      ;clear busy flag
ir2_ex:  pop      ds               ;restore AX and DS
         pop      ax
         iret
MY_IRQ2  ENDP
;***************************************************************************************************************
;  SET_TIM
;  This routine calls SET_INT to preserve the initial interrupt routine addresses, if necessary.  It reprograms the PC's timer interrupt to a
;  faster rate (twice the normal rate, as determined by TIM_CNT) and sets up a special interrupt routine for the timer interrupt.
         PUBLIC   SET_TIM
SET_TIM  PROC     NEAR
         push     bp               ;save BP
         mov      bp,sp
         sub      sp,2             ;allocate space for temporaries
         cmp      cs:INIT_FL,0
         jnz      start
         call     SET_INT          ;make sure SET_INT is called
start:   mov      [bp-2],ds        ;save DS in temporary
         cli
         mov      al,36            ;reprogram timer chip
         out      43,al
         mov      ax,TIM_CNT
         out      40,al            ;output timer count
         mov      al,ah
```

```
                out         40,al
                mov         cs:TIMER,0                  ;clear timer register
                xor         ax,ax
                mov         ds,ax                       ;set up local interrupt routine
                mov         WORD PTR ds:(8*4), OFFSET pgroup;MY_TIM
                mov         ds:*8*4+2),cs
                sti
                mov         ds,[bp-2]                   ;restore DS
                mov         sp,bp
                pop         bp                          ;restore BP
                ret
SET_TIM         ENDP
;*******************************************************************************************************************
;   Timer interrupt
;
;   This is the interrupt handler for IRQ0. It is written as a skeleton which calls the actual data acquisition routine, TIM_DAT. (The routine
;   TIM_DAT is not provided in this example.) Since all registers are saved, TIM_DAT may be written in a high-level language.
;
;   In order to maintain an accurate system clock, the PC's timer interrupt handler (the original INT 8 routine) is called every other time
;   the interrupt occurs.
                PUBLIC      MY_TIM
MY_TIM          PROC        FAR
                push        ax                          ;save registers
                push        ds
                push        bx
                push        cx
                push        dx
                push        si
                push        di
                push        bp
                push        es
                mov         ds,cs:D_SEG                 ;get program data segment
                mov         ex,cs:D_SEG
                mov         bp,sp                       ;save SP in BP
                call        TIM_DAT                     ;call data acquisition routine
                mov         sp,bp                       ;restore SP from BP
                pop         ex                          ;restore registers
                pop         bp
                pop         di
                pop         si
                pop         dx
                pop         cx
                pop         bx
                pop         ds
                add         cs:TIMER, TIM_CNT
                jc          tim_ex
                mov         al,20                       ;write EOI to 8259
                out         20,al
                pop         ax                          ;restore AX
                iret                                    ;return from interrupt
tim_ex:         pop         ax                          ;restore AX
                jmp         cs:INT_08                   ;call regular timer routine
MY_TIM          ENDP
prog            ENDS
                END
```

LISTING #2 { PCI-20000, TURBO-PASCAL, INTERRUPT HANDLING DEMONSTATION PROGRAM

HARDWARE: PCI-20001C-2A OR PCI-20001C-1A (Jumper W31 In For Interrupt Level 3)
PCI-20002M-1 (Mod 3), and PCI-20007M-1 (Mod 2) }

```
{$C-,U-}              {Disable Ctrl-Break}
Program InterDmo
Const
   MaxOff          =      619   ;  {  Maximum Data Buffer Offset          }
   MinOff          =       20   ;  {  Minimum Data Buffer Offset          }
   Stat 8259       =      $20   ;  {  8259 Status Register Port Address   }
   Mask 8259       =      $21   ;  {  8259 Mask Register Port Address     }
   KeysOnMask      =      $FD   ;  {  8259 Mask for Keyboard ONLY On      }
   EOI             =      $20   ;  {  8259 End of Interrupt Command       }
   ModNo2M         =        3   ;  {  Module position number of PCI2M     }
   CarSeg          =    $C000   ;  {  Segment address of carrier          }
   RGN1            =    $0378   ;  {  N1 for 3000 ticks in 1 second       }
   RGN2            =    $0003   ;  {  N2 for 3000 ticks in 1 second       }
   HdwintNo        =        3   ;  {  Hardware Interrupt Number           }
   PgmDS : Interger =       0   ;  {  Store for Program's Data Segment    }
Type
   DataBuffer = Array [MinOff..MaxOff] of Integer ; { Buffer for Data }
Var
   Set2M       :  Byte Absolute CarSeg:$0302      ;  {  Channel and Gain Setup                          }
   Strobe2M    :  Byte Absolute CarSeg:$0304      ;  {  Strobe address to start ADC                     }
   MSB2M       :  Byte Absolute CarSeg:$0304      ;  {  Read MSB address for ADC                        }
   LSB2M       :  Byte Absolute CarSeg$0305       ;  {  Read LSB address for ADC                        }
   RGCtrl      :  Byte Absolute CarSeg:$0207      ;  {  Rate Gen. Control address                       }
   RGCnt1      :  Byte Absolute CarSeg:$0204      ;  {  Rate Gen. Counter 1 address                     }
   RGCnt2      :  Byte Absolute CarSeg:$0205      ;  {  Rate Gen. Counter 2 address                     }
   RGGate      :  Byte Absolute CarSeg:$020C      ;  {  Rate Gen. Enable Gate address                   }
   IntOff      :  Integer Absolute $0000:$002C    ;  {  NOTE: Must be consistent                        }
   IntSeg      :  Integer Absolute $0000:$002E    ;  {     with HdwintNo.                               }
   IntMask     :  Byte                            ;  {  Storage for 8259 interrupt mask                 }
   SaveIntOff  :  Integer                         ;  {  Storage for interrupt handler offset address    }
   SaveIntSeg  :  Integer                         ;  {  Storage for interrupt handler segment address   }
   BufferOff   :  Integer                         ;  {  Pointer into Data Buffer for int. handler       }
   DispOff     :  Integer                         ;  {  Pointer into Data Buffer for grapher            }
   Buffer      :  DataBuffer                      ;  {  The Data Buffer                                 }
   Ch          :  Chac                            ;  {  Storage for a character pressed on keys         }
{  IntHandler -- this is the interrupt handler. }
Procedure IntHandler ;
Begin { IntHandler }
   { ***** Save the state of the 8088 CPU ***** }
InLine       ($50/      {  PUSH AX                      }
              $53/      {  PUSH BX                      }
              $51/      {  PUSH CX                      }
              $52/      {  PUSH DX                      }
              $56/      {  PUSH SI                      }
              $57/      {  PUSH DI                      }
              $1e/      {  PUSH DS                      }
              $06/      {  PUSH ES                      }
   $2E/$83/$13/>PgmDS { CS:MOV ds, PgmDS ; Setup DS     }
   );
{ ***** Process the interrupt *****}
If BufferOff < > (MaxOff + 1) Then { If Buffer is not full }
Begin
   If BufferOff < > (MinOff - 1) Then { No read on first pass )
   Begin
      { ***** Get the ADC value ***** }
      Buffer[BufferOff] := (MSB2M shl 4) or (LSB2M shr 4) ;
   End ;
   { ***** Update Buffer Pointer ***** }
   BufferOff := BufferOff + 1 ;
   { ***** Start the next conversion ***** }
   Strobe 2M :=0  ;
End
Else
Begin
   RGGate := 0  ; {Disable Rate Generator }
End ;
```

```
{ ***** Notify 8259 of EOI ***** }
Port[Stat8259] :=EOI ;
    { ***** Restore the state of the 8088 CPU ***** }
    Inline          ($07/       {   POP ES                          }
                     $1F/       {   POP DS                          }
                     $5F/       {   POP DI                          }
                     $5E/       {   POP SI                          }
                     $5A/       {   POP DX                          }
                     $59/       {   POP CX                          }
                     $5B/       {   POP BX                          }
                     $58/       {   POP AX                          }
                 $8B/$35/       {   MOV SP,BP                       }
                     $5D/       {   POP SP                          }
                     $CF        {   IRET                            }
End ; { IntHandler }
    { Installint -- this routine installs the interrupt handler. }
    Procedure InstallInt ;
    Begin { InstallInt }
        { **** Disable All Interrupts ***** }
        InLine ($FA) ;
        { ***** Save the current interrupt vector ***** }
    SaveIntOff := IntOff ;
    SaveIntSeg := IntSeg ;
    { ***** Store the new interrupt vector ***** }
    IntOff := Ofs(IntHandler) ;
    IntSeg := CSeg
    { ***** Save 8259 mask register ***** }
    IntMask := Port[Mask8259] ;
    { ***** Store new 8259 mask **** }
    Port[Mask8259] := KeysOnMask xor (1 shl HdwintNo) ;
    { ***** Re-Enable Interrupts ***** }
    Inline ($FB) ;               { STI }
End ; { Installint }
    { RemoveInt -- this routine removes the interrupt handler. }
    Procedure RemoveInt ;
    Begin { RemoveInt }
        { ***** Disable All Interrupts ***** }
        InLine ($FA) ;           ( CLI }
        { ***** Restore the old interrupt vector ***** }
        IntOff := SaveIntOff ;
        IntSeg := SaveIntSeg ;
        { ***** Restore old 8259 mask ***** }
        Port[Mask8259] := IntMask ;
        { ***** Re-Enable Interrupts ***** }
        InLine ($FB) ;           { STI }
        End ; { RemoveInt }
    Begin { InterDmo }
        { ***** Save the programs Data Segment Register ***** }
        PgmDS :=DSeg ;
        { ***** Delay long enough for diskette to go off ***** }
        Delay(2000) ;
        { ***** Setup the 2M module to read channel 0 at gain of 1 ***** }
        Set2M :=$40 ;
    { ***** Setup the Rate Generator ***** }
    RGCtrl          :  = $34                    ;  {  Setup RG Counter 1          }
    RGCtrl          :  = $74                    ;  {  Setup RG Counter 2          }
    RGCnt1          :  = Lo(RGN1)               ;  {  Write Low Count LSB         }
    RGCnt1          :  = Hi(RGN1)               ;  {  Write Low Count MSB         }
    RGCnt2          :  = Lo(RGN2)               ;  {  Write High Count LSB        }
    RGCnt2          :  = Hi(RGN2)               ;  {  Write High Count MSB        }
    RGGate          :  = 0                      ;  {  Disable Rate Generator      }
        { ***** Begin the demonstration ***** }
        HiRes                    ;   {Setting High Resolution Mode }
        InstallInt ;
    Repeat
        GotoXY(19,25) ;
        Write(' Press E to Exit, or A to Acquire data ? ') ;
    Repeat
        Repeat                       { Get A Key }
          Read(KBD, Ch) ;
        Until Not KeyPressed ;
        Ch := UpCase(Ch) ;
```

```
Until (Ch = 'A') or (Ch = "E') ;
HiRes               ;    { Setting High Resolution Mode }
If Ch = 'A' Then
Begin
   Draw(     10,    0,  629,    0,    1)     ;  { Draw Border    }
   Draw(    629,    0,  629,  186,    1)     ;
   Draw(    629,  186,   10,  186,    1)     ;
   Draw(     10,  186,   10,    0,    1)     ;
GotoXY(19,25) ;
Write(' Acquiring and Graphing Data ') ;
BufferOff       :=      MinOff -1;
DispOff         :=      MinOff;
RGGate          ;=      3   ; { Enable Rate Generator              }
Repeat
   If DispOff > (BufferOff -1) Then
   Begin
   Draw  (DispOff,    Trunc(186-(Buffer[DisOff      ]/4096.0*177)),
          DispOff+1,  Trunc(186-(Buffer[DispOff+1 ]/4096.0*177)), 1) ;
   DispOff := DisOff + 1 ;
End ;
Until DispOff = MaxOff ;
End ;
Until Ch = "3" ;
RemoveInt ;
{ ***** Clean Up the Screen ***** }
TextMode ;
End. { InterDmo }
```

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Direct Memory Access (DMA) Techniques for Data Acquisition

Direct memory access and computerized data acquisition are two concepts that have traditionally gone hand-in-hand. There is no faster and more efficient way to get large quantities of data into a personal computer than DMA.

Data acquisition generally involves the monitoring of several sources of physical data at a regular rate defined by a clock or external timing signal. The sources of data are typically mixes of A/D converters, event counters, switches, and contact closures. A/D converters are normally multi-channel devices which convert analog signals from several sources into digital signals for consumption by the computer. Often, some pre-amplification is required to boost the analog signals to the level required by the converter. Event counters, switches and contact closures are already digital signals, and they typically require only buffering to bring their levels to the required value.

Once the mixture of analog and digital input signals has been conditioned into a form acceptable by a computer, they need to be sampled at a regular rate and stored in memory. The three techniques for doing this are polling, interrupts, and direct memory access, or DMA. If the goal is to acquire the maximum amount of data at the highest speed, using the minimum amount of the computer's resources, then DMA is the technique of choice.

The amount of time required to respond to a direct memory access request is infinitesimal compared to the amount of time required to service an interrupt or execute a polling loop. This makes the goals of true background operation and high speed possible. Throughputs of 360Kbytes/sec are achievable on an IBM PC or compatible computer using DMA. Burst rates of several megabytes/sec are not uncommon among minicomputers. Since DMA is a hardware technique, the only computer resource used is bus bandwidth.

DMA Basics

The IBM PC's DMA controller contains four separate channels. One channel is used to refresh the machine's dynamic memory, another handles transfers to and from the floppy disk drive, and a third is used to transfer data to and from the hard disk drive. This leaves one channel for general use. As with interrupts, the DMA channels are prioritized. The transfers occur so quickly, however, that at rates of less than 100K samples per second or so, data acquisition would not be impacted.

The DMA controller needs to know where in memory the data from the requesting device is to go (called the "base address") and how many items are to be transferred (called the "byte count"). Then, each time it processes a DMA request, the controller effectively "steals" a bus cycle from the processor, issues the appropriate address to memory, and sends an acknowledge signal to the requesting device so that it can gate its data onto the computer's data bus. The controller then increments the base address and decrements the byte count for the next request. Since all of this occurs without any software interaction, true background operation is achieved. The computer is free to do any task required, while data acquisition proceeds accurately and invisibly behind the scenes. However, at high-speeds there is a possible degradation of the foreground program execution speed.

Limitations of Some DMA Techniques

The main drawback to DMA data acquisition is that one can typically only transfer one type of data per DMA channel — usually a sequential group of analog inputs from an A/D converter; so, its versatility is limited. Many real applications require a mixture of digital, analog and counter channels. Indeed, most data acquisition systems offer all these data types, but not under DMA control.

The reason for this limitation is that DMA controller chips available today are designed to transfer data efficiently from a single device, or "pipe", to a large memory buffer in the computer. This is often referred to as *device-to-memory DMA* and is illustrated in FIGURES 5-1a and 5-1b. Typical applications are tape drive interfaces, disk drive interfaces, local area network interfaces, and high-speed communication interfaces. The DMA controller in the IBM PC is of this type.

The DMA controller in the IBM PC/AT can also be used for "memory-to-memory" DMA. Rather than transfer data from a single source to a block of memory, it can transfer data from one contiguous block of memory to another, as illustrated in FIGURES 5-2a and 5-2b. This is useful in graphics controllers, for example, where one may want to transfer a block of memory into a screen buffer.

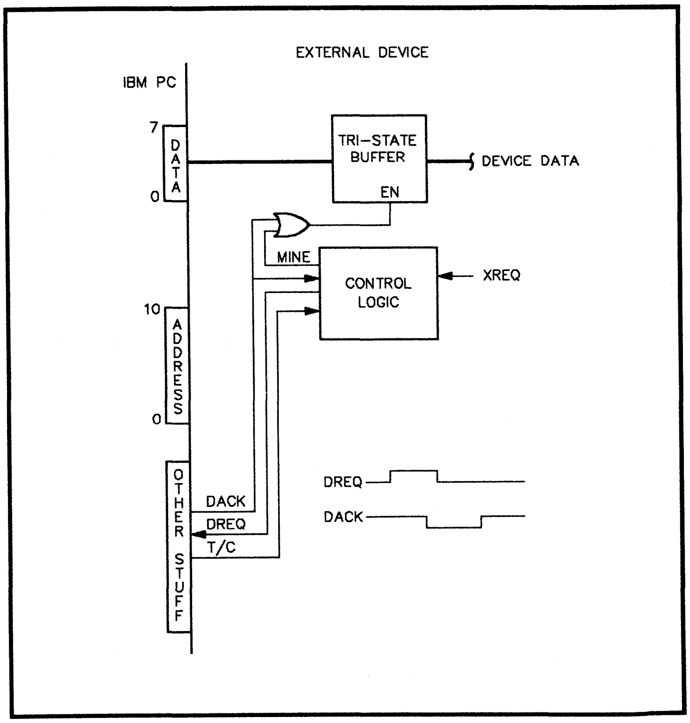


FIGURE 5-1a. Device-to-Memory DMA Block Diagram.

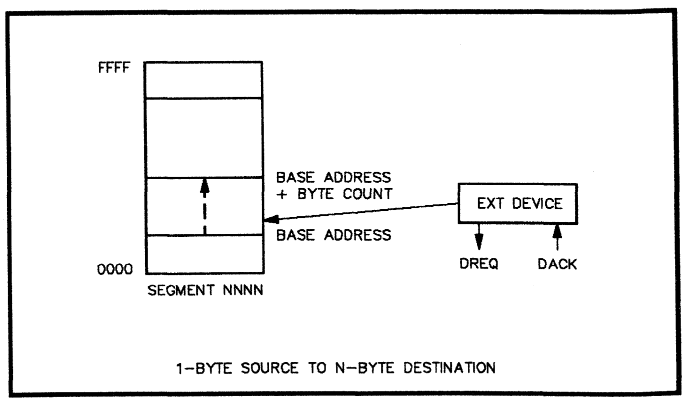


FIGURE 5-1b. Device-to-Memory DMA Memory Diagram.

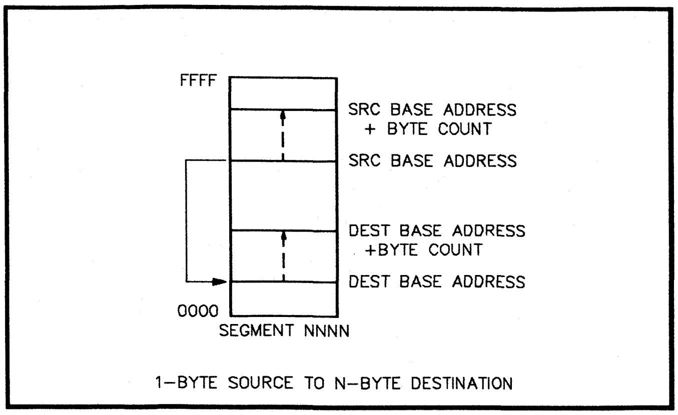


FIGURE 5-2a. Memory-to-Memory DMA Memory Diagram.

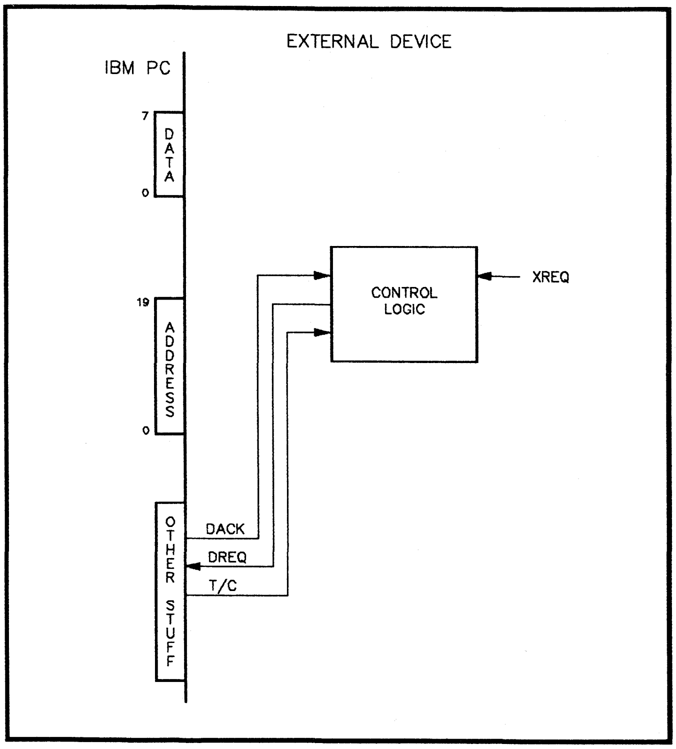


FIGURE 5-2b. Memory-to-Memory DMA Block Diagram.

The device-to-memory DMA technique works fine for most data processing applications. In a data acquisition system, however, only one device per DMA channel is allowed. That device must be designed to provide the handshaking required for DMA, in addition to the signals required to operate in a non-DMA mode. The typical approach using the classical device-to-memory DMA technique for data acquisition is to "hard-wire" a single A/D converter for both DMA and programmed transfer. Usually, the converter has some sort of sequential scanner on its input, allowing multiple channels. The channels to be sampled in the data acquisition run, then, have to be sequential. Some boards provide a "scan-list" memory for the scanner that will allow the sampling of non-sequential channels.

Memory-to-memory DMA doesn't provide much help for data acquisition. It typically transfers a large block of memory from one location to another. Both blocks are the same size and consist of contiguous addresses. For data acquisition, we need to transfer a large group of relatively small "frames" of random memory or I/O addresses to a large block of contiguous memory. This type of DMA has not existed until now.

A Better Way

A patented DMA technique has been developed which is targeted directly at efficient DMA transfer for data acquisition systems. The technique has been implemented on the PCI-20041C-3A High Performance Carrier for IBM PC/XT/AT/EISAs and compatibles. Using this system, any data type (e.g. digital, analog, counter, etc.) can be put under DMA control simultaneously with any other type.

The DMA technique starts with the PC's internal DMA controller, and is illustrated in FIGURES 5-4a. Prior to any transfers, it must be programmed to perform a normal DMA sequence. This means programming it for the number of bytes to be transferred, the direction of transfer, the base address of the data to be transferred, and a few other more esoteric things. The IBM PC's controller is a classic device-to-memory controller, so it transfers one byte from the data bus to memory on each DMA cycle. The external device is responsible for insuring that the byte appears on the data bus at exactly the right moment.

The Carrier works with the three DMA signals available on the PC's bus, shown in FIGURE 5-5. The first, DREQ, is issued by the Carrier to indicate that the data to be transferred should be put on the PC's data bus (or taken from it, depending on the direction of the transfer). The third signal, T/C, indicates that all the bytes that the controller was programmed for have been transferred. The PC's DMA controller takes care of putting the correct address on its own address bus so that the byte on the data bus falls into the correct memory location. From the PC's vantage point, this looks like classical, straightforward device-to-memory DMA.

The Big Difference

128 bytes of the 256 allotted to the PCI-20041C-3A Carrier's functions are set aside as a DMA "frame map", implemented as a dual-ported memory. The frame map is shown in FIGURES 5-4a and 5-5. This is the key element of the system and the thing that makes it different. In this map is stored a list of the addresses of all the bytes to be transferred in each DMA frame. For example, if one wanted to acquire data from an analog channel, one byte of digital I/O, and the contents of a 16-bit counter, then one would store the addresses of these items in the map.

The memory-mapped Carrier occupies a 1Kbyte block in the host computer's address space (FIGURE 5-3). The board can hold three memory-mapped data acquisition modules of various descriptions. Each module is allocated 256 bytes of the available 1K. Additionally, the Carrier itself is allocated 256 bytes for its own control functions. All of the functions of both the Carrier and the modules behave as though they were memory locations in the IBM PC. To read the results of an A/D conversion, for example, one would simply read the two memory locations in the Carrier's address space which contain the two bytes of the conversion. To output a digital I/O byte, merely write the desired value to the address corresponding to the digital I/O byte.

In this example, the first two entries in the list would be the addresses of the low- and high-order bytes of a 12-bit A/D converter module, the third entry would be the address of the digital I/O port, and the last two entries would be the addresses of the low and high bytes of the digital counter. So, the **data** in the list memory is the **address** of the **source** of the byte to be transferred. FIGURE 5-4a shows a logical block diagram of this technique, while FIGURE 5-4b shows the resulting memory map.

Each list entry contains the ten-bit address which uniquely identifies a byte in the Carrier's 1Kbyte address space, a Read/Write bit to identify the direction of transfer, and an End of Frame flag to identify

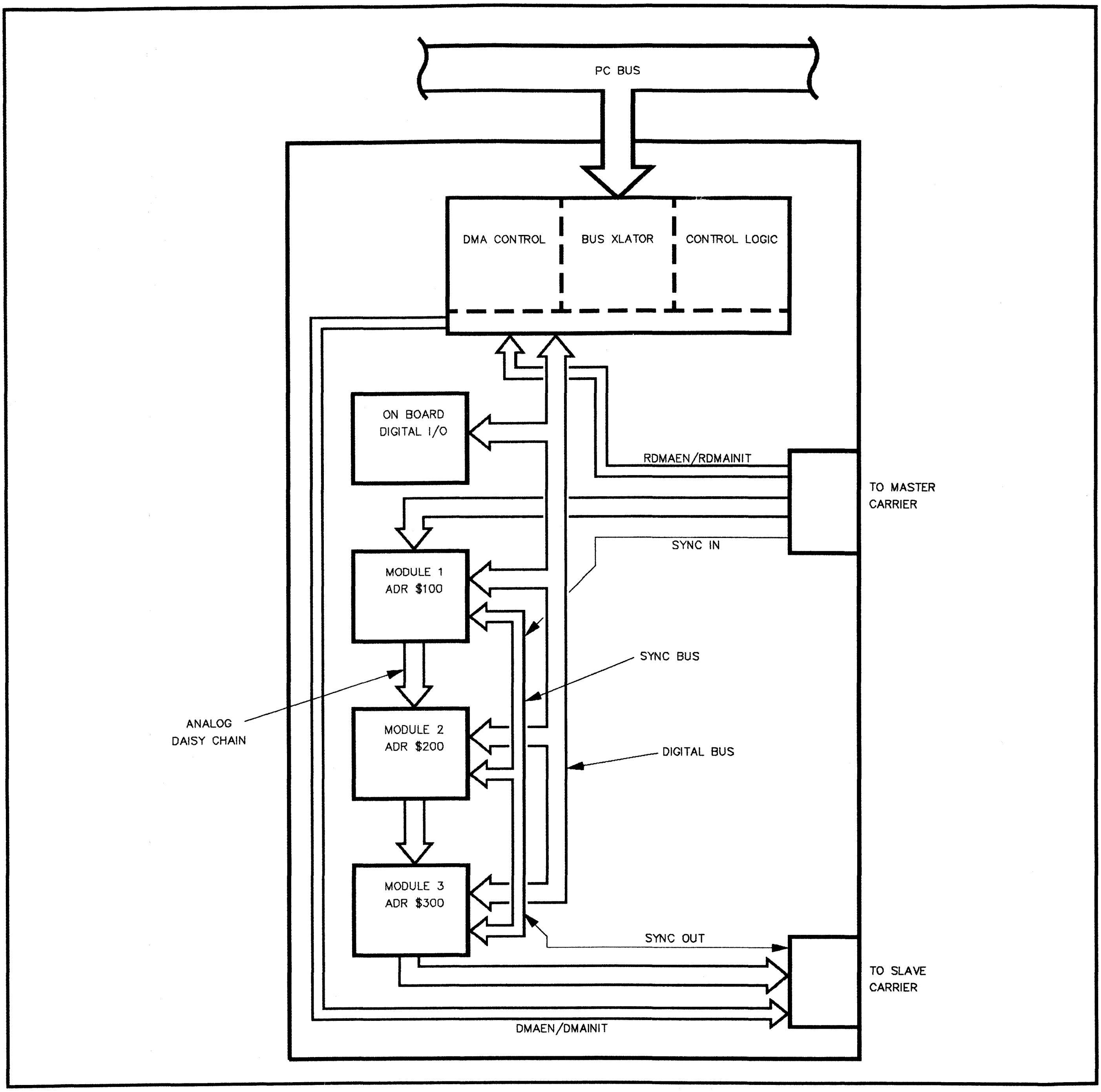


FIGURE 5-3. PCI-20041C-3A High-performance Carrier.

the last element of the list. To the host computer, the list looks like a sequential group of memory locations which are read from or written to in the normal fashion. The IBM PC then sees the list as 128 8-bit memory locations.

The list memory is dual ported. That is, it can be accessed from two independent sources. One source is obviously the host computer, and the other source is the on-board list controller, E in FIGURE 5-5. Any time the host computer writes to or reads from the list memory, it is the accessing source. Whenever a DMA transfer is called for, the list controller becomes the accessing source.

During each DMA cycle, the list controller controls the address of the list memory, pointing to one frame element. The contents of that frame element in the list becomes the address of the byte to be transferred for that DMA cycle through tri-state buffer F in FIGURE 5-5. At the end of each DMA cycle, the list controller increments the list address by one. This causes the controller to point to the next list element for the next transfer. If the End of Frame flag is set in the list memory's data, then the controller resets the list address to zero for the next transfer.

During the DMA transfer (i.e., as long as DACK from the computer is true), the Carrier switches control of the I^3 address bus from the IBM PC to the frame list. It does this by disabling buffer C and enabling buffer F in FIGURE 5-5. The **data** of the list memory becomes the **address** to the I^3 bus. As far as the I^3 bus is concerned, a normal memory transfer is occurring. The contents of the byte which is pointed to by the I^3 address bus is placed on the bus in the normal fashion. On the PC's side of the system, the final destination of that byte is waiting on the PC's address bus. When the DMA cycle is complete, the list controller switches control of the I^3 address bus back to the PC and increments the frame list's address counter so that it points to the next element in the list for the next transfer. If the End of Frame flag is set, then the address counter is reset at the end of the transfer so that the list controller is again pointing to the first list element for the next transfer.

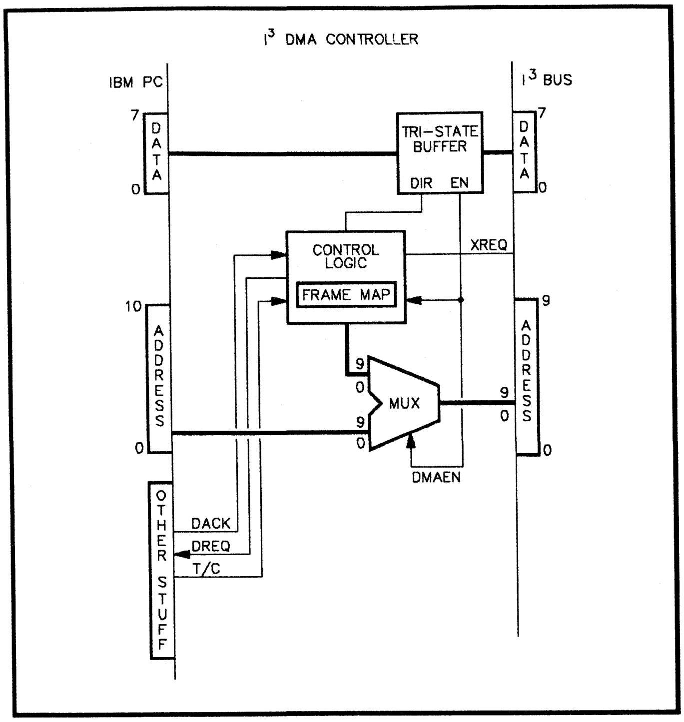


FIGURE 5-4a. I³ Bus-to-Memory DMA Block Diagram.

The list controller is started by a transaction request signal (XREQ). This signal can come from a variety of places in the system. Each time the XREQ signal is received by the list controller, it will issue one DREQ to the PC and complete the ensuing DMA cycle for each element in the list. So, the transfer of one entire frame of data becomes one indivisible event to the system.

The net result of this scheme is that the list of elements to be transferred by the DMA sequence can be any length up to 64 items, and the addresses of those items can be totally random —they don't have to be sequential at all. The PC believes it is doing normal device-to-memory DMA, and the I^3 bus devices believe they are doing normal programmed transfers. Only the Carrier's DMA controller, E in FIGURE 5-5, really knows what is going on.

