Personal488 User's Manual

PC/IEEE 488 Controller For DOS & Windows 3.X

the smart approach to instrumentation ™

IOtech, Inc.
25971 Cannon Road
Cleveland, OH 44146-1833
Phone: (440) 439-4091
Fax: (440) 439-4093
E-mail: sales@iotech.com
Internet: www.iotech.com

Personal488 User's Manual
PC/IEEE 488 Controller
For DOS & Windows 3.X

p/n **Personal488-902** Rev. **3.0**

Warranty Information

Your IOtech warranty is as stated on the *product warranty card*. You may contact IOtech by phone, fax machine, or e-mail in regard to warranty-related issues.
Phone: (440) 439-4091, fax: (440) 439-4093, e-mail: sales@iotech.com

Limitation of Liability

IOtech, Inc. cannot be held liable for any damages resulting from the use or misuse of this product.

Copyright, Trademark, and Licensing Notice

FCC Statement

IOtech devices emit radio frequency energy in levels compliant with Federal Communications Commission rules (Part 15) for Class A devices. If necessary, refer to the FCC booklet *How To Identify and Resolve Radio-TV Interference Problems* (stock # 004-000-00345-4) which is available from the U.S. Government Printing Office, Washington, D.C. 20402.

CE Notice

Many IOtech products carry the CE marker indicating they comply with the safety and emissions standards of the European Community. As applicable, we ship these products with a Declaration of Conformity stating which specifications and operating conditions apply.

Warnings, Cautions, Notes, and Tips

Refer all service to qualified personnel. This caution symbol warns of possible personal injury or equipment damage under noted conditions. Follow all safety standards of professional practice and the recommendations in this manual. Using this equipment in ways other than described in this manual can present serious safety hazards or cause equipment damage.

This warning symbol is used in this manual or on the equipment to warn of possible injury or death from electrical shock under noted conditions.

This ESD caution symbol urges proper handling of equipment or components sensitive to damage from electrostatic discharge. Proper handling guidelines include the use of grounded anti-static mats and wrist straps, ESD-protective bags and cartons, and related procedures.

This symbol indicates the message is important, but is not of a Warning or Caution category. These notes can be of great benefit to the user, and should be read.

In this manual, the book symbol always precedes the words "Reference Note." This type of note identifies the location of additional information that may prove helpful. References may be made to other chapters or other documentation.

Tips provide advice that may save time during a procedure, or help to clarify an issue. Tips may include additional reference.

Specifications and Calibration

Specifications are subject to change without notice. Significant changes will be addressed in an addendum or revision to the manual. As applicable, IOtech calibrates its hardware to published specifications. Periodic hardware calibration is not covered under the warranty and must be performed by qualified personnel as specified in this manual. Improper calibration procedures may void the warranty.

Quality Notice

IOtech has maintained ISO 9001 certification since 1996. Prior to shipment, we thoroughly test our products and review our documentation to assure the highest quality in all aspects. In a spirit of continuous improvement, IOtech welcomes your suggestions.

General Table of Contents

Detailed Table of Contents

Introduction to this Manual

About this Manual

This edition of the *Personal488 User's Manual* supersedes all previous editions.

The material in this manual reflects the particular combinations of IEEE 488 I/O adapter and driver software, and is comprised of four primary Sections: *Hardware Guides, Software Guides, Command References*, and *Troubleshooting*, followed by two more Sections: *Appendix* and *Index*. The last two pages contain a *List of IEEE 488 Acronyms & Abbreviations* and a *List of ASCII Acronyms & Abbreviations* as additional references for this manual and for other related literature.

Before calling for technical assistance, check the *Troubleshooting* section for a possible solution to the problem.

Since much of the hardware and software material in this manual is similar to material elsewhere in the manual, make sure you view the material which corresponds to your specific hardware and software. For example, do not read about Driver488/DRV when your application pertains to Driver488/W31

Information which may have changed since the time of printing will be found in a **`README.TXT`** file on disk, or in an addendum to the manual.

How to Use this Manual

Because this manual contains a large volume of information, a four-level table of contents system is used in addition to a complete *Detailed Table of Contents*. In this four-level system, the *General Table of Contents* at the front of this manual should be used primarily to locate the main *Sections* of the manual, i.e., specific hardware guides and software guides. The first page of each *Section* contains a second-level table, listing the *Chapters* with their page locations. Next, many of these *Chapters* contain a third-level table, listing the *Sub-Chapters* or specific *Topics* with their page locations. Finally, many of these *Sub-Chapters* contain a fourth-level table, listing the specific *Topics* with their page locations. While this multi-level method is easy to use, experienced users may prefer the traditional table of contents.

As mentioned above, this manual also includes an *Index*, so you can quickly find the page(s) pertaining to a specific topic.

Header Files & Command References

Since changes are taking place in Driver488/W95 and Driver488/WNT software as this publication goes to press, please refer to your operating system header file for the latest available information specific to your application.

Section I:

HARDWARE GUIDES

I. HARDWARE GUIDES

Chapters

1. Overview

Topics

Introduction

The Hardware Guides section contains chapters pertaining to different Personal488 Drivers, as indicated in the previous Section I Table of Contents. Each Driver488 section contains information regarding specific PC/IEEE 488 controllers. The hardware guide describes the I/O adapter and includes instructions for inspecting, configuring, and installing the adapter.

In addition to this manual, Power488 and Power488CT users receive a manual supplement describing the Standard Commands for Programmable Instruments (SCPI) command set and the **`IOTTIMER.DLL`**, a Microsoft Windows Dynamic Link Library of functions. This overview introduces the hardware and software sections of this manual.

The Personal488 converts your PC or PC/AT into an IEEE 488.2-compliant controller. Each controller package includes an interface board or module, driver software and complete documentation. The following information provides a brief overview of a specific PC/IEEE 488 interfaces and software drivers, and of the Driver488 components.

IEEE 488.2 Interface Boards

The family of PC/IEEE 488 controllers includes the GP488B, the GP488/2, the AT488, the MP488, the MP488CT, the GP488/MM and the NB488. All are IEEE 488.2 compatible and supported by Driver488 software. The MP488 and MP488CT also provide digital I/O, and the MP488CT provides a set of programmable counter/timers, all of which are fully supported by Driver488. Some features of the interfaces are listed below:

- **GP488B** interface board (for PC/XT/AT): Features five jumper-selectable interrupt lines. Three 8-bit jumper-selectable DMA channels are also available. The 8-bit DMA mode provides full compatibility with programs written for GP488 series boards.
- **AT488** interface board (for PC/XT/AT and PS/2 with the ISA bus): Features eleven jumper-selectable interrupt lines. Three 16-bit and four 8-bit jumper-selectable DMA channels are also available. The 8-bit DMA mode provides full compatibility with programs written for the GP488 series boards.
- **MP488** interface board (for PC/XT/AT and PS/2 with the ISA bus): Features eleven jumper-selectable interrupt lines. Three 16-bit and four 8-bit jumper-selectable DMA channels are also available. The 8-bit DMA mode provides full compatibility with programs written for the GP488 series boards. The digital I/O section of this board provides 40 digital I/O lines which can be programmed for a mix of input and output.
- **MP488CT** interface board (for PC/XT/AT and PS/2 with the ISA bus): Features eleven jumper-selectable interrupt lines. Three 16-bit and four 8-bit jumper-selectable DMA channels are also available. The 8-bit DMA mode provides full compatibility with programs written for the GP488 series boards. The digital I/O section of this board provides 40 input or output lines which can be programmed for a mix of input and output. The counter/timer section features a programmable clock generator plus 5 fully independent versatile counter/timer channels.
- **GP488/2** interface board (for Personal Systems/2 with MicroChannel architecture): Features seven software selectable interrupt lines and fourteen 8-bit software selectable DMA arbitration levels.
- **GP488B/MM** interface board: Converts your Ampro PC/104 Single Board PC into an IEEE 488.2 compliant controller or peripheral.
- **NB488** external interface module (for notebook, laptop and desktop PCs): Connects to a PC's parallel port eliminating the need for an internal expansion slot.

Driver488 Software Interface

Driver488 is the software interface between DOS or Windows and the IEEE 488 controller board. Driver488 software includes the driver itself, an installation program, other utility programs, and programming examples. Driver488 provides a full implementation of the IEEE 488.2 standard, plus advanced capabilities such as high-speed DMA data transfers, interrupt vectoring on specified events, automatic error detection, callable subroutines, and serial (COM) port support.

Driver488 monitors all IEEE 488 bus monitoring and control lines and generates an interrupt based on `SRQ` status and various other bus conditions. Driver488 software supports automatic program vectoring to service routines for C, Pascal, and BASIC. On a specified event (**`Error, SRQ, Peripheral, Controller, Trigger, Clear, Talk, Listen, Idle, ByteIn, ByteOut, Change`**), Driver488 can either call a specified application routine or simulate a light pen interrupt to signal that the event has occurred.

Versions with HP-style character commands can be accessed by virtually any language that can communicate with DOS files, and additionally provide standard DOS device driver interfaces which permit communications with the IEEE 488 bus and/or connected devices in the same manner as LPT1, COM1, etc. Versions with the Subroutine API offer higher performance and can be used with most popular C, Pascal, and Basic languages. The Driver488 commands and bus protocol are very similar to those used by the Hewlett-Packard HP-85 controller.

Versions of Driver488 are described in the following text and table.

- **Driver488/DRV**: The industry's easiest-to-use IEEE 488.2 driver, offering HP-style commands, support for all programming languages and spread sheets, and features such as automatic program vectoring on **SRQ**.
- **Driver488/SUB** : A subroutine-style IEEE 488.2 driver that provides all the function of Driver488/DRV, as well as high performance for fast, interrupt-driven programmed I/O operations.
- **Driver488/W31**: A Dynamic Link Library (DLL) that brings IEEE 488.2 control to Microsoft Windows 16-bit applications. Includes support for Visual Basic, C, Quick C, Turbo C and Borland C++.
- **Driver488/W95**: A Dynamic Link Library (DLL) that brings IEEE 488.2 control to Microsoft Windows 95 for 32-bit applications. Pending software revisions, it includes support for Microsoft C, Visual Basic, and Borland C++.
- **Driver488/WNT**: A Dynamic Link Library (DLL) that brings IEEE 488.2 control to Windows NT version 3.1 or 3.5 applications. Pending software revisions, it includes support for Windows NT SDK, or C language compiler Visual Basic 4.
- **Driver488/LIB**: An IEEE 488.2 library of C function calls that link directly to your application for maximum speed with minimal memory requirements, adding as few as as 25 Kbytes to a compiled program. Available with an optional license that allows unlimited copies of compiled applications.
- **Driver488/OEM**: A compact IEEE 488.2 function-call library that enables quick and easy integration of IEEE 488.2 capability into PC-based instruments.
- **Driver488/IUX**: A high performance IEEE 488.2 driver for running Interactive Systems UNIX System V and AT&T UNIX STREAMS.
- **Driver488/SCX**: A high performance driver for SCO UNIX System V and AT&T UNIX STREAMS.

Driver488 Family Overview

Driver488 Driver Type	**Description**	**Compatible Operating System**	**Compatible Languages**	**Driver Architecture**	**COM Support**	**Power488 Digital I/O & Counter-Timer Support**
W95[1]	High performance driver for Windows 95	Microsoft Windows 95	C, C++ for Windows & Visual Basic	Dynamic Link Library (DLL)	No	No
WNT[1]	High performance driver for Windows NT	Microsoft Windows NT	C	Dynamic Link Library (DLL)	No	No
W31	High performance driver for Windows	Microsoft Windows 3.x	C & Visual Basic	Dynamic Link Library (DLL)	No	Yes
SUB	Higher performance driver for subroutine-style programming.	DOS	C, Pascal, & QuickBASIC	Memory resident	Yes	Yes
DRV	Device driver, compatible with all languages	DOS	All, including spreadsheets	Memory resident	Yes	Yes
LIB[2]	Fast, compact, no resident driver.	DOS	C	Linkable function calls	No	No
OEM[2]	Specially designed to operate as an IEEE 488.2 peripheral.	DOS[3]	C	Linkable function calls	Optional	No
IUX[2] SCX[2]	For Interactive Systems & SCO UNIX.	UNIX	C	Memory resident.	No	No

[1] Note: Driver488/W95 and Driver488/WNT are minimally discussed in this manual, pending current software revisions. Refer to your operating system header file for the latest available information specific to your application.

[2] Note: Driver488/LIB, OEM, IUX, and SCX are not discussed in this manual. These drivers are shipped with their respective manuals.

[3] Note: Call the factory regarding Driver488/OEM compatibility with other operating systems.

Interface & Interface Board Specifications

Note 1: The IOT7210 IEEE 488 Controller Chip is 100% compatible with the NEC μPD7210 chip and exhibits better performance, as well as lower power consumption.

Note 2: Specifications subject to change without notice.

IEEE 488.1-1987 Interface

SH1, AH1, T6, TE0, L4, LE0, SR1, PP0, RL0, DC1, DT1, E1/2
Controller Subsets: C1, C2, C3, C4 and C9
Terminator: Software selectable characters and/or `EOI`
Connector: Standard Amphenol 57-20240 with metric studs

IEEE 488.2-1987 Interface

IEEE 488 Bus Readback Registers: `NDAC`, `NRFD`, `DAV`, `EOI`, `SRQ`
Bus Error Handling

GP488B Interface Board

IEEE 488 Controller Device: IOT7210 (See Note)
Power Consumption: 750mA max @ 5V from PC supply
Dimensions: Occupies one short PC slot size (5.25" long, plus IEEE 488 connector)
Speed: 8-bit DMA: 330K byte/s (reads); 220K byte/s (writes)
Environment: 0 to 50° C, 0 to 95% RH, non-condensing
DMA Capability: 8-bit on channels 0 - 3
Interrupt Capability: IRQ 2 - 7
I/O Base Address: `&H02E1`, `&H22E1`, `&H42E1`, or `&H62E1`

AT488 Interface Board

IEEE 488 Controller Device: IOT7210 (See Note)
Power Consumption: 750mA max @ 5V from PC supply
Dimensions: Occupies one short PC slot size (5.25" long, plus IEEE 488 connector)
Speed: 16-bit DMA: 1M byte/s (reads); 800K byte/s (writes).8-bit DMA: 330K byte/s (reads); 220K byte/s (writes)
Environment: 0 to 50° C, 0 to 95% RH, non-condensing
DMA Capability: Channels 1 - 3 (8 - bit) are selectable in a PC/XT or PC/AT.Channels 0 - 3 (8 - bit) and 5 - 7 (16 - bit) are selectable in a PC/AT. Multiple AT488 boards may share the same DMA channel.
Interrupt Capability: IRQ 2 - 7 for PC/XT, IRQ 2 - 7, 9, 10 - 12, 14, or 15 for PC/AT 16-bit slot
I/O Base Address: `&H02E1`, `&H22E1`, `&H42E1`, or `&H62E1`

MP488 Interface Board

IEEE 488 Controller Device: IOT7210 (See Note)
Power Consumption: 2A max @ 5V from PC supply
Dimensions: Occupies one 16-bit PC/AT full slot or 8-bit PC/XT full slot. Fits in PC/ATwith low PC/XT form-factor. 13.13" long x 3.9" high (333mm x 99mm).
Speed: 16-bit DMA: 1M byte/s (reads); 800K byte/s (writes).8-bit DMA: 330K byte/s (reads); 220K byte/s (writes)
Environment: 0 to 50° C, 0 to 95% RH, non-condensing
DMA Capability: Channels 1-3 (8-bit) are selectable in a PC/XT or PC/AT.Channels 0-3 (8-bit) and 5-7 (16-bit) are selectable in a PC/AT. Multiple MP488 boards may share the same DMA channel.
Interrupt Capability: IRQ 2-7 for PC/XT, IRQ 2 - 7, 9, 10 - 12, 14, or 15 for PC/AT 16-bit slot
I/O Base Address: `&H02E1`, `&H22E1`, `&H42E1`, or `&H62E1`
Digital I/O: 40 digital I/O lines; 24 configurable as input or output, 8 fixed input,and 8 fixed output lines.

MP488CT Interface Board

IEEE 488 Controller Device: IOT7210 (See Note)
Power Consumption: 2A max @ 5V from PC supply
Dimensions: Occupies one 16-bit PC/AT full slot or 8-bit PC/XT full slot. Fits inPC/AT with low PC/XT form-factor. 13.13" long x 3.9" high (333mm x 99mm).
Speed: 16-bit DMA: 1M byte/s (reads); 800K byte/s (writes).8-bit DMA: 330K byte/s (reads); 220K byte/s (writes)
Environment: 0 to 50° C, 0 to 95% RH, non-condensing
DMA Capability: Channels 1-3 (8-bit) are selectable in a PC/XT or PC/AT. Channels 0-3 (8-bit) and 5-7 (16-bit) are selectable in a PC/AT.Multiple MP488 boards may share the same DMA channel.
Interrupt Capability: IRQ 2 - 7 for PC/XT, IRQ 2 - 7, 9, 10 - 12, 14, or 15 for PC/AT 16-bit slot
I/O Base Address: **`&H02E1`**, **`&H22E1`**, **`&H42E1`**, or **`&H62E1`**
Digital I/O: 40 digital I/O lines; 24 configurable as input or output, 8 fixed input, 8 fixed output lines.
Counter/Timer: AMD Am9513A, 1 frequency output, 5 counter/timers.
Counter/Timer Frequency: DC - 7 MHz.
Internal Timebase: Up to 1 MHz, accuracy of 0.01%.

GP488/2 Interface Board

IEEE 488 Controller Device: IOT7210 (See Note)
Power Consumption: 1A max @ 5V from PC supply.
Dimensions: Occupies one full length slot in a MicroChannel bus.
Speed: 8-bit DMA: 330K byte/s (reads); 220K byte/s (writes).
Environment: 0 to 50° C, 0 to 95% RH, non-condensing
DMA Capability: 8-bit on channels 0 through 14
Interrupt Capability: IRQ 4, 5, 6, 7, 10, 11, or 15.

GP488/MM Interface Board

IEEE 488 Controller Device: IOT7210 (See Note)
Maximum Transfer Rate: 330K byte/s (reads and writes)
Connector: 26-pin header ribbon cable to standard IEEE 488 connectors
Environment: 0 to 70° C; 0 to 95% RH (non-condensing)
DMA Capability: Channels 0, 1, 2., or 3 (jumper selectable)
Interrupts: IRQ 2, 3, 4, 5, 6, or 7
IEEE Base I/O Addresses: **`&H02E1`**, **`&H22E1`**, **`&H42E1`**, or **`&H62E1`**

NB488 Interface Module

Speed: 170 Kbyte/s (reads and writes)
Dimensions: 5.5" x 4" x 1.5"
IEEE 488 Connector: Accepts standard IEEE 488 connector with metric studs
Parallel Port Input Connector: Male DB25
Parallel Port Output Connector to Printer IEEE: Female DB25
Instrument Fan-out: Can control up to 14 IEEE instruments
Power: 400-500 mA at 5 VDC from PC keyboard port or 7-15 VDC at 400-500 mA from external power source
Environment: 0 to 70° C; 0 to 95% RH (non-condensing)

PCMCIA Interface Card

Speed: 1.0M byte/s
Dimensions: Type II (5 mm) PCMCIA Card
Power: 100 mA
I/O: 16-byte, relocatable

2. Personal488 (with GP488B)

Topics

The Package

Personal488, including the IEEE 488 interface board and the Driver488 software, is carefully inspected, both mechanically and electrically, before shipment. When you receive the product, unpack all items carefully from the shipping carton and check for any obvious signs of physical damage that may have occurred during shipment. Report any such damage to the shipping agent immediately. Remember to retain all shipping materials in the event shipment back to the factory becomes necessary.

For the following software versions, the Personal488 package varies:

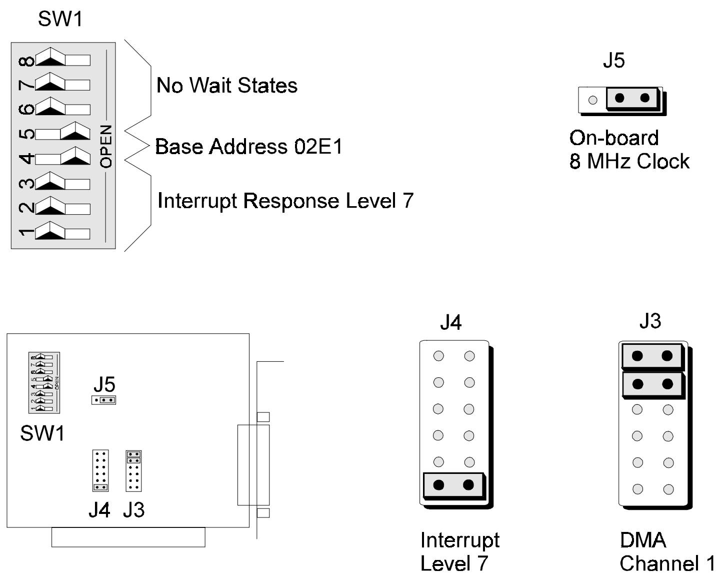
- **Driver488/DRV, SUB, or W31:** This package includes: The GP488B IEEE 488 Bus Interface Board, Driver488 Software Disks (Driver488/DRV, Driver488/SUB, Driver488/W31), and the Personal488 User's Manual.
- **Driver488/W95:** This package includes: The GP488B IEEE 488 Bus Interface Board, Driver488 Software Disks (Driver488/W95), and the Personal488 User's Manual.
- **Driver488/WNT:** This package includes: The GP488B IEEE 488 Bus Interface Board, Driver488 Software Disks (Driver488/WNT), and the Personal488 User's Manual.

Hardware Installation (for PC/XT/AT)

Installation & Configuration of the Interface Card

The following paragraphs explain configuration and physical installation of the interface card. Software installation and setup are covered in a separate section. After configuring your board, please make note of the following. This information is needed for Driver488 software installation.

- I/O Base Address
- Interrupt Channel
- DMA channel, if applicable
- Whether or not the board is the System Controller



GP488B Default Settings

Note: The GP488B, as illustrated, has one DIP switch, two 12-pin headers and one 3-pin header, labeled SW1, J3, J4, and J5, respectively. The DIP switch setting, along with the arrangement of the jumpers on the headers, set the hardware configuration.

Default Settings

The figure indicates the GP488B default configuration. Notice that SW1 controls the wait state generation, the I/O base address and interrupt response level, J4 sets the interrupt request level, J3 selects the DMA channel, and J5 selects the clock source.

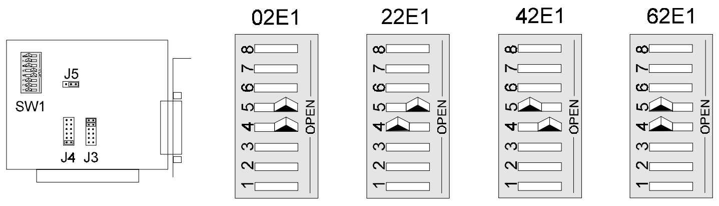
I/O Base Address Selection

The I/O base address sets the addresses used by the computer to communicate with the IEEE 488 interface hardware on the board. The address is normally specified in hexadecimal and can be `02E1`, `22E1`, `42E1`, or `62E1`. The registers of the IOT7210 IEEE 488 controller chip and other auxiliary registers are then located at fixed offsets from the base address.

Most versions of Driver488 are capable of managing as many as four IEEE 488 interface boards. To do so, the board configurations must be arranged to avoid conflict among themselves. No two boards may have the same I/O address, but they may, and usually should, have the same DMA channel and interrupt level.

The factory default I/O base address is `02E1`. To use another, set SW1 switches 4 and 5 according to the following table and figure.

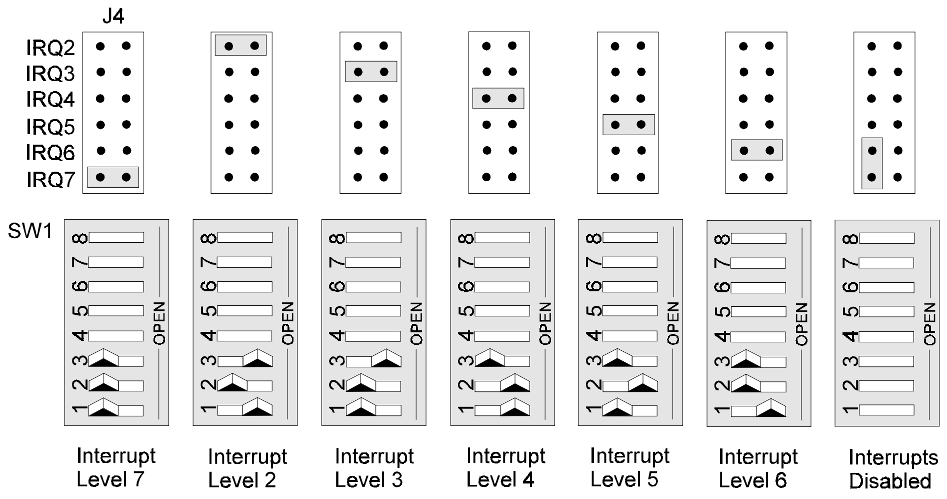
I/O Base Address				**Register**	
02E1	22E1	42E1	62E1	**Read Register**	**Write Register**
02E1	22E1	42E1	62E1	Data In	Data Out
06E1	26E1	46E1	66E1	Interrupt Status 1	Interrupt Mask 1
0AE1	2AE1	4AE1	6AE1	Interrupt Status 2	Interrupt Mask 2
0EE1	2EE1	4EE1	6EE1	Serial Poll Status	Serial Poll Mode
12E1	32E1	52E1	72E1	Address Status	Address Mode
16E1	36E1	56E1	76E1	CMD Pass Through	Auxiliary Mode
1AE1	3AE1	5AE1	7AE1	Address 0	Address 0/1
1EE1	3EE1	5EE1	7EE1	Address 1	End of String



GP488 I/O Base Address Settings, SW1 Configurations

Interrupt Selection

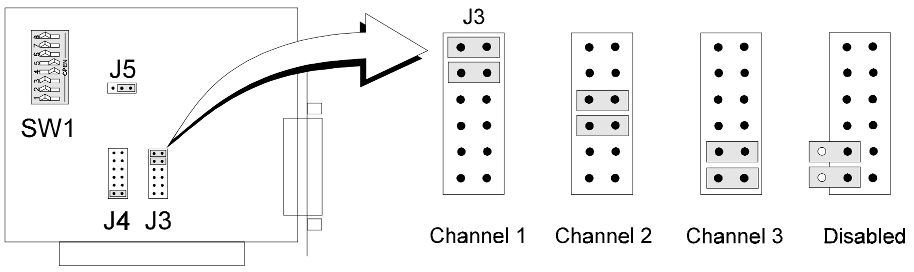
The GP488B interface board may be set to interrupt the PC on the occurrence of certain hardware conditions. The level of the interrupt generated is set by J4. The GP488B adheres to the "AT-style" interrupt sharing conventions. When an interrupt occurs, the interrupting device must be reset by writing to I/O address **`02FX`**, where X is the interrupt level (from 0-7). This interrupt response level is set by switches 1, 2, and 3 of SW1 which must be set to correspond to the J4 interrupt level setting. Interrupt selection is illustrated in the following figure.



GP488B Interrupt Selection

DMA Channel Selection

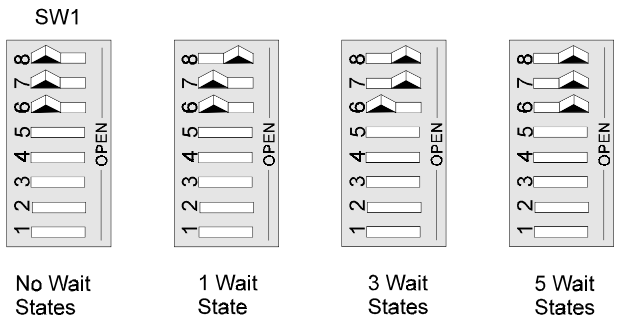
Direct Memory Access (DMA) is a high-speed method of transferring data from or to a peripheral, such as a digitizing oscilloscope, to or from the PC's memory. The PC has four DMA channels, but channel 0 is used for memory refresh and is not available for peripheral data transfer. Channel 2 is usually used by the floppy disk controller, and is also unavailable. Channel 3 is often used by the hard disk controller in PCs, XTs, and the PS/2 with the ISA bus, but is usually not used in ATs. So, depending on your hardware, DMA channels 1 and possibly 3 are available. Under some rare conditions, it is possible for high-speed transfers on DMA channel 1 to demand so much of the available bus bandwidth that simultaneous access of a floppy controller will be starved for data due to the relative priorities of the two channels. Configure the board according to which DMA channel, if any, is available.



GP488B DMA Selection

Wait State Configuration

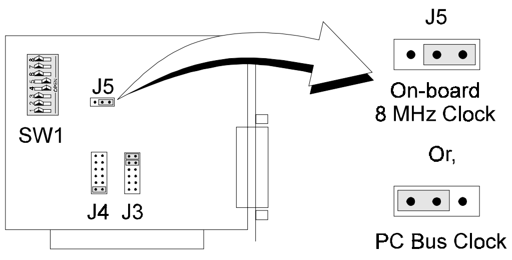
The GP488B is fast enough to be compatible with virtually every PC/XT/AT-compatible computer on the market. Even if the computer is very fast, the processor is normally slowed to 8MHz or below when accessing the I/O channel. If the I/O channel runs faster than 8 MHz, it may be faster than the GP488B card. If you suspect this is a problem, the computer can be made to wait for the GP488B by enabling wait states. Increasing the number of wait states slows down access to the GP488B card, but the overall performance degradation is usually only a few percent.



GP488B Wait State Configurations

Internal Clock Selection

The IEEE 488 bus interface circuitry requires a master clock. This clock is normally connected to an on-board 8 MHz clock oscillator. However, some compatible IEEE 488 interface boards connect this clock to the PC's own clock signal. Using the PC clock to drive the IEEE 488 bus clock is not recommended because the PC clock frequency depends on the model of computer. A standard PC has a 4.77 MHz clock, while an AT might have a 6 MHz or 8 MHz clock. Other manufacturers' computers may have almost any frequency clock. If you are using a software package designed for an interface board (that derived its clock from the PC clock) and you need to do the same to use GP488B with that particular software, the clock source can be changed. However, the clock frequency must never be greater than 8 MHz, and clock frequency must be correctly entered in the Driver488 software.



GP488B Internal Clock Settings, via J5

Board Installation

The IEEE 488 interface board(s) are installed into expansion slots inside the PC's system unit. PC/AT-compatible computers have two types of expansion slots: 8-bit (with one card-edge receptacle), and 16-bit (with two card-edge receptacles). Eight-bit boards, such as the IEEE 488 interface boards, may be used in either type of slot, 8- or 16-bit. Some machines may have special 32-bit memory expansion slots which should not be used for IEEE 488 interface boards.

Install each IEEE 488 interface board into the expansion slots as follows: Ensure the PC is turned off and unplug the power cord. Remove the cover mounting screws from the rear of the PC system unit. Remove the system unit cover by sliding it forward and tilting it upward.

A rear panel opening is provided at the end of each expansion slot for mounting I/O connectors. If a slot is unused, this opening is covered by a metal plate held in place with a screw. Remove this screw and the cover plate from the desired expansion slot, saving the screw.

Insert the IEEE 488 interface board carefully into the expansion slot, fitting the IEEE 488 connector through the rear panel opening, and inserting its card edge into the motherboard card edge receptacle. With the board firmly in place, fix its mounting bracket to the rear panel, using the screw removed from the cover plate.

Slide the system unit cover back on, re-attaching it with the screws. Plug the power cord in and turn on the PC. If all is well, the system should boot normally. If not, carefully check that none of the I/O addresses conflict with any other devices or boards. If you are not sure, contact your PC's dealer or manufacturer.

3. Personal488/AT

Topics

The Package

Personal488/AT, including the IEEE 488 interface board and the Driver488 software, is carefully inspected, both physically and electronically, before shipment. When you receive the product, unpack all items carefully from the shipping carton and check for any obvious signs of physical damage that may have occurred during shipment. Report any such damage to the shipping agent immediately. Remember to retain all shipping materials in the event shipment back to the factory becomes necessary.

The Personal488/AT includes:

- AT488 IEEE Bus Interface Board
- Driver488 Software Disks
  (Driver488/DRV, Driver488/SUB, Driver488/W31, & Driver488W95)
- Personal488 User's Manual

Hardware Installation (for PC/XT/AT)

Installation & Configuration of the Interface Card

The following paragraphs explain configuration and physical installation of the interface card. Software installation and setup are covered in a separate section. After configuring your board, please make note of the following: the I/O Base Address, the interrupt channel, the DMA channel, if any, and whether or not the board is the System Controller. This information is needed for Driver488 software installation.

The Personal488/AT has two DIP switches (S1 and S2), and three 14-pin headers (IRQ, DACK and DRQ). The DIP switch settings, along with the arrangement of the jumpers on the headers, set the hardware configuration.

Default Settings

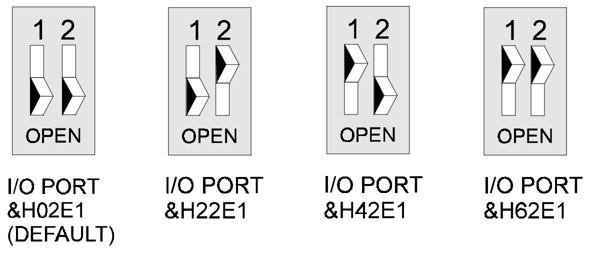
Notice that S1 and IRQ set the interrupt response level, S2 controls the I/O base address, and DACK and DRQ select the DMA channel.

I/O Base Address Selection

The I/O base address sets the addresses used by the computer to communicate with the IEEE 488 interface hardware on the board. The address is normally specified in hexadecimal and can be `02E1`, `22E1`, `42E1`, or `62E1`. The registers of the IOT7210 IEEE 488 controller chip and other auxiliary registers are then located at fixed offsets from the base address.

Most versions of Driver488 are capable of managing as many as four IEEE 488 interface boards. To do so, the board configurations must be arranged to avoid conflict among themselves. No two boards may have the same I/O address, but they may, and usually should, have the same DMA channel and interrupt level.

The factory default I/O base address is `02E1`. To use a different base address, set S2 according to the figure.

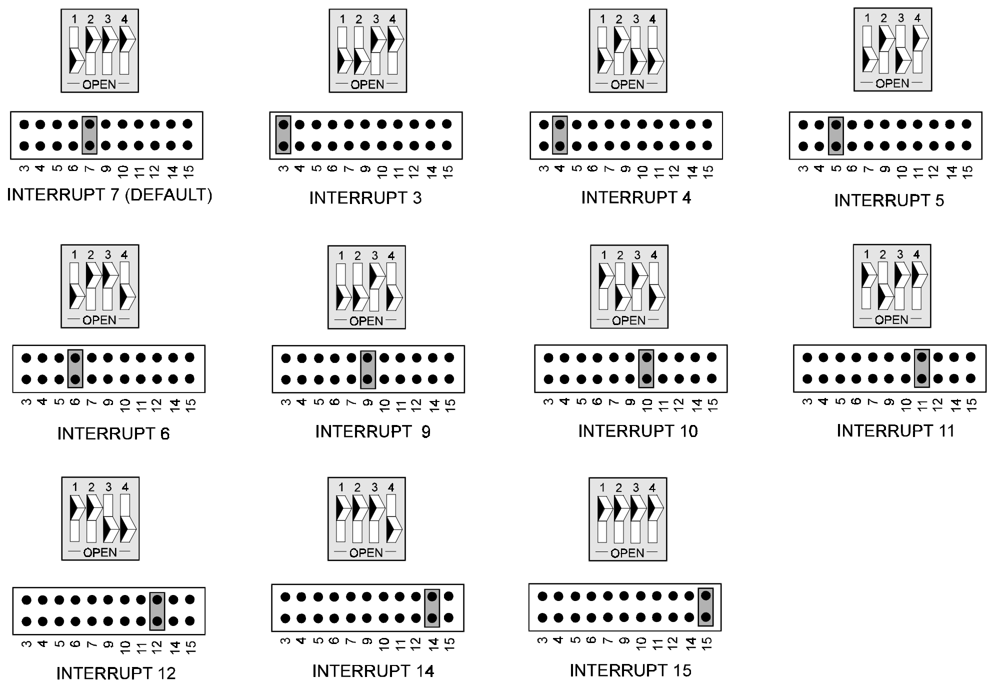


Personal488/AT I/O Base Address Settings

I/O Base Address				Register	
`02E1`	`22E1`	`42E1`	`62E1`	**Read Register**	**Write Register**
`02E1`	`22E1`	`42E1`	`62E1`	Data In	Data Out
`06E1`	`26E1`	`46E1`	`66E1`	Interrupt Status 1	Interrupt Mask 1
`0AE1`	`2AE1`	`4AE1`	`6AE1`	Interrupt Status 2	Interrupt Mask 2
`0EE1`	`2EE1`	`4EE1`	`6EE1`	Serial Poll Status	Serial Poll Mode
`12E1`	`32E1`	`52E1`	`72E1`	Address Status	Address Mode
`16E1`	`36E1`	`56E1`	`76E1`	CMD Pass Through	Auxiliary Mode
`1AE1`	`3AE1`	`5AE1`	`7AE1`	Address 0	Address 0/1
`1EE1`	`3EE1`	`5EE1`	`7EE1`	Address 1	End of String

Interrupt Selection

The AT488 interface board may be set to interrupt the PC on the occurrence of certain hardware conditions. The main board interrupt may be set to IRQ level 3 through 7, 9 through 12, 14, or 15.

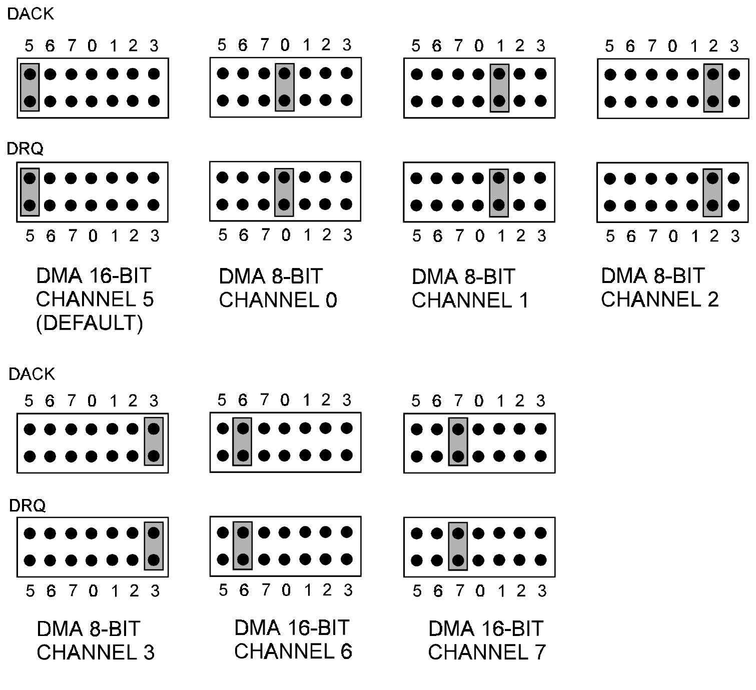


Personal488/AT Interrupt Selection

Interrupts 10 through 15 are only available in a 16-bit slot on an AT-class machine. Interrupt 9 becomes synonymous with interrupt 2 when used in a PC/XT bus. The selected interrupt may be shared among several AT488s in the same PC/AT chassis. The AT488 adheres to the "AT-style" interrupt sharing conventions. When the AT488 requires service, the IRQ jumper determines which PC interrupt level is triggered. When an interrupt occurs, the interrupting device must be reset by writing to an I/O address which is different for each interrupt level. The switch settings determine the I/O address to which the board's interrupt rearm circuitry responds. The IRQ jumper and switch settings must both indicate the same interrupt level for correct operation with interrupts. The previous figure shows the settings for selected interrupts.

DMA Channel Selection

Direct Memory Access (DMA) is a high-speed method of transferring data from or to a peripheral, such as a digitizing oscilloscope, to or from the PC's memory. The AT class machine has seven DMA channels. Channels 0-3 (8-bit), 5, 6, and 7 (16-bit) are available only in a 16-bit slot on a PC/AT-class machine. Channel 2 is usually used by the floppy disk controller, and is unavailable. Channel 3 is often used by the hard disk controller in PCs, XTs, and the PS/2 with the ISA bus, but is usually not used in ATs. Channels 5 through 7 are 16-bit DMA channels. They offer the highest throughput (up to 1 Megabyte per second). Channels 0 through 3 are 8-bit DMA channels. Although slower, they offer compatibility with existing GP488B applications that only made use of 8-bit DMA channels. Under some rare conditions, it is possible for high-speed transfers on DMA channel 1 to demand so much of the available bus bandwidth that simultaneous access of a floppy controller will be starved for data due to the relative priorities of the two channels. Both the DRQ and DACK jumpers must be set to the desired DMA channel for proper operation. Configure the board according to which DMA channel is available. The following figure shows settings for selecting the DMA channels.



Personal488/AT DMA Selection

Board Installation

The IEEE 488 interface board(s) are installed into expansion slots inside the PC's system unit. PC/AT-compatible computers have two types of expansion slots: 8-bit (with one card-edge receptacle), and 16-bit (with two card-edge receptacles). Eight-bit boards, such as the IEEE 488 interface boards, may be used in either type of slot, 8- or 16-bit. Some machines may have special 32-bit memory expansion slots which should not be used for IEEE 488 interface boards.

Install each IEEE 488 interface board into the expansion slots as follows: Ensure the PC is turned off and unplug the power cord. Remove the cover mounting screws from the rear of the PC system unit. Remove the system unit cover by sliding it forward and tilting it upward.

A rear panel opening is provided at the end of each expansion slot for mounting I/O connectors. If a slot is unused, this opening is covered by a metal plate held in place with a screw. Remove this screw and the cover plate from the desired expansion slot, saving the screw.

Insert the IEEE 488 interface board carefully into the expansion slot, fitting the IEEE 488 connector through the rear panel opening, and inserting its card edge into the motherboard card edge receptacle. With the board firmly in place, fix its mounting bracket to the rear panel, using the screw removed from the cover plate.

Slide the system unit cover back on, re-attaching it with the screws. Plug the power cord in and turn on the PC. If all is well, the system should boot normally. If not, carefully check that none of the I/O addresses conflict with any other devices or boards. If you are not sure, contact your PC’s dealer or manufacturer.

4. Personal488/NB

Topics

The Package

Personal488/NB, including the IEEE 488 interface hardware and the Driver488 software, is carefully inspected, both mechanically and electrically, before shipment. When you receive the product, unpack all items carefully from the shipping carton and check for any obvious signs of physical damage that may have occurred during shipment. Report any such damage to the shipping agent immediately. Remember to retain all shipping materials in the event shipment back to the factory becomes necessary.

Personal488/NB includes:

- NB488 IEEE 488 Bus Interface Board
- Driver488 Software Disks (Driver488/DRV, Driver488/SUB & Driver488/W31)
- Printer Port to Interface Cable (CA-35-2)
- Keyboard Port Power Adapter (CA-107)
- AC Power Adapter (TR-2)
- DIN-5 to DIN-6 Adapter (CN-15-6) for CA-107 (Optional; Contact factory if required)
- Driver488 User's Manual

Hardware Installation (for Notebook, Laptop, & Desktop PCs)

Personal488/NB does not need to be disassembled during installation, as there are no internal switches or controls to set. Simply connect the Personal488/NB to any PC parallel printer port (female DB25) by unplugging the printer cable and plugging the supplied cable's (CA-35-2) male end into the computer and the female end into the mating connector on the Personal488/NB. Any printer port: **`LPT1`**, **`LPT2`**, or **`LPT3`** may be used, but should be noted for future software installation. Next connect the IEEE 488 cable to the mating connector on the Personal488/NB.

Personal488/NB allows for LPT pass-through for simultaneous IEEE 488 instrument control and printer operation. When using a printer in the system configuration, attach the original printer cable (male DB25) into the remaining mating connector on the Personal488/NB.

The Personal488/NB may be powered with a supplied cable (CA-107) from the PC's keyboard port or via a supplied external power unit (TR-2) that plugs into any standard AC wall outlet.

If powering the unit through the PC keyboard port, attach the supplied power cord to the keyboard port and connect to the power jack on the Personal488/NB. If using an AC power adapter, plug it into a 120 VAC outlet and attach the low voltage end to the jack on the Personal488/NB. The POWER LED should now be on and hardware installation complete.

At power-on, the printer should behave normally and can be checked by issuing a **`Print Screen`** command (or any other convenient method of checking the printer). However, installation of the software will be necessary before the Personal488/NB can communicate with IEEE 488 instruments.

Once the NB488 is installed, a utility program has been included to help identify the LPT port type. Software installation requires the user to specify whether the LPT port is a standard IBM PC/XT/AT/PS/2 compatible port or a slower 4-bit option. Type **`NBTEST.EXE`** to run this program.

5. Personal488/MM

Topics

The Package

Personal488/MM, including IEEE 488 interface board and Driver488 software, is carefully inspected, both physically and electronically, before shipment. When you receive the product, carefully remove all items carefully from the shipping carton and check for any obvious signs of physical damage that may have occurred during shipment. Report any such damage to the shipping agent immediately. Remember to retain all shipping materials in the event shipment back to the factory becomes necessary.

The Personal488/MM includes:

- GP488/MM IEEE 488 Bus Interface Board
- Driver488 Software Disks
  (Driver488/DRV, Driver488/SUB, Driver488/W31 & Driver488/W95)
- Personal488 User's Manual

Hardware Installation (for PC/XT/AT)

Installation & Configuration of the Interface Card

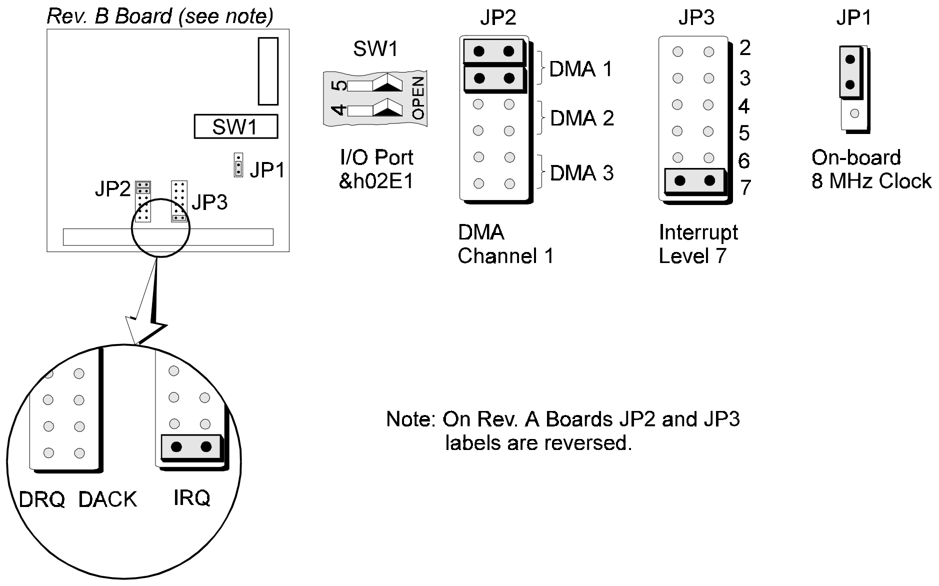
The following paragraphs explain configuration and physical installation of the interface card. Software installation and setup are covered in a separate section. After configuring your board, please make note of the following. This information is needed for Driver488 software installation.

- I/O Base Address
- Interrupt Channel
- DMA channel, if applicable
- Whether or not the board is the System Controller

Note: The GP488/MM is only compatible with the Ampro PC/104. The board includes one DIP switch, two 12-pin headers and one 3-pin header, labeled SW1, JP2, JP3, and JP1, respectively. The DIP switch setting, along with the arrangement of the jumpers on the headers, set the hardware configuration.

Default Settings

There are presently two revision levels of GP488/MM board, Rev. A and Rev. B. The following figure indicates the GP488/MM default configuration on a Rev. B board. The configuration is the same for



GP488/MM Default Settings

Rev. A, however, on Rev. A boards the JP2 and JP3 labels are reversed from that illustrated. Switch SW1 controls the wait state generation and the I/O base address and interrupt response level. On the Rev. B board, JP2 sets the interrupt request level and JP3 selects the DMA channel. On Rev. A boards, the JP2 and JP3 labels are reversed from those shown in the following diagram. For both board revision levels JP1 selects the clock source.

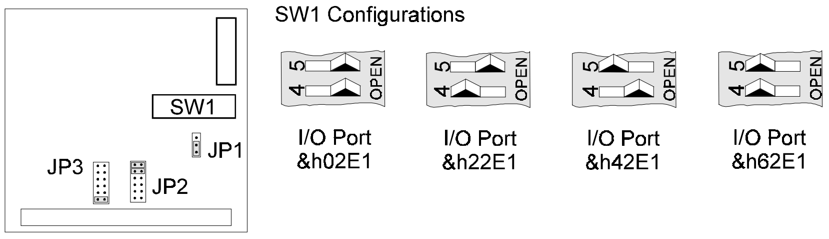
I/O Base Address Selection

The I/O base address sets the addresses used by the computer to communicate with the IEEE 488 interface hardware on the board. The address is normally specified in hexadecimal and can be **`02E1`**, **`22E1`**, **`42E1`**, or **`62E1`**. The registers of the IOT7210 IEEE 488 controller chip and other auxiliary registers are then located at fixed offsets from the base address.

Most versions of Driver488 are capable of managing as many as four IEEE 488 interface boards. To do so, the board configurations must be arranged to avoid conflict among themselves. No two boards may have the same I/O address, but they may, and usually should, have the same DMA channel and interrupt level.

The factory default I/O base address is **`02E1`**. To use another, set SW1 switches 4 and 5 according to the following table and figure.

I/O Base Address				Register	
02E1	22E1	42E1	62E1	**Read Register**	**Write Register**
02E1	22E1	42E1	62E1	Data In	Data Out
06E1	26E1	46E1	66E1	Interrupt Status 1	Interrupt Mask 1
0AE1	2AE1	4AE1	6AE1	Interrupt Status	Interrupt Mask 2
0EE1	2EE1	4EE1	6EE1	Serial Poll Status	Serial Poll Mode
12E1	32E1	52E1	72E1	Address Status	Address Mode
16E1	36E1	56E1	76E1	CMD Pass Through	Auxiliary Mode
1AE1	3AE1	5AE1	7AE1	Address 0	Address 0/1
1EE1	3EE1	5EE1	7EE1	Address 1	End of String

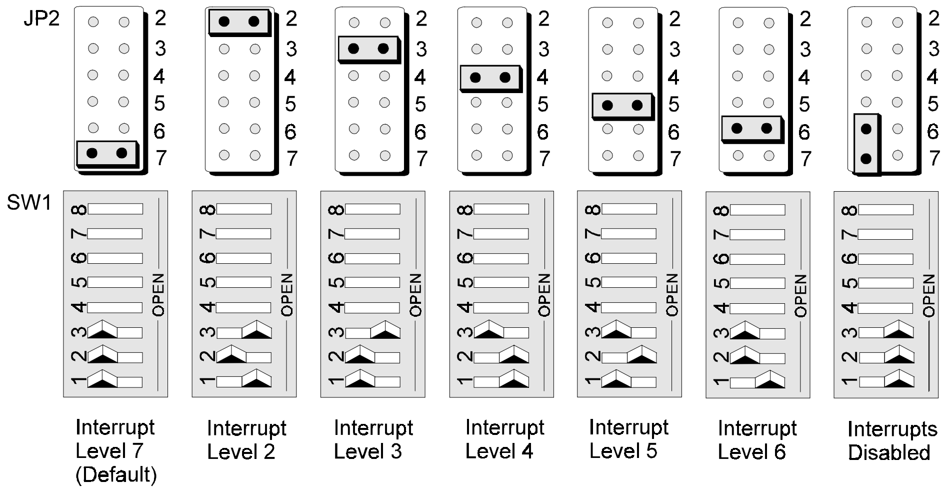


GP488/MM I/O Base Address Settings

Interrupt Selection

The GP488/MM interface board may be set to interrupt the PC on the occurrence of certain hardware conditions. The level of the interrupt generated is set by JP3 on Rev. B boards (JP2 on Rev. A boards). The GP488/MM interface board adheres to the “AT-style” interrupt sharing conventions. When an interrupt occurs, the interrupting device must be reset by writing to I/O address `02FX`, where X is the interrupt level (from 0-7). This interrupt response level is set by switches 1, 2, and 3 of SW1 which must be set to correspond to the JP3 (Rev. B board) interrupt level setting. Interrupt selection for a Rev. B board is illustrated in the following figure.

Note: The jumper label would read JP2 for Rev. A boards.

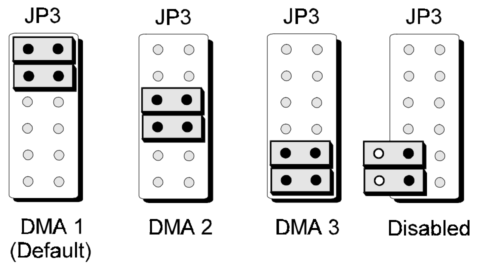


GP488/MM Interrupt Selection

DMA Channel Selection

Direct Memory Access (DMA) is a high-speed method of transferring data from or to a peripheral, such as a digitizing oscilloscope, to or from the PC’s memory. The factory default selection is DMA channel 1. Note that jumper JP2 is used to configure revision B boards while the jumper labeled JP3 is used to select the DMA channel on version A boards.

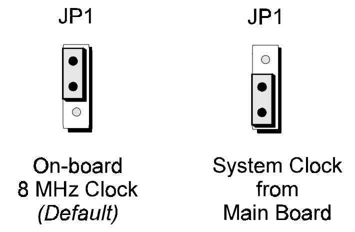
Note: Check your computer documentation to ensure the selected DMA channel is not being used by another device. The GP488B/MM board has circuitry which allows for more than one GP488/MM board to share the same channel. Most computers use DMA channel 2 for floppy disk drives, making that channel unavailable.



GP488/MM DMA Selection

Internal Clock Selection

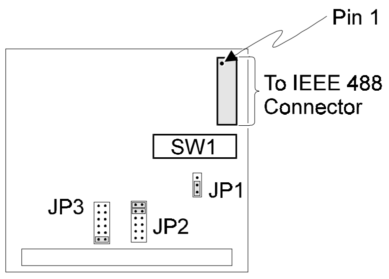
The IEEE 488 bus interface circuitry requires a master clock. This clock is normally connected to an on-board 8 MHz clock oscillator. However, some compatible IEEE 488 interface boards connect this clock to the PC's own clock signal. Using the PC clock to drive the IEEE 488 bus clock is not recommended because the PC clock frequency depends on the model of computer. A standard PC has a 4.77 MHz clock, while an AT might have a 6 MHz or 8 MHz clock. Other manufacturers' computers may have almost any frequency clock. If you are using a software package designed for an interface board (that derived its clock from the PC clock) and you need to do the same to use GP488/MM with that particular software, the clock source can be changed. However, the clock frequency must never be greater than 8 MHz, and clock frequency must be correctly entered in the Driver488 software.



GP488/MM Internal Clock Selection

Board Installation

IEEE 488 interface board(s) are installed into expansion slots inside the PC's system unit. PC/AT-compatible computers have two types of expansion slots: 8-bit (with one card-edge receptacle), and 16-bit (with two card-edge receptacles). Eight-bit boards, such as the IEEE 488 interface boards, may be used in either type of slot, 8- or 16-bit. Some machines may have special 32-bit memory expansion slots which should not be used for IEEE 488 interface boards.



IEEE 488 Connection

Install each IEEE 488 interface board into the expansion slots as follows: Ensure the PC is turned off and unplug the power cord. Remove the cover mounting screws from the rear of the PC system unit. Remove the system unit cover by sliding it forward and tilting it upward.

A rear panel opening is provided at the end of each expansion slot for mounting I/O connectors. If a slot is unused, this opening is covered by a metal plate held in place with a screw. Remove this screw and the cover plate from the desired expansion slot, saving the screw.

Insert the IEEE 488 interface board carefully into the expansion slot, fitting the IEEE 488 connector through the rear panel opening, and inserting its card edge into the motherboard card edge receptacle. With the board firmly in place, fix its mounting bracket to the rear panel, using the screw removed from the cover plate.

Slide the system unit cover back on, re-attaching it with the screws. Plug the power cord in and turn on the PC. If all is well, the system should boot normally. If not, carefully check that none of the I/O addresses conflict with any other devices or boards. If you are not sure, contact your PC's dealer or manufacturer.

6. Personal488/CARD

Topics

The Package

The Personal488/CARD components were carefully inspected prior to shipment. After receiving your order, carefully unpack all items from the shipping carton and check for any signs of physical damage which may have occurred during shipment. Immediately report any damage to the shipping agent.

Retain all shipping materials in case you must return the unit to the factory. If the unit is damaged, a RMA # (Return Material Authorization Number) must be obtained before returning it. An RMA # can be obtained by calling (216) 439-4091 or your sales representative.

Every Personal488/CARD is shipped with the following items:

- IEEE 488 PCMCIA interface Card
- Interface Cable (CA-137)
- Initialization Software: *Client Driver*, and *Enabler*
- Driver Software (Programming Support including Configuration Utilities): Driver488/DRV, Driver488/W31, and Driver488/SUB
- Personal488 User's Manual

Introduction

The Personal488/CARD is a low-power Type II PCMCIA IEEE 488 interface that enables IEEE 488.2 control from notebook and desktop PCs. This card plugs into any Type II (5mm) PCMCIA socket and is PCMCIA PC Card Standard Specification 2.1 compliant. CardSoft^{TM} Card and Socket services are available on the majority of notebook PCs currently sold. If your notebook has different software, you may purchase the CardSoft^{TM} software from the Personal488/CARD manufacturer. The Personal488/CARD does not require an ISA-bus expansion slot or external power.

The Personal488/CARD is highly flexible with respect to I/O addressing and interrupt level use. It can, by default, automatically configure itself upon insertion into your notebook or desktop PC or upon system startup. In addition, users may specify any interrupt level and any I/O space base address for the Personal488/CARD. The card permits "Hot-Swapping", that is, insertion of the PCMCIA card while the system is powered.

Hardware Installation (for Notebook & Desktop PCs)

Hardware installation topics are covered in the following paragraphs. It is strongly suggested that you read and perform the following instructions to assure the proper installation and usage of the Personal488/CARD.

The hardware installation topics include:

- Personal488/CARD-to-Interface Cable connection
- Installation of Personal488/CARD into PC
- Interface Cable connection with IEEE 488 compatible accessories

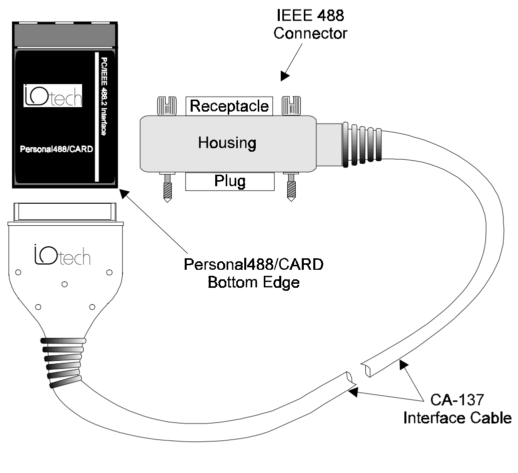
The plug and play operation of the Personal488/CARD allows for the operating parameters to be configured via software, circumventing the need for switch or jumper settings.

Interfaces & Connectors

The Personal488/CARD is shipped with an interface cable (CA-137) that permits the card to directly interface with up to fourteen (14) IEEE 488 instruments.