Start/Stop

The system also solves one other problem which is normally encountered in DMA-driven data acquisition. In most data processing applications, the DMA transfer process can be started and stopped by software. If, for example, the computer is transferring one sector buffer from a disk drive to memory, it can totally control the timing of the process. It can start when the computer tells it to and stop when the data is transferred. In a data acquisition system, this is not always the case.

Data acquisition events tend not to be as well-behaved as disk- drive transfers are. They occur asynchronously, and the computer has to react to them quickly. Suppose, for example, that it's wanted to monitor a strain gage attached to a steel rod. The steel rod is to be flexed, and one is interested in the strains occurring just before the rod breaks. Obviously, one must acquire data at high speed both before, during, and after breakage. The only problem is that the exact moment of breakage can't be accurately predicted, so it's difficult to know when to start taking data. If one starts too soon, memory fills up before the event of interest occurs. If one waits too long, he misses the "pre-trigger" data.

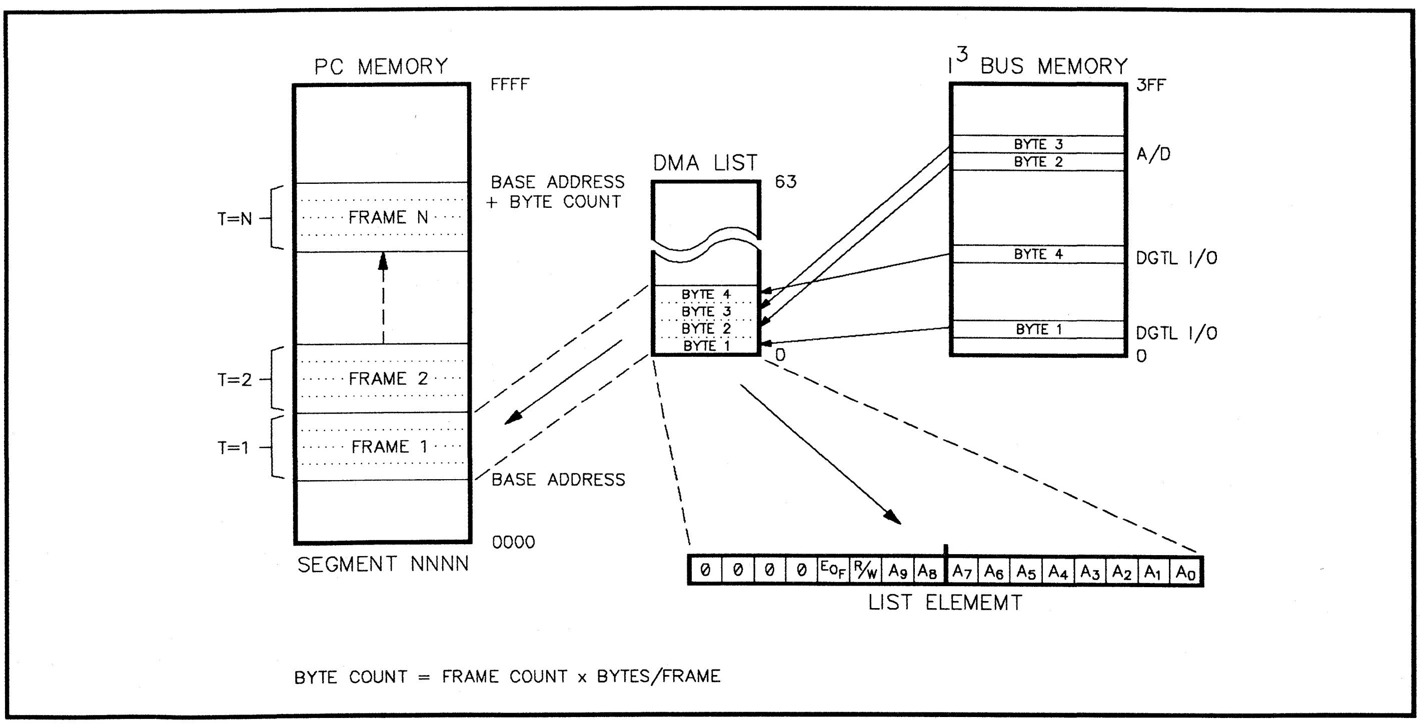


FIGURE 5-4b. I³ Bus-to-Memory DMA Memory Diagram.

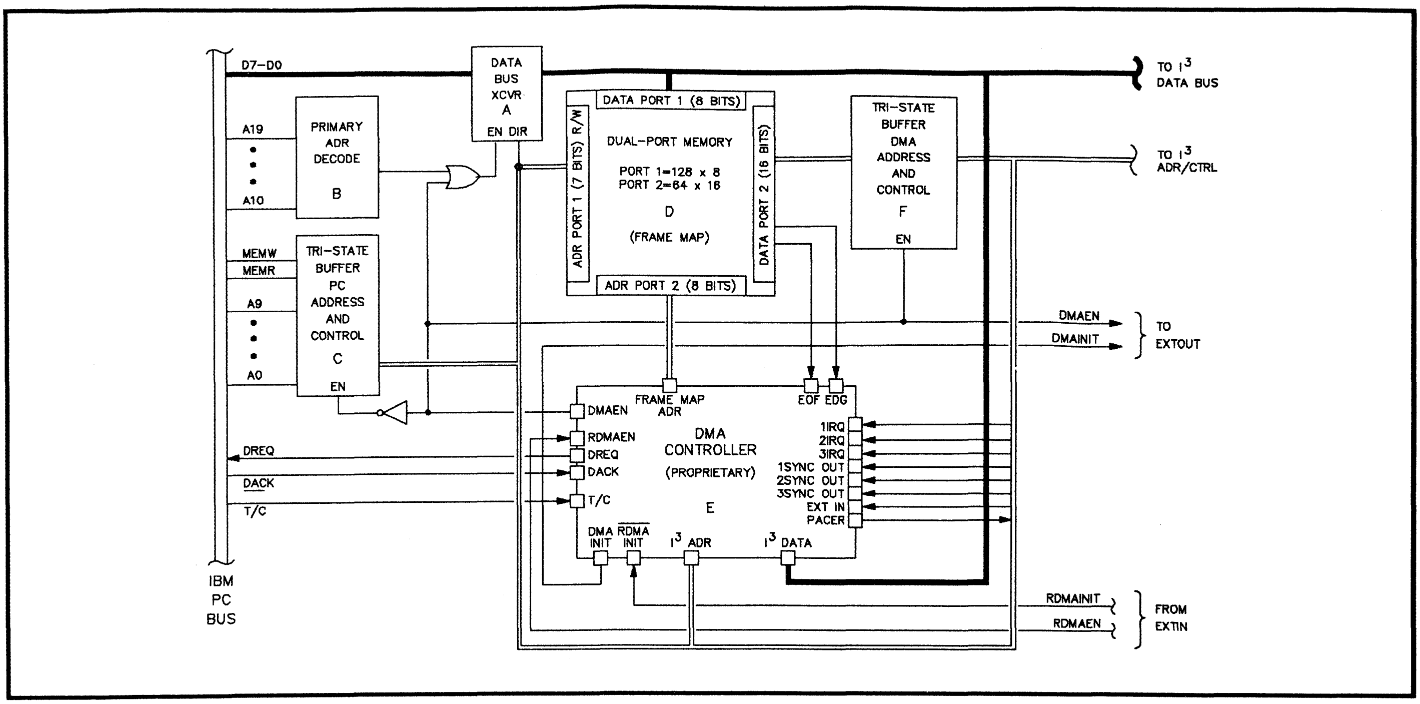


FIGURE 5-5. DMA System Block Diagram.

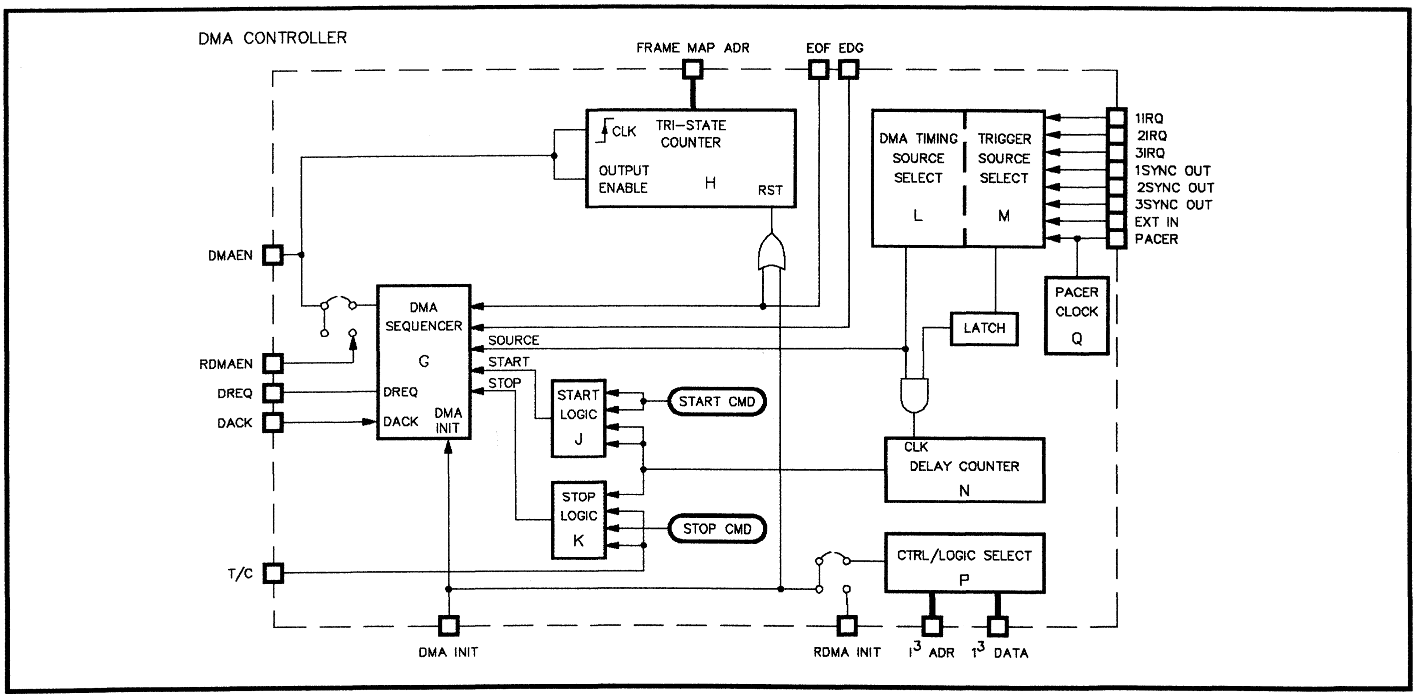


FIGURE 5-6. DMA Controller Block Diagram.

This problem is easily solved by specialized start/stop hardware on the Carrier —items J, K, L and M on FIGURE 5-6. The Carrier's control circuitry supports four different methods of starting and stopping DMA. They are:

Mode 1: Start on trigger event after delay, stop on software command.

Mode 2: Start on software command, stop on terminal count.

Mode 3: Start on software command, stop on trigger event after delay.

Mode 4: Start on software command, stop on software command.

Mode 2 is the one used for most data processing applications. The other modes are useful only for data acquisition. Mode 2 is typically the only mode employed in the IBM PC. In data acquisition, Mode 2 is useful for capturing a block of data at a regular rate from a repetitive signal to be used for digital signal processing, for example. In this case, it is not important for the acquisition to be synchronized to anything.

Modes 1 and 4 are most useful for DMA output. They both involve the use of a circular buffer. In both cases, when the DMA controller has transferred all the bytes in the DMA buffer, it resets its pointers and starts over again. Using either Mode 1 or Mode 4, then, one could build an analog waveform in memory and then continuously output it through a D/A converter module to develop an arbitrary waveform.

Mode 3 is the most useful for most data acquisition applications and is the one best used to solve the problem above. Using a circular buffer, Mode 3 provides both pre-trigger and post-trigger information — just right for this application.

There are two significant types of events implied by the four DMA modes above. The first is the trigger event.

This is the event which starts or stops the whole series of DMA transactions which comprise a data acquisition "run". The second is the timing source event. This is the source of the XREQ signal which causes each individual frame to be transmitted.

Both of these two signals can come independently from any one of eight sources in the system under software control. The sources are:

— The SYNCOUT signal of any of the three modules.

— The IRQ0 signal of any of the three modules.

— The on-board pacer clock.

— The External SYNCOUT from another carrier.

Here's how to solve the problem of the breaking bar:

First, the modules required are the PCI-20019M-1A High Speed A/D Module, and the PCI-20020M-1 Trigger/Alarm Module. Also, the PCI- 20026S and PCI-20027S software packages will ease the software burden.

It is assumed that the strain gage signal is externally conditioned to a voltage between at least ±2.5V. This can be done with the PCI-20044T-1 Active Signal Conditioner, for example. The output of the strain gage amplifier is connected to the inputs of both the A/D and the Trigger/Alarm.

The PCI-20026/27S Series allows control of the system by using simple calls from high-level language programs— BASIC, TURBO PASCAL, or C.

Using PCI-20026-27S, the Trigger/Alarm is programmed to trigger when the strain exceeds a threshold. Presumably, when the rod breaks, the strain gage voltage will suddenly increase. The internal pacer clock is programmed for the desired sample rate — say 80kHz. With jumper selections, this also becomes the start convert signal for the PCI-20019M-1A.

Using PCI-20027S, we will set up the DMA transfer. The IRQ0 output of the A/D indicates that a conversion is complete, so it could be used for the timing source event for frame transfers. The IRQ0 output of the Trigger/Alarm module is selected as the trigger event. Also, we will select Mode 3 to give both pre- and post-trigger data. Finally, we need to program the system to monitor the appropriate A/D channel. All of these selections are made through the "Configure DMA" (CNF.DMA) call of PCI-20027S. It handles setting up all of the hardware on the Carrier, programming the frame map, and programming the PC's DMA controller.

DMA.RUN call will set the number of frames to be acquired and the trigger delay in frames. This call handles programming the PC's DMA controller for the proper operation and actually begins the DMA transfer. For our example, we will acquire 10,000 frames, and set the delay to 1000 frames. Thus, our total buffer will consist of 10,000 A/D readings, and the last 1000 will be post- trigger data. After executing this call, data will be acquired by DMA at 80K samples per second.

The machine which bends the rod can now be started, and the data acquisition occurs automatically, filling up the PC's buffer in a circular fashion. When the rod finally breaks, the Trigger/Alarm module will issue the trigger event signal. The delay counter will then count 1000 more A/D samples and stop the DMA process. The data in the buffer now represents 9000 samples of pre-trigger data and 1000 samples of post-trigger data.

Suppose one would like to put a turns counter on the lead screw of the bending machine so that he could correlate screw position with strain. The modifications required to accomplish this are quite simple.

First, add an incremental shaft encoder to output TTL pulses with the turning of the lead screw. Next, add a PCI-20007M-1 Counter/Timer Module to the system. Then, connect the output of the shaft encoder to the clock input of one of the counters on the PCI-20007M-1. The counters on this module are 16-bit counters; so, each requires two memory bytes.

Code to initialize the counters must be added to the setup program. The channel number of the counter used is added to the CNF.DMA call. This call will double the PC DMA controller's byte count to account for the two extra bytes of the counter, and it will extend the size of each from two to four bytes.

Now, after the data acquisition run, the first two bytes in each frame are the two bytes from the A/D converter, and the last two are the two bytes of the counter. The first 9000 frames are still pre-trigger data, and the last 1000 frames are post-trigger data.

This technique represents a quantum leap in power and flexibility for personal computer-driven data acquisition. It provides answers to most of the standard data acquisition problems — precise timing; mixed data types; accurate, event-driven starting and stopping; and pre- and post-trigger data capture capability.

Capturing and Analyzing Transient Waveforms with a Personal Computer

Until recently, the acquisition of transient analog data in the 100Hz to 100kHz region was dominated by storage oscilloscopes and expensive, dedicated, data acquisition systems (DAS). Any non-repetitive phenomenon is a candidate for analysis with this type of system. Some examples include:

— Mechanical shock and vibration studies

— Monitoring the onset of high-speed chemical reactions such as explosions

— Measuring medical signals such as QRS complexes, HIS bundle response, and nerve impulses

— Analyzing audio transients.

In addition to capturing transient signals, some processing oscilloscopes and dedicated DASs also provide a limited level of analysis capability. Usually, however, a computer is required to archive the data, to do special-purpose analysis and to generate graphs and reports. These types of systems are usually linked to a host computer via an RS-232 or IEEE-488 bus. As a result, speed is severely limited. Obviously, it would be far more efficient to use the computer as part of the system that took the data in the first place. The recent availability of powerful, low-cost personal computers (PCs) has enhanced the above methods and, more importantly, has opened the door to new techniques.

The PCI System

State-of-the-art data acquisition systems are now available as board-level products. For example, the PCI System can plug directly inside any IBM-compatible PC/XT/AT/EISA, forming the basis of a complete data acquisition, test, measurement and control system. With appropriate software, a package can be put together to acquire, display, measure and analyze transient signals for a fraction of the cost of yesterday's scopes or DASs. Besides the advantage of lower cost, the PCI System approach has greater overall speed and versatility. The system's data acquisition rate can be as high as 180kHz in the PC.

The PCI System is based upon a motherboard, or carrier, approach. The carrier plugs into the computer, and modules plug onto the carrier to add desired functionality. A large family of modules is available. Up to three modules can plug into a given carrier. Typically, each module performs one data acquisition function such as analog input, analog output, counter/timer, digital input/output, etc. Multiple carriers can be used if required to accommodate a very large application.

Thus, the PCI System combines the high speed of a computer-based product with the flexibility, modularity, and expandability of a plug-in board device.

The Transient Recorder

This describes how to combine the IBM PC (or compatible) with the PCI System to produce a low-cost, high-performance transient data recorder. A complete program listing is included. The features of the transient capture system include:

— Menu-driven, no programming required

— 12-bit resolution and linearity

— Sample rates from 150Hz to 50kHz

— Hardware slope and level triggering

— Capture of up to 25,000 samples

— Selection of one of eight channels

— Auto-scaled graphic display

— Data stored and recalled to and from disk

The hardware (PC and PCI) is combined with a BASIC language program to provide the fundamental capabilities that a transient capture system needs. The system can acquire data, display data, store data to disk, and recall stored data from disk. The data is stored in ASCII format so that it can be manipulated, analyzed and printed by other BASIC programs or word processors. There is an extensive library of PCI software drivers (PCI-20026S-1, PCI-20027S-1 and PCI-20096S-1) to interface with the PCI hardware. These drivers make it easy for a programmer to "talk" to the hardware, without being familiar with the details of multiplexers, programmable-gain amplifiers, sample holds, analog-to-digital converters, etc. The program shown here makes wide use of this library.

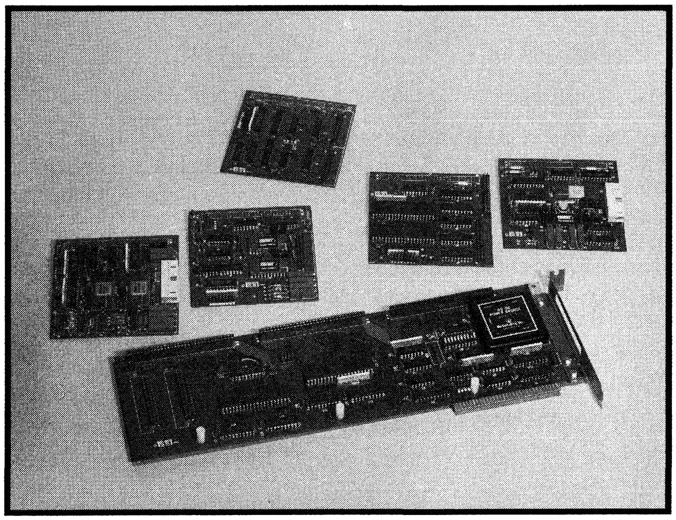


FIGURE 5-7. The PCI System

Software Highlights

The program begins by drawing a box for the graph on the screen and by displaying the default data acquisition parameters along with the system menu (FIGURE 5-8). The data acquisition parameters include:

— Sample rate

— Trigger level and slope

— Channel number

— Amount of data to be taken.

The menu allows you to:

— Exit the program

— Set the acquisition parameters

— Acquire and display a data set with the above parameters

— Execute one of the file operations.

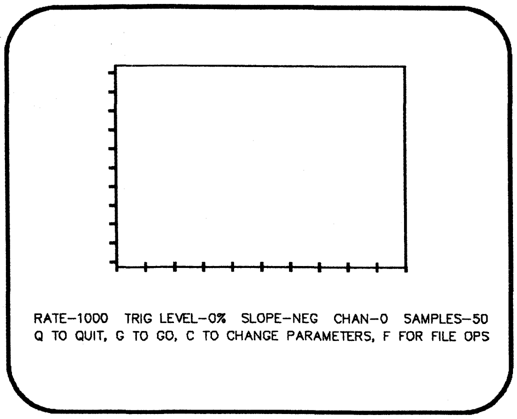


FIGURE 5-8. System Menu.

If you choose to take data, the system automatically acquires, scales and plots the data on the screen. The autoscale function insures an optimum fit for all of the data on the graph.

If you choose one of the file operations, a second menu is displayed. You can choose to look at the disk directory, store the current data set to a file, recall a data set from a previously stored file, or re-plot the current data set.

Capturing the Data

The hardware and the software is dedicated to the task of capturing the transient data. In this type of system, the amount of software which actually interacts with the hardware is small, yielding maximum speed. The majority of the work related to capturing the data is done directly by the hardware. Most of the software is involved in generating the data display and in supporting the menu-driven user interface.

The fundamental requirements of a useful transient capture system are:

1) **The Ability to Begin Data Capture at the Right Time** — Because the PC has finite memory space, acquiring data at high speed can quickly fill up available memory. Therefore, it is important to be able to "trigger" the beginning of data capture at the point of interest.

2) **The Establishment of a Stable Data Acquisition Rate** — Data is usually time correlated. Many algorithms, such as the FFT, require the exact interval between data points to be known.

In this system, the capture of data begins when the input signal crosses a specified threshold in a given direction (as with an oscilloscope). Once this trigger condition has been met, the acquisition is paced by a crystal-controlled rate generator. Thus, both of the above criteria are met; the slope/level triggering insures that the event of interest is captured, and the crystal-controlled time base insures a stable, jitter-free acquisition rate.

The triggering, timing and data acquisition functions are all available, in hardware, with PCI System Instrument Modules. The hardware is configured by selecting the appropriate modules from the wide variety available and by plugging them into a carrier. For this high-speed system the choices are:

— PCI-20001C Series Carrier for the IBM PC/XT/AT/EISA

— PCI-20007M-1 Counter/Timer/Rate Generator Modules

—or—

— PCI-20041C Series High Performance Carrier for the IBM PC/XT/AT/EISA

—and—

— PCI-20019M-1A High Speed Data Acquisition Module

— PCI-20020M-1 Trigger/Alarm Module.

Note that if you use a PCI-20041C Series Carrier, no PCI-20007M-1 Rate Generator module is required. This function is built into the PCI-20041C Series.

To facilitate connecting the input signals to the modules, termination panels and cables are also selected:

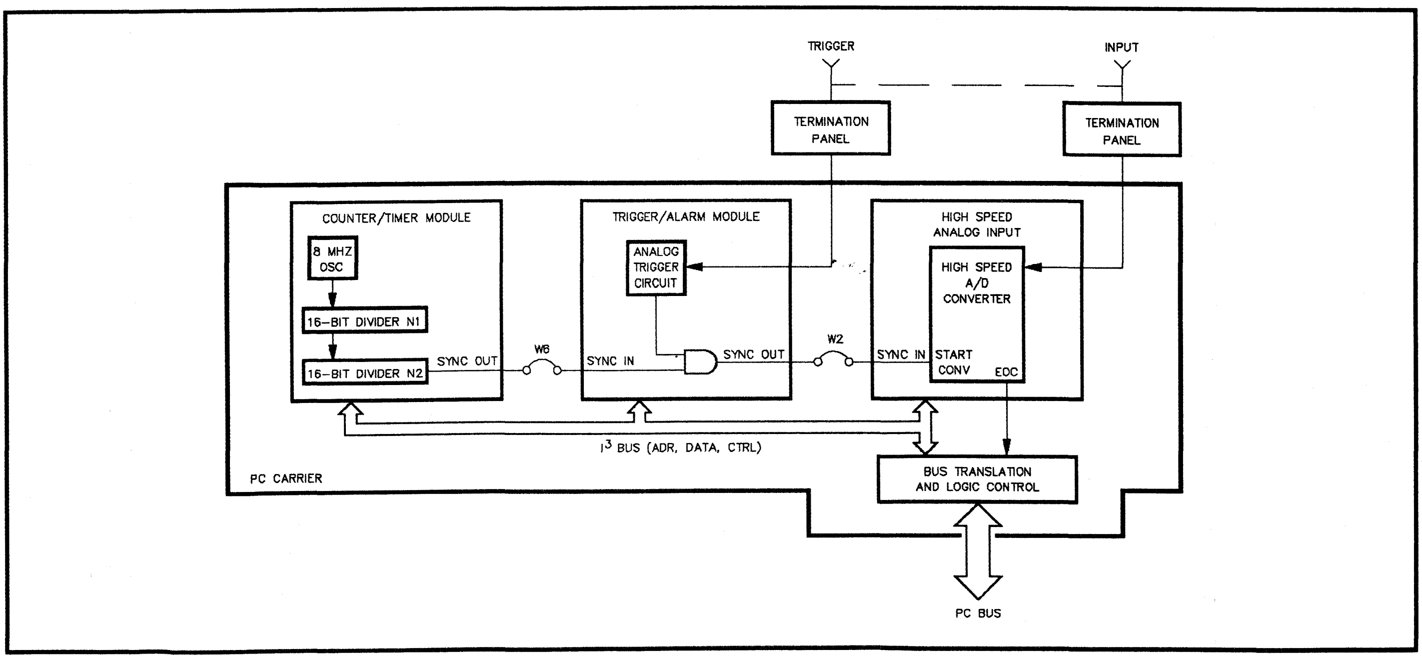


FIGURE 5-9. System Block Diagram

— PCI-20303T-1 Euro-Style Analog Termination Panel, 2 required.

— PCI-20310A-1 2m Shielded Analog Cables, 2 required.

Finally, the PCI Language Software Support Package mentioned earlier makes implementing the desired application much easier. While BASIC is used in this example, TURBO PASCAL, C, and ASYST are also available.

— PCI-20026S-1 BASIC Language Modular Software Support Package.

Appendix A contains the details on how to configure the individual modules and plug them together. FIGURE 5-9 shows a block diagram of the system.

Hardware Description

The carrier contains space for up to three plug-in modules. It also has facilities which allow one module to pass both data and synchronization signals to other modules on the carrier. These unique abilities are made possible by the Intelligent Instrumentation Interface Bus (I^3 Bus, patented). Each module has a SYNCIN and a SYNCOUT connection. Jumpers on the carrier determine the source of a module's SYNCIN and the destination of its SYNCOUT. The ability to pass hardware timing signals from one module to another results in a very close timing relationship between the various modules. This is a key factor in the performance of this system.

As seen in FIGURE 5-9, the Rate Generator's output connects through the Trigger/Alarm Module (via the I^3 Bus) to become the timing source for the Analog Input Module (A/D). When the desired input conditions are satisfied, the Trigger/Alarm Module gates the Rate Generator signal to the A/D. Once triggered, the A/D continues to convert the input data at the rate set by the Rate Generator, until the specified amount of data has been gathered.

Operation

While it is the hardware that defines the performance limits of this type of system, its utility and ease of use are defined by the software (program) which drives it. The program presented here provides all of the basic capabilities that a transient recorder must have: data capture, data display, and store/recall (to/from disk) capabilities for post-processing of the data. Many variations on this basic theme are possible. If desired, this program can be used as a model and can be easily modified to implement a different approach.

The program makes extensive use of existing machine language subroutines. The subroutines provide a software interface to the hardware, eliminating the requirement that the user "handle" the multiplexers, sample/holds, A/D converters, etc. These routines are found in the PCI-20026S-1 BASIC Language Modular Software Support Package. The routines are loaded (before executing the main program) by running PCI26S_1.EXE from DOS, provided on the package's distribution disk. Once installed, the subroutines are accessed via BASIC's CALL statements. Running PCI26S_1.EXE will load the support routines into memory and leave them resident. The base address of the routines is stored in the PC at user interrupt vector 60 (hex). This information is used by the program to determine where in memory the routines are located. The header file, which is also provided on the distribution disk, defines the variable names and the other conventions of the subroutine package.

The User Interface

Referring again to FIGURE 5-8, we can describe in more detail the user interface portion of the program. Using the single keystrokes indicated on the menu, you can choose to exit the program (quit), start an acquisition using the current parameters (go), change the acquisition parameters (change), or execute a file operation (file).

If you select "q", the program will terminate and return to BASIC.

Selecting "g" causes the system to first acquire a data set using the defined parameters (if none have been specified, the default parameters will be used). The data is then scaled to fit optimally on the graph and plotted. The minimum and maximum values of both axes along with the value of the first data sample are labeled (see FIGURE 5-10). The program assumes that the A/D module is set up for ±10V full scale. If you choose to jumper the module for another range, remember to modify the related equations accordingly. If desired, the program can be changed to prompt the user for the range being used.

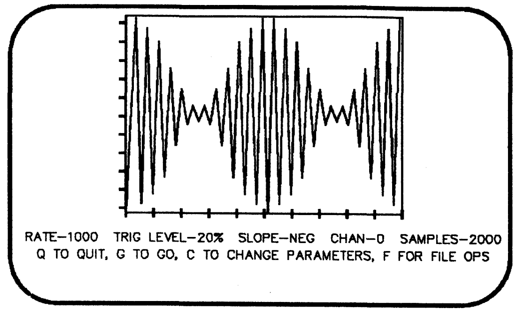


FIGURE 5-10. Data Display.

If you select "c", the program will erase the graph, redisplay the current parameters, and prompt you to enter new ones. The acquisition parameters which need to be specified are:

— Sample rate (default = 1000 samples per second)

— Trigger level (default = 0 volts)

— Trigger slope (default = negative)

— Channel number (default = 0)

— Number of samples (default = 50)

When you have specified all of the parameters, the system will automatically execute a "go" command.

Selecting "f" erases the graph and displays the File Operations menu, as shown in FIGURE 5-11. The available options allow you to store the current data set to disk, recall a previously stored data set from disk, plot the current data set, and show the disk directory.

If you select "s", the program will prompt you for a file name and will then store the current data set, along with the acquisition of parameters, to the named file.

Selecting "r" generates a prompt for a file name. The screen is then erased and the new data set, along with its acquisition parameters, is plotted.

Selecting "d" will list the disk directory so you can see what files are available, while "p" will return you to the main menu, re-plotting the current data set.

FILE OPERATIONS

s to save the current data and setup

r to recall stored data and setup

p to plot current data

d for directory listing

** Your choice, please**

FIGURE 5-11. File Operations Menu.

The Program Details

The program consists of several well-defined functional blocks (subroutines). Each subroutine is called from one of the two menus, or during initialization. A complete listing of the BASIC source code is shown in Appendix B. The titles and location of each subroutine are listed below:

Line 100	Merge the Header file into the program
Lines 1000 - 1170	Initialization
Lines 1180 - 1410	Main menu routine
Lines 1420 - 1490	Error checking for PCI System calls
Lines 1500 - 1650	Disk operations menu
Lines 1660 - 1760	Directory display
Lines 1770 - 2000	Save to disk
Lines 2010 - 2250	Recall from disk
Lines 2260 - 2580	Get input parameters from user
Lines 2590 - 2900	Set up the hardware
Lines 2910 - 3050	Acquire data
Lines 3060 - 3450	Draw the plotting window and annotate the screen
Lines 3460 - 3570	Calculate Min, Max, Span, and X interval of the data
Lines 3580 - 3860	Scale and plot the data

Since it is impossible to anticipate all the ways that a user might apply this system, a concerted effort was made to write the subroutines so that they could be lifted from this program and applied elsewhere with a minimum of effort. To this end, the structure was designed so that changes could be made to any one routine with a minimum of side-effects on the others.