The PCMCIA card connects to the CA-137 cable via the female slot connector found along its "bottom" edge, as shown in the figure. The unit itself, being a PCMCIA socket card, constitutes a Type II (5mm) PCMCIA socket interface.

The opposite end of the CA-137 Interface Cable is terminated in an IEEE 488 connector with metric studs. A pin-out of this connector is provided below.

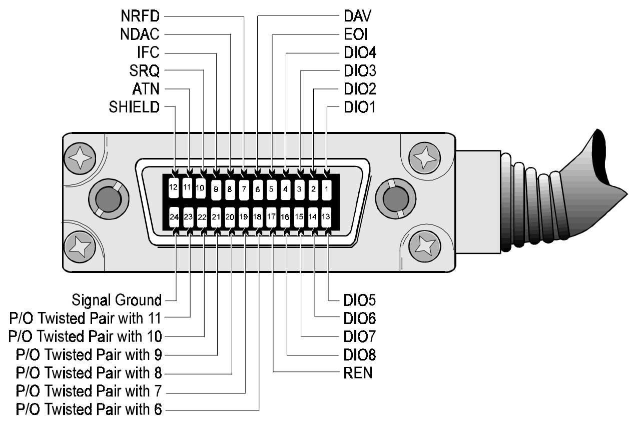


Personal488/CARD and Interface Cable

Interface Cable Connection

Follow the instructions below to connect the Personal488/CARD to the Interface Cable (CA-137).

Note: The PCMCIA Card and the Slot Connector End of the Interface Cable are *keyed* to ensure proper connection. The card and cable should connect easily and fit snug. **DO NOT force the PCMCIA Card / Interface Cable mating.** Refer to the figures on this page while performing these instructions.



IEEE 488 Connector Pin-Out

1. In one hand, hold the PCMCIA Card so that the company logo is face up and the bottom edge of the card is facing you.
2. In the other hand, hold the Slot Connector End of the Interface Cable so that the groove (keyed portion of the connector) is face down and the company logo is face up.
3. Press the Slot Connector into the PCMCIA Card. The Personal488/CARD should now be firmly connected to the Interface Cable.

Note: The slot connector *is keyed to match* the PCMCIA Card so that an improper connection *can not* be made. Therefore, **DO NOT force this connection as damage may result!** For proper contact, the connection of the card and cable must be snug.

Installation into a PC

With your PC powered-down (turned off), install your Personal488/CARD using the instructions provided below.

Note: If the Client Driver Software is used, you are *not required* to power down your PC before installing the Personal488/CARD. The Client Driver Software enables insertion and removal of the card into any Type II socket at any time, and automatically configures the card upon its insertion ("Hot-Swapping").

Note: Enabler Software, on the other hand, does not allow "Hot-Swapping." More detailed information is provided later in this chapter.

Note: "Hot-Swapping" refers to the insertion and removal of the PCMCIA card while the system is powered.

1. With your PC powered down (turned off), insert the PCMCIA Card into the PCMCIA socket with the company logo face up (for most Notebook PCs).
2. Push the PCMCIA Card into the PCMCIA socket as if you were loading a diskette into a diskette drive. Stop once the card is engaged into the socket. This is marked by hearing a "click" and seeing that the socket eject button has been engaged (pushed out).

Note: CardSoft™ Card and Socket Services are available on the majority of notebook PCs currently sold. If your notebook has incompatible software, you may purchase the CardSoft™ software from the Personal488/CARD manufacturer.

Interface Cable & IEEE 488 Accessories

Only IEEE 488 compatible accessories (instruments) can interface with the Personal488/CARD. The Personal488/CARD and cable permit a fan-out of fourteen (14) directly interfaced IEEE 488 instruments.

1. Plug the IEEE 488 connector end of the Interface Cable into any compatible IEEE 488 accessories.
2. With your fingers and/or applicable flat bladed screw driver, tighten the screw pins (metric studs) located on the IEEE 488 connector to secure the connection.

Note: You will need additional IEEE 488 interface cables (terminated at both ends with IEEE 488 connectors) for subsequent IEEE 488 instruments.

At this point, the default configuration of the Personal488/CARD will be used. The default configuration is the initialization of the "CARD" upon system boot-up having *not used the Client Driver or Enabler to make changes to the "CARD's" settings*. Once all connections have been checked for correctness, the "system" can be powered up. If communication problems exist due to initialization conflicts, the Client Driver or Enabler will have to be installed in order to make initialization changes. This subject is covered in the following paragraphs.

Note: The Client Driver or Enabler is needed even if there are no configuration conflicts but a desire to change the Personal488/CARD's configuration to meet predetermined specifications and/or needs.

Software Installation

The Personal488/CARD is provided with both Initialization and Configuration Software (the Configuration Software is driver specific and therefore included with each driver). This text introduces support for the Initialization Software (Client Driver and Enabler). For more information, refer to the driver-specific "Installation & Configuration" Sub-Chapters found in Chapters 8 through 12. The following drivers are available for the Personal488/CARD: Driver488/DRV, Driver488/SUB, and Driver488/W31.

Initialization Software

Initialization of the Personal488/CARD is software oriented. The Client Driver and Enabler files conform to the PCMCIA (PC Card) Card Services Specification 2.1. When used with CardSoft™ Card and Socket Services (or compatible) software, the Personal488/CARD automatically configures itself upon system start-up. The use of CardSoft™ is not required, however, the chosen utility software must be compatible with the PCMCIA (PC Card) Card Services Specification 2.1.

If you need to control which resources the Personal488/CARD utilizes, you must load either the Client Driver or Enabler, *but not both*. The Personal488/CARD's resources are IRQ level, base I/O port address for sixteen consecutive ports, and PCMCIA Type II socket number (with 0 being the first socket).

Using the Client Driver

The Client Driver sets the IRQ, Socket # (if more than one PCMCIA socket is available), and an I/O Address Range for communication purposes. The settings which result are referred to as default. There is no predetermined default setting since these settings depend on *what the Client Driver finds vacant* and, therefore, usable. This does not take into account transparent devices not seen by the Client Driver.

Note: Depending on your system configuration, the default settings may conflict with the IRQ, Socket #, and I/O Address Range that your system has already allocated to another device. *If this is the case,* change the initialization settings as described below.

Using the Enabler

The Enabler performs the same function of setting up the needed system resources as the Client Driver, but in a more direct and somewhat limited way. The only real advantage of using the Enabler is the amount of PC memory rescued (about 7 kb). This memory would be used indefinitely by the Client Driver, since the Client Driver must store a program in memory to manage "Hot-Swapping." If the Card and Socket Services are only needed for the Client Driver, you could save more memory by not loading them when using the Enabler.

On the down side of using the Enabler, the Personal488/Card must be installed before you run the Enabler. Also, every time the Personal488/Card is removed, and reinstalled, the Enabler must be run.

The Enabler requires explicit IRQ, Socket #, and I/O Address Range parameters. If Card and Socket Services are running, they will not know that the Enabler allocated some resources, and may therefore allocate them to another device.

Changing Initialization Settings

Use the following steps to change the initialization settings, or to initialize the Personal488/CARD system to your specifications and/or needs.

Note: If your PC has a valid version of PCMCIA Card and Socket Services software, it is recommended that you use Client Driver, since Client Driver supports

Note: "Hot-Swapping" refers to the insertion and removal of the PCMCIA card while the system is powered.

1. Choose between the Client Driver (**`IOT488CL.SYS`**) or Enabler (**`IOT488EN.EXE`**) files as to which one best suits your needs. The choice heavily depends upon the host computer environment and the desire for Plug and Play functionality.
2. If you choose the Client Driver file option, you will need to update your **`CONFIG.SYS`** file by adding the following command line:

   ```
   DEVICE=path\IOT488CL.SYS options
   ```

3. The Personal488/CARD must be installed before using the Enabler. The initialization is only valid as long as the Personal488/CARD is present. You will need to update your **`AUTOEXEC.BAT`** file with the following command line:

```
path\IOT488EN.EXE options
```

Client Driver

The Client Driver has the following **`CONFIG.SYS`** file line syntax:

```
DEVICE=path\IOT488CL.SYS  [  (GROUP)  [  (GROUP)  [  ...  ]]]
```

where the following parts are described as follows:

Part	Client Driver Description
`GROUP`	`[ITEM[,ITEM[,ITEM]]]`
`ITEM`	`Sxx │ Bxxx │ Ixx`
`Sxx`	The socket number, `xx` in `[0...15]`, default to any available socket, if omitted.
`Bxxx`	The I/O base address (hex), `xxx` in `[100...3F0]`, default to any available I/O address, if omitted.
`Ixx`	The IRQ level, `xx` in `[0...15]`, 0 means no interrupt, default to any available IRQ level, if omitted.

```
IOT488CL.SYS
```

The simplest command line, shown above, will configure the card in any PCMCIA socket with available consecutive 16 bytes in the system I/O space, and an available IRQ level. Note that you should not assume the resource selections will always be the same.

```
IOT488CL.SYS   (s0,b300,i5)
```

The command line above will configure the card in socket 0 with I/O base address at **`300H`** and IRQ level 5, if those resources are available.

```
IOT488CL.SYS   (b300,i5)   (i10)   ( )
```

This command line tells the client driver to configure the card in *any* socket with a base address of **`300H`** and IRQ 5. If not available, the client driver will then try to configure it with a base address and socket number assigned by the Card and Socket Services and IRQ 10. If IRQ 10 is not available, the Client Driver will then try to configure the card with a base address, socket number, and an IRQ level assigned by the Card and Socket Services.

Space characters are only allowed in between the groups, not inside a group. The items within a group are separated by a single comma. The order of items in a group does not make any difference. Nor are the characters in an item case sensitive.

Enabler

The command line syntax for the Enabler is similar to that used by the Client Driver.

```
DEVICE=path\IOT488EN.EXE     (Sxx,Bxxx,Ixx[,Wxx])
```

where the following parts are described as follows:

Part	Enabler Description
`GROUP`	`[ITEM[,ITEM[,ITEM]]]`
`ITEM`	`Sxx │ Bxxx │ Ixx`
`Sxx`	The same as the Client Driver syntax, except it must be specified to enable the card.
`Bxxx`	The same as the Client Driver syntax, except it must be specified to enable the card.
`Ixx`	The same as the Client Driver syntax, except it must be specified to enable the card.
`Wxx`	Specifies the PCIC memory window, `xx (hex)` in `[80...EF]`, default to D0 if omitted.

```
IOT488EN.EXE   (Sxx,R[,Wxx])
```

To reset the card, the command line syntax above can be used, in which R is the reset switch. Socket number must be specified, but **`Wxx`** can be omitted (default memory window at D0000H). After executing an **`IOT488EN.EXE`** command with the reset option, **`IOT488EN.EXE`** must be run again to set the card's resources.

```
IOT488EN.EXE   (s0,r)
```

This command line resets the card in socket 0 (default memory window at D0000H),

```
IOT488EN.EXE   (s1,r,wc8)
```

This command line resets the card in socket 1 (with PCIC memory window at C8000H).

Configuration Software

For ease of use, this text repeats material found in the driver-specific "Installation & Configuration" Sub-Chapters found in Chapters 8 through 12 of this manual. In addition, this text includes Personal488/CARD information not contained elsewhere. Aside from this chapter on Personal488/CARD, you should also read through the "External Device Interfacing" Sub-Chapters found in Chapters 8, 9, and 10 of this manual.

Configuration Utility

The configuration utility permits you to specify the Driver488 system configuration, add interfaces, define external devices, etc. It does so by modifying the Driver488 startup configuration and is specified in a Windows-style initialization file named **`DRVR488.INI`**. The first screen of the **`CONFIG.EXE`** program is used to enter the configuration settings so the Driver488 software can be correctly modified to reflect the state of the hardware.

The driver can be reconfigured at any time by running the **`CONFIG.EXE`** program. Changes to the configuration will not be recognized by the driver until the driver is unloaded and reloaded. Typically, this is accomplished by rebooting your computer or using the utilities **`MARKDRVR`** and **`REMDRVR`**. For details regarding utilities, refer to the "Utility Programs" Sub-Chapters found in Chapters 8, 9, and 10 of this manual

To start the **`CONFIG`** program, type **`CONFIG`** within the directory in which the configuration utility resides, typically **`C:\IEEE488`**.

The minimum requirement for configuring your system is to make certain that your Personal488/CARD is selected under "Device Type." The default settings in all of the other fields match those of the interface as shipped from the factory. If you are unsure of a setting, it is recommended that you leave it as is.

Interfaces and External Devices

The **`CONFIG`** program can configure both interfaces and external devices. Interfaces are the Personal488/Card and serial ports. External devices are instruments or other devices attached to the IEEE 488 bus or the MP488(CT) Counter/Timers and Digital I/O devices.

Configuration Program Screens

In general, all Driver488 configuration utility screens have three main windows: the "name" of the interfaces or devices on the left, the "configuration" window on the right, and the "instruction" window at the bottom of the screen. Based on current cursor position, the valid keys for each window will display in the Instructions box.

To begin the interface configuration, move the cursor in the name window to select an interface description for modification. (Interfaces can be added or deleted using **`<F3>`** and **`<F4>`**). Notice moving the cursor up and down the list of interfaces or devices in the left window changes the parameters in the configuration window. The configuration fields always correspond with the currently selected interface and device type.

Once all modifications have been made to the configuration screen, **`<F10>`** must be pressed to accept the changes made or **`<F9>`** can be pressed to exit without saving any change. Additional function keys allow the user to continue onto the configuration of external devices via **`<F5>`** or to view a graphic representation of the interface card with the selected settings via **`<F7>`**.

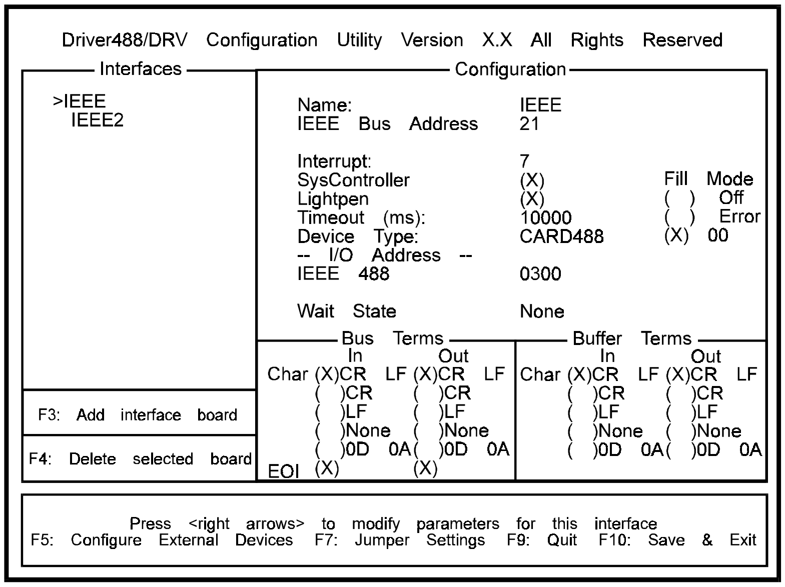
Configuring Driver488 Interfaces

Driver488 supports two types of interfaces: IEEE and Serial. Once the **`CONFIG.EXE`** program is entered, highlight the Device Type selection from the Configuration Window and choose the CARD488 option from the resulting pop-up menu. The Driver488/DRV screen, shown next, or one similar, will be displayed.

Once an interface is selected, the fields and default entries which appear in the configuration window depend on the device type specified. To add another IEEE interface, select **`<F3>`**. If you will be using more than one interface, refer to other sections of this manual for additional information, as needed. The configuration parameters of the IEEE interface are described following the figure of the Driver488/DRV screen.

Configuration Parameters

- **Name:** This field is a descriptive instrument name which is manually assigned by the user. This must be a unique name. Typically, **`IEEE`** or **`COM`** is used (up to 8 characters).
- **IEEE Bus Address:** This is the setting for the IEEE bus address of the board. It will be checked against all the instruments on the bus for conflicts. It must be a valid IEEE bus address from `0` to `30`.



```
Driver488/DRV  Configuration  Utility  Version  X.X  All  Rights  Reserved
 Interfaces              Configuration
 >IEEE                   Name:                 IEEE
   IEEE2                 IEEE  Bus  Address    21

                         Interrupt:            7
                         SysController         (X)           Fill  Mode
                         Lightpen              (X)           (  )  Off
                         Timeout  (ms):        10000         (  )  Error
                         Device  Type:         CARD488       (X)   00
                         --  I/O  Address  --
                         IEEE  488             0300

                         Wait  State           None
                          Bus  Terms                  Buffer  Terms
                              In        Out               In        Out
                     Char (X)CR  LF (X)CR  LF   Char (X)CR  LF (X)CR  LF
                          (  )CR    (  )CR           (  )CR    (  )CR
 F3:  Add  interface  board  (  )LF    (  )LF        (  )LF    (  )LF
                          (  )None  (  )None         (  )None  (  )None
 F4:  Delete  selected  board  (  )0D  0A(  )0D  0A  (  )0D  0A(  )0D  0A
                     EOI  (X)       (X)

              Press  <right  arrows>  to  modify  parameters  for  this  interface
 F5:  Configure  External  Devices  F7:  Jumper  Settings  F9:  Quit  F10:  Save  &  Exit
```

Configuration of Personal488/CARD

- **Interrupt:** A hardware interrupt level can be specified to improve the efficiency of the I/O adapter control and communication using Driver488. Personal488/CARDs may not share the same interrupt level. If no interrupt level is to be used, select NONE. Valid interrupt levels depend on the type of interface, since interrupt sharing is not permitted in the PCMCIA 2.1 specification. Settings are as follows: Levels 3-7, Levels 9-12, Levels 14-15, or NONE.
- **SysController:** This field determines whether or not the Personal488/CARD is to be the System Controller. The system controller has ultimate control of the IEEE 488 bus, and the ability of asserting the interface clear (**`IFC`**) and remote enable (**`REN`**) signals. Each IEEE 488 bus can have only one system controller. If the PCMCIA IEEE Card is a peripheral, it may still take control of the IEEE 488 bus if the Active Controller passes control to it. The “CARD” may then control the bus and, when it is done, pass control back to the System Controller or another controller, which then becomes the active controller. If the “CARD” will be operating in Peripheral mode (not System Controller), leave this field blank.
- **LightPen:** This field determines whether the LightPen command is to be used. If selected, it will disable the detection of interrupts via setting the light pen status. The default is light pen interrupt enabled.
- **Timeout (ms):** The time out period is the amount of time that data transfers wait before assuming that the device does not transfer data. If the time out period elapses while waiting to transfer data,

an error signal occurs. This field is the default timeout for any bus request or action, measured in milliseconds. If no timeout is desired, the value may be set to zero.

- **Device Type:** This field specifies the type of board or module, in this case a Personal488/CARD (CARD488), represented by the IEEE device name selected.

I/O Address

- **IEEE 488:** This field is the I/O base address which sets the addresses used by the computer to communicate with the IEEE interface hardware on the board. The address is specified in hexadecimal and can be 100 through 3F0 on even 16-byte boundaries (those ending in 0). The Personal488/CARD uses sixteen (16) consecutive I/O ports.

Note: Since many I/O ports in the allowed range are [*or may be*] in use by other system hardware, we recommend using port 300 to 360 hex. **Using a port *already in use* could cause loss of data, or physical damage.**

- **Wait State:** Wait States can be generated if IEEE 488 bus I/O synchronization between the Personal488/CARD and PC is an issue. It should be noted that the time out specification is independent of wait state(s). The Personal488/CARD is fast enough to be compatible with virtually every PC/XT/AT-compatible computer on the market. Even if the computer is very fast, the processor is normally slowed to 8 MHz or below when accessing the I/O channel. If the I/O channel runs faster than 8 MHz, it may be faster than the Personal488/CARD. If this is a suspected problem, the computer can be made to wait for the "CARD" by enabling wait states. Increasing the number of wait states slows down the access to the "CARD". The overall resultant performance degradation is usually only a few percent.
- **Bus Terminators:** The IEEE 488 bus terminators specify the characters and/or end-or-identify (**`EOI`**) signal that are to be appended to data that is sent to the external device, or mark the end of data that is received from the external device.

In conclusion, to save your changes to disk press **`<F10>`**. All changes will be saved in the directory where you installed Driver488. If at any time you wish to alter your Driver488 configuration, simply rerun **`CONFIG`**. The changes made will not take effect until the system is rebooted (Warm or Cold).

Driver488/W31 Configuration Utility

The configuration utility provided with Driver488/W31 has been updated to provide a familiar Windows user interface. The interface contains the same characteristics as the DOS configuration program, however, the file storage differs as indicated by the table below.

Driver File Storage		
Driver Version	**File Name**	**File Location**
Windows	`DRVR488W.INI`	`WIN.COM` (in Windows Directory)
DOS	`DRVR488.INI`	`CONFIG.EXE` (in assigned directory)

Functionality

The Personal488/CARD transfers data to the host computer via the PCMCIA interface. This interface provides access to the PC's data bus, allowing real-time data collection and storage to disk at 1.0 M byte/sec.

The Personal488/CARD built-in 7210 controller device controls the IEEE 488 bus using the IOT7210 Controller Chip, which is 100% compatible with the NEC μPD7210. However, the IOT7210 exhibits better performance and lower power consumption.

The programmed I/O mode allows the host computer to acquire individual data samples or large blocks of data under application control.

The interrupt transfer mode allows the host computer to perform other tasks until the Personal488/CARD has sent or received a programmed amount of data. This mode provides the most efficient use of computer resources and data transfer.

Note: For more information on the functionality of the Personal488/CARD, refer to the “Data Transfers,” “Operating Modes,” and “Command Descriptions” Sub-Chapters found in Chapters 8 and 9 of this manual.

Section II:

SOFTWARE GUIDES

II. SOFTWARE GUIDES

Chapters

7. Overview

The Software Guides section contains chapters pertaining to various Driver488 software. Information includes instruction for installation and configuration, device interfacing, and API (Application Program Interface) command references. Note that more detailed *topic-specific* tables of contents are included with each of the topics identified above.

In addition to this manual, Power488 and PowerCT users receive a manual supplement describing the Standard Commands for Programmable Instruments (SCPI) command set and the **`IOTTIMER.DLL`**, a Microsoft Windows Dynamic Link Library of functions.

8. Driver488/DRV

Sub-Chapters

8A. Introduction

Driver488 represents a family of software drivers for IEEE 488 interfaces and other peripherals, emphasizing a consistent, easy to use interface to simplify IEEE 488 instrument control and application program development. Different versions of the driver are available to suit almost any application. For maximum functionality and ease of use, a resident driver is accessible via both Character Command Language (CCL) and subroutine calls to control a multitude of IEEE 488 interfaces and other instruments. At the opposite extreme is a small, fast driver entirely linked to the application program, which can control just one IEEE 488 interface and instruments attached thereto. Portability of any given application among the Driver488 family members is ensured with a consistent interface, which allows an application using CCL to use any driver offering that interface with minimal change. Similarly, any application using the subroutine interface would require little if any change to be used with another version of Driver488.

Driver488/DRV uses HP (Hewlett-Packard) style commands which simplify IEEE 488 instrument control and application development by transparently executing multiple low-level bus management tasks, shielding the user form the complexities of IEEE 488 protocol. These commands can be used in application programs written in any popular software language. Driver488/DRV features a menu-driven installation/configuration program with options for programming language; type and number of hardware interfaces (IEEE 488 board type and options); and external devices, such as time out limits, terminators, symbolic device names, and device numeric addresses.

To get optimal use of your PC's conventional 640Kbyte memory, Driver488/DRV automatically detects and loads itself into high memory when used with a system employing DOS 5.0 or higher.

Driver488/DRV provides PC serial (COM) port support, enabling direct serial communication from programming languages and spreadsheets. In addition, Driver488/DRV supports asynchronous communication and automatic program vectoring to service routines for Basic, C and Pascal programs. For example, upon the occurrence of a specified event, such as **`SRQ`**, **`TRIGGER`**, **`TALK`**, or **`ERROR`**, Driver488/DRV will automatically vector to your interrupt service routine.

Using Driver488/DRV, SCPI (Standard Command for Programmable Instruments) programmability can be brought to Power488 I/O functions. SCPI is a language that defines common commands and syntax for communication between controller and instruments. As such, it provides a consistent programming environment for all SCPI-compatible equipment, simplifying programming and letting you exchange instruments regardless of their make or type, without the need for extensive reprogramming.

Driver488/DRV supports up to four IEEE 488 interfaces. There can be multiple external devices on each interface up to the limits imposed by either electrical loading (14 devices), or with a product such as Expander488, to the limits of the IEEE 488 addressing protocols.

Driver488/DRV supports the GP488B, AT488, GP488/MM, MP488, MP488CT and NB488 series of IEEE 488.2 interface hardware. All interaction between the application and the driver takes place via subroutine calls.

8B. Installation & Configuration

Topics

Before You Get Started

Prior to Driver488/DRV software installation, configure your interface board by setting the appropriate jumpers and switches as detailed in “Section I: Hardware Guides.” Note the configuration settings used, as they must match those used within the Driver488/DRV software installation.

Once the IEEE 488 interface hardware is installed, you are ready to proceed with the steps outlined within this Sub-Chapter to install and configure the Driver488/DRV software. The Driver488/DRV software disk(s) include the driver files themselves, installation tools, example programs, and various additional utility programs. A file called **`README.TXT`**, if present, is a text file containing new material that was not available when this manual went to press.

NOTICE

1. The Driver488/DRV software, including all files and data, and the diskette on which it is contained (the "Licensed Software"), is licensed to you, the end user, for your own internal use. You do not obtain title to the licensed software. You may not sublicense, rent, lease, convey, modify, translate, convert to another programming language, decompile, or disassemble the licensed software for any purpose.

2. You may:

- **only use the software on one single machine**
- **copy the software into any machine-readable or printed form for backup in support of your use of the program on the single machine**
- **transfer the programs and license to use to another party if the other party agrees to accept the terms and conditions of the licensing agreement. If you transfer the programs, you must at the same time either transfer all copies whether in printed or in machine-readable form to the same party and destroy any copies not transferred.**

The first thing to do, before installing the software, is to make a backup copy of the Driver488/DRV software disks onto blank disks. To make the backup copy, follow the instructions given below.

Making Backup Disk Copies

1. Boot up the system according to the manufacturer's instructions.
2. Type the command `CD\` to go back to your system's root directory.
3. Place the first Driver488/DRV software disk into drive `A:`.
4. Type `DISKCOPY A:A:` and follow the instructions given by the `DISKCOPY` program. (You may need to swap the original (source) and blank (target) disks in drive `A:` several times to complete the `DISKCOPY`. If your blank disk is unformatted, the `DISKCOPY` program allows you to format it before copying.)
5. When the copy is complete, remove the backup (target) disk from drive `A:` and label it to match the original (source) Driver488/DRV software disk just copied.
6. Store the original Driver488/DRV software disk in a safe place.
7. Place the next Driver488/DRV software disk into drive `A:` and repeat steps 4-6 for each original (source) disk included in the Driver488/DRV package.
8. Place the backup copy of the installation disk into drive `A:`, type `A:INSTALL,` then follow the instructions on the screen.

Driver Installation

There are two steps involved in installing Driver488/DRV onto your working disk: The required files must first be extracted from the distribution disk to the working disk, and the software must be configured. Since the Driver488/DRV files are compressed on the distribution disks, the `INSTALL` program must be used to properly extract them.

Driver488/DRV should normally be installed on a hard disk. Installing Driver488/DRV on a floppy disk, while possible, is not recommended. Assuming that the Driver488/DRV disk is in drive `A:`, start the installation procedure by typing `A:INSTALL` at the prompt.

Selective Installation of Support files

The installation program allows you to choose which files are to be copied to your working disk. A menu will display a listing of the following files:

Files	**Description**
Driver488/DRV Driver Modules	Contains the driver modules needed for the initial installation and proper execution.
Driver488/DRV Executable	The primary file which loads the driver; required for proper execution.
ReadMe File	Contains any new information about the driver not already included in the user manual.
Default Config Files	These are **`.INI`** files which contain suggested configurations for the various interfaces.
Character Command Language Files	Programming language specific examples and utilities.
IEEE 488 Utility Files	Includes utilities for redirection of COM and LPT ports, the Keyboard Controller, and utilities for removing Driver488/DRV from memory after use.
Transfer488 Utilities	Utilities for transferring files to and from HP computers using HP BASIC (Rocky Mountain Basic).
Example Files	Sample programs.

All the files will appear with a check mark beside them, indicating that they are selected for installation. If you wish to unselect an item, please move the cursor to the item bar and press the **`<Space Bar>`** to toggle the check mark off. Pressing the **`<Space Bar>`** again will toggle the check mark on. In this way you can select or omit those file categories you wish to install.

For a normal first installation, allow **`INSTALL`** to install all parts of Driver488/DRV. For a first-time installation, the Device Driver files are mandatory. However, if hard disk space is extremely limited, certain parts, such as language support and examples for languages not immediately used, may be omitted. The distribution disks may be used to install or reinstall any or all parts of Driver488/DRV at a later time. You may rerun **`INSTALL`** at any time to install files that you previously omitted.

When you have finished your selection, press **`<Enter>`**. The Directory Selection screen will appear with two horizontal windows.

Driver Installation to Disk

The Directory Selection screen allows you to specify where the Driver488/DRV files are to be installed. The upper window will be highlighted and contain the words “Install from:” on the first line, and the path from which you are installing Driver488/DRV (typically “A:”) on the second line. If this “Install from:” path is correct, press **`<Enter>`** to accept and move to the next window. If it is not correct, edit the path before pressing **`<Enter>`**.

Pressing **`<Enter>`** will move you to the second window, with the words “Install to:” on the first line and the default directory “C:\IEEE488" on the second line. Simply press **`<Enter>`** to accept the default or edit the path as you prefer and then press **`<Enter>`**.

Two smaller boxes will display below the two directory windows: “Start” and “Cancel.” “Start” should be highlighted. To proceed with installing Driver488/DRV, press **`<Enter>`**. Otherwise move the cursor to “Cancel” and press **`<Enter>`** to abort the installation.

If you proceed with the installation, the files selected from the previous menu will be extracted from the distribution disk to your hard disk. **`INSTALL`** will prompt you for disk insertion if you have a multiple disk distribution set of Driver488/DRV. When **`INSTALL`** is finished transferring the files to your hard disk, the message “Driver488/DRV Software Installation is Complete” will appear. At this point, press **`<Enter>`** to continue with the installation.

Next, the install program displays a prompt regarding the modification of your **`AUTOEXEC.BAT`** file. This file holds operating system commands that are executed after all other system setup and configuration is done, and just before commands are accepted from the keyboard. The **`AUTOEXEC.BAT`** file can be used for many purposes. For more details, see your operating system manual.

The Driver488/DRV installation program provides the following options:

- If "Yes" is selected, the Driver488/DRV command line will be added to the beginning of your **`AUTOEXEC.BAT`** file.
- If "No" is selected, no changes will be made to the **`AUTOEXEC.BAT`** file.
- If "Manually" is selected, you can choose where the Driver488/DRV command line is to be added in your **`AUTOEXEC.BAT`** file.

After modifying the **`AUTOEXEC.BAT`** file, the installation program automatically invokes the configuration program: **`CONFIG`**. You may also run **`CONFIG`** from the command line at a later time to modify your configuration as required. Note if any error messages display when you are trying to load **`DRVR488.EXE`** in memory, If so, refer to "Section IV: Troubleshooting" in this manual.

Configuration Utility

The configuration utility permits you to specify the Driver488/DRV system configuration, add interfaces, define external devices, etc. It does so by modifying the Driver488/DRV startup configuration specified in a Windows-style initialization file named **`DRVR488.INI`**. The first screen of the **`CONFIG`** program is used to enter the configuration settings so the Driver488/DRV software can be correctly modified to reflect the state of the hardware.

The driver can be reconfigured at any time by running the **`CONFIG`** program. Changes to the configuration will not be recognized by the driver until the driver is unloaded and reloaded. Typically, this is accomplished by rebooting your computer or using the utilities **`MARKDRVR`** and **`REMDRVR`**. For details on these utilities, refer to the "Utility Programs" Sub-Chapters found in Chapters 8 and 9 in this manual.

To start the **`CONFIG`** program, type **`CONFIG`** within the directory in which the configuration utility resides, typically **`C:\IEEE488`**.

Interfaces

The minimum requirement for configuring your system is to make certain that your IEEE 488.2 interface board or module is selected under "Device Type." The default settings in all of the other fields match those of the interface as shipped from the factory. If you are unsure of a setting, it is recommended that you leave it as is.

External Devices

The **`CONFIG`** program can configure both interfaces and external devices. Interfaces are IEEE interface boards and serial ports. External devices are instruments or other devices attached to the IEEE 488 bus or the MP488(CT) Counter/Timers and Digital I/O devices. For more details, refer to the topic "Configuration of IEEE 488 External Devices" found later in this Sub-Chapter.

Opening the Configuration Utility

In general, all Driver488/DRV configuration utility screens have three main windows: the "name" of the interfaces or devices on the left, the "configuration" window on the right, and the "instruction" window at the bottom of the screen. Based on current cursor position, the valid keys for each window will display in the Instructions box.

To begin the interface configuration, move the cursor in the name window to select an interface description for modification. (Interfaces can be added or deleted using **`<F3>`** and **`<F4>`**.) Notice moving the cursor up and down the list of interfaces or devices in the left window changes the parameters in the configuration window. The configuration fields always correspond with the currently selected interface and device type.

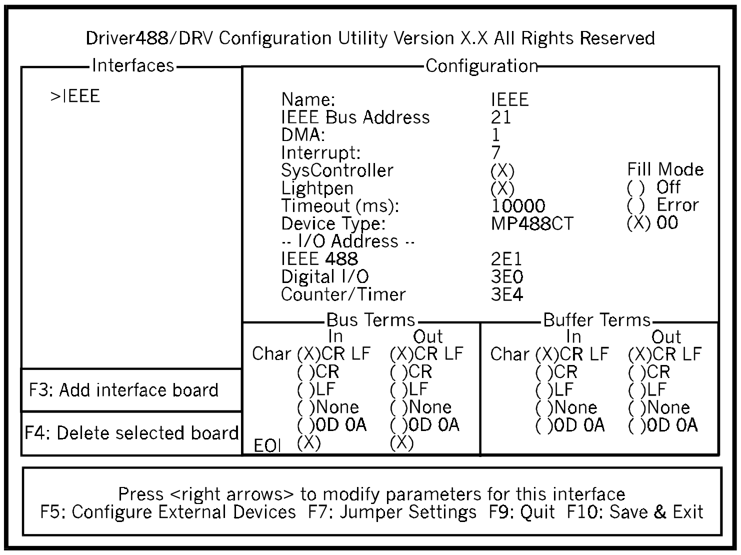
Once all modifications have been made to the configuration screen, **`<F10>`** must be pressed to accept the changes made or **`<F9>`** can be pressed to exit without making any change. Additional function keys allow the user to continue onto the configuration of external devices via **`<F5>`** or to view a graphic representation of the interface card with the selected settings via **`<F7>`**.

Configuration of IEEE 488 Interfaces

The Driver488/DRV supports two types of interfaces: IEEE and Serial (COM). The following Driver488/DRV figure displays the configuration screen of an MP488CT IEEE 488.2 interface.

To add another IEEE interface, select **`<F3>`**. If you will be using more than one interface, refer to the final topic “Multiple Interface Management” in this Sub-Chapter.

Once an interface is selected, the fields and default entries which display in the configuration window depend on the device type specified. The configuration parameters of the interface, are as follows:



```
Driver488/DRV Configuration Utility Version X.X All Rights Reserved
Interfaces                  Configuration
>IEEE                       Name:               IEEE
                            IEEE Bus Address    21
                            DMA:                1
                            Interrupt:          7
                            SysController       (X)        Fill Mode
                            Lightpen            (X)        ( )  Off
                            Timeout (ms):       10000      ( )  Error
                            Device Type:        MP488CT    (X) 00
                            -- I/O Address --
                            IEEE 488            2E1
                            Digital I/O         3E0
                            Counter/Timer       3E4
                                  Bus Terms                   Buffer Terms
                                 In        Out               In        Out
                            Char (X)CR LF  (X)CR LF    Char (X)CR LF  (X)CR LF
F3: Add interface board          ( )CR     ( )CR            ( )CR     ( )CR
                                 ( )LF     ( )LF            ( )LF     ( )LF
                                 ( )None   ( )None          ( )None   ( )None
F4: Delete selected board        ( )0D 0A  ( )0D 0A         ( )0D 0A  ( )0D 0A
                            EOI  (X)       (X)

       Press <right arrows> to modify parameters for this interface
F5: Configure External Devices  F7: Jumper Settings  F9: Quit  F10: Save & Exit
```

Configuration Utility for MP488CT

Configuration Parameters

- **Name:** This field is a descriptive instrument name which is manually assigned by the user. This must be a unique name. Typically, IEEE or COM is used.

- **IEEE Bus Address:** This is the setting for the IEEE bus address of the board. It will be checked against all the instruments on the bus for conflicts. It must be a valid address from **`0`** to **`30`**.

- **DMA:** A *direct memory access* (DMA) channel can be specified for use by the I/O interface card. If DMA is to be used, select a channel as per the hardware setting. If no DMA is to be used, select NONE. The NB488 does not support DMA, so the DMA field will not display if this device type is used. Valid settings are shown in the table.

I/O Board	Specified DMA Channel
GP488B	1, 2, 3 or none
AT488	1, 2, 3, 5, 6, 7 or none
MP488	1, 2, 3, 5, 6, 7 or none
MP488CT	1, 2, 3, 5, 6, 7 or none
NB488	Not applicable
CARD488	Not applicable

- **Interrupt:** A hardware interrupt level can be specified to improve the efficiency of the I/O adapter control and communication using Driver488/DRV. For DMA operation or any use of **`OnEvent`** and **`Arm`** functions, an interrupt level must be selected. Boards may share the same interrupt level. If no interrupt level is to be used, select NONE. Valid interrupt levels depend on the type of interface. Possible settings are shown in the table.

I/O Board	Specified Interrupt Level
GP488B	levels 2-7 or none
AT488	levels 3-7, 9-12, 14-15 or none
MP488	levels 3-7, 9-12, 14-15 or none
MP488CT	levels 3-7, 9-12, 14-15 or none
NB488	level 7 for LPT1, level 5 for LPT2
CARD488	levels 3-7, 9-12, 14-15 or none

- **SysController:** This field determines whether or not the IEEE 488 interface card is to be the System Controller. The System Controller has ultimate control of the IEEE 488 bus, and the ability of asserting the interface clear (**`IFC`**) and remote enable (**`REN`**) signals. Each IEEE 488 bus can have only one System Controller. If the board is a peripheral, it may still take control of the IEEE 488 bus if the Active Controller passes control to the board. The board may then control the bus and, when it is done, pass control back to the System Controller or another computer, which then becomes the active controller. If the board will be operating in Peripheral mode (not System Controller), select NO in this field.

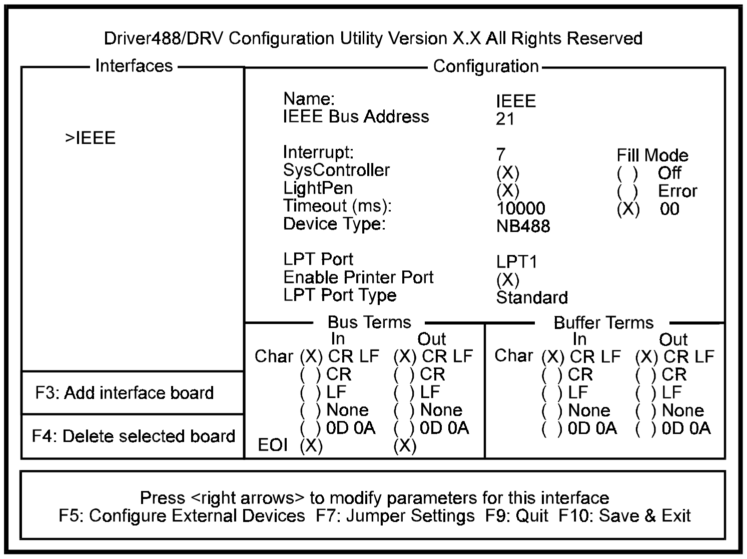
- **LightPen:** This field determines whether the `LIGHT PEN` command is to be used. If selected, it will disable the detection of interrupts via setting the light pen status. The default is light pen interrupt enabled.
- **Timeout (ms):** The time out period is the amount of time that data transfers wait before assuming that the device does not transfer data. If the time out period elapses while waiting to transfer data, an error signal occurs. This field is the default timeout for any bus request or action, measured in milliseconds. If no timeout is desired, the value may be set to zero.
- **Device Type:** This field specifies the type of board or module (such as GP488, MP488CT or NB488) represented by the IEEE device name selected.

I/O Address

- **IEEE 488:** This field is the I/O base address which sets the addresses used by the computer to communicate with the IEEE interface hardware on the board. The address is specified in hexadecimal and can be `02E1`, `22E1`, `42E1` or `62E1`.

  Note: This field does not apply to the NB488. Instead, the NB488 uses the I/O address of the data register (the first register) of the LPT port interface, typically `0x0378`.
- **Digital I/O:** This field is the base address of the Digital I/O registers. It is only applicable for MP488 and MP488CT boards. Note that the Digital I/O SCPI communication parameters are configured as an external device. Refer to the "Section I: Hardware Guides" for more information.
- **Counter/Timer:** This field is the base address of the Counter/Timer registers. It is only applicable for MP488CT boards. Note the Counter/Timer SCPI communication parameters are configured as an external device. Refer to the "Section I: Hardware Guides" for more information.
- **Bus Terminators:** The IEEE 488 bus terminators specify the characters and/or end-or-identify (`EOI`) signal that is to be appended to data that is sent to the external device, or mark the end of data that is received from the external device.

This second Driver488/DRV configuration example displays an IEEE interface with the NB488 interface module specified. This screen resembles the previous IEEE interface example with the exception of 3 different configuration parameters which are described below.



```
Driver488/DRV Configuration Utility Version X.X All Rights Reserved
Interfaces                Configuration
                          Name:                 IEEE
                          IEEE Bus Address      21
>IEEE
                          Interrupt:            7          Fill Mode
                          SysController         (X)        ( )  Off
                          LightPen              (X)        ( )  Error
                          Timeout (ms):         10000      (X)  00
                          Device Type:          NB488

                          LPT Port              LPT1
                          Enable Printer Port   (X)
                          LPT Port Type         Standard
                               Bus Terms                Buffer Terms
                              In        Out            In        Out
                          Char (X) CR LF  (X) CR LF   Char (X) CR LF  (X) CR LF
                               ( ) CR     ( ) CR           ( ) CR     ( ) CR
F3: Add interface board        ( ) LF     ( ) LF           ( ) LF     ( ) LF
                               ( ) None   ( ) None         ( ) None   ( ) None
F4: Delete selected board      ( ) 0D 0A  ( ) 0D 0A        ( ) 0D 0A  ( ) 0D 0A
                          EOI  (X)        (X)

        Press <right arrows> to modify parameters for this interface
F5: Configure External Devices  F7: Jumper Settings  F9: Quit  F10: Save & Exit
```

Configuration Utility for NB488

Configuration Parameters

- **LPT Port:** The LPT port is the external parallel port to be connected to the NB488. Valid selections are: `LPT1`, `LPT2` or `LPT3`. This field takes the place of the I/O Address field.
- **Enable Printer Port:**
  Because most laptop and notebook PCs provide only one LPT port, the NB488 offers LPT pass-through for simultaneous IEEE 488 instrument control and printer operation. If this option is selected, a printer connected to the NB488 will operate as if it were connected directly to the LPT port. If not enabled, then the printer will not operate when the NB488 is active. The disadvantage

of pass-through printer support is that it makes communications with the NB488 about 20% slower.

- **LPT Port Type:** This field is used to specify whether the LPT port is a standard IBM PC/XT/AT/PS/2 compatible port. Valid options are: Standard or 4-bit. The slower 4-bit option is provided for those computers which do not fully implement the IBM standard printer port. These computers can only read 4 bits at a time from the NB488 making communication with the NB488 up to 30% slower.

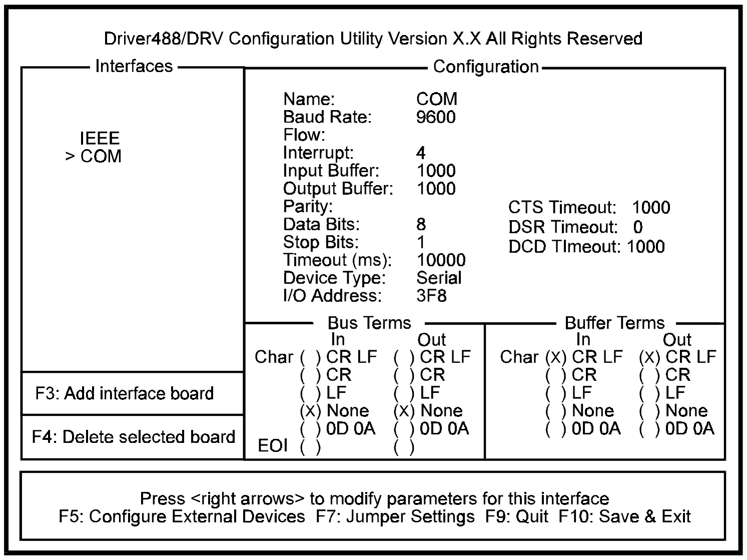
  A test program has been provided with NB488 to help identify the user's LPT port type. Once the NB488 is installed, type: **`NBTEST.EXE`**. This program will determine if your computer can communicate with the NB488 and what type of LPT port is installed (Standard or 4-bit).

  It is important to note there are four different versions of the NB488 driver. The **`CONFIG`** utility determines which is to be used based on the user-defined parameters. If both pass-through printer support and the 4-bit LPT port support are selected, then the communication with the IEEE 488 bit may be slowed as much as 40% compared with the fastest case in which neither option is selected. The actual performance will very depending on the exact type and speed of the computer used.

To save your changes to disk, press **`<F10>`**, or to exit without making any changes, press **`<F9>`**. All changes will be saved in the directory where you installed Driver488/DRV. If at any time you wish to alter your Driver488/DRV configuration, simply rerun **`CONFIG`**.

Configuration of Serial Interfaces

The following Driver488/DRV screen displays the configuration of a Serial (COM) interface.



```
Driver488/DRV Configuration Utility Version X.X All Rights Reserved
Interfaces            Configuration
                      Name:           COM
                      Baud Rate:      9600
    IEEE              Flow:
  > COM               Interrupt:      4
                      Input Buffer:   1000
                      Output Buffer:  1000
                      Parity:                      CTS Timeout:  1000
                      Data Bits:      8            DSR Timeout:  0
                      Stop Bits:      1            DCD TImeout: 1000
                      Timeout (ms):   10000
                      Device Type:    Serial
                      I/O Address:    3F8
                         Bus Terms                    Buffer Terms
                         In         Out               In          Out
                  Char ( ) CR LF  ( ) CR LF   Char (X) CR LF  (X) CR LF
                       ( ) CR     ( ) CR           ( ) CR     ( ) CR
F3: Add interface board ( ) LF    ( ) LF           ( ) LF     ( ) LF
                       (X) None   (X) None         ( ) None   ( ) None
F4: Delete selected board ( ) 0D 0A ( ) 0D 0A     ( ) 0D 0A  ( ) 0D 0A
                  EOI  ( )        ( )

        Press <right arrows> to modify parameters for this interface
 F5: Configure External Devices  F7: Jumper Settings  F9: Quit  F10: Save & Exit
```

Configuration Utility for Serial Interfaces

To add another serial interface, select **`<F3>`**. The following serial interface parameters are available for modification.

Configuration Parameters

- **Name:** This field is a descriptive instrument name which is manually assigned. This must be a unique name.
- **Baud Rate:** The allowable Data Rates range from 75 to 115.2K and all standard rates therein. This includes: 75, 110, 150, 300, 600, 1200, 1800, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, and 115.2K. Slower processors may have difficulty at the higher data rates because of the amount of processing required for terminator, end of buffer, and fill processing.
- **Flow:** **`X-ON/X-OFF`** is supported. With this configured, Driver488/DRV scans incoming characters for an **`X-OFF`** character. Once it is received, no more characters are transmitted until an **`X-ON`** character is received. The driver also issues an **`X-OFF`** to ask the attached device to stop sending when its internal buffer becomes three-quarters full and issues an **`X-ON`** when its buffer has emptied to one-quarter full.

- **Interrupt:** A hardware interrupt level can be specified to improve the efficiency of the I/O adapter control and communication using Driver488/DRV. For any use of `OnEvent` and `Arm` functions, an interrupt level must be selected. If no interrupt level is to be used, select NONE. Valid interrupt levels depend on the device type.

I/O Comm.	Typical Interrupt Level
COM1	typically level 4
COM2	typically level 3
COM3	typically level 4 or 5
COM4	typically level 2 or 3

- **Input Buffer:** This field is used to enter the buffer sizes for I/O.
- **Output Buffer:** This field is used to enter the buffer sizes for I/O.
- **Parity:** Parity can be EVEN, ODD, NONE, MARK, or SPACE.
- **CTS Timeout:** The driver supports 3 hardware handshake lines: Data Carrier Detect (`DCD`), Data Set Ready (`DSR`), and Clear To Send (`CTS`). Each line can be individually designated to be ignored, used with no specified timeout, or used with a selected timeout. The timeout is selected by specifying the number of milliseconds to wait for the indicated condition to become satisfied.
- **Data Bits:** Data formats from 5 though 8 Data Bits are supported.
- **DSR Timeout:** The driver supports 3 hardware handshake lines: Data Carrier Detect (`DCD`), Data Set Ready (`DSR`), and Clear To Send (`CTS`). Each line can be individually designated to be ignored, used with no specified timeout, or used with a selected timeout. The timeout is selected by specifying the number of milliseconds to wait for the indicated condition to become satisfied.
- **Stop Bits:** With 6, 7, or 8 Data Bits specified, either 1 or 2 Stop Bits are allowed. With 5 Data Bits specified, 1 or 1.5 Stop Bits may be selected.
- **DCD Timeout:** The driver supports 3 hardware handshake lines: Data Carrier Detect (`DCD`), Data Set Ready (`DSR`), and Clear To Send (`CTS`). Each line can be individually designated to be ignored, used with no specified timeout, or used with a selected timeout. The timeout is selected by specifying the number of milliseconds to wait for the indicated condition to become satisfied.
- **Timeout (ms):** The time out period is the amount of time that data transfers wait before assuming that the device does not transfer data. If the time out period elapses while waiting to transfer data, an error signal occurs. This field is the default timeout for any bus request or action, measured in milliseconds. If no timeout is desired, the value may be set to zero.
- **Device Type:** This field specifies the type of device represented by the serial external device name selected.
- **I/O Address:** The I/O Address is the computer bus address for the board. It is set to default values, as listed in the table, during the initial installation. These values can be changed, however, using the default address values is recommended. Any conflict will be noted by a pop up help screen.

I/O Comm.	Default Address Values
COM1	typically address 3F8
COM2	typically address 2F8
COM3	typically address 3E8
COM4	typically address 2E8

- **Bus Terminators:** The bus terminators specify the characters to be appended to data that is sent to the external device, or mark the end of data that is received from the external device.

Configuration of IEEE 488 External Devices

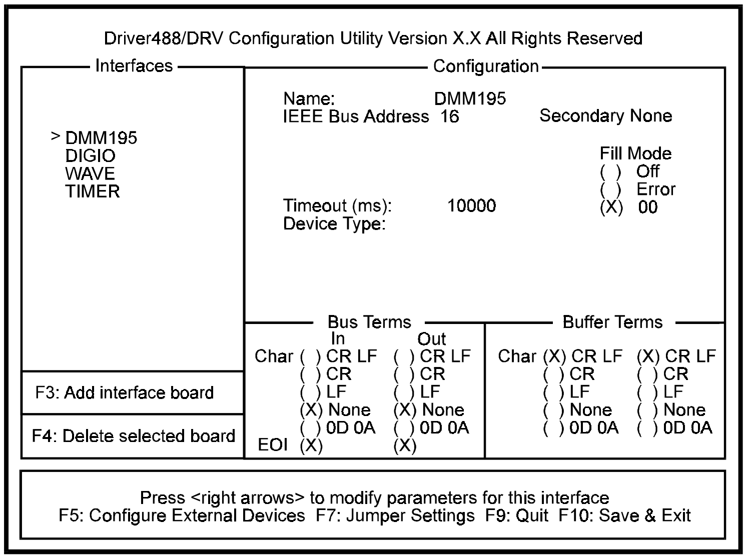
Within your IEEE 488.2 application program, devices on the bus may be accessed by name. These names must be created and configured with the `CONFIG` program, after you have configured your interfaces.

The following figure displays the configuration screen of an external device named `DMM195`. When configuring an IEEE interface, this screen can be accessed by selecting `<F5> Configure External Devices`.

To add additional devices, use **`<F3>`**. Note this external device screen is also used to configure MP488CT Digital I/O (**`DIGIO`**) and Counter/Timers (**`TIMER`**).

The following parameters are available for modification.

Configuration Parameters



```
Driver488/DRV Configuration Utility Version X.X All Rights Reserved
 Interfaces          Configuration
                     Name:              DMM195
                     IEEE Bus Address  16          Secondary None
> DMM195
  DIGIO                                               Fill Mode
  WAVE                                                ( )  Off
  TIMER                                               ( )  Error
                     Timeout (ms):      10000         (X)  00
                     Device Type:

                       Bus Terms                 Buffer Terms
                         In        Out
                     Char ( ) CR LF  ( ) CR LF   Char (X) CR LF  (X) CR LF
                          ( ) CR     ( ) CR           ( ) CR     ( ) CR
F3: Add interface board   ( ) LF     ( ) LF           ( ) LF     ( ) LF
                          (X) None   (X) None         ( ) None   ( ) None
F4: Delete selected board ( ) 0D 0A  ( ) 0D 0A        ( ) 0D 0A  ( ) 0D 0A
                     EOI  (X)        (X)

        Press <right arrows> to modify parameters for this interface
   F5: Configure External Devices  F7: Jumper Settings  F9: Quit  F10: Save & Exit
```

Configuration Utility for External Devices

- **Name:** External device names are user defined names which are used to convey the configuration information about each device, from the initialization file to the application program. Each external device must have a name to identify its configuration to Driver488/DRV. The name can then be used to obtain a handle to that device which will be used by all of the Driver488/DRV commands. External device names consist of 1 to 6 characters, and the first character must be a letter. The remaining characters may be letters, numbers, or underscores (_). External device names are case insensitive; upper and lower case letters are equivalent. **`ADC`** is the same device as **`adc`**.
- **IEEE Bus Address:** This is the setting for the IEEE 488 bus address of the device. It will be checked against all the devices on the bus for conflicts. The IEEE 488 bus address consists of a primary address from `00` to `31`, and an optional secondary address from `00` to `31` or "NONE".
- **Timeout (ms):** The time out period is the amount of time that data transfers wait before assuming that the device does not transfer data. If the time out period elapses while waiting to transfer data, an error signal occurs. This field is the default timeout for any bus request or action, measured in milliseconds. If no timeout is desired, the value may be set to zero.
- **Device Type:** This field specifies the type of device represented by the external device name selected.
- **Bus Terminators:** The IEEE 488 bus terminators specify the character(s) and/or end-or-identify (**`EOI`**) signal that is to be appended to data that is sent to the external device, or mark the end of data that is received from the external device.

Note: Because secondary addresses and bus terminators are specified for each external device name, it may be useful to have several different external devices defined for a single IEEE 488 bus device. For example, separate names would be used to communicate with different secondary addresses within a device. Also, different names might be used for communication of command and status strings (terminated by carriage return/line feed) and for communication of binary data (terminated by **`EOI`**).

Note: If installation or configuration problems exist, refer to "Section IV: Troubleshooting."

To save your changes to disk, press **`<F10>`**. All changes will be saved in the directory where you installed Driver488/DRV. If at any time you wish to alter your Driver488/DRV configuration, simply rerun **`CONFIG`**.

Multiple Interface Management

When designing a complex data acquisition system, it might be necessary to have more than one IEEE 488 bus interface controlled by the computer. Typical instances include: A system with more than 15 devices, the use of distributed control or the simultaneous operation of multiple transactions.

System With More Than 15 Devices

The IEEE 488 electrical specification limits the number of devices on a single bus (including the controller) to 15. While a bus expander, such as the Expander488, can increase that limit to 28, complex systems may require two or more IEEE 488 buses and have more controllers.

In this case, two or more interfaces would be used, each configured as a System Controller. Because they are attached to completely separate buses, the two interfaces do not affect each other. They can have the same IEEE 488 bus address, and the addresses of the devices on one bus may be the same as the addresses of the devices on the other bus.

Use of Distributed Control

Two or more IEEE 488 buses can also be useful when they have different functions. For example, a computer might use one bus as a System Controller to control instruments, while using another bus as a Peripheral, to communicate with another computer.

Simultaneous Operation of Multiple Transactions

Another use of two IEEE 488 buses is to allow simultaneous operation of two separate transactions. Some instruments, such as spectrum analyzers, have the ability to send their results, through the IEEE 488 bus, directly to a printer or a plotter. Such an instrument, along with a printer or plotter, would be attached to one interface, while other devices would be attached to another IEEE 488 interface. The computer could configure the spectrum analyzer to plot its results and then pass control to it, allowing it to control the printer or plotter. Meanwhile, the computer would be using the other bus to control other equipment.

To allow such complex systems, Driver488/DRV supports as many as four interfaces on a single computer. The **`CONFIG`** program helps you to configure multiple interfaces and notifies you of possible conflicts.

The examples in this manual assume, for the most part, that only one board is installed in the system, and that it is accessed through the three device names given above for the first board. If multiple interfaces are installed, then they are accessed in just the same manner as the first board, except that different device names, as given above, are used. If, for example, two interfaces are installed, then a BASIC program to use them might be:

```
100 OPEN "\DEV\IEEEIN" FOR INPUT AS #1
110 OPEN "\DEV\IEEEOUT" FOR OUTPUT AS #2
120 OPEN "\DEV\IEEEIN2" FOR INPUT AS #3
130 OPEN "\DEV\IEEEOUT2" FOR OUTPUT AS #4
140 PRINT#2,"OUTPUT 10;R0X"
150 PRINT#4,"OUTPUT 10;R1X"
```

where line 140 sends **`R0X`** to device **`10`** on the IEEE 488 bus controlled by board 1, and line 150 send **`R1X`** to device **`10`** on the second IEEE 488 bus. Because they are on two physically different IEEE 488 buses, there is no confusion as to which device **`10`** is being accessed.

Note: If installation or configuration problems exist, refer to “Section IV: Troubleshooting.”

8C. External Device Interfacing

Topics

Introduction

This Sub-Chapter is a technical review of external device interfacing. It contains information on how to use external devices, DOS devices and multiple interfaces.

Driver488/DRV controls I/O interfaces and their attached external devices. In turn, Driver488/DRV is controlled by one of two access methods: the *Character Command Language (CCL)*, and *direct DOS I/O devices*.

Driver488/DRV communicates directly with I/O interfaces, such as an IEEE 488 interface board and a serial (RS-232) port. More than one I/O interface may reside on a single plug-in board. For example, an RS-232 board often contains two or four functionally separate I/O interfaces, one for each port. The GP488B board contains the IEEE 488 I/O interface; and an MP488CT board contains an IEEE 488 interface, a digital I/O interface, and a counter/timer I/O interface.