Initialization

Line 100 merges the PCI-20026S header file with the main program. This file defines all of the PCI-20026S constants. The first time the program is run, the system merges the header and overwrites Line 100 with a comment. This procedure insures that the latest version of the header file will always be used. Line 1000 defines all variables not beginning with the letter "F" as integer variables. This is a convenient way to make sure that you don't accidentally attempt to send a floating point number to a routine expecting an integer. All of the calls to the PCI-20026S software routines expect their parameters to be integers.

Line 1040 initializes the PCI-20000 software system, and line 1050 initializes the hardware.

Line 1120 dimensions the data array used in the program. The maximum number of data points allowed in this program is 5000. This number was selected because interpreted BASIC takes a very long time to process and plot large arrays. A speed improvement of approximately 18:1 can be made by adapting the program to run under Microsoft QuickBASIC, which is fully supported by PCI-20026S-1. If this is done, the maximum number of data points may be increased to 25,000, while retaining reasonable execution times.

The default values for the data acquisition parameters are set in lines 1130 and 1140. The parameters and values are:

— Sample Rate (FSPS), Initialized to 1000 samples per second

— Trigger Level (FTL), Initialized to 0 volts

— Trigger Slope (S$), Initialized to negative ("-")

— Channel Number (AI.CHN(1)), Initialized to channel 0

— Number of Samples (PASSES), Initialized to 50

Line 1150 calls the routine which sets up the hardware with the defined parameters, and line 1160 calls the routine which draws the window that the plot will appear in. Both of these routines will be discussed in detail later.

The Main Menu Routine

This routine uses the INKEY$ function to accept a single-keystroke input from the user. The available choices are displayed by lines 1220 and 1230. Line 1240 accepts the input and lines 1250 through 1280 determine which operation was requested. If the input was not one of the permitted keys, line 1290 beeps and loops back to line 1240 for another input.

Lines 1340 through 1400 list the subroutines which do the work of setting parameters, acquiring data and displaying data. Two keys can activate these routines. A "g" will enter at line 1360, acquire a new data set and plot it using the parameters already in force. A "c" enters at line 1340 to first get the new parameters. The code then sets up the hardware and executes a data acquisition. Finally, the new data is plotted.

The other two menu choices either activate the File Operations Menu (f) or the exit program (q).

Getting User-Entered Parameters

If a "c" is typed from the main menu, the Change subroutine is called. The routine begins at line 2290 by clearing the screen and by reprinting the current set of parameters for reference. The program then prompts you for each of the parameters required and checks your inputs against limits. A different user interface could be substituted if desired, so long as when you exit from this routine, the variables FSPS, FTL, S$, AI.CHN(1), and PASSES are all set to the desired values.

Setting Up the System

This is the routine which passes the user-supplied inputs to the hardware for the data acquisition run. Most of the calls to the PCI-20026S-1 Software Support Package are executed from here.

In lines 2670-2700, the Rate Generator Module is set up to deliver a timing signal at a frequency equal to FSPS. The rate generator consists of an 8MHz oscillator followed by two dividers. COUNT1 and COUNT2 set the divide values and, hence, set the output frequency to the desired value. FSPS = 8MHz/(COUNT1 * COUNT2). In this program, we have arbitrarily set COUNT2 = 2, so that COUNT1 = 4MHz/FSPS. Since both COUNT1 and COUNT2 can assume only integer values, it is possible that the frequency generated will not be exactly that which was requested.

Therefore, in line 2690, we compute the actual value of FSPS and display it on the main menu.

Line 2700 contains the actual call to the Software Support Package that writes data to the chips on the Rate Generator Module. The format of this call is representative of all the calls used in this program. The keyword CALL tells the computer to jump to a machine language subroutine. The variable name following the call (in this case CNF.RG) defines the starting address of this particular routine within the subroutine library. This offset is specified in the header file which was CHAIN MERGEd at line 100. Any parameters to be passed to the routine are contained in parentheses following the call name.

Lines 2750-2780 set up the Trigger/Alarm Module. This module tests the trigger input signal against both high and low limits. The limits can be programmed to produce a trigger when the input either enters or leaves the "window" defined by the programmed limits. This establishes the system's trigger level and slope. Because limits are set with eight-bit resolution, a code of zero corresponds to -10V while 255 corresponds to +10 - 1LSB, which is equal to 9.92V. Line 2750 sets one of the limits to FTL, defining the trigger level. The other limit (S$) is set to 0 for a negative slope or 255 for a positive slope.

Lines 2860-2880 set up the parameters for CNF.HS, the routine which defines the high-speed, block-mode, analog acquisition. This high-speed routine will scan a channel list specified by the array AI.CHNS. In this program there is only one analog channel. The variables PAC.TYPE and PAC.CHN specify the signal which is to pace the data acquisition. In our case, it will be rate generator channel zero —either the rate generator on the PCI- 20007M-1 Module or the built-in pacer clock on the PCI-20041C Series Carrier, depending on which you are using. The variables TR.TYPE and TR.CHN specify a signal which is to trigger the acquisition sequence. In our case, it will be the PCI-20020M-1 Trigger/Alarm Module. The variable HSMODE specifies the type of high-speed acquisition to be performed. Setting it to four specifies total hardware control — the fastest possible mode without DMA. In this mode, the Trigger/Alarm Module prevents rate generator pulses from reaching the PCI-20019M-1A until the trigger conditions have been met. When the trigger occurs, A/D conversions are to be initiated directly by hardware. Thus, the system needs to monitor only the A/D's end-of-conversion signal. Each time "EOC" is true, data is stored in memory.

Getting the Data

Line 2960 is the start of the subroutine which acquires the data, while CALL HS.RUN actually performs the data acquisition. Once triggered, the HS.RUN routine monitors the A/D for an EOC signal and then stores the data in array Y(I), in the order in which it was taken. After the routine has stored the number of values specified by the variable PASSES, it returns control to BASIC. The variable SEGMNT must be set to 0.

The data in Y(I) is in complementary offset binary format. Line 3030 converts the array into straight offset binary. A value of 0 corresponds to minus full scale (-10V), and a value of 4095 represents plus full scale (10V - 1LSB = 9.9951V).

Drawing the Box

This subroutine establishes a plotting window of defined size and draws it on the screen. Other routines automatically scale the data to fit within the window.

Lines 3090 and 3100 clear the screen, erase the function key assignments and set the display to the high-resolution graphics mode.

Line 3150 defines the size and location of the plotting window. With IBM PC/XT/AT/EISAs and compatibles, coordinates 0,0 lie at the upper left-hand corner of the screen, while 640,200 are at the lower right. This means that increasing values of Y move the trace toward the bottom of the screen, which is backwards from what most people would expect. The size and location of the window are defined by specifying the upper left-hand corner and the lower right-hand corner of the window with variables TOPX,TOPY and BOTX,BOTY. Specifying the corners like this will take care of the inversion of the Y axis. In this program, you can place the window anywhere on the screen simply by changing the values of these variables. However, depending upon the size and location of the window, you may have to move some text to avoid overlap.

Lines 3190-3230 use the LINE command to draw the box. The variable BORD is used to draw the box two pixels larger, in the Y direction, than the actual size of the data window. This assures that if the data is scaled to exactly fit the defined window, it will never be plotted over the box lines themselves.

Lines 3270-3340 draw tic marks on the X and Y axes to form ten evenly spaced intervals for each axis. The size of the tics is adjustable and is set by XTIC and YTIC.

Lines 3380-3450 establish a text line at screen line 22 to display the acquisition parameters.

Finding Min and Max Data Values

In order to scale the data to fit the plotting window, this routine goes through all the data to find the highest and lowest data values. This is done in lines 3500-3570.

Line 3550 calculates two important parameters: the span of the A/D counts covered by the data and the number of Y pixels available in the plotting window. The value of FYFACT tells the plotting routine how many Y pixels each A/D count is worth.

Line 3560 calculates how many pixels represent each sample along the "Y" axis.

Scaling and Plotting the Data

This routine uses the constants computed in the Min/Max routine to autoscale and plot the data. The vertical data to be plotted is in the array Y(I) in the form of A/D counts (integers between 0 and 4095, corresponding to -10V to 9.9951V). To enhance the plot, a line will be drawn from each point in the array to the next. On the time axis, each X coordinate is greater than the previous one by FXINC. The Y increments are computed based upon YSPAN and FYFACT.

Lines 3630-3720 convert the values of the min, max and first data points to volts, and print them out on the left-hand side of the graph. Line 3960 computes and print the total elapsed time represented by the graph on the right-hand side, along the X axis. Lines 3700 and 3710 establish the location of the first data point.

The actual scaling and plotting algorithm occupies lines 3760- 3860. For each pass through the loop, the current "new" X,Y point becomes the "old" point for the next pass, resulting in a continuous line being drawn through the data points.

The pixel value of the Y coordinate is computed in line 3770. The expression Y(J)-YMIN yields the distance, in A/D counts, from the smallest value in the array to the current data point. This value is multiplied by FYFACT and then added to the offset BOTY to find the correct Y pixel location on the physical screen.

The File Operations Menu

The File Operations Menu is displayed when "f" is selected on the main menu. The routine allows you to type a single character to select one of several tasks: storing data to disk, retrieving data from disk, viewing the disk directory, or replotting the current data set.

Lines 1530-1600 display the menu choices on the screen and prompt you for a response, while line 1610 uses the INKEY$ function to scan the keyboard for an input. When an input is detected, lines 1620-1650 test for a valid choice. Invalid inputs cause the program to go back to the top of the menu.

The Directory Display

Lines 1690-1760 give you the ability to view the currently active directory of either disk drive A or B. The routine prompts you for a single character choice and then prints the selected directory using the FILES command. If you are using a hard disk with many sub-directories, you may want to expand this routine.

Storing Data

This routine stores data to disk. Lines 1830 and 1840 prompt you for a filename and then create that file. Lines 1960-1980 actually store the data to disk from array Y(I). In lines 1880- 1920 the user-defined parameters are also written to the above file. This allows the complete display to be reconstructed when data is recalled from disk by the plotting routine.

The order in which the data is stored is as follows:

PASSES	The number of data points to expect in the file.
FSPS	The sample rate at which the data was taken. We need this in order to label the X axis properly.
S$	The trigger slope. Either "pos" or "neg".
FTL	The trigger level.
AI.CHN(1)	The desired channel number.
Y(I)	The data array. Must contain the number of samples indicated by PASSES.

Recalling Data From Disk

This routine prompts you for an existing filename and reads the data from disk to RAM. It uses the saved parameters to set up the system as it was when the data was originally taken.

Lines 2110-2150 get the user-defined parameters and put them in the appropriate variables. Lines 2190-2210 then reads the data points from the file and stores it in array Y(I).

Line 2230 calls the setup subroutine which restores the system as directed by the retrieved parameters. At this point, data is in the array Y(I) as if just acquired. Returning to the main menu automatically causes the data to be plotted.

Note that any BASIC program or word processor could have created the data file Y(I), since it is just a list of ASCII characters. This means that data could be entered by hand and then plotted. Alternatively, a program could be written to transfer data from a file created by another data acquisition system. In either case, the data might first have to be manipulated so that the final numbers are in the range from zero to 4095. Also, remember that the parameters must be stored in the order the plotting routine expects, or the system will not function properly.

Converting the Code to Compiled BASIC

Appendix B lists the interpreted BASIC version of this program. While interpreted BASIC is easy to write and debug, it is slow when you need to crunch large amounts of data. For this reason, this version of the program limits the data array to a maximum of 5000 points. At an acquisition rate of 50kHz, it would take 0.1 seconds to acquire the 5000 points of data. However, using interpreted BASIC on an IBM PC, it would take 5-1/2 minutes to process and plot the data.

The IBM BASIC Compiler can improve the speed of processing by a significant amount. However, the compiler is not 100% compatible with the interpreter. Therefore, some changes must be made to the program before compiling.

Compiled BASIC does not permit the use of the CHAIN MERGE statement. The first change, then, is to merge the file PCIHEAD.BAS with the interpreted version of the program. The header will then be compiled into the program.

The only other changes that need to be made in the example program involve call statements.

The syntax of a call in interpreted BASIC is as follows:

CALL<name>(<param1>,<param2>,..,<paramn>).

For example, the call to the CON.RG routine looks like:

CALL CON.RG (CHN, COUNT1, COUNT2)

where: name is CON.RG and the parameters are CHN, COUNT1, and COUNT2.

To achieve the same meaning with compiled BASIC we have to use the CALL ABSOLUTE statement. The syntax for this is:

CALL ABSOLUTE (<param1>,<param2>,...,
<paramn>,<name>)

Therefore, for each CALL statement in the program we only have to add the key word, ABSOLUTE, and move the function name to the last item inside the parentheses. Our CON.RG example above would now appear as:

CALL ABSOLUTE (CHN, COUNT1, COUNT2, CON.RG)

APPENDIX A
Hardware Configuration

This appendix discusses in detail what data acquisition hardware is required, how to configure the jumpers on the carrier and modules, and how to interconnect the termination panels and cables.

The system is set up to monitor an input in the range of ±10V full scale. For trigger purposes, it will detect when the signal crosses a threshold and will then initiate digitizing the input signal at a rate of up to 50kHz. The data is automatically stored in RAM. The system uses hardware timing and control to insure the highest possible performance.

The complete list of hardware required is:

PCI-20019M-1A High Speed Data Acquisition Module

PCI-20020M-1 Trigger/Alarm Module

—and either—

PCI-20001C Series IBM PC Carrier without digital I/O

PCI-20007M-1 Counter/Timer/Rate Generator Module

—or—

PCI-20041C Series High Performance Carrier.

For convenience in connecting the signals to the modules, termination panels and cables are suggested:

(2) PCI-20303T-1 Euro-Style Analog Termination Panel

(2) PCI-20310A-1 2m Shielded Analog Cable

The Carrier and Modules are configured as follows:

PCI-20001C Series IBM PC Carrier

Normally, the address switches are set to D000 (hex). Switches one through six and eight of DIP switch U8 should be in the on position, and switches seven, nine and ten should be off. This establishes the base address of the Carrier card in the PC's memory map. In some circumstances, hardware conflicts may require a different address choice. Please refer to the PCI user manual for instructions.

Install the following jumpers:

W6	SYNCOUT of Module position 3 to SYNCIN of Module position 2.
W2	SYNCOUT of Module Position 2 to SYNCIN of Module position 1.

These two jumpers form the path by which clock pulses are passed from the Counter/Timer Module through the Trigger/Alarm Module to the Data Acquisition Module.

Remove all other user-selectable jumpers (plug-in type jumpers) on the Carrier.

PCI-20007M-1 Counter/Timer/Rate Generator Module

Install the following jumpers:

W10, W12, W14, W16, W18, W20— All channels software gated.

Remove all other jumpers on the PCI-20007M-1.

PCI-20041C Series High Performance Carrier

If you use this Carrier, then no PCI-20007M-1 Module is required, since a rate generator is included on the Carrier. The base address of the Carrier is normally set at D000 (hex) as is the PCI-20001C Series. The same cautions about hardware address conflicts apply.

Install the following jumpers:

W46	Pacer out to SYNCIN Module position 2
W5, W11	SYNCOUT Module position 2 to SYNCIN Module position 1

As with the PC20001C Series, this is the path which routes the clock pulses of the Rate Generator through the Trigger/Alarm Module to the Data Acquisition Module.

All other plug-in jumpers should be removed on the PCI-20041C Series Carrier.

PCI-20020M-1 Trigger/Alarm Module

Install the following jumpers:

W7, W9	Select single input from the termination panel.
W19	SYNCIN gated to SYNCOUT when trigger is true.

Remove all other jumpers on the PCI-20020M-1.

PCI-20019M-1A High Speed Data Acquisition Module

Install the following jumpers:

W2, W4	Set the input range to ±10V.
W8, W9	Start conversion on rising edge of SYNCIN.
W11	Single channel mode (disable channel scan).

Remove all other jumpers on the PCI-20019M-1A.

After all the jumpers are set as outlined above, the Modules are installed in the Carrier as follows if the PCI-20001C Series Carrier is used:

— Install the PCI-20019M-1A High Speed DAS in J1 (module position 1) on the carrier

— Install the PCI-20020M-1 Trigger/Alarm in J2 (module position 2) on the carrier

— Install the PCI-20007M-1 Rate Generator in J3 (module position 3) on the carrier.

If the PCI-20041C Series Carrier is used:

— Install the PCI-20019M-1A High Speed DAS in J1 on the carrier

— Install the PCI-20020M-1 Trigger/Alarm in J2 on the carrier.

J1 is the connector nearest to the IBM PC bus connector. After the Modules are plugged in, insert the assembly into the computer (or expansion chassis if you are using one).

It is suggested that the accessory Strain Relief Bracket (PCI-20028A-3) be used to facilitate making cable connections. In this case, run the cables out through the open rear port of the PC, next to the Carrier. Plug the cables onto the Trigger/Alarm and DAS Modules. Make sure that the end marked "computer" goes to the Modules, otherwise the shielding will not be connected properly. Orient the connectors such that the cable naturally goes from the module toward the rear of the computer without doubling back.

Plug the other end of the cable coming from the DAS Module into P2 of the PCI-20303T-1 Euro-Style Analog Termination Panel. Likewise, plug the other end of the cable connected to the Trigger/Alarm Module into P2 of the other PCI-20303T-1 panel. Connect your input signal to any of the terminals marked zero through seven, and the ground return to any of the ground terminals.

Normally, the input signal also serves as the trigger. In this case a connection should be made on the termination panel from the selected analog input to the input of the Trigger Module. If an external event is to be used as a trigger, then that signal can be connected to the trigger input. Any signal in the range of ±10V will do. If you are triggering from the input signal, run a jumper from your input channel to terminal eight on the termination panel connected to the PCI-20020M-1. This is the input to the Trigger/Alarm Module. If you are triggering from an external source, connect the external signal here. The hardware is now set up and ready to acquire data.

APPENDIX B
Transient Capture System Program Listing

```
100     CHAIN MERGE "PCIHEAD.BAS", 100, ALL
1000    DEFINT A-E, G-Z
1010    '
1020    ' Initialize the hardware and software system
1030    '
1040    CALL SYSINIT
1050    SEGMT = &HD000
1060    CALL INIT(SEGMT)
1070    GOSUB 1470 ' check for init errors
1080    '
1090    ' This section of the program sets all the default
1100    ' parameters and configures the system
1110    '
1120    DIM Y(5000) : EN = 1 : DIM AI.CHN(2)
1130    FSPS = 1000 : FTL = 0 : S$ = "-"
1140    AI.CHN(1) = 0 : PASSES = 50
1150    GOSUB 2590 'set up system
1160    GOSUB 3090 'draw box
1170    '
1180    ' Main menu routine. All action is initiated from here. The
1190    ' various setup, acquire, and plot routines are all arranged
1200    ' as a group of subroutines called from here.
1210    '
1220    LOCATE 24,12 : PRINT " q to quit, g to go, c to change";
1230    PRINT " parameters, f for file ops ";
1240    P$ = INKEY$ : IF P$ = " " THEN 1240
1250    IF P$ = "g" OR P$ = "G" THEN 1360
1260    IF P$ = "c" OR P$ = "C" THEN 1340
1270    IF P$ = "q" OR P$ = "Q" THEN 1410
1280    IF P$ = "f" OR P$ = "F" THEN 1530
1290    BEEP : GOTO 1240   ' an illegal character was typed.
1300    '
1310    ' These are the subroutine calls which actually do the
1320    ' work.
1330    '
1340    GOSUB 2290 ' get parameters
1350    GOSUB 2590 ' set up system
1360    GOSUB 2910 ' get the data
1370    GOSUB 3090 ' draw the box
1380    GOSUB 3500 ' find min/max
1390    GOSUB 3630 ' plot the data
1400    GOTO 1180
1410    SCREEN 0,0,0 : END
1420    ' Subroutine to check for errors in the PCI-20k calls.
1430    ' This call is executed after every PCI-20k call.
1440    ' All we do is check for nonzero error codes, print them out,
1450    ' and abort. One could be more imaginative if desired.
1460    '
1470    CALL ERR.SYS(Z)
1480    IF Z< >0 THEN PRINT "Error    ";Z : GOTO 1410
1490    RETURN
1500    '
1510    ' File operation submenu
1520    '
1530    CLS : LOCATE 8, 30 : PRINT "FILE OPERATIONS"
1540    PRINT
1550    P$ = " "
1560    PRINT "s to save the current data and setup"
1570    PRINT "r to recall stored data and setup"
1580    PRINT "p to plot current data"
1590    PRINT "d for directory listing"
1600    LOCATE 15,25 :PRINT " ** Your choice, please ** "
1610    P$ = INKEY$ : IF P$ = " " THEN 1610
1620    IF P$ = "s" OR P$ = "S" THEN 1770
1630    IF P$ = "r" OR P$ = "R" THEN 2010
1640    IF P$ = "p" OR P$ = "P" THEN GOSUB 2590 : GOTO 1370
1650    IF P$  < > "d" AND P$  < >"D" THEN 1530
1660    '
1670    ' If we got here, the file operation choice was "d" for directory
1680    '
1690    INPUT "Disk ( a or b ) -- ",D$
1700    IF D$ = "a" THEN GOTO 1720
```

```
1710    GOTO 1730
1720    FILES "a:*.*"
1730    IF D$ = "b" THEN FILES "b:*.*"
1740    PRINT: PRINT " Hit any key to continue"
1750    IF INKEY$ = " " THEN 1750
1760    GOTO 1530
1770    '
1780    ' Save data to disk routine.  The data is written to disk in
1790    ' ASCII form. The first thing stored is the number of data points
1800    ' in the file. The next four items are the rest of the user
1810    ' entered parameters. Finally all the data points are stored.
1820    '
1830    CLS : INPUT "Filename to write data to -- ",FILNAM$
1840    OPEN FILNAM$ FOR OUTPUT AS #1
1850    '
1860    ' Store the user entered parameters
1870    '
1880    PRINT #1, PASSES
1890    PRINT #1, FSPS
1900    PRINT #1, S$
1910    PRINT #1, FTL
1920    PRINT #1, AI.CHN(1)
1930    '
1940    ' Store the data
1950    '
1960    FOR I = 1 TO PASSES
1970    PRINT #1, Y(I)
1980    NEXT I
1990    CLOSE #1
2000    GOTO 1530
2010    '
2020    ' Recall data from disk routine. The data must be retrieved
2030    ' in the same order in which it was stored.
2040    '
2050    '
2060    CLS : INPUT "Filename to recall -- ",FILNAM$
2070    OPEN FILNAM$ FOR INPUT AS #1
2080    '
2090    ' Retrieve the user entered parameters
2100    '
2110    INPUT #1, PASSES
2120    INPUT #1, FSPS
2130    INPUT #1, S$
2140    INPUT #1, FTL
2150    INPUT #1, AI.CHN(1)
2160    '
2170    ' Retrieve the data
2180    '
2190    FOR I = 1 TO PASSES
2200    INPUT #1, Y(I)
2210    NEXT I
2220    CLOSE #1
2230    GOSUB 2590
2240    CLOSE #1
2250    GOTO 1530           ' Return to file menu
2260    '
2270    ' Subroutine to get acquisition parameters from the user
2280    '
2290    CLS : GOSUB 3380  ' Clear screen and print current params
2300    LOCATE 1,1
2310    '
2320    ' Get sample rate
2330    '
2340    INPUT "Samples per second (150 - 50000) -----------    ",FSPS
2350    IF FSPS <150 OR FSPS> 50000! THEN 2290
2360    '
2370    ' Get trigger level
2380    '
2390    INPUT "Trigger level (+/-  %FS) ----------------------- ", FTL
2400    IF FTL > 100 OR FTL <-100 THEN 2390
2410    '
2420    ' Get trigger slope
2430    '
2440    INPUT "Trigger slope ( + or - ) -----------------------    ",S$
2450    IF S$ = "+" THEN S$ = "pos"
```

```
2460    IF S$ = "-" THEN S$ = "neg"
2470    IF S$ < > "pos" AND S$ < > "neg" THEN 2440
2480    '
2490    ' Select the input channel. Must be in the range of 0 - 7
2500    '
2510    INPUT "Input channel (0 - 7 ) ------------------------     ", AI.CHN(1)
2520    IF AI.CHN(1) > 7 or AI.CHN(1) < 0 THEN 2510
2530    '
2540    ' Get number of passes
2550    '
2560    INPUT "Number of samples (10 - 5000) -----------     ", PASSES
2570    IF PASSES >5000 OR PASSES <10 THEN GOTO 2560
2580    RETURN
2590    '
2600    ' Subroutine to set up system to selected parameters
2610    '
2620    ' Configure rate generator for correct scan rate
2630    ' Since not all scan rates can be hit exactly, we will get as
2640    ' close as possible, and then report the actual rate we got.
2650    ' The rate generator mode will be 2
2660    '
2670    FMEG4 = 4000000! : FMEG8 = 8000000! : COUNT1 = FMEG4 / FSPS
2680    COUNT2 = 2 : CHN = 0 : FCNT1 = COUNT1 : FCNT2 = COUNT2 : RGMODE = 2
2690    FSPS = FMEG8 / (FCNT1 * FCNT2) ' recompute the actual sample rate
2700    CALL CNF.RG(CHN, COUNT1, COUNT2, RGMODE)
2710    GOSUB 1470          ' Test for errors after every call
2720    '
2730    ' Set up the Trigger/Alarm module for the level and slope
2740    '
2750    LEVEL1 = ((FTL / 100)) * 128 + 127 : WINDW = 0
2760    IF S$ = "pos" THEN LEVEL2 = &HFF
2770    IF S$ = "neg" THEN LEVEL2 = 0
2780    CALL CNF.TRIG(CHN, LEVEL1, LEVEL2, WINDW)
2790    GOSUB 1470
2800    '
2810    ' Set up the channel list for the high speed acquisition,
2820    ' and execute the configure instruction. We will use mode 4 -
2830    ' hardware controlled acquisition. Trigger will be the PCI-20020M-1,
2840    'and acquisition will be paced by the PCI-20007M-1
2850    '
2860    AI.CHN(2) = -1 : PACER = RG : PCHN = 0 : HSMODE = 4
2870    TTYP = TRIG : TCHN = 0
2880    CALL  CNF.HS(PACER, PCHN, HSMODE, TTYP, TCHN, AI.CHN(1))
2890    GOSUB 1470
2900    RETURN
2910    '
2920    ' Execute the high speed acquisition.
2930    ' This is the routine which actually takes the data. All
2940    ' parameters have been set elsewhere.
2950    '
2960    SEGMNT = 0
2970    PRINT "running";
2980    CALL HS.RUN(PASSES, Y(1), SEGMNT)
2990    '
3000    ' The DAS module's code is complimentary binary, so invert the data
3010    ' to get sensible numbers
3020    '
3030    FOR I = 1 TO PASSES : Y(I) = Y(I)  XOR  &HFFF : NEXT I
3040    GOSUB 1470
3050    RETURN
3060    '
3070    ' Subroutine to draw the plotting window
3080    '
3090    CLS : KEY OFF       ' Clear the screen and keys
3100    SCREEN 2            ' Select high resolution graphics
3110    '
3120    ' Define the locations and size of the graph.  The upper left hand
3130    ' is at topx,topy and the lower right at botx,boty.
3140    '
3150    TOPX = 600 : BOTX =56 : TOPY = 5 : BOTY = 145
3160    '
3170    ' Draw the box with a clear border of 2 pixels at top and bottom.
3180    '
3190    BORD = 2
3200    LINE (BOTX,BOTY+BORD) - (BOTX,TOPY-BORD)
```

```
3210    LINE (BOTX,BOTY+BORD) - (TOPX,BOTY+BORD)
3220    LINE (TOPX,TOPY-BORD) - (TOPX,BOTY+BORD)
3230    LINE (TOPX,TOPY-BORD) - (BOTX,TOPY-BORD)
3240    '
3250    ' Divide the x and y axes into 10 intervals, and draw tic marks
3260    '
3270    FXINT = (TOPX - BOTX) / 10 : FYINT = (TOPY - BOTY) /10
3280    YTIC = 5 : XTIC = 10
3290    FOR I = 0 TO 10
3300    LINE (BOTX, BOTY + I * FYINT) - (BOTX - XTIC, BOTY + I * FYINT)
3310    NEXT I
3320    FOR I = 0 TO 10
3330    LINE (BOTX + I * FXINT, BOTY) - (BOTX + I * FXINT, BOTY + YTIC)
3340    NEXT I
3350    '
3360    ' Print out the acquisition parameters below the graph
3370    '
3380    TEXTLIN = 22
3390    LOCATE TEXTLIN, 5
3400    PRINT "Rate --";FSPS;"  ";
3410    IF S$ = "-" THEN S$ = "neg"
3420    IF S$ = "+" THEN S$ = "pos"
3430    PRINT "Trig Level --";FTL;"% Slope --";S$;" Chan --";AI.CHN(1);
3440    PRINT " Samples --";PASSES
3450    RETURN
3460    '
3470    ' Subroutine to find the min and max data values
3480    ' and calculate the span and x interval of the data points
3490    '
3500    YMIN = 4095 : YMAX = 0
3510    FOR I = 1 TO PASSES
3520    IF Y(I)>YMAX THEN YMAX = Y(I)
3530    IF Y(I)<YMIN THEN YMIN = Y(I)
3540    NEXT I
3550    YSPAN = YMAX - YMIN : FYFACT = (TOPY - BOTY) / YSPAN
3560    FXINC = (TOPX - BOTX) / (PASSES - 1)
3570    RETURN
3580    '
3590    ' Subroutine to label the axes and scale and plot the data
3600    '
3610    ' First, label the x and y axes, and the first data value
3620    '
3630    FLO = (YMIN/4096) * 20 -10 ' Label the y axis
3640    FHI = (YMAX/4096) * 20 -10
3650    FTRIG = (Y(1)/4096) * 20 -10
3660    LOCATE 1,BOTX/8-6 : PRINT USING "###.##"; FHI
3670    LOCATE BOTY/8+1,BOTX/8-6 : PRINT USING "###.##"; FLO
3680    LOCATE BOTY/8 + 2, BOTX/8: PRINT "0"; ' Label the X axis
3690    LOCATE BOTY/8 + 2, TOPX/8-3 : PRINT USING "##.####"; PASSES/FSPS
3700    FOLDX = BOTX-FXINC
3710    OLDY = (Y(1) - YMIN) * FYFACT + BOTY
3720    LOCATE OLDY/8+1 ,BOTX/8-6 : PRINT USING "###.##"; FTRIG
3730    '
3740    ' Scale and plot the data
3750    '
3760    FOR J = 1 TO PASSES
3770    NEWY = (Y(J) - YMIN) * FYFACT + BOTY
3780    FXNEW = FOLDX + FXINC
3790    '
3800    ' Special adjustment to put the first point on the graph
3810    '
3820    IF FOLDX < BOTX THEN FOLDX = BOTX
3830    LINE (FOLDX, OLDY) - (FXNEW, NEWY)
3840    FOLDX = FXNEW : OLDY = NEWY
3850    NEXT J
3860    RETURN
```

Personal Computers Challenge Minicomputers

Almost as soon as the IBM PC was introduced, data acquisition boards to plug into them appeared on the market. These early boards were basic -- they handled analog to digital (A/D) conversion, digital to analog (D/A) conversion, and digital I/O.

As time went on, the boards became increasingly sophisticated. Faster A/D converters with programmable gain instrumentation amplifier front-ends were incorporated. Powerful features such as on-board memory and sophisticated DMA techniques began to appear. The number of competitors also increased, and existing products were quickly made obsolete by newer products with more powerful features. Today, there is a wide array of products covering the gamut from low-end digital I/O boards to array processing systems costing several times as much as the personal computer itself.

Fixed Configurations

Most manufacturers offer fixed configuration, multi-function data acquisition boards. Typically, such a board contains 16 single-ended or 8 differential analog inputs, two analog outputs, 16 digital I/O bits, some sort of pacer clock or timer for generating A/D conversions, and often one or more event counters. The main differentiating factor among these boards is generally either the speed or resolution of the A/D converter or the mix of I/O offered.

One problem with the fixed multi-function board approach is the difficulty of expanding or upgrading a system. This is often necessary in R&D applications, where a system may be used for many different applications over a period of time. Even in fixed-configuration production systems, the number of channels provided by the board may be insufficient to handle the given problem. To expand the number of analog or digital I/O channels, one is faced with purchasing a complete second board. This can be a significant penalty if all you need is a few more digital I/O points, for example. To upgrade speed, you must buy an entirely different board with a higher performance A/D. Often, this also involves different software -- the program you have written based on the slower board may need re-writing to accommodate the different architecture of the faster board. For other applications, there may be functions provided by the multifunction boards which are not needed. For example, typically only 30% of data acquisition users require analog outputs. If they are provided, you pay for them whether or not they are used.

Modularity = Flexibility

Burr-Brown solved this problem by offering a modular system. Burr-Brown's PCI product family began with a simple motherboard, called a carrier, and function modules which plugged into the carrier. The carrier plugs into the PC's backplane, and handles all the bus interfacing tasks. The function modules plug into the carrier, with each module handling one specific data acquisition task, such as A/D conversion. The interface between the modules and the carrier is the patented I3 (Intelligent Instrumentation Interface) Bus.

The current list of modules includes several different multi-channel A/D input modules, 12- and 16-bit D/A modules, a Digital I/O module, a Counter/Timer module, a Trigger/Alarm module, and an Analog Input Expander with automatic scan list. The list of modules grows continuously in response to advances in technology and requirements of customers. As new carriers and modules are introduced, compatibility with existing products is insured by maintaining conformance to the I^3 bus specification.

Solving the Real-Time Crunch

A major limitation of the IBM PC/XT/AT/EISA family of computers in data acquisition applications is the fact that they were designed with office automation in mind. They were intended to be single-user, single-tasking, simple, low-cost machines. They excel at word processing and spreadsheet applications but often are not up to the real-time requirements of high-performance data acquisition and control. Indeed, many of the technical advances found in the data acquisition and control boards on the market today have been directed at overcoming this sort of limitation.

One excellent solution to this problem is to put a high-performance processor right on the data acquisition board itself. This processor can assume control of the data acquisition functions, allowing the personal computer to act in a supervisory role. The PC can download programs to the data acquisition system and leave all the time-critical operations where they are most effectively dealt with.

The architecture of the PCI System lends itself particularly well to this approach, since the data acquisition functions are already on modules. This allows the limited available carrier board space to be dedicated to the on-board processor's functions.

A recent offering in the PCI family, the PCI-20202C-1 *Smart* Carrier, is such a board. This carrier includes positions for two standard PCI I/O Modules. The high-performance processor used is the industry standard TMS320C25 Digital Signal Processor from Texas Instruments. The board also includes high-speed program and data memory and provisions for synchronizing the system to external events. This carrier begins to transcend traditional notions of what a PC can accomplish in a data acquisition and control system.

It was originally thought of as a DSP oriented product. It has actually proven to be most useful in many sophisticated data acquisition and control applications. While there are other DSP processor boards readily available, none have the I/O versatility required for serious data acquisition and control. Often, in this sort of application, traditional DSP algorithms, such as FFT's and digital filtering, never come into play.

PC-Controlled Ultrasonic Welder

One such data acquisition and control application was developed by DISTEC Hard- und Software Gmbh, a small company in West Germany. They used this carrier in a system to monitor and control 16 ultrasonic welders in real- time. The hardware used to accomplish this task was the PCI- 20202C-1 *Smart* Carrier, a PCI-20002M-1 16 channel Analog Input Module, and a PCI-20004M-1 32 Channel Digital I/O Module. See FIGURE 5-11.

Upon system initialization, the personal computer downloads the control program into the carrier from disk. It also downloads standard maxima for various parameters, as explained below, and then starts the carrier's processor running. After this point, the PC has no further interaction with the welding system other than to act as a power supply. The PC is now available to run an inventory control program.

Sixteen of the Digital I/O channels are connected to relays used to turn the individual welders on and off. Additional channels are connected to an external machine controller which provides supervisory control. For example, it determines when a part is available for welding and informs the carrier. It also monitors various system-level alarm conditions, such as open welder doors, and communicates these to the carrier as well.

Each of the 16 analog input channels is connected to one of the 16 welders. These are used to monitor the power output of the individual welders whenever a part is being welded. The bandwidth of interest is 50Hz for each channel. To attain a clean 50Hz bandwidth, the welder power for each channel is sampled at 1000 samples per second. These samples are passed through a finite impulse response (FIR) digital filtering algorithm to remove 50 Hz hum. A 20 to 1 downsampling algorithm is then used to develop 50 clean samples per second per channel. Please refer to FIGURE 5-12.

Note that since there are 16 channels and each must be sampled at 1000 samples per second, the maximum aggregate system throughput is 16,000 samples per second if all 16 welders are operating concurrently. Since all required processing must be performed in real-time, each channel's processing must be completed in between two successive samples -- 1/16,000 seconds or 62.5 microseconds! This would be an impossible task for the PC alone.

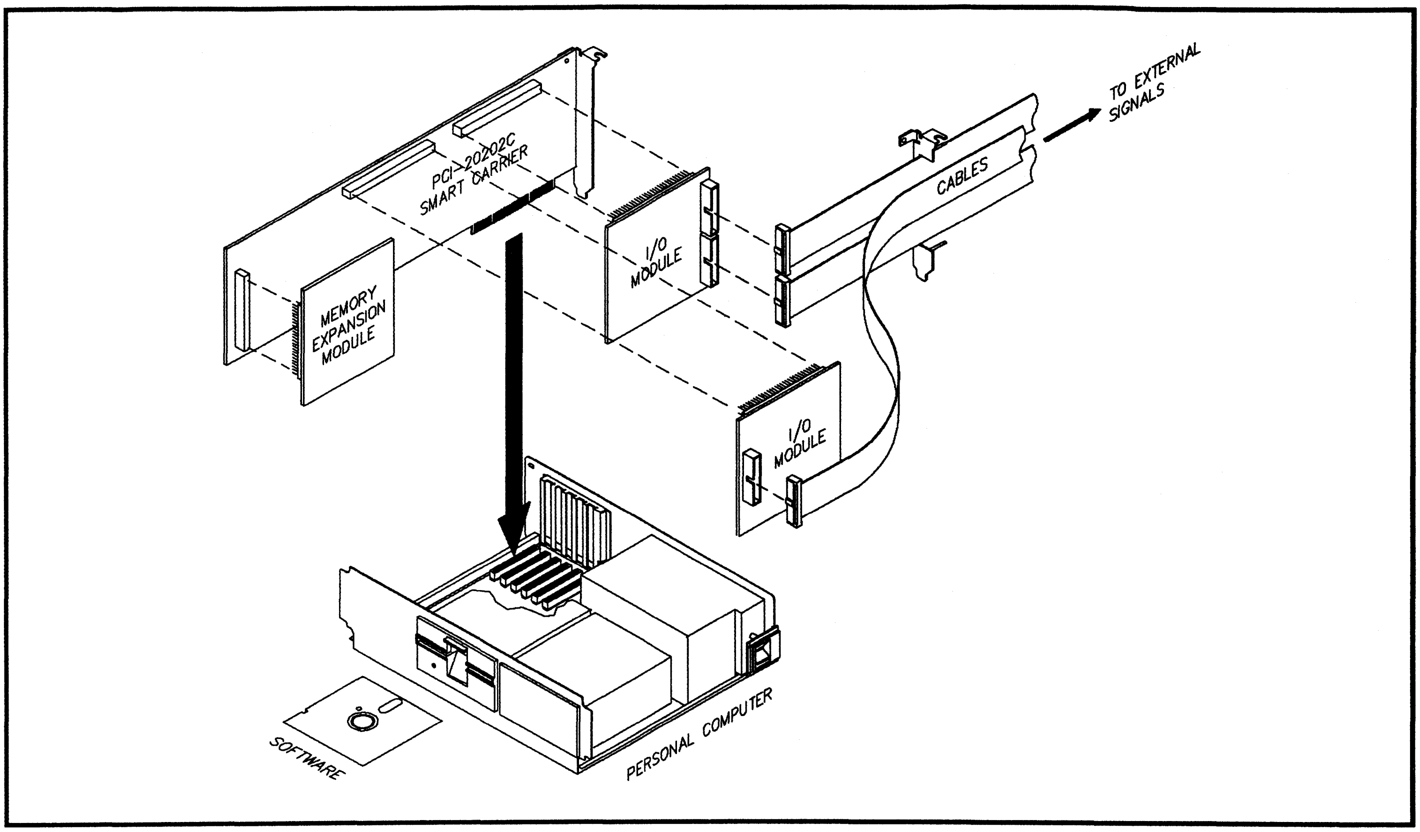


FIGURE 5-11. PCI Hardware Configuration.

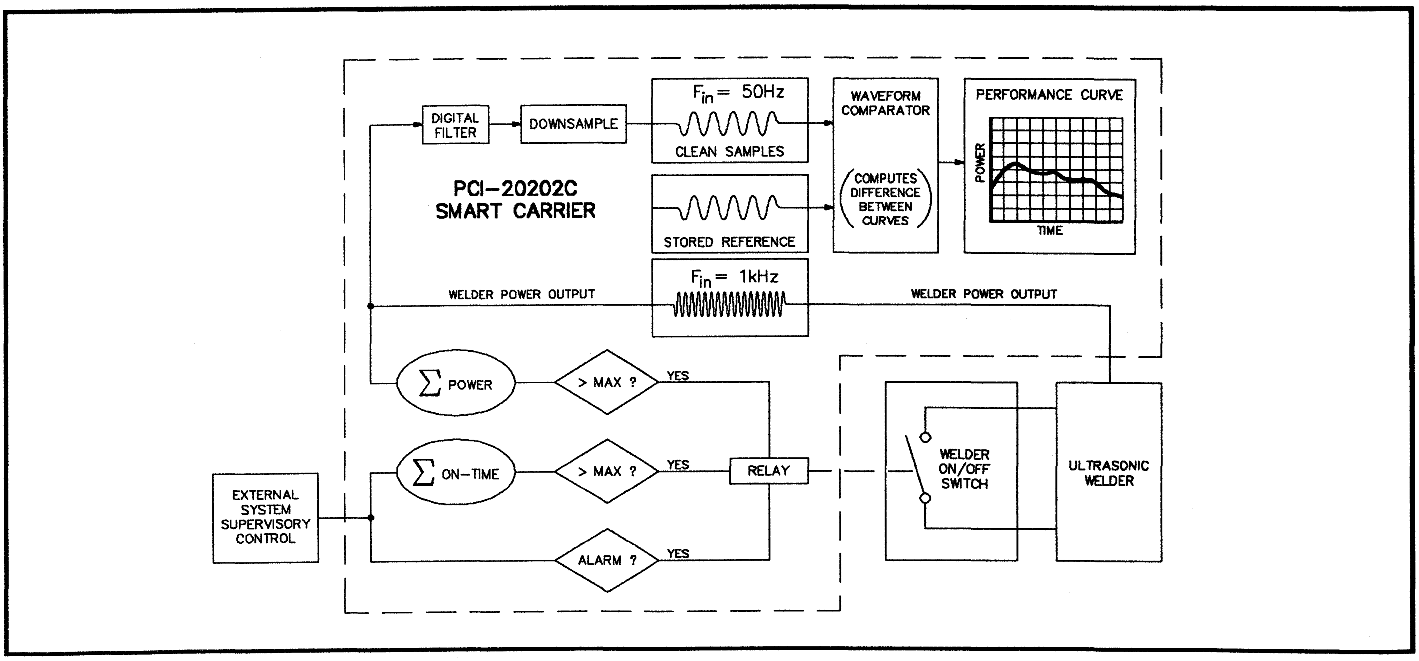


FIGURE 5-12. Ultrasonic Welder Flow Diagram.

The power-vs-time data developed above is compared with a stored optimum which was downloaded from the PC at system initialization. Additionally, alarm signals from the system supervisory controller are monitored, the on-time of each individual welder is monitored, and total power for each welder is summed to give energy. Any anomalies in any of the monitored inputs are used to shut down the offending welder. This provides early detection of error conditions, prevents serious damage to the machine, and prevents the production of large amounts of scrap material.

Pneumatic Actuator Controller

Another challenging data acquisition and control application was in a high-speed pneumatic actuator system. Such systems can be found in a variety of industrial applications, including aircraft simulators, automotive frame testing, and high-speed manipulators. This application used only digital I/O (unavailable on other processor boards) along with the serial I/O of the TMS320C25 to monitor and control the position of a piston in a pneumatic tube.

The position of the piston in the tube is controlled by four solenoid valves connected to a high-pressure compressed air system. Two of the valves pressurize the cylinder to move the position up, while the other two pressurize the cylinder to move it down. See FIGURE 5-13.

The position of the piston is monitored by a sophisticated linear magnetic detection system. A small magnet is attached to the piston inside the tube. Hundreds of sensors are positioned on the outside of the tube to detect the position of the piston. An accuracy of better than 0.1mm over a length of 1m is maintained.

The detector system communicates with the *Smart* Carrier with a serial data stream at 1.5 Mbaud on the processor's serial input. The *Smart* Carrier uses a PCI-20004M-1 32 Channel Digital I/O Module to drive the four solenoid valves in response to setpoint commands from the host PC. The PC's role is only supervisory -- all the complex feedback control algorithms are performed locally in the program running on the carrier. With the actuator attaining speeds of several meters per second, this is a demanding real-time data acquisition and control application which would be very difficult for a PC on its own.

Airframe Stress Testing

Another demanding application having appeal in a variety of industries was demonstrated to a major U.S. aircraft manufacturer. Their specific interest was in airframe structural testing, but the principles involved would apply equally in virtually any high-speed, multi-channel control application.

The manufacturer wanted to construct a stress test control system. Hydraulic jacks, controlled by analog proportional valves, was used to stress an aircraft's wings. Strain gages monitor the resulting forces. Each hydraulic jack would have one or two strain gages associated with it. On computer command, a given stress level would be called for, and the system would then drive the jacks and monitor the strain gages to achieve that level in a feedback control arrangement. FIGURE 5-14 suggests the system configuration.

As many as 32 jacks, with up to 64 strain gages as feedback elements, needed to be controlled. An update rate of 200 points per second for each hydraulic jack was calculated to be optimum. Considering that there would be a maximum of 64 analog inputs to monitor, this would be an aggregate system throughput of 12,800 points per second.

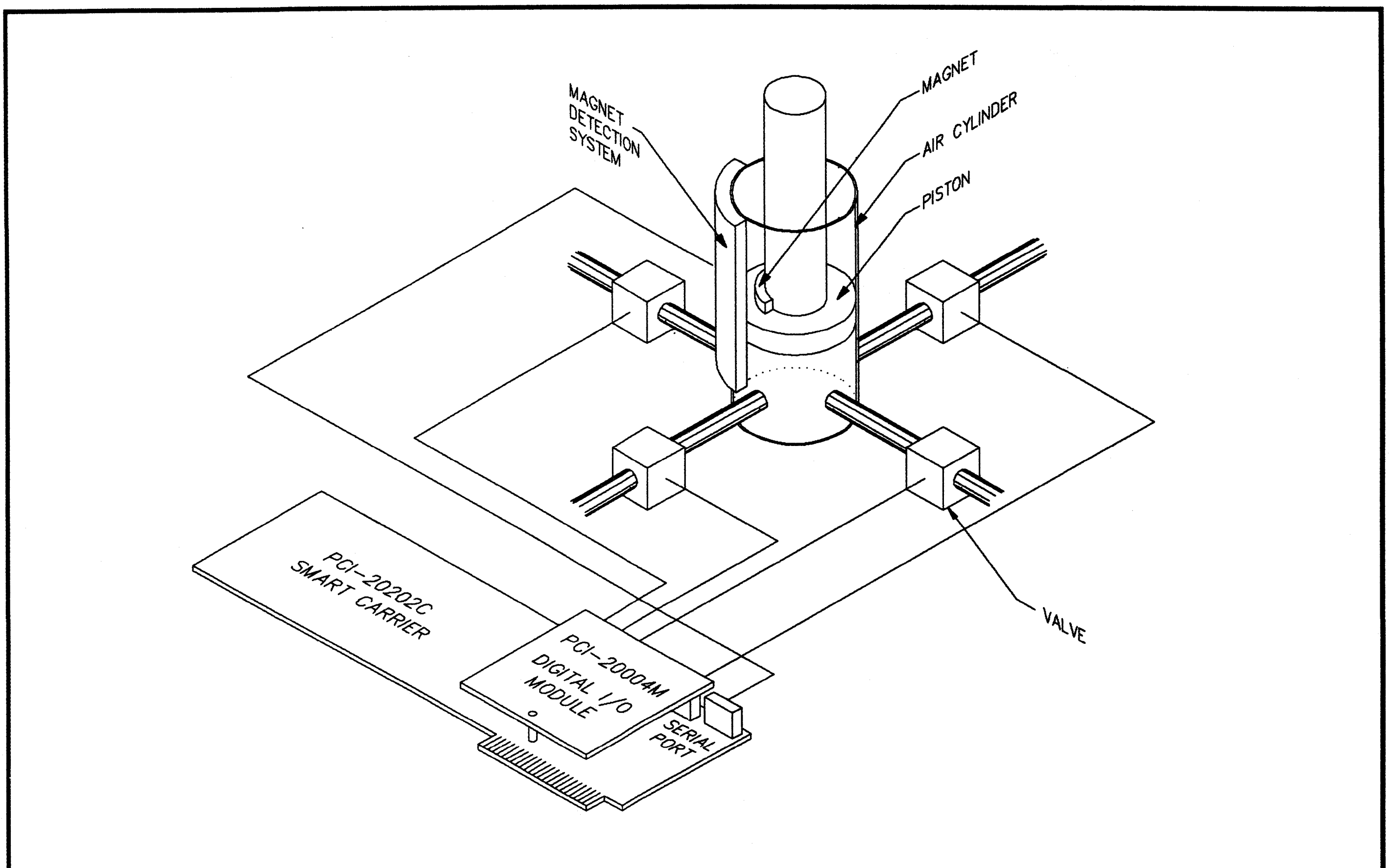


FIGURE 5-13. Pneumatic Actuator Block Diagram.

Sixty-four analog inputs and 32 analog outputs are required. Because of the large channel count, the system will involve a number of carriers and modules. The *Smart* Carrier can accept two modules. One will be used for a PCI-20019M-1A high-speed analog input module. A PCI-20041C-2A (standard type) carrier with two PCI-20031M-1 32 channel expander/sequencer modules will provide the required 64 inputs. The inter-carrier connector on this PCI-20041C-2A is cabled to the PCI-20329M-1 prototype module in position 2 on the *Smart* Carrier. The expander/sequencer modules are preprogrammed with a scan sequence at system initialization and run automatically thereafter, synchronized by the *Smart* Carrier's pacer clock.

The analog outputs are handled by two PCI-20041C-3A DMA Carriers, with two PCI-20021M-1B eight-channel analog output modules each, giving a total of 32 analog outputs. Note that both the PCI-20041C-2A and PCI-20041C-3A can accept up to three modules each. Therefore, additional channels could easily be added to this application.

The *Smart* Carrier would acquire the analog inputs, perform all necessary calculations, and send the analog control output values to a small block of the PC's memory via DMA control. Through a second DMA process, again synchronized by the *Smart* Carrier's pacer clock, these values are removed from the PC's memory and sent to the analog output modules.

All data transfer through the PC is via DMA, so none of the PC's computing time is required after system startup. The total data transfer rate to the PC is 32 outputs, times 2 bytes per output, times 200 updates per second. This is equivalent to a total of 12,800 bytes per second. The DMA transfer rate from the PC's memory to the analog outputs is the same, resulting in a total rate of 25,600 bytes per second. Since a PC is capable of transfers of up to 400 Kbytes per second, this system uses very little of the PC's capacity.

The software overhead required to acquire each sample, put it into 2's-complement binary format, re-format the result of the algorithms for the analog output modules, and output the samples to the PC in approximately 5 microseconds. Since the control algorithm for each channel must run in the time between analog samples (within 78 microseconds), this leaves 73 microseconds available to process each channel.

A PCI-20202C-1 (TMS320C25 at 28MHz) machine cycle requires 140nsec (a 100nsec model is available), and a typical instruction requires two cycles (280nsec). In this system, roughly 250 instructions are allowed for each of the 32 algorithms. The Texas Instruments TMS320 User's Guide gives an example of a simple PID loop, roughly equivalent to the task at hand, which requires 11 instructions running in approximately 5.3 microseconds. From these thumbnail calculations, it is clear that there is plenty of time to execute a fairly complex control algorithm in real-time for each channel.

Applications such as those described above are usually being satisfied today with high-powered VME and Multibus systems, with their attendant high cost and long development times. With sophisticated PC-based data acquisition and control processors, such as the PCI-20202C-1 *Smart* Carrier, many of these tasks can now be accomplished with a much lower hardware cost. In addition, system integration and software development are greatly simplified, resulting in a total system cost that is a fraction of previous levels.

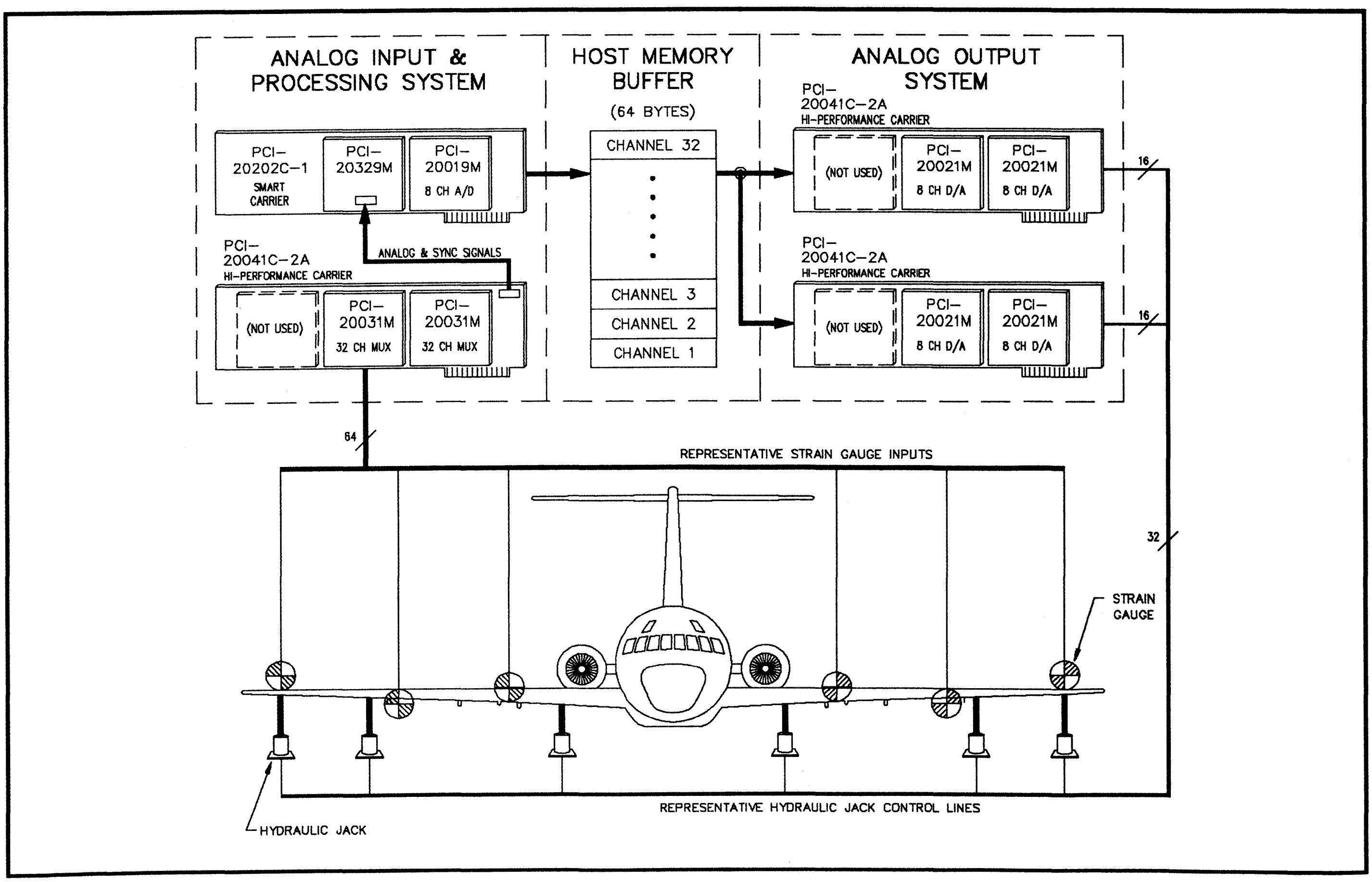


FIGURE 5-14. Airframe Stress Testing System.

Advanced Applications for the PCI-20007M-1 Counter/Timer Module

The PCI-20007M-1 Counter/Timer Module finds wide application in tasks such as interval timing, event counting, frequency measurement, speed monitoring, time-base or pulse (frequency) generation, and position measurement.

This module is based upon the Intel 8254 integrated circuit, which provides a spectrum of useful functions. To exploit many of the features of this module, however, can require a detailed knowledge and understanding of the chip itself. To assist users of the PCI System, an array of software tools has been created. This software provides a broad range of capabilities while eliminating the need for the user to program the 8254 directly.

Some of the characteristics of the 8254 merit clarification in order to avoid possible difficulties. For example: how does a counter load an initial value and record input pulses? This segment will offer useful background information and solutions to what some might call shortcomings of the 8254. Also included are alternate techniques for frequency measurement and external hardware approaches to speed monitoring, time measurements and programmable pulse generation.

Talking to the Counters

The PCI-20007M-1 consists of four independent counter channels and one "rate generator". Each counter has three input/output terminals: clock input (CLK), gate input (GATE) and output (OUT). Six different operating modes can be selected, each with unique characteristics. A complete description of the various modes can be found in the PCI-20007M-1 user manual. Of importance here is that the initial output level and its response to both CLK and GATE inputs are strongly dependent upon the mode chosen. Assumptions are often wrong. Please read the manual. In addition to the above I/O points, there are a number of on-board registers that permit software to set up the control parameters and to read the status of the counters. Each register function is explained in the user manual. The rate-generator consists of an 8MHz crystal oscillator driving two divide-by- "n" counters (separate from above), connected in series. The resulting output is a software-programmable pulse generator. By selecting the *n* values for the two counters, a wide range of pulse frequencies and duty cycles can be obtained. All counters are 16-bit devices capable of representing numbers between 0 and 65,535 (2^{16}).

In the context of the PCI-20007M-1, a pulse is defined as a digital signal which changes from a low-to-high-to-low state. An example of this is shown in FIGURE 5-15.

Any of the counters on the PCI-20007M-1 module can be configured to accumulate input pulses (input to CLK). The Rate Generator can be used to produce an accurate time-base (input to GATE). The number of input impulses counted will be directly related to the length of time that the gate input is held high.

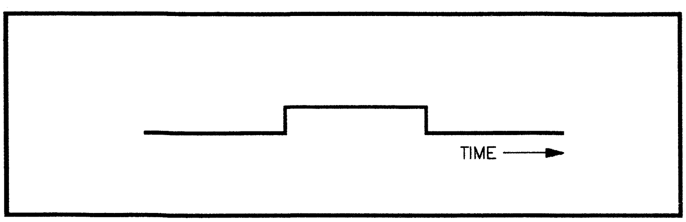


FIGURE 5-15. A Single Pulse.

The counter gates can be jumper-programmed to respond to either signal or software inputs. In the signal mode, each independent counter can be inhibited from counting by holding its gate low (TTL 0). Internal pull-up resistors are not provided; so, it is very important to drive the gates to the desired level. In the absence of an input, operation is not predictable. Remember, for the Rate Generator to be active, both associated counters must be gated "on".

Counting

Often it is desired to initialize a counter with a given number ("NUM", for example) and to either count inputs with reference to NUM or to generate a hardware output upon NUM inputs. The count value contained in the output register decrements (reduces) with each clock pulse. However, the defined value, NUM, is not actually loaded into the counter until the first clock pulse occurs. The result is that the contents of the output register contains one less count than was actually applied. It is normally very easy to account for this condition, by adding 1 to the reading. But, what if fewer than two pulses are received? Under these conditions, the value contained in the register is unpredictable. Fortunately, there are solutions to this problem. One method using the PCI-20026S-1 is outlined below.

Method 1:

a) Disable the counter . . . . (WRITE.CH with 0)
b) Set the Initial Count to 65, 535 . . . . (CNF.CNTR)
c) Start counting . . . . (WRITE.CH with 1)
d) Read the counter's STATUS & COUNT . . (STAT.CNT)

If STATUS=0, zero pulses have arrived
If STATUS=1, read the counter (COUNT)

The number of input pulses=65,536-COUNT

Sometimes it is required to count events in excess of 65,535. It may seem logical to cascade two counters to produce a 32-bit device, but this is not quite as simple as might be expected. In the divide-by-*n* mode, the counter output is initially HIGH and it goes LOW when decremented to 1. The next input pulse causes the output to return to a HIGH state. Unfortunately, this is NOT the correct waveform to decrement the second counter. Intel defines an input pulse as a LOW to HIGH to LOW transition. As a result, 65K pulses will be missed before this condition is met. There is, however, an external way (Method 2, below) of correcting the hardware levels. In addition, a software solution is also available. This technique uses the fact that when a counter decrements to zero it automatically rolls under to full scale (65,535) and continues counting (Method 3, below).

Method 2:

a) Use two counters.

b) Add a hardware inverter between the output of the first counter and the input of the second. This corrects the "sense" of the pulse.

c) Set up and read both counters following the general procedure suggested in Method 1. However, compute the total input pulses by applying the proper "weighting" factor to the second counter.

Method 3:

a) Use only one counter.

b) Follow the procedure in Method 1.

c) Read the counter often enough to detect a "roll-under".

d) For each "roll-under" add 65,535 to the count computed in Method 1. That is: Total = (65,536 - COUNT) + (65,535 · number of zero crossings).

Frequency Measurement

The structure of the PCI-20007M-1 is well suited to frequency measurement. Depending upon the application, several configurations are possible. The PCI-20026S Software Drivers support the most popular arrangement. This technique is suggested in FIGURE 5-16.

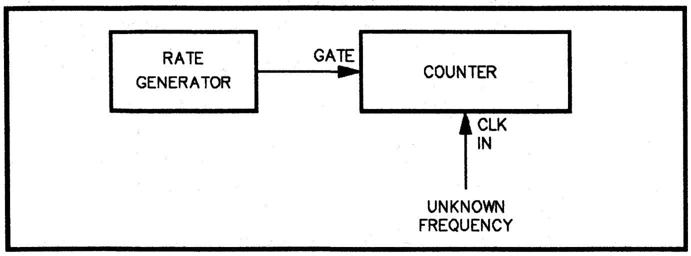


FIGURE 5-16. High-frequency Measurement Circuit.

This circuit counts input pulses for a known time interval (Gate time), as defined by the Rate Generator. Gate times of 1ms to one second are very common. Clearly, the longer the measurement interval, the larger will be the accumulated count (for a given input frequency). Resolution and accuracy are proportionally enhanced. Maximum resolution is limited by the requirement that no more than 65K pulses be accumulated in any one measurement interval. The practical (useful) frequency range for this circuit extends from about 100Hz to beyond 8MHz.

Period Measurement

An alternate approach to low-frequency measurement is suggested in FIGURE 5-17. This circuit differs in that it counts high-frequency clock pulses for the duration of the unknown input signal. The result is enhanced resolution at low frequencies. In the simple form shown here, the count value is a function of the input signal's duty-cycle (counting takes place while the input is high). Therefore, the exact value of the duty-cycle must be known to accurately compute the true input frequency. Given this information, practical measurements are possible from a small fraction of a Hertz to beyond 1kHz. In fact, the lower limit is only restricted by the time available to make the measurement (i.e., measuring 0.01Hz requires 100 seconds). Both of these circuits have an ultimate (maximum) resolution of one part in 65K. Note, however, that this resolution is not available at all frequencies within the measurement range. Programmers can implement this technique using the PCI-20026S, but it is not directly supported by the READ.FRQ command.