I/O interfaces connect to external devices such as: digitizers, multimeters, plotters, and oscilloscopes (IEEE 488 interface); and serial devices such as printers, plotters, and modems (serial RS-232 port). Driver488/DRV allows direct control of IEEE 488 external devices, but it does not support other external devices such as an RS-232 plotter. Such devices are supported by directly controlling the I/O interface (serial port).

Driver488/DRV is controlled by sending data and commands, and receiving responses and status by one of two access methods: the Character Command Language, and Direct DOS I/O devices. These methods, also known as Application Program Interfaces or APIs, are available to connect the application (user's) program to Driver488/DRV.

Character Command Language (CCL)

The Character Command Language (CCL) API is a type of DOS device driver that can control and communicate with Driver488/DRV. A DOS device driver is a special type of program that appears to the user's program as a file that can be written to and read from like any disk file, but that does not actually read and write the disk. For example, the DOS command:

```
COPY FILE.LST LPT1
```

copies the disk file **`FILE.LST`** to the device driver **`LPT1`** which prints **`FILE.LST`**. There is no file named **`LPT1`**; the **`LPT1`** device driver program has the responsibility for communicating with the printer. The **`COPY`** command can write to **`LPT1`** just like an ordinary file, but DOS knows **`LPT1`** is only a device driver and allows it to process the data.

The Character Command Language is a device driver that writes commands to, and reads responses from, Driver488/DRV. To use the Character Command Language, the application program opens a file with a special name, such as: **"\DEV\IEEE"**, and uses standard DOS file I/O commands to communicate with the Character Command Language device driver. Since the CCL is a device driver, standard DOS commands such as: **TYPE** and **COPY** may be used to communicate with Driver488/DRV via the CCL.

DOS Devices

Driver488/DRV may also be controlled by using DOS Devices. A DOS Device is a special type of DOS device driver that uses Driver488/DRV to communicate with a single External Device. Remember that, as a DOS device driver, a DOS Device may be written to and read from, like any disk file. When writing data to a DOS Device, the device driver commands Driver488/DRV to send the data to the corresponding External Device. Similarly, when reading from the DOS Device, the device driver commands Driver488/DRV to read data from the External Device.

Driver488/DRV allows DOS Devices to be created that refer to specific External Devices, just as LPT1 refers to the printer. For example, if an IEEE 488 plotter were configured as a DOS Device named **PLOTDD** (**DD** for DOS Device), then we could use **COPY** to send a plot file to it:

```
COPY PLOTFILE.PLT PLOTDD
```

Configuration of Named Devices

External Devices and DOS Devices are most easily configured by using **CONFIG**. The device names, terminators, time out period, and bus addresses may be entered into **CONFIG** which then writes a configuration file containing the device configuration information. This configuration file is automatically read when Driver488/DRV loads to install the configured devices.

Every device to be accessed by Driver488/DRV must have a valid device name. Driver488/DRV comes with several device and interface names preconfigured for use. Among those already configured for the GP488B board, for example, are: **IEEE** and **COM1**. You can configure up to 50 external devices for the IEEE 488 bus.

It is also possible to configure new named devices by using the Driver488/DRV command **MAKE DEVICE**. The **MAKE DEVICE** command creates a temporary device that is an identical copy of an already existing Driver488/DRV device. The new device has default configuration settings identical to those of the existing device. The new device can then be reconfigured by calling the proper functions, such as **BUS ADDRESS**, **INT LEVEL**, and **TIME OUT**. When Driver488/DRV is closed, the new device is forgotten unless the **KEEP DEVICE** command is used to make it permanent.

The following code illustrates how the Character Command Language API version of the **MAKE DEVICE** command could be used to configure several new named devices:

```
100 PRINT#1,"MAKE DEVICE DMM =ADC"
110 PRINT#1,"BUSADDRESS 16"
120 PRINT#1,"TERM CR LF EOI"
200 PRINT#1,"MAKE DEVICE SCOPECMD =ADC"
210 PRINT#1,"BUSADDRESS 1200"
220 PRINT#1,"TERM LF"
300 PRINT#1,"MAKE DEVICE SCOPE =ADC"
310 PRINT#1,"BUSADDRESS 1201"
320 PRINT#1,"TERM EOI"
```

Lines 100-120 of the above example define an external device named **DMM** (digital multi-meter) as device **16** with bus terminators of carriage-return line-feed (**CR LF**) and **EOI**. Lines 200-220 configure an oscilloscope command channel to use line-feed as its IEEE 488 bus terminator at a primary address of **12** and secondary address **00**. Lines 300-320 configure the oscilloscope data channel to use **EOI** only as the bus terminator so that it can transfer binary data to its address of **1201**: primary address **12**, secondary address **01**.

External Devices and DOS Devices defined at installation time are permanent. Their definitions last until they are explicitly removed or until the computer is restarted. Devices defined after installation are normally temporary. They are forgotten as soon as the program finishes. The **KEEP DEVICE** and **KEEP DOS NAME** commands can be used to make these devices permanent. The **REMOVE DEVICE** and **REMOVE DOS NAME** commands remove the definitions of devices even if they are permanent. These commands are described in further detail in the "Section III: Command Reference" of this manual.

Use of External Devices

Once we have configured the external devices, we can refer to devices by name. For example, using the Character Command Language, the following program allows Driver488/DRV to communicate with a digital multimeter:

```
200 PRINT#1,"CLEAR DMM"
210 PRINT#1,"OUTPUT DMM;VDC"
220 PRINT#1,"ENTER DMM"
230 INPUT#2,VOLTAGE
300 PRINT#1,"TRIGGER SCOPECMD"
320 PRINT#1,"ENTER SCOPE #1000 BUFFER 11";DS%;":";VARPTR(ARRAY)
```

In these commands we **CLEAR** the **DMM**, configure it for DC volts, take a reading and store it in the variable **VOLTAGE**. Next, we **TRIGGER** the **SCOPE** at its command address and then read from its binary data channel into an array. While these commands are hypothetical, they show how device names can be used wherever a device address is allowed.

As mentioned above, named devices have another advantage: they automatically use the correct bus terminators and time out. When a named device is defined, it is assigned bus terminators and a time out period. When communication with that named device occurs, Driver488/DRV uses these terminators and time out period automatically. Thus **TERM** statements are not needed to reconfigure the bus terminators for devices that cannot use the default terminators (which are usually carriage-return line-feed **EOI**). It is still possible to override the automatic bus terminators by explicitly specifying the terminators in an **ENTER** or **OUTPUT** command. For more information, see the **ENTER**, **OUTPUT**, and **TERM** commands described in "Section III: Command References."

Direct I/O with DOS Devices

DOS Devices can be opened as files for direct communication. For example, we can configure two names to refer to a plotter with an IEEE 488 bus address of **05**:

```
400 PRINT #1,"MAKE DEVICE PLOTTER BUSADDRESS 05"
410 PRINT #1,"MAKE DOS NAME PLOT=PLOTTER"
420 PRINT #1,"MAKE DOS NAME PLOTIN=PLOTTER"
```

Then we can open them, one for input and one for output:

```
430 OPEN "PLOT" FOR OUTPUT AS #3
440 OPEN "PLOTIN" FOR INPUT AS #4
```

Two different names are used to communicate with the plotter because, in BASIC, the same file cannot be used for both input and output. In other languages, it might be possible to use the same file (with the same device name) for both input and output. Also note that BASIC normally has a limit of 3 open files. To open more than 3 files (as in this example; 2 for Driver488/DRV commands, and 2 for the plotter), BASIC must be started with the parameter **/F:n** (where **n** is the number of files). See your BASIC manual for more details.

For clarity, the DOS Device names are not the same as External Device names. In normal use, one of the DOS Device names might be chosen to be the same as an External Device name to show that they communicate with the same External Device. Of course, the two DOS Device names must be different.

Once the files are opened, we can communicate **PRINT** commands to the plotter and **INPUT** responses from the plotter without using the Driver488/DRV **OUTPUT** or **ENTER** commands. When a named device is used as a file, the **OUTPUT** and **ENTER** commands occur automatically.

```
500 PRINT#3,"IN; SP1; PA1000,1000;" 'Send plot commands
510 PRINT#3,"OE;" 'Request plotter status
520 INPUT#4,ST$ 'Read plotter status
```

```
530 PRINT ST$ 'and display it
```

Once a named device is configured, standard DOS commands may be used to transfer data to that device. For example:

```
COPY PLOTFILE.DAT PLOT
```

copies the plot data file `PLOTFILE.DAT` to the IEEE 488 bus plotter.

CAUTION

Because named devices can be used as files, some care must be taken so that they do not interfere with other file or device names in the system:

1. **Device names should not be the same as the primary name (the part before the period) of any existing files or directories. For example, if you define a device with the name "BASIC", then you cannot use the program "`BASIC.EXE`", and if you name a device "IEEE 488", then you cannot access the Driver488/DRV subdirectory.**
2. **Device names should not be one of the standard DOS device names: COM, AUX, CON, LPT, or PRN. This could interfere with normal DOS operation.**
3. **Device names should normally not be duplicated. If duplicate device names are used, only the last one of them installed is accessible. To avoid confusion, duplicate device names are not recommended.**

With the considerations noted in the above warning, External Devices and DOS Devices make Driver488/DRV significantly easier to use. External Devices allow IEEE 488 bus devices to be referenced symbolically, by a name, rather than by their bus address. They also automatically use the appropriate IEEE 488 bus terminators and time out period. Finally, it is possible to communicate directly with DOS Devices just as you would communicate with any file.

Extensions For Multiple Interfaces

Driver488/DRV allows the simultaneous control of multiple interfaces each with several attached devices. To avoid confusion, external devices may be referred to by their "full name" which consists of two parts. The "first name" is the hardware interface **`name`**, followed by a colon separator (**`:`**). The "last name" is the external device **`name`** on that interface. For example, the "full name" of **`DMM`** might be **`IEEE:DMM`**.

Duplicate Device Names

Duplicate device names are most often used in systems that consist of several identical sets of equipment. For example, a test set might consist of a signal generator and an oscilloscope. If three test sets were controlled by a single computer using three separate IEEE 488 interfaces, then each signal generator and each oscilloscope might be given the same name and the program would specify which test set to use by opening the correct interface (**`OPEN"IEEE"`** for one, **`OPEN"IEEE2"`** for the other), or by using the interface names when communicating with the devices (**`"IEEE:GENERATOR"`** for one and **`"IEEE2:GENERATOR"`** for the other.)

Unique names are appropriate when the devices work together, even if more than one interface is used. If two different oscilloscopes, on two different interfaces are used as part of the same system, then they would each be given a name appropriate to its function. This avoids confusion and eliminates the need to specify the interface when opening the devices.

Access of Multiple Interfaces

If the computer only has one IEEE 488 interface, then there is no confusion, for every external device is known to be on that interface. However, if the computer has more than one IEEE 488 interface, then rules apply when using the Character Command Language:

1. If the external device name is defined on the current hardware interface, then that interface is used to communicate with that device. The current hardware interface is the one that was opened to communicate with Driver488/DRV. This would be **`IEEE`** for the first IEEE 488 interface, **`IEEE2`** for the second, etc.
2. If the name is defined on another hardware interface, that other interface is used to communicate with that device.
3. If the name is defined on more than one other interface (and not on the current interface) then one of those interfaces is used. The choice of which particular interface is not defined.
4. In order to specify the interface to use, the interface name may be prefixed with a colon to the device name. For example, **`IEEE2:DMM`** refers to the digital multimeter attached to interface **`IEEE2`**. If the specified device does not exist on the specified interface, then an error occurs.

Example

Assume there are three IEEE 488 interfaces: **`IEEE`**, **`IEEE2`**, and **`IEEE3`** controlling multiple devices: **`SCOPE`** (on **`IEEE`**), **`DA`** (on **`IEEE2`**) and **`DA`** (on **`IEEE3`**). Since there are two external devices, both named **`DA`**, their full name must be used to specify them.

After opening the interfaces with the following command lines:

```
OPEN "IEEE" AS #1
OPEN "IEEE2" AS #2
OPEN "IEEE3" AS #3
```

we can communicate with the external devices, according to the four rules above.

`PRINT #1,"OUTPUT SCOPE;..."`	**`SCOPE`** on **`IEEE`**. See Rule 1
`PRINT #3,"OUTPUT SCOPE;..."`	**`SCOPE`** on **`IEEE`** (not **`IEEE2`**). See Rule 2
`PRINT #1,"OUTPUT DA;..."`	**`DA`** on **`IEEE2`** or **`IEEE3`** (not specified). See Rule 3
`PRINT #1,"OUTPUT IEEE2:DA;..."`	**`DA`** on **`IEEE2`**. See Rule 4
`PRINT #1,"OUTPUT IEEE2:SCOPE;..."`	**`ERROR`** (not **`IEEE:SCOPE`**). See Rule 4

8D. Getting Started

Topics

Introduction

Once Driver488/DRV has been installed in your system, it is ready to begin controlling IEEE 488 bus devices. This Sub-Chapter describes methods of controlling the bus directly from the keyboard. Other Sub-Chapters in this Chapter develop short programs, in various languages, to control a Keithley Instruments Model 195 digital multimeter. The techniques used in these programs are quite general, and apply to the control of most instruments.

It is not necessary to write programs to control IEEE 488 bus devices using Driver488/DRV. Instead, using the *Character Command Language Application Program Interface* (CCL API), commands to the bus may be sent directly from the keyboard, with responses displayed on the screen or sent to a file. The Keyboard Controller program provides this capability, as do the standard MS-DOS commands.

Keyboard Controller Program

The program `KBC.EXE` is a utility program that allows you to enter Driver488/DRV commands from the keyboard and see what effect they have. When `KBC` is run, it displays an `IEEE>` prompt and waits for a command to be entered from the keyboard. When the `<Enter>` key is pressed, `KBC` sends the command to Driver488/DRV and displays any response or error messages that occur. This allows you to test the various Driver488/DRV commands and their effects on your instruments without having to write a program. A dialog with `KBC` might be:

First, we can use the `HELLO` command to display the Driver488/DRV revision identification:

```
IEEE> HELLO <Enter>
Driver488 Revision X.X ©199X IOtech, Inc.
```

Then check the Driver488/DRV status:

```
IEEE> STATUS <Enter>
CS21 1 I000 000 T0 C0 P0 OK
```

The following indicators describe each component of the Driver488/DRV status:

Indicator	Driver488/DRV Status
`C`	It is in the Controller state.
`S`	It is the System Controller.
`21`	The value of its IEEE 488 bus address.
`1`	An Address Change has occurred.
`I`	It is idle (neither a talker nor a listener).
`0`	There is no `ByteIn` available.
`0`	It is not ready to send a `ByteOut`.
`0`	Service Request (`SRQ`) is not asserted.
`000`	There is no outstanding error.
`T0`	It has not received a bus device `TRIGGER` command (only applicable in the Peripheral mode).
`C0`	It has not received a `CLEAR` command (only applicable in the Peripheral mode).
`P0`	No `CONTINUE` transfer is in progress.
`OK`	The error message is “OK”.

Next, take a reading from IEEE 488 bus device `16`:

```
IEEE> ENTER 16 <Enter>
NDCV=035.679E-3
```

Now, list the commands that have been executed so far and re-execute the `ENTER` command:

```
IEEE> .L <Enter>
3 HELLO
2 STATUS
1 ENTER 16
IEEE .1 <Enter>
IEEE> ENTER 16 <Enter>
NDCV+032.340E-3
```

Notice that the `.L` and `.1` commands are not Driver488/DRV commands. Instead, they are supplied by the `KBC` program. The `.L` command is used to show a list of the previously entered commands. `KBC` keeps the last 20 commands in this list. Any of these commands can be reentered by typing a period followed by the number of that command. For example, the `.1` command reenters the last command that was entered. The user may then edit this command, or may just press `<Enter>` re-executing the command.

Finally, **`EXIT`** causes **`KBC`** to terminate:

```
        IEEE> EXIT <Enter>
```

As already mentioned, **`KBC`** obeys the standard DOS editing keys. In using these editing keys, the previous command is used as a template. Characters from the template are copied into the current command line under control of the editing keys. These editing keys, coupled with the ability to retrieve previous commands, greatly ease the task of trying various Driver488/DRV commands.

The editing keys and their actions are:

Editing Key	**Editing Function**
`<F1> or <→>`	Copies one character from the template to the command line.
`<F2>char`	Copies characters from the template to the command line up to the character specified.
`<F3>`	Copies all remaining characters from the template to the command line.
`<F4>char`	Skips over (does not copy) characters from the template up to the character specified.
`<F5>`	Replaces the template with the current command line.
`<Del>`	Skips over (does not copy) one character in the template.
`<Ins>`	Toggles insert mode. When insert mode is off (the default) characters from the template are skipped as characters are entered from the keyboard. When insert mode is on, no characters in the template are skipped.
`<Esc>`	Clears the command line and leaves the template unchanged.

Direct Control from DOS Using CCL

Because Driver488/DRV is a standard MS-DOS device driver, any program that can read and write characters to files can control the IEEE 488 bus. In particular, MS-DOS (and PC-DOS) provide several commands that can communicate directly with Driver488/DRV. To begin communication, it is helpful to turn on the Driver488/DRV automatic error display:

```
        C:\> ECHO ERROR ON> IEEE <Enter>
```

and tell Driver488/DRV to end its responses with an end-of-file character (**`control-Z, ASCII 26`**):

```
        C:\> ECHO FILL $26> IEEE <Enter>
```

Note the format of these commands: the DOS command **`ECHO`**, followed by the Driver488/DRV command **`ERROR ON`** or **`FILL $26`**, which is redirected by the **`>`** to a file named **`IEEE`**. When **`ECHO`** tries to write the command to **`IEEE`**, DOS notices that **`IEEE`** is the name of a device driver, not a file, and so sends the command to the device driver which of course is Driver488/DRV.

Once the input terminator is initialized to the end-of-file character, DOS can be used to get responses from Driver488/DRV and the attached IEEE 488 bus devices.

First, we can use the **`HELLO`** command to display the Driver488/DRV revision identification:

```
        C:\> ECHO HELLO> IEEE <Enter>
        C:\> TYPE IEEE <Enter>
        Driver488 Revision X.X ©199X IOtech Inc.
```

Then check the Driver488/DRV status:

```
        C:\> ECHO STATUS> IEEE <Enter>
        C:\> TYPE IEEE <Enter>
        CS21 1 I000 000 T0 C0 P0 OK
```

The following indicators describe each component of the Driver488/DRV status:

Indicator	Driver488/DRV Status
`C`	It is in the Controller state.
`S`	It is the System Controller.
`21`	The value of its IEEE 488 bus address.
`1`	An Address Change has occurred.
`I`	It is idle (neither a talker nor a listener).
`0`	There is no **`ByteIn`** available.
`0`	It is not ready to send a **`ByteOut`**.
`0`	Service Request (**`SRQ`**) is not asserted.
`000`	There is no outstanding error.
`T0`	It has not received a bus device **`TRIGGER`** command (only applicable in the Peripheral mode).
`C0`	It has not received a **`CLEAR`** command (only applicable in the Peripheral mode).
`P0`	No **`CONTINUE`** transfer is in progress.
`OK`	The error message is "OK".

Next, take a reading from IEEE 488 bus device **`16`**:

```
C:\> ECHO ENTER 16> IEEE <Enter>
C:\> TYPE IEEE <Enter>
NDCV=035.679E-3
```

Now, if an IEEE 488 bus device name has been defined using the **`INSTALL`** program, that name can be used to refer to the bus device. For example, assume that a Keithley Instruments Model 195 digital multimeter has been given the name **`K195`**. The meter could be reset to its power-on conditions with a **`CLEAR`** command:

```
C:\> ECHO CLEAR K195> IEEE <Enter>
```

To program the 195 for the 2 VDC range, send it the **`R3F0X`** command:

```
C:\> ECHO OUTPUT K195;R3F0X> IEEE <Enter>
```

This could also be achieved by sending the command directly to the device:

```
C:\> ECHO R3F0X> K195 <Enter>
```

To check the status of the 195, use the **`SERIAL POLL,`** or **`SPOLL`** command:

```
C:\> ECHO SPOLL K195> IEEE <Enter>
C:\> TYPE IEEE <Enter>
```

To display a reading from the 195, use the **`ENTER`** command:

```
C:\> ECHO ENTER K195> IEEE <Enter>
C:\> TYPE IEEE <Enter>
```

To view continuous readings from the 195, read directly from the **`K195`** device:

```
C:\> TYPE K195 <Enter>
```

This causes readings to be taken from the 195 and displayed until **`<Ctrl-Break>`** is typed. Note that **`<Ctrl-Break>`** may halt Driver488/DRV in the middle of a transaction, causing the first attempt at another command to give a **`SEQUENCE ERROR`**. If this should occur, simply retry the last command.

It is also possible to save the bus device data into a file:

```
C:\> ECHO ENTER K195> IEEE <Enter>
C:\> TYPE IEEE> DATA <Enter>
C:\> ECHO ENTER FREQ> IEEE <Enter>
C:\> TYPE IEEE>> DATA <Enter>
```

The first two commands create a file named **`DATA`** that holds a reading from the 195. The next two commands append a reading from the device **`FREQ`** to the data file. Note the use of the **`>>`** to indicate append.

8E. Microsoft C

Topics

Use of the Character Command Language

In order to simplify programming Driver488/DRV with C, the following files are provided on the Driver488/DRV program disk:

- `IEEEIO.C:` Communications routines for Driver488/DRV
- `IEEEIO.H:` Header file, contains declarations from `IEEEIO.C`
- `IEEEDEMO.C:` Example file showing use of `fputs` and `fgets` with Driver488/DRV (included with Microsoft C only)
- `CRITERR.ASM:` Critical error handler assembly language source file (included with Microsoft C and Turbo C only)
- `CRITERR.OBJ:` Object file produced from `CRITERR.ASM` (included with Microsoft C and Turbo C only)
- `CRITERR.H:` Header file, contains declarations for using `CRITERR.ASM`

The actual demonstration program is contained in `195DEMO.C`.

All files for Microsoft C are in the `\MSC` directory.

To execute the demonstration program, the files must be compiled and then linked. The following DOS commands perform these steps:

```
C> msc 195demo;
C> msc ieeeio;
C> link 195demo ieeeio;
```

Finally, the demonstration program is run by typing `195DEMO <Enter>`. Notice that the critical error handler `CRITERR.ASM` is not required for the demonstration program. Its use is described later in "CRITERR.ASM (Microsoft C & Turbo C)," one of the last topics in this Sub-Chapter.

The above command assumes that you have Microsoft C and that the files have been copied into the appropriate directory for use with your C compiler. Notice that the program uses a small data model because it uses less than 64K of code and data.

Initialization of the System

Any program using Driver488/DRV must first establish communications with the Driver488/DRV software driver. In C, this is accomplished using the `OPEN` statement. Communication both to and from Driver488/DRV is required. Thus, the file must be opened for both reading and writing (`RDWR`).

Also, in Microsoft C and Turbo C, the file must be opened in **`BINARY`** mode so that end-of-line characters are not translated.

In Microsoft C and Turbo C, the file is opened with the following statement:

```
ieee=open("ieee",O_RDWR | O_BINARY);
```

which is part of the **`IEEEINIT`** function contained in **`IEEEIO.C`**. **`IEEEIO.C`** supplies several other useful routines and definitions. These routines and definitions are described later in more detail in "Interrupt Handling," an upcoming topic in this Sub-Chapter.

In the above statement, the value returned by **`OPEN`** and placed into the integer variable **`IEEE`**, is either the handle of the opened file, or **`-1`** if some error has occurred. The **`IEEEINIT`** routine checks for this error indication and returns a **`-1`** if there has been such an error.

Of course, the file descriptor variable name **`IEEE`** may be changed as desired, but throughout this manual and the program files, **`IEEE`** has been used. Once the file is opened, we can send commands and receive responses from Driver488/DRV.

Normally, when DOS communicates with a file, it checks for special characters, such as **`control-Z`** which can indicate end-of-file. When communicating with IEEE 488 devices, DOS's checking would interfere with the communication. The **`RAWMODE`** function prevents DOS from checkings for special characters:

```
rawmode(ieee);
```

As an additional benefit, communication with Driver488/DRV is much more efficient when DOS does not check for special characters.

Driver488/DRV can accept commands only when it is in a quiescent, ready state. While Driver488/DRV should normally be ready, it is possible that it was left in some unknown state by a previous program failure or error. In order to force Driver488/DRV into its quiescent state, we use the **`IOCTL_WT`** function:

```
ioctl_wt(ieee,"break",5);
```

This **`IOCTL_WT`** function is equivalent to the BASIC statement **`IOCTL#1,"BREAK"`** which sends the **`BREAK`** command through a "back door" to Driver488/DRV. Driver488/DRV recognizes this "back door" command regardless of what else it might be doing and resets itself so that it is ready to accept a normal command. We can then completely reset the Driver488/DRV with the **`RESET`** command:

```
ieeewt("reset\r\n");
```

which resets the operating parameters of the Driver488/DRV back to their normal values (those that were set during system boot by the **`DRVR488`** DOS command). Notice that the **`EOL OUT`** terminators that mark the end of a Driver488/DRV command are reset to carriage return and line feed by the **`IOCTL_WT`** command. Thus, the **`RESET`** command must be terminated by both a carriage return (**`\r`**) and a line feed (**`\n`**). As it is more convenient if Driver488/DRV accepts line feed only as the command terminator, we use the **`EOL OUT`** command to set the command terminator to just line feed (**`\n`**):

```
ieeewt("eol out lf\r\n");
```

Notice that this command must also be terminated by both a carriage return and a line feed because the command terminator is not changed until after the **`EOL OUT`** command is executed.

Character strings in C are normally terminated by a null (an **`ASCII 0`**). Thus, it is appropriate for Driver488/DRV to terminate its responses to the program with a null so that the response can be treated as a normal character string. We can use the **`EOL IN`** command to configure Driver488/DRV so that it does provide an ASCII null terminator:

```
ieeewt("eol in $0\n");
```

Finally, we enable **`SEQUENCE - NO DATA AVAILABLE`** error detection by setting the **`FILL`** mode to **`ERROR`**:

```
ieeewt("fill error\n");
```

All the commands discussed so far: **`OPEN`**, **`RAWMODE`**, **`IOCTL_WT`**, **`RESET`**, **`EOL OUT`**, **`EOL IN`** and **`FILL ERROR`** are part of the **`IEEEINIT`** function included in **`IEEEIO.C`**. **`IEEEINIT`** returns a zero if these steps were executed successfully, and a **`-1`** if some error was encountered. Thus, to accomplish all the above steps, we just use the following:

```
#include "ieeeio.h"
#include <stdio.h>
if (ieeeinit() == -1) {
printf("Cannot initialize IEEE system.\n");
exit(1);
}
```

The two **`INCLUDE`** statements provide the program with definitions of the standard I/O and IEEE I/O functions so they can be referenced by the demo program. **`IEEEINIT`** is called to initialize the system, and if it indicates an error (returns a **`-1`**), we print an error message and exit. If there was no error, we just continue with the program.

Once everything is reset, we can test the communications and read the Driver488/DRV revision number with the **`HELLO`** command:

```
char response[256];
ieeewt("hello\n");
ieeerd(response);
printf("%s\n",response);
```

We first **`IEEEWT`** the **`HELLO`** command, then **`IEEERD`** the response from Driver488/DRV into the character string response (**`IEEEWT`** and **`IEEERD`** are both supplied in **`IEEEIO.C`**). Finally, we display the response with a **`PRINTF`**.

It is not necessary to perform the **`HELLO`** command, but it is included here as a simple example of normal communication with Driver488/DRV. Its response is the revision identification of the Driver488/DRV software: **`Driver488 Revision X.X ©199X IOtech, Inc.`**

We can also interrogate Driver488/DRV for its status:

```
ieeewt("status\n");
ieeerd(response);
printf("%s\n",response);
```

Subsequently, the printed response is similar to the following:

```
CS21 1 I000 000 T0 C0 P0 OK
```

The following indicators describe each component of the Driver488/DRV status:

Indicator	Driver488/DRV Status
`C`	It is in the Controller state.
`S`	It is the System Controller.
`21`	The value of its IEEE 488 bus address.
`1`	An Address Change has occurred.
`I`	It is idle (neither a talker nor a listener).
`0`	There is no **`ByteIn`** available.
`0`	It is not ready to send a **`ByteOut`**.
`0`	Service Request (**`SRQ`**) is not asserted.
`000`	There is no outstanding error.
`T0`	It has not received a bus device **`TRIGGER`** command (only applicable in the Peripheral mode).
`C0`	It has not received a **`CLEAR`** command (only applicable in the Peripheral mode).
`P0`	No **`CONTINUE`** transfer is in progress.
`OK`	The error message is "OK".

Configuration of the 195 DMM

Once the system is initialized we are ready to start issuing bus commands. The IEEE 488 bus has already been cleared by the Interface Clear (**IFC**) sent by the **RESET** command, so we know that all bus devices are waiting for the controller to take some action. To control an IEEE 488 bus device, we output an appropriate device-dependent command to that device. For example, the **F0R0X** command line below sets the 195 to read DC volts with automatic range selection:

```
ieeewt("output 16;F0R0X\n");
```

The **OUTPUT** command takes a bus device address (**16** in this case) and data (**F0R0X**) and sends the data to the specified device. The address can be just a primary address, such as **12**, or **05**, or it can include a secondary address: **1201**. Note that both the primary address and, if present, the secondary address are two-digit decimal numbers. A leading zero must be used, if necessary to make a two-digit address.

Taking Readings

Once we have set the 195's operating mode, we can take a reading and display it:

```
float voltage;
ieeewt("enter 16\n");
ieeescnf("%*4s%e",&voltage);
printf("The read value is %g\n",voltage);
```

The **ENTER** command takes a bus address (with an optional secondary address) and configures that bus device so that it is able to send data (addressed to talk). No data is actually transferred, however, until the **IEEESCNF** statement requests the result from Driver488/DRV at which time data is transferred to the program into the variable **voltage**. A typical reading from a 195 might be **NDCV+1.23456E-2**, consisting of a four character prefix followed by a floating point value. The format passed to **IEEESCNF** causes it to skip the four character prefix (**%*4s**) and then convert the remaining string into the float variable **voltage**.

All the power of C may be used to manipulate, print, store, and analyze the data read from the IEEE 488 bus. For example, the following statements print the average of ten readings from the 195:

```
int i;
float sum;
sum=0.0;
for (i=0; i<10; i++) {
  ieeewt("enter 16\n");
  ieeescnf("%*4s%e",&voltage);
  sum=sum+voltage;
}
printf("The average of 10 readings is %g\n",sum/10.0);
```

Buffer Transfers

Instead of using an **IEEERD(_)** function to receive the data from a device, we can direct Driver488/DRV to place the response directly into a data buffer of our choosing. For example, each reading from the 195 consists of 17 bytes: a four-byte prefix and an eleven-byte reading followed by the two-byte command terminator. So, we can collect 100 readings in a 1700-byte array. To do this, we must first allocate the required space in an array:

```
char hundred[1700];
```

Now that we have allocated a place for the readings, we can direct Driver488/DRV to put readings directly into **hundred** with the **ENTER #count BUFFER** command:

```
ieeeprtf("ENTER 16 #1700 BUFFER %d:%d\n",
segment(hundred),offset(hundred));
```

This command consists of the keyword **ENTER**, followed by the bus device address (**16**), a number sign (**#**), the number of bytes to transfer (**1700**), and the keyword **BUFFER**, followed by the memory address of the buffer. The buffer address is specified as **segment:offset** where **segment** and **offset** are each 16-bit numbers and the colon (`:`) is required to separate them. The `segment` and `offset` values we need are returned by the `segment` and `offset` functions, respectively.

Once the data has been received, we can print it out:

```
for (i=0; i<1700; i++) putchar(hundred[i]);
```

The program could process the previous set of data while collecting a new set into a different buffer. To allow the program to continue, specify `continue` in the command:

```
ieeeprtf("ENTER 16 #1700 BUFFER continue\n",
segment(hundred),offset(hundred));
```

Once we have started the transfer, we can check the status:

```
ieeewt("status\n");
ieeerd(response);
printf("%s\n",response);
```

The status that is returned is typically:

```
CS21 1 L100 000 T0 C0 P1 OK
```

Notice `P1` which states a transfer is in progress, and `L` which shows we are still a listener. If the bus device is so fast that the transfer completes before the program can check status, the response is `P0` showing that the transfer is no longer in progress. We can also `WAIT` for the transfer to complete and check the status again:

```
ieeewt("wait\n");
ieeewt("status\n");
ieeerd(response);
printf("%s\n",response);
```

This time the status must be `P0` as the `WAIT` command waits until the transfer has completed. Now that we know the transfer is complete, we are ready to print out the received data as shown above.

Interrupt Handling

The IEEE 488 bus is designed to be able to attend to asynchronous (unpredictable) events or conditions. When such an event occurs, the bus device needing attention can assert the Service Request (`SRQ`) line to signal that condition to the controller. Once the controller notices the `SRQ`, it can interrogate the bus devices, using Parallel Poll (`PPOLL`) and/or Serial Poll (`SPOLL`) to determine the source and cause of the `SRQ`, and take the appropriate action.

Parallel Poll is the fastest method of determining which device requires service. Parallel Poll is a very short, simple IEEE 488 bus transaction that quickly returns the status from many devices. Each of the eight IEEE 488 bus data bits can contain the Parallel Poll response from one or more devices. So, if there are eight or fewer devices on the bus, then just the single Parallel Poll can determine which requires service. Even if the bus is occupied by the full complement of 15 devices, then Parallel Poll can narrow the possibilities down to a choice of no more than two.

Unfortunately, the utility of Parallel Poll is limited when working with actual devices. Some have no Parallel Poll response capability. Others must be configured in hardware, usually with switches or jumpers, to set their Parallel Poll response. If Parallel Poll is not available, or several devices share the same Parallel Poll response bit, then Serial Polling is still required to determine which device is requesting service.

Serial Poll, though it is not as fast as Parallel Poll, does offer three major advantages: it gives an unambiguous response from a single bus device; it returns additional status information beyond the simple request/no-request for service; and, most importantly, it is implemented on virtually all bus devices.

The `SRQ` line can be monitored in two ways: it can be periodically polled by using the `STATUS` command, or by checking the "light pen status."

BASIC provides a method for detecting and servicing external interrupts: the `ON PEN` statement. The `ON PEN` statement tells BASIC that, when an external interrupt is detected, a specific subroutine, known as the interrupt service routine (ISR), is to be executed. Normally, the interrupt detected by **ON PEN** is the light pen interrupt. However, Driver488/DRV redefines this "light pen interrupt" to signal when an IEEE 488 bus related interrupt (such as **SRQ**) has occurred.

Unlike BASIC, C does not provide an automatic method of checking for light pen interrupts. Therefore, a function is needed to check for the interrupt. The function could use the **STATUS** command, but it is much faster to check the interrupt status directly using a BIOS interrupt. The **CKLPINT** (check light pen interrupt) function provided in **IEEEIO.C** uses the BIOS to check for Driver488/DRV interrupts and returns true (**1**) if one is pending. Interrupts are checked automatically by the **IEEEWT** routine before sending any data to Driver488/DRV. However, **IEEEWT** does not call **CKLPINT** directly. Instead, it calls the routine that is pointed to by **IEEE_CKI** (**IEEE** check interrupt). If **IEEE_CKI** points to **CKLPINT**, then **IEEEWT** checks for Driver488/DRV interrupts, but if **IEEE_CKI** points to **_false_**, a function that always returns **0**, then interrupt checking is disabled. Initially, **IEEE_CKI** does point to **_false_**, and so interrupt checking is disabled. To enable interrupt checking **IEEE_CKI** must be redirected to **CKLPINT**:

```
int cklpint();
ieee_cki = cklpint;
```

Once an interrupt has been detected, an interrupt service routine must be invoked to handle the interrupting condition. When **IEEEWT** detects an interrupt, it calls the interrupt service routine (ISR). Just as **IEEEWT** does not call the check-for-interrupt routine directly, it does not call the ISR directly, either. Instead, it calls the routine pointed to by **IEEE_ISR** (**IEEE** interrupt service routine). If **IEEE_ISR** is set to point to some specific ISR, then that ISR is executed when **IEEEWT** detects an interrupt. Initially, **IEEE_ISR** points to **no_op**, a function that does nothing. So, unless **IEEE_ISR** is redirected to another routine, nothing is done when an interrupt is detected. In the **195DEMO** example program an interrupt service routine, called **isr**, has been provided. So, **IEEE_ISR** must be set to point this routine for interrupts to be handled properly:

```
ieee_isr = isr;
```

Once we have enabled interrupt checking by setting **IEEE_CKI** to point to **CKLPINT**, and specified the interrupt service routine by setting **IEEE_ISR** to point to **isr**, then we can specify which conditions are to cause an interrupt. The **ARM** command specifies those conditions. In this example we want the interrupt to occur on the detection of a Service Request (**SRQ**):

```
ieeewt("arm srq\n");
```

The 195 can be set to request service on any of several different internal conditions. In particular, the **M2** command causes an **SRQ** on the detection of any invalid command or command option by the 195:

```
ieeewt("output 16;M2X");
```

This **OUTPUT** command is placed early in the program so that all subsequent commands to the 195 cause an **SRQ**, if they are invalid.

Now that interrupt detection is enabled, and the interrupt service routine is specified, we must specify the actions to take to service the interrupt. We first display a message indicating that an interrupt was detected, and then turn off interrupt checking:

```
void isr()
{ int _false_();
printf("Interrupt detected...");
ieee_cki = _false_;
```

We next check the Driver488/DRV Serial Poll Status to determine if an **SRQ** actually caused the interrupt:

```
int sp;
ieeewt("spoll\n");
ieeescnf("%d",&sp);
if (sp==0) {
printf("Non-SRQ Interrupt!\n");
exit(1);
}
```

We then Serial Poll the 195 to determine its status. If there were other devices on the bus that could be generating the **SRQ**, each of them would be have to be checked in turn.

```
int st195;
ieeewt("spoll 16\n");
ieeescnf("%d",&st195);
if ((st195 & 0x40) == 0 ) {
printf("Non-195 SRQ!\n");
exit();
}
```

Bit **DIO7**, with a value of **0x40**, is returned as true (**1**) in the Serial Poll response of those devices requesting service. In our simple example we expect that the 195 is the only possible cause of an **SRQ**, and if not, there must be some error.

Now that we have identified the device that is requesting service, we can further examine the Serial Poll status to classify the request:

```
if ((st195 & 0x20) == 0) {
if (st195 & 0x01)
printf("Overflow\n");
if (st195 & 0x02)
printf("Buffer Full\n");
if (st195 & 0x04)
printf("Buffer 1/2 Full\n");
if (st195 & 0x08)
printf("Reading Done\n");
if (st195 & 0x10)
printf("Busy\n");
} else {
if (st195 & 0x01)
printf("Illegal Command Option\n");
if (st195 & 0x02)
printf("Illegal Command\n");
if (st195 & 0x04)
printf("No Remote\n");
if (st195 & 0x08)
printf("Trigger Overrun\n");
if (st195 & 0x10)
printf("Failed Selftest\n");
}
```

The action taken depends on the system design, but in this example, a message display is adequate. Now, after decoding the cause of the **SRQ**, we can re-enable interrupts and return to the main program:

```
ieee_cki = cklpint;
```

IEEEIO.C

The **IEEEIO.C** file contains several useful declarations and functions, many of which have been used in the **195DEMO** example program. They are:

- **IEEE** is an integer that holds the file descriptor (MS-DOS handle) returned by **OPEN**.

  ```
  int ieee
  ```

- **segment** and **offset** return the 16-bit **segment** and **offset** values that make up a pointer.

  ```
  int segment(ptr)
  void *ptr
  int offset(ptr)
  void *ptr
  ```

  The implementation of these functions depends on the memory model being used. In the small data model, pointers are 16 bits and are exactly the **offset** desired. Here, the **segment** is always the internal **ds** register value. In the large data model, pointers are 32 bits, one word of which is the **segment** and the other is the **offset**. For more information on memory models, see the "Other Languages" Sub-Chapter in this Chapter.

- **ERRNO** holds the error code for I/O and other errors.

  ```
  extern int errno;
  ```

- **IOCTL_RD** and **IOCTL_WT** are special versions of **IOCTL_IO** which reads and writes to the I/O control channel of a device.

  ```
  int ioctl_io(handle,chars,size,iocall)
  int handle,
  size,
  iocall;
  char chars[];
  #define ioctl_rd(handle,chars,size) \
  ioctl_io(handle,chars,size,0x4402)
  #define ioctl_wt(handle,chars,size) \
  ioctl_io(handle,chars,size,0x4403)
  ```

  The I/O control channel of a device is read from and written to exactly as the normal (data) channel is read and written, but the data transferred is not to be treated in the same way. Normally, the I/O control channel is used to communicate setup and status information regarding the device without actually transferring any data to or from it. When using Driver488/DRV, **IOCTL_WT** is used to force Driver488/DRV to be ready to accept a command, and **IOCTL_RD** is used to return status information from the driver. These functions correspond exactly to the **IOCTL** and **IOCTL$** commands, as described in “Section III: Command References.”

- **CKLPINT, IEEE_CKI,** and **IEEE_ISR** are functions and pointers which provide for automatic interrupt detection and servicing.

  ```
  int cklpint()
  int _false_()
  int (*ieee_cki)() = _false_
  void no_op()
  void (*ieee_isr)() = no_op
  ```

  Driver488/DRV signals interrupts, which are enabled with the **ARM** command, by causing the light pen signal to appear “true.” The **CKLPINT** checks that Driver488/DRV is able to service an interrupt (the response from **IOCTL_RD** is **0**) and then checks if an interrupt is pending by checking the light pen status. The **IEEEWT** routine (described below) calls the function pointed to by **IEEE_CKI** to determine if an **IEEE** interrupt needs to be serviced. The **IEEE_CKI** normally points to the function **_false_** which always returns zero (**0**). To enable interrupt checking **IEEE_CKI** must be redirected to point to **CKLPINT**. Interrupt checking is disabled by pointing **IEEE_CKI** back to **_false_**. Once an interrupt has been detected, **IEEEWT** calls the interrupt service routine pointed to by **IEEE_ISR** to service the interrupt. The **IEEE_ISR** initially points to **no_op**, a function that does nothing, but it may be redirected as needed to specify the appropriate interrupt service routine for each part of a program.

- **_IEEEWT** and **_IEEERD** are very similar to the unbuffered **WRITE** and **READ** routines provided in the C library.

  ```
  int _ieeewt(handle,chars)
  int handle
  char chars[]
  int _ieeerd(handle,chars,size)
  int handle,
  size
  char chars[]
  #define ieeewt(chars) _ieeewt(ieee,chars)
  #define ieeerd(chars) _ieeerd(ieee,chars,sizeof(chars))
  ```

  The **_IEEEWT** differs from **WRITE** in that it checks for Driver488/DRV interrupts before writing, determines the number of characters to write by using **STRLEN**, and prints an error message if an error has occurred during writing. The **_IEEERD** differs from **READ** only in that it prints an error message if an error has occurred during reading. **IEEEWT** and **IEEERD** (without the leading underscore) write and read to the file **IEEE**. Notice that **IEEERD** uses **SIZEOF** to determine the number of characters to read. This only works if **SIZEOF** can determine the number of bytes in the receive buffer, **`chars`**. This means **`chars`** must be an array of known size, for example, **`char chars[256]`**, not **`char*chars`**.

- **`IEEEPRTF`** and **`IEEESCNF`** are IEEE 488 versions of **`PRINTF`** and **`SCANF`**, respectively.

```
int ieeeprtf(format,...)
char *format
int ieeescnf(format,a,b,c,d,e)
char *format,*a,*b,*c,*d,*e
```

The **`IEEEPRTF`** accepts a format string and a list of arguments. It formats its arguments according to the specified format and sends the formatted string to Driver488/DRV. The **`IEEESCNF`** accepts a format string and up to 5 pointers (to the types specified in the format string). It reads a string of up to 256 bytes from Driver488/DRV, terminates it with a zero, converts it according to the format string, and places the converted values into the variables pointed to by the specified pointers.

- **`RAWMODE`** sets the file specified by **`handle`** for "raw mode" I/O.

```
int rawmode(handle)
int handle
```

In "raw mode" MS-DOS does not interpret the characters received from the file. In particular, **`control-Z`** is not taken as end-of-file. "Raw mode" is usually appropriate for IEEE 488 communications because it does not interfere with the transfer of binary data and because it is much more efficient than "non-raw mode" I/O.

- **`IEEEINIT`** establishes communications with Driver488/DRV and configures it for use with C.

```
int ieeeinit()
```

It first opens the file **`IEEE`** for both reading and writing and puts the file descriptor into **`IEEE`**. It then puts the file into "raw mode". Driver488/DRV is then initialized by sending the **`IOCTL "BREAK"`** and **`RESET`** commands. Normal output from C is terminated by a new-line (line feed) character, and returned strings should be terminated by a null, so **`EOL OUT LF`** and **`EOL IN $0`** commands are then issued. Finally a **`FILL ERROR`** command is issued to enable **`SEQUENCE - NO DATA AVAILABLE`** error detection. If an error is detected during any of these commands, **`IEEEINIT`** returns a **`-1`**, otherwise it returns a zero (**`0`**).

CRITERR.ASM (Microsoft C & Turbo C)

Normally, when Driver488/DRV detects an error, perhaps due to a syntax error in a command, it responds with an I/O error to DOS. When this happens, DOS normally issues an **`ABORT`**, **`RETRY`** or **`IGNORE`** message and waits for a response from the keyboard. There is no way for the user's program to detect such an error, determine the cause, and take appropriate action. However, DOS does provide a method of redefining the action to be taken on such a "critical error". **`CRITERR.ASM`** contains a critical error handler that, when invoked, makes it appear to the calling program that some less-critical error has occurred. The critical error handler is installed by **`CRIT_ON()`** and removed by **`CRIT_OFF()`**.The critical error handler is also automatically removed by DOS when the program exits. The following program fragment demonstrates the use of the critical error handler:

```
#include "criterr.h"
crit_on(ieee);
if (ieeewt("output 16;F0X") == -1) {
printf("Error writing F0X to device 16, \n");
crit_off();
ioctl_wt(ieee,"break",5);
ieeewt("eol out lf\r\n");
ieeewt("status\n");
ieeerd(response);
printf("status = %s\n",response);
crit_on(ieee);
}
```

We must first **`#include`** the header file with the definitions of the critical error routines. We then enable critical error trapping with **`CRIT_ON`** which takes as a parameter the handle of the file for which critical error trapping is to be enabled. Only read and write commands to that handle are trapped. Errors caused by other actions, or associated with other files are not trapped. Error trapping may only be enabled for one file at a time.

Now, if **`IEEEWT`** signals an error by returning a **`-1`**, we can check what happened. We first **`PRINTF`** an error message, then we turn critical error trapping off with **`CRIT_OFF`** so that, if another critical error occurs, we get the **`ABORT`**, **`RETRY`** or **`IGNORE`** message and know a catastrophic double error has occurred. We then **`IOCTL_WT(_BREAK_)`** to force Driver488/DRV to listen to our next command. The **`IOCTL_WT`** also resets the **`EOL OUT`** terminator so we can be sure that Driver488/DRV detects the end of our commands. We next reset the **`EOL OUT`** terminator to our preferred line feed only and ask Driver488/DRV for its status. On receiving the response, we could interpret the status and take whatever action is appropriate. However, in this example, we just display the status. Finally, we re-enable the critical error handler and continue with the program.

Sample Program

```
#include “ieeeio.h”
#include <stdio.h>
void main (void){
int ieee
char response[256];
float voltage;
int i;
float sum;
char hundred[1700];
ieee=open(“ieee”,O_RDWR | O_BINARY);
rawmode(ieee);
ioctl_wt(ieee,"break",5);
ieeewt(“reset\r\n”);
ieeewt(“eol out lf\r\n”);
ieeewt(“eol in $0\n”);
ieeewt(“fill error\n”);
if (ieeeinit() == -1) {
printf(“Cannot initialize IEEE system.\n”);
exit(1);
}
ieeewt(“hello\n”);
ieeerd(response);
printf(“%s\n”,response);
ieeewt(“status\n”);
ieeerd(response);
printf(“%s\n”,response);
ieeewt(“output 16;F0R0X\n”);
ieeewt(“enter 16\n”);
ieeescnf(“%*4s%e”,&voltage);
printf(“The read value is %g\n”,voltage);
sum=0.0;
for (i=0; i<10; i++) {
ieeewt(“enter 16\n”);
ieeescnf(“%*4s%e”,&voltage);
sum=sum+voltage;
}
printf(“The average of 10 readings is %g\n”,sum/10.0);
ieeeprtf(“ENTER 16 #1700 BUFFER %d:%d\n”,
segment(hundred),offset(hundred));
for (i=0; i<1700; i++) putchar(hundred[i]);
ieeeprtf(“ENTER 16 #1700 BUFFER continue\n”,
segment(hundred),offset(hundred));
ieeewt(“status\n”);
ieeerd(response);
printf(“%s\n”,response);
int cklpint();
ieee_cki = cklpint;
ieee_isr = isr;
ieeewt(“arm srq\n”);
ieeewt("output 16;M2X");
}
void isr()
{ int _false_();
int st195;
printf("Interrupt detected...");
ieee_cki = _false_;
int sp;
ieeewt("spoll\n");
ieeescnf("%d",&sp);
if (sp==0) {
printf("Non-SRQ Interrupt!\n");
exit(1);
}
ieeewt("spoll 16\n");
ieeescnf("%d",&st195);
if ((st195 & 0x40) == 0 ) {
printf("Non-195 SRQ!\n");
exit();
}
if ((st195 & 0x20) == 0) {
if (st195 & 0x01)
printf("Overflow\n");
if (st195 & 0x02)
printf("Buffer Full\n");
if (st195 & 0x04)
printf("Buffer 1/2 Full\n");
if (st195 & 0x08)
printf("Reading Done\n");
if (st195 & 0x10)
printf("Busy\n");
} else {
if (st195 & 0x01)
printf("Illegal Command Option\n");
if (st195 & 0x02)
printf("Illegal Command\n");
if (st195 & 0x04)
printf("No Remote\n");
if (st195 & 0x08)
printf("Trigger Overrun\n");
if (st195 & 0x10)
printf("Failed Selftest\n");
}
ieee_cki = cklpint;
```

8F. Microsoft Fortran

Note: The following short program illustrates the use of Driver488/DRV with Microsoft Fortran. Most of the program length is composed of utilities that simplify character I/O in Fortran.

Sample Program

```
Character Result*127
Integer StrLen
Call OpenIeee
Write(1,*)'RESET'
Write(1,*)'REMOTE 16'
Write(1,*)'OUTPUT 16;Z1X'
Write(1,*)'ENTER 16'
Call FlushIeee
Read(2) Result
Write(*,*)Result(1:StrLen(Result,127))
END
```

```
SUBROUTINE OpenIeee
Open(1,File='\dev\ieeeout',Status='OLD',
1 Access='SEQUENTIAL')
Open(2,File='\dev\ieeein',Status='OLD',
1 Access='SEQUENTIAL',Form='BINARY')
END
SUBROUTINE FlushIeee
Rewind 1
Rewind 2
END
FUNCTION StrLen(String,MaxLen)
Character String*127
StrLen=MaxLen-1
DO 10 i=1,MaxLen-2
If (String(i:i) .eq. CHAR(13) .and.
1 String(i+1:i+1) .eq. CHAR(10)) then
StrLen=i-1
Goto 20
EndIf
10 Continue
20 Continue
END
```

8G. QuickBASIC

Topics

Use of the Character Command Language

Several versions of Microsoft QuickBASIC are currently popular: 2.0, 3.0, 4.0, and 4.5. While they vary considerably in their user interface and performance, they are virtually identical when it comes to controlling Driver488/DRV. Two demonstration programs are included for QuickBASIC: **`195DEMO.BAS`** and **`195DEMO4.BAS`**. **`195DEMO.BAS`** is compatible with versions 2.0 and higher of QuickBASIC, while **`195DEMO4.BAS`** requires version 4.0 or version 4.5. These examples can be found on the Driver488/DRV disk in the **`\QB`** directory.

To execute the demo program, start QuickBASIC with the **`QB /L`** command. The **`/L`** parameter tells QuickBASIC to load the default library containing the **`ABSOLUTE`** subroutine. This **`/L`** parameter is not needed in version 4.0 using **`195DEMO4.BAS`**. Also, in earlier versions of QuickBASIC, such as 2.0, the **`EVENT TRAPPING`** and **`CHECKING BETWEEN STATEMENTS`** compiler options must be turned on for the program to compile and execute correctly.

Initialization of the System

Any program using Driver488/DRV must first establish communications with the Driver488/DRV software driver. In BASIC and most other languages this is accomplished using an **`OPEN`** statement. Communication both to and from Driver488/DRV is required. In BASIC, this means that two files must be opened, one for input, and one for output. Other languages may allow the same file to be opened for both input and output. Three file names are allowed: **`\DEV\IEEEOUT`**, **`\DEV\IEEEIN`**, and **`\DEV\IEEE`**. By convention, they are used for output, input, and both input and output, respectively. But in actuality, they are all the same and any one of them can be used for input, output, or both, depending on the programming language.

In BASIC, the files are opened with the following commands:

```
110 OPEN "\DEV\IEEEOUT" FOR OUTPUT AS #1
200 OPEN "\DEV\IEEEIN" FOR INPUT AS #2
```

Of course, file numbers may change as desired, but throughout this manual, file **`#1`** is assumed to output to Driver488/DRV, and file **`#2`** is assumed to input from Driver488/DRV.

Once these files are opened, we can send commands and receive responses from Driver488/DRV. While Driver488/DRV should normally be in a reset, inactive state, it is possible that it was left in some unknown state by a previous program failure or error. In order to force Driver488/DRV into its quiescent state we can use the **`IOCTL`** statement:

```
160 IOCTL#1,"BREAK"
```

`IOCTL` is a BASIC statement that sends commands through a "back door" to Driver488/DRV. Driver488/DRV recognizes this "back door" command regardless of what else it might be doing and resets itself so that it is ready to accept a normal command. We can then completely reset the Driver488/DRV with the **`RESET`** command:

```
170 PRINT#1,"RESET"
```

which resets the operating parameters of the Driver488/DRV back to their normal values (those that were set during system boot by the **`DRVR488`** DOS command).

The **`IOCTL BREAK`** and **`RESET`** commands guarantee that Driver488/DRV is ready for action. Note that the **`IOCTL BREAK`** and **`RESET`** commands are placed before the **`OPEN`** statement for file **`#2`**. This guarantees that BASIC is able to open Driver488/DRV for input. For more details, see the **`FILL`** command in "Section III: Command References."

With the initialization commands and some comments, the program now appears as:

```
100 'Establish communications with Driver488/DRV
110 OPEN "\DEV\IEEEOUT" FOR OUTPUT AS #1
120 '
150 'Reset Driver488/DRV
160 IOCTL#1,"BREAK"
170 PRINT#1,"RESET"
180 '
190 'Open file to read responses from Driver488/DRV
200 OPEN "\DEV\IEEEIN" FOR INPUT AS #2
```

Once everything is reset, we can enable the **`SEQUENCE - NO DATA AVAILABLE`** error detection by setting the **`FILL`** mode to **`ERROR`**:

```
225 PRINT#1,"FILL ERROR"
```

We can also test the communications and read the Driver488/DRV revision number with the **`HELLO`** command:

```
310 PRINT#1,"HELLO"
320 INPUT#2,A$
330 PRINT A$
```

First we **`PRINT`** the **`HELLO`** command to file **`#1`**, then we **`INPUT`** the response from file **`#2`** into the character string variable **`A$`** ("A-string"). Finally we display the response with a **`PRINT`** to the screen. Because BASIC cannot both **`PRINT`** and **`INPUT`** from the same file, we use two **`OPEN`** statements, and two different file numbers to communicate with Driver488/DRV. **`PRINT`** must reference the file opened for output (in these examples, file **`#1`**) and **`INPUT`** must reference the file opened for input (file **`#2`**). Attempting to communicate with the wrong file (such as **`INPUT#1`**) results in an error.

It is not necessary to perform the **`HELLO`** command, but it is included here as a simple example of normal communication with Driver488/DRV. Its response is the revision identification of the Driver488/DRV software: **`Driver488 Revision X.X ©199X IOtech, Inc.`**

We can also interrogate Driver488/DRV for its status:

```
410 PRINT#1,"STATUS"
420 INPUT#2,ST$
430 PRINT ST$
```

Subsequently, the printed response is similar to the following:

```
CS21 1 I000 000 T0 C0 P0 OK
```

The following indicators describe each component of the Driver488/DRV status:

Indicator	Driver488/DRV Status
`C`	It is in the Controller state.
`S`	It is the System Controller.
`21`	The value of its IEEE 488 bus address.
`1`	An Address Change has occurred.
`I`	It is idle (neither a talker nor a listener).
`0`	There is no **`ByteIn`** available.
`0`	It is not ready to send a **`ByteOut`**.
`0`	Service Request (**`SRQ`**) is not asserted.
`000`	There is no outstanding error.
`T0`	It has not received a bus device **`TRIGGER`** command (only applicable in the Peripheral mode).
`C0`	It has not received a **`CLEAR`** command (only applicable in the Peripheral mode).
`P0`	No **`CONTINUE`** transfer is in progress.
`OK`	The error message is “OK”.

Configuration of the 195 DMM

Once the system is initialized we are ready to start issuing bus commands. The IEEE 488 bus has already been cleared by the Interface Clear (**`IFC`**) sent by the **`RESET`** command, so we know all bus devices are waiting for the controller to take some action. To control an IEEE 488 bus device, we **`OUTPUT`** an appropriate device-dependent command to that device. For example, the command **`F0R0X`** sets the 195 to read DC volts with automatic range selection:

```
610 PRINT#1,"OUTPUT 16;F0R0X"
```

The **`OUTPUT`** command takes a bus device address (**`16`** in this case) and data (**`F0R0X`**) and sends the data to the specified device. The address can be just a primary address, such as **`12`**, or **`05`**, or it can include a secondary address: **`1201`**. Note that both the primary address and, if present, the secondary address are two-digit decimal numbers. A leading zero must be used, if necessary, to make a two-digit address.

Taking Readings

Once we have set the 195’s operating mode, we can take a reading and display it:

```
710 PRINT#1,"ENTER 16"
720 INPUT#2,R$
730 PRINT R$
```

The **`ENTER`** command takes a bus address (with an optional secondary address) and configures that bus device so that it is able to send data (addressed to talk). No data is actually transferred, however, until the **`INPUT`** statement requests the result from Driver488/DRV at which time data is transferred to the program into the variable **`R$`**.

Once the result has been received, any BASIC functions or statements can be used to modify or interpret it. In this example, the result is in the form **`NDCV+1.23456E-2`** showing the range (**`NDCV`**) and the numeric value of the reading (**`+1.23456E-2`**). The BASIC **`MID$`** function can be used to strip off the range characters and keep only the numeric part (the fifth character and beyond), and the **`VAL`** function can be used to convert this string to a number:

```
740 N$=MID$(R$,5)
741 N=VAL(N$)
742 PRINT “The read value is”;N
```

These may be combined for efficiency:

```
740 PRINT “The read value is”;VAL(MID$(R$,5))
```

All the power of BASIC may be used to manipulate, print, store, and analyze the data read from the IEEE 488 bus. For example, the following statements print the average of ten readings from the 195:

```
810 SUM=0
820 FOR I=1 TO 10
830 PRINT#1,"ENTER 16"
840 INPUT#2,R$
850 SUM=SUM+VAL(MID$(R$,5))
860 NEXT I
870 PRINT “The average of ten readings is”;SUM/10
```

Buffer Transfers

Instead of using an **`INPUT#2`** statement to receive the data from a device, we can direct Driver488/DRV to place the response directly into a data buffer of our choice. For example, each reading from the 195 consists of 17 bytes: a four-byte prefix and an eleven-byte reading followed by the two-byte command terminator. So, we can collect 100 readings in a 1700-byte string.

To do this, we must first allocate the required space in a string variable:

```
910 R$=SPACE$(1700)
```

And then we must tell Driver488/DRV where **`R$`** is located in memory.

In QuickBASIC 4.0, the **`VARSEG`** function allows us to determine the segment address of a variable.

```
DS%=VARSEG(R$)
```

Now that we know the segment address of **`R$`**, we can get its offset address by using **`SADDR`**:

```
RDESC=0
RDESC=SADDR
```

Notice that we first create **`RDESC`** by setting it to zero. This prevents **`R$`** from being moved as a result of creating **`RDESC`** after calling **`SADDR`**.

Now we have the segment and offset of **`R$`**, we can pass it directly to Driver488/DRV with the **`ENTER #count BUFFER`** command:

```
PRINT#1,"ENTER16 #1700 BUFFER"; DS%; “:”;RDESC
```

This command consists of the keyword **`ENTER`**, followed by the bus device address (**`16`**), a number sign (**`#`**), the number of bytes to transfer (**`1700`**), and the keyword **`BUFFER`**, followed by the memory address of the buffer. The buffer address is specified as **`segment:offset`** where **`segment`** and **`offset`** are each 16-bit numbers and the colon (**`:`**) is required to separate them. The **`segment`** value we need, is the BASIC data segment value that we have just acquired into **`DS%`** with **`GET.SEGMENT`**. The **`offset`** value is the offset of the string in that data segment, which is **`RDESC`**.

Once the data has been received, we can print it out:

```
980 PRINT R$
```

The program can continue with other work while the transfer occurs. For example, the program could process the previous set of data while collecting a new set into a different buffer. To allow the program to continue, specify **`CONTINUE`** in the command:

```
PRINT#1,"ENTER16 #1700 BUFFER"; DS%; “:”;RDESC; “CONTINUE”
```

Once we have started the transfer, we can check the status:

```
980 PRINT#1,"STATUS"
990 INPUT#2,ST$
1000 PRINT ST$
```

The status that is returned is typically:

```
CS21 1 L100 000 T0 C0 P1 OK
```

Notice **`P1`** which states a transfer is in progress, and **`L`** which shows we are still a listener. If the bus device is so fast that the transfer completes before the program can check status, the response is **`P0`** showing that the transfer is no longer in progress. We can also **`WAIT`** for the transfer to complete and check the status again:

```
1010 PRINT#1,"WAIT"
1020 PRINT#1,"STATUS"
1030 INPUT#2,ST$
1040 PRINT ST$
```

This time the status must be **`P0`** as the **`WAIT`** command waits until the transfer has completed. Now that we know the transfer is complete, we are ready to print out the received data as shown above.

BASIC VARPTR & SADDR

The **`BASIC VARPTR`** and **`SADDR`** functions must be used with caution. The first time a variable such as **`I`** or **`ST$`** is encountered, or an array such as **`R%()`** is dimensioned, space is made for it in BASIC's data space. The other variable or arrays may be moved to make room for the new item. If the memory location of an item must be fixed, then BASIC cannot be allowed to encounter any new variables or arrays. For example, in the **`ENTER`** statement shown above, Driver488/DRV is told the memory address of **`R$`** (for GW-BASIC, **`R%(0)`**). Then, while the transfer is going on, the Driver488/DRV status is read into the string variable **`ST$`**. If **`ST$`** has not been used previously then BASIC would have to create a new **`ST$`** and might move **`R$`**. Of course, Driver488/DRV would have no way of knowing that **`R$`** has been moved, and the data would not be placed correctly into **`R$`**.

Interrupt Handling

The IEEE 488 bus is designed to be able to attend to asynchronous (unpredictable) events or conditions. When such an event occurs, the bus device needing attention can assert the Service Request (**`SRQ`**) line to signal that condition to the controller. Once the controller notices the **`SRQ`**, it can interrogate the bus devices, using Parallel Poll (**`PPOLL`**) and/or Serial Poll (**`SPOLL`**) to determine the source and cause of the **`SRQ`**, and take the appropriate action.

Parallel Poll is the fastest method of determining which device requires service. Parallel Poll is a very short, simple IEEE 488 bus transaction that quickly returns the status from many devices. Each of the eight IEEE 488 bus data bits can contain the Parallel Poll response from one or more devices. So, if there are eight or fewer devices on the bus, then just the single Parallel Poll can determine which requires service. Even if the bus is occupied by the full complement of 15 devices, then Parallel Poll can narrow the possibilities down to a choice of no more than two.

Unfortunately, the utility of Parallel Poll is limited when working with actual devices. Some have no Parallel Poll response capability. Others must be configured in hardware, usually with switches or jumpers, to set their Parallel Poll response. If Parallel Poll is not available, or several devices share the same Parallel Poll response bit, then Serial Polling is still required to determine which device is requesting service.

Serial Poll, though it is not as fast as Parallel Poll, does offer two major advantages: it returns additional status information beyond the simple request/no-request for service, and it is implemented on virtually all bus devices.

The **`SRQ`** line can be monitored in two ways: it can be periodically polled using the **`STATUS`** command, or it can be used to cause an external interrupt when asserted.

BASIC provides a method for detecting and servicing external interrupts: the **`ON PEN`** statement. The **`ON PEN`** statement tells BASIC that, when an external interrupt is detected, a specific subroutine, known as the interrupt service routine (ISR), is to be executed. Normally, the interrupt detected by **`ON PEN`** is the light pen interrupt. However, Driver488/DRV redefines this "light pen interrupt" to signal when an IEEE 488 bus related interrupt (such as **`SRQ`**) has occurred.

When Driver488/DRV detects an interrupt, it informs the user's program that an interrupt has occurred by making it appear that a light pen interrupt has occurred. To allow BASIC and Driver488/DRV to work together to detect and service the interrupt, the following steps are required:

1. BASIC must be told which subroutine to execute upon detection of the interrupt.
2. BASIC interrupt detection must be enabled.
3. Driver488/DRV must be configured to detect the interrupt.

The **`ON PEN GOSUB`**, **`PEN ON`**, and **`ARM SRQ`** commands, respectively, perform these steps:

```
250 ON PEN GOSUB ISR
260 PEN ON
270 PRINT#1,"ARM SRQ"
```

1. The **`ON PEN GOSUB`** command tells BASIC that the subroutine called **`ISR`** is to be executed when the light pen interrupt is detected. Driver488/DRV causes the light pen interrupt to occur on detection of an IEEE 488 interrupt.
2. The **`PEN ON`** command enables the actual checking for light pen interrupt status.
3. The **`ARM SRQ`** command tells Driver488/DRV that an interrupt is to be signaled on detection of a service request from the IEEE 488 bus.

These commands are placed near the beginning of the program to catch Service Requests (**`SRQ`**) whenever they occur.

The 195 can be set to request service on any of several different internal conditions. In particular, the **`M2`** command causes an **`SRQ`** on the detection of any invalid command or command option by the 195:

```
550 PRINT#1,"OUTPUT 16;M2X"
```

This **`OUTPUT`** command is placed early in the program so that all subsequent commands to the 195 cause an **`SRQ`**, if they are invalid.

At this point BASIC is checking for an interrupt, and knows to **`GOSUB SRQ`** when an interrupt is detected. Driver488/DRV is set to generate an interrupt on detection of an SRQ generated by the 195 on detection of an invalid command. We must still, however, specify what action should be taken once an interrupt is detected.

Upon entering the interrupt service routine, we first check Driver488/DRV to see if it is ready for a command and if so, read the Serial Poll Status to determine if an **`SRQ`** actually caused the interrupt:

```
2000 SRQ: 'Interrupt service routine—Entered due to SRQ
2010 '
2020 'RETURN if Driver488/DRV is not ready for commands.
2030 IF IOCTL$(2)"0" THEN RETURN
2040 '
2050 'Check that it is indeed an SRQ
2060 PRINT#1,"SPOLL"
2070 INPUT#2,SP
2080 IF SP=0 THEN PRINT "Non-SRQ Interrupt!": STOP
```

Next we Serial Poll the 195 to determine its status. If there were other devices on the bus that could be generating the **`SRQ`**, each of them would be have to be checked in turn.

```
2110 PRINT#1,"SPOLL 16"
2120 INPUT#2,ST195
2130 IF (ST195 AND 64) = 0 THEN PRINT "Non-195 SRQ!": STOP
```

Bit `DIO7`, with a value of `64`, is returned as true (`1`) in the Serial Poll response of those devices requesting service. In our simple example, we expect that the 195 is the only possible cause of an `SRQ`, and if not, there must be some error.

Now that we have identified the device that is requesting service, we can further examine the Serial Poll status to classify the request. If DIO6 is set, then the 195 is signaling an error condition. If that bit is clear, some non-error condition caused the `SRQ`:

```
2160 IF (ST195 AND 32)=0 THEN 'Test ERROR Status Bit
'Interpret no-error status
2210 IF ST195 AND 1 THEN PRINT "Overflow"
2220 IF ST195 AND 2 THEN PRINT "Buffer Full"
2230 IF ST195 AND 4 THEN PRINT "Buffer 1/2 Full"
2240 IF ST195 AND 8 THEN PRINT "Reading Done"
2250 IF ST195 AND 16 THEN PRINT "Busy"
2260 ELSE
'Interpret error status
2310 IF ST195 AND 1 THEN PRINT "Illegal Command Option"
2320 IF ST195 AND 2 THEN PRINT "Illegal Command"
2330 IF ST195 AND 4 THEN PRINT "No Remote"
2340 IF ST195 AND 8 THEN PRINT "Trigger Overrun"
2350 IF ST195 AND 16 THEN PRINT "Failed Selftest"
2360 END IF
```

Finally, once we have diagnosed the error, we are ready to return to the main program:

```
2400 RETURN
```

Sample Program

```
100 'Establish communications with Driver488/DRV
110 OPEN "\DEV\IEEEOUT" FOR OUTPUT AS #1
120 '
150 'Reset Driver488/DRV
160 IOCTL#1,"BREAK"
170 PRINT#1,"RESET"
180 '
190 'Open file to read responses from Driver488/DRV
200 OPEN "\DEV\IEEEIN" FOR INPUT AS #2
225 PRINT#1,"FILL ERROR"
250 ON PEN GOSUB ISR
260 PEN ON
270 PRINT#1,"ARM SRQ"
310 PRINT#1,"HELLO"
320 INPUT#2,A$
330 PRINT A$
410 PRINT#1,"STATUS"
420 INPUT#2,ST$
430 PRINT ST$
550 PRINT#1,"OUTPUT 16;M2X"
610 PRINT#1,"OUTPUT 16;F0R0X"
710 PRINT#1,"ENTER 16"
720 INPUT#2,R$
730 PRINT R$
740 N$=MID$(R$,5)
741 N=VAL(N$)
742 PRINT "The read value is";N
740 PRINT "The read value is";VAL(MID$(R$,5))
810 SUM=0
820 FOR I=1 TO 10
830 PRINT#1,"ENTER 16"
840 INPUT#2,R$
850 SUM=SUM+VAL(MID$(R$,5))
860 NEXT I
870 PRINT "The average of ten readings is";SUM/10
910 R$=SPACE$(1700)
980 PRINT#1,"STATUS"
```

```
990 INPUT#2,ST$
1000 PRINT ST$
1010 PRINT#1,"WAIT"
1020 PRINT#1,"STATUS"
1030 INPUT#2,ST$
1040 PRINT ST$
2000 SRQ: ‘Interrupt service routine—Entered due to SRQ
2010 ‘
2020 ‘RETURN if Driver488/DRV is not ready for commands.
2030 IF IOCTL$(2)"0" THEN RETURN
2040 ‘
2050 ‘Check that it is indeed an SRQ
2060 PRINT#1,"SPOLL"
2070 INPUT#2,SP
2080 IF SP=0 THEN PRINT “Non-SRQ Interrupt!”: STOP
2110 PRINT#1,"SPOLL 16"
2120 INPUT#2,ST195
2130 IF (ST195 AND 64) = 0 THEN PRINT “Non-195 SRQ!”: STOP
2160 IF (ST195 AND 32)=0 THEN ‘Test ERROR Status Bit
‘Interpret no-error status
2210 IF ST195 AND 1 THEN PRINT “Overflow”
2220 IF ST195 AND 2 THEN PRINT “Buffer Full”
2230 IF ST195 AND 4 THEN PRINT “Buffer 1/2 Full”
2240 IF ST195 AND 8 THEN PRINT “Reading Done”
2250 IF ST195 AND 16 THEN PRINT “Busy”
2260 ELSE
‘Interpret error status
2310 IF ST195 AND 1 THEN PRINT “Illegal Command Option”
2320 IF ST195 AND 2 THEN PRINT “Illegal Command”
2330 IF ST195 AND 4 THEN PRINT “No Remote”
2340 IF ST195 AND 8 THEN PRINT “Trigger Overrun”
2350 IF ST195 AND 16 THEN PRINT “Failed Selftest”
2360 END IF
2400 RETURN
```

8H. Turbo C

Topics

Use of the Character Command Language

In order to simplify programming Driver488/DRV with C, the following files are provided on the Driver488/DRV program disk:

- **`IEEEIO.C:`** Communications routines for Driver488/DRV
- **`IEEEIO.H:`** Header file, contains declarations from **`IEEEIO.C`**
- **`CRITERR.ASM:`** Critical error handler assembly language source file (included with Microsoft C and Turbo C, only)
- **`CRITERR.OBJ:`** Object file produced from **`CRITERR.ASM`** (included with Microsoft C and Turbo C, only)
- **`CRITERR.H:`** Header file, contains declarations for using **`CRITERR.ASM`**

The actual demonstration program is contained in **`195DEMO.C`** (described by the project file **`195DEMO.PRJ`** in Turbo C, only).

All files for Microsoft C are in the **`\MSC`** directory; all files for Turbo C are in the **`\TURBOC`** directory.

To execute the demonstration program, enter Turbo C and perform the following steps:

1. Type **`<Alt-p>`** (for Project) **`p`** (for Project Name) **`195demo`**.
2. Press **`<Enter>`** to set up the project to run.
3. Then type **`<Alt-r>`** to compile and run the demonstration program.

The above process assumes that you have Turbo C, and that the files have been copied into the appropriate directory for use with your C compiler. Note that the program uses a small data model because it uses less than 64K of code and data.

Initialization of the System

Any program using Driver488/DRV must first establish communications with the Driver488/DRV software driver. In C, this is accomplished using the **`OPEN`** statement. Communication both to and from Driver488/DRV is required. Thus, the file must be opened for both reading and writing (**`RDWR`**). Also, in Microsoft C and Turbo C, the file must be opened in **`BINARY`** mode so that end-of-line characters are not translated.

In Microsoft C and Turbo C, the file is opened with the following statement:

```
ieee=open("ieee",O_RDWR | O_BINARY);
```

In Aztec C, the file is opened with the following statement:

```
ieee=open("ieee",O_rdwr);
```

which is part of the **`IEEEINIT`** function contained in **`IEEEIO.C`**. **`IEEEIO.C`** supplies several other useful routines and definitions. These are described in more detail in “Interrupt Handling,” an upcoming topic in this Sub-Chapter.

In the above statement, the value returned by **`OPEN`** and placed into the integer variable **`IEEE`**, is either the handle of the opened file or **`-1`** if some error has occurred. The **`IEEEINIT`** routine checks for this error indication and returns a **`-1`** if there has been such an error.

Of course, the file descriptor variable name **`IEEE`** may be changed as desired, but throughout this manual and the program files, **`IEEE`** has been used. Once the file is opened, we can send commands and receive responses from Driver488/DRV.

Normally, when DOS communicates with a file, it checks for special characters, such as control-Z which can indicate end-of-file. When communicating with IEEE 488 devices, DOS’s checking would interfere with the communication. The **`RAWMODE`** function prevents DOS from checkings for special characters:

```
rawmode(ieee);
```

As an additional benefit, communication with Driver488/DRV is much more efficient when DOS does not check for special characters.

Driver488/DRV can accept commands only when it is in a quiescent, ready state. While Driver488/DRV should normally be ready, it is possible that it was left in some unknown state by a previous program failure or error. In order to force Driver488/DRV into its quiescent state, we use the **IOCTL_WT** function:

```
ioctl_wt(ieee,"break",5);
```

This **IOCTL_WT** function is equivalent to the BASIC statement **IOCTL#1,"BREAK"** which sends the **BREAK** command through a "back door" to Driver488/DRV. Driver488/DRV recognizes this "back door" command regardless of what else it might be doing and resets itself so that it is ready to accept a normal command. We can then completely reset the Driver488/DRV with the **RESET** command:

```
ieeewt("reset\r\n");
```

which resets the operating parameters of the Driver488/DRV back to their normal values (those that were set during system boot by the **DRVR488** DOS command). Notice that the **EOL OUT** terminators that mark the end of a Driver488/DRV command are reset to carriage return and line feed by the **IOCTL_WT** command. Thus, the **RESET** command must be terminated by both a carriage return (**\r**) and a line feed (**\n**). As it is more convenient if Driver488/DRV accepts line feed *only* as the command terminator, we use the **EOL OUT** command to set the command terminator to line feed (**\n**):

```
ieeewt("eol out lf\r\n");
```

Notice that this command must also be terminated by both a carriage return and a line feed because the command terminator is not changed until after the **EOL OUT** command is executed.

Character strings in C are normally terminated by a null (an **ASCII 0**). Thus, it is appropriate for Driver488/DRV to terminate its responses to the program with a null so that the response can be treated as a normal character string. We can use the **EOL IN** command to configure Driver488/DRV so that it does provide an ASCII null terminator:

```
ieeewt("eol in $0\n");
```

Finally, we enable **SEQUENCE - NO DATA AVAILABLE** error detection by setting the **FILL** mode to **ERROR**:

```
ieeewt("fill error\n");
```

All the commands discussed so far: **OPEN**, **RAWMODE**, **IOCTL_WT**, **RESET**, **EOL OUT**, **EOL IN** and **FILL ERROR** are part of the **IEEEINIT** function included in **IEEEIO.C**. **IEEEINIT** returns a zero if these steps were executed successfully, and a **-1** if some error was encountered. Thus, to accomplish all the above steps, we just use the following:

```
#include "ieeeio.h"
#include .h
if (ieeeinit() == -1) {
printf("Cannot initialize IEEE system.\n");
exit(1);
}
```

The two **INCLUDE** statements provide the program with definitions of the standard I/O and IEEE I/O functions so they can be referenced by the demo program. **IEEEINIT** is called to initialize the system, and if it indicates an error (returns a **-1**), we print an error message and exit. If there was no error, we just continue with the program.

Once everything is reset, we can test the communications and read the Driver488/DRV revision number with the **HELLO** command:

```
char response[256];
ieeewt("hello\n");
ieeerd(response);
printf("%s\n",response);
```

We first **IEEEWT** the **HELLO** command, then **IEEERD** the response from Driver488/DRV into the character string response (**IEEEWT** and **IEEERD** are both supplied in **IEEEIO.C**). Finally, we display the response with a **PRINTF**.

It is not necessary to perform the **`HELLO`** command, but it is included here as a simple example of normal communication with Driver488/DRV. Its response is the revision identification of the Driver488/DRV software: **`Driver488 Revision X.X ©199X IOtech, Inc.`**

We can also interrogate Driver488/DRV for its status:

```
ieeewt("status\n");
ieeerd(response);
printf("%s\n",response);
```

Subsequently, the printed response is similar to the following:

```
CS21 1 I000 000 T0 C0 P0 OK
```

The following indicators describe each component of the Driver488/DRV status:

Indicator	Driver488/DRV Status
`C`	It is in the Controller state.
`S`	It is the System Controller.
`21`	The value of its IEEE 488 bus address.
`1`	An Address Change has occurred.
`I`	It is idle (neither a talker nor a listener).
`0`	There is no **`ByteIn`** available.
`0`	It is not ready to send a **`ByteOut`**.
`0`	Service Request (**`SRQ`**) is not asserted.
`000`	There is no outstanding error.
`T0`	It has not received a bus device **`TRIGGER`** command (only applicable in the Peripheral mode).
`C0`	It has not received a **`CLEAR`** command (only applicable in the Peripheral mode).
`P0`	No **`CONTINUE`** transfer is in progress.
`OK`	The error message is "OK".

Configuration of the 195 DMM

Once the system is initialized we are ready to start issuing bus commands. The IEEE 488 bus has already been cleared by the Interface Clear (**`IFC`**) sent by the **`RESET`** command, so we know that all bus devices are waiting for the controller to take some action. To control an IEEE 488 bus device, we output an appropriate device-dependent command to that device. For example, the **`F0R0X`** command line below sets the 195 to read DC volts with automatic range selection:

```
ieeewt("output 16;F0R0X\n");
```

The **`OUTPUT`** command takes a bus device address (**`16`** in this case) and data (**`F0R0X`**) and sends the data to the specified device. The address can be just a primary address, such as **`12`**, or **`05`**, or it can include a secondary address: **`1201`**. Note that both the primary address and, if present, the secondary address are two-digit decimal numbers. A leading zero must be used, if necessary to make a two-digit address.

Taking Readings

Once we have set the 195's operating mode, we can take a reading and display it:

```
float voltage;
ieeewt("enter 16\n");
ieeescnf("%*4s%e",&voltage);
printf("The read value is %g\n",voltage);
```

The **`ENTER`** command takes a bus address (with an optional secondary address) and configures that bus device so that it is able to send data (addressed to talk). No data is actually transferred, however, until the **`IEEESCNF`** statement requests the result from Driver488/DRV at which time data is transferred to the program into the variable **`voltage`**. A typical reading from a 195 might be **`NDCV+1.23456E-2`**, consisting of a four character prefix followed by a floating point value. The format passed to **`IEEESCNF`** causes it to skip the four character prefix (**`%*4s`**) and then convert the remaining string into the float variable **`voltage`**.

All the power of C may be used to manipulate, print, store, and analyze the data read from the IEEE 488 bus. For example, the following statements print the average of ten readings from the 195:

```
int i;
float sum;
sum=0.0;
for (i=0; i; i++) {
  ieeewt("enter 16\n");
  ieeescnf("%*4s%e",&voltage);
  sum=sum+voltage;
}
printf("The average of 10 readings is %g\n",sum/10.0);
```

Buffer Transfers

Instead of using an `IEEERD(_)` function to receive the data from a device, we can direct Driver488/DRV to place the response directly into a data buffer of our choosing. For example, each reading from the 195 consists of 17 bytes: a four-byte prefix and an eleven-byte reading followed by the two-byte command terminator. So, we can collect 100 readings in a 1700-byte array. To do this, we must first allocate the required space in an array:

```
char hundred[1700];
```

Now that we have allocated a place for the readings, we can direct Driver488/DRV to put readings directly into `hundred` with the `ENTER #count BUFFER` command:

```
ieeeprtf("ENTER 16 #1700 BUFFER %d:%d\n",
segment(hundred),offset(hundred));
```

This command consists of the keyword `ENTER`, followed by the bus device address (`16`), a number sign (`#`), the number of bytes to transfer (`1700`), and the keyword `BUFFER`, followed by the memory address of the buffer. The buffer address is specified as `segment:offset` where `segment` and `offset` are each 16-bit numbers and the colon (`:`) is required to separate them. The `segment` and `offset` values we need are returned by the `segment` and `offset` functions, respectively.

Once the data has been received, we can print it out:

```
for (i=0; i<1700; i++) putchar(hundred[i]);
```

The program could process the previous set of data while collecting a new set into a different buffer. To allow the program to continue, specify `continue` in the command:

```
ieeeprtf("ENTER 16 #1700 BUFFER continue\n",
segment(hundred),offset(hundred));
```

Once we have started the transfer, we can check the status:

```
ieeewt("status\n");
ieeerd(response);
printf("%s\n",response);
```

The status that is returned is typically:

```
CS21 1 L100 000 T0 C0 P1 OK
```

Notice `P1` which states a transfer is in progress, and `L` which shows we are still a listener. If the bus device is so fast that the transfer completes before the program can check status, the response is `P0` showing that the transfer is no longer in progress. We can also `WAIT` for the transfer to complete and check the status again:

```
ieeewt("wait\n");
ieeewt("status\n");
ieeerd(response);
printf("%s\n",response);
```

This time the status must be `P0` as the `WAIT` command waits until the transfer has completed. Now that we know the transfer is complete, we are ready to print out the received data as shown above.

Interrupt Handling

The IEEE 488 bus is designed to be able to attend to asynchronous (unpredictable) events or conditions. When such an event occurs, the bus device needing attention can assert the Service Request (**SRQ**) line to signal that condition to the controller. Once the controller notices the SRQ, it can interrogate the bus devices, using Parallel Poll (**PPOLL**) and/or Serial Poll (**SPOLL**) to determine the source and cause of the **SRQ**, and take the appropriate action.

Parallel Poll is the fastest method of determining which device requires service. Parallel Poll is a very short, simple IEEE 488 bus transaction that quickly returns the status from many devices. Each of the eight IEEE 488 bus data bits can contain the Parallel Poll response from one or more devices. So, if there are eight or fewer devices on the bus, then just the single Parallel Poll can determine which requires service. Even if the bus is occupied by the full complement of 15 devices, then Parallel Poll can narrow the possibilities down to a choice of no more than two.

Unfortunately, the utility of Parallel Poll is limited when working with actual devices. Some have no Parallel Poll response capability. Others must be configured in hardware, usually with switches or jumpers, to set their Parallel Poll response. If Parallel Poll is not available, or several devices share the same Parallel Poll response bit, then Serial Polling is still required to determine which device is requesting service.

Serial Poll, though it is not as fast as Parallel Poll, does offer three major advantages: it gives an unambiguous response from a single bus device; it returns additional status information beyond the simple request/no-request for service; and, most importantly, it is implemented on virtually all bus devices.

The **SRQ** line can be monitored in two ways: it can be periodically polled by using the **STATUS** command, or by checking the “light pen status.”

BASIC provides a method for detecting and servicing external interrupts: the **ON PEN** statement. The **ON PEN** statement tells BASIC that, when an external interrupt is detected, a specific subroutine, known as the interrupt service routine (ISR), is to be executed. Normally, the interrupt detected by **ON PEN** is the light pen interrupt. However, Driver488/DRV redefines this “light pen interrupt” to signal when an IEEE 488 bus related interrupt (such as **SRQ**) has occurred.

Unlike BASIC, C does not provide an automatic method of checking for light pen interrupts. Therefore, a function is needed to check for the interrupt. The function could use the **STATUS** command, but it is much faster to check the interrupt status directly using a BIOS interrupt. The **CKLPINT** (check light pen interrupt) function provided in **IEEEIO.C** uses the BIOS to check for Driver488/DRV interrupts and returns true (**1**) if one is pending. Interrupts are checked automatically by the **IEEEWT** routine before sending any data to Driver488/DRV. However, **IEEEWT** does not call **CKLPINT** directly. Instead, it calls the routine that is pointed to by **IEEE_CKI** (**IEEE** check interrupt). If **IEEE_CKI** points to **CKLPINT**, then **IEEEWT** checks for Driver488/DRV interrupts, but if **IEEE_CKI** points to **_false_**, a function that always returns **0**, then interrupt checking is disabled. Initially, **IEEE_CKI** does point to **_false_**, and so interrupt checking is disabled. To enable interrupt checking **IEEE_CKI** must be redirected to **CKLPINT**:

```
int cklpint();
ieee_cki = cklpint;
```

Once an interrupt has been detected, an interrupt service routine must be invoked to handle the interrupting condition. When **IEEEWT** detects an interrupt, it calls the interrupt service routine (ISR). Just as **IEEEWT** does not call the check-for-interrupt routine directly, it does not call the ISR directly, either. Instead, it calls the routine pointed to by **IEEE_ISR** (**IEEE** interrupt service routine). If **IEEE_ISR** is set to point to some specific ISR, then that ISR is executed when **IEEEWT** detects an interrupt. Initially, **IEEE_ISR** points to **no_op**, a function that does nothing. So, unless **IEEE_ISR** is redirected to another routine, nothing is done when an interrupt is detected. In the **195DEMO** example program an interrupt service routine, called **isr**, has been provided. So, **IEEE_ISR** must be set to point this routine for interrupts to be handled properly:

```
ieee_isr = isr;
```

Once we have enabled interrupt checking by setting **`IEEE_CKI`** to point to **`CKLPINT`**, and specified the interrupt service routine by setting **`IEEE_ISR`** to point to **`isr`**, then we can specify which conditions are to cause an interrupt. The **`ARM`** command specifies those conditions. In this example we want the interrupt to occur on the detection of a Service Request (**`SRQ`**):

```
ieeewt("arm srq\n");
```

The 195 can be set to request service on any of several different internal conditions. In particular, the **`M2`** command causes an **`SRQ`** on the detection of any invalid command or command option by the 195:

```
ieeewt("output 16;M2X");
```

This **`OUTPUT`** command is placed early in the program so that all subsequent commands to the 195 cause an **`SRQ`**, if they are invalid.

Now that interrupt detection is enabled, and the interrupt service routine is specified, we must specify the actions to take to service the interrupt. We first display a message indicating that an interrupt was detected, and then turn off interrupt checking:

```
void isr()
{ int _false()_;
printf("Interrupt detected...");
ieee_cki = _false_;
```

We next check the Driver488/DRV Serial Poll Status to determine if an **`SRQ`** actually caused the interrupt:

```
int sp;
ieeewt("spoll\n");
ieeescnf("%d",&sp);
if (sp==0) {
printf("Non-SRQ Interrupt!\n");
exit(1);
}
```

We then Serial Poll the 195 to determine its status. If there were other devices on the bus that could be generating the **`SRQ`**, each of them would be have to be checked in turn.

```
int st195;
ieeewt("spoll 16\n");
ieeescnf("%d",&st195);
if ((st195 & 0x40) == 0 ) {
printf("Non-195 SRQ!\n");
exit();
}
```

Bit **`DIO7`**, with a value of **`0x40`**, is returned as true (**`1`**) in the Serial Poll response of those devices requesting service. In our simple example we expect that the 195 is the only possible cause of an **`SRQ`**, and if not, there must be some error.

Now that we have identified the device that is requesting service, we can further examine the Serial Poll status to classify the request:

```
if ((st195 & 0x20) == 0) {
if (st195 & 0x01)
printf("Overflow\n");
if (st195 & 0x02)
printf("Buffer Full\n");
if (st195 & 0x04)
printf("Buffer 1/2 Full\n");
if (st195 & 0x08)
printf("Reading Done\n");
if (st195 & 0x10)
printf("Busy\n");
} else {
if (st195 & 0x01)
printf("Illegal Command Option\n");
if (st195 & 0x02)
printf("Illegal Command\n");
if (st195 & 0x04)
printf("No Remote\n");
if (st195 & 0x08)
printf("Trigger Overrun\n");
if (st195 & 0x10)
printf("Failed Selftest\n");
}
```

The action taken depends, of course, on the design of the system, but in this example, simply displaying a message is adequate.

Finally, after decoding the cause of the **SRQ**, we are ready to re-enable interrupts and return to the main program:

```
ieee_cki = cklpint;
```

IEEEIO.C

The **IEEEIO.C** file contains several useful declarations and functions, many of which have been used in the **195DEMO** example program. They are:

- **IEEE** is an integer that holds the file descriptor (MS-DOS handle) returned by **OPEN**.

```
int ieee
```

- **segment** and **offset** return the 16-bit **segment** and **offset** values that make up a pointer.

```
int segment(ptr)
void *ptr
int offset(ptr)
void *ptr
```

The implementation of these functions depends on the memory model being used. In the small data model, pointers are 16 bits and are exactly the **offset** desired. Here, the **segment** is always the internal **ds** register value. In the large data model, pointers are 32 bits, one word of which is the **segment** and the other is the **offset**. For more information on memory models, see the "Other Languages" Sub-Chapter in this Chapter.

- **ERRNO** holds the error code for I/O and other errors.

```
extern int errno;
```

- **IOCTL_RD** and **IOCTL_WT** are special versions of **IOCTL_IO** which reads and writes to the I/O control channel of a device.

```
int ioctl_io(int handle
chars,chars[],
int size,
int iocall)
#define ioctl_rd(handle,chars,size) \
ioctl_io(handle,chars,size,0x4402)
#define ioctl_wt(handle,chars,size) \
ioctl_io(handle,chars,size,0x4403)
```

The I/O control channel of a device is read from and written to exactly as the normal (data) channel is read and written, but the data transferred is not to be treated in the same way. Normally, the I/O control channel is used to communicate setup and status information regarding the device without actually transferring any data to or from it. When using Driver488/DRV, **IOCTL_WT** is used to force Driver488/DRV to be ready to accept a command, and **IOCTL_RD** is used to return status information from the driver. These functions correspond exactly to the **IOCTL** and **IOCTL$** commands, as described in "Section III: Command References." The Turbo C library function **IOCTL** could be used to perform these functions for small-data programs, but it is not compatible with the large-data models.

- **CKLPINT, IEEE_CKI,** and **IEEE_ISR** are functions and pointers which provide for automatic interrupt detection and servicing.

```
int cklpint(void)
int _false_(void)
int (*ieee_cki)(void) = _false_
void no_op(void)
void (*ieee_isr)(void) = no_op
```

Driver488/DRV signals interrupts, which are enabled with the `ARM` command, by causing the light pen signal to appear "true." The `CKLPINT` checks that Driver488/DRV is able to service an interrupt (the response from `IOCTL_RD` is `0`) and then checks if an interrupt is pending by checking the light pen status. The `IEEEWT` routine (described below) calls the function pointed to by `IEEE_CKI` to determine if an `IEEE` interrupt needs to be serviced. The `IEEE_CKI` normally points to the function `_false_` which always returns zero (`0`). To enable interrupt checking `IEEE_CKI` must be redirected to point to `CKLPINT`. Interrupt checking is disabled by pointing `IEEE_CKI` back to `_false_`. Once an interrupt has been detected, `IEEEWT` calls the interrupt service routine pointed to by `IEEE_ISR` to service the interrupt. The `IEEE_ISR` initially points to `no_op`, a function that does nothing, but it may be redirected as needed to specify the appropriate interrupt service routine for each part of a program.

- `_IEEEWT` and `_IEEERD` are very similar to the unbuffered `_WRITE` and `_READ` routines provided in the C library.

```
int _ieeewt(int handle,char chars[])
int _ieeerd(int handle,char chars[],int size)
#define ieeewt(chars) _ieeewt(ieee,chars)
#define ieeerd(chars) _ieeerd(ieee,chars,sizeof(chars))
```

The `_IEEEWT` differs from `_WRITE` in that it checks for Driver488/DRV interrupts before writing, determines the number of characters to write by using `STRLEN`, and prints an error message if an error has occurred during writing. The `_IEEERD` differs from `_READ` only in that it prints an error message if an error has occurred during reading. `IEEEWT` and `IEEERD` (without the leading underscore) write and read to the file `IEEE`. Notice that `IEEERD` uses `SIZEOF` to determine the number of characters to read. This only works if `SIZEOF` can determine the number of bytes in the receive buffer, `chars`. This means `chars` must be an array of known size, for example, `char chars[256]`, not `char*chars`.

- `IEEEPRTF` and `IEEESCNF` are IEEE 488 versions of `PRINTF` and `SCANF`, respectively.

```
int ieeeprtf(char *format, ...)
int ieeescnf(char *format, ...)
```

The `IEEEPRTF` accepts a format string and a list of arguments. It formats its arguments according to the specified format and sends the formatted string to Driver488/DRV. The `IEEESCNF` accepts a format string and pointers (to the types specified in the format string). It reads a string of up to 256 bytes from Driver488/DRV, terminates it with a zero, converts it according to the format string, and places the converted values into the variables pointed to by the specified pointers.

- `RAWMODE` sets the file specified by `handle` for "raw mode" I/O.

```
int rawmode(int handle);
```

In "raw mode" MS-DOS does not interpret the characters received from the file. In particular, `control-Z` is not taken as end-of-file. "Raw mode" is usually appropriate for IEEE 488 communications because it does not interfere with the transfer of binary data and because it is much more efficient than "non-raw mode" I/O.

- `IEEEINIT` establishes communications with Driver488/DRV and configures it for use with C.

```
int ieeeinit(void);
```

It first opens the file `IEEE` for both reading and writing and puts the file descriptor into `IEEE`. It then puts the file into "raw mode". Driver488/DRV is then initialized by sending the `IOCTL "BREAK"` and `RESET` commands. Normal output from C is terminated by a new-line (line feed) character, and returned strings should be terminated by a null, so `EOL OUT LF` and `EOL IN $0` commands are then issued. Finally a `FILL ERROR` command is issued to enable `SEQUENCE - NO DATA AVAILABLE` error detection. If an error is detected during any of these commands, `IEEEINIT` returns a `-1`, otherwise it returns a zero (`0`).

CRITERR.ASM (Microsoft C & Turbo C)

Normally, when Driver488/DRV detects an error, perhaps due to a syntax error in a command, or due to an IEEE 488 bus error (such as time out on data transfer), it responds with an I/O error to DOS. When this happens, DOS normally issues an **`ABORT`**, **`RETRY`** or **`IGNORE`** message and waits for a response from the keyboard. There is no way for the user's program to detect such an error, determine the cause, and take appropriate action. However, DOS does provide a method of redefining the action to be taken on such a "critical error". **`CRITERR.ASM`** contains a critical error handler that, when invoked, makes it appear to the calling program that some less-critical error has occurred. The critical error handler is installed by **`CRIT_ON()`** and removed by **`CRIT_OFF()`**.The critical error handler is also automatically removed by DOS when the program exits.

The following program fragment demonstrates the use of the critical error handler:

```
#include "criterr.h"
crit_on(ieee);
if (ieeewt("output 16;F0X") == -1) {
printf("Error writing F0X to device 16, \n");
crit_off();
ioctl_wt(ieee,"break",5);
ieeewt("eol out lf\r\n");
ieeewt("status\n");
ieeerd(response);
printf("status = %s\n",response);
crit_on(ieee);
}
```

We must first **`#include`** the header file with the definitions of the critical error routines. We then enable critical error trapping with **`CRIT_ON`** which takes as a parameter the handle of the file for which critical error trapping is to be enabled. Only read and write commands to that handle are trapped. Errors caused by other actions, or associated with other files are not trapped. Error trapping may only be enabled for one file at a time.

Now, if **`IEEEWT`** signals an error by returning a **`-1`**, we can check what happened. We first **`PRINTF`** an error message, then we turn critical error trapping off with **`CRIT_OFF`** so that, if another critical error occurs, we get the **`ABORT`**, **`RETRY`** or **`IGNORE`** message and know a catastrophic double error has occurred. We then **`IOCTL_WT(_BREAK_)`** to force Driver488/DRV to listen to our next command. The **`IOCTL_WT`** also resets the **`EOL OUT`** terminator so we can be sure that Driver488/DRV detects the end of our commands. We next reset the **`EOL OUT`** terminator to our preferred line feed only and ask Driver488/DRV for its status. On receiving the response, we could interpret the status and take whatever action is appropriate. However, in this example, we just display the status. Finally, we re-enable the critical error handler and continue with the program.

Sample Program

```
#include "ieeeio.h"
#include .h
void main (void) {
char response[256];
float voltage;
int i;
float sum;
char hundred[1700];
ieee=open("ieee",O_RDWR | O_BINARY);
ieee=open("ieee",O_rdwr);
rawmode(ieee);
ioctl_wt(ieee,"break",5);
ieeewt("reset\r\n");
ieeewt("eol out lf\r\n");
ieeewt("eol in $0\n");
ieeewt("fill error\n");
if (ieeeinit() == -1) {
printf("Cannot initialize IEEE system.\n");
exit(1);
```

```
}
ieeewt("hello\n");
ieeerd(response);
printf("%s\n",response);
ieeewt("status\n");
ieeerd(response);
printf("%s\n",response);
ieeewt("output 16;F0R0X\n");
ieeewt("enter 16\n");
ieeescnf("%*4s%e",&voltage);
printf("The read value is %g\n",voltage);
sum=0.0;
for (i=0; i; i++) {
ieeewt("enter 16\n");
ieeescnf("%*4s%e",&voltage);
sum=sum+voltage;
}
printf("The average of 10 readings is %g\n",sum/10.0);
ieeeprtf("ENTER 16 #1700 BUFFER %d:%d\n",
segment(hundred),offset(hundred));
for (i=0; i<1700; i++) putchar(hundred[i]);
ieeeprtf("ENTER 16 #1700 BUFFER continue\n",
segment(hundred),offset(hundred));
ieeewt("status\n");
ieeerd(response);
printf("%s\n",response);
ieeewt("wait\n");
ieeewt("status\n");
ieeerd(response);
printf("%s\n",response);
ieee_cki = cklpint;
ieee_isr = isr;
ieeewt("arm srq\n");
ieeewt("output 16;M2X");
}
void isr()
{ int _false()_;
int sp;
int st195;
printf("Interrupt detected...");
ieee_cki = _false_;
ieeewt("spoll\n");
ieeescnf("%d",&sp);
if (sp==0) {
printf("Non-SRQ Interrupt!\n");
exit(1);
}
ieeewt("spoll 16\n");
ieeescnf("%d",&st195);
if ((st195 & 0x40) == 0 ) {
printf("Non-195 SRQ!\n");
exit();
}
if ((st195 & 0x20) == 0) {
if (st195 & 0x01)
printf("Overflow\n");
if (st195 & 0x02)
printf("Buffer Full\n");
if (st195 & 0x04)
printf("Buffer 1/2 Full\n");
if (st195 & 0x08)
printf("Reading Done\n");
if (st195 & 0x10)
printf("Busy\n");
} else {
if (st195 & 0x01)
printf("Illegal Command Option\n");
```

```
if (st195 & 0x02)
printf("Illegal Command\n");
if (st195 & 0x04)
printf("No Remote\n");
if (st195 & 0x08)
printf("Trigger Overrun\n");
if (st195 & 0x10)
printf("Failed Selftest\n");
}
```

8I. Turbo Pascal

Topics

Use of Character Command Language

In order to simplify programming Driver488/DRV with Turbo Pascal 4.0 and Turbo Pascal 6.0, the following files are provided on the Driver488/DRV program disk in the `\TURBOP40` directory:

- `IEEEIO.PAS:` Communications routines unit for Driver488/DRV.
- `IEEEIO.TPU:` Compiled unit for using Driver488/DRV.

The actual demonstration program is contained in `195DEMO.PAS`.

The `IEEEIO.PAS` unit contains initialization code that prepares for communication with Driver488/DRV. It opens the `IeeeOut` and `IeeeIn` files, sets them into "raw mode", resets Driver488/DRV with `IOCTL` followed by `Writeln(IeeeOut,'RESET')`, and enables `NO DATA AVAILABLE` error detection by `Writeln(IeeeOut,'FILLERROR')`.

These and several other declarations and subroutines contained in the `IEEEIO` unit, are further discussed below:

```
VAR
Regs: REGISTERS;
IeeeOut, IeeeIn: TEXT;
PROCEDURE IOCTL;
PROCEDURE IOCTLRead(var Command:STRING);
PROCEDURE RawMode(var AFile:TEXT);
PROCEDURE IeeeComplete;
```

- `Regs`, defined as a `REGISTERS` type in the DOS unit, is a record that is used to pass the microprocessor registers to and from the MS-DOS and IntrPascal procedures. Each of the accessible registers is referred to as a component of `Regs`. For example `Regs.AX:=$1234` is the same as `Regs.AH:=$12;Regs.AL:=$34`.
- `IeeeOut` and `IeeeIn` are two `TEXT` file variables that are used for writing to, and reading from, Driver488/DRV, respectively. They are opened by the `IEEEIO` unit initialization code, and closed by `IeeeComplete`.

- **IOCTL** is equivalent to the **IOCTL#1** BASIC statement that is described in "Section III: Command References." Its effect is to cause Driver488/DRV to listen to the program regardless of what state it was previously in. This is used by **IeeeInit** to reset Driver488/DRV.
- **IOCTLRead** is equivalent to the **IOCTL$** BASIC function that is described in "Section III: Command References." It returns a single character, either **0** or **1**, stating whether (**1**) or not (**0**) Driver488/DRV has a response to be read by the program. While it is not used in this sample program, it is included for completeness.
- All strings are of type **STRING** which is a 255 character string. Unless more memory is needed, there is no reason to define strings with fewer than their maximum of 255 characters.
- **RawMode** is a procedure that tells DOS not to check for control characters when communicating with the specified **TEXT** file. This greatly improves the efficiency of communicating with Driver488/DRV.
- **IeeeComplete** should be called at the end of programs that use Driver488/DRV to close the **IeeeOut** and **IeeeIn** files.

Initialization of the System

Any program using Driver488/DRV must first establish communications with the Driver488/DRV software driver. In Turbo Pascal ("Turbo") this is accomplished using **ASSIGN**, **REWRITE** and **RESET** statements. Communication both to and from Driver488/DRV, is required. In Turbo, this means that two files must be opened, one for input, and one for output. Other languages may allow the same file to be opened for both input and output. Three file names are allowed: **IEEEOUT**, **IEEEIN**, and **IEEE**. By convention, they are used for output, input, and both input and output, respectively. But actuality, they are all the same and any one of them can be used for input, output, or both, depending on the programming language. Note that, unlike BASIC (refer to the "QuickBASIC" Sub-Chapter in Chapter 8), the **\DEV** prefix is not used in Turbo Pascal.

In Turbo, the files are opened with the following statements:

```
VAR IeeeOut, IeeeIn: TEXT;
Assign(IeeeOut,'IeeeOut'); Rewrite(IeeeOut);
Assign(IeeeIn,'IeeeIn'); Reset(IeeeIn);
```

which are contained in the **IEEEIO** unit initialization procedure.

Of course, the **TEXT** file variable names (**IeeeOut** and **IeeeIn**) may be changed as desired, but throughout this manual, **IeeeOut** and **IeeeIn** are used.

Once the files are opened, we can tell DOS that they are used for binary communications and that DOS should not check for control characters. To do this, we use **RawMode**:

```
RawMode(IeeeOut);
RawMode(IeeeIn);
```

Now that the files are ready, we can send commands and receive responses from Driver488/DRV. While Driver488/DRV should normally be in a reset, inactive state, it is possible that it was left in some unknown state by a previous program failure or error. In order to force Driver488/DRV into its quiescent state we can use the supplied **IOCTL** procedure:

```
IOCTL; {Invoke IOCTL procedure}
```

The **IOCTL** procedure is equivalent to the BASIC statement **IOCTL#1,"BREAK"** which sends the **BREAK** command through a "back door" to Driver488/DRV. Driver488/DRV recognizes this "back door" command regardless of what else it might be doing and resets itself so that it is ready to accept a normal command. We can then completely reset the Driver488/DRV with the **RESET** command:

```
Writeln(IeeeOut,'RESET');
```

which resets the operating parameters of the Driver488/DRV back to their normal values (those that were set during system boot by the **DRVR488** DOS command).

Next, we can enable **SEQUENCE - NO DATA AVAILABLE** error detection by setting the **FILL** mode to **ERROR**:

```
Writeln(IeeeOut,'FILL ERROR');
```

The **IOCTL**, **RESET**, and **FILL ERROR** statements are also included in the **IEEEIO** unit initialization code.

Once everything is reset, we can test the communications and read the Driver488/DRV revision number with the **HELLO** command:

```
VAR Response: STRING;
Writeln(IeeeOut,'HELLO');
Readln(IeeeIn,Response);
Writeln(Response);
```

First we **Writeln** the **HELLO** command to **IeeeOut**, then we **Readln** the response from **IeeeIn** into the character variable **Response**. Finally we display the response with a **Writeln** to the screen. Because Turbo Pascal cannot both **Writeln** and **Readln** from the same text file, we use two different files to communicate with Driver488/DRV. **Writeln** must reference the file opened for output (in these examples, **IeeeOut**) and **Readln** must reference the file opened for input (**IeeeIn**). Attempting to communicate with the wrong file (such as **Writeln(IeeeIn_)**) results in an error.

It is not necessary to perform the **HELLO** command, but it is included here as a simple example of normal communication with Driver488/DRV. Its response is the revision identification of the Driver488/DRV software: **Driver488 Revision X.X ©199X IOtech, Inc.**

We can also interrogate Driver488/DRV for its status:

```
Writeln(IeeeOut,'STATUS');
Readln(IeeeIn,Response);
Writeln(Response);
```

Subsequently, the printed response is similar to the following:

```
CS21 1 I000 000 T0 C0 P0 OK
```

The following indicators describe each component of the Driver488/DRV status:

Indicator	Driver488/DRV Status
C	It is in the Controller state.
S	It is the System Controller.
21	The value of its IEEE 488 bus address.
1	An Address Change has occurred.
I	It is idle (neither a talker nor a listener).
0	There is no **ByteIn** available.
0	It is not ready to send a **ByteOut**.
0	Service Request (**SRQ**) is not asserted.
000	There is no outstanding error.
T0	It has not received a bus device **TRIGGER** command (only applicable in the Peripheral mode).
C0	It has not received a **CLEAR** command (only applicable in the Peripheral mode).
P0	No **CONTINUE** transfer is in progress.
OK	The error message is "OK".

Configuration of the 195 DMM

Once the system is initialized we are ready to start issuing bus commands. The IEEE 488 bus has already been cleared by the Interface Clear (**IFC**) sent by the **RESET** command, so we know all bus devices are waiting for the controller to take some action. To control an IEEE 488 bus device, we **OUTPUT** an appropriate device-dependent command to that device. For example, the command **F0R0X** sets the 195 to read DC volts with automatic range selection:

```
        Writeln(IeeeOut,'OUTPUT 16;F0R0X');
```

The **`OUTPUT`** command takes a bus device address (**`16`** in this case) and data (**`F0R0X`**) and sends the data to the specified device. The address can be just a primary address, such as **`12`**, or **`05`**, or it can include a secondary address: **`1201`**. Note that both the primary address and, if present, the secondary address are two-digit decimal numbers. A leading zero must be used, if necessary, to make a two-digit address.

Taking Readings

Once we have set the 195's operating mode, we can take a reading and display it:

```
        VAR Reading: STRING;
        Writeln(IeeeOut,'ENTER 16');
        Readln(IeeeIn,Reading);
        Writeln(Reading);
```

The **`ENTER`** command takes a bus address (with an optional secondary address) and configures that bus device so that it is able to send data (addressed to Talk). No data is actually transferred, however, until the **`Readln`** statement requests the result from Driver488/DRV at which time data is transferred to the program into the variable **`Reading`**.

Once the result has been received, any Turbo Pascal functions or statements can be used to modify or interpret it. In this example, the result is in the form **`NDCV+1.23456E-2`** showing the range (**`NDCV`**) and the numeric value of the reading (**`+1.23456E-2`**). The Turbo Pascal **`Copy`** function can be used to strip off the range characters and keep only the numeric part (the fifth character and beyond), and the **`VAL`** procedure can be used to convert this string to a number:

```
        VAR
        voltage: REAL;
        code: INTEGER;
        Reading:=Copy(Reading,5,255);
        Val(Reading,voltage,code);
        Writeln('The read value is ',voltage);
```

These may be combined for efficiency:

```
        Val(Copy(Reading,5,255),voltage,code);
        Writeln('The read value is ',voltage);
```

All the power of Turbo Pascal may be used to manipulate, print, store, and analyze the data read from the IEEE 488 bus. For example, the following statements print the average of ten readings from the 195:

```
        VAR
        sum: REAL;
        i: INTEGER;
        sum:=0.;
        FOR i:=1 TO 10 DO BEGIN
        Writeln(IeeeOut,'ENTER 16');
        Readln(IeeeIn,Reading);
        Val(Copy(Reading,5,255),voltage,code);
        sum:=sum+voltage;
        END;
        Writeln('The average of 10 readings is ',sum/10);
```

Buffer Transfers

Instead of using a **`Readln(IeeeIn_)`** statement to receive the data from a device, we can direct Driver488/DRV to place the response directly into a data buffer of our choice. For example, each reading from the 195 consists of 17 bytes: a four-byte prefix and an eleven-byte reading followed by the two-byte command terminator. So, we can collect 100 readings in a 1700 byte array.

To do this we must first allocate the required space in an array:

```
        VAR r: ARRAY[0..1699] of CHAR;
```

Now that we have allocated a place for the readings, we can direct Driver488/DRV to put readings directly into the `r` array with the `ENTER #count BUFFER` command:

```
Writeln(IeeeOut,'ENTER 16 #1700 BUFFER',
Seg(r[0]),':',Ofs(r[0]));
```

This command consists of the keyword `ENTER`, followed by the bus device address (`16`), a number sign (`#`), the number of bytes to transfer (`1700`), and the keyword `BUFFER`, followed by the memory address of the buffer. The buffer address is specified as `segment:offset` where `segment` and `offset` are each 16-bit numbers and the colon (`:`) is required to separate them. The `segment` value we need, is the value returned by the Turbo Pascal `Seg` function. The `offset` is the offset of the array in that data segment, which is the value returned by `Ofs(r[0])`.

Once the data has been received, we can print it out:

```
FOR i:=0 TO 1699 DO Write(r[i]);
```

The program could process the previous set of data while collecting a new set into a different buffer. To allow the program to continue, specify `CONTINUE` in the command:

```
Writeln(IeeeOut,'ENTER 16 #1700 BUFFER ',
Seg(r[0]),':',Ofs(r[0]),' CONTINUE');
```

Once we have started the transfer, we can check the status:

```
Writeln(IeeeOut,'STATUS');
Readln(IeeeIn,Response);
Writeln(Response);
```

The status that is returned is typically:

```
CS21 1 L100 000 T0 C0 P1 OK
```

Notice `P1` which states a transfer is in progress, and `L` which shows we are still a listener. If the bus device is so fast that the transfer completes before the program can check status, the response is `P0` showing that the transfer is no longer in progress. We can also `WAIT` for the transfer to complete and check the status again:

```
Writeln(IeeeOut,'WAIT');
Writeln(IeeeOut,'STATUS');
Readln(IeeeIn,Response);
Writeln(Response);
```

This time the status must be `P0` as the `WAIT` command waits until the transfer has completed. Now that we know the transfer is complete, we are ready to print out the received data as shown above.

Interrupt Handling

The IEEE 488 bus is designed to be able to attend to asynchronous (unpredictable) events or conditions. When such an event occurs, the bus device needing attention can assert the Service Request (`SRQ`) line to signal that condition to the controller. Once the controller notices the `SRQ`, it can interrogate the bus devices, using Parallel Poll (`PPOLL`) and/or Serial Poll (`SPOLL`) to determine the source and cause of the `SRQ`, and take the appropriate action.

Parallel Poll is the fastest method of determining which device requires service. Parallel Poll is a very short, simple IEEE 488 bus transaction that quickly returns the status from many devices. Each of the eight IEEE 488 bus data bits can contain the Parallel Poll response from one or more devices. So, if there are eight or fewer devices on the bus, then just the single Parallel Poll can determine which requires service. Even if the bus is occupied by the full complement of 15 devices, then Parallel Poll can narrow the possibilities down to a choice of no more than two.

Unfortunately, the utility of Parallel Poll is limited when working with actual devices. Some have no Parallel Poll response capability. Others must be configured in hardware, usually with switches or jumpers, to set their Parallel Poll response. If Parallel Poll is not available, or several devices share the same Parallel Poll response bit, then Serial Polling is still required to determine which device is requesting service.

Serial Poll, though it is not as fast as Parallel Poll, does offer three major advantages: it gives an unambiguous response from a single bus device; it returns additional status information beyond the simple request/no-request for service; and, most importantly, it is implemented on virtually all bus devices.

The **SRQ** line can be monitored in two ways: it can be periodically polled using the **STATUS** command, or it can be used to cause an external interrupt when asserted.

BASIC provides a method for detecting and servicing external interrupts: the **ON PEN** statement. The **ON PEN** statement tells BASIC that, when an external interrupt is detected, a specific subroutine, known as the interrupt service routine (ISR), is to be executed. Normally, the interrupt detected by **ON PEN** is the light pen interrupt. However, Driver488/DRV redefines this "light pen interrupt" to signal when an IEEE 488 bus related interrupt (such as **SRQ**) has occurred.

Unlike BASIC, Turbo Pascal does not provide an automatic method of checking for light pen status. Therefore, a procedure is needed to check for the interrupt. The procedure could use the **STATUS** command, but it is much faster to check the interrupt status directly, using a BIOS interrupt:

```
PROCEDURE CheckInt(Signal:integer);
BEGIN
Regs.AX=$0400;
{Function 4, check light pen status}
Intr($10,Regs); {BIOS interrupt $10}
WHILE Registers.AH 0 DO BEGIN
{A Driver488/DRV interrupt has occurred}

{Take the appropriate action}

Regs.AX=$0400;
{Check if another interrupt has occurred}
Intr($10,Regs);
END
END; {of procedure CheckInt}
```

Inside the **WHILE** loop, where **Registers.AH** is not zero, we know that a Driver488/DRV interrupt has occurred. The **ARM** command is used to specify which conditions should cause that interrupt. In this example we want the interrupt to occur on the detection of a Service Request:

```
Writeln(IeeeOut,'ARM SRQ');
```

The 195 can be set to request service on any of several different internal conditions. In particular, the **M2** command causes an **SRQ** upon the detection of any invalid command or command option by the 195:

```
Writeln(IeeeOut,'OUTPUT 16;M2X');
```

This **OUTPUT** command is placed early in the program so that all subsequent commands to the 195 cause an **SRQ**, if they are invalid.

Now we can check for interrupts by calling **CheckInt** at appropriate places in the program. The only place **CheckInt** should not be used, is between a command that requests a response, such as **STATUS** or **ENTER**, and the statement(s) that reads the response. The **CheckInt** parameter, **Signal**, can be used to identify where the interrupt was detected. A typical sequence might be the following:

```
Writeln(IeeeOut,'STATUS');
Readln(IeeeIn,Response); CheckInt(10);
Writeln(IeeeOut,'ENTER 16');
Readln(IeeeIn,Reading); CheckInt(20);
```

Each time **CheckInt** is called, Driver488/DRV interrupts are checked. Now we must specify what action should be taken when an interrupt is detected.

Upon detecting an interrupt, we first display a message indicating that an interrupt was found, and then check the Driver488/DRV Serial Poll Status to determine if an **SRQ** actually caused the interrupt:

```
VAR sp: INTEGER;
Writeln(‘Interrupt detected at signal ‘,Signal);
Writeln(IeeeOut,’SPOLL’);
Readln(IeeeIn,sp);
IF sp=0 THEN BEGIN
Writeln(‘Non-SRQ Interrupt!’); Halt
END;
```

Next we Serial Poll the 195 to determine its status. If there were other devices on the bus that could be generating the `SRQ`, each of them would be have to be checked in turn.

```
VAR st195: INTEGER;
Writeln(IeeeOut,’SPOLL 16’);
Readln(IeeeIn,st195);
IF (st195 and 64)=0 THEN BEGIN
Writeln(‘Non-195 SRQ!’); Halt
END;
```

Bit `DIO7`, with a value of `64`, is returned as true (`1`) in the Serial Poll response of those devices requesting service. In our simple example, we expect that the 195 is the only possible cause of an `SRQ`, and if not, there must be some error.