Gate Generation and Speed Measurement

As was stated above, FIGURE 5-17 requires a known duty-cycle. Very often this information is not available. For example, when measuring speed (i.e., motor rotation, conveyor travel, linear motion) with an optical or magnetic pickup, duty-cycle is variable. One solution is to use the circuit shown in FIGURE 5-18. This circuit uses flip-flops to convert the input signal into a positive pulse that is the width of a complete input cycle. Thus, measurements are now duty-cycle independent. An external logic input is applied to control the arming of the "gate generator". One of the PCI digital output lines can be used to produce this level internally. The selection of the Rate Generator frequency requires a balancing of two competing factors. The higher the frequency, the greater is the resolution of the final reading. However,remember that the counter is limited to 65,535. "Speed" or "inputs per second" are proportional to:

$$\frac{\text{Frequency (Rate Generator)}}{\text{Number of Pulses Counted}}$$

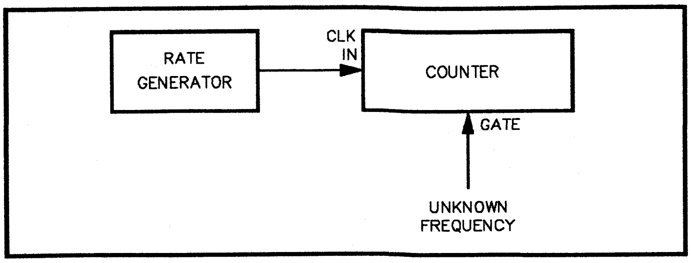


FIGURE 5-17. Low-Frequency Measurement Circuit.

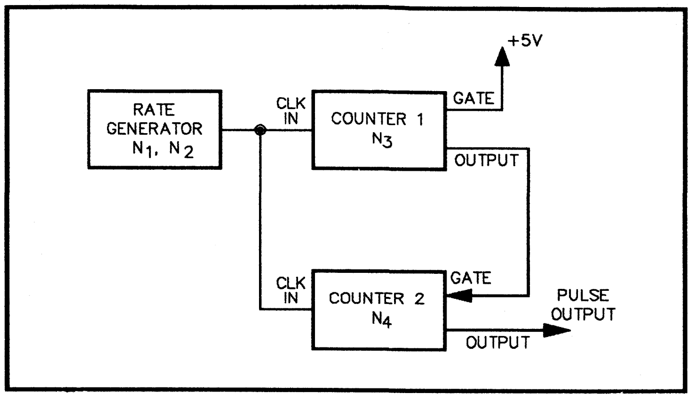


FIGURE 5-18. Gate Generator Circuit.

Wide-Range, Programmable Duty-cycle, Pulse Generator

The Rate Generator within the PCI-20007M-1 can be programmed in both frequency and duty-cycle by selecting the "N" values for each of the two related counters. "N_1" and "N_2" designate the division factor for each counter. Because the crystal oscillator is 8MHz, the rate generator's output frequency is 8MHz/(N_1 . N_2). Consider that the output waveform consists of a "low-" and "high-level" portion, represented by t_1 and t_2. Thus:

$t_1 = N_1 . 125$ns, while $t_2 = N_1 . 125$ns $(N_2 - 1)$.

Combinations of N_1 and N_2 allow a wide range of frequencies and duty-cycles to be selected. However, both parameters are interdependent.

FIGURE 5-19 shows a circuit configuration, using two counters in addition to the rate generator, that allows duty-cycle variation without interfering with the separately programmed frequency. Define the four "N" values:

N_1=Rate Generator, counter 1
N_2=Rate Generator, counter 2
N_3= Independent counter 1 (operate in Mode 2)
N_4=Independent counter 2 (operate in Mode 1)

The frequency and duty-cycle for this circuit are:

Frequency = 8MHz/($N_1 \cdot N_2 \cdot N_3$),
Duty-Cycle = $[(N_3 - N_4)/N_3] \cdot 100$, in percent.

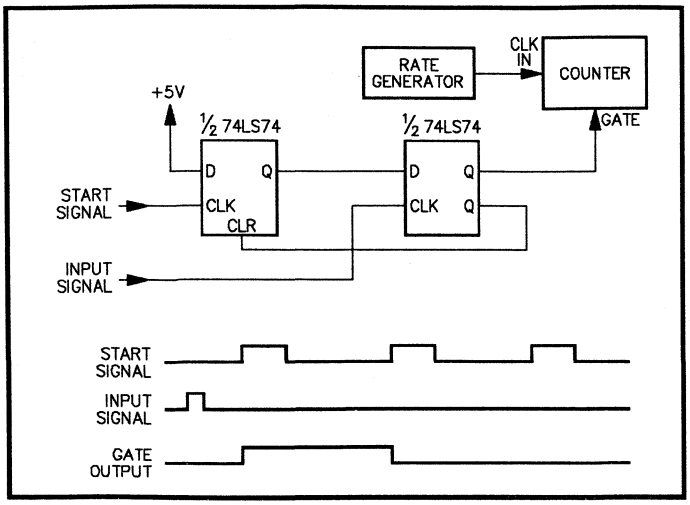


FIGURE 5-19. High-resolution, Variable Duty-Cycle Pulse Generator.

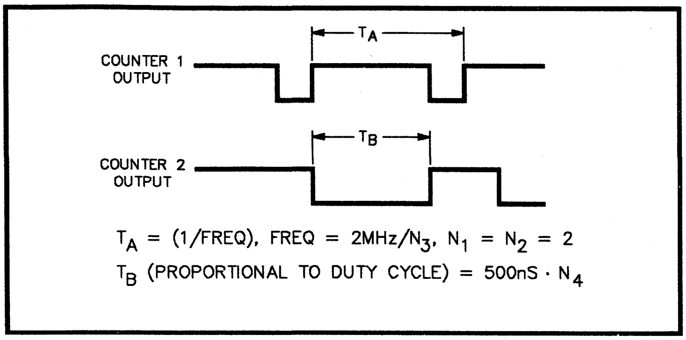


FIGURE 5-20. Waveforms for Variable Duty-Cycle Generator.

Measuring the Time Between Pulses

The following applications are related to the measurement of time *between* pulses. Three different circuits are shown:

— Low speed, time between two pulses on the same line.

— High-speed, time between two pulses on the same line.

— High-speed, time between two pulses on different lines.

The trick is to generate an appropriate gate signal corresponding to the time between two input pulses. This is suggested in FIGURE 5-21.

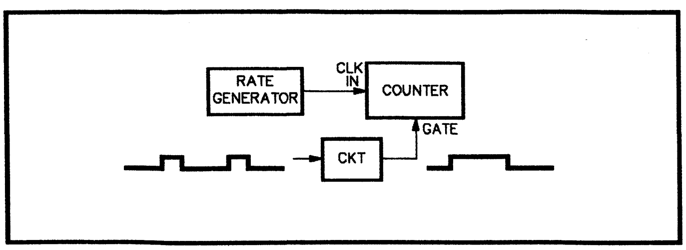


FIGURE 5-21. Basic Counting Circuit.

Before choosing the frequency of the rate generator, the user must first know the maximum duration of time that the pulse at the gate will exist. The product of the maximum gate time and the frequency must not exceed the 16-bit counters' limit of 65,535. However, the higher the Rate Generator frequency, the greater the resolution of the interval measurement will be.

FIGURE 5-22 shows a simple circuit for converting successive input pulses, on a single line, to a gate signal. This circuit is slow because once armed, the counter must be read before a third input pulse occurs. If this condition is not satisfied, the counter will be restarted and an incorrect count will result. Another alternative is to bring the Arm signal low after the second input pulse. This condition can be detected by reading the counter output until a stable count is observed.

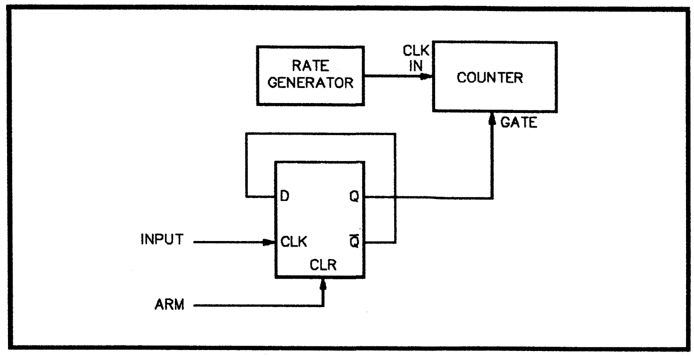


FIGURE 5-22. Simple Time Interval Measurement Circuit.

FIGURE 5-23 shows a variation on the above circuit. Here, the acquisition of the desired time interval is latched with hardware. Thus, the measurement of the desired data is assured without intervention from the host computer.

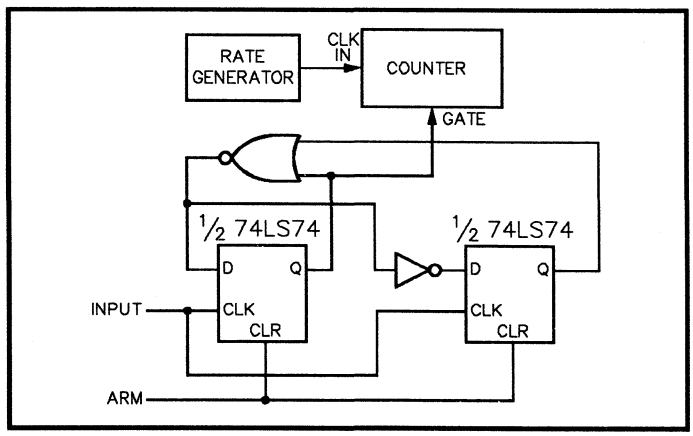


FIGURE 5-23. Fast Time Interval Measurement Circuit.

This circuit will capture one full cycle of an input pulse train and wait for the Arm line to go high-to-low and then low-to-high. The timing characteristics for FIGURE 5-23 are shown in FIGURE 5-24.

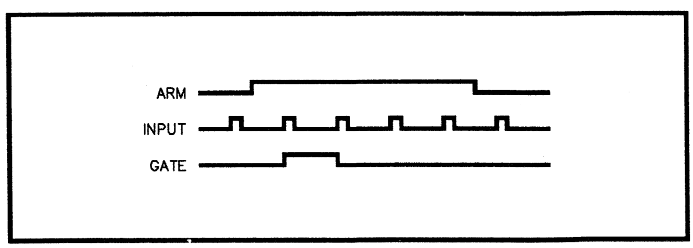


FIGURE 5-24. Timing Characteristics of the Ciruict in FIGURE 5-23.

In both of the above circuits, the time interval was measured between two pulses occurring on the same input line. FIGURE 5-25 shows a circuit that performs the same function with separate START and STOP inputs. The timing characteristics for FIGURE 5-25 are shown in FIGURE 5-26.

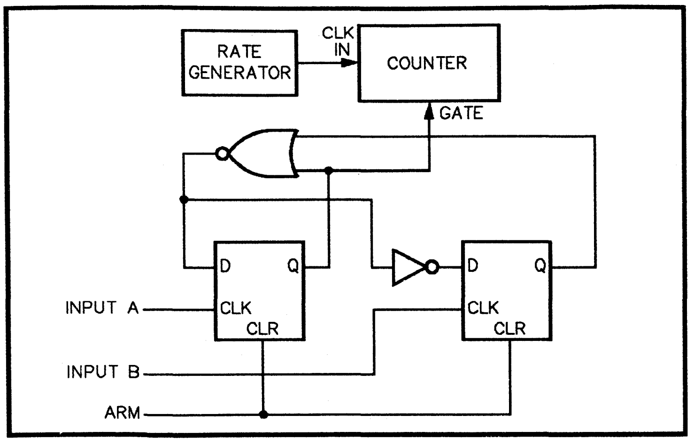


FIGURE 5-25. Double-Input Time Interval Measurement Circuit.

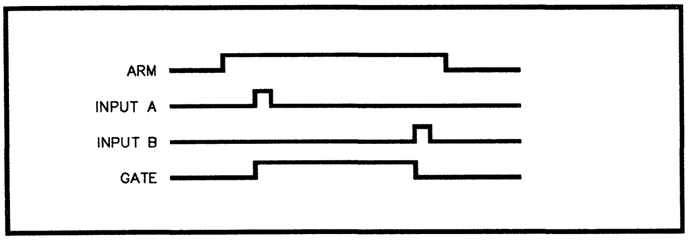


FIGURE 5-26. Timing Characteristics of the Circuit in FIGURE 5.25.

Input A gives the START pulse, and Input B gives the STOP pulse. The time between the START/STOP signals is what this circuit is measuring. As in FIGURE 5-17, this circuit is most suitable for high-speed pulses. The timing is controlled by hardware so that computer intervention is not required for correct measurement.

Generating Bursts of Pulses

Frequently it is desirable to pace the data acquisition process with a series of bursts of pulses rather than a continuous pulse train. The advantage of the burst method is to reduce the amount of data collected (prevent over sampling) while minimizing the time (skew) between readings of multiple channels. Note that there is no advantage if only one channel is being sampled. The PCI multifunction products (PCI-20098C-1, PCI-601W/PCI-602W, and PCI-701C) include a burst generator. When using other products, a burst generator can be built with the PCI-20007M-1 module.

By using the rate generator and two of the counters on a PCI-20007M-1 module, bursts can be generated. FIGURE 5-27 shows a circuit to do this.

The number of pulses in each burst is determined by the count programmed into Counter 0. The frequency of the pulses in each burst is the same as the output frequency of the rate generator. The frequency of the bursts is the rate generator frequency divided by the count in Counter 1. The output is a series of bursts of positive-going pulses. A timing diagram is shown in FIGURE 5-28.

The required external components can be assembled on a PCI-20305T-1 or PCI-20025T Series Termination Panels. Power for the logic chips can come from the PC's 5V supply via ther interconnecting cable.

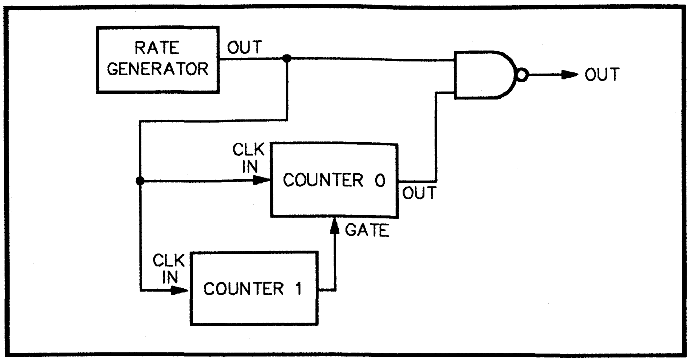


FIGURE 5-27. Generating Bursts of Pulses.

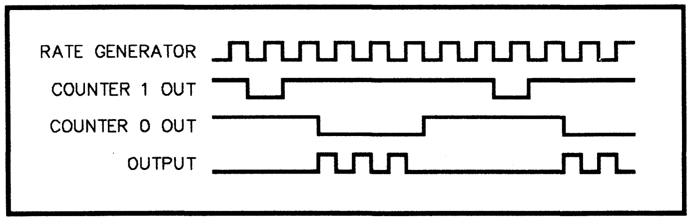


FIGURE 5-28. Timing Characteristics of the Ciruict in FIGURE 5-27.

Measuring Position with Optical Encoders

An incremental optical encoder is a transducer which converts mechanical movement to electrical signals by detecting light through windows in a rotating disk. The output of the encoder can be interpreted to give position and/or speed. Acceleration can also be obtained by taking the derivative of speed.

Incremental encoders generate two different square wave pulses which are out of phase with each other (see FIGURE 5-29). This is called a quadrature signal. By properly decoding and counting these pulses, the speed, direction of motion, and relative position of the encoder's shaft can be determined.

FIGURE 5-30 shows a circuit which provides the proper decoding to supply the correct output signals to any PCI product with two or more counters. This includes the PCI-20007M-1 module, PCI-601W/PCI-602W Micro Channel board, PCI-20098C-1 PC carrier, and the PCI-701C *NuCarrier*.

The pulses are counted by the counters (one channel for CW and one for CCW counts). The counter contents are compared against each other in software, and the relative position of the shaft is determined from the difference.

The software procedure for measuring *position* is outlined in FIGURE 5-30.

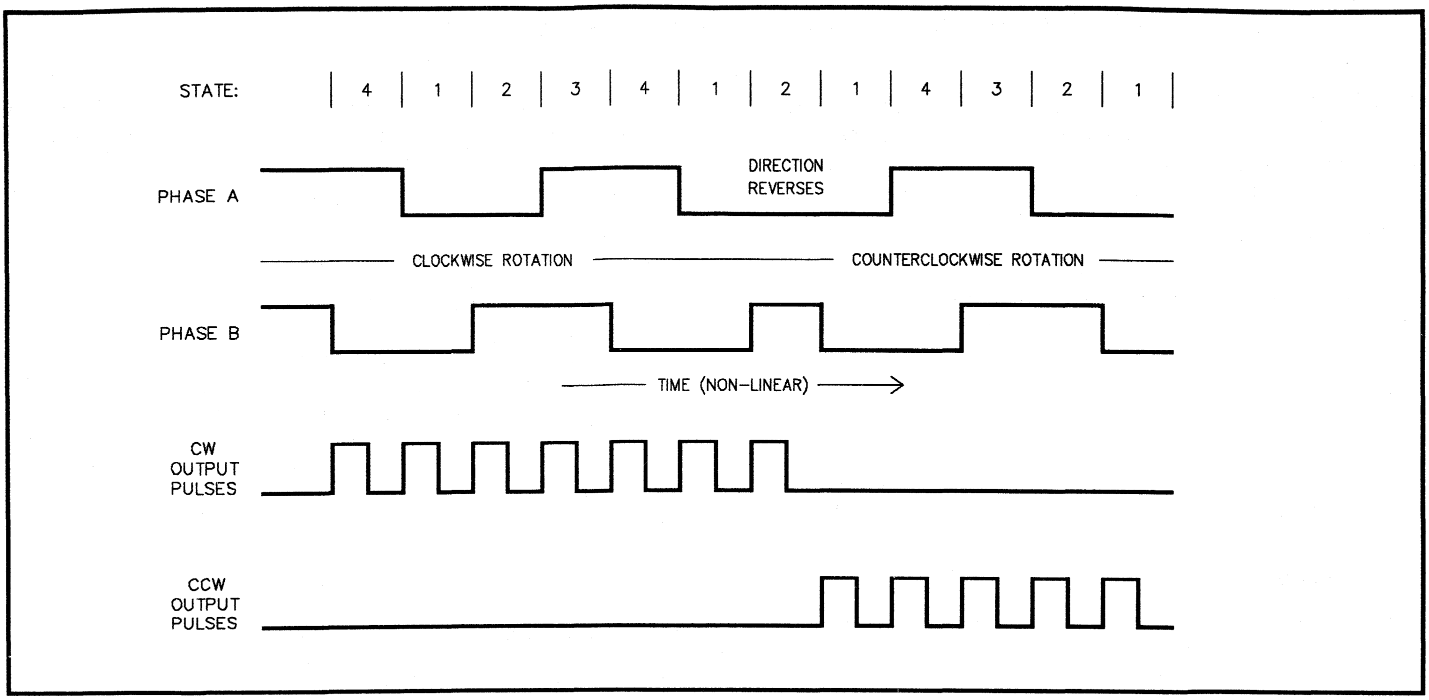


FIGURE 5-29. Quadrature Signals for a Typical Incremental Encoder.

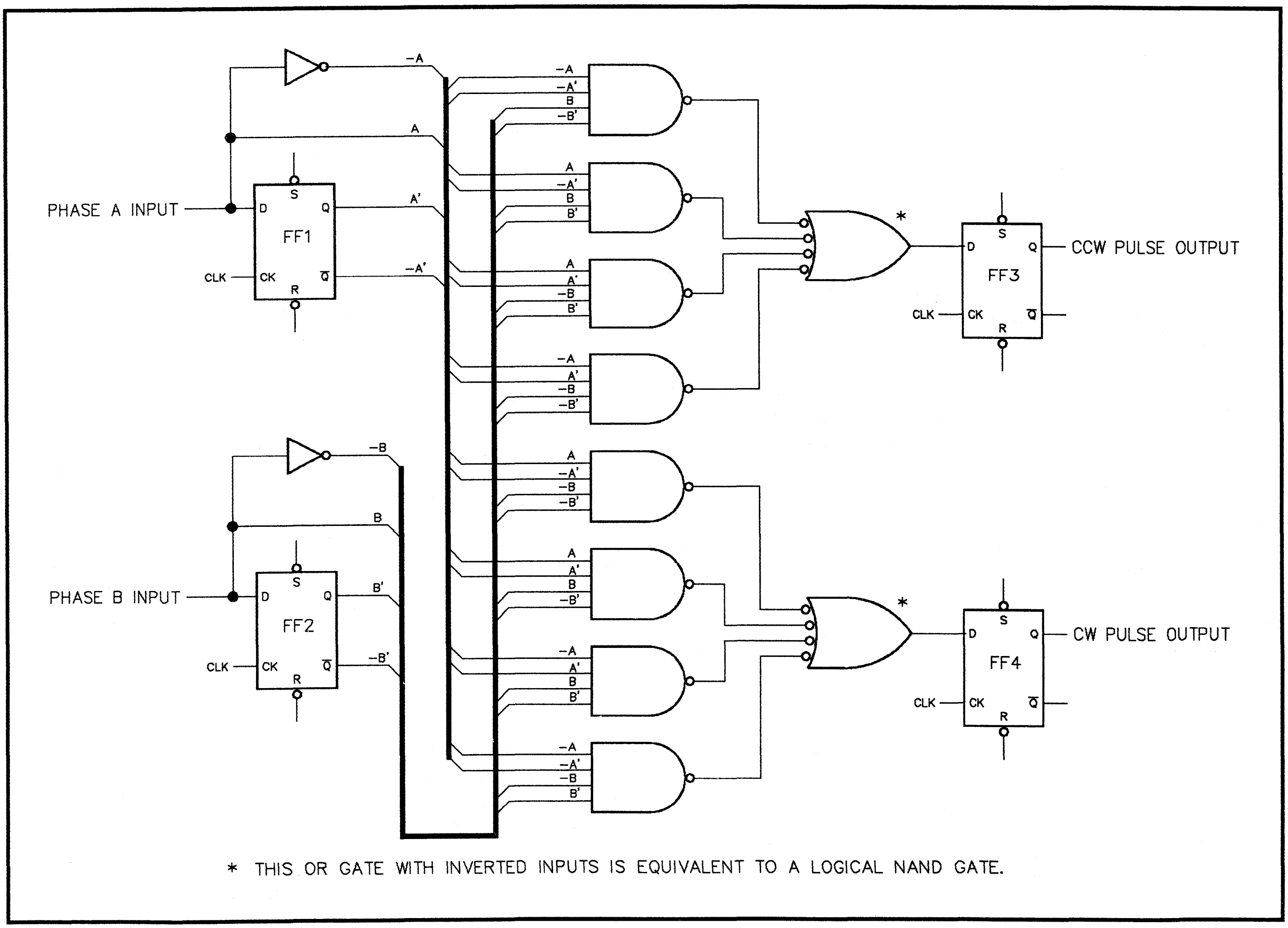


FIGURE 5-30. Decoder Circuitry for an Optical Encoder.

Stepper Motor Control Using a Personal Computer

This application note suggests how standard stepper motors can be controlled with a personal computer. The control features provided by this technique are not equal to those found in high- cost, integrated stepper motor control packages. Specifically, this technique is not applicable where micro-stepping or half-stepping are required. However, this method does provide simple, full-step control for most common types of stepper motors— at a very low cost! Programmed moves, with acceleration and deceleration ramps, are supported. This technique is especially useful where motion control is only part of a larger application requiring PC-based data acquisition.

PCI hardware and software can be very useful in this type of application. These building blocks make the integration of a practical system easy to accomplish. A demonstration system based upon the principles described below has been constructed. A description of the control circuitry and the software considerations are included.

Stepper Motor Basics

The most popular type of stepper motors have a permanent magnet rotor surrounded by four stator windings. The windings are generally connected in pairs as shown in FIGURE 5-31.

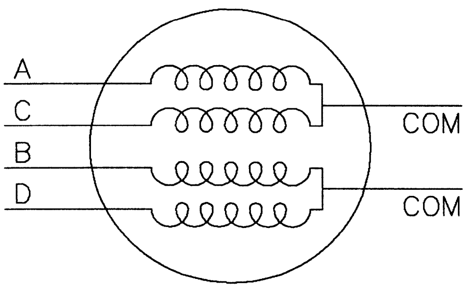


FIGURE 5-31. Typical Configuration of a Stepper Motor's Stator Windings.

Sequencing power to each of the stator windings, in proper order, will cause the rotor to rotate. The angle of rotation, per step, is a function of the motor's construction. Inexpensive motors are generally available with either 15 or 7.5 degrees of rotation per step. More expensive motors feature smaller steps (e.g., 1.8 degrees). The following table shows the required power sequencing order to each winding for proper rotation. Reversing the order will reverse the direction of rotation.

STEP #	STATOR A	STATOR B	STATOR C	STATOR D
1	ON	OFF	OFF	OFF
2	OFF	ON	OFF	OFF
3	OFF	OFF	ON	OFF
4	OFF	OFF	OFF	ON

Time

This type of motor is well suited to digital control. The common wires are connected to the positive side of the motor's power supply. To energize a particular stator, the other wire corresponding to that winding is switched to ground (the return side of the power supply).

The Motor Control Technique

A stepper motor controller consists of two major sections: the pulse sequence generator and the motor driver. In some applications, pulse sequencing can be accomplished totally in software. This is true when low step rates are needed and precise step timing is not important. In these applications a digital output port (on a PCI-20087W-1, PCI-20001C-2A, etc.) can be used to generate the required pulses. In demanding situations where high speed or accurate timing is required, the addition of hardware to augment the pulse generation process is recommended. This approach is described below. While more complex than the software, intensive method, additional hardware provides higher performance and presents less burden on the PC's processor. In either case a motor drive circuit is required. This is because typical TTL devices cannot switch the motor directly. Low cost, external switches (transistors or FETs) are used to drive the motor windings.

This system consists of:

a). PCI-20001C-2A General-purpose Carrier.
Installs in VIPc or another PC-compatible computer.
Provides 32 bits of digital I/O and accommodates up to 3 PCI Modules.

b). PCI-20007M-1 Counter/Timer/Pulse Generator Module.
Occupies 1 socket position of PCI-20001C-2A carrier.
It provides pulse generation and counting functions.

c). PCI-20025T-2 Digital Termination Panel.
Provides screw-terminals for connections and breadboard area for construction of the interface and driver circuits.

d). PCI-20036A-1 Digital I/O Cables (2 required).
These connect the Carrier's digital I/O section and the Counter Module to the termination panel.

e). Custom interface circuitry, detailed below, constructed on the PCI-20025T-2 Termination Panel.

f). A power supply capable of providing the proper voltage and current to the motor's stator windings. The demonstration model used a 12-volt, 0.5 amp supply.

The functions of the hardware items are described in the following paragraphs. FIGURE 5-32 suggests the physical configuration.

PCI-20001C-2A Digital Outputs

BIT 0: Controls the direction of motor stepping.
BIT 1: Enables/disables stepping (leaves motor energized)
BIT 2: Enables/disables the stator coil drivers. (Turns the motor on/off).

PCI-20007M-1 Counter/timer Module Rate Generator Output
Provides a pulse stream output at a programmable frequency. Each pulse output will cause the motor to step if stepping is enabled by Bit 2 above.

Counter #0
Counts the number of steps which have occurred. Allows the controlling software to track the progress of a move.

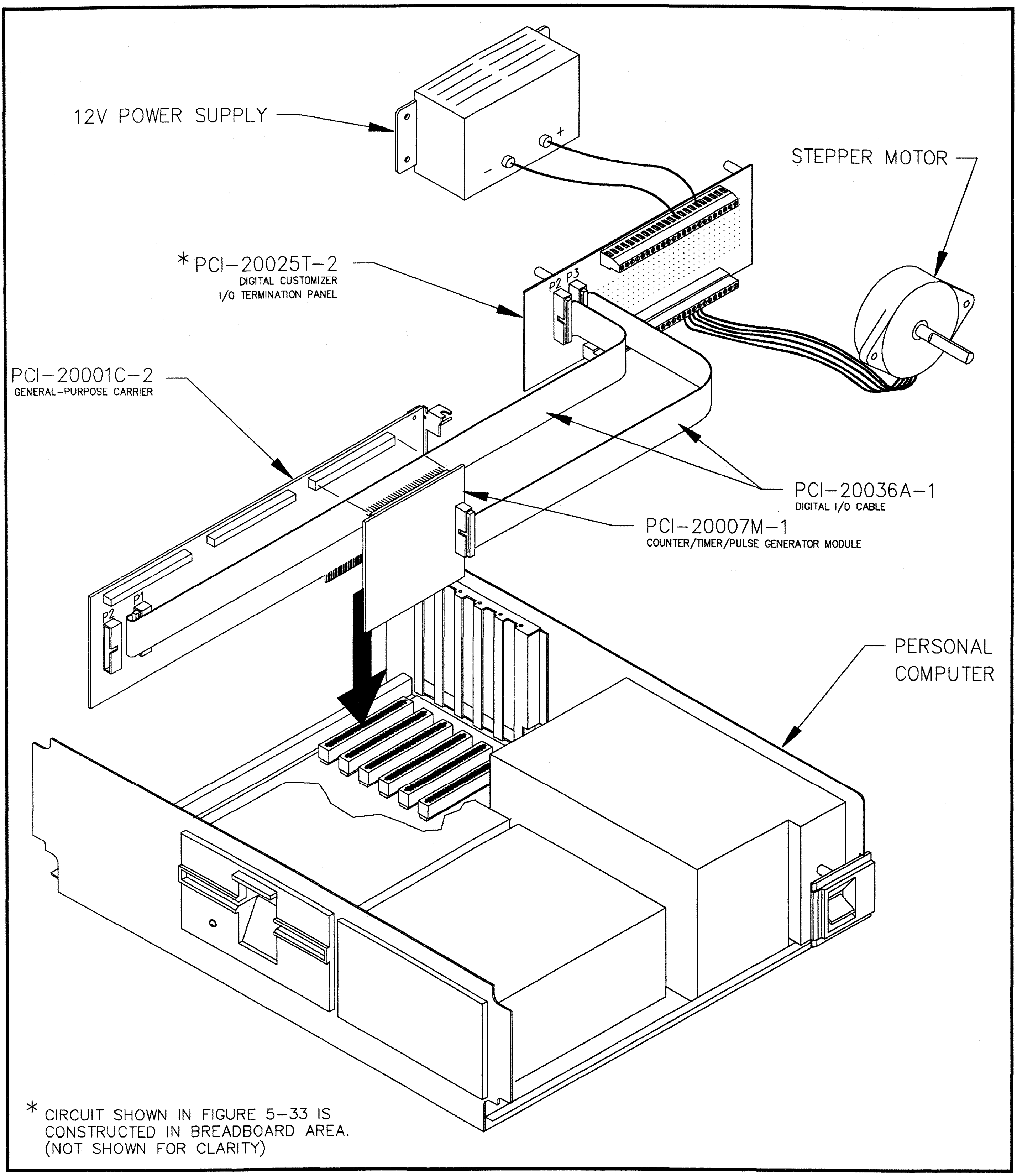


FIGURE 5-32. The Physical Configuration of the Motor Control Hardware.

The Stepper Motor Interface (Constructed On The PCI-20025T-2 Termination Panel)

Please refer to FIGURES 5-33 and 5-34 (Schematic and Timing Diagrams).

— IC1 is a binary up/down counter. Its clock input is driven by the PCI-20007M-1 Module's rate generator.

Manipulation of the direction input (up/down) controls the direction in which the motor will step.

Manipulation of the enable input will enable/disable rotation of the stepper motor by allowing/inhibiting the counting function of this IC. This counter's two least-significant outputs, Qa and Qb, are used to generate the phase state.

— IC2 is a binary 3-to-8 line decoder. It is used to translate the state of IC1's count outputs into 4 phase lines which, when properly buffered, will drive the stepper motor's stator windings.

The !G2A enable input controls whether power is delivered to the stepper motor. When this line is high, decoding is inhibited, and all outputs are forced high. This de-energizes ALL the stepper motor coils.

— Two elements of IC4 (a quad exclusive-or gate) form an edge-to-pulse converter, which will generate an output pulse each time the phase (output of IC1) changes. Its output drives the input to counter #0 of the PCI-20007M-1 Module.

— IC5, R2-5, Q1-4, and D1-4 form the driver stage. These components switch the power to the motor's stator windings, based on the outputs of IC2.

Component Selection Notes

— Transistors Q1 through Q4 must be selected on the basis of the motor drive requirements. These characteristics must be considered:

a). The V_{ceo} parameter must be sufficient to withstand the motor's power supply voltage.

b) The maximum collector current rating must be sufficient to support the motor current (consider heat sink requirements):

$$I_c\,(\text{Max}) = \frac{\text{Motor Supply Voltage}}{\text{Stator Coil Reistance}} \quad (\text{Amps})$$

c) The current gain (Beta) must be high enough to avoid drawing excess current from the outputs of the IC4 inverters. If a transistor with an adequate beta cannot be obtained, consider a Darlington arrangement or use MOSFET output devices.

2N2222 transistors were used in the prototype for a motor with a 12-volt supply and a stator coil resistance of 36 ohms.

— Diodes D1 through D4 recirculate the flyback (inductive) current generated when a stator coil is switched off. 1N4001 diodes were used in the prototype.

— Adjustment of the values of R_1 and C_1 may be necessary, especially if the circuit is implemented using a logic family other than "ls". Best results will be obtained by using the smallest delay possible while reliably generating "stepped" pulses.

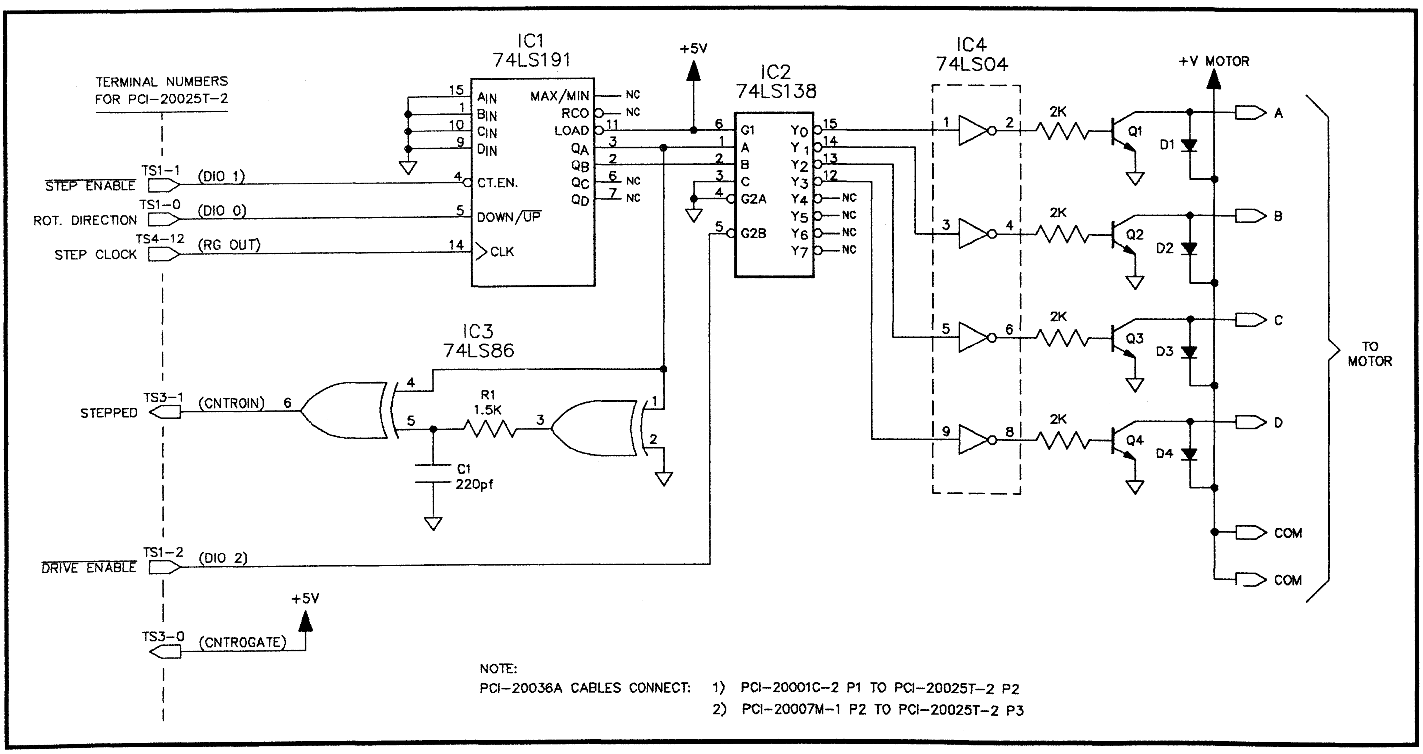


FIGURE 5-33. Schematic Diagram of the Motor Control Pulse Generator and Driver Circuit.

Software Tips

The PCI-20026S Series driver software may be used to ease the task of software development.

— Use the cnf_do (port 0) to program port 0's mode as output and to initialize these control lines to their inactive states.

— Use the cnf_rg() instruction to program the initial frequency of the rate generator to a low value (1 Hz or so).

— Use the cnf_ctr() instruction to program counter 0 to operate as a simple down-counter (mode 3), and to set its initial count to FFFF hex. The value of the count will decrease as the motor steps. Track the number of steps which have occurred by comparing the count value to the original count value.

— Use the write_ch() instruction to enable/disable the rate generator. This will cause the motor to start/stop stepping.

— Use a "poke" instruction to program the output frequency of the rate generator and, thereby, control the step rate. This technique causes the frequency of the rate generator's output to change smoothly, because it does not reinitialize the counter when the rate is changed. The output frequency of the rate generator equals 8 MHz/(n1·n2). n1 and n2 are 16-bit values and may be set by "poking" to module offsets 04 and 05, respectively. Refer to the PCI-20007M-1 User Manual for more information.

Motor Wire Identification

In practice, it is often initially unclear which stator wires correspond to an individual winding. An ohmmeter will quickly reveal which wires are the commons. Connect the common wires to the positive supply voltage. Trial and error can be used to determine the proper connection for each of the remaining four leads. When connected properly, the shaft will rotate in a uniform direction. When the coils are pulsed out of sequence, the shaft will wobble about without any clear direction.

Conclusion

Countless applications exist in which low-cost stepper motor manipulation is required, such as process control, product testing, and laboratory instrumentation. The personal computer is a natural platform for many of these tasks. Coupled with PCI hardware and software components, the PC is easily transformed into the required data acquisition and control system. This application note suggests both a simple and useful stepper motor control approach.

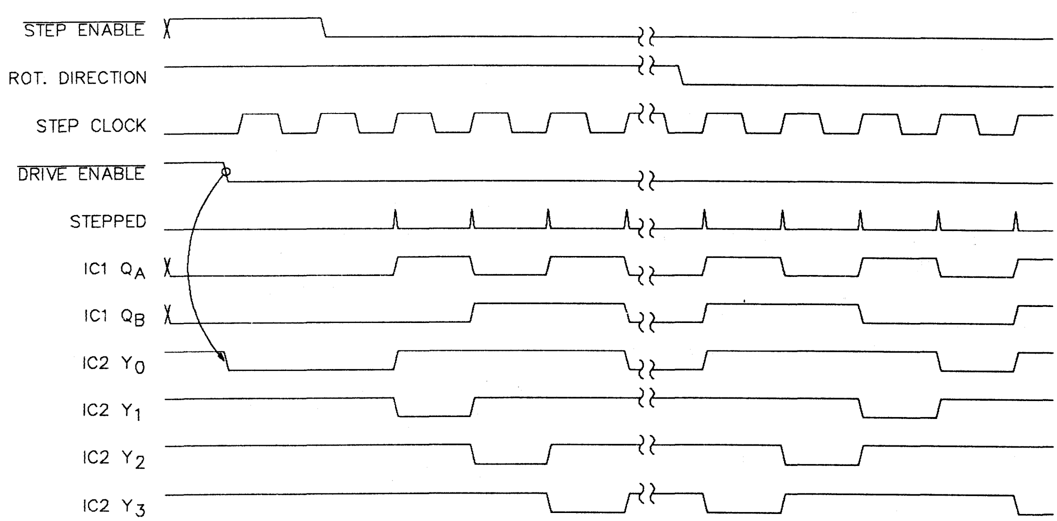


FIGURE 5-34. Motor Controller, Timing Diagram.

Synchronization and Triggering of Data Acquisition Processes

Analog signals can represent a variety of real-world conditions: pressure, flow, speed, temperature, vibration, strain, etc. Many of these signals may not be continuous or repetitive. In addition, the occurrence of transient events may not even be predictable. For example, signals can be related to fault conditions, static discharge, combinations of asynchronous events, or misuse. Therefore, recording desired information usually requires level detection and timing. In principle, the simplest way to capture a transient event is to continuously record data. At some time in the future, the data can be reviewed for evidence of an event. However, this approach can require very large amounts of memory and extensive analysis to find the unique (desired) data. Generally, it is more efficient to utilize a system that can automatically detect and record the desired event. This Application Note describes several techniques that can be used with PCI products for capturing transient events. These include polling, interrupts, hardware gating of the pacing signal, hardware inhibit, and direct memory access (DMA) methods.

Definition of Terms

Normally it is desired to sample a given input signal at regular intervals. Timing is regulated with what is usually called a pacer signal, pacer clock, or just *pacer*. The pacer may come from one of several places: the computer's clock, an internal rate/burst generator, or from an external source. The pacing signal can be monitored by software, used directly by the acquisition hardware, or used to activate the DMA controller (if DMA is used).

An event which causes a data acquisition process to start, stop, or change the test parameters is called a *trigger*. Trigger sources can include a keypress, an input voltage reaching a predefined level, or an external digital event. When the data acquisition system is set up (armed) and waiting for a trigger, it is said to be *enabled*.

Often the event which causes a trigger is defined by a signal reaching a threshold. Imagine an application which requires an oven to be controlled at a certain temperature. The power to the heater could be disconnected when the desired temperature is reached. An *analog trigger* is established when the input signal matches a predefined level criteria. This can be accomplished in software by reading an input channel and then comparing it to a predefined level. However, *software triggering* on an analog signal is usually only effective at low sampling rates. The delay caused by the software manipulations required to make the trigger decision limits its usefulness at speeds above approximately 100Hz.

Hardware triggering is recommended above 100Hz. Hardware triggering techniques include gating the pacer, inhibiting conversion, interrupts, and DMA. The PCI-20020M-1 Trigger/Alarm Module is an analog input device that provides both pacer gating and digital trigger output capabilities. It can be programmed to generate a trigger if the input signal goes above a limit, below a limit, inside a window, or outside a window. All limits are software programmable. A trigger can be derived from one of the signals being recorded, or it can be a separate signal. A digital signal can also be used as a hardware trigger. *Digital triggers* are those that are generated by discrete events. Examples of a digital trigger could include a switch being closed or a widget on a conveyer belt passing a given point.

Be careful not to be confused here. Many of the sources of pacing signals could also be the source of triggering signals in other applications. The widget which generated a trigger in the previous example could as easily have generated the pacing signal, depending on the data one wishes to collect.

How does the computer detect the occurrence of a trigger? One of the simplest ways is *polling*. With this method the software continuously tests for a change-of-state in a program loop. When the program detects a given condition, the loop is exited and the acquisition process is begun. While polling requires no special hardware, it can't respond as fast as most hardware-based methods.

Interrupts can provide unique capabilities in systems with involved task scheduling. However, they are often complex to program and yield the slowest triggering response. It should be noted that fast response to a trigger is not always required. Interrupts have the ability to provide data acquisition and control as a background task, allowing other processes to run in the foreground. This feature may outweigh the faster response of other methods. More information on interrupts can be found elsewhere in this handbook.

Using Pacing Signals

Before continuing with the discussion of triggering methods, the use of the pacing signal must be understood. In most digital input or counter/timer applications the pacer is polled for a transition, and then the channel is read. This software intensive method can also be used for slow analog inputs. Because of the time required to convert an analog signal to digital, high-speed analog sampling uses another strategy. In this case, the pacing signal is used to start the A/D conversion process directly. The processor polls the end-of-convert (EOC) signal from the A/D converter. This speeds up the process by reducing software overhead. To make the system as fast as possible, the software remains in a tight loop until the EOC occurs. This fact makes it impossible to perform any software functions after the acquisition has started. Therefore, any triggering or synchronization operation must be totally hardware controlled.

Whether the pacer or the EOC is polled, the pacing signal may also be used to sequence the multiplexer to the next channel. It is important to remember that the system will be consumed (unavailable to process other functions) until the acquisition run is completed. If the pacer signal does not arrive, the computer will appear locked-up.

Triggering can be accomplished by gating the pacing signal before it reaches the acquisition circuit, an approach which is effective for either the polled-pacer or DMA methods. As mentioned above, gating of the pacing signal is easily done with the PCI-20020M-1 Trigger/Alarm Module. In the latched mode a single trigger, satisfying the programmed criteria, gates the pacer through to the acquisition circuit. In the unlatched mode the pacing signal is turned on and off in synchronization with the input signal satisfying the programmed criteria.

The Trigger/Alarm Module

A standard technique for capturing transient events is to also connect the signal which is to be sampled to the input of the Trigger/Alarm Module. In the context of an oscilloscope, this is known as internal triggering. The module is programmed to trigger when the signal satisfies the desired conditions, starting the acquisition. This occurs with little delay since it all happens in hardware. The pacer signal is routed through the module's gating circuitry via the I^3 bus.

Some data acquisition products allow direct gating of the pacing signal without the need for a PCI-20020M-1 Module. However, this feature supports only digital triggering. An enable/disable input is provided on the PCI-20019M-1, PCI-20023M-1, and PCI-20091W-1 analog input products. When this line is held low, all start-convert and hardware channel sequencing functions are inhibited. Therefore, even if the pacer is active, this line can be used as a trigger. The operator must insure that the enable pin is held low until after the software has enabled the system to collect proper data.

The Counter/Timer Module

When the PCI-20007M-1 Counter/Timer Module is used as the pacer it can be externally triggered. Holding the module's gate low inhibits the rate generator output. Again, the trigger must not occur prior to the system being enabled. (The rate generator on the PCI-20041C Series Carriers do not have this external gate capability).

The DMA Mode

In the DMA mode several unique triggering options are available. DMA normally requires a hardware trigger. This is apparent when one realizes that DMA is executed totally in hardware with no software intervention. Software is used to program, enable, and stop the process. A trigger input is provided to the DMA circuit which can start or stop the process under hardware control. This function can also have a programmable delay. Triggers that are connected to the DMA trigger input are not polled but take action through hardware, thus they are fast-acting. The system can also be programmed to poll for a trigger condition and, when it occurs, enable the DMA process in a mode that requires no hardware trigger. The reaction time of this arrangement will be relatively long.

Data can also be captured in a *circular buffer* in the DMA mode. This technique uses a storage space that can be described as having its end tied back to the beginning (a circle). When the buffer is filled, the next data point overwrites the first (oldest) point. Therefore, the buffer always contains the "n" most recent set of data points. The size of the buffer, "n", is user-definable. In contrast to program control, the DMA mode allows data collection to be started before the trigger. The trigger can be programmed to stop the DMA process with control over *delay*. Delay pertains to the number of samples to record AFTER the trigger occurs. Using delay, it is easy to capture both pre- and post-trigger data. This is ideal for fault detection and analysis.

The Possibility of Channel Rotation

If a start-convert input is received before the system is ready to read data from the A/D converter, a condition known as channel rotation can occur. Analog channels are collected in the correct order, but the first data point does not correspond to the first channel. For example, assuming that the channel list includes

0, 1, 2, 3, 0, 1, 2, 3 ...etc., the returned data might correspond to channels
2, 3, 0, 1, 2, 3, 0, 1 ...etc.

The pacer has caused the multiplexer to step to the next channel before the current conversion was read. This fault requires a set of conditions to be satisfied:

— More than one analog channel is being acquired

— Automatic channel sequencing is being used under pacer control (e.g., high-speed mode 4 or DMA)

— Either no trigger is being used, or the trigger occurs prior to the system being enabled.

Solutions to this problem include slowing down the pacer (reducing the acquisition rate) or using a trigger to stop channel sequencing even though pacing pulses are being generated. Reducing the sample rate to prevent channel rotation is often unacceptable. Under these conditions, some kind of triggering is required. The trigger must not take place until the system is enabled to prevent channel rotation.

In some applications it may be possible to determine the correct order of the data in software (after the acquisition). This is only possible if at least one channel's data can be identified by content (the other data points will follow in order). For example, an extra input channel can be connected to a known voltage (outside the normal data range) to act as a channel position flag.

This application note has discussed the basic techniques for synchronizing data acquisition with events external to the computer. Synchronization is required to insure capture of the desired data. Combinations of techniques are possible and may be required in some situations.

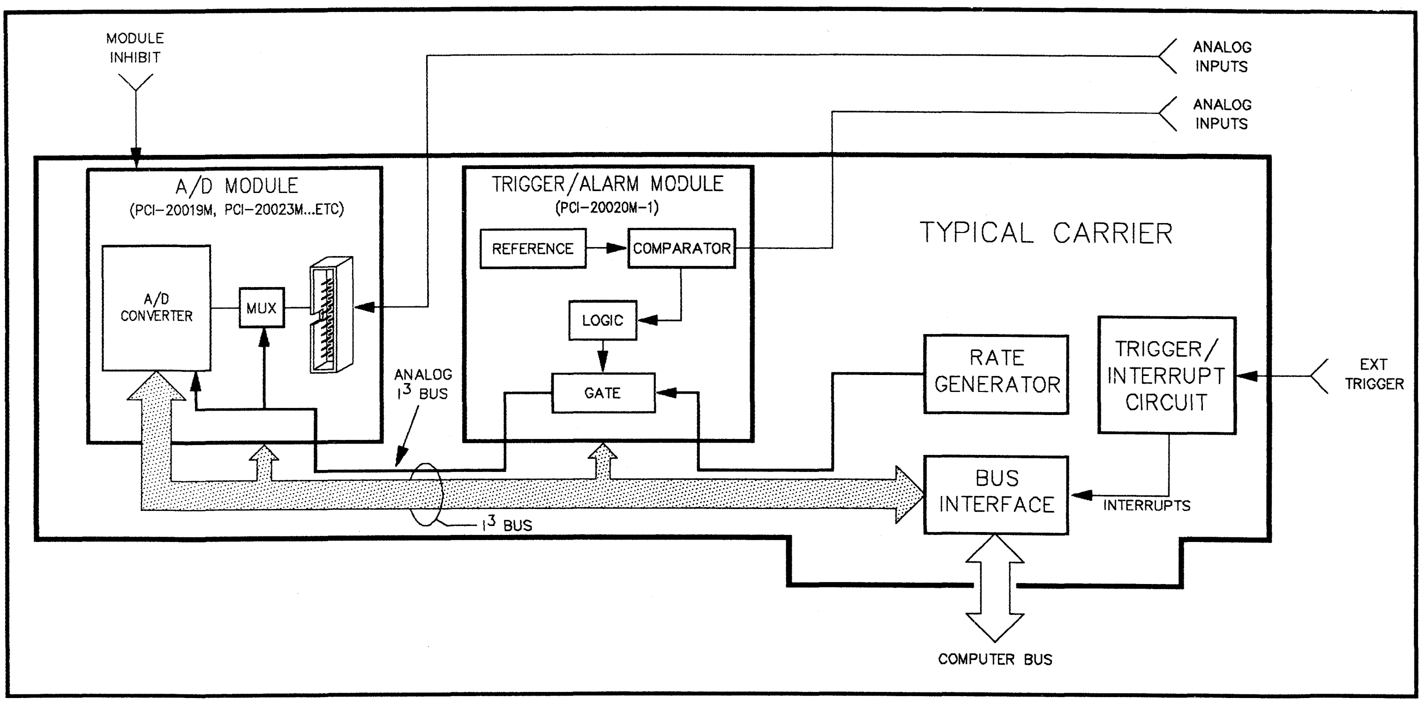


FIGURE 5-35. The Pacing Signal Can Be Routed Through the Trigger/Alarm Module to Provide Synchronization/Trigger With An Analog Input Signal.

Integrating VIPc with a PCI-2500-1 Microterminal

Abstract

Burr-Brown's PC-based VIPc is an ideal platform for developing and fabricating instrumentation type products. Its internal card cage and customizable panels make it perfect for a wide range of portable, table-top, rack-mountable, and wall-mount applications. In these environments it is often desirable to replace the conventional PC-style keyboard and monitor with a compact "terminal". This is true not only in portable products but wherever a rugged and simplified user interface is desired. The Burr-Brown PCI-2500-1 Microterminal combines a keypad and back-lit function keys in a sealed keyboard with an easy-to-read, single-line 16-character LCD display. This note describes how to combine the PCI-2500-1 with VIPc.

Contents:

Front-Panel Mounting

The PCI-2500-1 may be easily recess-mounted on VIPc's front panel. We recommend that you use the PCI-5023A-1 mounting kit that was shipped with the Microterminal. This kit includes a pre-cut VIPc faceplate, mounting hardware, and cable assembly. Apply the adhesive-backed gasket ring (supplied with the PCI-2500-1) to the front of the Microterminal, around the outside of the raised rib. Install the Microterminal to the faceplate from the rear of the faceplate, using the standoffs, screws, and washers supplied with the faceplate. Excess adhesive-backed gasket material may be cut and used to protect the rear of the Microterminal from the washers, as well as providing a snug fit at the standoffs.

Mount the faceplate onto the front panel of VIPc using three screws at each side of the plate, and one each at the top and bottom center.

Note that the cutout in the PCI-5023A-1 faceplate is offset towards the top right corner. This leaves space for connectors or other devices to be mounted below or to the left of the PCI-2500-1. If you wish to make your own cutout, in the standard faceplate included with VIPc, please refer to the instructions provided with the PCI-2500-1.

Wiring— PCI-2500-1 Signals and Power

RS-232 signals to and from the PCI-2500-1 are routed through a female 9-pin D-subminiature connector on the rear of the Microterminal.

When the PCI-2500-1 is mounted on the front panel of the VIPc, +5V DC power may be routed through the same connector used for RS-232 communications.

Pins on D-subminiature connections are generally numbered. Below are the pin assignments at the host-communications connector on the PCI-2500-1:

Pin	Function	Direction
1	Power Ground (-)	
2	TX DATA	out
3	RX DATA	in
4	no connection	
5	CTS	in
6	DTR	out
7	Signal Ground	
8	Tie to Pin 9 for +5VDC Power	
9	Power Input (+)	

Wiring— VIPc Signals

RS-232 signals to and from VIPc are connected to the motherboard at a 10-pin header-- either J19 (COM1) or J20 (COM2). Ordinarily J19 and J20 are connected to 9-pin D-subminiature connectors externally accessible on the rear panel of VIPc. However, if the PCI-2500-1 is mounted on the front panel, a direct internal connection to J19 (or J20) is desirable. Prepare a 10-pin insulation-displacement connector (IDC) with a ribbon cable to make this connection.

9	7	5	3	1
10	8	6	4	2

The pins on J19 and J20 follow the pattern shown below. Pin 1 on the connector is labeled on the motherboard for orientation purposes.

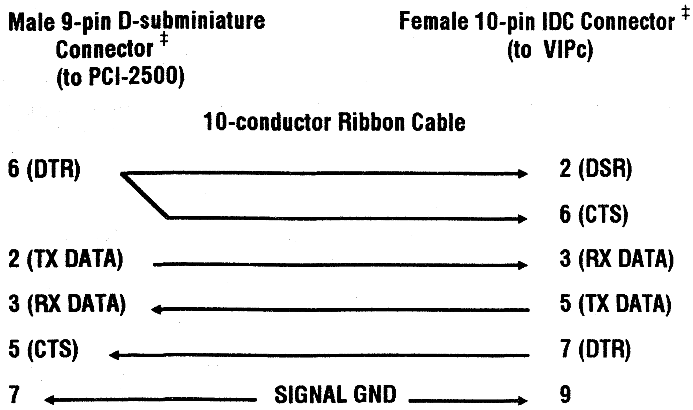
Pin assignments at J19 (or J20) on the VIPc motherboard are as follows:

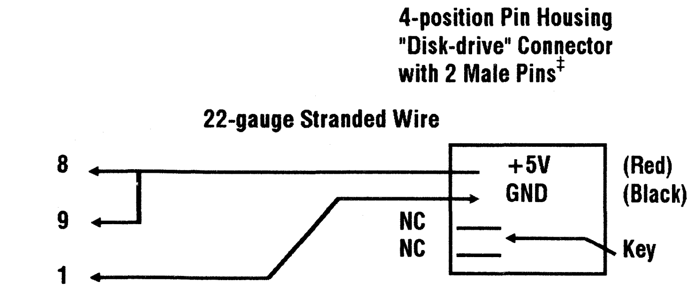
Pin	Signal	Direction
1	DCD	in
2	DSR	in
3	RX DATA	in
4	RTS	out
5	TX DATA	out
6	CTS	in
7	DTR	out
8	RI	in
9	Signal Ground	
10	No connection	

Comparing the RS-232 signals at the VIPc COM-ports with the RS-232 signals at the host-communications connector on the PCI-2500-1 shows that a "null-modem" type of cable connection, between the two, is required.

Wiring— Front-Panel Cable Assembly

The following cable assembly may be wired for use with the front-panel-mounted installation. Both the ribbon cable and the power cable in the assembly should be approximately 22" in length. Pins not listed are not connected.





‡ Representative connectors:
Male 9-pin D-subminiature: Amphenol 117DE09P
10-pin IDC Connector: Berg 66902-310
"Disk-drive" Connector: Amp Pin Housing (Cap) #1-480426-0
Amp Pins #60620-1

Plug the 9-pin D-subminiature connector into the host-communications connector at the rear of the PCI-2500. Plug the 10-pin IDC connector into either J19 (COM1) or J20 (COM2) on the VIPc motherboard. Disconnect the internal COM-port cable, if necessary. Make sure that pin 1 on the 10-pin IDC connector mates with pin 1 on the J19 (J20) header on the motherboard.

Plug the "disk-drive" connector into one of the unused disk-drive power connectors in the VIPc.

Communications— PCI-2500-1 Setup

Turn on the power to VIPc power is being used). Following the instructions in the Microterminal's User's Guide, place the PCI-2500-1 in the setup mode. Complete the setup as shown below. Be sure to save this setup and use it to verify basic operations with VIPc. Later, you may find that other setup options are more appropriate in a specific application.

VW	Viewing Angle:	4	
TM	Terminal Mode:	1	(block mode)
MA	Multidrop Address:	00	
TD	Turnaround Delay:	0	(mSec)
BR	Baud Rate:	2	(9600)
DF	Data Format:	4	(8 bits no parity)
HS	Handshaking:	1	(DTR asserted/CTS control)
(LE	Local Echo:		not applicable in block mode)
EN	Enter/line terminator:	3	(CRLF)
KC	Key Click:	1	(on)
KR	Key Repeat:	1	(on)
CU	Cursor:	2	(flashing block)

Communications— VIPc Setup

Following the instructions in the VIPc Handbook, enter the Setup Screen on VIPc, and make sure that the appropriate communications port (COM1 or COM2) is enabled (this depends upon which connector you are using: J19 = COM1, J20 = COM2).

After you have saved the setup and returned to DOS, activate the appropriate COM port with one of the following commands:

MODE COM1:9600,N,8,1
or
MODE COM2:9600,N,8,1

Communications— Testing

You are now ready for the PCI-2500-1 and VIPc to communicate with each other. We will assume in all of the subsequent examples that the PCI-2500 is connected to J19 (COM1) on the VIPc mother board. If you are using J20 (COM2), change COM1 to COM2 as appropriate.

Type the following command on the VIPc keyboard:

ECHO HELLO PCI-2500 > COM1

You should see the words HELLO PCI-2500 on the PCI-2500-1 display. If not, check the connections and your wiring, and the PCI-2500-1 setup choices. When you see the correct response, you are ready for the next step.

Now that you know the VIPc is communicating with the PCI-2500-1, you will want to determine that the PCI-2500-1 can communicate with the VIPc. Since the PCI-2500-1 has only a numeric keypad and function keys (which have the letters A through F assigned to them), it will be necessary to create a batch file on the VIPc with a name composed of characters available on the PCI-2500-1. If you name the batch file "1234.BAT", for instance, you can run the batch file by sending "1234" from the PCI-2500-1.

Create a batch file on the VIPc by typing the following:

COPY CON 1234.BAT
PAUSE
CTTY CON

then press the <F6> function key and the <ENTER> key to save the batch file to disk. The batch file will consist of the second and third lines above, which will send a message through the COM1 port to the PCI-2500-1 and then wait for a response from the PCI-2500-1. Pressing a key on the PCI-2500-1 will then return control to the VIPc console (keyboard and monitor).

Type the following command on the VIPc keyboard, to cause VIPc to communicate with the PCI-2500-1 (instead of with the keyboard and monitor):

CTTY COM1

You should now see the DOS prompt (such as "C>") on the PCI-2500-1 display.

Type the following command on the PCI-2500-1 keys:

1234

and then press the <ENTER> key on the PCI-2500-1. As the "1234.BAT" file runs, you should see the message EN READY... appear on the display. You can use the "<" (left arrow) key on the PCI-2500-1 to scroll the remainder of the message STRIKE ANY KEY WHEN READY... into view.

Now press the <ENTER> key on the PCI-2500-1. You should see the DOS prompt followed by CTTY CON on the PCI-2500-1 display, and the DOS prompt should reappear on the VIPc monitor. If the batch file does not run as expected, the VIPc system will probably have to be reset in order to start over.

When the above series of tests are successful, you are ready to disconnect the VIPc keyboard and monitor (if desired) and to exercise the PCI-2500-1 in your final application. If VIPc is to be operated without an external keyboard, be sure to select the keyboard "NOT INSTALLED" option on the VIPc Setup Screen.

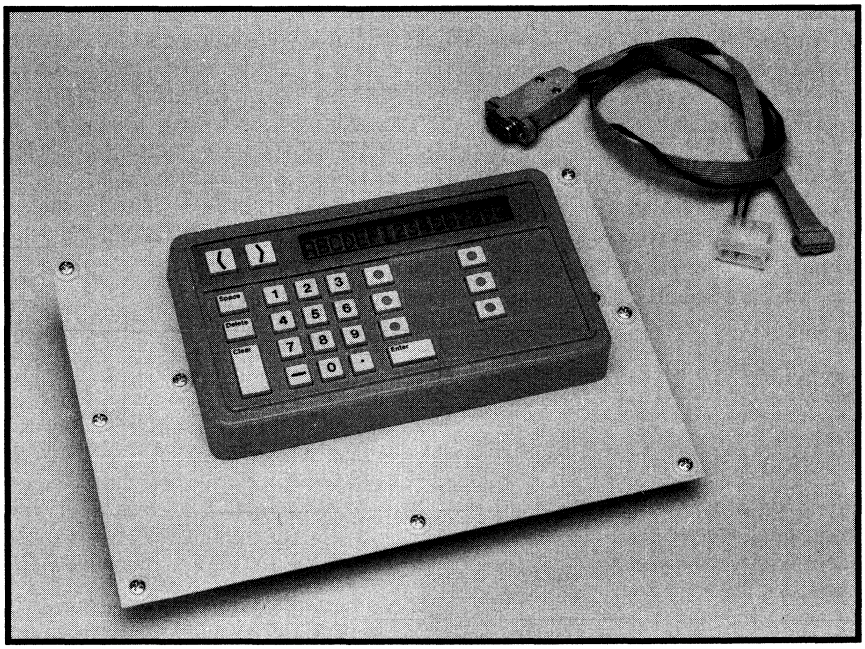
About the PCI-2500-1

The PCI-2500-1 is a compact, rugged, industrial data entry and display terminal. It is intended for use as an operator panel or as a service/setup panel in microprocessor based equipment. The PCI-2500-1 has an RS-232-C communications interface. PCI-2500-1 is functionally the same as the Burr-Brown TM2500-DC.