Now that we have identified the device that is requesting service, we can further examine the Serial Poll status to classify the request:

```
IF (st195 and 32)=0 THEN BEGIN {
ERROR is not set}
IF (st195 and 1) 0 THEN Writeln(‘Overflow’);
IF (st195 and 2) 0 THEN Writeln(‘Buffer Full’);
IF (st195 and 4) 0 THEN Writeln(‘Buffer 1/2 Full’);
IF (st195 and 8) 0 THEN Writeln(‘Reading Done’);
IF (st195 and 16) 0 THEN Writeln(‘Busy’)
END ELSE BEGIN {ERROR is set}IF (st195 and 1) 0 THEN
Writeln(‘Illegal Command Option’);
IF (st195 and 2) 0 THEN Writeln(‘Illegal Command’);
IF (st195 and 4) 0 THEN Writeln(‘No Remote’);
IF (st195 and 8) 0 THEN Writeln(‘Trigger Overrun’);
IF (st195 and 16) 0 THEN Writeln(‘Failed Selftest’)
END;
```

The action taken depends, of course, on the design of the system, but in this example, simply displaying a message is adequate.

Sample Program

```
BEGIN
VAR IeeeOut, IeeeIn: TEXT;
VAR Response: STRING;
VAR Reading: STRING;
VAR
voltage: REAL;
code: INTEGER;
VAR
sum: REAL;
i: INTEGER;
VAR r: ARRAY[0..1699] of CHAR;
Assign(IeeeOut,’IeeeOut’); Rewrite(IeeeOut);
Assign(IeeeIn,’IeeeIn’); Reset(IeeeIn);
RawMode(IeeeOut);
RawMode(IeeeIn);
IOCTL; {Invoke IOCTL procedure}
Writeln(IeeeOut,’RESET’);
Writeln(IeeeOut,’FILL ERROR’);
Writeln(IeeeOut,’HELLO’);
Readln(IeeeIn,Response);
Writeln(Response);
Writeln(IeeeOut,’STATUS’);
```

```
Readln(IeeeIn,Response);
Writeln(Response);
Writeln(IeeeOut,'OUTPUT 16;F0R0X');
Writeln(IeeeOut,'ENTER 16');
Readln(IeeeIn,Reading);
Writeln(Reading);
Reading:=Copy(Reading,5,255);
Val(Reading,voltage,code);
Writeln('The read value is ',voltage);
Val(Copy(Reading,5,255),voltage,code);
Writeln('The read value is ',voltage);
sum:=0.;
FOR i:=1 TO 10 DO BEGIN
Writeln(IeeeOut,'ENTER 16');
Readln(IeeeIn,Reading);
Val(Copy(Reading,5,255),voltage,code);
sum:=sum+voltage;
END;
Writeln('The average of 10 readings is ',sum/10);

Writeln(IeeeOut,'ENTER 16 #1700 BUFFER ',
Seg(r[0]),':',Ofs(r[0]));
FOR i:=0 TO 1699 DO Write(r[i]);
Writeln(IeeeOut,'ENTER 16 #1700 BUFFER ',
Seg(r[0]),':',Ofs(r[0]),' CONTINUE');
Writeln(IeeeOut,'STATUS');
Readln(IeeeIn,Response);
Writeln(Response);
Writeln(IeeeOut,'WAIT');
Writeln(IeeeOut,'STATUS');
Readln(IeeeIn,Response);
Writeln(Response);
PROCEDURE CheckInt(Signal:integer);
BEGIN
VAR sp: INTEGER;
VAR st195: INTEGER;
Regs.AX=$0400;
{Function 4, check light pen status}
Intr($10,Regs); {BIOS interrupt $10}
WHILE Registers.AH 0 DO BEGIN
{A Driver488/DRV interrupt has occurred}

{Take the appropriate action}

Regs.AX=$0400;
{Check if another interrupt has occurred}
Intr($10,Regs);
END
Writeln(IeeeOut,'ARM SRQ');
Writeln(IeeeOut,'OUTPUT 16;M2X');
Writeln(IeeeOut,'STATUS');
Readln(IeeeIn,Response); CheckInt(10);
Writeln(IeeeOut,'ENTER 16');
Readln(IeeeIn,Reading); CheckInt(20);
Writeln('Interrupt detected at signal ',Signal);
Writeln(IeeeOut,'SPOLL');
Readln(IeeeIn,sp);
IF sp=0 THEN BEGIN
Writeln('Non-SRQ Interrupt!'); Halt
END;
Writeln(IeeeOut,'SPOLL 16');
Readln(IeeeIn,st195);
IF (st195 and 64)=0 THEN BEGIN
Writeln('Non-195 SRQ!'); Halt
END;
IF (st195 and 32)=0 THEN BEGIN {
ERROR is not set}
```

```
IF (st195 and 1) 0 THEN Writeln('Overflow');
IF (st195 and 2) 0 THEN Writeln('Buffer Full');
IF (st195 and 4) 0 THEN Writeln('Buffer 1/2 Full');
IF (st195 and 8) 0 THEN Writeln('Reading Done');
IF (st195 and 16) 0 THEN Writeln('Busy')
END ELSE BEGIN {ERROR is set}IF (st195 and 1) 0 THEN
Writeln('Illegal Command Option');
IF (st195 and 2) 0 THEN Writeln('Illegal Command');
IF (st195 and 4) 0 THEN Writeln('No Remote');
IF (st195 and 8) 0 THEN Writeln('Trigger Overrun');
IF (st195 and 16) 0 THEN Writeln('Failed Selftest')
END;
END; {of procedure CheckInt}
```

8J. Spreadsheets

Topics

Use of Direct DOS I/O Devices

Once Driver488/DRV has been installed in your system, it is ready to begin controlling IEEE 488 bus devices. To show how this is done, we develop a short program, in the Lotus 1-2-3 macro language, to control a Keithley Instruments Model 195 digital multimeter. This program should also be compatible with Symphony, and a very similar Quattro program is also included on the Driver488/DRV program disk. The techniques used in this program are quite general, and apply to the control of most instruments.

Initialization of the System

Any program using Driver488/DRV must first establish communications with the Driver488/DRV software driver. In Lotus 1-2-3 and most other languages this is accomplished using an **`OPEN`** command:

```
{OPEN IEEE,W}
```

Once the file is opened, we can send commands and receive responses from Driver488/DRV. First, completely reset the Driver488/DRV with the **`RESET`** command:

```
{WRITELN RESET}
```

which resets the operating parameters of the Driver488/DRV back to their normal values (those that were set during system boot by the **`DRVR488`** DOS command).

When Lotus 1-2-3 reads from Driver488/DRV it expects that the responses are terminated by a single carriage return character. As Driver488/DRV normally appends both carriage return and line feed to its responses, it must be configured to use the correct terminator:

```
{WRITELN EOL IN CR}
```

Next, we can enable **`SEQUENCE - NO DATA AVAILABLE`** error detection by setting the **`FILL`** mode to **`ERROR`**:

```
{WRITELN FILL ERROR}
```

All of the commands discussed so far: `OPEN`, `RESET`, `EOL IN CR`, and `FILL ERROR` are placed in a separate subroutine called `IeeeInit`. Thus, to accomplish all of the above steps, use `IeeeInit`:

```
{IeeeInit}
```

Once everything is reset, we can test the communications and read the Driver488/DRV revision number with the `HELLO` command:

```
{WRITELN "HELLO"}
{READLN Hello}
```

We first `WRITELN` the `HELLO` command, then `READLN` the response into the cell named `Hello` (lower case). Notice the quotation marks (`" "`) around the word `HELLO` (upper case) in the `WRITELN` command. These force Lotus to write the word `HELLO` (upper case) rather than the contents of the cell named `Hello` (lower case). Otherwise, since upper-case and lower-case letters are considered identical, both `HELLO` and `Hello` would refer to the same cell.

It is not necessary to perform the `HELLO` command, but it is included here as a simple example of normal communication with Driver488/DRV. Its response is the revision identification of the Driver488/DRV software: `Driver488 Revision X.X ©199X IOtech, Inc.`

We can also interrogate Driver488/DRV for its status:

```
{WRITELN "STATUS"}
{READLN Status}
```

Subsequently, the printed response is similar to the following:

```
CS21 1 I000 000 T0 C0 P0 OK
```

The following indicators describe each component of the Driver488/DRV status:

Indicator	Driver488/DRV Status
`C`	It is in the Controller state.
`S`	It is the System Controller.
`21`	The value of its IEEE 488 bus address.
`1`	An Address Change has occurred.
`I`	It is idle (neither a talker nor a listener).
`0`	There is no `ByteIn` available.
`0`	It is not ready to send a `ByteOut`.
`0`	Service Request (`SRQ`) is not asserted.
`000`	There is no outstanding error.
`T0`	It has not received a bus device `TRIGGER` command (only applies in Peripheral mode).
`C0`	It has not received a `CLEAR` command (only applicable in the Peripheral mode).
`P0`	No `CONTINUE` transfer is in progress.
`OK`	The error message is "OK".

Configuration of the 195 DMM

Once the system is initialized we are ready to start issuing bus commands. The IEEE 488 bus has already been cleared by the Interface Clear (`IFC`) sent by the `RESET` command, so we know that all bus devices are waiting for the controller to take some action. To control an IEEE 488 bus device, we output an appropriate device-dependent command to that device. For example, the `F0R0X` command line below sets the 195 to read DC volts with automatic range selection:

```
{WRITELN "OUTPUT 16;F0R0X"}
```

The `OUTPUT` command takes a bus device address (`16` in this case) and data (`F0R0X`) and sends the data to the specified device. The address can be just a primary address, such as `12`, or `05`, or it can include a secondary address: `1201`. Note that both the primary address and, if present, the secondary address are two-digit decimal numbers. A leading zero must be used, if necessary to make a two-digit address.

Notice that the entire `OUTPUT` command is enclosed in quotation marks (`" "`). This is necessary because the command includes a semicolon character (`;`) which would interfere with the `WRITELN` command if it were not enclosed in quotes.

Taking Readings

Once we have set the 195's operating mode, we can take a reading:

```
{WRITELN ENTER 16}
{READLN Reading}
```

The **`ENTER`** command takes a bus address (with an optional secondary address) and configures that bus device so that it is able to send data (addressed to talk). No data is actually transferred, however, until the **`READLN`** statement requests the result from Driver488/DRV at which time data is transferred to the program into the cell **`Reading`**.

Once the result has been received, any Lotus 1-2-3 functions or statements can be used to modify or interpret it. In this example, the result is in the form **`NDCV+1.23456E-2`** showing the range (**`NDCV`**) and the numeric value of the reading (**`+1.23456E-2`**). The Lotus 1-2-3 **`@MID`** function can be used to strip off the range characters and keep only the numeric part (the fifth character and beyond), and the **`@VALUE`** function can be used to convert this string to a number:

```
{LET Voltage,@VALUE(@MID(Reading,4,11))}
```

All the power of Lotus 1-2-3 may be used to manipulate, print, store, and analyze the data read from the IEEE 488 bus. For example, the following statements compute the average of ten readings from the 195:

```
{FOR Index,0,9,1,Sum1}
Sum1:
{WRITELN ENTER 16}
{READLN Reading}
{PUT Voltages,0,Index,@VALUE(@MID(Reading,4,11))}
{RETURN}
```

The **`FOR`** statement sets **`Index`** to each of the successive values from **`0`** to **`9`**, calling the **`Sum1`** subroutine for each value of **`Index`**. **`Sum1`** takes a reading from the 195, converts it to a numeric value, and places it into a row of the range **`Voltages`**. The ten readings in **`Voltages`** are finally averaged by a formula in the cell named **`Average`** which can be seen in the example spreadsheet.

Interrupt Handling

The IEEE 488 bus is designed to be able to attend to asynchronous (unpredictable) events or conditions. When such an event occurs, the bus device needing attention can assert the Service Request (**`SRQ`**) line to signal that condition to the controller. Once the controller notices the **`SRQ`**, it can interrogate the bus devices, using Parallel Poll (**`PPOLL`**) and/or Serial Poll (**`SPOLL`**) to determine the source and cause of the **`SRQ`**, and take the appropriate action.

Parallel Poll is the fastest method of determining which device requires service. Parallel Poll is a very short, simple IEEE 488 bus transaction that quickly returns the status from many devices. Each of the eight IEEE 488 bus data bits can contain the Parallel Poll response from one or more devices. So, if there are eight or fewer devices on the bus, then just the single Parallel Poll can determine which requires service. Even if the bus is occupied by the full complement of 15 devices, then Parallel Poll can narrow the possibilities down to a choice of at most two.

Unfortunately, the utility of Parallel Poll is limited when working with actual devices. Some have no Parallel Poll response capability. Others must be configured in hardware, usually with switches or jumpers, to set their Parallel Poll response. If Parallel Poll is not available, or several devices share the same Parallel Poll response bit, then Serial Polling is still required to determine which device is requesting service.

Serial Poll, though it is not as fast as Parallel Poll, does offer two major advantages: it returns additional status information beyond the simple request/no-request for service, and it is implemented on virtually all bus devices.

The **`SRQ`** line can be monitored in two ways: it can be periodically polled using the **`STATUS`** command, or it can be used to cause an external interrupt when asserted.

BASIC provides a method for detecting and servicing external interrupts: the **`ON PEN`** statement. The **`ON PEN`** statement tells BASIC that, when an external interrupt is detected, a specific subroutine, known as the interrupt service routine (ISR), is to be executed. Normally, the interrupt detected by **`ON PEN`** is the light pen interrupt. However, Driver488/DRV redefines this "light pen interrupt" to signal when an IEEE 488 bus related interrupt (such as **`SRQ`**) has occurred.

Unlike BASIC, Lotus 1-2-3 does not provide an automatic method of checking for light pen status. Therefore, a subroutine is needed to check for the interrupt. This subroutine uses the **`SPOLL`** command to check for **`SRQ`**:

```
CheckSRQ:
{DEFINE Signal:VALUE}
{WRITELN SPOLL}
{READLN SP}
{LET SP,@VALUE(@MID(SP,0,@LENGTH(SP)-1))}
{IF SP=0}{BLANK ST195}{RETURN}
```

The **`CheckSRQ`** takes a numeric parameter, **`Signal`**, which can be used to note where in the program the interrupt occurred. The subroutine begins by reading the response to the **`SPOLL`** command and converting that response to a numeric value, **`SP`**. If **`SP`** is zero (**`0`**), then no **`SRQ`** is pending and we clear the 195 status cell, **`ST195`**, and then return. If SP is non-zero, we know that an **`SRQ`** is pending.

The 195 can be set to request service on any of several different internal conditions. In particular, the **`M2`** command causes an **`SRQ`** upon the detection of any invalid command or command option by the 195:

```
{WRITELN "OUTPUT 16;M2X"}
```

This **`OUTPUT`** command is placed early in the program so that all subsequent commands to the 195 cause an **`SRQ`**, if they are invalid.

Now check for service requests by calling **`CheckSRQ`** at appropriate places in the program. The only place **`CheckSRQ`** should not be used, is between a command that requests a response, such as **`STATUS`** or **`ENTER`**, and the statement(s) that read that response. The **`CheckSRQ`** parameter, **`Signal`** can be used to identify where the interrupt was detected. A typical sequence might be:

```
{WRITELN "STATUS"}
{READLN Status}
{CheckSRQ 10}
{WRITELN ENTER 16}
{READLN Reading}
{CHECKSRQ 20}
```

Once **`CheckSRQ`** has determined, with a Serial Poll, that a service request is indeed pending, it then checks the 195 to determine if it is the source of the interrupt. If there were other devices on the bus that could be generating the **`SRQ`**, each of them would be have to be checked in turn.

```
{WRITELN SPOLL 16}
{READLN ST195}
{LET ST195,@VALUE(@MID(ST195,0,@LENGTH(ST195)-1))}~
```

The tilde (~) at the end of the **`LET`** statement forces evaluation of the spreadsheet. In particular, it causes the values of the cells **`DIO8`** through **`DIO1`** to be set to the values of the bits of **`ST195`**. These cells can then be examined to inspect the 195's status:

```
{IF DIO7}{BRANCH 195SRQ}
{BEEP}{GETLABEL "Non-195 SRQ detected! Press Return.",TypeHere}
{RESTART}{RETURN}
```

Bit **`DIO7`**, is returned as true (**`1`**) in the Serial Poll response of those devices requesting service. In our simple example, we expect that the 195 is the only possible cause of an **`SRQ`**, and if it is not, there must be some error. If **`DIO7`** is set, we **`BRANCH`** to **`195SRQ`** and continue with the subroutine. Otherwise we **`BEEP`**, display an error message, and terminate macro execution. **`TypeHere`** is a blank cell that holds anything that is typed by the user before the return **`<Enter>`** is pressed.

Now that we have identified the device that is requesting service, we can further examine the Serial Poll status to classify the request. If `DIO6` is set, then the 195 is signaling an error condition. If that bit is clear, then some non-error condition caused the `SRQ`:

```
195SRQ:
{IF DIO6}{BRANCH 195ERR}
{IF DIO5}{BEEP}
{GETLABEL "195 Status: BUSY. Press Return.",TypeHere}
{IF DIO4}{BEEP}
{GETLABEL "195 Status: READING DONE. Press Return.",TypeHere}
{IF DIO3}{BEEP}
{GETLABEL "195 Status: BUFFER 1/2 FULL. Press Return." TypeHere}
{IF DIO2}{BEEP}
{GETLABEL "195 Status: BUFFER FULL. Press Return.",TypeHere}
{IF DIO1}{BEEP}
{GETLABEL "195 Status: OVERFLOW. Press Return.",TypeHere}
{RETURN}
195ERR:
{IF DIO5}{BEEP}
{GETLABEL "195 Status: FAILED SELFTEST. Press Return.",TypeHere}
{IF DIO4}{BEEP}
{GETLABEL "195 Status: TRIGGER OVERRUN. Press Return.",TypeHere}
{IF DIO3}{BEEP}
{GETLABEL "195 Status: NO REMOTE. Press Return.",TypeHere}
{IF DIO2}{BEEP}
{GETLABEL "195 Status: ILLEGAL COMMAND. Press Return.",TypeHere}
{IF DIO1}{BEEP}
{GETLABEL "195 Status: ILLEGAL COMMAND OPTION. Press
Return.",TypeHere}
```

Finally, once we have diagnosed the service request, we are ready to return to the main program:

```
{RETURN}
Sample Program
{OPEN IEEE,W}
{WRITELN RESET}
{WRITELN EOL IN CR}
{WRITELN FILL ERROR}
{IeeeInit}
{WRITELN "HELLO"}
{READLN Hello}
{WRITELN "STATUS"}
{READLN Status}
{WRITELN "OUTPUT 16;F0R0X"}
{WRITELN ENTER 16}
{READLN Reading}
{LET Voltage,@VALUE(@MID(Reading,4,11))}
{FOR Index,0,9,1,Sum1}
Sum1:
WRITELN ENTER 16}
{READLN Reading}
{PUT Voltages,0,Index,@VALUE(@MID(Reading,4,11))}
{RETURN}
CheckSRQ:
{DEFINE Signal:VALUE}
{WRITELN SPOLL}
{READLN SP}
{LET SP,@VALUE(@MID(SP,0,@LENGTH(SP)-1))}
{IF SP=0}{BLANK ST195}{RETURN}
{WRITELN "OUTPUT 16;M2X"}
{WRITELN "STATUS"}
{READLN Status}
{CheckSRQ 10}
{WRITELN ENTER 16}
{READLN Reading}
{CHECKSRQ 20}
{WRITELN SPOLL 16}
```

```
{READLN ST195}
{LET ST195,@VALUE(@MID(ST195,0,@LENGTH(ST195)-1))}~
{IF DIO7}{BRANCH 195SRQ}
{BEEP}{GETLABEL "Non-195 SRQ detected! Press Return.",TypeHere}
{RESTART}{RETURN}
195SRQ:
{IF DIO6}{BRANCH 195ERR}
{IF DIO5}{BEEP}
{GETLABEL "195 Status: BUSY. Press Return.",TypeHere}
{IF DIO4}{BEEP}
{GETLABEL "195 Status: READING DONE. Press Return.",TypeHere}
{IF DIO3}{BEEP}
{GETLABEL "195 Status: BUFFER 1/2 FULL. Press Return." TypeHere}
{IF DIO2}{BEEP}
{GETLABEL "195 Status: BUFFER FULL. Press Return.",TypeHere}
{IF DIO1}{BEEP}
{GETLABEL "195 Status: OVERFLOW. Press Return.",TypeHere}
{RETURN}
195ERR:
{IF DIO5}{BEEP}
{GETLABEL "195 Status: FAILED SELFTEST. Press Return.",TypeHere}
{IF DIO4}{BEEP}
{GETLABEL "195 Status: TRIGGER OVERRUN. Press Return.",TypeHere}
{IF DIO3}{BEEP}
{GETLABEL "195 Status: NO REMOTE. Press Return.",TypeHere}
{IF DIO2}{BEEP}
{GETLABEL "195 Status: ILLEGAL COMMAND. Press Return.",TypeHere}
IF DIO1}{BEEP}
{GETLABEL "195 Status: ILLEGAL COMMAND OPTION. Press
Return.",TypeHere}
{RETURN}
```

8K. Other Languages

Topics

Introduction

Driver488/DRV is compatible with virtually every MS-DOS programming language. If you wish to use Driver488/DRV with a language that is not covered in this chapter, try the following:

- Check the Driver488/DRV disk. Support for languages not described in this manual may be included in the Driver488/DRV program disk.
- Try the examples given for a language that is similar to the one you wish to use. Different varieties of BASIC, Pascal, or other languages may be similar enough in their implementation that they can be used identically to control Driver488/DRV. The **`DDAEMON.EXE`** (driver daemon) program that is provided on the Driver488/DRV disk can help in determining just how a language communicates with Driver488/DRV.
- Call your service representative for technical support. New language support examples will be available to you as they are developed.

If no support is available or appropriate for your language, it is still practical to control Driver488/DRV so long as your language supports system interrupt calls. A system interrupt is a special type of subroutine call that is used to gain access to the MS-DOS and BIOS internal procedures. They are used by the I/O library of every language to control the disk, keyboard, screen, printer, and other hardware in the system. The same system interrupts are used to control Driver488/DRV.

Most programming languages have subroutines that allow interrupts to be invoked. The often have names such as **`Int86`**, **`SysInt`**, or **`DOSInt`**. If you are not sure that your language has such a subroutine, then check with the language manufacturer.

To control Driver488/DRV you need to be able to do the following:

- Find the segment and offset addresses of variables (or arrays) in your program
- Open and close the **`IEEE`** file that is used to communicate with Driver488/DRV
- Configure the **`IEEE`** file for binary communication
- Send and receive commands and data to and from the **`IEEE`** file, and
- Perform **`IOCTL"BREAK"`** and **`IOCTL$`** functions as described in "Section III: Command References."

The examples throughout this Sub-Chapter are in *assembly language* to demonstrate the low-level commands that communicate with DOS and Driver488/DRV. However, it is likely that your programming language has the ability to perform all these functions without directly using assembly language.

Finding Addresses

The system interrupts that transfer command and data to and from Driver488/DRV need to be told where in memory the data is to be transferred. Addresses in an MS-DOS computer are composed of two 16-bit numbers: a **`segment`** and an **`offset`**. The actual memory address of an object is computed during memory access by multiplying the segment value by 16 and adding the offset to the result. This forms a 20-bit address that covers the address range available in MS-DOS. All MS-DOS addresses are specified in this **`segment:offset`** form.

A segment of memory is a region of memory in which all data elements have the same segment value. Each **`segment`** is 64K bytes long, with locations within the segment determined by the **`offset`** address. Segments can and often do overlap. For example, all of the following **`segment:offset`** pairs refer to the same address (**`2CF89 hex`**): **`2CF8:0009`**, **`2CF0:0089`**, **`2C00:0F89`**, **`2000:CF90`**, **`1E32:EC69`** (**`1E320 + EC69 = 2CF89`**).

There is no universal way of determining the **`segment`** and **`offset`** address of a data object in a programming language. Some languages, such as interpreted GW-BASIC or BASICA, keep all their variables in a single segment known as the data segment. However, they do not provide a convenient method of determining the segment address of that data segment. A special *assembly-language* subroutine, must be used to find the data segment address. Once the data segment address is found, it is fixed. All variables reside in this single, fixed data segment. These BASICs do provide a function, **`VARPTR`**, that returns a variable's offset address within the data segment.

Other types of BASICs include a function called **`VARSEG`** that returns the segment address of a variable. This eliminates the need for a special assembly-language routine, but, in these languages, the segment address may be different for each variable or array. **`VARSEG`** may need to be called for each variable whose address is required.

Note that the address (**`segment`** and **`offset`**) of a variable or array may not be the address of the portion of that variable that holds the data. The address may instead be the address of a variable descriptor, a data structure that describes the structure of the variable or array. The descriptor usually includes the current length of the variable as well as its actual address. The descriptor of an array may include the number of elements in the array, the number of subscripts used to refer to the array elements, and the ranges of the subscripts. You should check with the language manufacturer to determine just what **`VARPTR`** (or its equivalent) points to. When trying to determine addresses you may have to consider garbage collection, memory models, and calling protocols.

Garbage Collection

Garbage collection is a process whereby a language with variable-length data structures, such as strings in BASIC or lists in LISP, can reuse the memory that is no longer being used by any variables. When a program is running, it can move variables around to consolidate this unused space and reclaim it for new variables. Garbage collection can occur at almost any time and invalidate any stored values of variable addresses. Thus, in languages that use garbage collection, addresses should be “fresh” and recalculated whenever they might have changed.

Memory Models

Some languages, most notably C, allow a choice of memory models. These are known by various names such as: “tiny,” “small,” “medium,” “compact,” “large,” or even “huge.” The exact meaning of these names may vary between different languages, but they typically have the following interpretation:

Memory Model	Total Code/Data	Largest Data Structure	Typical Interpretation
Tiny	≤ 64K bytes	≤ 64K bytes	Code and data fit together within a single 64K segment. Might be in the format necessary to convert to a **`.COM`** file.
Small	≤ 64K bytes	≤ 64K bytes	Both code and data each reside within their own 64K segment. Near (16-bit, offset only) references to code and data elements are possible.
Medium	> 64K bytes (for code only) ≤ 64K bytes (for data only)	≤ 64K bytes	More than 64K of code, in multiple segments, while data fits within a single 64K segment. No subprogram may exceed 64K.
Compact	≤ 64K bytes (for code only) > 64K bytes (for data only)	≤ 64K bytes	Code fits within a single 64K segment, while data may occupy more than one segment. Explicit segment addresses are required to address data elements. No single data structure, such as an array or record, may be more than 64K.
Large	> 64K bytes	≤ 64K bytes	More than 64K of both code and data. Still, no single subprogram or data structure may exceed 64K.
Huge	> 64K bytes	> 64K bytes	More than 64K of both code and data. Data structures may be larger than 64K.

When using the Tiny, Small, or Medium memory models, all data elements are in the same **`segment`**. Once the segment address of one is known, it can be used to refer to any address. In the Compact, Large, and Huge memory models, data elements have a 32-bit address composed of a **`segment`** and an **`offset`**. The segment values may be different for each data element.

Many languages do not offer the same flexibility of memory models as does C, but addressing methods used by other languages may often be viewed as one of the standard C models.

The following program fragment, taken from the Microsoft C support file **`IEEEIO.C`** shows how **`segment`** and **`offset`** addresses are computed in the various memory models:

```
#if defined(M_I86SM) || defined(M_I86MM)
int segment(ptr)
void near *ptr;
{ static struct SREGS segs = { 0, 0, 0, 0, };
if (segs.ds==0) segread(&segs);
return segs.ds;
}
#define offset(ptr) (int)ptr
#else
#define offset(ptr) ((unsigned)(fp))
#define segment(ptr) ((unsigned)((unsigned long)(fp) > 16))
#endif
```

The **`#IF`** statement checks if we are using the Small (**`M_I86SM`**) or Medium (**`M_I86MM`**) models (Microsoft C does not support the Tiny model) and, if we are, defines a function segment that returns the (constant) segment value that can be used for all data elements. The **`segment`** function takes a pointer (**`ptr`**) as an argument, but does not use it. Instead, the first time it is called, it calls the **`segread`** library function to read the **`ds`** segment register and returns that value. Each subsequent time **`segment`** is called, it returns the saved **`ds`** register value. In these small-data models, the pointer to a data object is just the **`offset`** address of that object, and so we define **`offset(ptr)`** as **`(int)ptr`**, which is just an integer with the same value as the pointer.

If we are using a large-data model, data pointers are 32 bits, and the **`segment`** and **`offset`** must be extracted from the 32-bit far pointer (**`fp`**). The **`offset`**, which is the least-significant word of the pointer, is extracted by converting the pointer to **`unsigned`**. This discards the upper 16-bit of the pointer, leaving the segment value. The **`segment`** is extracted by interpreting (casting) the pointer as an **`unsigned long`** (32-bit) integer, shifting the result right 16 places, and then taking the least significant word of the result. In this way, the **`offset`** and **`segment`** are extracted from the 32-bit far pointer.

Calling Protocols

If the programming language we are using does not provide functions that return the **`segment`** or **`offset`** of an object, we must write our own. The data object whose address we desire is passed as an argument to this function. The calling protocols for that language specify just how information about the arguments is passed to the function.

There are two popular methods of passing arguments: *call-by-value* and *call-by-reference*. Other methods, such as *call-by-name* which is used in Algol 60, are possible, but are not used in common microcomputer languages.

Call-By-Value

In call-by-value, which is the only method used by C, the actual arguments are copied, and these copies are passed to the subprogram. If the address of a variable is needed by the subprogram then that address must be explicitly passed to the subprogram. For example:

```
int i; Declare and integer variable i.
i=5; Set i to 5
fun1(i); Call fun1 with an argument of 5.
fun2(&i); Call fun2 with an argument equal to the address of i.
```

Notice that if **`fun1`** tries to change the value of **`i`**, it only changes its own copy of **`i`**, not the calling program's variable. In contrast, **`fun2`** has the address of **`i`** and can get access to the calling program's variable and change its value. In call-by-value, the entire data element must be duplicated and passed to the subprogram. This is not a problem for simple variables, but can be quite awkward if a large array must be copied to be passed to the subprogram. Large data structures are rarely passed using call-by-value. Instead, the address of the data structure is passed in what is, in effect, call-by-reference.

Call-By-Reference

Call-by-reference is the most common form of argument passing in languages other than C. In call-by-reference, the address of the argument is passed to the subprogram. The size of this address may be 16 or 32 bits depending on the language and its memory model.

If the argument is a data object, then the subprogram can modify that data object because it has that object's memory address. If an expression is passed using call-by-reference, the expression is evaluated and stored in a temporary location. The address of this temporary is then passed to the subprogram. The subprogram usually can change this value but it has no effect on the variables of the calling program.

Call-by-reference can be used to give the same effect as call-by-value. To do this, the arguments are first copied into temporary locations, then the addresses of these temporaries are passed using call-by-reference. The calling protocol is call-by-reference because the addresses of the data objects are passed to the subprogram. However, because these addresses are the addresses of copies of the arguments and not the actual arguments, the subprogram cannot know the actual addresses of the arguments, nor can it change their values. This type of call-by-reference is always used for expressions. When expressions are passed using call-by-reference, they are first evaluated and their results stored in temporary locations. Then the addresses of these temporaries are passed to the subprogram.

By forcing the data object to be treated as an expression, call-by-reference can be used with the same effect as call-by-value as described above. In BASIC, this is accomplished by surrounding the variable in parentheses:

```
CALL SUB(A)
```

calls **`SUB`** and passes the address of **`A`**, while:

```
CALL SUB((A))
```

calls **`SUB`** and passes the address of a temporary variable that contains the same value as **`A`**.

Differences

It is important to note the difference between call-by-value and call-by-reference. In call-by-value, the subprogram does not know the actual addresses of the arguments and cannot change their values, while in call-by-reference, the subprogram knows the addresses of its arguments and can change them. This can have important ramifications. For example, in True Basic, functions are always call-by-value. The arguments are copied and the addresses of these copies are passed to functions. In contrast, subroutines are call-by-reference and are passed the addresses of the actual arguments. Thus, if one tries to write a function that returns the address of a string variable, it does not work! The address returned is the address of the copy of the string, not the desired address of the actual string variable. Instead, a subroutine with two parameters must be used, the first being the string whose address is desired, and the second being set to that address when the subroutine is called.

Opening & Closing the Driver

Any program using Driver488/DRV must first establish communications with the Driver488/DRV software driver. This is accomplished using the MS-DOS **`OPEN`** function. In assembly language, this might appear as follows:

```
name       DB”        IEEE”,0    ;Driver488/DRV device name
ieee       DW0                   ;Place to hold Driver488/DRV file handle
           mov        AH, 3Dh    ;Open function
           mov        AL, 02     ;Access code = read/write
           mov        DX,offset  ;DS:DX - name
                      name
           int        21h        ;Execute DOS function
           jc         error      ;Error if carry set
           mov        ieee, AX   ;Save file handle
```

Once the file is opened, we can communicate with it to perform almost all the functions of Driver488/DRV. When the program is done, it should close the Driver488/DRV file:

```
mov        AH,3Eh     ;Close function
mov        BX,ieee    ;File handle
int        21h        ;Execute DOS function
jc         error      ;Check for error
or         DL,20h     :Set “don’t check for control characters” bit
```

I/O Control (IOCTL) Communication

DOS provides several I/O Control (IOCTL) functions that are useful with Driver488/DRV. Two of these: **`IOCTL GetDeviceData`** and **`IOCTL SetDeviceData`** allow Driver488/DRV to be configured for faster "Raw Mode" communication, while the other two: **`IOCTL Read`** and **`IOCTL Write`**, perform the functions of the BASIC **`IOCTL$`** function and **`IOCTL#1`** command, respectively.

IOCTL Get & Set Device Data

When communicating with character devices, DOS normally checks the transferred data for control characters such as **`X-ON`**, **`X-OFF`** and **`control-Z`**. However when communicating with Driver488/DRV, this is not desirable. First of all, it might interfere with control characters that are supposed to be transferred to or from Driver488/DRV. Second, and more importantly, while DOS is checking for control characters, it only transfers one character at a time to or from Driver488/DRV. This is much less efficient than transferring large blocks of data. Thus, whenever possible, DOS should be configured to *not* check for control characters when communicating with Driver488/DRV. This is typically accomplished by a function called **`RawMode`** in the language-specific support files (such as **`IEEEIO.C`**) provided with Driver488/DRV. The DOS **`IOCTL Get and SetDeviceData`** functions are used together to configure Driver488/DRV for **`RawMode`** (binary) communication as:

```
mov       AX,4400h   ;DOS Get Device Data Function
mov       BX,ieee    ;File handle for Driver488/DRV
int       21h        ;Execute DOS function
mov       DH,0       ;Must clear DH
or        DL,20h     :Set "don't check for control characters" bit
mov       AX,4401h   ;DOS Set Device Data Function
mov       BX,ieee    ;File handle
int       21h        ;Execute DOS function
```

The first part of this code fragment reads the current device control settings from DOS. These are returned in the **`DX`** register which is then modified to tell DOS *not* to check for control characters. Finally, DOS is again called to implement the new control settings. Once the **`ieee`** file has been opened and configured for **`RawMode`**, we are ready to communicate with Driver488/DRV.

IOCTL Read & Write

`IOCTL Read` and **`IOCTL Write`** provide a "back-door" communication channel to Driver488/DRV. This alternate method of communication is normally used to send special commands (**`Write`**) and request status (**`Read`**) from Driver488/DRV.

Driver488/DRV recognizes only one **`IOCTL Write`** command: **`BREAK`**. When **`IOCTL Write`** is used to send **`BREAK`** to Driver488/DRV, it forces Driver488/DRV into a quiescent, ready state in which it is waiting for a new command. The **`BREAK`** command also forces the **`EOL OUT`** terminators to their default values. Thus Driver488/DRV is reset so that it is ready and able to receive new commands, regardless of what it was previously doing.

It is recommended that the **`BREAK`** command be sent before any other Driver488/DRV commands. In assembly language, **`BREAK`** may be sent as indicated in the table.

```
brk       DB        "BREAK"        ;BREAK command text
brklen    EQU       $-brk          ;Length of BREAK command
          mov       AX, 4403h      ;IOCTL Write function
          mov       BX, ieee       ;File handle
          mov       CX, brklen     ;# chars to send
          mov       DX, offset     ;DS:DX -> command
                    brk
          int       21h            ;Execute DOS function
          jc        error          ;Check for error
```

This is identical to the BASIC command **`IOCTL`** described in "Section III: Command References" of this manual.

The **`IOCTL Read`** command is used to receive status from Driver488/DRV. It receives a single ASCII character, either **`0`**, **`1`**, **`2`**, or **`3`**. The meaning of each response is:

- **`0:`** A response of `0` indicates that Driver488/DRV is ready to receive a command. It has no data to read, nor is it expecting data for output to the IEEE 488 bus. Driver488/DRV is forced into this state by the **`IOCTL BREAK`** command.
- **`1:`** A response of `1` indicates that Driver488/DRV has a response ready to be read by the user's program. The program must read the response before sending a new command (except **`IOCTL BREAK`**) or a **`SEQUENCE - DATA HAS NOT BEEN READ`** error occurs.
- **`2:`** A response of `2` indicates that Driver488/DRV is waiting for data to **`OUTPUT`** to the IEEE 488 bus. The user's program must send the appropriate data with terminators as needed to Driver488/DRV. Attempting to read from Driver488/DRV while it is waiting for data causes a **`SEQUENCE - NO DATA AVAILABLE`** error.
- **`3:`** A response of `3` indicates that Driver488/DRV is waiting for the completion of a command. This is similar to a response of `2` except that Driver488/DRV is waiting for a command, rather than for data to **`OUTPUT`**.

The **`IOCTL Read`** response can be read from Driver488/DRV as:

```
ioctlbufDB     0              ;IOCTL Read response buffer
ioctllenEQU    $-ioctllen     ;Length of buffer
mov            AX,4402h       ;IOCTL Read
mov            BX,ieee        ;File handle
mov            CX,ioctllen    ;# chars to read
mov            DX,offset      ;DS:DX - buffer
               ioctlbuf
               int 21h        ;Execute DOS function
               jc error       ;Check for error
```

Data & Command Communication

Once Driver488/DRV has been opened, configured for **`RawMode`** communication, and reset with the **`IOCTL Write`** command **`BREAK`**, we are ready to communicate with Driver488/DRV and control the IEEE 488 bus. The BASIC commands:

```
PRINT#1,"HELLO"
LINE INPUT#1,A$
```

might be implemented in assembly language as:

```
cr             EQU     0Dh                ;Carriage-return
lf             EQU     0Ah                ;Line-feed
hello          DB      "HELLO",,cr,,lf    ;HELLO command with terminators
hellolen       EQU     $-hello            ;HELLO command length
response       DB      256 DUP (?)        ;Place to put Driver488/DRV response
responselen    EQ      $-response         ;Length of response buffer
recvdlen       DW      ?                  ;Place to keep # chars in response
mov                    AH, 40h            ;DOS Write function
mov                    BX, ieee           ;File handle
mov                    CX, hellolen       ;Command length
mov                    DX, offset hello   ;DS:DX - command
int                    21h                ;Execute DOS function
jc                     error              ;Check for error
mov                    AH, 3Fh            ;DOS Read function
mov                    BX, ieee           ;File handle
mov                    CX, responselen    ;Buffer length
mov                    DX, offset         ;DS:DX - buffer
                       response
int                    21h                ;Execute DOS function
jc                     error              ;Check for error
mov                    recvdlen, AX       ;Save # of characters received
```

In this way, data and commands can be transferred to or from Driver488/DRV.

ARM Condition Detection

It is sometimes desirable to be able to easily check for asynchronous bus conditions, such as Service Request (**SRQ**), without having to use the Driver488/DRV **STATUS** command. This can be accomplished by using the light pen interrupt emulation feature of Driver488/DRV. When this feature is enabled, Driver488/DRV preempts the normal function of the light pen BIOS status request interrupt. Instead of returning the light pen switch status, this interrupt returns an indicator that is non-zero if any of the **ARM** conditions are true. See the **ARM** command in “Section III: Command References” for more details about the conditions that can be checked.

Checking the Driver488/DRV light pen emulation status is straight forward, as illustrated by the following table.

```
mov         AX,0400h   ;Test light pen function
int         10h        ;BIOS video interrupt
or          AH,AH      ;Check AH
jnz         GotInt     ;Non-zero means interrupt
mov         AX,0400h   ;Repeat the test
int         10h
or          AH,AH
jnz         GotInt
```

There are two items to notice about this routine: it uses the BIOS video interrupt **10h** rather than the DOS function call interrupt **21h**, and it checks twice to see if a condition has been detected. The test must be repeated if **IOCTL Read** is used to check the Driver488/DRV status. **IOCTL Read** causes the light pen interrupt emulation to return **no interrupt** status on the next status read, regardless of the actual **ARM** condition status. This allows the BASIC function **ON PEN** to operate properly, but requires the status to be checked twice in other languages.

Sample Program

```
name           DB”            IEEE”, 0          ;Driver488/DRV device name
ieee           DWO                              ;Place to hold Driver488/DRV file
                                                   handle

               ioctlbufDB     0                 ;IOCTL Read response buffer
               ioctllenEQU    $-ioctllen        ;Length of buffer

cr             EQU            0Dh               ;Carriage-return
lf             EQU            0Ah               ;Line-feed

hello          DB             “HELLO”,,cr,,lf   ;HELLO command with terminators
hellolen       EQU            $-hello           ;HELLO command length

response       DB             256 DUP (?)       ;Place to put Driver488 response
responselen    EQ             $-response        ;Length of response buffer
                                                ;
recvdlen       DW             ?                 ;Place to keep # chars in response

start          mov            Ah, 3Dh           ;Open function
               mov            AL, 02            ;Access code = read/write
               mov            DX, offset name   ;DS:DX-name
               int            21h               ;Execute DOS function
               jc             error             ;Error if carry set
               mov            ieee,AX           ;Save file handle
               mov            AH, 3Eh           ;Close function
               mov            BX, ieee          ;File handle
               int            21h               ;Execute DOS function
               jc             error             ;Check for error
               mov            AX, 4400h         ;DOS GetDeviceData Function
               mov            BX, ieee          ;File handle for Driver488/DRV
               int            21h               ;Execute DOS function
               mov            DH, 0             ;Must clear
               or             DL, 20h           ;Set “don’t check for control
                                                   characters” bit
               mov            AX, 4401h         ;DOS SetDeviceData Function
               mov            BX, ieee          ;File handle
               int            21h               ;Execute DOS function
```

```
brk         DB          "BREAK"           ;BREAK command text
brklen      EQU         $-brk             ;Length of break command

            mov         AX, 4403h         ;IOCTL Write function
            mov         BX, ieee          ;File handle
            mov         CX, brklen        ;# chars to send
            mov         DX, offset brk    ;DS:DX -> command
            int         21h               ;Execute DOS function
            jc          error             ;Check for error

            mov         AX, 4402h         ;IOCTL Read function
            mov         BX, ieee          ;File handle
            mov         CX, ioctllen      ;# chars to read
            mov         DX, offset        ;DS:DX - buffer
                        ioctlbuf
            int         21h               ;Execute DOS function
            jc          error             ;Check for error

            mov         AH, 40h           ;DOS Write function
            mov         BX, ieee          ;File handle
            mov         CX, hellolen      ;Command length
            mov         DX, offset hello  ;DS:DX - command
            int         21h               ;Execute DOS function
            jc          error             ;Check for error

            mov         AH, 3Fh           ;DOS Read function
            mov         BX, ieee          ;File handle
            mov         CX, responselen   ;Buffer length
            mov         DX, offset        ;DS:DX - buffer
                        response
            int         21h               ;Execute DOS function
            jc          error             ;Check for error
            mov         recvdlen, AX      ;Save # of characters received

            mov         AX, 0400h         ;Test light pen function
            int         10h               ;Video BIOS interrupt
            or          AH, AH            ;Check AH
            jnz         GotInt            ;Non-zero means interrupt detected

            mov         AX, 0400h         ;Repeat the test
            int         10h
            or          AH, AH
            jnz         GotInt
```

8L. Language-Specific Information

Topics

Aztec C

Use of Character Command Language

In order to simplify programming Driver488/DRV with C, the following files are provided on the Driver488/DRV program disk:

- **`IEEEIO.C`**: Communications routines for Driver488/DRV
- **`IEEEIO.H`**: Header file, contains declarations from **`IEEEIO.C`**
- **`CRITERR.C`**: Critical error handler routines (included with Aztec C, only)
- **`CRITERR.H`**: Header file, contains declarations for using **`CRITERR`**

The actual demonstration program is contained in **`195DEMO.C`**. All files for Aztec C are in the **`\AZTECC`** directory.

To execute the demonstration program, the files must be compiled and then linked. The following DOS commands perform these steps:

```
C> cc 195demo
C> cc ieeeio
C> ln 195demo ieeeio -lm -lc
```

Finally, the demonstration program is run by typing **`195demo <Enter>`**. Note that the critical error handler (**`CRITERR.C`**) is not required for the demonstration program.

CRITERR.C (for Aztec C)

Normally, when Driver488/DRV detects an error, perhaps due to a syntax error in a command, or due to an IEEE 488 bus error (such as time out on data transfer), it responds with an I/O error to DOS. When this happens, DOS normally issues an **`ABORT`**, **`RETRY`** or **`IGNORE`** message and waits for a response from the keyboard. There is no way for the user's program to detect such an error, determine the cause, and take appropriate action. However, DOS does provide a method of redefining the action to be taken on such a "critical error". **CRITERR.ASM** contains a critical error handler that, when invoked, makes it appear to the calling program that some less-critical error has occurred. The critical error handler is installed by **CRIT_ON()** and removed by **CRIT_OFF()**. The critical error handler is also automatically removed by DOS when the program exits.

The following program fragment demonstrates the use of the critical error handler:

```
#include "criterr.h"
crit_on(ieee);
if (ieeewt("output 16;F0X") == -1) {
printf("Error writing F0X to device 16, \n");
crit_off();
ioctl_wt(ieee,"break",5);
ieeewt("eol out lf\r\n");
ieeewt("status\n");
ieeerd(response);
printf("status = %s\n",response);
crit_on(ieee);
}
```

We must first **#include** the header file with the definitions of the critical error routines. We then enable critical error trapping with **CRIT_ON** which takes as a parameter the handle of the file for which critical error trapping is to be enabled. Only read and write commands to that handle are trapped. Errors caused by other actions, or associated with other files are not trapped. Error trapping may only be enabled for one file at a time.

Now, if **IEEEWT** signals an error by returning a **-1**, we can check what happened. We first **PRINTF** an error message, then we turn critical error trapping off with **CRIT_OFF** so that, if another critical error occurs, we get the **ABORT**, **RETRY** or **IGNORE** message and know a catastrophic double error has occurred. We then **IOCTL_WT(_BREAK_)** to force Driver488/DRV to listen to our next command. The **IOCTL_WT** also resets the **EOL OUT** terminator so we can be sure that Driver488/DRV detects the end of our commands. We next reset the **EOL OUT** terminator to our preferred line feed only and ask Driver488/DRV for its status. On receiving the response, we could interpret the status and take whatever action is appropriate. However, in this example, we just display the status. Finally, we re-enable the critical error handler and continue with the program.

GW-BASIC (for GW-BASIC or Interpreted BASIC)

Use of Direct DOS I/O Devices

Once Driver488/DRV has been installed in your system, it is ready to begin controlling IEEE 488 bus devices. To show how this is done, we develop a short program in BASIC to control a Keithley Instruments Model 195 digital multimeter. The complete sample program is provided on the Driver488/DRV disk as **195DEMO.BAS** in the **\MSBASIC** directory.

BASIC VARPTR & SADDR

The **BASIC VARPTR** and **SADDR** functions must be used with caution. The first time a variable such as **I** or **ST$** is encountered, or an array such as **R%()** is dimensioned, space is made for it in BASIC's data space. The other variable or arrays may be moved to make room for the new item. If the memory location of an item must be fixed, then BASIC cannot be allowed to encounter any new variables or arrays. For example, in the **ENTER** statement shown above, Driver488/DRV is told the memory address of **R$** (for GW-BASIC, **R%(0)**). Then, while the transfer is going on, the Driver488/DRV status is read into the string variable **ST$**. If **ST$** has not been used previously then BASIC would have to create a new **ST$** and might move **R$**. Of course, Driver488/DRV would have no way of knowing that **R$** has been moved, and the data would not be placed correctly into **R$**.

GET & PUT (for GW-BASIC only)

Users of GW-BASIC and/or Interpreted BASIC can also manipulate two commands not available in QuickBASIC: **`GET`** and **`PUT`**, as detailed in the following paragraphs.

The BASIC **`INPUT`** and **`PRINT`** statements communicate with Driver488/DRV one character at a time. That is, the **`PRINT`** statement breaks up each command into single characters and transfers those characters separately to Driver488/DRV, and the **`INPUT`** statement reads one character at a time from Driver488/DRV until it detects the carriage-return and line-feed that marks the end of the line. It is more efficient, especially for long transfers, to read and write blocks of characters. The **`GET`** and **`PUT`** statements can be used to gain this improved efficiency.

`GET` and **`PUT`** are normally used to communicate with fixed-length random access files. Driver488/DRV can be accessed as a random access file:

```
100 OPEN "\DEV\IEEE" FOR RANDOM AS #3
```

This opens the third Driver488/DRV name, **`IEEE`**, for I/O as a random access file with 128-byte records. (The other two names: **`IEEEOUT`** and **`IEEEIN`**, are used for **`PRINT`** and **`INPUT`**).

BASIC normally limits the number of opened files to 3. Opening additional files can cause a **`TOO MANY FILES`** error. If you should get such an error, you might need to save your program, leave BASIC (with the **`SYSTEM`** command), and reenter BASIC specifying a **`/F:n`** parameter. See your BASIC reference manual for more details.

JPI TopSpeed Modula-2

Use of Direct DOS I/O Devices

Once Driver488/DRV has been installed in your system, it is ready to begin controlling IEEE 488 bus devices. To show how this is done, we develop a short program, in JPI TopSpeed Modula-2 and Logitech Modula-2, to control a Keithley Instruments Model 195 digital multimeter. The techniques used in this program are quite general, and apply to the control of most instruments.

In order to simplify programming Driver488/DRV with Modula-2, the following files are provided on the Driver488/DRV program disk:

- **`IEEEIO.MOD`:** Communication routines for Driver488/DRV.
- **`IEEEIO.DEF`:** Declaration file for **`IEEEIO.MOD`**.

The actual demonstration program is contained in **`K195DEMO.MOD`**. A Modula-2 version of the keyboard controller program is also included.

Logitech Modula-2

Use of Direct DOS I/O Devices

Once Driver488/DRV has been installed in your system, it is ready to begin controlling IEEE 488 bus devices. To show how this is done, we develop a short program, in JPI TopSpeed Modula-2 and Logitech Modula-2, to control a Keithley Instruments Model 195 digital multimeter. The techniques used in this program are quite general, and apply to the control of most instruments.

In order to simplify programming Driver488/DRV with Modula-2, the following files are provided on the Driver488/DRV Program disk:

- **`CHARDEV.MOD`:** General purpose character device I/O routines.
- **`CHARDEV.DEF`:** Declaration file for **`CHARDEV.MOD`**.
- **`IEEEIO.MOD`:** Communication routines for Driver488/DRV.
- **`IEEEIO.DEF`:** Declaration file for **`IEEEIO.MOD`**.

The actual demonstration program is contained in **`K195DEMO.MOD`**. A Modula-2 version of the keyboard controller program is also included.

True Basic

Use of Character Command Language

In order to simplify programming Driver488/DRV with True Basic, the following files are provided on the Driver488/DRV program disk in the TRUEBAS directory:

- **`IEEEIO.TRU`:** Communications routines for Driver488/DRV.
- **`IEEEIO.TRC`:** Compiled version of **`IEEEIO.TRU`**.
- **`TOOLKIT.LIB`:** Utility routines from the True Basic Developer's Toolkit.
- **`KYBDCTRL.TRU`:** True Basic version of the Keyboard Controller Program.

IEEEIO.TRU

The **`IEEEIO.TRU`** file contains several useful declarations and functions, many of which have been used in the **`195DEMO`** example program. It is divided into two modules: **`DosIO`** and **`IeeeIO`**.

- **`DosIO`** includes interfaces to several MS-DOS (or PC-DOS) function requests. It requires the functions from the True Basic Developer's Toolkit that are included in ToolKit.Lib. They are:

  ```
  Def Read(handle,bufseg,buflen)
  Def Write(handle,bufseg,buflen)
  Def IoctlRead(handle,bufseg,buflen)
  Def IoctlWrite(handle,bufseg,buflen)
  ```

  These routines read and write to a character device such as Driver488/DRV. They each take the following file handle returned by **`OPEN`**, as the arguments handle: **`bufseg`**, the segment address of the data buffer to read or write, and **`buflen`**, the length of the data buffer.

- **`IeeeIO`** includes routines for the convenient control of Driver488/DRV.

TOOLKIT.LIB

`TOOLKIT.LIB` contains four routines from the True Basic Developer's Toolkit: **`Convert`**, **`Interrupt`**, **`Signal_e_`**, and **`String_ptr`** .

- **`Convert`** (from **`HEXLIB.TRC`**) is used to convert hexadecimal string constants such as **`H3D02`** into numeric form.
- **`Interrupt`** (from **`DOSLIB.TRC`**) is used to call low-level DOS and BIOS functions.
- **`Signal_e_`** (from **`DOSLIB.TRC`**) interprets any error codes returned by **`Interrupt`**.
- **`String_ptr`** (from **`DOSLIB.TRC`**) returns the segment address of a string variable. The text of the string is located at an offset of 8 from the segment address.

More information about these routines, as well as other useful routines are included in the True Basic Developer's Toolkit, available from True Basic.

If you already have the Developer's Toolkit, you can substitute **`HEXLIB.TRC`** or **`DOSLIB.TRC`** library statements for the **`TOOLKIT.LIB`** library statements in these routines.

Turbo Basic

Use of Character Command Language

In order to simplify programming Driver488/DRV with Turbo Basic, the following files are provided on the Driver488/DRV program disk in the **`\TURBOBAS`** directory:

- **`IEEEIO.BAS`:** Communications routines for Driver488/DRV.
- **`IEEEIO.ASM`:** Assembly language file for direct DOS access without Turbo Basic interference.
- **`IEEEIO.COM`:** Executable version of **`IEEEIO.ASM`**.
- **`KYBDCTRL.BAS`:** Turbo Basic version of the Keyboard Controller Program.

The actual demonstration program is contained in **`195DEMO.BAS`**. These examples also require the file **`REGNAMES.INC`** which is included with Turbo Basic.

8M. Data Transfers

Topics

Terminators

Every transfer of data, between a program and Driver488/DRV, or between Driver488/DRV and a bus device, must have a definite end. This is a common requirement in most systems. For example, most printers do not print a line until they receive the carriage return that ends that line. Similarly, a BASIC **`INPUT`** statement waits for the **`<Enter>`** key to be pressed before returning the entered data to the program. The only time that some terminator is not required is when the number of characters that compose the data is known in advance or is transferred along with the data. This is the case, for example, when fixed-length records are read from a random access disk file.

Driver488/DRV actually uses four terminators:

- The end-of-line (**`EOL`**) terminator for output from the program to Driver488/DRV.
- The end-of-line (**`EOL`**) terminator for input to the program from Driver488/DRV.
- The data terminator (**`TERM`**) for output to bus devices from Driver488/DRV.
- The data terminator (**`TERM`**) to input from bus device into Driver488/DRV.

End-Of-Line (EOL) Terminators

The **`EOL`** terminators mark the end of character strings transferred between the user's program and Driver488/DRV. The **`EOL`** output terminator marks the end of strings transferred from the user's program to Driver488/DRV, and the **`EOL`** input terminator marks the end of strings transferred into the user's program from Driver488/DRV.

The **`EOL`** terminators normally consist of one or two ASCII characters. The characters do not need to be printable. In fact they are usually special characters such as carriage return and line feed. Also, input and output terminators need not be the same.

It is possible to specify that no characters are to be used as **`EOL`** terminators. If the **`EOL`** output terminator is set to **`NONE`**, then Driver488/DRV assumes that it receives an entire command in each transfer, and when the `EOL` input terminator is set to `NONE`, Driver488/DRV does not append any characters to the returned data.

Driver488/DRV senses the `EOL` output terminator to detect the end of a command or, in the case of the `OUTPUT` data command, to detect the end of the data. Most commands have many different variations. It is the `EOL` output terminator that lets Driver488/DRV know when the command has been completely received and is ready for execution. Without the `EOL` output terminator, there would be no way of determining when one command ends and the next begins.

Driver488/DRV provides the `EOL` input terminator to the user's program so that the program is able to detect the end of a response. For example, BASIC needs to receive a carriage-return and line-feed combination when using the `INPUT` statement to receive a response from Driver488/DRV. Driver488/DRV automatically provides this EOL input terminator to the program.

For most programming languages, in most situations, both input and output `EOL` terminators should be carriage-return line-feed (`CR LF`). These are the default values set up by `INSTALL`, but they can be changed by using the `INSTALL` program. The `EOL` output terminator should be set to whatever is conventionally sent at the end of a `PRINT` or equivalent statement to Driver488/DRV, and the `EOL` input terminator should be set to whatever is required at the end of a line of input from Driver488/DRV.

As mentioned previously, the `EOL` output terminator is used to delimit the data portion of an `OUTPUT` command. If, in the `OUTPUT` command, no character count is specified, the `EOL` output terminator does delimit data. However, if a character count is specified, Driver488/DRV will accept exactly that number of characters from the program for output to the bus, even if the `EOL` output terminator is among those characters. Furthermore, if a character count is not specified, the `TERM` output terminator will be sent to the bus devices after the data. If a character count is specified, nothing will be sent to the bus except the exact characters that were sent from the program. For example:

```
PRINT#1,"OUTPUT10;ABC"
```

sends `ABC <TERM output terminator>` to device `10`, while

```
PRINT#1,"OUTPUT10#5;DEF"
```

sends `DEF <CR><LF>` to device `10` because BASIC will send a carriage return and line feed (`<CR><LF>`) at the end of the command, and a character count of `5` was specified.

The `EOL` input terminator delimits character strings returned to the program by Driver488/DRV. However, if the character count is specified in an `ENTER` command, then exactly that number of characters, without the `EOL` input terminator appended, will be returned to the program. In this case, the normal `INPUT` statement will not be able to read the data from Driver488/DRV. Instead, a function like `INPUT$(count,file)` that reads a specific number of characters, must be used. For example, the following statements :

```
PRINT#1,"ENTER 16"
INPUT#2,A$
```

read a line of data from device `16`, while the following :

```
PRINT#1,"ENTER 16#10"
A$=INPUT$(10,2)
```

statements read exactly `10` characters from device `16`. Finally, the `EOL` terminators are not used in `BUFFERED` transfers, either `ENTER` or `OUTPUT`.

EOL IN NONE

As mentioned above, the input or output `EOL` terminators may be set to `NONE`. To understand how communication with Driver488/DRV is possible without terminators, it is necessary to understand in more detail how programs communicate with Driver488/DRV.

When a program sends information to Driver488/DRV, it uses an MS-DOS `Write Data` command. It tells DOS where to send the data (to Driver488/DRV), the number of characters to send (from `1` to

65,535 characters), and where the data is to be found in memory (the address of the data buffer). For example, in C:

```
ieeewt("HELLO\r\n");
```

calls **Write Data**, telling it to send 7 characters to Driver488/DRV. In contrast, the BASIC command

```
PRINT#1,"HELLO"
```

causes the DOS **Write Data** command to be called 7 times, once for each character of the command, and once for each carriage return and line feed that terminate the command. Each time **Write Data** is called it is told to write just one character to Driver488/DRV from a specified location in memory. Whether written all at once, or one character at a time, the command is transferred to DOS to be passed to Driver488/DRV.

Once DOS has been told to write some data to Driver488/DRV, it calls Driver488/DRV with essentially the same information that the program had told DOS: a command code that specifies **Write Data**, a character count, and the location of the data. Driver488/DRV responds to DOS by processing the data and returning the number of characters that have been accepted along with any error indicators.