The unit offers a large, 16-character liquid crystal display. The viewing angle may be operator adjusted electronically. The sealed keyboard consists of 24 keys, including a numeric keypad and six back-lit function keys. The unit includes an audible tone generator which may be used to provide a key "click", and may be controlled by the host.

The PCI-2500-1 offers two operating modes: character mode and block mode. In character mode, characters are transmitted as a key is depressed. In block mode, output messages are transmitted as a whole when the "ENTER" key is pressed. The specific mode demonstrated here for test purposes is the block mode.

Operating parameters, which can be selected, are viewing angle, mode, turnaround delay, baud rate, data format, handshaking, local echo, terminators, key click, key repeat, and cursor type. These selections are made during SETUP through the keyboard. Most can be controlled by downline host commands as well.



PCI-2500-1 Microterminal with Mounting Kit Components.

Integrating VIPc with a PCI-8500-1 Microterminal

Abstract

Burr-Brown's PC-based VIPc is an ideal platform for developing and fabricating instrumentation type products. Its internal card cage and customizable panels make it perfect for a wide range of portable, table-top, rack-mountable, and wall-mount applications. In these environments it is often desirable to replace the conventional PC-style keyboard and monitor with a compact "terminal". This is true not only in portable products but wherever a rugged and simplified user interface is desired. The Burr-Brown PCI-8500-1 Microterminal combines a full-featured sealed keyboard with an easy-to-read, two-line 40-character LCD display. This note describes how to combine the PCI-8500-1 with VIPc.

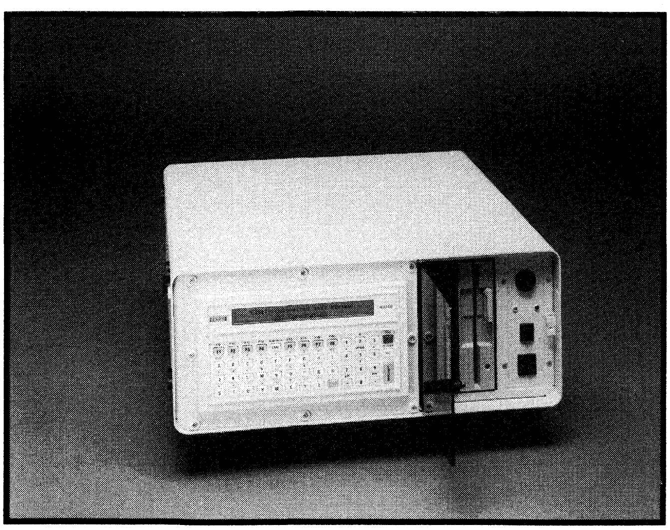
Contents:

PCI-8500-1 Preparation

Following the instructions in the Microterminal's User's Guide, select the RS-232 communications interface and install any option modules.

Front-Panel Mounting

The PCI-8500-1 may be easily recess-mounted on VIPc's front panel. We recommend that you use the PCI-5022A-1 mounting kit that was shipped with the Microterminal. This kit includes a pre-cut VIPc faceplate, mounting hardware, and cable assembly. First, mount the faceplate onto the front panel of VIPc using four screws in the corners of the plate and one at the bottom center. Second, install the PCI-8500-1 from the front side of the faceplate, using the supplied spring clips and screws. Offset the spring clips (one of them towards the top of the panel and the other towards the bottom), and secure them with one screw each.



PCI-8500-1 Installed on VIPc.

Note that the cutout in the faceplate is offset towards the top. This leaves space for connectors or other devices to be mounted below the PCI-8500. If you wish to make your own cutout in the standard faceplate included with VIPc, please refer to the instructions provided with the PCI-8500.

Wiring— PCI-8500-1 Signals and Power

RS-232 signals to and from the PCI-8500-1 are routed through a female 25-pin D-subminiature connector on the rear of the Microterminal.

When the PCI-8500-1 is mounted on the front panel of the VIPc, +5V DC power may be routed through the same connector used for RS-232 communications.

Pins on D-subminiature connections are generally numbered. Below are the pin assignments at the host-communications connector on the PCI-8500-1 (pins not listed are not connected):

Pin	Function	Direction
1	Ground	
2	TX Data	out
3	RX Data	in
4	RTS	out
5	CTS	in
7	Signal Ground	
10	Beeper	out
14	+5V DC	in
15	Power Input	
20	DTR	out

Wiring— VIPc Signals

RS-232 signals to and from VIPc are connected to the motherboard at a 10-pin header-- either J19 (COM1) or J20 (COM2). Ordinarily J19 and J20 are connected to 9-pin D-subminiature connectors externally accessible on the rear panel of VIPc. However, when the PCI-8500-1 is mounted on VIPc's front panel, a direct internal connection to J19 (or J20) is desirable. Prepare a 10-pin insulation-displacement connector (IDC) with a ribbon cable to make this connection.

The pins on J19 and J20 follow the pattern shown below. Pin 1 on the connector is labeled on the motherboard for orientation purposes.

9	7	5	3	1
10	8	6	4	2

Pin assignments at J19 (or J20) on the VIPc motherboard are:

Pin	Signal	Direction
1	DCD	in
2	DSR	in
3	RX DATA	in
4	RTS	out
5	TX DATA	out
6	CTS	in
7	DTR	out
8	RI	in
9	Signal Ground	
10	No Connection	

Comparing the RS-232 signals at the VIPc COM-ports with the RS-232 signals at the host-communications connector on the PCI-8500-1 shows that a "null-modem" type of cable connection, between the two, is required.

Wiring— Front-Panel Cable Assembly

The following cable assembly may be wired for use with the front-panel-mounted installation. Both the ribbon cable and the power cable in the assembly should be approximately 22" in length. Pins not listed are not connected.

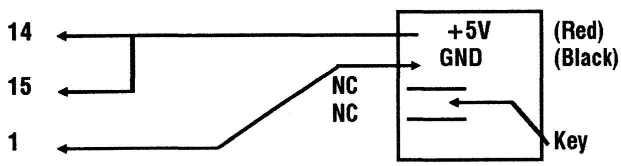
Male 25-pin D-subminiature Connector ‡ (to PCI-8500) — **Female 10-pin IDC Connector‡ (to VIPc)**

10-conductor Ribbon Cable

Male 25-pin (to PCI-8500)		Female 10-pin (to VIPc)
20 (DTR)	→	2 (DSR)
20 (DTR)	→	6 (CTS)
2 (TX DATA)	→	3 (RX DATA)
3 (RX DATA)	←	5 (TX DATA)
5 (CTS)	←	7 (DTR)
7	← SIGNAL GND →	9

4-position Pin Housing "Disk-drive" Connector with 2 Male Pins‡

22-gauge Stranded Wire



‡ Representative connectors:

Male 25-pin D-subminiature:	Amphenol 117DB25P
10-pin IDC Connector:	Berg 66902-310
"Disk-drive" Connector:	Amp Pin Housing (Cap) #1-480426-0 Amp Pins #60620-1

Plug the 25-pin D-subminiature connector into the host-communications connector at the rear of the PCI-8500-1. Plug the 10-pin IDC connector into either J19 (COM1) or J20 (COM2) on the VIPc motherboard. Disconnect the internal COM-port cable, if necessary. Make sure that pin 1 on the 10-pin IDC connector mates with pin 1 on the J19 (J20) header on the motherboard.

Plug the "disk-drive" connector into one of the unused disk-drive power connectors in the VIPc.

Communications— PCI-8500-1 Setup

Turn on the power to VIPc (and to the PCI-8500-1 if external power is being used). Following the instructions in the Microterminal's User's Guide, place the PCI-8500-1 in the setup mode. Complete the setup as shown below. Be sure to save this setup and use it to verify basic operations with VIPc. Later, you may find that other setup options are more appropriate in a specific application.

Setup:	English
Terminal Mode:	Character
Baud Rate:	9600
Data Format:	8 bits no parity
Line Terminator:	CR
Handshaking:	Modem Control
Backlight:	On
Auto Wrap:	On
Newline:	No
Display Width:	40
Local Echo:	Off
Key Repeat:	Off
Key Click:	On
Peripheral mode:	Off
Symbology:	(don't care)

Communications— VIPc Setup

Following the instructions in the VIPc Handbook, enter the Setup Screen on VIPc, and make sure that the appropriate communications port (COM1 or COM2) is enabled (this depends upon which connector you are using: J19 = COM1, J20 = COM2).

After you have saved the setup and returned to DOS, activate the appropriate COM port with one of the following commands:

MODE COM1:9600,N,8,1
or
MODE COM2:9600,N,8,1

Communications— Testing

You are now ready for the PCI-8500-1 and VIPc to communicate with each other. We will assume in all of the subsequent examples that the PCI-8500-1 is connected to J19 (COM1) on the VIPc mother board. If you are using J20 (COM2), change COM1 to COM2 as appropriate.

Type the following command on the VIPc keyboard:

ECHO HELLO PCI-8500> COM1

You should see the words HELLO PCI-8500 on the PCI-8500-1 display. If not, check the connections and your wiring and the PCI-8500-1 setup choices. When you see the correct response, you are ready for the next step.

Type the following command on the VIPc keyboard, to cause VIPc to communicate exclusively with the PCI-8500-1 (instead of with the keyboard and monitor):

CTTY COM1

You should now see the DOS prompt (such as "C>") on the PCI-8500-1 display.

Type the following command on the PCI-8500-1 keys:

DIR

and then press the <ENTER> key. You should see the disk directory scroll by, followed by the DOS prompt again.

Now type the following command on the PCI-8500-1 keys:

CTTY CON

and control should be returned to the CONsole (the VIPc keyboard and monitor).

When the above series of tests are successful, you are ready to disconnect the VIPc keyboard and monitor (if desired) and to exercise the PCI-8500-1 in your final application. If VIPc is to be operated without an external keyboard, be sure to select the keyboard "NOT INSTALLED" option on the VIPc Setup Screen.

About the PCI-8500-1

The PCI-8500-1 is a compact data entry/display terminal with the versatility to meet the varied needs of industrial data collection. It may be used in applications requiring simple keyboard entry or those requiring a complex, multifunction workstation. PCI-8500-1 is functionally the same as the Burr-Brown TM8500-100.

As with any computer terminal, the primary function of the PCI-8500 is to interface a human operator with a computer system. The base unit of the terminal contains the display, keyboard, and terminal electronics.

The PCI-8500-1's liquid crystal display can show two lines of 40 characters. For ease of viewing in low-light areas, the display is illuminated with a soft, blue electroluminescent backlight which may be controlled either from the keyboard or from the host computer. Display attributes include protected line and character flashing. Contrast and viewing angle are electronically adjustable from the keyboard.

The keyboard of the PCI-8500-1 contains 51 key locations and is capable of entering the entire ASCII character set. The unique design of this keyboard features plastic keycaps retained in a removable bezel over a sealed elastomer (silicon rubber) base. The logical layout of the keyboard is totally definable by the application programmer. The removable bezel allows keys to be physically rearranged in any sequence.

To provide audible feedback to the operator, the PCI-8500-1 features a two-tone beeper. In extremely noisy environments, an external annunciator can be triggered by a special digital output signal from the terminal which is activated whenever the beeper sounds.

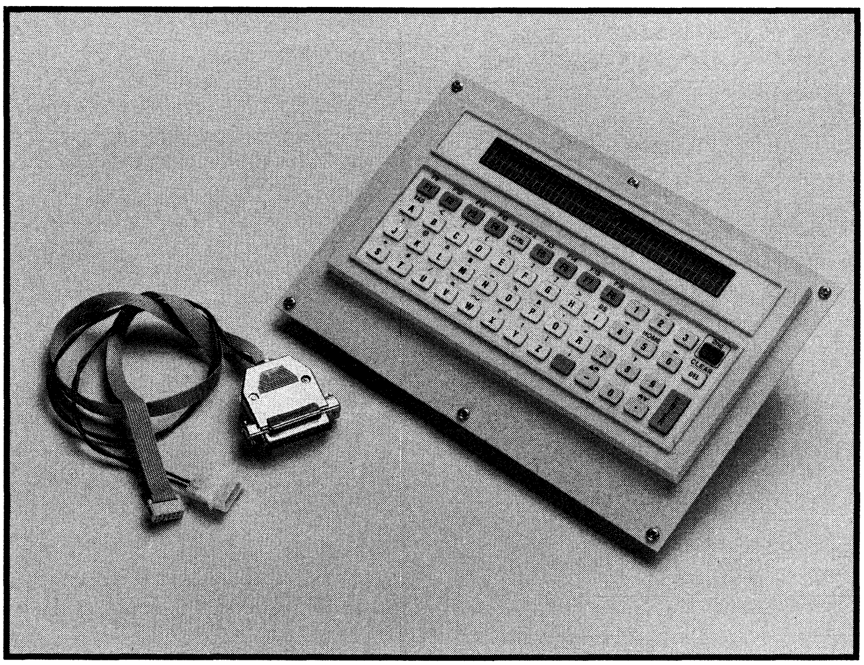
The PCI-8500-1 features a choice of three Operating Modes. The operating mode selected depends on the application and host computer software. The operating mode is selected in SETUP.

Monitor Mode allows the PCI-8500-1 to serve as a monitor on the host serial line for troubleshooting communications.

In the Character Mode, input and output to the terminal is character oriented; characters are transmitted as soon as a key is pressed and displayed as soon as they are received. When in character mode, the PCI-8500-1 uses a 1920-character virtual screen to hold display data. This may be either 24 lines of 80 characters or 48 lines of 40 characters.

In the Block Mode, input and output to the terminal is line oriented; message lines are transmitted as a whole when the ENTER key is pressed and displayed only after the entire line and its terminator has been received. When in block mode, the virtual screen is used to retain the last 24 or 48 displayed lines for operator review.

The specific mode demonstrated here for test purposes is the character mode.



PCI-8500-1 Microterminal with Mounting Kit Components.

Decatur, Indiana needed more clean water for its growing community. An addition to the water treatment plant was built, but the current plant control system was obsolete. How did Decatur modernize their control system?

Burr-Brown Hardware with LABTECH CONTROL provided the solution....

Decatur's Water Superintendent and City Engineer needed to replace their obsolete monitoring and control system. Their existing system was installed in 1972, and much of the technology was based upon the 1950's. This made replacement parts next to impossible to obtain. In addition, the older control system could not provide comprehensive control and data logging for the expanded Water Treatment Facility.

In planning the new system, firm requirements were defined. The main objectives for the control system included reliability and the use of readily available components of proven technology. It was also desirable for the control system to include data analysis, data logging, report generation, and alarm capabilities. Burr-Brown data acquisition and control (DA&C) hardware with LABTECH CONTROL software satisfied these requirements for the following reasons.

Decatur's System Requirements and Burr-Brown's System Solutions

Requirement Process control to control plant pumps based on well and tank levels.

Solution Burr-Brown's digital I/O hardware with CONTROL's digital output function blocks turn pumps on and off based on inputs from wells and tanks.

Requirement Easy-to-use software that minimizes application building time.

Solution CONTROL's icon/menu system allows for quick and flexible configuration.

Requirement Alarm annunciation when pumps fail or tanks are at critical levels.

Solution CONTROL provides alarm annunciation, display, and logging.

Requirement Interface to industry-standard hardware.

Solution Burr-Brown is an established leader in DA&C hardware.

Requirement Ease of future expandability.

Solution With Burr-Brown's PCI modular product line and CONTROL's support, expansion is as easy as adding another I/O module to the hardware configuration.

Requirement Simple operator interface.

Solution CONTROL's display functions and drawing package allow the creation of custom screens. CONTROL also features a run-time control panel which lets operators enter control parameters without entering the menus.

Requirement Reliability.

Solution Burr-Brown and CONTROL's leadership in the monitoring and control industry -- and an experienced support staff -- guarantee quick and reliable service.

Requirement Competitive price.

Solution The Burr-Brown/CONTROL solution meets all of the plant's system requirements for the lowest price. CONTROL's ease-of-use also reduces installation costs.

Designing the Application

The Decatur Treatment Facility has two plants. The older plant has seven wells each providing water at a rate of 250 gallons per minute. After passing through a treatment system that includes four zeolite filters, the water is stored in a 500-thousand gallon clearwell. Two high-service pumps deliver water as needed to Decatur's two water towers.

The newer plant has two wells that, together, provide water at a rate of 1650 gallons per minute. As in the older plant, the water is treated, stored, and pumped to the water towers as needed. FIGURE 5-36 shows a block diagram of Decatur's application.

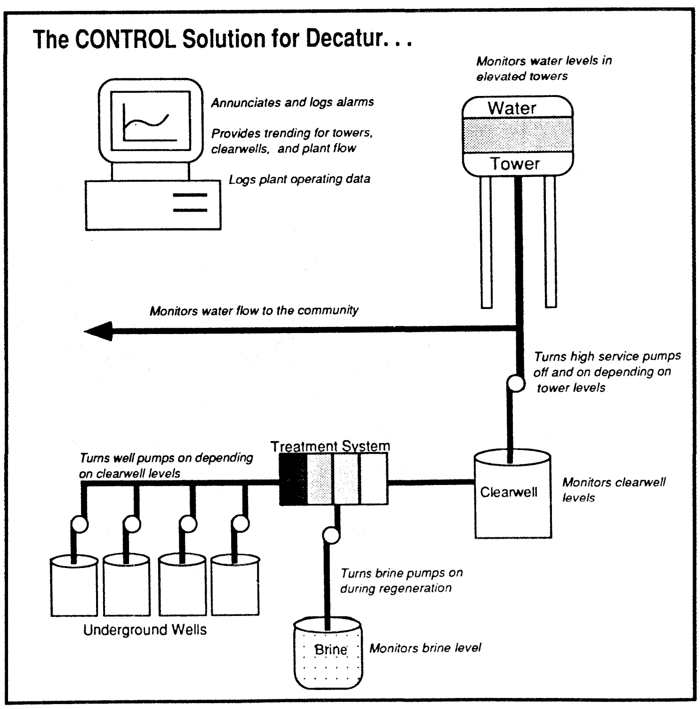


FIGURE 5-36. Decatur's Application.

The Hardware Solution

This application was built around a Tandy 386SX computer with internal Burr-Brown PCI DA&C hardware for local monitoring and control. External DGH modules were used for remote site monitoring via RS-232 communications.

It was determined that the DA&C requirements consisted of the following I/O:

6 Differential Analog Inputs (water flow, pressure and level)

8 Digital Outputs, 110 VAC output switching (turn on/off pumps and valves)

3 Digital Inputs, 24 VDC (regeneration status)

The following Burr-Brown system was configured:

1 PCI-20097S-1 LABTECH CONTROL software
1 PCI-20098C-1 Multifunction Carrier
1 PCI-20304T-1 Euro-Style analog termination panel
1 PCI-20008A-1B Analog high-density shielded cable
1 PCI-20325T-1 Euro-Style opto digital termination panel
8 PCI-1110 AC output signal conditioner blocks
1 PCI-20326T-1 Euro-Style Expander opto digital termination panel
3 PCI-1107 AC/DC input signal conditioner blocks
1 PCI-20009A-1B Digital high-density cable
1 PCI-20308H-1 Euro-Style 19-inch card cage (for termination panels)

Please refer to FIGURE 5-37 for a block diagram of this configuration.

The PCI-20098C-1 was a natural choice, since both analog and digital I/O functions are included on this Multifunction Carrier. The PCI-20098C-1 is completely software programmable, which means that the user does not have to configure hardware jumpers or switches to set voltage ranges, gains or whether the analog inputs are single-ended or differential. CONTROL handles all of these details. All the user has to do is install the PCI-20098C-1 into an expansion slot of the computer, connect the ribbon cables between the carrier and termination panels, and run CONTROL. In this application two module positions are available for future analog and digital I/O expansion.

Euro-Style termination panels were selected because of their 19-inch rack-mount capability and signal conditioning features. Many of the low-level analog signals required filtering to eliminate 60 Hz line noise. Custom filters were installed on the PCI-20304T-1 termination panel. PCI-1100 series digital signal conditioning blocks were used to monitor regeneration status and to turn on/off the pumps and valves.*

Process Monitoring and Control

The flow of water at the discharge site is a function of the water level in the tower. To maintain the water flow, the tower level ideally should be between 17 feet and 27 feet. The level is monitored

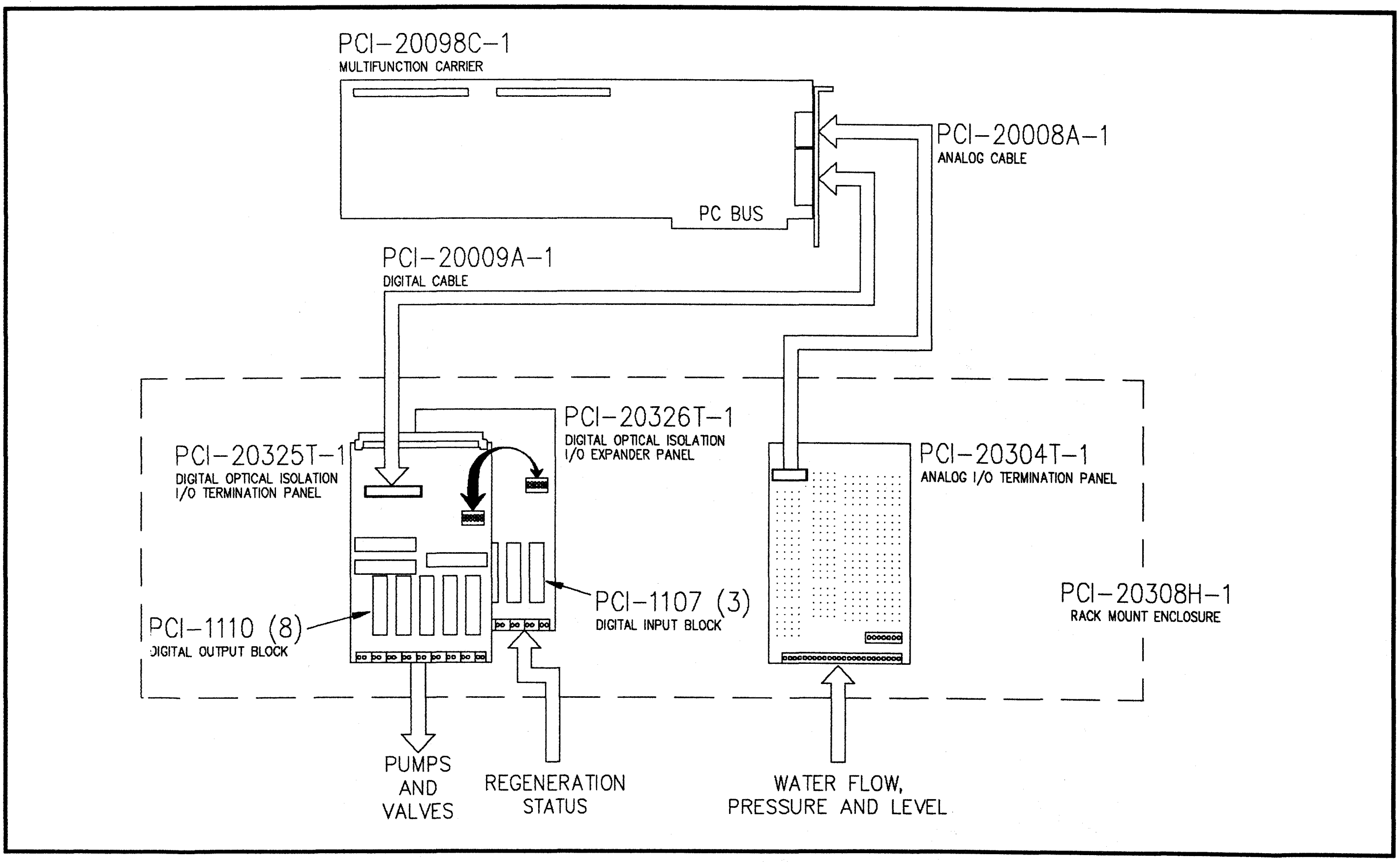


FIGURE 5-37. Block Diagram of Decatur's DA&C Hardware Solution.

** Operators of critical systems such as this usually purchase duplicate PCI components— one for the actual application and the other for use as a backup. This is in recognition of the fact that any system can fail. The cost of down time, even for a few hours, is extremely high compared to the cost of spare boards. If the main system fails, it is easy to switch to the backup equipment. This can be used to run the process while the first system is being evaluated/repaired.*

remotely by a DGH module via an Everex 2400+ modem which has MNP5 error correction capabilities.

The module input is read into CONTROL via an RS-232 block (channel) which scales the input to represent the tower level in feet. CONTROL sends the value of this RS-232 block to a digital closed-loop control block, which turns on the high service pumps when the tank level falls below 17 feet and turns the pump off when the level exceeds 27 feet.

The RS-232 block also inputs to another digital output block, which turns on the chlorine pump whenever the high service pumps are on, thus enabling chlorination.

If communication with the tower is lost, the control mechanism reverts to the pressure monitoring function, and CONTROL turns the high service pumps on and off, depending on the pressure in the system.

CONTROL monitors the clearwell level with the analog input section of the PCI-20098C-1 Multifunction Carrier. CONTROL reads the level and scales the signal to reflect depth in feet. In addition, this analog input block is also the input to a digital output block, which turns on well pumps when the clearwell level is less than 12 feet and turns them off when the level exceeds 17 feet.

A digital input block monitors the regeneration status of the treatment system. This status is sent to a digital output block, which turns on the high service pumps when the plant goes into regeneration, thus preventing clearwell overflow. The regeneration reading is also the input to another digital output block, which turns on the brine plants when the plant is in regeneration.

An analog input block monitors the level of brine in the brine tank and notifies the operator when the brine tank needs to be refilled.

Each time a pump is turned on, a time block is triggered so that it records the amount of time that the pump runs. The value of this block is an input to a calculated block, which sums the data to store the total run time of the pump.

Alarming

In addition to process monitoring and control tasks, the configuration provides for alarm annunciation, display and logging. Each block that monitors tank or well levels has hi-hi and lo-lo limits. If a block value falls outside of these limits, alarms are annunciated, displayed on the operator interface, printed out, and logged to disk.

Logging

CONTROL records the following information: plant flow and pressure, total run times for pumps, total time in regeneration, alarm conditions, and tower levels.

Operator Interface

CONTROL's graphic capabilities, which include animated flow diagrams, multiple trace types, and multiple operator screens, enabled Decatur to custom design an easy-to-use operator interface. One of the user interface screens is shown in FIGURE 5-38.

The cornerstone of the operator interface is a HELP screen that acts as a road map for the operator. The help screen lists all the screens and gives the keystrokes necessary to bring up a particular screen. In addition, the help screen displays other CONTROL keystrokes that may be used during run-time operation.

Other screens enable the operators to observe tank level trending, to be alerted when alarms occur, and to be informed of pump and regeneration status. The operator interface serves as an efficient graphic overview of facility operation.

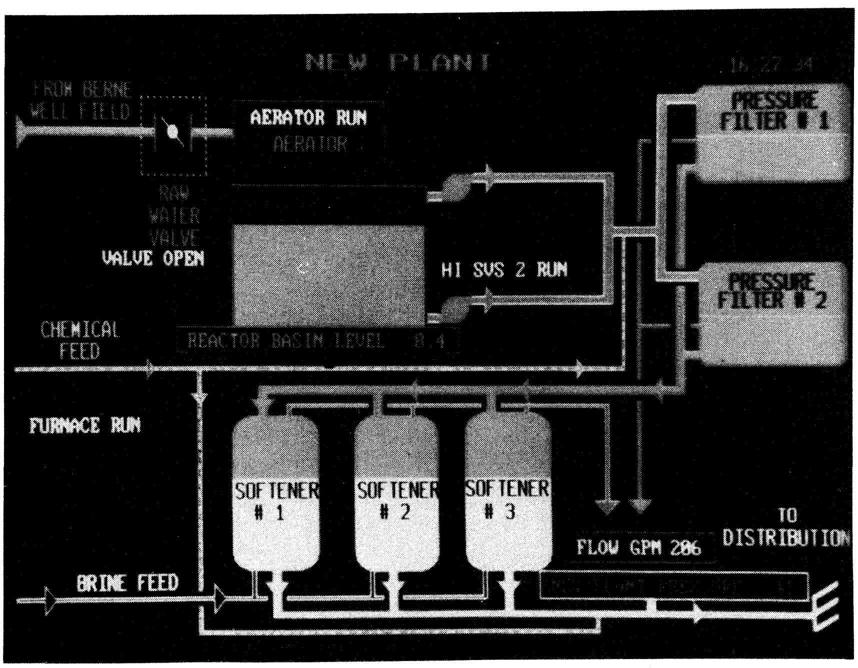


FIGURE 5-38. One of the Requirements Was An Interface to Notify Operators of the Status of Vital Plant Functions. The Plant's Treatment System Includes Alarm Windows and Status Windows. CONTROL's Display Functions Were Used to Create This Interface.

Glossary of Terms

This glossary consists of terms and their definitions as they normally pertain to the personal computer area and does not attempt to include every possible variation that might be used in the broader computer field that would include mainframes and specialized, dedicated machines.

A/D. A term that refers to the Analog to Digital conversion process. Analog voltages are received by the system, converted to digital numbers, then stored or analyzed by the computer.

Acquisition. The process by which data is gathered by the computer for analysis or storage.

Active Filter. An electronic filter that combines active circuit devices, usually amplifiers with passive circuit elements, such as resistors and capacitors. Active filters typically have characteristics that more closely match ideal filters than do strictly passive filters.

Alias Frequency. A false lower frequency component that appears in analog data reconstructed from original data acquired at an insufficient sampling rate.

Algorithm. A set of rules or detailed plan, with a finite number of steps, for solving a problem. An algorithm can be used as a model for a computer program.

Analog. A continuous signal or process.

Analog Input Device. Converts signal sources (thermocouples, RTDs, pressure sensors, strain gages, etc.) to a digital representation (fixed amplitude, two states) that can be further processed by the host PC.

Analog-to-digital Conversion (A/D). The process of changing an analog signal into a digital value that represents the magnitude of the signal at the moment of conversion.

Analog-to-digital Converter (A/D or ADC). An electronic device, often an integrated circuit, that produces a digital output directly proportional to an analog signal input.

Analog Output Device. Converts digital data (fixed amplitude, two states) from the host PC into a signal with a wide range of amplitudes.

ANSI. American National Standards Institute.

Array. Data arranged in single or multidimensional rows and columns.

ASCII. American Standard Code for Information Interchange. Code that is used to represent symbols in computers.

ASCII Files. Files on disk which contain ASCII coded data.

Assembler. A program that converts a list of computer instructions written in a specific assembly-language format into binary instructions that can be executed by a specific processor.

Assembly-language Program. A program written directly with processor commands using mnemonic representations of the commands. The program is then processed by an assembler to produce executable machine code.

Asynchronous. A communications protocol where information can be transmitted at an arbitrary, unsynchronized point in time, without synchronization to a reference timer or "clock".

Background. A secondary task performed by the computer in conjunction with the primary or foreground task.

Bandpass Filter. A type of filter that allows a band of signal frequencies between two set frequencies to pass while attenuating all signal frequencies outside the bandpass range.

Base Address. A memory address that serves as a point of reference. All other points are located by offsetting (adding to or subtracting from) in relation to the base address.

BASIC. The most common computer language, BASIC is an abbreviation for Beginners All-purpose Symbolic Instruction Code. Relies on English-like instructions which accounts for its popularity and ease of learning.

Baud Rate. Serial communications data transmission rate; the number of bits-per-second.