When a program requests information from Driver488/DRV, it uses an MS-DOS **Read Data** command. It tells DOS where to get the data (from Driver488/DRV), the size of the data buffer (from **1** to **65,535** characters), and where the data is to be put in memory (the address of the data buffer). In BASIC, for example, the command:

```
LINE INPUT#1,A$
```

causes the DOS **Read Data** command to be called repeatedly, reading one character at a time into **A$** until the carriage-return and line-feed combination that marks the end of the line, is read. Conversely, in C:

```
ieeerd(response);
```

calls **Read Data** only once, requesting as many characters as there are in the array response.

When DOS has been told to read some data from Driver488/DRV, it calls Driver488/DRV with essentially the same information that the program has told DOS: a command code that specifies **Read Data**, a character count, and the location of the data buffer. Driver488/DRV responds to DOS by filling some or all of the data buffer, and returning the number of characters that have been read along with any error indicators. DOS then returns the number of characters read to the calling program.

If **EOL IN NONE** is specified, Driver488/DRV never appends terminators to data being read by the program. This means that the program cannot search for a specified character or combination of characters to know when to stop reading. Hence, **EOL IN NONE** cannot be used in languages such as BASIC or Turbo Pascal which require carriage return and line feed at the end of input lines. Languages such as C or True Basic, that use MS-DOS calls to communicate with Driver488/DRV, can use **EOL IN NONE** by using the following procedure:

1. Read data from Driver488/DRV into a buffer of reasonable size (typically 64 to 1024 bytes long). DOS returns to the program the number of bytes read.
2. If the number of bytes read is less than the length of the buffer, then the reading is done. Otherwise, go on with step 3.
3. Use the **IOCTL** function to check if Driver488/DRV has more information available. If it does (**IOCTL** returned a **1**, ASCII **31h**), then go to step 1 to read more data into a new buffer. Otherwise, the reading is done.

The following C code fragment reads data using the above procedure:

```
#define bufsize 256
char response[bufsize],           /* holds read data */
       ioctlbuf[1];               /* holds IOCTL status */
int len,                          /* number received this time */
       total=0;                   /* total received */
do {len=ieeerd(response);         /* read some data */
       if (len==-1) {...error...} /* check for error */
       total += len;              /* add len to total */
       /* process len characters at this point */
       if (len<bufsize) break;    /* done if partial */
       ioctl_rd(ieee,ioctlbuf,1); /* repeat while more */
} while (ioctlbuf=='1');
```

Notice that the ability to use **`EOL IN NONE`** requires the ability to use the character count returned by the DOS **`Read Data`** command, and the ability to check Driver488/DRV status using **`IOCTL`**. The advantage of using **`EOL IN NONE`** is that only data is returned to the program. Driver488/DRV does not have to add terminators to the data, and the program does not need to search for terminators to know the amount of data it received.

RawMode Communication

When communicating with character devices, DOS normally checks the transferred data for control characters such as **`X-ON`**, **`X-OFF`** and **`control-Z`**. However, when communicating with Driver488/DRV, this is not desirable. First, it might interfere with control characters that are supposed to be transferred to or from Driver488/DRV. Second, and more importantly, when DOS is checking for control characters, it only transfers one character at a time to or from Driver488/DRV. This is much less efficient than transferring large blocks of data. Therefore, whenever possible DOS should be configured *not* to check for control characters when communicating with Driver488/DRV. This is typically accomplished by a function called **`RawMode`** in the language-specific support files (such as **`IEEEIO.C`**) provided with Driver488/DRV. The assembly-language fragment, provided in the following table, performs this function.

```
mov       AX,4400h   ;DOS Get Device Data Function
mov       BX,ieee    ;File handle for Driver488/DRV
int       21h        ;Execute DOS function
mov       DH,0       ;Must clear DH
or        DL,20h     :Set “don’t check for control characters” bit
mov       AX,4401h   ;DOS Set Device Data Function
mov       BX,ieee    ;File handle
int       21h        ;Execute DOS function
```

The first part of this code fragment reads the current device control settings from DOS. These are returned in the **`DX`** register which is then modified to tell DOS *not* to check for control characters. Finally, DOS is again called to implement the new control settings.

`RawMode` can greatly improve the efficiency of communication with Driver488/DRV, and should be used whenever possible, but it is not required unless **`EOL OUT NONE`** is to be used.

EOL OUT NONE

Once DOS has been told not to check for control characters, and we have chosen a programming language (such as C or True Basic, but not BASIC) that can send an entire command in one DOS **`Write Data`** call, we can use **`EOL OUT NONE`** so that we do not have to append termination characters to Driver488/DRV commands.

If **`EOL OUT NONE`** is specified, Driver488/DRV assumes that the data it receives from DOS is the complete command. Obviously, **`EOL OUT NONE`** cannot be used with the BASIC **`PRINT#`** statement because **`PRINT#`** transfers characters one at a time to DOS, which passes them along individually to Driver488/DRV. Commands are not given to Driver488/DRV in a single transfer. Even when the language does pass the command to DOS in a single transfer, DOS does not pass the command to Driver488/DRV in one transfer unless we have configured DOS to use **`RawMode`** as described above.

EOL OUT NONE does eliminate the inconvenience of appending terminators to Driver488/DRV commands, but it does require that the entire command be contained in one transfer. Without **EOL OUT NONE** it is possible to split a long Driver488/DRV command into several, smaller phrases:

```
ieeewt("ENTER 16 #1000 ");
ieeewt("BUFFER &HB800:0 ");
ieeewt("CONTINUE\n");
```

which would have to be combined into a single transfer with **EOL OUT NONE** :

```
ieeewt("ENTER 16 #1000 BUFFER &HB800:0 CONTINUE");
```

TERM Terminators

Just as the **EOL** terminators delimit the end of strings transferred between the user's program and Driver488/DRV, the **TERM** terminators delimit the end of strings transferred between Driver488/DRV and bus devices. The **TERM** output terminator marks the end of strings transferred from Driver488/DRV to bus devices, and the **TERM** input terminator marks the end of strings transferred into Driver488/DRV from bus devices.

The **TERM** terminators differ from the **EOL** terminators in one important aspect. While the **EOL** terminators are composed of one or two characters, the **TERM** terminators can include the IEEE 488 bus *end-or-identify* (**EOI**) signal. The **EOI** signal, when asserted during a character transfer, marks that character as the last of the transfer. This allows the detection of the end of data regardless of which characters comprise the data. This feature is very useful in binary data transfers which might contain any ASCII values from **0** to **255**.

To support the **EOI** signal, the **TERM** input and output terminators can be composed of just **EOI**, one or two characters, or one or two characters with **EOI**. If **EOI** is specified, it has a slightly different meaning on input than on output.

When **EOI** alone is specified as the **TERM** output terminator, the **EOI** bus signal is asserted during the last data character transmitted. If **EOI** is specified with one or two characters, then **EOI** is asserted on the last of the characters. In this way, **EOI** is asserted on the last character transmitted to the bus device.

When **EOI** alone is specified as the **TERM** input terminator, then all the characters received from the bus device, including the one on which **EOI** was asserted are returned to the user's program. When one or two characters are specified, without **EOI**, all the characters up to, but not including, the **TERM** input terminator characters, are returned to the program. However, if both **EOI** and characters are specified, the following considerations apply:

- If **EOI** is received, and the complete terminator character sequence has not been received (even if the first of the two characters has been received), then all the received characters are returned to the program.
- If the complete terminator character sequence has been received, with or without **EOI** asserted on the last character, then only the characters up to but not including the terminator characters are returned.
- If only one character is specified for input termination, the complete terminator character sequence consists of just that one character, but if two characters are specified, then it consists of both characters, received consecutively.

During normal **OUTPUT**, without a specified character count or buffer, the **EOL** output terminator received by Driver488/DRV is replaced by the **TERM** output terminator before sending the data to the bus devices. During normal **ENTER**, the **TERM** input terminator received by Driver488/DRV is replaced with the **EOL** input terminator before being returned to the program. In this way, the program communicates with Driver488/DRV using the **EOL** terminators, and Driver488/DRV communicates with bus devices using the **TERM** terminators.

See the **ENTER** and **OUTPUT** command descriptions in the following text, and in "Section III: Command References" for more information.

Direct I/O & Buffered I/O

Direct I/O is communication through the use of the **PRINT** and **INPUT** statements, or their equivalent. Direct I/O is the simplest method of communicating with Driver488/DRV and, through it, with bus devices. However, direct I/O has a relatively large overhead and so, for large data transfers, buffered I/O is preferable. In buffered I/O, the program tells Driver488/DRV where in memory to find or put the data and Driver488/DRV takes care of the actual transfer.

Direct Bus OUTPUT

The **OUTPUT** command sends data to bus devices. For example, the statement

```
PRINT#1,"OUTPUT 05;SP1;"
```

sends the characters **SP1;** to device **5**. This is an example of direct I/O as the data is communicated directly to Driver488/DRV through the **PRINT** statement. As discussed above, Driver488/DRV recognizes the **EOL** output terminator as the end of the data and sends the **TERM** output terminator in its place after sending the data. Binary direct output is also possible. For example, the following statements send all **256** ASCII characters:

```
PRINT#1,"OUTPUT 05 #256;";
FOR I=0 TO 255
PRINT#1,CHR$(I);
NEXT I
```

The first statement tells Driver488/DRV to expect **256** characters to follow that are to be sent to device **5**. Notice the semicolon (**;**)just after the **#256**. This marks the end of the actual **OUTPUT** command and the start of the data. The semicolon at the end of the line tells BASIC not to send anything else, such as the normal carriage-return and line-feed combination, after sending the quoted characters. The next three lines send the **256** ASCII characters from **0** to **255** in order, to Driver488/DRV for transfer to device **5**. The semicolon at the end of the third line has the same function as the semicolon at the end of the first line: it prevents BASIC from sending any extra characters. In this example, we are performing a binary transfer. Driver488/DRV knows how many characters are to be transferred and neither requires **EOL** output terminators to end the command, nor sends **TERM** output terminators to the bus device. The data is transferred to the bus device exactly as sent from the program.

Direct Bus ENTER

The **ENTER** command is used to read data from bus devices. For example, the statements:

```
PRINT#1,"ENTER 16"
INPUT#2,A$
```

read data from device **16** and store the returned data in the **A$** variable. This is an example of direct **ENTER** input since the data received from the bus is read into the program via the **INPUT** statement that reads the result directly from Driver488/DRV. As discussed above, Driver488/DRV accepts data from device **16** until it detects the **TERM** input terminator. It replaces the **TERM** input terminator with the **EOL** output terminator and returns the result to the program. BASIC accepts the data just as it accepts character data from any file. This allows us to use the varieties of BASIC input statements to control how the data is received. For example, if the data read form the device is in the form of a valid number then we can read it as a number:

```
PRINT#1,"ENTER 16"
INPUT#2,N
```

Or, if the data consists of several values separated by commas, we can read it as several values:

```
PRINT#1,"ENTER 16"
INPUT#2,A$,N,B$,I
```

Or, if we want to read the entire input, even if it includes commas or other special characters, we can use **LINE INPUT**:

```
PRINT#1,"ENTER 16"
LINE INPUT#2,L$
```

Finally, just as we can perform direct binary **OUTPUT**, we can also perform direct binary **ENTER**:

```
PRINT#1,"ENTER 16#128"
A$=INPUT$(128,2)
```

When performing a binary **ENTER**, Driver488/DRV does not check for **TERM** input terminators when reading from the bus, nor does it provide **EOL** input terminators to the program. The data is returned to the program just as it is received from the bus device. The **INPUT$** function which is designed to read a specific number of characters from a file or device, is ideal for reading the result from Driver488/DRV. Note that a normal **INPUT** statement does not work, as Driver488/DRV does not provide the **EOL** input terminators on binary **ENTER**s.

Buffered I/O

In buffered I/O, the program does not transfer data to or from Driver488/DRV. All it does is send the address and quantity of data to be transferred, and Driver488/DRV takes care of the details of the transfer. The program must be able to tell Driver488/DRV when in memory to find the data. In other words, it must be able to provide Driver488/DRV with the actual memory address of the buffer. In BASIC, the capability is partially provided by the **VARPTR** function. **VARPTR** returns a number from **0** to **65,535** giving the address of its argument. For example:

```
PRINT VARPTR(A%(0))
```

prints the address of the first byte of the **A%** array. This address, however, is relative to the start of BASIC's data segment.

The first three statements ask Driver488/DRV for the location of its callable subroutines, and configure BASIC (via the **DEF SEG** statement) to be able to call them. The **offset** of **GET.SEGMENT**, which is **0**, from the start of the **IEEESEG** area must be specified, and then **GET.SEGMENT** can be called. The **VARSEG** function is used in a similar manner to determine the value of the BASIC data **segment**. This data segment value remains fixed during program execution, and so these statements need only be performed once to set the value of the data segment.

With the data segment value determined, and the **VARPTR** function able to find the **offset**s into that **segment**, we are able to completely specify the memory address of any BASIC variable or array. However, character string variables, such as **A$**, are not stored in the same manner as numeric variables and are not recommended for **BUFFERED** I/O.

The following is a typical **BUFFERED ENTER** command:

```
DIM W%(10)
PRINT#1,"ENTER 12 #20 BUFFER"; VARSEG(W%(1)); ":"; VARPTR(W%(1))
```

The **PRINT** statement in this example sends to Driver488/DRV the command (**ENTER**), the bus device address (**12**) and number of bytes to transfer (**20**), the **BUFFER** keyword, the **segment** (**VARSEG(W%(1))**), a colon character (**:**) that lets Driver488/DRV know that the memory address is given as a **segment** followed by an **offset**, and the **offset** (**VARPTR(W%(1))**). If BASIC's **segment** and **offset** to **W%(1)** are **2540** and **1320**, respectively, then the **PRINT** statement would send:

```
"ENTER 12 #20 BUFFER 2450:1320"
```

to Driver488/DRV. This gives Driver488/DRV all the information it needs to be able to transfer the received data directly into the **W%** array.

BUFFERED OUTPUT is also possible. For example, say we wanted to send the data just received in the example above to a device **17**. We would use the following command:

```
PRINT#1,"OUTPUT17 #20 BUFFER"; VARSEG(W%(1)); ":"; VARPTR(W%(1))
```

Normally, **BUFFERED** I/O is performed without any terminator detection. However, it is possible to explicitly specify that the **ENTER** should stop on detection of **EOI**, or on detection of **EOI** or some single character. For example, if we want to terminate on **EOI**:

```
PRINT#1,"ENTER 12#20 BUFFER"; VARSEG(W%(1));":"; VARPTR(W%(1));"EOI"
```

This reads data into **W%** until either **20** characters have been received, or **EOI** has been detected. However, if **EOI** causes the transfer to stop, we can discover how much data has been received by using the **BUFFERED** command:

```
PRINT#1,"BUFFERED"
INPUT#2,N
```

The number of bytes transferred is read into **N**. Now we can use this value to send the read data out to device **17**:

```
PRINT#1,"OUTPUT17#";N;"BUFFER";VARSEG(W%(1));":";VARPTR(W%(1));"EOI"
```

Note that the variable **N** has been used in place of the literal **20** to specify how many bytes to transmit.

Clearly, **BUFFERED** I/O is more complex than simple direct I/O. However, it can be very useful. **BUFFERED** I/O is normally much faster than direct I/O because the characters go directly from memory to the bus under the control of Driver488/DRV without the intervention of BASIC or DOS. Also, **BUFFERED** I/O is not limited by the 255-character limit on **INPUT$** that can hinder binary **ENTER**s.

Asynchronous Transfers

Driver488/DRV can return to the user's program while a transfer is in progress. This is useful whenever the transfer takes a substantial amount of time, and other processing could proceed while waiting. For example, suppose a certain bus device can transfer only 1000 bytes per second. If there are 10,000 bytes to transfer, it takes 10 seconds to complete the transfer. The following statements might be used to receive this data:

```
DIM R%(5000)
PRINT#1,"ENTER 09 #10000 BUFFER"; DS%;
":"; VARPTR(R%(1)); "CONTINUE"

        Now do other work while
        the transfer is continuing

PRINT#1,"WAIT"
```

The **CONTINUE** keyword tells Driver488/DRV to return to the program after setting up the transfer. The program is then free to do other processing, as long as it does not need access to the IEEE 488 bus. Finally, when the program is ready to process the received data it performs a **WAIT** to check that the data has been completely received. In this way, **CONTINUE** transfers overlap IEEE 488 bus data transfers with program execution.

The use of DMA and interrupts requires proper hardware and software configuration. For more information, refer to the Sub-Chapter "Installation & Configuration" early in this Chapter.

8N. Operating Modes

Topics

Introduction

There are four types of IEEE 488 bus devices: Active Controllers, Peripherals, Talk-Only devices, and Listen-Always devices:

- In simple systems, *Talk-Only* and *Listen-Always* devices are usually used together, such as a Talk-Only digitizer sending results to a Listen-Always plotter. In these systems, no Controller is needed because the Talker assumes it is the only Talker on the bus, and the Listener(s) assume they are all supposed to receive all data sent over the bus. This is a simple and effective method of transferring data from one device to another, but is not adequate for more complex systems where, for example, one computer is controlling many different bus devices.
- In more complex systems, the *Active Controller* sends commands to the various bus *Peripherals*, telling them what to do. The controller sends bus commands such as: **`Unlisten`**, **`Listen Address Group`**, **`Untalk`**, and **`Talk Address Group`** to specify which device(s) send data, and which receive it.

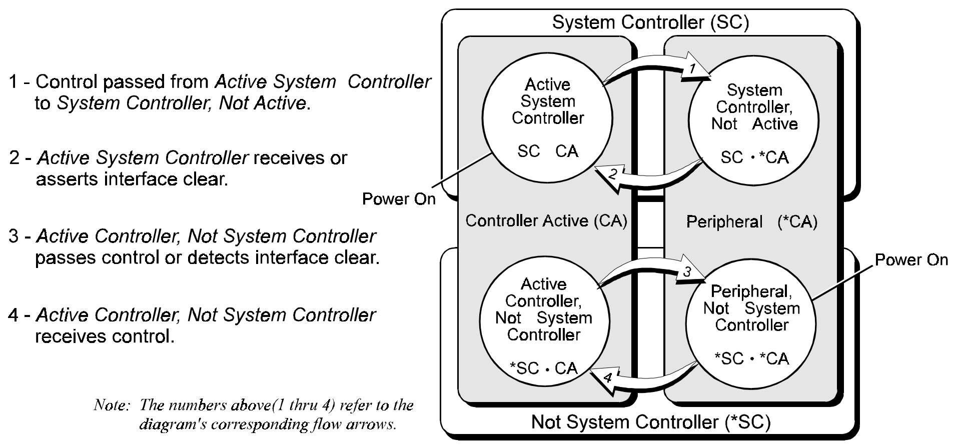
When an IEEE 488 bus system is first turned on, some device must be the Active Controller. This device is the System Controller and always keeps some control of the bus. In particular, the System Controller controls the Interface Clear (**`IFC`**) and Remote Enable (**`REN`**) bus management lines. By asserting Interface Clear, the System Controller forces all other bus devices to stop their bus operations, and regains control as the Active Controller.

Operating Mode Transitions

The System Controller is initially the Active Controller. It can, if desired, Pass Control to another device and thereby make that device the Active Controller. Notice that the System Controller remains the System Controller even when it is not the Active Controller. Of course, the device to which control is passed must be capable of taking the role of Active Controller. It would make no sense to try to pass control to a printer. Control should only be passed to other computers that are capable, and ready, to become the Active Controller. Note further that there must be exactly one System Controller on the IEEE 488 bus. All other potential controllers must be configured as Peripherals when they power up.

The state diagram which follows, shows the relationships between the various operating modes. The top half of the state diagram shows the two operating states of a System Controller. At power on, it is the active controller. It directs the bus transfers by sending the bus commands mentioned previously. It also has control of the Interface Clear and Remote Enable bus lines. The System Controller can pulse Interface Clear to reset all of the other bus devices.

Furthermore, the System Controller can pass control to some other bus device and thereby become a Peripheral to the new Active Controller. If the System Controller receives control from the new Active Controller, then it once again becomes the Active Controller. The System Controller can also force the Active Controller to relinquish control by asserting the Interface Clear signal.


1 - Control passed from Active System Controller to System Controller, Not Active.
2 - Active System Controller receives or asserts interface clear.
3 - Active Controller, Not System Controller passes control or detects interface clear.
4 - Active Controller, Not System Controller receives control.
Note: The numbers above(1 thru 4) refer to the diagram's corresponding flow arrows.
System Controller (SC)
Active System Controller SC CA
System Controller, Not Active SC • *CA
Power On
Controller Active (CA)
Peripheral (*CA)
Power On
Active Controller, Not System Controller *SC • CA
Peripheral, Not System Controller *SC • *CA
Not System Controller (*SC)
1
2
3
4

IEEE 488 Bus Operating Modes State Diagram

The bottom half of the state diagram shows the two operating states of a Not System Controller device. At power on, it is a Peripheral to the System Controller which is the Active Controller. If it receives control from the Active Controller, it becomes the new Active Controller. Even though it is the Active Controller, it is still not the System Controller. The System Controller can force the Active Controller to give up control by asserting Interface Clear. The Active Controller can also give up control by passing control to another device, which may or may not be the System Controller.

In summary, a bus device is set in hardware as either the sole System Controller in the system, or as a non-System Controller. At power on, the System Controller is the Active Controller, and the other devices are Peripherals. The System Controller can give up control by Passing Control, and can regain control by asserting Interface Clear, or by receiving control. A Peripheral can become the Active Controller by receiving control, and can give up control by passing control, or on detecting Interface Clear.

System Controller Mode

The most common Driver488/DRV configuration is as the System Controller, controlling several IEEE 488 bus instruments. In this mode, Driver488/DRV can perform all the various IEEE 488 bus protocols necessary to control and communicate with any IEEE 488 bus devices. As the System Controller in the Active Controller mode, Driver488/DRV can use all the commands available for the Active Controller state, plus control the Interface Clear and Remote Enable lines. The available bus commands and their actions are:

Command	Action
`ABORT`	Pulse Interface Clear.
`LOCAL`	Unassert Remote Enable, or send Go To Local to selected devices.
`REMOTE`	Assert Remote Enable, optionally setting devices to Remote.
`LOCAL LOCKOUT`	Prevent local (front-panel) control of bus devices.
`CLEAR`	Clear all or selected devices.
`TRIGGER`	Trigger selected devices.
`ENTER`	Receive data from a bus device.
`OUTPUT`	Send data to bus devices.
`PASS CONTROL`	Give up control to another device which becomes the Active Controller.
`SPOLL`	Serial Poll a bus device, or check the Service Request state.
`PPOLL`	Parallel Poll the bus.
`PPOLL CONFIG`	Configure Parallel Poll responses.
`PPOLL DISABLE`	Disable the Parallel Poll response of selected bus devices.
`PPOLL UNCONFIG`	Disable the Parallel Poll response of all bus devices
`SEND`	Send low-level bus sequences.
`RESUME`	Unassert Attention. Use to allow Peripheral-to-Peripheral transfers.

System Controller, Not Active Controller Mode

After passing control to another device, the System Controller is no longer the Active Controller. It acts as a Peripheral to the new Active Controller, and the allowed bus commands and their actions are modified accordingly. However, it still maintains control of the Interface Clear and Remote Enable lines. The available bus commands and their actions are:

Command	Action
`ABORT`	Pulse Interface Clear.
`LOCAL`	Unassert Remote Enable.
`REMOTE`	Assert Remote Enable.
`ENTER`	Receive data from a bus device as directed by the Active Controller.
`OUTPUT`	Send data to bus devices as directed by the Active Controller.
`REQUEST`	Set own Serial Poll request (including Service Request) status.
`SPOLL`	Get own Serial Poll request status.

As a bus Peripheral, Driver488/DRV must respond to the commands issued by the Active Controller. The controller, for example, can address Driver488/DRV to Listen in preparation for sending data.

There are two ways to detect our being addressed to Listen: through the `STATUS` command, or by detecting an interrupt with the `ARM` command.

The `STATUS` command can be used to watch for commands from the Active Controller. The Operating Mode, which is a `"P"` while Driver488/DRV is a Peripheral, changes to a `"C"` if the Active Controller passes control to Driver488/DRV. The Addressed State goes from `Idle "I"` to `Listen "L"` or `Talk "T"` if Driver488/DRV is addressed to Listen or to Talk, and goes back to `IDLE "I"` when the Active Controller issues `Unlisten` (`UNL`), `Untalk` (`UNT`), or specifies another `Talker Address Group` (`TAG`). The `TRIGGER "T1"` and `CLEAR "C1"` indicators are set when Driver488/DRV is triggered or cleared, and reset when `STATUS` is read. The Address Change indicator is set to `CHANGE "G1"` when the Addressed State changes. These indicators allow the program to sense the commands issued to Driver488/DRV by the Active Controller.

The various `STATUS` indicators and their descriptions are provided in the following table:

STATUS Indicator	Description
`"P" (Peripheral)`	Driver488/DRV is in the Peripheral (`*CA`) operating mode.
`"C" (Controller)`	Driver488/DRV is the Active Controller (`CA`).
`"T1" (Trigger)`	Driver488/DRV, as a Peripheral, has received a `TRIGGER` bus command.
`"C1" (Clear)`	Driver488/DRV, as a Peripheral, has received a `CLEAR` bus command.
`"T" (Talk)`	Driver488/DRV is in the `Talk` state and can `OUTPUT` to the bus.
`"L" (Listen)`	Driver488/DRV is in the `Listen` state and can `ENTER` from the bus.
`"I" (Idle)`	Driver488/DRV is in neither the `Talk` nor `Listen` state.
`"G1" (Change)`	An Address Change has occurred, that is, a change between Peripheral and Controller, or among `Talk`, `Listen`, and `Idle` has occurred. This is, perhaps, the most useful interrupt in the Peripheral mode.

The following BASIC program fragment illustrates the use of the Address Change and Addressed State indicators to communicate with the Active Controller.

First, check `STATUS` until it indicates there has been an Address Change:

```
200 PRINT#1,"STATUS"
210 INPUT#2 ST$
220 'Has there been no Address Change?
230 IF MID$(ST$,7,1)="0" THEN 200
240 'Are we still in the idle state?
250 STATE$=MID$(ST$,9,1)
260 IF STATE$="I" THEN 200
270 'Are we addressed to listen?
280 IF STATE$="L" THEN 400
290 'Are we addressed to talk?
300 IF STATE$="T" THEN 500
310 PRINT "BAD ADDRESSED STATE VALUE: ";ST$: STOP
```

If addressed to `Listen`, then `ENTER` a line from the controller and `PRINT` it out:

```
400 'Listen state
410 PRINT#1,"ENTER"
420 LINE INPUT#2,A$
430 PRINT A$
440 GOTO 200
```

If addressed to `Talk`, then `INPUT` a line from the keyboard and `OUTPUT` it to the controller:

```
500 'Talk state
510 LINE INPUT A$
520 PRINT#1,"OUTPUT;";A$
530 GOTO 200
```

It is also possible to detect these conditions with the `ARM` command and handle them in an Interrupt Service Routine (ISR). The `Peripheral`, `Controller`, `Talk`, `Listen`, and `Idle` conditions cause interrupts only when the Address Change indicator `"G1"` in the `STATUS` response is set. The `Change`, `Trigger`, and `Clear` indicators are all reset by the `STATUS` command. Thus, the `STATUS` command should be used in the Interrupt Service Routine to prevent re-interruption by an indicator which has not been reset.

The various **ARM** conditions and their descriptions are provided in the following table:

ARM Condition	Description
SRQ	The internal Service Request state is set. See the **SPOLL** command in "Section III: Command References" for more information.
Peripheral	Driver488/DRV is in the Peripheral (***CA**) operating mode.
Controller	Driver488/DRV is the Active Controller (**CA**).
Trigger	Driver488/DRV, as a Peripheral, has received a **TRIGGER** bus command.
Clear	Driver488/DRV, as a Peripheral, has received a **CLEAR** bus command.
Talk	Driver488/DRV is in the **Talk** state and can **OUTPUT** to the bus.
Listen	Driver488/DRV is in the **Listen** state and can **ENTER** from the bus.
Idle	Driver488/DRV is in neither the **Talk** nor **Listen** state.
Bytein	Driver488/DRV has been received a byte from the IEEE 488 bus.
Byteout	Driver488/DRV can output a byte to the IEEE 488 bus.
Error	Driver488/DRV has detected an error condition.
Change	An Address Change has occurred, that is, a change between Peripheral and Controller, or among **Talk**, **Listen**, and **Idle** has occurred. This is, perhaps, the most useful interrupt in the Peripheral mode.

Not System Controller Mode

If Driver488/DRV is not configured as the System Controller, then at power on, it is a bus Peripheral. It might use a program like the one previously described to communicate with the Active Controller. When Driver488/DRV is not the System Controller and not the Active Controller (***SC*CA**), the available bus commands and their actions are:

Command	Action
ENTER	Receive data from a bus device as directed by the Active Controller.
OUTPUT	Send data to bus devices as directed by the Active Controller.
REQUEST	Set own Serial Poll request (including Service Request) status.
SPOLL	Get own Serial Poll request status.

Active Controller, Not System Controller Mode

If the Active Controller passes control to the Driver488/DRV, then it becomes the new Active Controller. This can be detected by the **STATUS** command or as an **ARM**ed interrupt. As an Active Controller, but not the System Controller, the available bus commands and their actions are:

Command	Action
ABORT	Assert Attention and send My Talk Address to stop any bus transfers.
LOCAL	Send Go To Local to selected devices.
LOCAL LOCKOUT	Prevent local (front-panel) control of bus devices.
CLEAR	Clear all or selected devices.
TRIGGER	Trigger selected devices.
ENTER	Receive data from a bus device.
OUTPUT	Send data to bus devices.
PASS CONTROL	Give up control to another device which becomes the Active Controller.
SPOLL	Serial Poll a bus device, or check the Service Request state.
PPOLL	Parallel Poll the bus.
PPOLL CONFIG	Configure Parallel Poll responses.
PPOLL DISABLE	Disable the Parallel Poll response of selected bus devices.
PPOLL UNCONFIG	Disable the Parallel Poll response of all bus devices.
SEND	Send low-level bus sequences.
RESUME	Unassert Attention. Used to allow Peripheral-to-Peripheral transfers.

8O. Utility Programs

Topics

Printer & Serial Redirection

`IEEELPT` and **`IEEECOM`** are stand-alone utilities (Driver488/DRV need not be installed to use them) that allow programs which are unaware of the IEEE 488 bus to control IEEE 488 bus devices as if they were printer (**`IEEELPT`**) or serial (**`IEEECOM`**) devices. They automatically redirect communications destined for printer or serial ports to specified IEEE 488 bus devices. For example, the command:

```
C> IEEELPT IEEE05
```

will configure IEEE 488 bus device **`5`** to appear as the first parallel printer port (**`LPT1:`**). Any text that is destined for **`LPT1:`** will, instead be send to bus device **`5`**. For example, the **`COPY`** command:

```
C> COPY TEXTFILE.DOC LPT1:
```

will copy the contents of **`TEXTFILE.DOC`** to the IEEE 488 bus. Any software which prints to **`LPT1:`** will now send its data to IEEE 488 bus device **`5`**.

Similarly, the command:

```
C> IEEECOM IEEE12
```

will redirect communications to and from the **`COM1:`** serial port to IEEE 488 bus device **`12`**. Thus, a plotting program which expects a serial plotter can communicate with an IEEE 488 plotter using Power488.

Serial port redirection is often less effective than printer port redirection because many programs control the serial port hardware directly and bypass the redirection program. It is still possible to redirect output from such a program to an IEEE device if that program can be configured to send its output to a disk file rather than directly to the printer or plotter. If a file such as **`\DEV\COM1`** is specified, the program will act as though the data were being written to an actual disk file, while the output will be sent to the IEEE 488 bus device to which **`COM1`** was redirected. The program may even issue a warning message that the specified file exists and will be overwritten. If it does, then the user may tell it that it may delete or overwrite the file. No harm can result from trying to delete a device.

To understand how these programs are used, it is necessary to keep in mind the difference between logical and physical devices. When the computer first boots up, it takes an inventory of the installed hardware. It might, for example, find two parallel printer ports, and one serial communications port. These are the physical devices. The physical device, **`LPT1`** (note the *absence* of the colon) is the printer port first identified by the computer. The logical device **`LPT1:`** (*with* the colon) refers to the device which is currently configured to receive data to be printed. The computer maintains two tables of four entries each to keep track of physical devices by logical device name. In the case of two printer and one serial port, these tables initially appear as:

Printer Port Assignments			
LPT1:	**LPT2:**	**LPT3:**	**LPT4:**
LPT1	**LPT2**	**(none)**	**(none)**

Serial Port Assignments			
COM1:	**COM2:**	**COM3:**	**COM4:**
COM1	**(none)**	**(none)**	**(none)**

The **IEEELPT** command takes up to four optional device arguments. Each argument is of the form **IEEEpp**, **IEEEppss** or **LPTn**, where **pp** is an IEEE 488 bus primary address from **00** to **30**, **ppss** is a bus address composed of a primary address from **00** to **30** followed by a secondary address from **00** to **31**, and **n** is a physical printer port device number, from **1** to **4**.

If **IEEELPT** is executed with no arguments, then it just displays the current logical printer port assignments. If one or more arguments are provided, then the first logical printer port (**LPT1:**) is redirected to the physical device specified by the first argument, the next logical port (**LPT2:**) is redirected to the next specified physical device, and so on. If fewer than four devices are specified, then the remaining logical printers are directed to any unused physical parallel printer ports. For example, on a machine with two physical parallel printer ports these commands have the effects indicated in the following table:

Command	Printer Port Assignments			
	LPT1:	**LPT2:**	**LPT3:**	**LPT4:**
(Boot-Up)	LPT1	LPT2	(none)	(none)
IEEELPT (No change)	LPT1	LPT2	(none)	(none)
IEEELPT IEEE05	IEEE05	LPT1	LPT2	(none)
IEEELPT IEEE05 IEEE1201	IEEE05	IEEE1201	LPT1	LPT2
IEEELPT IEEE05 IEEE1201 IEEE17	IEEE05	IEEE1201	IEEE17	LPT1
IEEELPT IEEE05 IEEE1201 IEEE17 IEEE29	IEEE05	IEEE1201	IEEE17	IEEE29
IEEELPT LPT1 IEEE05	LPT1	IEEE05	LPT2	(none)
IEEELPT LPT2 LPT1 IEEE1201	LPT2	LPT1	IEEE1201	(none)

Note that the port assignments are flexible, any order may be used. Also note how the physical printer ports are added to the assignments if there is room for them and if they have not already been specified.

Serial port redirection is accomplished by **IEEECOM**. **IEEECOM** is used identically to **IEEELPT** except that the physical port names (without colons) are **COM1** through **COM4** rather than **LPT1** through **LPT4**. For example, the **IEEECOM** command:

```
IEEECOM IEEE12 COM2 COM1
```

will redirect communications from **COM1:** to IEEE 488 bus device **12**, **COM2:** to **COM2**, and **COM3:** to **COM1**.

In addition to the port specifications, both **IEEELPT** and **IEEECOM** allow two optional parameters. The **/Aioaddr** parameter is used to specify the I/O base address of the IEEE 488 interface board and the **/Baddr** parameter sets its IEEE 488 bus address.

The I/O base address must be specified when the associated IEEE 488 interface board is not at the default I/O address of **02E1 (hex)**. The I/O base address is usually given as a hexadecimal number. For example, to use the default I/O address, the parameter would be **/A&H02E1**. If the hexadecimal I/O address ends in a **0** or an **8** then consecutive I/O addresses will be used. If the address ends in a **1** then I/O addresses will be separated by **&H400**. I/O addresses ending in other than **0**, **1**, or **8** are not allowed. For example, the command:

```
IEEELPT IEEE05 /A&H22E1
```

would configure **LPT1:** for output to IEEE 488 bus address **05** on a second interface card located at **22E1 (hex)**. The I/O base address is usually set by switches or jumpers on the interface card. Refer to the manufacturer's instructions for your IEEE 488 board to determine its I/O address. The default I/O port base address for **IEEELPT** and **IEEECOM** is **/A&H02E1**.

The **/B** sets the primary IEEE 488 bus address of IEEE 488 interface card. Every IEEE 488 bus device, including the controller must have a unique IEEE 488 address in the range of **00** to **30 (decimal)**. The default address for the interface card is **21**, but must be changed if any IEEE Peripheral uses the same address. For example, the command:

```
IEEECOM IEEE21 /B00
```

sets the interface card bus address to **00** so that **COM1:** may be redirected to an IEEE 488 bus device with an address of **21**.

Removal & Reinstallation

Driver488/DRV is a special type of *terminate-and-stay-resident* (TSR) program that controls Power488, Personal488, and LAN488. When **DRVR488.COM** is executed, it installs itself permanently into memory and connects itself into DOS so that it appears to be a standard device driver that can be used to control IEEE 488 devices. Normally, Driver488/DRV is present in memory whenever the computer is operating, even if it is not being used. Most computers have enough memory so that the amount taken by Driver488/DRV is not critical, but some very large programs need so much memory that they cannot operate if Driver488/DRV is installed.

It is possible to temporarily remove Driver488/DRV by editing the **AUTOEXEC.BAT** file. Once Driver488/DRV is installed, the **AUTOEXEC.BAT** file will contain one or more lines similar to the following:

```
C:\IEEE488\DRVR488
```

These are the commands that install Driver488/DRV. They can be disabled by adding the word **REM**, followed by a space, to convert them to remarks:

```
REM C:\IEEE488\DRVR488
```

When the computer is rebooted, these lines will be ignored, Driver488/DRV will not be loaded, and the memory that would have been used for Driver488/DRV will now be available for other programs. If Driver488/DRV is needed later, the **AUTOEXEC.BAT** file must be re-edited to remove the **REM**s and to re-enable Driver488/DRV, and then the computer must be rebooted.

A more practical method involves the creation of a separate batch file that holds the **DRVR488** commands. When Driver488/DRV is installed, the **DRVR488** commands are placed in the **AUTOEXEC.BAT** file. By moving these commands to a separate batch file, it is possible to avoid installing Driver488/DRV before it is needed. To create a separate batch file, first copy **AUTOEXEC.BAT** to a new file, perhaps **DRIVER.BAT**. Then edit the **AUTOEXEC.BAT** file, deleting the **DRVR488** commands, and edit **DRIVER.BAT**, leaving only the **DRVR488** commands. When the system is rebooted, Driver488/DRV will no longer be installed because the **AUTOEXEC.BAT** file no longer contains the DRVR488 commands. However, whenever Driver488/DRV is needed, it can be installed by typing **DRIVER** which will execute the **DRVR488** commands in the **DRIVER.BAT** file. Once Driver488/DRV has been installed, it will remain installed until the system is rebooted.

MARKDRVR & REMDRVR

Using the techniques described above, it is possible to install Driver488/DRV only when it is needed. However, it is still necessary to reboot the computer to remove Driver488/DRV. The **MARKDRVR** and **REMDRVR** utilities allow Driver488/DRV and other TSR programs, such as **Sidekick** and **Superkey**, to be installed and removed at will, without rebooting.

Before installing the TSR program, the **MARKDRVR** command should be used to "snapshot" the system state:

```
C:> MARKDRVR comment
C:> C:\IEEE488\DRVR488
```

The **MARKDRVR** command is followed by an optional **comment** of up to 119 character that is normally used to note which TSR programs are about to be installed. When the above command is executed it saves internal system information including the interrupt vectors, the device driver chain, and the free memory pointer. This information, along with the specified comment, is saved for use by **`REMDRVR`**.

The **`MARKDRVR`** command is then followed by the commands needed to install the TSR programs. When using Driver488/DRV, these would be the **`DRVR488`** commands. When these commands have completed, Driver488/DRV is installed and ready for use.

When Driver488/DRV is no longer needed, it can be removed by using the **`REMDRVR`** command:

```
C: >REMDRVR
```

`REMDRVR` prints out the **`comment`** that was saved by **`MARKDRVR`** and then uses the information that **`MARKDRVR`** saved to restore the system to the state it had before **`MARKDRVR`** had been executed. This removes Driver488/DRV and any other TSR programs that had been loaded in the interim and recovers their memory for reuse.

If several different TSR programs are being used, then it might be appropriate to use **`MARKDRVR`** more than once. Then, when **`REMDRVR`** is used, it will only remove the TSR programs that were installed after the last **`MARKDRVR`** command. Each time **`REMDRVR`** is used, it will remove one more "layer" of TSR programs. The comment saved by **`MARKDRVR`** can help keep track of which TSR programs are removed at each step.

Note that the most recently installed programs are always removed first. It is not possible to remove a program until all the more recently installed programs have been removed.

When working with Power488, it is good practice to create a **`DRIVER.BAT`** file that includes the **`DRVR488`** commands as described above. Then a **`MARKDRVR`** command, such as **`MARKDRVR Driver488`** can be added to the beginning of the **`DRIVER.BAT`** file. Then, Driver488/DRV can be installed by typing **`DRIVER`** and removed by typing **`REMDRVR`**. Driver488/DRV can thus be installed and removed as desired, without rebooting the computer.

Moving Files from an IEEE 488 (HP-IB) Controller to a PC

Included on the Driver488/DRV release disk is a utility program that allows files to be transferred from any IEEE controller to the PC in which Driver488/DRV resides. This utility program configures the PC as a Peripheral on the IEEE network, much like a standard IEEE 488 printer. Any controller capable of sending information to an IEEE 488 printer, including controllers like the HP 9000 series computers, can send any type of data to the PC.

Once launched to the PC, the file transfer utility allows the operator to redirect the incoming data either to the PC screen, a PC disk file, or a printer attached to the PC.

PRNTEMUL Files

In the **`\UTILS`** subdirectory of the Driver488/DRV diskette, there are 2 files:

- **`PRNTEMUL.EXE`:** This file is the MS-DOS executable version of the program. This is all that you will need to emulate an IEEE 488 printer on a PC/AT or PS/2 computer.
- **`PRNTEMUL.C`:** This is the C source code of the **`PRNTEMUL.EXE`** program. It uses a C subroutine interface of Driver488/DRV, which is located in the **`\SUBAPI`** directory of the main Driver488/DRV directory.

Configuration of the IEEE Interface for PRNTEMUL

The **`PRNTEMUL`** program requires the Driver488/DRV to be configured as a Peripheral (same as an IEEE printer). Make sure that the IEEE interface is configured at a unique IEEE address.

Once Driver488/DRV is configured properly, reboot the computer and connect your PC/AT to your IEEE controller.

Running PRNTEMUL

After the IEEE interfaces of each computer has been configured and connected, run the `PRNTEMUL` program from the `\UTILS` directory by typing one of the following commands at the DOS prompt:

Command	Description
`PRNTEMUL <ENTER>`	Prints information received from the IEEE 488 bus to the screen.
`PRNTEMUL > MYPROG.BAS <ENTER>`	Redirects information to a file called `MYPROG.BAS`
`PRNTEMUL > LPT1 <ENTER>`	Redirects information to the printer port (`LPT1`).

Once the `PRNTEMUL` program is started, it will continue to send any information received from the IEEE bus to the specified destination until any key is pressed. Once a key is pressed, the `PRNTEMUL` program will return to DOS at which time it can be run again, with a different destination specified, if so desired.

Data Transfer

Data is transferred to the computer running `PRNTEMUL` the same way information is sent to an IEEE printer. For a description of how to print information out, refer to the documentation of your IEEE controller.

For example, the following commands might be used on an HP 9000 computer running HP BASIC:

Command	Description
`LOAD "MYPROG.BAS"`	Load a program to print out.
`PRINTER IS 710`	Set the current printer to address `10` of the IEEE bus.
`LIST`	List the current program to the selected printer (computer running `PRNTEMUL`).

The output of the `PRNTEMUL` program could be redirected to a datafile to transfer source files from the IEEE controller to a PC/AT or PS/2.

8P. Command Descriptions

Topics

Introduction

There are two types of commands: Bus commands and system commands. *Bus commands* communicate with the IEEE 488 bus. *System commands* configure or request information from Driver488/DRV. This Sub-Chapter contains a detailed description of the bus and system command formats available for Driver488/DRV. For more detail on the individual system commands, see “Section III: Command References.”

Format

The format for the Driver488/DRV command descriptions consists of several sections which together define the command. Using the QuickBASIC language, this format is implemented for the system commands found in Sub-Chapter 15A: “Driver488/DRV Commands” of the “Section III: Command References” in this manual.

Syntax

The Syntax section of the system command description describes the proper command syntax that must be sent to Driver488/DRV. The following conventions for syntax descriptions, use the QuickBASIC language:

- No command may be more than 255 characters long. The data part of the **`OUTPUT`** command does not count in this length and so the **`OUTPUT`** data may be as long as necessary.
- Items in upper case, such as **`ENTER`** or **`OUTPUT`** must be used exactly as stated except that command keywords are not case sensitive: **`Enter`**, **`enter`**, **`ENTER`**, and **`eNtEr`** are all equivalent.
- Items in lower case, such as **`addr`** or **`count`**, represent parameters that must be substituted with an appropriate value.
- Blank spaces in commands are generally ignored. Thus, **`LOCAL LOCKOUT`** is the same as **`LOCALLOCKOUT`**. Spaces are *not* ignored when: in the data part of an **`OUTPUT`** command, within quoted strings in a **`SEND`** command, after an apostrophe (**`'`**) in a terminator specification (**`term`**), at the end of a device name, or within a number.
- Items enclosed in square brackets (**`[item]`**) are optional. Multiple items enclosed in square brackets separated by vertical lines (**`[item1|item2|item3]`**) are optional, any one or none may be chosen. No more than one item may be selected.
- Ellipses within square brackets (**`[...]`**)mean that the items in the brackets may be repeated as many times as desired. For example **`[,addr...]`** means that any number of address separator-address combinations may be used.
- Braces, or curly brackets, (**`{item1|item2}`**) mean that exactly one of the enclosed items is required.
- Combinations of brackets are possible. For example, **`{term[term][EOI]|EOI}`** allows the choice of **`term`**, **`term term`**, **`term term EOI`**, **`term EOI`**, or just **`EOI`**, but does not allow the choice of “nothing.”
- Numeric parameters (those that are given as numbers) are decimal unless preceded by **`&H`** or **`0X`**, in which case they are hexadecimal. Thus, **`100`** is decimal **`100`**, **`&H64`** is hexadecimal **`64`** which equals decimal **`100`**, **`0XFF`** is decimal **`255`**, and **`0ff`** is invalid because **`F`** is not a valid decimal digit. The only exception to this rule is that bus addresses, both primary and secondary, must be specified as decimal numbers. Hexadecimal bus addresses are not allowed.

Several of the commands are accompanied by required or optional *syntax parameters*. These are further described with each command, but the more common ones are discussed below, using QuickBASIC:

Bus Addressing

- **`pri-addr :`** A primary device address in the range **`0`** to **`30`**.
- **`sec-addr :`** An optional two-digit secondary device address in the range **`00`** to **`31`**.
- **`name :`** A one- to eight-character device name composed of letters, numbers, and underscores (_) used to represent the address of a particular bus device.

- **`addr :`** An IEEE 488 bus address. A numeric primary address optionally followed by a secondary address, or a device name. Thus, **`addr`** is of the form **`{name|pri-addr[sec-addr]}`** where **`name`** is a device name, **`pri-addr`** is a primary address, and **`sec-addr`** is a two-digit secondary address.
- **`[,addr...] :`** An optional list of bus addresses, each one preceded by an address separator; either a comma (**`,`**) or a blank.

No more than 50 bus addresses are allowed in any single command.

Character Count

- **`#count :`** The number of characters to be transferred, using a pound sign (**`#`**) followed by an integer in the range **`1`** to **`4,294,967,295`** (or $2^{32} - 1$). It may be specified in hexadecimal by preceding it with **`&H`** or **`0X`**. The hexadecimal range is **`&H1`** to **`&HFFFFFFFF`**. A character count of zero is invalid.

ASCII Characters

- **`$char :`** A single character whose ASCII value is the number **`char`**, a decimal number in the range **`0`** to **`255`** or a hexadecimal number in the range **`$H0`** to **`$HFF`**, or **`&H0`** to **`&HFF`**. For example, **`65`** is the letter **`A`**, as is **`$41`** or **`&H41`**.
- **`CR :`** The carriage return character (**`$13`**, **`$0D`** or **`&H0D`**).
- **`LF :`** The line feed character (**`$10`**, **`$0A`** or **`&H0A`**).
- **`'X :`** Any (usually) printable character. The apostrophe is immediately followed, without any intervening spaces, by a single character that is taken as the character specified.

For a complete description of ASCII control codes and character sets, refer to the tables in “Section V: Appendix” of this manual.

ASCII Character Strings

- **`data :`** An arbitrary string of characters. None of the special forms given above (**`$char`**, **`CR`**, **`LF`**, or **`'X`**) are used. For example, **`CRLF`** as data is taken as the letters: **`C`**, **`R`**, **`L`**, and **`F`**, not as carriage return line feed **`CR LF`**.
- **`'data' :`** An arbitrary string of characters enclosed in apostrophes.

Terminators

- **`term :`** Any single character, specified as **`CR`**, **`LF`**, **`'X`**, or **`$char`** as described above (**`{CR|LF|'X|$char}`**). Part of terminator sequence used to mark the end of lines of data and commands.
- **`[term] :`** An optional term character. For example, **`term[term]`** means that one or two terminators may be specified.
- **`EOI :`** The IEEE 488 bus end-or-identify signal. When asserted during the transfer of a character, **`EOI`** signals that that character is the last in the transfer. On input, EOI, if specified, causes the input to stop. On output, **`EOI`** causes the bus **`EOI`** signal to be asserted during transmission of the last character transferred.
- **`NONE :`** The no end-of-line characters indicator. When **`EOL OUT NONE`** is specified, Driver488/DRV assumes that entire, complete, commands are transferred with a single DOS-level output command. When **`EOL IN NONE`** is specified, Driver488/DRV does not append any input terminators to received data.

I/O Base Address

- **`ioaddr :`** The I/O base address for the interface card, in the range **`&H0`** to **`&HFFFF`**, usually specified in hexadecimal, though decimal is allowed.

Interrupts

- **`interrupt`** **:** One of the following: **`SRQ`**, **`ERROR`**, **`PERIPHERAL`**, **`CONTROLLER`**, **`TRIGGER`**, **`CLEAR`**, **`TALK`**, **`LISTEN`**, **`IDLE`**, **`BYTEIN`**, **`BYTEOUT`**, **`CHANGE`**.
- **`[,interrupt...]`** **:** An optional list of interrupts, each preceded by a comma.

Memory Buffer Addresses

- **`segment`** **:** A **`segment`** address in the range **`-32768`** to **`65535`** (**`&H0`** to **`&HFFFF`**). An address of the form **`segment:offset`** is converted into a real 20-bit address by multiplying the **`segment`** by 16 and adding the **`offset`**. As the **`segment`** is often stored in an integer variable, values greater than **`32767`** (**`32768`** to **`65535`**) are printed as negative numbers (**`-32768`** to **`-1`**, respectively). Driver488/DRV automatically interprets negative **`segment`** values as their corresponding positive values.
- **`offset`** **:** The **`offset`** part of a **`segment:offset`** address. An integer in the range **`-32768`** to **`65535`**. As with **`segment`**, negative offset values are interpreted as their corresponding positive values.
- **`absolute`** **:** A real 20-bit address. An integer in the range **`0`** to **`1,048,575`** (**`&H0`** to **`&HFFFFF`**).
- **`buf-addr`** **:** The memory address of the current data buffer. The **`buf-addr`** may be given either as **`segment:offset`** (the colon is required), or as an **`absolute`** memory address.

Response

The Response section of the system command description describes the response that the user's program should read after sending the command. If a response is provided, it must be read. Errors occur if another command is issued before reading the response.

Mode

This section of the command description format specifies the operating modes in which the command is valid. Driver488/DRV may be configured as the System Controller in which case it is initially the Active Controller, or as a Not System Controller in which case it is initially in the Peripheral state. The Driver488/DRV configuration as System Controller or Not System Controller can be changed by the **`INSTALL`** program.

Note: Even if Driver488/DRV is not configured as the System Controller, it can still become the Active Controller if another controller on the IEEE 488 bus passes control to Driver488/DRV.

The modes are referred to by their names and states, as shown below:

Mode Name	State
System Controller	**SC**
Active Controller	**CA**
Active System Controller	**SC•CA**
Not System Controller, Active Controller	***SC•CA**

Mode Name	State
Not System Controller	***SC**
Peripheral (Not Active Controller)	***CA**
System Controller, Not Active	**SC•*CA**
Not System Controller, Not Active Controller	***SC•*CA**

Bus States

This section of the command description format indicates the state of the bus device. The mnemonics abbreviations for these bus states, as well as the relevant bus lines and bus commands, are listed in the following two tables:

Bus State	**Bus Lines**	**Data Transfer (DIO) Lines**							
		8	**7**	**6**	**5**	**4**	**3**	**2**	**1**
	Hex Value (QuickBASIC)	&H80	&H40	&H20	&H10	&H08	&H04	&H02	&H01
	Decimal Value	128	64	32	16	8	4	2	1
	Bus Management Lines								
`IFC`	Interface Clear								
`REN`	Remote Enable								
	IEEE 488 Interface: Bus Management Lines								
`ATN`	Attention (&H04)	0	0	0	0	0	1	0	0
`EOI`	End-Or-Identify (&H80)	1	0	0	0	0	0	0	0
`SRQ`	Service Request (&H40)	0	1	0	0	0	0	0	0
	IEEE 488 Interface: Handshake Lines								
`DAV`	Data Valid (&H08)	0	0	0	0	1	0	0	0
`NDAC`	Not Data Accepted (&H10)	0	0	0	1	0	0	0	0
`NRFD`	Not Ready For Data (&H20)	0	0	1	0	0	0	0	0
	Serial Interface: Bus Management Lines								
`DTR`	Data Terminal Ready (&H02)	0	0	0	0	0	0	1	0
`RI`	Ring Indicator (&H10)	0	0	0	1	0	0	0	0
`RTS`	Request To Send (&H01)	0	0	0	0	0	0	0	1
	Serial Interface: Handshake Lines								
`CTS`	Clear To Send (&H04)	0	0	0	0	0	1	0	0
`DCD`	Data Carrier Detect (&H08)	0	0	0	0	1	0	0	0
`DSR`	Data Set Ready (&H20)	0	0	1	0	0	0	0	0

Bus State (IEEE 488)	**Bus Commands** (ATN is asserted "1")	**Data Transfer (DIO) Lines**							
		8	**7**	**6**	**5**	**4**	**3**	**2**	**1**
	Hex Value (QuickBASIC)	&H80	&H40	&H20	&H10	&H08	&H04	&H02	&H01
	Decimal Value	128	64	32	16	8	4	2	1
`DCL`	Device Clear (&H14)	x	0	0	1	0	1	0	0
`GET`	Group Execute Trigger (&H08)	x	0	0	0	1	0	0	0
`GTL`	Go To Local (&H01)	x	0	0	0	0	0	0	1
`LAG`	Listen Address Group (&H20-3F)	x	0	1	a	d	d	r	n
`LLO`	Local Lock Out (&H11)	x	0	0	1	0	0	0	1
`MLA`	My Listen Address	x	0	1	a	d	d	r	n
`MTA`	My Talk Address	x	1	0	a	d	d	r	n
`PPC`	Parallel Poll Config	x	1	1	0	S	P2	P1	P0
`PPD`	Parallel Poll Disable (&H07)	x	0	0	0	0	1	1	1
`PPU`	Parallel Poll Unconfig (&H15)	x	0	0	1	0	1	0	1
`SCG`	Second. Cmd. Group (&H60-7F)	x	1	1	c	o	m	m	d
`SDC`	Selected Device Clear (&H04)	x	0	0	0	0	1	0	0
`SPD`	Serial Poll Disable (&H19)	x	0	0	1	1	0	0	1
`SPE`	Serial Poll Enable (&H18)	x	0	0	1	1	0	0	0
`TAG`	Talker Address Group (&H40-5F)	x	1	0	a	d	d	r	n
`TCT`	Take Control (&H09)	x	0	0	0	1	0	0	1
`UNL`	Unlisten (&H3F)	x	0	1	1	1	1	1	1
`UNT`	Untalk (&H5F)	x	1	0	1	1	1	1	1
	(x = "don't care")								

If a command is preceded by an asterisk (**`*`**), that command is unasserted. For example, **`*REN`** states that the remote enable line is unasserted. Conversely, **`REN`** without the asterisk states that the line becomes asserted.

The bus states are further described, according to the following bus lines:

Bus Management Lines

For the general control and coordination of bus activities, five bus management lines are used by either an IEEE 488 interface or a serial interface:

- **Interface Clear (`IFC`):** Employed by either IEEE 488 or serial interfaces, this line is used only by the System Controller to place all bus devices in a known, quiescent state. Specifically, the **`IFC`** places the devices in the **`Talk`** and **`Listen Idle`** states (neither Active Talker nor Active Listener) and makes the System Controller the Active Controller.
- **Remote Enable (`REN`):** Employed by either IEEE 488 or serial interfaces, this line is used only by the System Controller to allow bus devices to respond to remote (bus) commands. When **`REN`** is asserted, all listeners capable of remote operation enter remote operation when addressed to Listen. If **`REN`** is unasserted, then the bus devices may ignore the bus and remain in local operation. Generally, the **`REN`** command should be issued before any bus programming is attempted.
- **Attention (`ATN`):** Employed by an IEEE 488 interface, this is one of the most important lines for bus management, and can only be driven by the Active Controller. When **`ATN`** is *asserted*, the information contained on the data lines is to be interpreted as a bus (multiline) command. When it is *unasserted*, that information is to be interpreted as data for the Active Listeners.
- **End-Or-Identify (`EOI`):** Employed by an IEEE 488 interface, this line is used to signal the last byte of a multibyte data transfer. The device that is sending the data asserts **`EOI`** during the transfer of the last data type. The **`EOI`** signal is not always necessary, since the end of the data may be indicated by some special character such as the carriage return. The Active Controller also uses **`EOI`** to perform a Parallel Poll by simultaeously asserting **`EOI`** and **`ATN`**.
- **Service Request (`SRQ`):** Employed by an IEEE 488 interface, this line is asserted by any device to attract the immediate attention of the Active Controller. Consequently, it can be used to interrupt the current sequence of events. The device may be reporting that it has data to send, an error condition to report or both. The Controller can determine which device requested service using Serial Poll or Parallel Poll. The Serial Poll will clear the **`SRQ`** line unless some other device is requesting service.
- **Data Terminal Ready (`DTR`):** Employed by a serial interface, this line is specified to indicate the presence and readiness of data terminal and data communication equipment (DEC). The **`DTR`** is asserted by the terminal equipment when terminal power is on, indicating to the modem or other DCE that the terminal is ready.
- **Ring Indicator (`RI`):** Employed by a serial interface, this line indicates that a ringing signal is being received on the communication equipment.
- **Request To Send (`RTS`):** Employed by a serial interface, this line is specified to assist half-duplex communication equipment in transmitting and receiving data. Before a transmission, the sender's **`RTS`** signal is asserted, requesting the receiver to switch its circuitry to the receive mode.