Binary-coded Decimal. A code for representing decimal digits in a binary format.

BIOS. Basic input-output system. Part of the computer's software operating system, BIOS is responsible for controlling data inputs from, and outputs to, peripherals such as the keyboard, screen display, printer, floppy disk and hard disk.

Bipolar. A signal range that includes both positive and negative values.

Block. A single-channel signal conditioning device. Available for both analog and digital signal applications. In addition to usually providing isolation, they can offer filtering, amplification, power switching, and level translation functions.

Board. A fixed-function device that plugs inside a PC and makes direct electrical connection to the PC bus. Available for analog I/O, digital I/O, and counter/timer/generator functions.

Box. An external device that connects to the host PC via RS-232, RS-422, or IEEE-488 (GPIB).

Bubble Memory. A type of non-volatile computer memory that uses magnetic domains (bubbles) for data storage. Access to information stored in bubble memory is serial and therefore relatively slow compared to RAM. However, bubble memory is faster than floppy or hard disk. In addition, bubble memory is considerably more rugged than mechanical memory devices making it desirable in many industrial applications.

Buffer. A storage location used for holding information that is to be used at a later time.

Bus. Conductors used to interconnect individual circuitry in a computer. The conductors as a whole are called a bus.

Bus Interface. A board or box product that converts a given bus protocol (PC/XT/AT, Micro Channel, NuBus, IEEE-488, RS-232, etc.) to some other bus protocol.

Byte. A term referring to eight related bits of information. Eight bits equals one byte.

C. A programming language, developed around the concept of structured programming, that bears a strong resemblance to PASCAL.

Cable. A multi-wire assembly used to interconnect related components of the system (e.g., I/O device to a signal conditioner, etc.). Shielded, flat ribbon cable is used in most applications.

Cache Memory. Fast memory used to improve the performance of a CPU. Instructions that will soon be executed are placed in cache memory shortly before they are needed. This process speeds up the operation of the CPU.

CAD. Computer-aided design. A computer-based drafting and documentation system used for design engineering.

CAE. Computer-aided engineering. A computer system designed to aid engineering development.

CAM. Computer-aided manufacturing. A computer system used for automating manufacturing operations.

Call. A software instruction used to pass control to a subroutine of a program. At the completion of this subroutine, control is returned to the original program at the point of the "call" statement. Often used for specialized routines such as "analog read" from a data acquisition system.

Carrier. A multifunction device that plugs inside a PC and makes direct electrical connection to the PC Bus. It is distinguished from a "board" in that is can accept plug-in "modules" to add I/O capabilities. Carriers are available to support analog I/O, digital I/O, and counter/timer/generator applications.

Central Processing Unit (CPU). The central part of a computer system that performs operations on data. In a personal computer the CPU is typically a single microprocessor integrated circuit.

Code. As a noun, the text of a computer program. As a verb, to "code" mean to write a program.

Cold-junction Compensation. A method of providing an artificial reference level and compensation for ambient temperature variations in thermocouple circuits.

Command. An instruction given directly to an active program from a keyboard or terminal rather than from a program.

Common-mode Rejection Ratio (CMR). A measure of an instrument's ability to ignore or reject interference from a voltage common to its input terminals relative to ground. CMR is usually expressed in dB (decibels).

Comparator. An electronic circuit used to compare two values and set an indicator that identifies which value is greater.

Compiler. A particular type of high-level language used to preprocess a program in order to convert it to a form that a processor can execute directly.

Computer Platform. A personal computer suitable for integration with PCI I/O products for use in a wide variety of applications, including data acquisition, test, measurement, and control.

Concurrent. Software that can perform more than on task simultaneously.

Configure. This is a process by which software or hardware is set by the user to function in a certain way.

Contact Closure. The closing of a switch, often controlled by an electromagnetic or solid state relay.

Conversion Time. The time required, in an analog input or output system, from the moment a channel is interrogated (such as with a read instruction) to the moment that accurate data is available. This could include: switching time, settling time, acquisition time, A/D conversion time, etc.

Converter Resolution. A term that refers to how accurately the A/D converter chip represents an analog signal with a binary value. Accuracy is determined by how many bits are used to make up the binary value.

Coprocessor. Another computer processor unit that operates in conjunction with the standard CPU. Can be used to enhance execution speed. For example, the 8087 is designed to do floating-point arithmetic.

Counter. In software, a memory location used by a program for the purpose of counting certain occurrences. In hardware, a circuit that can count pulses.

Counter/Timer Device. Converts time-dependent digital signals to a form that can be further processed by the host PC. Typical functions include pulse counting, frequency measurement, and pulsewidth measurement. This can relate to time, number of events, speed, etc.

CPU. Acronym for central processing unit. refers to the microprocessor.

Cross Assembler. A computer program that translates machine language code so that it can be read by a different type CPU.

Crosstalk. In communications, a phenomenon in which a signal in one or more channels interferes with a signal or signals in other channels. In an analog multiplexer, the ratio of the output voltage to the input voltage with all channels connected in parallel and turned off.

Current Loop. Communications method that allows data to be transmitted over relatively long distances and through relatively high noise environments. With a current loop, the voltage levels are converted to currents to that the signals are transmitted in the form of current instead of voltage in a closed-loop circuit. Current loops are less sensitive to noise pickup.

D/A. A term that refers to the output of analog voltage signals that were converted from digital numbers. Reverse of A/D.

DAS. Acronym for data acquisition system.

Data Acquisition. Gathering information from sources such as sensors and transducers in an accurate, timely and organized manner. Modern systems convert this information to digital data which can be stored and processed by a computer.

Data Reduction. The process of analyzing a large volume of data to extract and refine a subset of the data for some particular purpose. As in the statistical summarization of data.

Debouncing. Either a hardware circuit or a delay built into software to prevent false inputs from a bouncing key or switch contact.

Decibel. A logarithmic measure of the ratio of two signal levels: $dB=20\log_{10}(V_1/V_2) = 10\log_{10}(P_1/P_2)$.

Default. A value assigned or an action taken automatically unless another is specified.

Digital. A signal which has distinct states. Digital computers process data as binary information having either 1 or 0 states.

Digital-to-analog Conversion. The process of changing discrete data into a continuously varying signal. Common uses are to present the output of a digital computer as a graphic display or as a test stimulus.

Digital-to-analog Converter (DAC). A device that converts digital information into a corresponding analog voltage or current.

Digital Input Device. Translates external discrete (on/off) conditions to a form that is electrically compatible with the host PC.

Digital Output Device. Translates on/off software instructions from the host PC to a form that is suitable for driving external digital devices.

DIP Switch. A set of switches contained in a dual in-line package.

Direct Memory Access (DMA). A method by which information can be transferred from the computer memory to a device on the bus while the processor does something else. Also one of three methods of transferring data acquisition system measurements to computer memory (the other methods being polling and interrupt).

DMA. Direct memory access, see above.

DOS. Disk operating system.

Down-load. The copying of information from one computer to another.

Drivers. Part of the software that is used to control a specific hardware device such as a data acquisition board or a printer.

Duplex. The ability to both send and receive data simultaneously over the same communications line.

Dynamic Range. The ratio of the full-scale range (FSR) of a data converter to the smallest difference it can resolve. Dynamic Range (DR) = 2^n. Generally expressed in dB, DR = 20 log 2^n. "n" is the resolution in bits.

Enclosure. A mounting and/or protective device. Usually associated with termination and signal conditioning panels.

Event Counter. A circuit used to count pulses that are related to the occurrences of a certain condition, such as an item coming off the end of the assembly line. An event counter can typically be preset, reset and can totalize.

Expanded Memory. Memory that exists outside of the normal PC computer memory area. May be referred to as bank switched memory.

Expansion Board. A plug in circuit board that adds features or capabilities beyond those basic to a computer, such as a data acquisition system expansion board.

Expansion Chassis. An enclosure used to increase the capabilities of a computer system by providing space for additional expansion boards.

Expansion Slots. The spaces provided in a computer for expansion boards that enhance the basic operation of the computer.

Expert Systems. A highly specialized data base and computational computer program that acts like a human expert on a particular subject.

Extended Memory. Memory that is addressable by the PC as part of the normal memory area of the computer, but is not used by DOS for user programs.

FFT (Fast Fourier Transform). An algorithm which quickly determines frequency components of a waveform.

Firmware. A program permanently recorded in a ROM and therefore essentially a piece of hardware that performs software functions. BIOS is an example of firmware.

Floating-point Numbers. Numbers that contain decimal parts or are presented in scientific notation (digits multiplied by a power of 10). Also known as "real" numbers. Integers are a subset of reals containing whole numbers only.

Foreground. In a PC system, the activity subject to direct operator intervention. Other (background) activities continue as previously defined.

Front End. The preprocessing of data before a program uses it. Could refer to signal conditioning in a data acquisition system.

GPIB. General-purpose interface bus. A standard bus used for controlling electronic instruments with a computer. Also designated IEEE-488.

Generator Device. A rate or burst generator used to produce TTL level signals for internal or external timing applications. Usually associated with establishing data acquisition sampling rate (speed).

Ground. An electrically neutral wire having the same potential as the surrounding earth. Normally, a non-current-carrying circuit intended for safety purposes.

Handshake/Handshaking. Method whereby two communicating electronic devices verify the integrity of the communication.

Hardware. The visible parts of a computer system, such as the circuit boards, chassis, enclosures, peripherals, cables, etc. It does not include data or computer programs.

Hexadecimal. A numbering system to the base 16.

Hierarchical. A method of organizing data with a series of levels, each with further subdivisions, as in a pyramid or tree structure.

High-level Language. A program used to simplify the creation of computer code. Allows the specification of a computer action using a smaller number of steps than assembly language.

IEEE-488. The Institute of Electrical and Electronic Engineers' designation for the GPIB instrumentation control bus standard.

I^3 Bus. Intelligent Instrumentation Interface Bus. A patent-pending interconnection bus for modular data acquisition components which is used to create a complete personal computer interface system.

Input/Output (I/O). The process of transferring data from or to a computer system including communications channels, operator interface, or data acquisition and control channels.

Instrumentation Amplifier (IA). An amplifier circuit with both high-impedance differential inputs and high common-mode rejection.

Integer. A whole number, not requiring a fraction, a decimal point or scientific notation for representation.

Integrating A/D Converter. an A/D conversion technique in which the analog input is integrated over time. Different types of integrating A/D converters include dual slope, triple slope, and charge-balancing types.

Interface. A device which allows two devices to communicate. For example, a computer can interface with printers, other computers, analog signals, etc.

Interpreter. A high-level language in which the command statements are converted, one at a time and in the order they are used, into code that can be executed by the processor.

Interrupt. A computer signal indicating that the CPU should suspend its current task to service a designated activity. One of three methods for transferring data acquisition measurements to the computer's memory (the other methods being DMA and polling).

Interrupt Handler. The section of a program that performs the necessary operations to service an interrupt when it occurs.

I/O Address. A method that allows the CPU to distinguish between the different boards in a system. Unique addresses usually are set with DIP switches. All boards must have different addresses.

I/O Mapping. Method of connecting I/O devices to the CPU ion an addressable fashion without using memory space. Disk drives, printers and monitors are usually I/O mapped. However, there is a limited address space available and a limited set of I/O instructions. For these reasons, advanced data acquisition systems tend to be memory mapped.

Isolation Amplifier. An amplifier with electrically isolated inputs and outputs which allows it to amplify a differential signal superimposed on a high common-mode voltage.

Isolation Voltage. The voltage which an isolated circuit can normally withstand. Isolation voltage is usually specified from input to input and/or from any input to the amplifier output, or to the computer bus.

Isothermal. A process or area that is maintained at a constant temperature.

K. Kilo. In referring to computers, a "kilo" is 1024 or 2 to the 10th power. (Note that it is actually slightly more than an even 1000.)

Latch. A term used to indicate that the state of a digital signal will remain stored until changed by the CPU or specified external command signal.

Linearity. The adherence of a device's response to a straight line relationship.

Linker. A program which combines different sections of a compiled program.

Listener. A device on the GPIB bus that receives information from the bus.

Machine Language. Binary code that is executed directly by a computer CPU and translated into electronic actions. Machine language is different for each CPU type.

Macro. A small set of program steps combined to act as a single, more powerful, program step.

Math Coprocessor. Companion processor to the microprocessor. Contains hard coded programs to carry out fast and highly precise floating point operations along with mathematical functions.

Memory. Electronic devices that enable a computer to store and recall information. In its broadest sense, memory refers to any hardware capable of serving that end, e.g., disk, tape, or semi-conductor storage.

Mnemonics. A method of helping a software programmer remember the various commands of a specific computer system. A relatively easy-to-remember alphabetic code is assigned to each command and usually consists of letters extracted from, and thus suggestive of, the command it symbolizes.

Modem. A device used to translate serial data to/from a form that can be transmitted/received over telephone or other communication channels. (Short for MOdulator-DEModulator.)

Modular. The use of building blocks (modules) in a computer or data acquisition system. A modular device, for instance, is one that is built, tailored and expanded by connecting various mutually compatible components. An example of a modular data acquisition system is the PCI-20000 Personal Computer Interface System.

Module. In the PCI-20000 Personal Computer Interface System, the Instrument Modules provide specialized data acquisition functions. A configuration of Instrument Modules is combined with a motherboard Carrier to create a data acquisition/control system in a personal computer.

Monotonicity. The desirable characteristic of a digital-to-analog converter to produce a continuously increasing analog output for a correspondingly increased digital input code.

Multidrop. A single communications line used to connect three or more points.

Multiplexer (mux). An array of semiconductor or electromechanical switches with a common output used for selecting one of a number of input signals.

Multitasking. The characteristic of an operating system that allows a processor to perform several operations at once.

Noise. An undesirable electrical interference to a signal. Sources of noise include the AC power line, motors, generators, transformers, fluorescent lights, soldering irons, CRT displays, computers, electrical storms, welders, radio transmitters, and others.

Nonvolatile. A memory or data storage device that retains its information content when electrical power is removed. Ordinary RAM is volatile whereas ROM, bubble memory, battery-backed-up CMOS RAM, floppy, and hard disks are nonvolatile.

Nyquist Sampling Theorem. If a continuous bandwidth-limited signal contains no frequency components higher than a specified frequency, then the original signal can be recovered without distortion if it is sampled at a rate of at least twice the specified frequency.

Offset Binary. A coding scheme for converting analog signals to a decimal equivalent. The smallest analog voltage will equal a decimal 0. The highest analog voltage would equal a large (i.e., 4095, 32768) digital value. That is, negative decimal representations are not used.

Operating System. The master control program that governs the operation of a computer system. Software or firmware that manages the internal memory allocation and the control of peripheral devices for applications programs.

Optical Isolation. Two networks connected only through an optoelectric transmitter and receiver with no electrical continuity between the two networks.

Overhead. The amount of computer processing resources, such as time or memory, required to accomplish some task.

Pascal. A high-level programming language originally developed as a tool for teaching the concepts of structured programming. It has evolved into a powerful general-purpose language popular for writing scientific and business programs.

Passive Filter. A filter circuit using only resistors, capacitors, and inductors. (No active devices such as integrated-circuit amplifiers.)

PC. Personal computer such as an IBM PC/XT/AT/EISA compatible, PS/2 or Mac II computer system.

PCI. Personal computer instrumentation. Prefix for a series of personal computer interface products from the Burr-Brown Corporation and Intelligent Instrumentation Incorporated. For example, the PCI-20000 is a modular, board-level data acquisition and control system that fits directly inside a PC.

Peripheral. The input-output and data storage devices attached to a computer such as disk drives, printers, keyboards, displays, data acquisition systems, etc.

PID. Proportional, integral, derivative. A three-mode control algorithm.

Polling. A round-robin canvassing of data acquisition inputs synchronized in software to a clock or external trigger. One of three methods of transferring data acquisition measurements to the computer's memory (the others being DMA and interrupt).

Port. A communications connection on a computer or a remote controller.

Power Supply. A device for generating desired DC voltages. Usually associated with powering signal conditioning products (blocks and panels).

Protocol. The exact sequence of bits, characters and control codes used to transfer data between computers and peripherals through a communications channel.

Quantizing Error. The inherent uncertainty in digitizing an analog value due to the finite resolution of the conversion process. This error can be reduced only by increasing the resolution of the converter.

Queue. A temporary storage location or list of things to be done such as messages that are awaiting transmission.

RAM. Random access memory, see below.

Random Access Memory (RAM). Computer memory that allows data to be read or written at a particular location without having to pass sequentially through preceding locations.

Range. Refers to the maximum allowable full-scale signal (input or output) that yields a specified performance level.

Rate Generator. A device that provides a TTL -level pulse output at a software-programmable frequency.

Read Only Memory (ROM). Computer memory in which data can be routinely read but written to only using special means when the ROM is manufactured. ROM is used for storing data or programs on a permanent basis.

Real Numbers. Numbers that can express a fractional value. Also called floating-point numbers.

Real Time. Data acted upon immediately instead of being accumulated and processed at a later time.

Real-world. Referring to events, signals and conditions that occur naturally or in everyday life.

Reduction or Data Reduction. The selection of data subsets based on given criteria. Some examples of such criteria are: Frequency: Filtering, smoothing. Position: Cross section, sub array. Math Operations: Averaging, standard deviation.

Repeatability. The ability of an instrument to give the same output or reading under repeated identical conditions.

Resolution. The smallest significant number to which a measurement can be determined. For example, a converter with 12-bit resolution can resolve 1 part in 4096.

Ribbon Cable. A flat cable in which the conductors are side by side rather than in a bundle.

Routine. A self-contained program designed to accomplish a specific task.

RS-232C. A serial asynchronous communications standard used to connect modems, terminals and printers with serial interfaces. Although RS232C is only specified for use in transmission lengths up to 50 feet, it is often used for greater distances at lower baud rates.

RTD. Resistance temperature detector. An electrical circuit element characterized by a positive coefficient of resistivity.

R/W. Read/write, abbreviation.

Sample/Hold. A circuit which acquires and stores an analog voltage on a capacitor for a short period of time.

Sampling Theorem. See Nyquist Sampling Theorem.

Seebeck Effect. The basic principle behind thermocouples. When a circuit is created by the junctions of two dissimilar metals and the junctions are held at different temperatures, a current caused by the difference in temperature between the two junctions will flow in the circuit.

Sensitivity. A measure of the minimum change in an input signal that an instrument can detect.

Sensor. A device that responds to a physical stimulus (heat, light, sound, pressure, motion, etc.) and produces a corresponding electrical output.

Serial I/O. A common form of data transmission, in which the bits of each character are sent one at a time over the line.

Serial Port. A communications interface that uses one data line to transfer data bits sequentially. On the IBM PC the serial port refers to a standard serial interface which uses the RS-232C and ASCII standards.

Set Point. A "level" or control point in a feedback system.

Settling Time. The time required, after application of a step input signal, for the output voltage to settle and remain within a specified error band around the final value. The settling time of a system includes that of all of the components of the system.

Shielded Cable. A cable with foil or other sheathing around it to stop radio frequency interference and magnetic fields from generating extraneous signals on cable conductors.

Signal Conditioner. A panel or block specifically intended to provide signal scaling, filtering, linearization, cold-junction compensation, power gain, amplification, level translation, etc.

Signal-to-noise Ratio. On a communications line, the ratio of signal strength to the level of noise.

Simultaneous Sample/Hold. A data acquisition system in which several sample/hold circuits are used to sample a number of analog channels at the same instant. One sample/hold per analog channel is required.

Software. The non-physical parts of a computer system that includes computer programs such as the operating system, high-level languages, applications programs, etc.

Span. The difference between the lower and upper limits of a range. Span is expressed in the same units as the range.

Spike. A transient disturbance of an electrical circuit. Due, for example, to load variations on the AC power line.

Stability. The ability of an instrument or sensor to maintain a consistent output when a constant input is applied.

Strain Relief. A bracket or clamp used to secure a cable so that it does not become disconnected accidentally or apply stress at the point of connection to the system.

Subroutine. A sequence of computer instructions that perform a specific task and can be called repeatedly in a program whenever that specific task is required.

Successive-approximation A/D Converter. An analog-to-digital conversion method that sequentially compares a series of binary-weighted values with an analog input to produce an output digital word in "n" steps, where "n" is the bit resolution of the A/D converter. This process is analogous to weighing an unknown quantity on a balance scale using a set of binary standard weights.

Surge. A sudden change (usually an increase) in the voltage on a power line. A surge is similar to a spike, but is longer lasting.

Surge Protector. A device placed in an electrical circuit to prevent spikes and some surges that might otherwise damage electronic equipment connected to that circuit.

Synchronization. The coordination of the activities of several circuit elements together.

Syntax. Comparable to the grammar of a human language, syntax is the set of rules used for forming statements in a particular programming language.

20K. A slang term for the PCI-20000 Personal Computer Interface System.

Talker. A device on the GPIB bus that simply sends information on to the bus without actually controlling the bus.

Termination Panel. A circuit board with screw terminations or another connector system that allows convenient connection of field signals to a data acquisition system.

Throughput Rate. The maximum repetitive rate at which a data conversion system can operate with a specified accuracy. It is determined by summing the various times required for each part of the system and then by taking the inverse of this time.

Time Stamp. Information added to a message, record, or other unit of data indicating the time at which it was processed by the system.

Transducer. A device that converts length, position, temperature, pressure, level, etc. to a different energy form (i.e., voltage or current).

Triac. A solid-state switching device used to switch alternating current waveforms.

Trigger. Pulse or signal that is used to start or stop a particular action. Triggers are frequently used to control data acquisition processes.

Turnkey. A system that combines all the hardware and software required for a specific application.

UART. Universal asynchronous receiver-transmitter, see below.

Universal Asynchronous Receiver-transmitter (UART). An electronic circuit that translates the data format between a parallel representation within computer and the serial method of transmitting them over a communications line.

Uninterruptible Power Supply (UPS). A power conditioning unit placed between the commercial power service and the protected device. The UPS uses line power to charge batteries, which in the case of a power failure can drive electronic circuitry to produce the appropriate AC requirements for some time period.

Virtual Memory. A method of making disk storage appear like RAM memory to the CPU, thus allowing programs to run that need more RAM memory than is installed in the system. This technique is slow compared to "real memory.

Volatile Memory. Memory that does not retain its contents when power is removed.

Voltage-to-frequency Converter (VFC). A device which converts an analog input voltage into a sequence of digital pulses with frequency proportional to the input voltage.

Word. The standard number of bits that a processor or memory manipulates at one time. Microprocessors typically use 8 or 16-bit words.

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Telephone 415-634-0952
FAX 415-634-0981

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Burr-Brown Sales Directory

NEVADA (Southern)

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FAX 619-485-6386

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NEW JERSEY (Northern)

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FAX 518-869-1362

Expert Industrial Systems
4515 Culver Road
Rochester, NY 14622
Telephone 716-323-1305
FAX 716-323-2338

Expert Industrial Systems
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Syracuse, NY 13211
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M-Tech
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FAX 612-830-1380

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Burr-Brown Sales Directory

TENNESSEE

Pen-Tech Associates
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FAX 205-883-4973

Pen-Tech Associates
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FAX 404-642-4688

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TEXAS (Southern)

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Austin, TX 78701
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FAX 512-478-8649

Acudata, Inc.
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Houston, TX 77090
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FAX 713-580-6421

TEXAS (El Paso County)

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FAX 206-852-7754

WASHINGTON (Eastern)

M-Tech
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Telex 134777 BBW A
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Telex 623486 SIEX D
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*Kløckner - Moeller Norsk A/S
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Telex 76936 KLOMO N
FAX 6.870201

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*Advanced Semiconductor Devices (Pty) Ltd.
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Madrid 28008
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FAX 1 542-7896

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Metric Teknik AB
Englundavägen 7, Box 1494
171 29 Solna
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Telex 10766 METRIC-S
FAX 08-29 08 56

GÖTEBORG AREA:

Metric Teknik AB
Åbäcksgatan 6
431 67 Mölndal
Telephone 031-20 06 50
FAX 031-18 76 47

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Aartec AG
Postfach
CH-5024 Küttigen
Telephone (064) 37 15 52
and (064) 37 16 56
FAX (064) 37 34 16

Elbatex AG
Hardstrasse 72
CH-5430 Wettingen
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FAX (056) 27 19 24

IFE
Ingenieurbüro für Elektronik
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Technisches Büro Frankfurt
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Technisches Büro München
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Telex 31767 ELZAS YU
FAX 061 328 744

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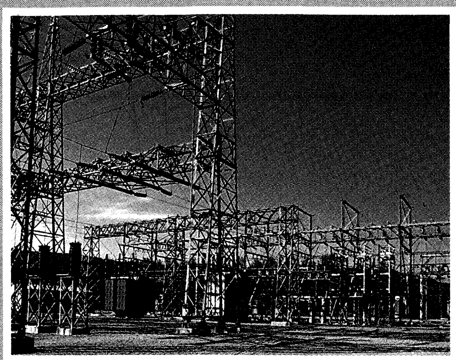

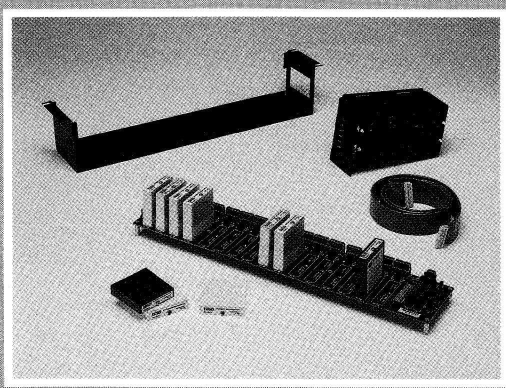

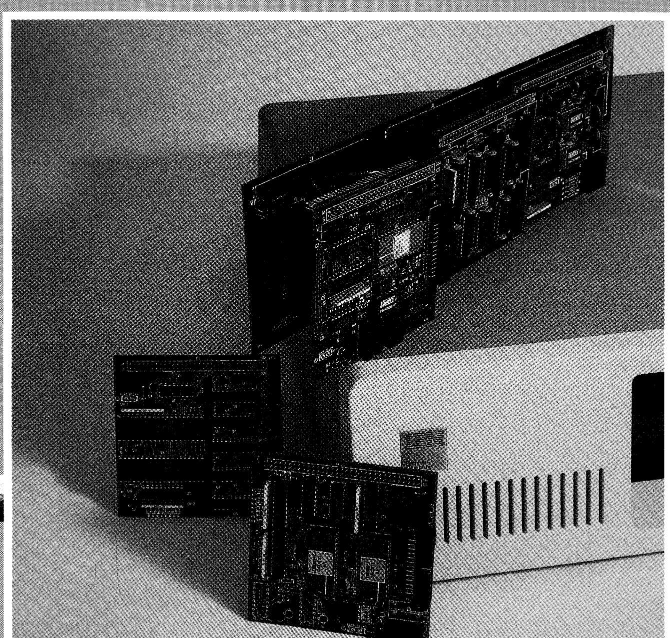

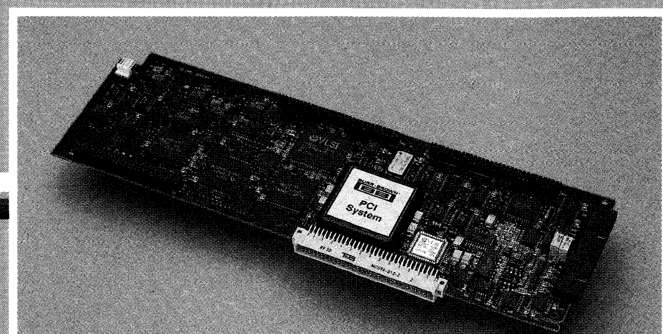
PCI
System

VIPc
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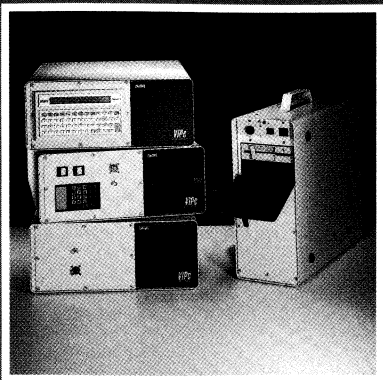

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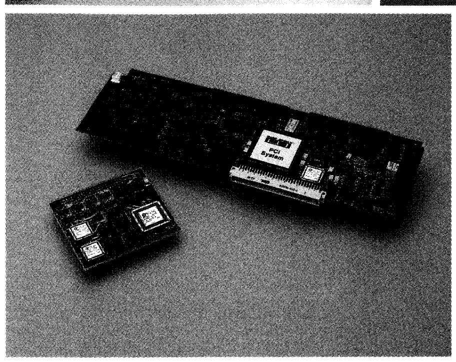

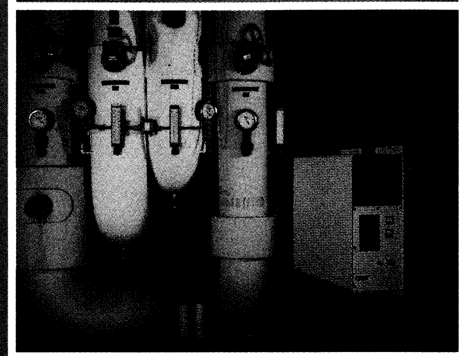

Applications
Section 5

Digital Signal
Processing (DSP)
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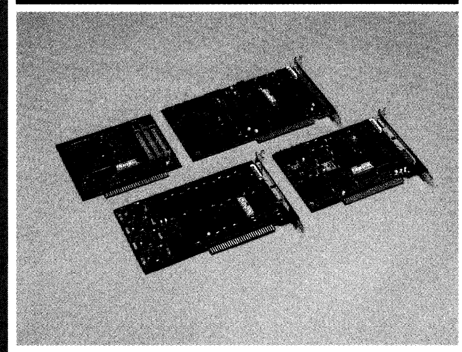

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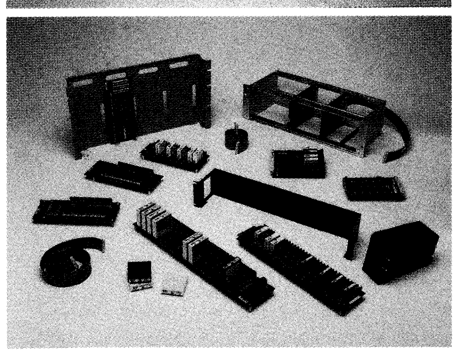

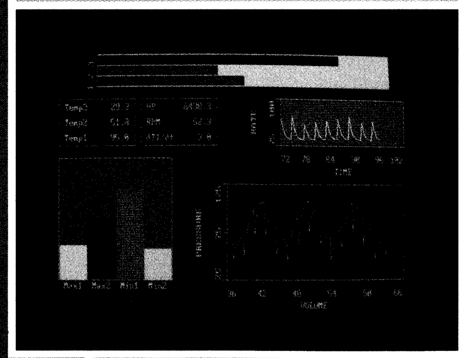

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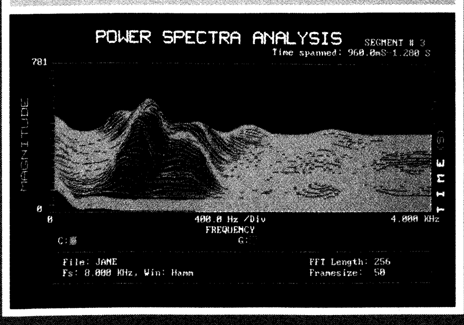

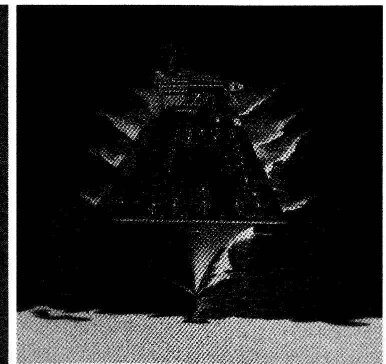

Super Carrier
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