Handshake Lines

To "handshake" the transfer of information across the data lines, three lines are used by either an IEEE 488 interface or a serial interface:

- **Data Valid (`DAV`):** Employed by an IEEE 488 interface, this line is controlled by the Active Talker. Before sending any data, the Talker verifies that **`NDAC`** (see below) is asserted, which indicates that all Listeners have accepted the previous data byte. The Talker then places a byte onto the data lines and waits until **`NRFD`** (see below) is unasserted, indicating that all Addressed Listeners are ready to accept the information. When **`NRFD`** and **`NDAC`** are in the proper state, the Talker asserts **`DAV`** to indicate that the data on the bus is valid.
- **Not Ready For Data (`NRFD`):** Employed by an IEEE 488 interface, this line is used by the Listeners to inform the Talker that they are ready to accept new data. The Talker must wait for each Listener to unasserted this line, which they do at their own rates, when they are ready for more data. This assures that all devices accepting the information are ready to receive it.

- **Not Data Accepted (`NDAC`):** Employed by an IEEE 488 interface, this line is also controlled by the Listeners, and indicates to the Talker that each device addressed to listen has accepted the information. Each device releases **`NDAC`** at its own rate, but **`NDAC`** does not do so until the slowest Listener has accepted the data byte. This type of handshaking permits multiple devices to receive data from a single data transmitter on the bus. All active receiving devices will participate in the data handshaking on a byte-by-byte basis and operate the **`NDAC`** and **`NRFD`** lines in a "wired-or" scheme so that the slowest active device will determine the rate at which the data transfers take place. In other words, data transfers are asynchronous and occur at the rate of the slowest participating device.
- **Clear To Send (`CTS`):** Employed by a serial interface, this line is specified to assist half-duplex communication equipment in transmitting and receiving data. When ready to receive, the receiver asserts its **`CTS`** line, allowing transmission to begin.
- **Data Carrier Detect (`DCD`):** Employed by a serial interface, this line is asserted by the modem or other data communication equipment (DCE) to indicate that it has established a communication link with the modem or DCE at the other end of the communication link (e.g., phone line). It must be asserted for the terminal to go on-line and receive data.
- **Data Set Ready (`DSR`):** Employed by a serial interface, this line is specified to indicate the presence and readiness of data terminal and data communication equipment (DCE). The **`DSR`** is asserted by the modem or other DCE to allow the terminal to go on-line and receive data.

Data Transfer Lines

To transfer information between devices on the bus, eight lines (**`DIO1`** through **`DIO8`**) are used by the IEEE 488 interface. As previously discussed, when **`ATN`** is *unasserted*, the information contained on the data lines is to be interpreted as data for the Active Listeners. However, when **`ATN`** is *asserted*, that information is to be interpreted as a bus (multiline) command.

Bus Command Groups

Bus commands are bytes sent by the Active Controller over the data bus with Attention (**`ATN`**) asserted. These commands are sent to all devices and are divided into the following 5 groups:

- **Addressed Command Group (`ACG`):** These commands affect only those devices which have previously been addressed to be a Listener. There are 5 bus line addressed commands: **`GET`**, **`GTL`**, **`PPD`**, **`SDC`** and **`TCT`**.
- **Universal Command Group (`UCG`):** These commands cause every instrument on the bus to carry out the bus function specified (if the instrument is capable of it). There are 5 bus line universal commands: **`DCL`**, **`LLO`**, **`PPU`**, **`SPD`**, and **`SPE`**.
- **Listen Address Group (`LAG`):** These commands address to Listen specified bus devices. The addressed device then becomes a Listener. There are 31 (`0` to `30`) listen addresses associated with this group. The 3 most significant bits of the data bus are set to **`001`** while the 5 least significant bits are the address of the device being told to Listen. The last command in this group is **`UNL`**.
- **Talk Address Group (`TAG`):** These commands address to Talk specified bus devices. The addressed device then becomes a Talker. There are 31 (`0` to `30`) talk addresses associated with this group. The 3 most significant bits of the data bus are set to `010` while the 5 least significant bits are the address of the device being told to Talk. The last command in this group is **`UNT`**.
- **Secondary Command Group (`SCG`):** These commands are used to specify a subaddress or subfunction within a given bus device. There are 32 (`0` to `31`) possible secondary commands used to specify a subaddress of subfunction within a given bus device. They are also used in the Parallel Poll Configure (**`PPC`**)sequence.
- Three bus commands not found in the above groups are: **`MLA`**, **`MTA`**, and **`PPC`**.

All of the IEEE 488 bus commands are further described individually, as follows:

Bus Commands

- **Device Clear (`DCL`):** This `UCG` command causes all bus devices to be initialized to a pre-defined or power-up state.
- **Group Execute Trigger (`GET`):** This `ACG` command usually signals all bus devices to begin executing a triggered action. This allows actions of different devices to begin simultaneously.
- **Go To Local (`GTL`):** This `ACG` command allows the selected devices to be manually controlled.
- **Local Lock Out (`LLO`):** This `UCG` command prevents manual control of the instrument's functions.
- **My Listen Address (`MLA`):** This command addresses a device to Listen. The device accepts data from the Active Talker and outputs this data through the serial interface. It substitutes the selected serial terminators for the received IEEE 488 bus terminators.
- **My Talk Address (`MTA`):** This command addresses a device to Talk. The device retrieves data from the serial input buffer and outputs it to the IEEE 488 bus. It substitutes the selected IEEE 488 bus terminators for the received serial terminators. The device will continue to output serial input buffer data as long as the IEEE 488 controller allows.
- **Parallel Poll Configure (`PPC`):** This command configures devices capable of performing a Parallel Poll via the data bit they are to assert in response to a Parallel Poll.
- **Parallel Poll Disable (`PPD`):** This `ACG` command disables the Parallel Poll response of selected devices.
- **Parallel Poll Unconfigure (`PPU`):** This `UCG` command disables all devices from responding to a Parallel Poll.
- **Selected Device Clear (`SDC`):** This `ACG` command causes a single device to be initialized to pre-defined or power-up state.
- **Serial Poll Disable (`SPD`):** This `UCG` command disables a device from sending its Serial Poll status byte.
- **Serial Poll Enable (`SPE`):** This `UCG` command, when `ATN` is unasserted, will cause a device that is addressed to talk, to output its Serial Poll status byte.
- **Take Control (`TCT`):** This `ACG` command passes bus control responsibilities from the current Controller to another device which has the ability to control.
- **Unlisten (`UNL`):** This `LAG` command places the device in the `Listen Idle` state.
- **Untalk (`UNT`):** This `TAG` command places the device in the `Talk Idle` state.

For more detailed information, many of these commands appear in Chapter 15 "Command References" of "Section III: Command References" in this manual. Also, for information on the relationship between bus messages and ASCII character codes, turn to "Section V: Appendix" in this manual.

Examples

The Examples section of the command description format lists one or more short examples of the command's normal use. These and additional programs can be found in language or example subdirectories of the Driver488/DRV installation directory.

Data Types

For information on the Driver488/DRV data bit masks, data constants, and data structures, turn to the topic "Data Types" found in the Sub-Chapter 9K "Command Descriptions" of Chapter 9 "Driver488/SUB."

CCL Reserved Words

The following alphabetized list contains words reserved for use by the Character Command Language (CCL) interface. These words may not appear as a device name nor as the first characters of a device name. Upper and lower cases are insignificant. Some examples of this are:

- **`all :`** This is a reserved word, therefore **`alloy`**, **`Alloy`**, or **`ALLOY`** are all invalid External Device names.
- **`cr:`** This is a reserved word, therefore **`crane`**, **`Crane`**, or **`CRANE`** cannot be used as the name of an External Device if the Character Command Language is to be used.
- **`in :`** This is a reserved word, so **`input`**, **`Input`**, or **`INPUT`** are all invalid External Device names.

List of Reserved Words

• **`all`**	• **`dma`**	• **`mla`**	• **`out`**
• **`buffer`**	• **`eoi`**	• **`monitor`**	• **`talk`**
• **`cmd`**	• **`error`**	• **`mta`**	• **`unl`**
• **`continue`**	• **`in`**	• **`none`**	• **`unt`**
• **`cr`**	• **`lf`**	• **`off`**	• **`until_rsv`**
• **`data`**	• **`listen`**	• **`on`**	• **`while_srq`**

8Q. Command Reference

To obtain a detailed description of the command references for Driver488/DRV, turn to Section III in this manual entitled “Command References.” The commands are presented in alphabetical order for ease of use.

9. Driver488/SUB

Sub-Chapters

9A. Introduction

Driver488/SUB is similar to Driver488/DRV in that it uses HP (Hewlett-Packard) style commands, has COM port support, offers asynchronous I/O capability, provides automatic event vectoring and error checking, and transfers data at the maximum DMA rate of the board being controlled.

Like Driver488/DRV, Driver488/SUB supports the Power488 series boards' additional input/output functions with SCPI (Standard Command for Programmable Instruments).

Driver488/SUB differs from Driver488/DRV in programming style and performance. You can access the memory-resident Driver488/SUB via a library of function calls, allowing for faster input/output operations. You can use Driver488/SUB with any of the languages for which function call libraries are offered, including: C, Pascal, and QuickBASIC.

The following example of programming a digital multimeter highlights the programming style differences between Driver488/DRV and Driver488/SUB:

Driver488/DRV, using C Language	Driver488/SUB, using C Language

```
main ( )
{
     ieeeinit ( );
     ieeewt (Output dmm; R0T1X");
     Ieeewt ("Enter dmm");
     ieeerd (val);
}
```
	```
	main ( )
	{
	     OpenName (dmm. "DMM");
	     Output (dmm, "R0T1X)
	     Enter (dmm, val);
	}
	```

Driver488/SUB lets you obtain optimal use of your PC's conventional 640K byte memory by automatically detaching and loading itself into high memory (when used with a test system employing DOS 5.0 or higher). If sufficient high memory is available, Driver488/SUB will not consume any conventional memory. This makes the driver particularly useful for applications executing long programs demanding large amounts of memory.

Driver488/SUB supports up to four IEEE 488 interfaces. Each interface can support multiple external devices up to the limits imposed by electrical loading (14 devices), or with a product such as Extender488, to the limits of the IEEE 488 addressing protocols.

Driver488/SUB supports the GP488B (not PCIIA, NI), AT488, MP488, MP488CT, and NB488 series of IEEE 488.2 interface hardware. There is no Character Command Language (CCL) support contained in Driver488/SUB. All interaction between the application and the driver takes place via normal subroutine.

9B. Installation & Configuration

Topics

Before You Get Started

Prior to Driver488/SUB software installation, configure your interface board by setting the appropriate jumpers and switches as detailed in the “Section I: Hardware Guides.” Note the configuration settings used, as they must match those used within the Driver488/SUB software installation.

Once the IEEE 488 interface hardware is installed, you are ready to proceed with the steps outlined within this Sub-Chapter to install and configure the Driver488/SUB software. The Driver488/SUB software disk(s) include the driver files themselves, installation tools, example programs, and various additional utility programs. A file called **`README.TXT`**, if present, is a text file containing new material that was not available when this manual went to press.

NOTICE

1. The Driver488/SUB software, including all files and data, and the diskette on which it is contained (the “Licensed Software”), is licensed to you, the end user, for your own internal use. You do not obtain title to the licensed software. You may not sublicense, rent, lease, convey, modify, translate, convert to another programming language, decompile, or disassemble the licensed software for any purpose.

2. You may:

- **only use the software on one single machine;**
- **copy the software into any machine-readable or printed form for backup in support of your use of the program on the single machine; and,**
- **transfer the programs and license to use to another party if the other party agrees to accept the terms and conditions of the licensing agreement. If you transfer the programs, you must at the same time either transfer all copies whether in printed or in machine-readable form to the same party and destroy any copies not transferred.**

The first thing to do, before installing the software, is to make a backup copy of the Driver488/SUB software disks onto blank disks. To make the backup copy, follow the instructions given below.

Making Backup Disk Copies

1. Boot up the system according to the manufacturer's instructions.
2. Type the command **`CD\`** to go back to your system's root directory.
3. Place the first Driver488/SUB software disk into drive **`A:`**.
4. Type **`DISKCOPY A:A:`** and follow the instructions given by the **`DISKCOPY`** program. (You may need to swap the original (source) and blank (target) disks in drive **`A:`** several times to complete the **`DISKCOPY`**. If your blank disk is unformatted, the **`DISKCOPY`** program allows you to format it before copying.)
5. When the copy is complete, remove the backup (target) disk from drive **`A:`** and label it to match the original (source) Driver488/SUB software disk just copied.
6. Store the original Driver488/SUB software disk in a safe place.
7. Place the next Driver488/SUB software disk into drive **`A:`** and repeat steps 4-6 for each original (source) disk included in the Driver488/SUB package.
8. Place the backup copy of the installation disk into drive **`A:`**, type **`A:INSTALL`**, then follow the instructions on the screen.

Driver Installation

There are two steps involved in installing Driver488/SUB onto your working disk. The required files must first be copied from the distribution disk to your working disk, and then the configuration must be established by modifying the supplied Windows-style initialization file.

Driver488/SUB should normally be installed on a hard disk. Installing Driver488/SUB on a floppy disk, while possible, is not recommended. Assuming that the Driver488/SUB disk is in drive **`A:`**, start the installation procedure by typing **`A:INSTALL`** at the prompt.

For a normal first installation, allow **`INSTALL`** to install all parts of Driver488/SUB. If hard disk space is extremely limited, certain parts, such as language support and examples for languages not immediately used, may be omitted. The distribution disks may be used to install or reinstall any or all parts of Driver488/SUB at a later time.

Note if any error messages display when you are trying to load **`DRVR488.EXE`** in memory. If so, refer to "Section IV: Troubleshooting" in this manual.

The **`CONFIG`** utility runs automatically upon calling installation and permits you to specify the system configuration, add interfaces, define external devices, etc. You may also run **`CONFIG`** from the command line at a later time to modify your configuration as required. The following text describes the configuration of interface boards, external devices and serial external devices.

Configuration Utility

The Driver488/SUB startup configuration is specified in a Windows-style initialization file named **`DRVR488.INI`**, which resides in the Driver488/SUB directory. The first screen of the **`CONFIG`** program is used to enter the configuration settings so the Driver488/SUB software can be correctly modified to reflect the state of the hardware.

The driver can be reconfigured at any time by running the **`CONFIG`** program. To start the **`CONFIG`** program, type **`CONFIG`** while in the directory in which the configuration utility resides, typically **`C:\IEEE488\UTILS`**.

Interfaces

The minimum requirement for configuring your system is to make certain that your IEEE 488.2 interface board or module is selected under "Device Type." The default settings in all of the other fields match those of the interface as shipped from the factory. If you are unsure of a setting, it is recommended that you leave it as is.

External Devices

Within your IEEE 488.2 application program, devices on the bus are accessed by name. These names must be created and configured within the **`CONFIG`** program. After configuring your interface parameters, press **`<F5>`** to open the External Devices window. All configured devices will be accessible in your application program via the **`OpenName`** command. For more details, refer to the topic "Configuration of IEEE 488 External Devices" found later in this Sub-Chapter.

Opening the Configuration Utility

In general, all Driver488/SUB configuration utility screens have three main windows: the "name" of the interfaces or devices on the left, the "configuration" window on the right, and the "instruction" window at the bottom of the screen. Based on current cursor position, the valid keys for each window will display in the Instructions box.

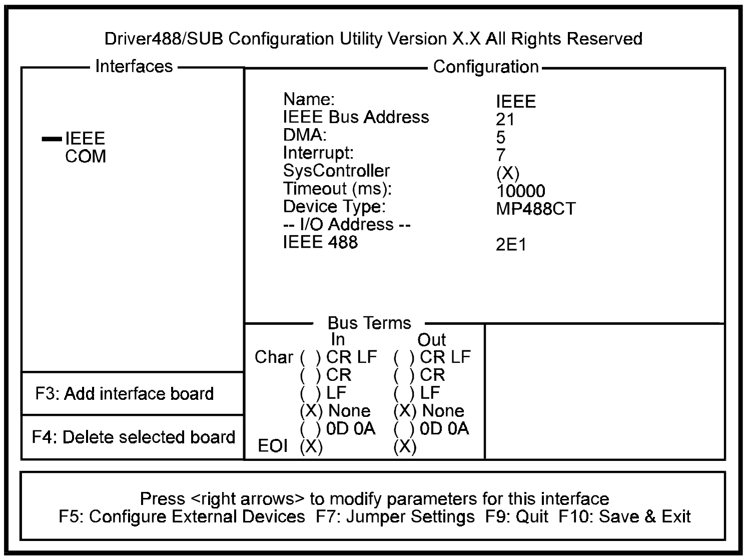
To begin the interface configuration, move the cursor in the name window to select an interface description for modification. (Interfaces can be added or deleted using **`<F3>`** and **`<F4>`**.) Notice moving the cursor up and down the list of interfaces or devices in the left window changes the parameters in the configuration window. The configuration fields always correspond with the currently selected interface and device type.

Once all modifications have been made to the configuration screen, **`<F10>`** must be pressed to accept the changes made or **`<F9>`** can be pressed to exit without making any change. Additional function keys allow the user to continue onto the configuration of external devices via **`<F5>`** or to view a graphic representation of the interface card with the selected settings via **`<F7>`**.

Configuration of IEEE 488 Interfaces

The Driver488/SUB supports two types of interfaces: IEEE and Serial (COM). The following Driver488/SUB figure displays the configuration screen of an MP488CT IEEE 488.2 interface.

To add another IEEE interface, select **`<F3>`**. For additional information on using more than one interface, refer to the final topic "Multiple Interface Management" in the Sub-Chapter "Installation & Configuration" of Chapter 8.



```
Driver488/SUB Configuration Utility Version X.X All Rights Reserved
Interfaces                  Configuration
                            Name:                  IEEE
                            IEEE Bus Address       21
━IEEE                       DMA:                   5
 COM                        Interrupt:             7
                            SysController          (X)
                            Timeout (ms):          10000
                            Device Type:           MP488CT
                            -- I/O Address --
                            IEEE 488               2E1

                                 Bus Terms
                                  In         Out
                            Char ( ) CR LF  ( ) CR LF
                                 ( ) CR     ( ) CR
F3: Add interface board          ( ) LF     ( ) LF
                                 (X) None   (X) None
F4: Delete selected board        ( ) 0D 0A  ( ) 0D 0A
                            EOI  (X)        (X)

      Press <right arrows> to modify parameters for this interface
 F5: Configure External Devices  F7: Jumper Settings  F9: Quit  F10: Save & Exit
```

Configuration Utility for MP488CT

Once an interface is selected, the fields and default entries which display in the configuration window depend on the device type specified. The configuration parameters of the IEEE interface, shown in the figure, are as follows:

Configuration Parameters

- **Name:** This field is a descriptive instrument name which is manually assigned by the user. This must be a unique name. Typically, IEEE or COM is used.
- **IEEE Bus Address:** This is the setting for the IEEE bus address of the board. It will be checked against all the instruments on the bus for conflicts. It must be a valid address from **`0`** to **`30`**.
- **DMA:** A *direct memory access* (DMA) channel can be specified for use by the I/O interface card. If DMA is to be used, select a channel as per the hardware setting. If no DMA is to be used, select NONE. The NB488 does not support DMA, therefore the DMA field will not display if this device type is used. Valid settings are displayed in the table.

I/O Board	Specified DMA Channel
GP488B	1, 2, 3 or none
AT488	1, 2, 3, 5, 6, 7 or none
MP488	1, 2, 3, 5, 6, 7 or none
MP488CT	1, 2, 3, 5, 6, 7 or none
NB488	Not applicable
CARD488	Not applicable

- **Interrupt:** A hardware interrupt level can be specified to improve the efficiency of the I/O adapter control and communication using Driver488/SUB. For DMA operation or any use of **`OnEvent`** and **`Arm`** functions, an interrupt level must be selected. Boards may share the same interrupt level. If no interrupt level is to be used, select NONE. Valid interrupt levels depend on the type of interface. Possible settings are shown in the table.

I/O Board	Specified Interrupt Level
GP488B	levels 2-7 or none
AT488	levels 3-7, 9-12, 14-15 or none
MP488	levels 3-7, 9-12, 14-15 or none
MP488CT	levels 3-7, 9-12, 14-15 or none
NB488	level 7 for LPT1, level 5 for LPT2
CARD488	levels 3-7, 9-12, 14-15 or none

- **SysController:** This field determines whether or not the IEEE 488 interface card is to be the System Controller. The System Controller has ultimate control of the IEEE 488 bus, and the ability of asserting the Interface Clear (**`IFC`**) and Remote Enable (**`REN`**) signals. Each IEEE 488 bus can have only one System Controller. If the board is a Peripheral, it may still take control of the IEEE 488 bus if the Active Controller passes control to the board. The board may then control the bus and, when it is done, pass control back to the System Controller or another computer, which then becomes the active controller. If the board will be operating in Peripheral mode (not System Controller), select NO in this field.
- **LightPen:** This field determines whether the **`LightPen`** command is to be used. If selected, it will disable the detection of interrupts via setting the light pen status. The default is light pen interrupt enabled.
- **Timeout (ms):** The time out period is the amount of time that data transfers wait before assuming that the device does not transfer data. If the time out period elapses while waiting to transfer data, an error signal occurs. This field is the default timeout for any bus request or action, measured in milliseconds. If no timeout is desired, the value may be set to zero.
- **Device Type:** This field specifies the type of board or module (such as GP488, MP488CT or NB488) represented by the IEEE device name selected.

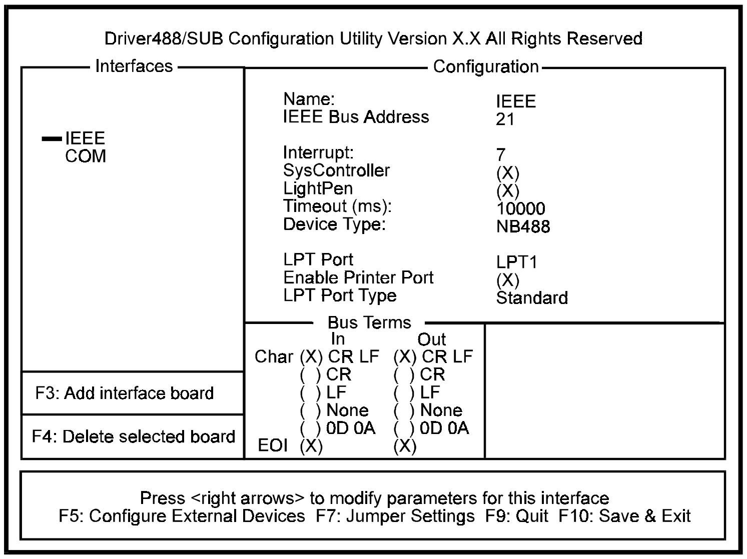
I/O Address

- **IEEE 488:** This field is the I/O base address which sets the addresses used by the computer to communicate with the IEEE interface hardware on the board. The address is specified in hexadecimal and can be **`02E1`**, **`22E1`**, **`42E1`** or **`62E1`**.

  Note: This field does not apply to the NB488. Instead, the NB488 uses the I/O address of the data register (the first register) of the LPT port interface, typically **`0x0378`**.
- **Digital I/O:** This field is the base address of the Digital I/O registers. It is only applicable for MP488 and MP488CT boards. Note the Digital I/O SCPI communication parameters are configured as an external device. Refer to the “Section I: Hardware Guides” for more information.

- **Counter/Timer:** This field is the base address of the Counter/Timer registers. It is only applicable for MP488CT boards. Note the Counter/Timer SCPI communication parameters are configured as an external device. Refer to the Hardware Guides and section for more information.
- **Bus Terminators:** The IEEE 488 bus terminators specify the characters and/or end-or-identify (**`EOI`**) signal that is to be appended to data that is sent to the external device, or mark the end of data that is received from the external device.

This second Driver488/SUB configuration example displays an IEEE interface with the NB488 interface module specified. This screen resembles the previous IEEE interface example with the exception of 3 different configuration parameters which are described below.



```
Driver488/SUB Configuration Utility Version X.X All Rights Reserved
 Interfaces            Configuration
                       Name:                 IEEE
                       IEEE Bus Address      21
 ━IEEE
  COM                  Interrupt:            7
                       SysController         (X)
                       LightPen              (X)
                       Timeout (ms):         10000
                       Device Type:          NB488

                       LPT Port              LPT1
                       Enable Printer Port   (X)
                       LPT Port Type         Standard
                            Bus Terms
                           In        Out
                      Char (X) CR LF  (X) CR LF
                           ( ) CR     ( ) CR
 F3: Add interface board   ( ) LF     ( ) LF
                           ( ) None   ( ) None
 F4: Delete selected board ( ) 0D 0A  ( ) 0D 0A
                      EOI  (X)        (X)

        Press <right arrows> to modify parameters for this interface
 F5: Configure External Devices  F7: Jumper Settings  F9: Quit  F10: Save & Exit
```

Configuration Utility for NB488

Configuration Parameters

- **LPT Port:** The LPT port is the external parallel port to be connected to the NB488. Valid selections are: **`LPT1`**, **`LPT2`** or **`LPT3`**. This field takes the place of the I/O Address field.
- **Enable Printer Port:**
  Because most laptop and notebook PCs provide only one LPT port, the NB488 offers LPT pass-through for simultaneous IEEE 488 instrument control and printer operation. If this option is selected, a printer connected to the NB488 will operate as if it were connected directly to the LPT port. If not enabled, then the printer will not operate when the NB488 is active. The disadvantage of pass-through printer support is that it makes communications with the NB488 about 20% slower.
- **LPT Port Type:** This field is used to specify whether the LPT port is a standard IBM PC/XT/AT/PS/2 compatible port. Valid options are: Standard or 4-bit. The slower 4-bit option is provided for those computers which do not fully implement the IBM standard printer port. These computers can only read 4 bits at a time from the NB488 making communication with the NB488 up to 30% slower.

  A test program has been provided with NB488 to help identify the user's LPT port type. Once the NB488 is installed, type: **`NBTEST.EXE`**. This program will determine if your computer can communicate with the NB488 and what type of LPT port is installed (Standard or 4-bit).

  It is important to note there are four different versions of the NB488 driver. The **`CONFIG`** utility determines which is to be used based on the user-defined parameters. If both pass-through printer support and the 4-bit LPT port support are selected, then the communication with the IEEE 488 bit may be slowed as much as 40% compared with the fastest case in which neither option is selected. The actual performance will vary depending on the exact type and speed of the computer used.

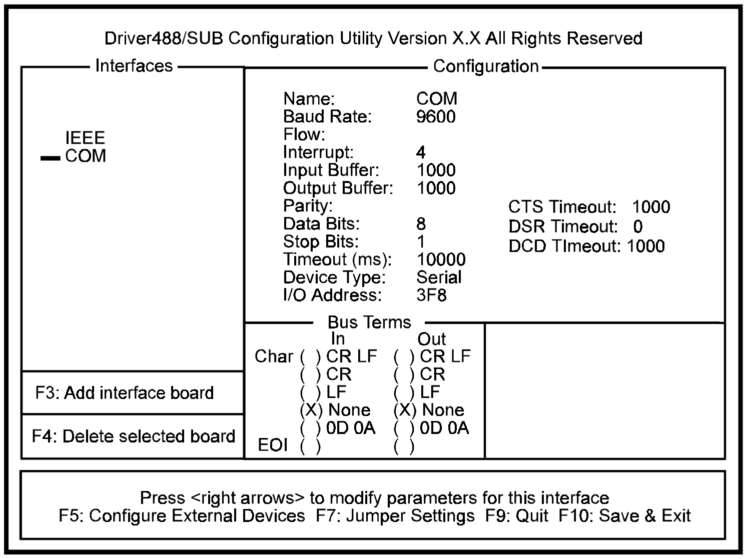
To save your changes to disk, press **`<F10>`**, or to exit without making any changes, press **`<F9>`**. All changes will be saved in the directory where you installed Driver488/SUB. If at any time you wish to alter your Driver488/SUB configuration, simply rerun **`CONFIG`**.

Configuration of Serial Interfaces

The following Driver488/SUB screen displays the configuration of a serial (COM) interface.

To add another serial interface, select **`<F3>`**.

The following serial interface parameters are available for modification.



```
Driver488/SUB Configuration Utility Version X.X All Rights Reserved
 Interfaces          Configuration
                     Name:            COM
                     Baud Rate:       9600
   IEEE              Flow:
 ▬ COM               Interrupt:       4
                     Input Buffer:    1000
                     Output Buffer:   1000
                     Parity:                     CTS Timeout:  1000
                     Data Bits:       8          DSR Timeout:  0
                     Stop Bits:       1          DCD TImeout: 1000
                     Timeout (ms):    10000
                     Device Type:     Serial
                     I/O Address:     3F8
                        Bus Terms
                          In          Out
                     Char ( ) CR LF   ( ) CR LF
                          ( ) CR      ( ) CR
 F3: Add interface board  ( ) LF      ( ) LF
                          (X) None    (X) None
 F4: Delete selected board ( ) 0D 0A  ( ) 0D 0A
                     EOI  ( )         ( )

 Press <right arrows> to modify parameters for this interface
 F5: Configure External Devices  F7: Jumper Settings  F9: Quit  F10: Save & Exit
```

Configuration Utility for Serial Interfaces

Configuration Parameters

- **Name:** This field is a descriptive instrument name which is manually assigned. This must be a unique name.
- **Baud Rate:** The allowable Data Rates range from 75 to 115.2K and all standard rates therein. This includes: 75, 110, 150, 300, 600, 1200, 1800, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, and 115.2K. Slower processors may have difficulty at the higher data rates because of the amount of processing required for terminator, end of buffer, and fill processing.
- **Flow:** **`X-ON/X-OFF`** is supported. With this configured, Driver488/SUB scans incoming characters for an **`X-OFF`** character. Once it is received, no more characters are transmitted until an **`X-ON`** character is received. The driver also issues an **`X-OFF`** to ask the attached device to stop sending when its internal buffer becomes three-quarters full and issues an **`X-ON`** when its buffer has emptied to one-quarter full.
- **Interrupt:** A hardware interrupt level can be specified to improve the efficiency of the I/O adapter control and communication using Driver488/SUB. For any use of **`OnEvent`** and **`Arm`** functions, an interrupt level must be selected. If no interrupt level is to be used, select NONE. Valid interrupt levels depend on the device type:

I/O Comm.	Typical Interrupt Level
COM1	typically level 4
COM2	typically level 3
COM3	typically level 4 or 5
COM4	typically level 2 or 3

- **Input Buffer:** This field is used to enter the buffer sizes for I/O.
- **Output Buffer:** This field is used to enter the buffer sizes for I/O.
- **Parity:** Parity can be EVEN, ODD, NONE, MARK, or SPACE.
- **CTS Timeout:** The driver supports 3 hardware handshake lines: Data Carrier Detect (**`DCD`**), Data Set Ready (**`DSR`**), and Clear To Send (**`CTS`**). Each line can be individually designated to be ignored, used with no specified timeout, or used with a selected timeout. The timeout is selected by specifying the number of milliseconds to wait for the indicated condition to become satisfied.
- **Data Bits:** Data formats from 5 though 8 Data Bits are supported.
- **DSR Timeout:** The driver supports 3 hardware handshake lines: Data Carrier Detect (**`DCD`**), Data Set Ready (**`DSR`**), and Clear To Send (**`CTS`**). Each line can be individually designated to be ignored, used with no specified timeout, or used with a selected timeout. The timeout is selected by specifying the number of milliseconds to wait for the indicated condition to become satisfied.
- **Stop Bits:** With 6, 7, or 8 Data Bits specified, either 1 or 2 Stop Bits are allowed. With 5 Data Bits specified, 1 or 1.5 Stop Bits may be selected.

- **DCD Timeout:** The driver supports 3 hardware handshake lines: Data Carrier Detect (`DCD`), Data Set Ready (`DSR`), and Clear To Send (`CTS`). Each line can be individually designated to be ignored, used with no specified timeout, or used with a selected timeout. The timeout is selected by specifying the number of milliseconds to wait for the indicated condition to become satisfied.
- **Timeout (ms):** The time out period is the amount of time that data transfers wait before assuming that the device does not transfer data. If the time out period elapses while waiting to transfer data, an error signal occurs. This field is the default timeout for any bus request or action, measured in milliseconds. If no timeout is desired, the value may be set to zero.
- **Device Type:** This field specifies the type of device represented by the serial external device name selected.
- **I/O Address:** The I/O Address is the computer bus address for the board. It is set to default values during the initial installation. These values, as listed in the table, can be changed. However, using the pre-selected values is recommended. Any conflict will be noted by a pop-up help screen.

I/O Comm.	Default Address Values
COM1	typically address 3F8
COM2	typically address 2F8
COM3	typically address 3E8
COM4	typically address 2E8

- **Bus Terminators:** The bus terminators specify the characters to be appended to data that is sent to the external device, or mark the end of data that is received from the external device.

Configuration of IEEE 488 External Devices

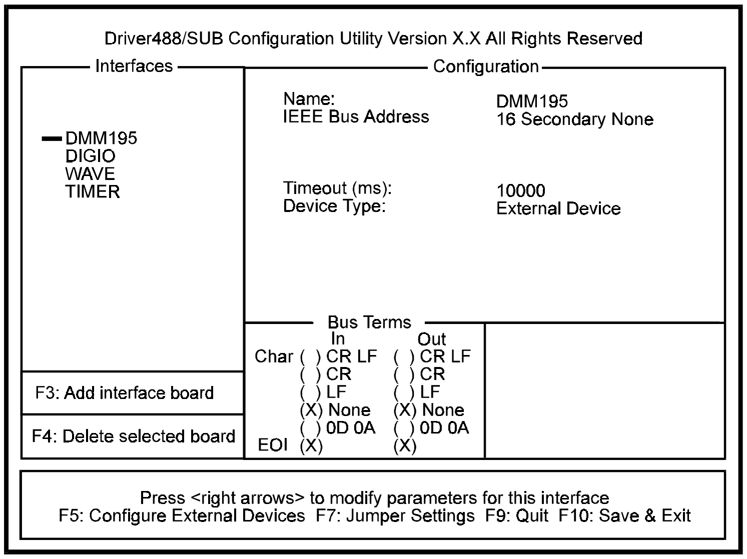
Configuration of IEEE 488 external devices under Driver488/SUB is done by editing an initialization file that stores the specific configuration information about all of the configured external devices. The configuration for each device is set when the Driver488/SUB loads itself into memory and is present at the start of the application program.

Each external device requires a handle to communicate with Driver488/SUB. An external device handle is a means of maintaining a record about 3 configurable items: its IEEE 488 bus address, its IEEE 488 bus terminators, and its time out period. Any communication with the external device uses these three items. The different configurable items are listed in the following figure. These items define the external device. All external devices have either a default value or a user supplied value for the different fields. All fields can be changed by Driver488/SUB commands during program execution.

The following figure displays the configuration screen of an external device named `DMM195`. When configuring an IEEE interface, this screen can be accessed by selecting **`<F5>: Configure External Devices`**.

To add additional devices, use **`<F3>`**. Note this external device screen is also used to configure MP488CT Digital I/O (**`DIGIO`**) and Counter/Timers (**`TIMER`**).

The following parameters are available for modification:



```
Driver488/SUB Configuration Utility Version X.X All Rights Reserved
Interfaces                 Configuration
                           Name:                DMM195
                           IEEE Bus Address     16 Secondary None
— DMM195
  DIGIO
  WAVE
  TIMER                    Timeout (ms):        10000
                           Device Type:         External Device

                               Bus Terms
                                In          Out
                           Char ( ) CR LF   ( ) CR LF
                                ( ) CR      ( ) CR
F3: Add interface board         ( ) LF      ( ) LF
                                (X) None    (X) None
F4: Delete selected board       ( ) 0D 0A   ( ) 0D 0A
                           EOI  (X)         (X)

Press <right arrows> to modify parameters for this interface
F5: Configure External Devices  F7: Jumper Settings  F9: Quit  F10: Save & Exit
```

Configuration Utility for External Devices

Configuration Parameters

- **Name:** External device names are user defined names which are used to convey the configuration information about each device, from the initialization file to the application program. Each external device must have a name to identify its configuration to Driver488/SUB. The name can then be used to obtain a handle to that device which will be used by all of the Driver488/SUB commands. External device names consist of 1 to 32 characters, and the first character must be a letter. The remaining characters may be letters, numbers, or underscores (_). External device names are case insensitive; upper and lower case letters are equivalent. **`ADC`** is the same device as **`adc`**.

- **IEEE Bus Address:** This is the setting for the IEEE 488 bus address of the board. It will be checked against all the devices on the bus for conflicts. The IEEE 488 bus address consists of a primary address from `00` to `30`, and an optional secondary address from `00` to `30`. Where required, Driver488/SUB accepts a secondary address of `-1` to indicate “NONE.”
- **Timeout (ms):** The time out period is the amount of time that data transfers wait before assuming that the device does not transfer data. If the time out period elapses while waiting to transfer data, an error signal occurs. This field is the default timeout for any bus request or action, measured in milliseconds. If no timeout is desired, the value may be set to zero.
- **Device Type:** This field specifies the type of device represented by the external device name selected.
- **Bus Terminators:** The IEEE 488 bus terminators specify the character(s) and/or end-or-identify (**`EOI`**) signal that is to be appended to data that is sent to the external device, or mark the end of data that is received from the external device.

Note: Because secondary addresses and bus terminators are specified by each handle, it may be useful to have several different external devices defined for a single IEEE 488 bus device. For example, separate device handles would be used to communicate with different secondary addresses within a device. Also, different device handles might be used for communication of command and status strings (terminated by carriage return/line feed) and for communication of binary data (terminated by **`EOI`**).

Note: If installation or configuration problems exist, refer to “Section IV: Troubleshooting.”

To save your changes to disk, press **`<F10>`**. All changes will be saved in the directory where you installed Driver488/SUB. If at any time you wish to alter your Driver488/SUB configuration, simply rerun **`CONFIG`**..

9C. External Device Interfacing

Topics

Introduction

This Sub-Chapter is a technical review of external device interfacing. It contains information on how to use external devices and multiple interfaces.

Driver488/SUB controls I/O adapters and their attached external devices. In turn, Driver488/SUB is controlled via *subroutine calls*.

Driver488/SUB communicates directly with I/O adapters such as an IEEE 488 interface board or a serial (RS-232C) port. More than one I/O adapter may reside on a single plug-in board. For example, an RS-232C board often contains two or four functionally separate I/O adapters, one for each port. The IEEE 488 interface board contains the IEEE 488 I/O adapter.

I/O adapters connect to external devices such as digitizers, multimeters, plotters, and oscilloscopes (IEEE 488 interface); and serial devices such as printers, plotters, and modems (serial RS-232C port). Driver488/SUB allows direct control of both IEEE 488 external devices and other external devices such as an RS-232C plotter.

Driver488/SUB is controlled by sending data and commands and receiving responses and status by *subroutine calls*. This method is the only Application Program Interface, API, available to connect the application (user's) program to Driver488/SUB.

Subroutine Calls

The subroutine API is a library of subroutines linked to the application program that are invoked like any other subroutines in that programming language. Once invoked, these routines can control Driver488/SUB.

Configuration of Named Devices

Named devices provide a method to maintain a permanent record of an external device's configuration that does not change between application programs. Once the configuration of a particular external device is established, its Driver488/SUB configuration for that device will remain the same until the next time you reconfigure it or unload and reload the driver. The external devices supported by Driver488/SUB are: IEEE 488 external devices and serial external devices.

External devices are most easily configured at installation. For Driver488/SUB, the device names, terminators, timeout period, and bus addresses may be entered into a configuration file which contains the device configuration information. This configuration file is automatically read during driver load to install the configured named devices. The application program can then refer to the external device by name and have all of the configuration information automatically set.

Every device to be accessed by Driver488/SUB must have a valid device name. Driver488/SUB comes with several device and interface names preconfigured for use. Among those already configured for the GP488B board, for example, are: **`IEEE`** and **`DEV`**. You can configure up to 32 external devices for each IEEE 488 interface. **`DEV`** can be used to create other devices.

It is also possible to configure new named devices by using the Driver488/SUB command **`MakeDevice`**. The **`MakeDevice`** command creates a temporary device that is an identical copy of an already existing Driver488/SUB device. The new device has default configuration settings identical to those of the existing device. The new device can then be reconfigured by calling the proper functions, such as **`BusAddress`**, **`IntLevel`**, and **`TimeOut`**. When Driver488/SUB is closed, the new device is forgotten unless the **`KeepDevice`** command is used to make it permanent.

The following code illustrates how the subroutine API version of the **`MakeDevice`** command could be used to configure several new named devices. Using the C language subroutine interface, three named devices can be configured as follows:

```
dev = OpenName ("dev")
dmm = MakeDevice (dev, "DMM");
if (dmm == -1) {process error . . .}
err = BusAddress (dmm, 16, NOADDRESS);
if (err == -1) {process error . . . }
term.EOI = TRUE;
term.nChars = 2;
term.termChar [0] = '\r';
term.termChar [1] = '\n';
err=Term (dmm, &term, BOTH);
if (err == -1 {process error . . . }
adc = MakeDevice (dev, "ADC");
if (a == -1) {process error . . . }
err = BusAddress (adc,14,00);
if (err == -1) {process error . . .}
term,EOI = FALSE;
term.nChars = 1;
term.termChar [0] = '\n';
err = Term (adc,&term,BOTH);
if (err == -1) {process error . . .}

scope = MakeDevice (dev,"SCOPE");
if (scope == -1) {process error . . .}
err = BusAddress (scope,12,01);
if (err == -1) {process error . . .}
term.EOI = TRUE;
term.nChars = 0;
err = Term (scope,&term,BOTH);
if (err == -1) {process error. . .}
```

The above example defines the following: An external device named **DMM** (digital multimeter) as device **16** with bus terminators of carriage return (**\r**), line feed (**\n**), and **EOI**; a second external device named **ADC** (analog-to-digital converter) as device **14** with bus terminators of carriage return and line feed (together as **\n**); and a third external device named **SCOPE** (oscilloscope) as device **12** with bus terminators of **EOI** only.

External devices defined in a configuration file are permanent. Their definitions last until they are explicitly removed or until the configuration file is changed and Driver488/SUB is restarted. Devices defined after installation are normally temporary. They are forgotten as soon as the program finishes. The **KeepDevice** command can be used to make these devices permanent. The **RemoveDevice** command removes the definitions of devices even if they are permanent. These commands are described in further detail in the "Section III: Command Reference" of this manual.

Use of External Devices

When using subroutine Application Program Interface (API) functions, it is first necessary to obtain a device handle for the device(s) with which you wish to interact.

When using Driver488/SUB, the **OpenName** function must be the first function called in the program. It takes the name of the device to open and returns a handle for the specified interface board or device. Every other function can then use that handle to access the device.

The following program illustrates how Driver488/SUB might communicate with an analog-to-digital converter (**adc**) and an oscilloscope (**scope**):

```
DevHandleT ieee;              // handle to access the interface board ieee
DevHandleT adc;               // handle to access a ADC488
DevHandleT scope;             // handle to acess the scope
DevHandleT deviceList [5];    // array containing a list of device handles;
int err;
```

Communication with a single device:

```
adc = OpenName ("ADC");
```

If you use several devices, you must open each one:

```
ieee = OpenName ("IEEE") ;
scope = OpenName ("SCOPE") ;
deviceList [0] = adc;         // Add adc to the list of devices
deviceList [1] = scope        // Add oscilloscope to the list of devices
deviceList [2] = -1 ;         // End of list marker

Abort(ieee) ;                 // Send Interface Clear (IFC)

Output(scope, "SYST:ERR:?");  // Read SCOPE error status
Enter(scope,data) ;
printf(data) ;
```

```
Output(adc, "A0 C1 G0 R3 T0 X") ;     // Set up ADC488
Enter(adc,data) ;
printf (data) ;

ClearList (deviceList) ;      // Send a Selected Device Clear (SDC) to a list
Close (adc) ;                 // Close ADC488. Handle is now unavailable for
                              // access.
```

If we tried to call **`Output`** by sending the handle **`adc`** without first opening the name **`ADC`**, an error would result and **`Output`** would return a **`-1`** as shown below:

```
result = Output (adc, "A0 C1 G0 R3 T0 X");
printf ("Output returned: %d.\n",result);
```

should print:

```
Output returned: -1.
```

As mentioned above, named devices have another advantage: they automatically use the correct bus terminators and time out. When a named device is defined, it is assigned bus terminators and a time out period. When communication with that named device occurs, Driver488/SUB uses these terminators and time out period automatically. Thus **`Term`** commands are not needed to reconfigure the bus terminators for devices that cannot use the default terminators (which are usually carriage-return line-feed **`EOI`**). It is still possible to override the automatic bus terminators by explicitly specifying the terminators in an **`Enter`** or **`Output`** command, or to change them semi-permanently via the **`Term`** command. For more information, see the **`Enter`**, **`Output`**, and **`Term`** commands described in "Section III: Command References."

Extensions for Multiple Interfaces

Driver488/SUB allows the simultaneous control of multiple interfaces each with several attached devices. To avoid confusion, external devices may be referred to by their "full name" which consists of two parts. The "first name" is the hardware interface **`name`**, followed by a colon separator (**`:`**). The "last name" is the external device **`name`** on that interface. For example, the "full name" of **`DMM`** might be **`IEEE:DMM`**.

Duplicate Device Names

Duplicate device names are most often used in systems that consist of several identical sets of equipment. For example, a test set might consist of a signal generator and an oscilloscope. If three test sets were controlled by a single computer using three separate IEEE 488 interfaces, then each signal generator and each oscilloscope might be given the same name and the program would specify which test set to use by opening the correct interface (**`OpenName("IEEE")`** for one, **`OpenName("IEEE2")`** for the other), or by using the interface names when opening the devices (**`OpenName("IEEE:GENERATOR")`** for one and **`OpenName("IEEE2:GENERATOR")`** for the other).

Unique names are appropriate when the devices work together, even if more than one interface is used. If two different oscilloscopes, on two different interfaces are used as part of the same system, then they would each be given a name appropriate to its function. This avoids confusion and eliminates the need to specify the interface when opening the devices.

Access of Multiple Interfaces

If the computer only has one IEEE 488 interface, then there is no confusion, for every external device is known to be on that interface. As noted above, duplicate device names on one interface are not recommended; if they exist, the most recently defined device with the requested name will be used. When more than one interface is available and duplicate names appear on different interfaces, the following rules apply:

1. If the external device name is specified without its interface name, then any external device with that name may be used. If more than one external device has that name, then the choice of which particular external device is not defined.

2. If the external device name is specified with its interface name prefixed, then that external device on that hardware interface is used. If that external device is not attached to the specified hardware interface, then an error occurs.

Example

Assume there are three IEEE 488 interfaces: **`IEEE`**, **`IEEE2`**, and **`IEEE3`** controlling multiple devices: **`SCOPE`** (on **`IEEE`**), **`DA`** (on **`IEEE2`**) and **`DA`** (on **`IEEE3`**). Since there are two external devices, both named **`DA`**, their full name must be used to specify them.

We can communicate with the external devices, according to the two rules above.

```
scope = OpenName ("SCOPE") ;          // SCOPE on IEEE (Rule 1)
da = OpenName ("DA")                  // DA on IEEE2 or IEEE3 (not specified)
da = OpenName ("IEEE2:DA") ;          // DA on IEEE2 (Rule 2)
scope = OpenName ("IEEE2:SCOPE");     // Error (not IEEE:SCOPE) (Rule 2)
```

9D. Getting Started

Topics

Introduction

The following text outlines the steps necessary to produce an application program that communicates with Driver488/SUB. The application is the simplest one possible, it merely requests the revision number of the resident driver using the **`Hello`** command. Examples are provided in C, QuickBASIC and Pascal. Each of these supported languages are described in more detail in each of the next three Sub-Chapters “C Languages,” “QuickBASIC,” and “Pascal” of this Chapter. For further information on the **`Hello`** command, see the “Section III: Command References” of this manual.

C Language

To successfully operate Driver488/SUB, several declarations must be included in the user’s application program. These declarations are found in two headers which must be included in the main module of your C program. The two required headers can be found in the language-specific subdirectory at the end of the path **`\IEEE488\SUBAPI`**, if installed under the default conditions.

In the same directory as the headers, are the libraries for the different memory models. One of these libraries must be linked with your C project to resolve Driver488/SUB external references.

Required Headers

For Microsoft C and Quick C Users

- All programs must include the following header files to run with Driver488/SUB:

```
iotmc60.h
iot_main.h
```

- These header files must be included in your test program. To do so, insert the following lines:

```
#include "iotmc60.h"
#include "iot_main.h"
```

These lines must be included at the top of your program before any calls to the Driver488/SUB subroutine functions are made. Notice that the header file `iot_main.h` must be in the module containing your `main ( )` function and may not appear in any other modules.

For Turbo C Users

- All programs must include the following header files to run with Driver488/SUB:

```
iottc20.h
iot_main.h
```

- These header files must be included in your test program. To do so, insert the following lines:

```
#include "iottc20.h"
#include "iot_main.h"
```

These lines must be included at the top of your program before any calls to the Driver488/SUB subroutine functions are made. Notice that the header file `iot_main.h` must be in the module containing your `main ( )` function and may not appear in any other modules.

For Turbo C++ and Borland C++ Users

- All Turbo C++ programs must include the following header files to run with Driver488/SUB:

```
iottx20.h
iot_main.h
```

- These header files must be included in your test program. To do so, insert the following lines:

```
#include "iottx10.h"
#include "iot_main.h"
```

These lines must be included at the top of your program before any calls to the Driver488/SUB subroutine functions are made. Notice that the header file `iot_main.h` must be in the module containing your `main ( )` function and may not appear in any other modules.

Required Libraries

For Microsoft C & Quick C Users

- Driver488/SUB supports four memory models: "small," "medium," "compact" and "large." Include the `iotm60.h` and `iot_main.h` header files in your program and link in the proper Driver488/SUB library files, as shown below:

`iotmc60s.lib`	for small memory model programs.
`iotmc60m.lib`	for medium memory model programs.
`iotmc60c.lib`	for compact memory model programs.
`iotmc60l.lib`	for large memory model programs.

For more information on memory models, see the Sub-Chapter "Other Languages" in Chapter 8.

- Use the following command-line commands to compile and link your program. For example, the following commands create a compact model executable file using Microsoft C:

```
cl/AC hello.c iotmc60c.lib;
```

or

```
cl/c/AC hello.c
link hello.obj,,,iotmc60c.lib;
```

Similarly, the following commands create a compact model executable file, using Quick C:

```
qcl/c/AC hello.c
qlink hello.obj,,,iotmc60c.lib;
```

- Use the example test program to query Driver488/SUB for its `Hello` message:

```
#include "iotmc60.h"
#include "iot_main.h"
main ( ) {
       DevHandleT ieee;
       char response [100] ;

       Hello (ieee,response) ;
       printf ("--%s\n,response) ;
}
```

Upon execution, the following response is printed on the screen:

```
-- Driver488 ver 4.0........
```

To run this program, Driver488/SUB must be installed and resident. Successful operation of this program proves that the driver is installed and the Driver488/SUB subroutines were properly linked to the application program. Errors in setting up board parameters like DMA channel and interrupts will not be detected by this program.

For Turbo C Users

- Driver488/SUB supports four memory models: "small," "medium," "compact" and "large." (See the Sub-Chapter "Other Languages" in Chapter 8, for more information on memory models.) Include the `iottc20.h` and `iot_main.h` header files in your program and link in the proper Driver488/SUB library files, as shown below:

`iottc20s.lib`	for small memory model programs.
`iottc20m.lib`	for medium memory model programs.
`iottc20c.lib`	for compact memory model programs.
`iottc20l.lib`	for large memory model programs.

- Use the following command-line commands to compile and link your program. For example, the following commands create a compact model executable file:

```
tcc -mc hello.c iottc20c.lib
```

or

```
tcc -c -mc hello.c
tlink hello.obj + c0c.obj,,,cc.lib iottc20c.lib
```

- Use the example test program to query Driver488/SUB for its `Hello` message:

```
#include "iottc20.h"
#include "iot_main.h"
main ( ) {
       DevHandleT ieee;
       char response [100];

       Hello (ieee, response);
       printf ("--%s\n",response);
}
```

Upon execution, the following response is printed on the screen:

```
-- Driver488 ver 4.0........
```

To run this program, Driver488/SUB must be installed and resident. Successful operation of this program proves that the driver is installed and the Driver488/SUB subroutines were properly linked to the application program. Errors in setting up board parameters like DMA channel and interrupts will not be detected by this program.

For Turbo C++ and Borland C++ Users

- Driver488/SUB supports four memory models: "small," "medium," "compact" and "large." (See the Sub-Chapter "Other Languages" in Chapter 8, for more information on memory models.) Include the **`iottx10.h`** and **`iot_main.h`** header files in your program and link in proper Driver488/SUB library files, as shown below:

  `iottx10s.lib` for small memory model programs.
  `iottx10m.lib` for medium memory model programs.
  `iottx10c.lib` for compact memory model programs.
  `iottx10l.lib` for large memory model programs.

- Use the following command-line command to compile and link your program. For example, the following commands create a compact model executable file using Turbo C++:

```
tcc -mc hello.c iottx10c.lib
```
    or
```
tcc -c -mc hello.c
tlink hello.obj + c0c.obj,,,cc.lib iottx10c.lib
```

  Similarly, these commands create a compact model executable file, using Borland C++:

```
bcc -mc hello.c iottx10c.lib
```
    or
```
bcc -c -mc hello.c
tlink hello.obj + c0c.obj,,,c.lib iottx10c.lib
```

- Use the example test program to query Driver488/SUB for its **`Hello`** message:

```
#include "iottx10.h"
#include "iot_main.h"
main ( ) {
        DevHandleT ieee;
        char response [100];

        Hello (ieee, response);
        printf ("--%s\n", response);
}
```

  Upon execution, the following response is printed on the screen:

```
-- Driver488 ver 4.0........
```

  To run this program, Driver488/SUB must be installed and resident. Successful operation of this program proves that the driver is installed and the Driver488/SUB subroutines were properly linked to the application program. Errors in setting up board parameters like DMA channel and interrupts will not be detected by this program.

QuickBASIC

To successfully operate Driver488/SUB, a definition file must be included in the user's application program. This definition file can be found in the **`\IEEE488\SUBAPI\QB45`** subdirectory, if installed under the default conditions.

In the same directory as the definition file, are the libraries needed to access Driver488/SUB from QuickBASIC.

Required Definition File

All programs must include the `iotmqb45.def` definition file to run with Driver488/SUB. To include this program in your test program, insert the following line:

```
'$INCLUDE:  'iotmqb45.def'
```

This line should be included at the top of your program before any calls to the Driver488/SUB subroutine functions are made.

Required Libraries

Driver488/SUB can be accessed from QuickBASIC using the integrated environment and the DOS command line. If the QuickBASIC integrated environment is used, the `iotmqb45.qlb` quick library must be loaded into QuickBASIC. To do so, start QuickBASIC with the following DOS command:

```
qb /liotmqb45.qlb
```

If the command line compiler is used, the `iotmqb45.lib` library must be linked with your program with the following commands:

```
bc hello.bas;
link hello.obj,,,iotmqb45.libc:\qb45\brun45.lib;
```

Use the example test program to query Driver488/SUB for its `Hello` message:

```
'$INCLUDE: 'iotmqb45.def'
response$ = SPACE$ (100)
rv% = iohello%(ieee%,response$)
PRINT response$
END
```

Upon execution, the following response is printed on the screen:

```
-- Driver488 ver 4.0........
```

To run this program, Driver488/SUB must be installed and resident. Successful operation of this program proves that the driver is installed and the Driver488/SUB subroutines were properly linked to the application program. Errors in setting up board parameters like DMA channel and interrupts will not be detected by this program.

Pascal

To successfully operate Driver488/SUB, a library file must be included in the user's application program. The required library can be found in the language-specific subdirectory at the end of the path `\IEEE488\SUBAPI\TPAS60`, if installed under the default conditions.

Required Libraries

All programs need to include the following library file to run with Driver488/SUB:

```
iottp60.tpu
```

This library file must be included in your test program. To do so, insert the following line:

```
uses iottp60;
```

This line must be included at the top of your program before any calls to the Driver488/SUB subroutine functions are made.

Use the following command-line commands to compile and link your program. For example, the following command creates a compact model executable file:

```
tpc hello.c
```

Use the example test program to query Driver488/SUB for its `Hello` message:

```
program hello;
uses iottp60;
var
ieee : Integer;            { Device handles }
response : string;         { Text buffer for Driver488/SUB responses }
rv : Integer ;             { General purpose return value }

begin
       { Query Driver488/SUB for its hello message }
       rv:=ioHello (ieee, response) ;
       Writeln (response) ;
end.
```

Upon execution, the following response is printed on the screen:

```
-- Driver488 ver 4.0........
```

To run this program, Driver488/SUB must be installed and resident. Successful operation of this program proves that the driver is installed and the Driver488/SUB subroutines were properly linked to the application program. Errors in setting up board parameters like DMA channel and interrupts will not be detected by this program.

9E. C Languages

Topics

Accessing from a C Program

Note: Subroutines may be used with all C languages ***except*** Aztec C.

Driver488/SUB provides support for Microsoft C, Turbo C and Borland C. To allow for ready access to all Driver488/SUB functions and type definitions, an include file provides all required declarations. In addition, one include file must be included in the main module to provide for automatic detection of certain compiler options and enable the required adjustments within the driver. Note that the header files (`*.h`) must be included in your program and linked to the proper Driver488/SUB library files, as described in the previous Sub-Chapter "Getting Started." The following `#include` directives should appear near the beginning of the main module.

- For Borland C compilers:

```
#include "iot_main.h"
#include "iotbc20.h"
```

- For Microsoft compilers:

```
#include "iot_main.h"
```

```
#include “iotmc60.h”
```

- For Turbo C++ and Borland C++ compilers:

```
#include “iottx10.h”
#include “iot_main.h”
```

Notice that the header file `iot_main.h` must be in the module containing your `main ( )` function and may not appear in any other modules.

The following declarations are assumed through the remainder of this discussion:

```
DevHandleT adc,adc2,ieee,dev; /*Device handles*/
int hundred [100];            /*Driver488/SUB status structure*/
char response [256];          /*Text buffer for Driver488/SUB responses*/
int i;                        /*General purpose loop counter*/
float voltage;                /*Single reading variable*/
float sum;                    /*Summation used to compute average*/
IeeeStatusT substat;          /*Driver488/SUB status structure*/
int sp, stadc;                /*Driver488/SUB and ADC488 spoll response*/
int errnum;                   /*ADC488 error number*/
char errtext [64];            /*ADC488 error response*/
TermT noterm;                 /*Driver488 terminator structure*/
```

Establishing Communications

For the sake of this discussion, assume that Driver488/SUB has been configured to start with a configuration including the devices **IEEE** (IEEE 488 interface) and **ADC** (ADC488/8S connected to the IEEE 488 interface). Additional interfaces and/or devices may also have been defined, as the driver can support up to 4 interfaces and 56 devices simultaneously. To open the two devices of interest, we use the following statements:

```
ieee = OpenName (“IEEE”) ;
adc = OpenName (“ADC”) ;
```

If the **ADC** was not configured within Driver488/SUB, it can be optionally created “on the fly.” First, verify that opening the **ADC** failed, then use the **GetError** command to clear the error condition generated by this failure. Next, use the handle of the device **DEVIEEE**, which is always available within Driver488/SUB, to clone a new device called **ADC** using the **MakeDevice** command. Lastly, the IEEE bus address **14** is assigned to the **ADC**:

```
if  ((adc=OpenName (“ADC”))==-1) {
       GetError (ieee,response);
       dev=OpenName (“DEVIEEE”);
       adc=MakeDevice (dev,”ADC”);
       BusAddress (adc,14,-1);
}
```

If other devices were needed for the application at hand, they could either be defined in the startup configuration for Driver488/SUB or they could be created “on the fly” from the application:

```
adc2=MakeDevice (adc,”ADC2”) ;    / *Clone a new device */
BusAddress (adc2,10,-1) ;         // Set the bus address
```

The new device **ADC2** is configured to reside at a different bus address so that the two devices may be distinguished. There is one other important difference between **ADC** and **ADC2** at this point. **ADC2** is a temporary device; that is, as soon as the creating application closes, **ADC2** ceases to exist. If our intent was to create a device that could be accessed after this application ends, we must tell Driver488/SUB this:

```
KeepDevice (adc2) ;
```

After executing the previous statement, **ADC2** is marked as being permanent; that is, the device will not be removed when the creating application exists. If we later wish to remove the device, however, we can do so explicitly:

```
RemoveDevice (adc2) ;
```

Confirming Communication

With or without an open device handle, the application can, if desired, confirm communication with Driver488/SUB via the **`Hello`** function:

```
Hello (ieee,response) ;
printf ("%s\n",response) ;
```

The function also fills in a string, from which information can be extracted if it is desirable to display facts about the driver in use.

Setting Up Event Handling

If the event notification mechanism of Driver488/SUB is to be used, it should normally be set up during application initialization and left in place until application shutdown. No special action is required if event notification is not needed for the particular application. First, the **`OnEvent`** function establishes the notification path by specifying the function to be called, as follows:

```
OnEvent (ieee,isr, (OpaqueP)0) ;
```

Either during initialization or at some appropriate later point in the application, specific event types may be **`Arm`**ed or **`Disarm`**ed for use in the event system. Individual event types may be turned on and off at will freely through the life of the application. In this case, we **`Arm`** to request notification of IEEE 488 bus service requests:

```
Arm (ieee,acSRQ) ;
```

To cease recognizing bus service requests, we might **`Disarm`** just the one class of events:

```
Disarm (ieee,acSRQ) ;
```

Or, to completely disable event notifications:

```
Disarm (ieee,0) ;
```

Note that an external device handle is acceptable in this and other functions which actually refer to the interface; the external device handle will simply be translated to the handle of the interface to which the device is attached, prior to taking action. This translation is fully automatic within Driver488/SUB and requires little overhead, so you need not and should not go to great lengths to pass an interface handle, if your application structure makes the use of external device handles the more logical choice.

Reading Driver Status

Your application may interrogate Driver488/SUB at any time to determining its status and other information. **`Status`** information is returned in a structure provided by the application and can be displayed by the **`showstat`** function shown below:

```
Status (ieee,&substat) ;
showstat (&substat) ;
```

Another function to display the information contained in the **`Status`** structure could be:

```
void showstat (IeeeStatusT * substattt) {
      printf ("SC         : %d\t",substat->SC) ;
      printf ("CA         : %d\t",substat->CA) ;
      printf ("Primaddr   : %d\t",substat->Primaddr) ;
      printf ("Secaddr    : %d\n",substat->Secaddr) ;
      printf ("SRQ        : %d\t",substat->SRQ) ;
      printf ("addrChange : %d\t",substat->addrChange) ;
      printf ("talker     : %d\t",substat->talker) ;
      printf ("listener   : %d\n",substat->listener) ;
      printf ("triggered  : %d\t",substat->triggered) ;
      printf ("cleared    : %d\t",substat->cleared) ;
      printf ("transfer   : %d\t",substat->transfer) ;
      printf ("byteIn     : %d\n",substat->byteIn) ;
      printf ("byteOut    : %d\n",substat->byteOut) ;
}
```

External Device Initialization

Refer to the device manufacturer's documentation on specific requirements for initializing your IEEE 488 instrument. In the case of the ADC488, appropriate initialization involves sending it a **`Clear`** command and placing it into **`Remote`** mode:

```
Clear (adc) ;
Remote (adc) ;
```

For our hypothetical application, we also wish to have the ADC488 generate a service request should it detect a command error. This involves sending a command string consisting of textual data to the ADC488:

```
Output (adc, "M8X") ;
```

We may also wish to perform other initialization and configuration. In this case, we set up the ADC488 (**`adc`**) in the following configuration:

```
/* Setup the ADC488
       Differential inputs (A0)
       Scan group channel 1 (C1)
       Compensated ASCII floating-point output format (G0)
       Channel 1 range to +/-10V (R3)
       One-shot trigger on talk (T6)
*/
```

The command to perform this configuration combines the above strings and adds the **`Execute`** (**`X`**) command for the ADC488:

```
Output (adc,"A0C1G0R3T6X") ;
```

Interrupt Handling

In case we send out an invalid command, either due to a programming error or an unanticipated condition in the equipment, Driver488/SUB will automatically notify the interrupt handling function as established above:

```
Output (adc,"V13X") ;
```

The interrupt handler as established above might consist of a function similar to the following:

```
void isr (OpaqueP param)  {
       int    sp,
              stadc,
              errnum;
       char   errtext [64] ;

       /* Print parameter passed to isr to screen */
       printf (" In intrrupt handler, param=%d\n",param) ;

       /* Check if the intrrupt was due to a Service Request */
       sp=SPoll (ieee) ;
       if (sp==0)  {
              printf (" No SRQ detected\n") ;
              exit (1) ;
       }

       /* Check that the Service Request was from the ADC488 */
       stadc=SPo;l (adc) ;
       if ((stadc&0x40)==0)  {
              printf (" Not an ADC488 SRQ.\n") ;
              exit (1) ;
       }

       /* Interpret the Serial Poll response */
       if (stadc&0x01)
              printf (" Triggered\n") ;
       if (stadc&0x02)
```

```
                        printf (" trigger overrun\n") ;
                if (stadc&0x04)
                        printf (" Buffer overrun\n") ;
                if (stadc&0x08)  {
                        /* Read and interpret the ADC488 error status */
                        printf (" ADC488 error\n") ;
                        Output (adc,"E?") ;
                        Enter (adc,errtext) ;
                        sscanf (errtext,"E%d",&errnum) ;
                        if (errnum&0x01)
                                printf ("  Invalid DDC\n") ;
                        if (errnum&0x02)
                                printf ("  Invalid DDC option\n") ;
                        if (errnum&0x04)
                                printf ("  Conflict error\n") ;
                        if (errnum&0x08)
                                printf (" NVRAM setup error\n") ;
                        if (errnum&0x10)
                                printf ("  Calibration error\n") ;
                        if (errnum&0x20)
                                printf ("  NVRAM calibration error\n") ;
                }
                if (stadc&0x20)
                        printf ("  Ready\n") ;
                if (stadc&0x40)
                        printf ("  SRQ asserted\n") ;
                if (stadc&0x80)
                        printf ("  Data acquisition complete\n") ;
                /* Set up interrupt pointers */
                OnEvent (ieee, isr, (OpaqueP)0) ;
        }
```

Basic Data Acquisition

With both Driver488/SUB and the external device ready for action, we next might try taking a simple reading using the ADC488. Here, we use the serial poll (`SPoll`) capabilities of Driver488/SUB to determine when a response is ready and to format the reply:

```
while((SPoll (adc) & 32) ==0) ;
Enter(adc,response) ;
sscanf(response,"%f",&voltage) ;
printf("ADC488 channel #1 reading valve is %g\n",voltage) ;
```

Block Data Acquisition

First, we set up the ADC488 (`adc`) in the following configuration:

```
/* Setup the ADC488:
        Compensated binary output format (G10)
        100 usec scan interval (I3)
        No pre-trigger scans, 100 post-trigger scans (N100)
        Continuous trigger on GET (T1)

*/
```

We then wait for the ADC488 to start the acquisition process. Once the acquisition is complete, which is determined by the MSB of the ADC488's serial poll response, the buffer pointer of the ADC488 is reset (`B0`).

```
Output(adc, "G10I3N100T1X");

/* wait for the ready bit of the ADC488 to be asserted */
while ((SPoll(adc) & 32) == 0);

/* Trigger the ADC488 */
Trigger(adc);

/* wait for the acquisition complete bit of ADC488 to be asserted */
while ((SPoll(adc) & 128) == 0);
```

```
/* Reset the buffer pointer of the ADC488 */
Output(adc, "B0X");
```

Next, we fill the buffer with 100 readings from the ADC488. Since the data being returned from the ADC488 is in a binary format, the `noterm` terminator structure is used to disable scanning for terminators such as carriage-return and line-feed:

```
noterm.EOI=0 ;
noterm.nChar=0 ;
EnterX (adc, (char*) hundred,200,1,&noterm,1,0L) ;
```

The `EnterX` function will use a DMA transfer if available. Because DMA transfers are performed entirely by the hardware, the program can continue with other work while the DMA transfer function occurs. For example, the program will process the previous set of data while collecting a new set of data into a different buffer. However, before processing the data we must wait for the transfer to complete. For illustration purposes, we query the Driver488/SUB status both before and after waiting.

```
/* Display DRIVER488/W31 status */
Status (ieee,&substat) ;
showstat (&substat) ;

/* Wait for completion of input operation*/
Wait (adc) ;

/* Display DRIVER488/W31 status */
Status (ieee,&substat) ;
showstat (&substat) ;
```

Now we process the buffer:

```
/* Print the received characters */
for (i=0;id;i++)  {
      printf ("%6d",hundred [i]) ;
      if ((i%10)==9)
            printf ("\n") ;
}
```

The functions described so far in this Sub-Chapter provide enough functionality for a *basic data acquisition* program. The following program listing covers the examples used. Additional functions provided by Driver488/SUB are described in the "Section III: Command References" of this manual.

Sample Program

```
#include<stdio.h>
#include<stdlib.h>
#include<string.h>
#include"iot_main.h"
#include"iottx10.h"

void showstat (IeeeStatusT*) ;
void isr (OpaqueP) ;  /*handle inerrupt*/

DevHandleT   adc,ieee,dev;
int          hundred[100] ;

void main ( )
{
      char   response [256] ;
      int    i;
      float  voltage,
             sum;
      IeeeStatusT  substat ;

      /*establish communications with Driver488/SUB*/
      if ((ieee=OpenName ("IEEE"))==-1)  {
            printf ("Cannot initialize IEEE system.\n") ;
            exit (1) ;
      }
```

```
/*Disable the automatic onscreen error display*/
Error (ieee,OFF) ;

/*Open the ADC488 devie handle or create if necessary*/
if ((adc=OpenName (“ADC”))==-1  {
       GetError (ieee,response) ;
       dev=OpenName (“DEVIEEE”) ;
       adc=MakeDevice (dev,”ADC”) ;
       BusAddress (adc,14,-1) ;
}

/* Read the Driver488/SUB revision number */
Hello (ieee,response) ;
printf (“%s\n”,response) ;

/*Set up interrupt pointers */
OnEvent (ieee,isr, (OpaqueP)0) ;

/*Enable Driver488/SUB interrupt on Error or Service Request */
Arm (ieee,acSRQ) ;

/*Display the Driver488/SUB system status */
Status (ieee,&substat) ;
showstat (&substat) ;

/*Put the ADC488 into remote mode */
Remote (adc) ;

/*Clear the ADC488*/
Clear (adc) ;

/*Enable ADC488 SRQ on command errors */
Output (adc,”M8X”) ;

/*Send an invlaid command to the ADC488 */
printf (“Sending invalid ADC command\n”) ;
Output (adc,”V13X”) ;

/*Setup the ADC488:
       Differential inputs (a0)
       Scan grou channel 1 (C1)
       Compensated ASCII floating-point output format (G0)
       Channel 1 range to +/-10v (R3)
       One-shot trigger on talk (T6)
*/
Output (adc,”A0C1G0R3T6X”) ;

/*Wait for the ready bit of the ADC488 to be asserted */
while ((SPoll (adc) & 32 ==0) ;

/*Display a reading */
Enter   (adc,reponse) ;
sscanf (response,”%f”,&voltage) ;
printf (“ADC488 channel #1 reading value is %g\n”,voltage) ;

/*Display the average of 10 readings */
sum=0.0 ;
for (i=0;i;i++)  {
       Enter (adc,response) ;
       sscanf (response,”%f”,voltage) ;
       sum=sum+voltage;
}
printf (“The average of 10 readings is %g\n”,sum/10.0) ;

/*Setup the ADC488:
       Compensated binary output format (G10)
       100u sec scan interval (I3)
       No pre-trigger scans, 100 post-trigger scans (n100)
       Continuous trigger on GET (T1)
*/
Output (adc,"G10I3N100T1X") ;

/*Wait for the ready bit of the ADC488 to be asserted*/
while ((SPoll (adc) &32)==0) ;

/*Trigger the ADC488 */
Trigger(adc);

/*Wait for the acquisition complete bit to be asserted*/
while ((SPoll (adc) &128)==0) ;

/*Reset the buffer pointer of the ADC488 */
Output (adc,"BOX") ;

/*Take 100 readings from the ADC488* /
noterm.EOI=0;
noterm.nChar=0;
EnterX(adc, (char*)hundred,200,1,&noterm,1,0L);

/*Check the Status before and after waiting */
Status (ieee,&substat) ;
showstat (&substat) ;

/* Wait for completion of input operation */
Wait (adc);

/*Display the Driver488/SUB system status */
Status (ieee,&substat) ;
showstate (&substat) ;

/* Print the received characters */
for (i=0;id;i++)  {
       printf("%6d",hundred[i]) ;
       if ((i%10)==9)
              printf ("\n") ;
       }
}

/*Interrupt service routine for Driver488/SUB interrupts */
void isr (OpaqueP param)  {
       int    sp,
              stadc,
              errnum;
       char   errtext [64] ;

/*Print parameter passed to isr to screen */
printf (" In interrupt handler, param=%d\n",param) ;

/* Check if the interrupt was due to a Service Request */
sp=SPoll (ieee) ;
if (sp==0)  {
       printf (" No SRQ detected\n") ;
       exit (1) ;
}

/* Check that the Service Request was from the ADC488 */
stadc=SPoll (adc) ;
if ((stadc&0x40)==0) {
       printf(" Not an ADC488 SRQ.\n") ;
       exit (1) ;
}

/* Interpret the Serial Poll response */
```

```
            if (stadc&0x01)
                  printf (" Triggered\n") ;
            if (stadc&0x02)
                  printf (" Trigger overrun\n") ;
            if (stadc&0x04)
                  printf (" Buffer overrun\n") ;
            if (stadc&0x08)  {
                  /* Read and interpret the ADC488 error status * /
                  printf (" ADC488 error\n") ;
                  errnum=5;
                  Output (adc,"E?") ;
                  Enter (adc,errtext) ;
                  sscanf (errtext,"E%d",&errnum) ;
                  if (errnum&0x01)
                        printf(" Invalid DDC\n") ;
                  if (errnum&0x02)
                        printf(" Invalid DDC option\n") ;
                  if (errnum&0x04)
                        printf(" Conflict error\n") ;
                  if (errnum&0x08)
                        printf(" NVRAM setup error\n") ;
                  if (errnum&0x10)
                        printf(" Calibration error\n") ;
                  if (errnum&0x20)
                        printf(" NVRAM calibration error\n") ;
            }
            if (stadc&0x20)
                  printf (" Ready\n") ;
            if (stadc&0x40)
                  printf(" SRQ asserted\n") ;
            if (stadc&0x80)
                  printf(" Data acquisition complete \n") ;

            /* Set up interrpt pointers */
            OnEvent (ieee,isr,(OpaqueP) 0) ;
      }

      /* Display Status from Driver488/SUB */
      void showstate (IeeeStatusT *substat)  {
            printf ("SC         : %d\t",substat->SC) ;
            printf ("CA         : %d\t",substat->CA) ;
            printf ("Primaddr   : %d\t",substat->Primaddr) ;
            printf ("Secaddr    : %d\t",substat->Secaddr) ;
            printf ("SRQ        : %d\t",substat->SRQ) ;
            printf ("addrChange : %d\t",substat->addrChange) ;
            printf ("talker     : %d\t",substat->talker) ;
            printf ("listener   : %d\t",substat->listener) ;
            printf ("triggered  : %d\t",substat->triggered) ;
            printf ("cleared    : %d\t",substat->cleared) ;
            printf ("transfer   : %d\t",substat->transfer) ;
            printf ("byteIn     : %d\t",substat->byteIn) ;
            printf ("byteOut    : %d\t",substat->byteOut) ;
      }
```

Command Summary

To obtain a summary of the C language commands for Driver488/SUB, turn to the "Section III: Command References" of this manual.

9F. QuickBASIC

Topics

Accessing from a QuickBASIC Program

Driver488/SUB provides support for Microsoft QuickBASIC. To allow for ready access to all Driver488/SUB functions and type definitions, a definition file provides all required declarations. Note the definition file (`*.def`) must be included in your program and linked to the proper Driver488/SUB library files, as described in the Sub-Chapter “Getting Started” earlier in this Chapter. The following `$include` directives should appear near the beginning of the program:

```
‘$include: ‘IOTMQB45.DEF’
```

The following declarations are assumed throughout the remainder of this discussion.

```
DIM adc%,adc2%,ieee%,dev,% ’ Device handles
DIM hundred% (100) ;       ’ Driver488/SUB status structure
DIM response$ (256)        ’ Text buffer for Driver488/SUB responses
DIM i%                     ’ General purpose loop counter
DIM voltage !              ’ Single reading variable
DIM sum !                  ’ Summation used to compute average
DIM substat as Ieee status ’ Driver488/SUB status structure
DIM sp%,stadc%             ’ Driver488/SUB and ADC488 spoll response
DIM errnum%                ’ ADC488 error number
DIM errtext$ (64)          ’ ADC488 error response
DIM rv%                    ’ Driver488/SUB return value
DIM noterm as terms        ’ Driver488/SUB terminator structure
```

Establishing Communications

For the sake of this discussion, assume that Driver488/SUB has been configured to start with a configuration including the devices `IEEE` (IEEE 488 interface) and `ADC` (ADC488/8S connected to the IEEE 488 interface). Additional interfaces and/or devices may also have been defined, as the driver can support up to four interfaces and 56 devices simultaneously. To open the two devices of interest, we use the following statements:

```
ieee% = ioOpenName% (“IEEE”)
adc% = ioOpenName% (“ADC”)
```

If the `ADC` was not configured within Driver488/SUB, it can be optionally created “on the fly.” First verify that opening the `ADC` failed, then use the `GetError` command to clear the error condition generated by this failure. Next, use the handle of the device `DEVIEEE`, which is always available within

Driver488/SUB, to clone a new device called **ADC** using the **MakeDevice** command. Lastly, the IEEE bus address **14** is assigned to the **ADC**.

```
adc% = ioOpenName% ("ADC")
IF (adc% = 1) THEN
      response$ = SPACES (256)
      rv% = ioGetError% (ieee%, response$)
      dev% =ioOpenName% ("DEVIEEE")
      adc% = ioMakeDevice% (dev%,"ADC")
      rv% = ioBusAddress% (adc%,14,-1)
END IF
```

If other devices were needed for the application at hand, they could either be defined in the startup configuration for Driver488/SUB or they could be created on the fly from the application:

```
adc2% = ioMakeDevice% (adc%,"ADC2") ;   /*Clone a new device */
rv% = ioBusAddress% (adc2%,10,-1) ;     // Set the bus address
```

The new device **ADC2** is configured to reside at a different bus address so that the two devices may be distinguished. There is one other important difference between **ADC** and **ADC2** at this point. **ADC2** is a temporary device; that is, as soon as the creating application closes, **ADC2** ceases to exist. If our intent was to create a device that could be accessed after this application ends, we must tell Driver488/SUB this:

```
rv%=ioKeepDevice% (adc2%) ;
```

After executing the above statement, **ADC2** is marked as being permanent; that is, the device will not be removed when the creating application exists. If we later wish to remove the device, however, we can do so explicitly:

```
rv%=ioRemoveDevice% (adc2) ;
```

Confirming Communications

With or without an open device handle, the application can, if desired, confirm communication with Driver488/SUB via the **Hello** function:

```
response$ = SPACES (256)
rv% = ioHello% (ieee%,response$)
PRINT response$
```

The function also fills in a string from which information can be extracted if it is desirable to display facts about the driver in use:

Setting Up Event Handling

If the event notification mechanism of Driver488/SUB is to be used, it should normally be set up during application initialization and left in place until application shutdown. No special action is required if event notification is not needed for the particular application. First, the **ONPEN GOSUB** and **PEN ON** functions establish the notification path by specifying the function to be called:

```
ON PEN GOSUB isr
PEN ON
rv% = ioLightPen% (ieee%, 1)
```

Either during initialization or at some appropriate later point in the application, specific event types may be **Arm**ed or **Disarm**ed for use in the event system. Individual event types may be turned on and off at will freely through the life of the application. In this case, we **Arm** to request notification of IEEE 488 bus service requests:

```
rv% = ioArm% (ieee%, acSRQ)
```

To cease recognizing bus service requests, we might **Disarm** just the one class of events:

```
rv% = ioDisarm% (ieee%, acSRQ) ;
```

Or, to completely disable event notifications:

```
rv% = ioDisarm% (ieee%, 0) ;
```

Note that an external device handle is acceptable in this and other functions which actually refer to the interface; the external device handle will simply be translated to the handle of the interface to which the device is attached, prior to taking action. This translation is fully automatic within Driver488/SUB and requires little overhead, so you need not and should not go to great lengths to pass an interface handle, if your application structure makes the use of external device handles the more logical choice.

Reading Driver Status

Your application may interrogate Driver488/SUB at any time to determine its status and other information. **`Status`** information is returned in a structure provided by the application and can be displayed by the **`showstat`** function shown below:

```
rv%=ioStatus%(ieee%,substat)
CALL showstat (substat)
```

Another function to display the information contained in the **`Status`** structure could be:

```
SUB showstat (substat AS IeeeStatus)
      PRINT "SC           :"; substat.SC,
      PRINT "CA           :"; substat.CA,
      PRINT "Primaddr     :"; substat.Primaddr
      PRINT "Secaddr      :"; substat.Secaddr,
      PRINT "SRQ          :"; substat.SRQ,
      PRINT "addrChange   :"; substat.addrChange
      PRINT "talker       :"; substat.talker,
      PRINT "listener     :"; substat.listene,
      PRINT "triggered    :"; substat.triggered
      PRINT "cleared      :"; substat.cleared,
      PRINT "transfer     :"; substat.transfer,
      PRINT "byteIn       :"; substat.byteIn
      PRINT "byteOut      :"; substat.byteOut
END SUB
```

External Device Initialization

Refer to the device manufacturer's documentation on specific requirements for initializing your IEEE 488 instrument. In the case of the ADC488, appropriate initialization involves sending it a **`Clear`** command and placing it into **`Remote`** mode:

```
rv% = ioRemote% (adc%)
rv% = ioClear% (adc%)
```

For our hypothetical application, we also wish to have the ADC488 generate a service request should it detect a command error. This involves sending a command string consisting of textual data to the ADC488:

```
rv% = ioOutput & (adc%, "M8X")
```

We may also wish to perform other initialization and configuration. In this case, we set up the ADC488 (**`adc`**) in the following configuration:

```
Differential inputs (A0)
Scan group channel 1 (C1)
Compensated ASCII floating-point output format (G0)
Channel 1 range to +/-10V (R3)
One-shot trigger on talk (T6)
```

The command to perform this configuration combines the above strings and adds the **`Output`** command for the ADC488:

```
rv% = ioOutput& (adc%, "A0C1G0R3T6X")
```

Interrupt Handling

In case we send out an invalid command, either due to a programming error or an unanticipated condition in the equipment, Driver488/SUB will automatically notify the interrupt handling function as established above:

```
rv% = ioOutput & (adc%, "V13X")
```

The interrupt handler as established above might consist of a function similar to the following:

```
' Interrupt service routine for Driver488/SUB interrupts
isr :
' Print isr message to screen
PRINT " In interrupt handler"

' Check if the intrrupt was due to a Service Request
sp% = ioSPoll % (ieee%)
IF (sp% = 0) THEN PRINT " No SRQ detected": END

' Check that the Service Request ws from the ADC488
stadc% = ioSPoll%(adc%)
IF ((stadc% AND 64) = 0) THEN PRINT " Not an ADC488 SRQ.": END

' Interpret the Serial Poll response
IF ((stadc% AND 1) >0) THEN PRINT "Triggered"
IF ((stadc% AND 2) >0) THEN PRINT "Trigger overrun"
IF ((stadc% AND 4) >0) THEN PRINT "Buffer overrun"
IF ((stadc% AND 8) >0) THEN
       ' Read and interpret the ADC488 error status
       PRINT " ADC488 error"
       rv% = ioOutput & (adc%, "E?")
       errtext$ = SPACE$ (64)
       rv% = ioEnter& (adc%, errtext$)
       errnum% = VAL (RIGHT$ (errtex$, LEN (errtext$) - 1))
       IF ((errnum AND 1) >0) THEN PRINT " Invalid DDC"
       IF ((errnum AND 2) >0) THEN PRINT " Invalid DDC option"
       IF ((errnum AND 4) >0) THEN PRINT " Conflict error"
       IF ((errnum AND 8) >0) THEN PRINT " NVRAM setup error"
       IF ((errnum AND 16) >0) THEN PRINT " Calibration error"
       IF ((errnum AND 32) >0) THEN PRINT " NRRAM calibration error"
END IF
IF ((stadc% AND 32) >0) THEN PRINT " ready "
IF ((stadc% AND 64) >0) THEN PRINT " SRQ asserted"
IF ((stadc% AND 128) >0) THEN PRINT " Data acquisition complete"
RETURN
```

Basic Data Acquisition

With both Driver488/SUB and the external device ready for action, we next might try taking a simple reading using the ADC488. Here, we use the serial poll (`SPoll`) capabilities of the system to determine when a response is ready and format the reply.

```
WHILE ((ioSPoll%(adc%) AND 32) = 0) : WEND
response$ = SPACE$ (256)
rv% = ioEnter& (adc%, response$)
voltage ! = VAL (reponse$)
PRINT "ADC488 channel #1 rading value is "; voltage!
```

Block Data Acquisition

First, we set up the ADC488 (`adc`) in the following configuration:

```
Compensated binary output format (G10)
100 usec scan interval (I3)
No pre-trigger scans = 0, 100 post-trigger scans (N100)
Continuous trigger on GET (T1)
```

We then wait for the ADC488 to start the acquisition process. Once the acquisition is complete, which is determined by the MSB of the ADC488's serial poll response, the buffer pointer of the ADC488 is reset (**B0**).

```
rv% = ioOutput& (adc%, "G10I3N100T1X")
WHILE ((ioSPoll% (adc%) AND 32) = 0) : WEND
rv% = ioTrigger% (adc%)
WHILE ((ioSPoll% (adc%) AND 128) = 0) : WEND
rv% = ioOutput& (adc%, "BOX")
```

Next, we fill the buffer with 100 readings from the ADC488. The **noterm** terminator structure is used to disable scanning for terminators such as carriage-return and line-feed.

```
noterm.eoi = 0
noterm.nChar = 0
hundred$ = SPACES (200)
rv% = ioEnterX& (adc%, hundred$, 200, 1, noterm, 1, 0)
```

The **EnterX** function will use a DMA transfer if available. Because DMA transfers are performed entirely by the hardware, the program can continue with other work while the DMA transfer function occurs. For example, the program will process the previous set of data while collecting a new set of data into a different buffer. However, before processing the data we must wait for the transfer to complete. For illustration purposes, we query the Driver488/SUB status both before and after waiting.

```
rv% = ioStatus% (ieee%, substat)
CALL showstat (substat)

rv% = ioWait% (adc%)

rv% = ioStatus% (ieee%, substat)
CALL showstat (substat)
```

Now we process the buffer:

```
FOR i = 0 to 99
       PRINT CVI (MID$ (hundred$, i * 2 +1, 2)) ;
       IF ((iMOD 10) = 9) THEN PRINT
NEXT I
```

The above functions provide enough functionality for a *basic data acquisition* program. Additional functions provided by Driver488/SUB are described in the "Section III: Command References" of this manual.

Sample Program

```
'$INCLUDE:'iotmqb45.def'
DECLARE SUB showstat (substat AS IeeeStatus)

COMMON SHARED adc%, ieee%, dev%
DIM hundred$ (200) , response$ (256), i%, voltage!, sum!, substat AS
IeeeStatus
DIM rv%, noterm AS terms

' establish communications with Driver488/SUB
ieee% = ioOpenName% ("IEEE")
IF (ieee% = -1) THEN PRINT "Cannot initialize IEEE system.": END

' Disable the automatic onscreen error display
rv% = ioError% (ieee%, TURNOFF)

' Open the ADC488 device handle or create if necessary
adc% = ioOpenName% ("ADC")
IF (adc% = -1) THEN
       response$ = SPACE$ (256)
       rv% = ioGet Error% (ieee%, response$)
       dev% = ioOpenName% (dev%, "ADC")
       rv% = ioBusAddress% (adc%, 14, -1)
END IF
```

```
‘ Read the Driver488/SUB revision number
response$ = SPACE$ (256)
rv% = ioHello% (ieee%, response$)
PRINT response%

‘ Set up interrupt pointers
ON PEN GOSUB isr
PEN ON
rv% = ioLightPen% (ieee%, 1)

‘ Enable Driver488/SUB interrupt on Error or Service Request
rv% = ioArm% (ieee%, acSRQ)

‘ Display the Driver488/SUB system status
rv% = ioStatus% (ieee%, substat)

CALL showstat (substat)

‘ Put the ADC488 into remote mode
rv% = ioRemote% (adc%)

‘ Clear the AC488
rv% = io Clear% (adc%)

‘ Enable ADC488 SRQ on command errors
rv% = ioOutput& (adc%, “M8X”)

‘ Send an invalid command to the ADC488
PRINT “Sending invalid ADC command”
rv% = ioOutput & (adc%, “V13X”)

‘ Setup the ADC488:
‘ Differential inputs (a0)
‘ Scan group channel 1 (C1)
‘ Compensated ASCII floating-point output format (G0)
‘ Channel 1 range to +/-10V (R3)
‘ One-shot trigger on talk (T6)
rv% = ioOutput& (adc%, “A0C1G0R3T6X”)

‘ Wait for the ready bit of the ADC488 to be asserted
WHILE ((ioSPoll%(adc%) AND 32) = 0) : WEND

‘ Display a reading
response$ = SPACE$ (256)
rv% = ioEnter& (adc%, response$)
voltage ! = VAL (response$)
PRINT “ADC488 channel #1 reading value is “; voltage!

‘ Display the average of 10 readings
sum ! = 0!
FOR i = 0 TO 9
       response$ = SPACE$ (256)
       rv% = ioEnter& (adc%, response$)
       voltage ! = VAL (response$)
       sum ! = sum! + voltage !
NEXT i
PRINT “The average of 10 readings is “; sum! / 10!

‘ Set up the ADC488 :
‘ Compensated binary output format (G10)
‘ 100uSec scan interval (I3)
‘ No pre-trigger scans, 100 post-trigger scans (n100)

‘ Continuous trigger on GET (T1)
rv% = ioOutput& (adc%, “G10I3N100T1X”)
```

```
‘ Wait for the ready bit of the ADC488 to be asserted
WHILE ((isSPoll%(adc%)AND 32) = 0 ) : WEND

‘ Trigger the ADC488
rv% = ioTrigger% (adc%)

‘ Wait for the data acquisition bit of the ADC488 to be asserted
WHILE ((ioSPoll%(adc%) AND 128) = 0) : WEND

‘ Reset the buffer pointer of the ADC488
rv% = ioOutput& (adc%, “BOX”)

‘ Take 100 readings from the ADC488
noterm.eoi = 0
noterm.nChar = 0
hundred$ = SPACE$ (200)
rv% = ioEnterX& (adc%, hundred$, 200, 1, noterm, 1, 0)

‘ Check the Status before and after waiting
rv% = ioStatus% (ieee%, substat)
CALL showstat (substat)

‘ Wait for completion of input operation
rv% = ioWait% (adc%)

rv% = ioStatus% (ieee%, substat)
CALL showstat (substat)

‘ Print the received characters
FOR i = 0 to 99
       PRINT CVI (MID$ (hundred$, i, * 2 + 1, 2)) ;
       IF ((i MOD 10) = 9) THEN PRINT
NEXT i

END

‘ Interrupt service routine for Driver488/SUB interrupts
isr:
‘ Print isr message to screen
PRINT “ In interrupt handler”

‘ Check if the interrupt was due to a Service Request
sp% = ioSPoll% (ieee%)
IF (sp% = 0) THEN PRINT “ No SRQ detected”: END

‘ Check that the Service Request was from the ADC488
stadc% = isSPoll% (adc%)
IF ((stadc% AND 64) = 0) THEN PRINT “ Not an ADC488 SRQ.”: END

‘ Interpret the Serial Poll response
IF ((stadc% AND 1)  0) THEN PRINT “ Triggered”
IF ((stadc% AND 2)  0) THEN PRINT “ Trigger overrun”
IF ((stadc% AND 4)  0) THEN PRINT “ Buffer overrun”
IF ((stadc% AND 8)  0) THEN
       ‘ Read and interpret the ADC488 error status
       PRINT “ ADC488 error”
       rv% = ioOutput& (adc%, “E?”)
       errtext$ = SPACE$ (64)
       rv% = ioEnter& (adc%, errtext$)
       errnum% = VAL (RIGHT$ (errtext$, LEN (errtext$) -1))
       IF ((errnum AND 1) > 0) THEN PRINT “  Invalid DDC”
       IF ((errnum AND 2) > 0) THEN PRINT “  Invalid DDC option”
       IF ((errnum AND 4) > 0) THEN PRINT “  Conflict error”
       IF ((errnum AND 8) > 0) THEN PRINT “  NVRAM setup error”
       IF ((errnum AND 16) > 0) THEN PRINT “  Calibration error”
       IF ((errnum AND 32) > 0) THEN PRINT “  NVRAM calibration error”
END IF
```

```
IF ((stadc% AND 32) > 0) THEN PRINT " Ready"
IF ((stadc% AND 64) > 0) THEN PRINT " SRQ asserted"
IF ((stadc% AND 128) > 0) THEN PRINT " Data acquisition complete"

RETURN

SUB, showstat (substat AS IeeeStatus)
      ' Display Status from Driver488/SUB
      PRINT "SC          :"; substate.SC>,
      PRINT "CA          :"; substate.CA,
      PRINT "Primaddr    :"; substate.Primaddr
      PRINT "Secaddr     :"; substate.Secaddr,
      PRINT "SRQ         :"; substate.SRQ,
      PRINT "addrChange  :"; substate.addrChange
      PRINT "talker      :"; substate.talker,
      PRINT "listener    :"; substate.listener,
      PRINT "triggered   :"; substate.triggered
      PRINT "cleared     :"; substate.cleared,
      PRINT "transfer    :"; substate.transfer,
      PRINT "byteIn      :"; substate.byteIn
      PRINT "byteOut     :"; substat.byteOut
END SUB
```

Command Summary

To obtain a summary of the QuickBASIC language commands for Driver488/SUB, turn to the "Section III: Command References" of this manual.

9G. Pascal

Topics

Accessing from a Pascal Program

Driver488/SUB provides support for Borland Turbo Pascal. To allow for ready access to all Driver488/SUB functions and type definitions, an include file provides all required declarations. In addition, one include file must be included in the main module to provide for automatic detection of certain compiler options and enable the required adjustments within the driver. Note that the header files (**`*.h`**) must be included in your program and linked to the proper Driver488/SUB library files, as described in the Sub-Chapter "Getting Started" earlier in this Chapter. The following include (**`uses`**) directives should appear near the beginning of the program:

```
uses iottp60;
```

The following declarations are assumed throughout the remainder of this discussion.

```
var
adc,ieee,dev,adc2 : Integer;         { Device handles }
code : Integer;                      { Return Code }
hundred : array [0..99] of Integer;  { Driver488/SUB status structure }
response : string;                   { Text buffer for Driver488/SUB responses }
i: Integer;                          { General purpose loop counter }
voltage : Real;                      { Single reading variable }
sum : Real;                          { Summation used to compute average }
substat : IeeeStatusrec;             { Driver488/SUB status structure }
nilptr : pointer;                    { General purpose pointer }
lrv : Longint;                       { General purpose long return value }
sp,stadc,                            { Driver488/SUB and ADC488 spoll response }
       errnum : Integer;             { ADC488 error number }
       errtext : string;             { ADC488 error response }
```

Establishing Communications

For the sake of this discussion, assume that Driver488/SUB has been configured to start with a configuration including the devices **`IEEE`** (IEEE 488 interface) and **`ADC`** (an ADC488/8S connected to the IEEE 488 interface). Additional interfaces and/or devices may also have been defined, as the driver can support up to four interfaces and 56 devices simultaneously. To open the two devices of interest, we use the following statements:

```
ieee: = ioOpenName ('IEEE');
adc: = ioOpenName ('ADC');
```

If the **`ADC`** was not configured within Driver488/SUB, it can be optionally created "on the fly." First, verify that opening the **`ADC`** failed, then use the **`GetError`** command to clear the error condition generated by this failure. Next, use the handle of the device **`DEVIEEE`**, which is always available within Driver488/SUB, to clone a new device called **`ADC`** using the **`MakeDevice`** command. Lastly, the IEEE bus address **`14`** is assigned to the **`ADC`**:

```
if adc = -1 then begin
       rv: = ioGetError (ieee, response);
       dev: = ioOpenName ('DEVIEEE');
       adc: = ioMakeDevice (dev,'ADC');
       rv: = ioBusAddress (adc,14,-1);
end;
```

If other devices were needed for the application at hand, they could either be defined in the startup configuration for Driver488/SUB or they could be created "on the fly" from the application:

```
dev: = ioOpenName ('DEVIEEE');
adc2: = ioMakeDevice (dev,'ADC2') ;
rv: = ioBusAddress (adc2,14,-1) ;
```

The new device **`ADC2`** is configured to reside at a different bus address so that the two devices may be distinguished. There is one other important difference between **`ADC`** and **`ADC2`** at this point. **`ADC2`** is a temporary device; that is, as soon as the creating application closes, **`ADC2`** ceases to exist. If our intent was to create a device that could be accessed after this application ends, we must tell Driver488/SUB this:

```
rv: = ioKeepDevice (adc2);
```

After executing the above statement, **`ADC2`** is marked as being permanent; that is, the device will not be removed when the creating application exists. If we later wish to remove the device, however, we can do so explicitly:

```
rv: = ioRemoveDevice% (adc2);
```

Confirming Communication

With or without an open device handle, the application can, if desired, confirm communication with Driver488/SUB via the `Hello` function.

```
rv: = ioHello (ieee,response);
Writeln (response);
```

The function also fills in a string from which information can be extracted if it is desirable to display facts about the driver in use.

Setting Up Event Handling

If the event notification mechanism of Driver488/SUB is to be used, it should normally be set up during application initialization and left in place until application shutdown. No special action is required if event notification is not needed for the particular application. First, the `OnEvent` function establishes the notification path by specifying the function to be called, as follows:

```
rv: = ioOnEvent (ieee,@isr,nilptr);
```

Either during initialization or at some appropriate later point in the application, specific event types may be `Arm`ed or `Disarm`ed for use in the event system. Individual event types may be turned on and off at will freely through the life of the application. In this case, we `Arm` to request notification of IEEE 488 bus service requests:

```
rv: = ioArm (ieee, acSRQ);
```

To cease recognizing bus service request, we might `Disarm` just the one class of events:

```
rv: = ioDisarm (ieee, acSRQ);
```

Or, to completely disable event notifications:

```
rv: = ioDisarm (ieee, 0);
```

Note that an external device handle is acceptable in this and other functions which actually refer to the interface; the external device handle will simply be translated to the handle of the interface to which the device is attached, prior to taking action. This translation is fully automatic within Driver488/SUB and requires little overhead, so you need not and should not go to great lengths to pass an interface handle if your application structure makes the use of external device handles the more logical choice.

Reading Driver Status

Your application may interrogate Driver488/SUB at any time to determine its status and other information. `Status` information is returned in a structure provided by the application and can be displayed by the `showstat` function shown below:

```
rv: = ioStatus (ieee, substat);
showstat (@substat);
```

Another function to display the information contained in the `Status` structure could be:

```
procedure showstat (substat : StatPtr);
begin
       Write(‘SC           : ‘, substat^.SC);
       Write(‘CA           : ‘, substat^.CA);
       Write(‘Primaddr     : ‘, substat^.Primaddr);
       Write(‘Secaddr      : ‘, substat^.Secaddr);
       Writeln(‘SRQ        : ‘, substat^.SRQ);
       Write(‘addrChange   : ‘, substat^.addrChange);
       Write(‘talker       : ‘, substat^.talker);
       Writeln(‘listener   : ‘, substat^.listener);
       Write(‘triggered    : ‘, substat^.triggered);
       Write(‘cleared      : ‘, substat^.cleared);
       Write(‘transfer     : ‘, substat^.transfer);
       Writeln(‘byteIn     : ‘, substat^.byteIn);
       Writeln(‘byteOut    : ‘, substat^.byteOut);
end;
```

External Device Initialization

Refer to the device manufacturer's documentation on specific requirements for initializing your IEEE 488 instrument. In the case of the ADC488, appropriate initialization involves sending it a `Clear` command and placing it into `Remote` mode:

```
rv: = ioClear (adc);
rv: = ioRemote (adc);
```

For our hypothetical application, we also wish to have the ADC488 generate a service request should it detect a command error. This involves sending a command string consisting of textual data to the ADC488:

```
lrv: = ioOutput (adc,'M8X');
```

We may also wish to perform other initialization and configuration. In this case, we set up the ADC488 (`adc`) in the following configuration:

```
Differential inputs (A0)
Scan group channel 1 (C1)
Compensated ASCII floating-point output format (G0)
Channel 1 range to +/-10V (R3)
One-shot trigger on talk (T6)
```

The command to perform this configuration combines the above strings and adds the `Output` command for the ADC488:

```
lrv: = ioOutput (adc,'A0C1G0R3T6X')
```

Interrupt Handling

In case we send out an invalid command, either due to a programming error or an unanticipated condition in the equipment, Driver488/SUB will automatically notify the interrupt handling function as established above:

```
lrv: = ioOutput (adc,'V13X')
```

The interrupt handler as established above might consist of a function similar to the following:

```
procedure isr (var param);far;

var
sp, stadc,                  { Driver488/SUB and ADC488 spoll response }
errnum : Integer;           { ADC488 error number }
errtext : string;           { ADC error response }

begin

      { Check if the interrupt was due to a Service Request }
      sp: = ioSPoll (ieee);
      if sp = 0 then begin
            Writeln ('No SRQ detected');
            halt;
      end;

      { Check that the Service Request was from the ADC488 }
      stadc: = ioSPoll (adc);
      if stadc = 64 then begin
            Writeln ('Not an ADC488 SRQ. SPOLL = ',stadc);
            halt;
      end;

      { Interpret the Serial Poll response }
      if bitSet(stadc,1) then
            Writeln('Triggered');
      if bitSet(stadc,2) then
            Writeln('Trigger overrun');
      if bitSet(stadc,4) then
```

```
                    Writeln('Buffer overrun');
              if bitSet(stadc,8) then
                    { Read and interpret the ADC488 error status }
                    Writeln('ADC488 error');
                    errnum: = 5;
                    lrv: = ioOutput (adc,'E?');
                    lrv: = ioEnter (adc,errtext);
                    Val (errtext,errnum,code);
                    ifbitSet (errnum,1) then
                          Writeln ('Invalid DDC');
                    ifbitSet (errnum,2) then
                          Writeln ('Invalid DDC option');
                    ifbitSet (errnum,4) then
                          Writeln ('Conflict error');
                    ifbitSet (errnum,8) then
                          Writeln ('NVRAM setup error');
                    ifbitSet (errnum,16) then
                          Writeln ('Calibration error');
                    ifbitSet (errnum,32) then
                          Writeln ('NVRAM calibration error');
              end;

              ifbitSet (stadc,32) then
                    Writeln ('Ready');
              ifbitSet (stadc,64) then
                    Writeln ('SRQ asserted');
              ifbitSet (stadc,128) then
                    Writeln ('Data acquisition complete');

              { Set up interrupt pointers }
              nilptr: = nil;
              rv: = ioOnEvent (ieee,@isr,nilptr);
        end;
```

Basic Data Acquisition

With both Driver488/SUB and the external device ready for action, we next might try taking a simple reading using the ADC488. Here, we use the serial poll (`SPoll`) capabilities of the system to determine when a response is ready and format the reply.

```
While not bitset (ioSPoll(adc),32) do begin end;
lrv: = ioEnter (adc,response);
Val (response,voltage,code);
Writeln ('ADC488 channel #1 reading value is',voltage);
```

Block Data Acquisition

First, we set up the ADC488 (`adc`) for the following configuration:

```
Compensated binary output format (G10)
100 usec scan interval (I3)
No pre-trigger scans = 0, 100 post-trigger scans (N100)
Continuous trigger on GET (T1)
```

We then wait for the ADC488 to start the acquisition process. Once the acquisition is complete, which is determined by the MSB of the ADC488's serial poll response, the buffer pointer of the ADC488 is reset (`B0`).:

```
lrv: = ioOutput (adc,'G10I3N100T1X');
while not bitset (ioSPoll (adc),32) do begin end;
rv: = ioTrigger (adc);
while not bitset (ioSPoll (adc),128) do begin end;
lrv: = ioOutput (adc,'BOX');
```

Next, we fill the buffer with 100 readings from the ADC488. The `noterm` terminator structure is used to disable scanning for terminators such as carriage-return and line-feed.

```
noterm.eoi: = false;
noterm.nChar: = 0;
lrv: = ioEnterX (adc,hundred,200,true,noterm,true,nilptr);
```

The `EnterX` function will use a DMA transfer if available. Because DMA transfers are performed entirely by the hardware, the program can continue with other work while the DMA transfer function occurs. For example, the program will process the previous set of data while collecting a new set of data into a different buffer. However, before processing the data we must wait for the transfer to complete. For illustration purposes, we query the Driver488/SUB status both before and after waiting.

```
rv: = ioStatus (ieee,substat);
showstat (@substat);

rv: = ioWait (adc);

rv: = ioStatus (ieee,substat);
showstat (@substat);
```

Now we process the buffer:

```
{ Print the received characters }
for i: = 0 to 99 do begin
       Write (hundred[i]);
       if (imod10) = 9 then
              Writeln ('');
end;
```

The above functions provide enough functionality for a *basic data acquisition* program. Additional functions provided by Driver488/SUB are described in the "Section III: Command References" of this manual.

Sample Program

```
program manual;

uses iottp60, dos;

var
adc,ieee,dev,adc2 : Integer;       { Device handles }
code : Integer;                    { Return Code }
hundred : array [0..99] of Integer; { Driver488/SUB status structure }
response : string;                 { Text buffer for Driver488 responses }
i: Integer;                        { General purpose loop counter }
rv: Integer;                       { General purpose return value }
voltage : Real;                    { Single reading variable }
sum : Real;                        { Summation used to compute average }
substat : IeeeStatusrec;           { Driver488/SUB status structure }
nilptr : pointer;                  { General purpose pointer }
lrv : Longint;                     { General purpose long return value }
noterm : termrec;                  { Driver488 terminator structure }

{ Function to determine if bit is set according to mask value }
function bitSet (source,mask : integer) : boolean;
begin
       if (source div mask) mod 2 = 0
              then bitSet: = false;
       else
              bitSet: = true;
       end;
end;

procedure isr (var param);far;

var
sp,stadc                           { Driver488 and ADC488 spoll response }
errnum : Integer;                  { ADC488 error number }
errtext : string;                  { ADC488 error response }
```

```
begin

      { Check if the interrupt was due to a Service Request }
      sp: = ioSPoll (ieee);
      if sp = 0 then begin
            Writeln ('No SRQ detected');
            halt;
      end;

      { Check that the Service Request was from the ADC488 }
      stadc: = ioSPoll (adc);
      if not bitSet (stadc,64) then begin
            Writeln ('Not an ADC488 SRQ.SPOLL = ',stadc);
            halt;
      end;

      { Interpret the Serial Poll response }
      if bitSet(stadc,1) then
            Writeln ('Triggered');
      if bitSet(stadc,2) then
            Writeln('Trigger overrun');
      if bitSet(stadc,4) then
            Writeln('Buffer overrun');
      if bitSet(stadc,8) then
            { Read and interpret the ADC488 error status }
            Writeln('ADC488 error');
            errnum: = 5;
            lrv: = ioOutput (adc,'E?');
            lrv: = ioEnter (adc,errtext);
            Val (errtext,errnum,code);
            ifbitSet (errnum,1) then
                  Writeln ('Invalid DDC');
            ifbitSet (errnum,2) then
                  Writeln ('Invalid DDC option');
            ifbitSet (errnum,4) then
                  Writeln ('Conflict error');
            ifbitSet (errnum,8) then
                  Writeln ('NVRAM setup error');
            ifbitSet (errnum,16) then
                  Writeln ('Calibration error');
            ifbitSet (errnum,32) then
                  Writeln ('NVRAM calibration error');
      end;

      ifbitSet (stadc,32) then
            Writeln ('Ready');
      ifbitSet (stadc,64) then
            Writeln ('SRQ asserted');
      ifbitSet (stadc,128) then
            Writeln ('Data acquisition complete');

      { Set up interrupt pointers }
      nilptr: = nil;
      rv: = ioOnEvent (ieee,@isr,nilptr);
end;

{ Display Status from Driver488/SUB }
procedure showstat (substat : StatPtr);

begin
      Write('SC            : ', substat^.SC);
      Write('CA            : ', substat^.CA);
      Write('Primaddr      : ', substat^.Primaddr);
      Write('Secaddr       : ', substat^.Secaddr);
      Writeln('SRQ         : ', substat^.SRQ);
      Write('addrChange    : ', substat^.addrChange);
      Write('talker        : ', substat^.talker);
```

```
             Writeln('listener    : ', substat^.listener);
             Write('triggered     : ', substat^.triggered);
             Write('cleared       : ', substat^.cleared);
             Write('transfer      : ', substat^.transfer);
             Writeln('byteIn      : ', substat^.byteIn);
             Writeln('byteOut     : ', substat^.byteOut);
      end;

      begin
             { Establish communications with Driver488/SUB }
             ieee: = ioOpenName ('IEEE');
             if ieee = -1 then begin
                    Writeln('Cannot initialize IEEE system');
                    halt;
             end;

             { Disable the automatic onscreen error display }
             if ioError (ieee,OFF) = -1 then begin end;

             { Open the ADC488 device handle or create if necessary }
             adc: = ioOpenName ('ADC');
             if adc = -1 then begin
                    rv: = ioGetError (ieee,response);
                    dev: = ioOpenName ('DEVIEEE');
                    adc: = ioMakeDevice (dev,'ADC');
                    rv: = ioBusAddress (adc,14,-1);
             end;

             { Read the Driver488/SUB revision number }
             rv: = ioHello (ieee,response);
             Writeln (response);

             { Set up interrupt pointers }
             rv: = ioOnEvent (ieee,@isr,nilptr);

             { Enable Driver488/SUB interrupt on Error or Service Request }
             rv: = ioArm (ieee,acSRQ);

             { Display the Driver488/SUB system status }
             rv: = ioStatus (ieee,substat);
             showstat (@substat);

             { Put the ADC488 into remote mode }
             rv: = ioRemote (adc);

             { Clear the ADC488 }
             rv: = ioClear (adc);

             { Enable ADC488 SRQ on command errors }
             lrv: = ioOutput (adc,'M8X');

             { Send an invalid command to the ADC488 }
             Writeln ('Sending invalid ADC command');
             lrv: = ioOutput (adc,'V13X');

             { Set up the ADC488:
                    Differential inputs (A0)
                    Scan group channel 1 (C1)
                    Compensated ASCII floating-point output format (G0)
                    Channel 1 range to 3 (+/-10V)
                    One-shot trigger on talk (T6)
             }
             lrv: = ioOutput (adc,'A0C1G0R3T6X');

             { Wait for the ready bit of the ADC488 to be asserted }
             while not bitset (ioSPoll (adc),32) do begin end;
```

```
        { Display a reading }
        lrv: = ioEnter (adc,response);
        Val (response,voltage,code);
        Writeln (‘ADC488 channel #1 reading value is ‘,voltage);

        { Display the average of 10 readings }
        sum: = 0.0;
        for i: 0 to 9 do begin
               lrv: = ioEnter (adc,response);
               Val (response,voltage,code);
               sum: = sum + voltage;
        end;
        Writeln (‘The average of 10 readings is ‘,sum/10.0);

        { Set up the ADC488:
               Compensated binary output format (G10)
               100uSec scan interval (I3)
               No pre-trigger scans, 100 post-trigger scans (n100)
               Continuous trigger on GET (T1)
        }
        lrv: = ioOutput (adc,’G10I3N100T1X’);

        { Wait for the ready bit of the ADC488 to be asserted }
        while not bitset (ioSPoll (adc),32 do begin end;

        { Trigger the ADC488 }
        rv: = ioTrigger (adc);

        { Wait for the ready bit of the ADC488 to be asserted }
        while not bitset (ioSPoll (adc),128) do begin end;

        { Reset the buffer pointer of the ADC488 }
        lrv: = ioOutput (adc,’BOX’);

        { Take 100 readings from the ADC488 }
        noterm.EOI: = false;
        noterm.nChar: = 0;
        lrv: = ioEnterX (adc,hundred,200,true,noterm,true,nilptr);

        { Check the Status before and after waiting }
        rv: = ioStatus (ieee,substat);

        { Wait for completion of input operation }
        rv: = ioWait (adc);

        rv: = ioStatus (ieee,substat);
        showstat (@substat);

        { Print the received characters }
        for i: = 0 to 99 do begin
               Write (hundred[i]);
               if (i mod 10) = 9 then
                      Writeln (‘’);
        end;
end.
```

Command Summary

To obtain a summary of the Pascal language commands for Driver488/SUB, turn to the “Section III: Command References” of this manual.

9H. Data Transfers

For Driver488/SUB, W31, W95, & WNT

Topics

Terminators

Every transfer of data, between a program and Driver488, or between Driver488 and a bus device, must have a definite end. This is a common requirement in most systems. For example, most printers do not print a line until they receive the carriage return that ends that line. Similarly, a BASIC **`Input`** statement waits for the **`<Enter>`** key to be pressed before returning the entered data to the program. The only time that some terminator is not required is when the number of characters that compose the data is known in advance or is transferred along with the data. This is the case, for example, when fixed-length records are read from a random access disk file.

Driver488 actually uses two terminators:

- The data terminator (**`Term`**) for output to bus devices from Driver488.
- The data terminator (**`Term`**) to input from bus device into Driver488.

TERM Terminators

The **`Term`** terminators delimit the end of strings transferred between Driver488 and bus devices. The **`Term`** output terminator marks the end of strings transferred from Driver488 to bus devices, and the **`Term`** input terminator marks the end of strings transferred into Driver488 from bus devices.

The **`Term`** terminators normally consist of one or two ASCII characters. The characters do not need to be printable and, in fact, are usually special characters such as carriage return and line feed. Input and output terminators need not be the same.

You can specify that no characters are to be used as **`Term`** terminators. If the **`Term`** output terminator is set to NONE, then Driver488 does not append any characters to the data sent to the device. When the **`Term`** input terminator is set to NONE, Driver488 does not check for terminator characters in the returned data.

The **`Term`** terminators can include the IEEE 488 bus *end-or-identify* (**`EOI`**) signal. The **`EOI`** signal, when asserted during a character transfer, marks that character as the last of the transfer. This allows the detection of the end of data regardless of which characters comprise the data. This feature is very useful in binary data transfers which might contain any ASCII values from `0` to `255`.

To support the **`EOI`** signal, the **`Term`** input and output terminators can be composed of just **`EOI`**, one or two characters, or one or two characters with **`EOI`**. If **`EOI`** is specified, it has a slightly different meaning on input than on output.

When **`EOI`** alone is specified as the **`Term`** output terminator, the **`EOI`** bus signal is asserted during the last data character transmitted. If **`EOI`** is specified with one or two characters, then **`EOI`** is asserted on the last character. In this way, **`EOI`** is asserted on the last character transmitted to the bus device.

When **`EOI`** alone is specified as the **`Term`** input terminator, then all the characters received from the bus device, including the one on which **`EOI`** was asserted are returned to the user's program. When one or two characters are specified, without **`EOI`**, all the characters up to, but not including, the **`Term`** input terminator characters, are returned to the program. However, if both **`EOI`** and characters are specified, the following considerations apply:

- If **`EOI`** is received, and the complete terminator character sequence has not been received (even if the first of the two characters has been received), then all the received characters are returned to the program.
- If the complete terminator character sequence has been received, with or without **`EOI`** asserted on the last character, then only the characters up to but not including the terminator characters are returned.
- If only one character is specified for input termination, the complete terminator character sequence consists of just that one character, but if two characters are specified, then it consists of both characters, received consecutively.

During normal **`Output`**, without a specified character count, the **`Term`** output terminator is appended to the data before sending the data to the bus devices. During normal **`Enter`**, the **`Term`** input terminator received by Driver488 is stripped off before being returned to the program. See the **`Enter`** and **`Output`** commands in the following text, and in "Section III: Command References."

Data Input and Output

When a program performs data I/O through Driver488, it tells Driver488 where in memory to find or put the data and the amount of data to transfer. Driver488 handles the actual transfer. The program sends the address and quantity of data to be transferred, and Driver488 takes care of the details of the transfer. The program must be able to tell Driver488 where in memory to find the data, that is, it must be able to provide Driver488 with the actual address of the buffer. In C language, a character array is usually used at the memory location for the incoming or outgoing data:

```
char buffer [20];
```

The following is a typical **`EnterX`** command:

```
char buffer [20]
EnterX (dev, buffer, sizeofbuffer, 1, 0L, 0, 0L);
```

The Driver488 **`EnterX`** command addresses the ADC bus device (**`dev`**), requests Driver488 to read **`20`** bytes of data and put the received data in the buffer memory location. This gives Driver488 all the information it needs to be able to transfer the received data directly into the buffer character array.

Data I/O using the Driver488 **`OutputX`** command is also possible. For instance, suppose the data from the above example was to be sent to a device called **`DAC`**. Here, we would use the following command:

```
OutputX (DAC, buffer, sizeofbuffer, 1, 0L, 0, 0L);
```

Data I/O is normally performed with terminator detection set to the default values of carriage-return line-feed (**`CR LF`**) with end-or-identify (**`EOI`**). However, it is possible to explicitly specify that the **`Enter`** should stop on detection of **`EOI`** only, or on detection of **`EOI`** or some single character. For example, to terminate on **`EOI`**:

```
term.eoi=1;
term.nChar=0;
EnterX (dev, buffer, sizeofbuffer, 1, &term, 0 0L);
```

This reads data into the buffer character array until either **`20`** characters have been received, or **`EOI`** has been detected. However, if **`EOI`** causes the transfer to stop, we may need to know how much data was received. This information can be obtained by using the **`Buffered`** command:

```
N=Buffered(dev)
```

The number of bytes transferred is read into **`N`**. This value can now be used to send the read data out to the device (**`dev`**), as follows:

```
OutputN (dev, buffer, N, 1, &term, 0, 0L);
```

Note that the variable **`N`** has been used in place of the literal **`20`** to specify how many bytes to transmit.

Asynchronous Transfers

Driver488 can return to the user's program while a transfer is in progress. This is useful whenever the transfer takes a substantial amount of time, and other processing could proceed while waiting. For example, suppose a certain bus device can transfer only 1000 bytes per second. If there are 10,000 bytes to transfer it takes 10 seconds to complete the transfer. The following statements might be used to receive this data:

```
char data [10000];
EnterX (ADC, data, 10000, 1, 0L, 1, 0L);

/*Now do other work while the transfer is processing*/

Wait (ADC);
```

The "true" **`async`** flag tells Driver488 to return to the program after setting up the transfer. The program is then free to do other processing, as long as it does not need access to the IEEE 488 bus. Finally, when the program is ready to process the received data, it performs a **`Wait`** to check that the data has been completely received. In this way, asynchronous transfers overlap IEEE 488 bus data transfers with program execution.

The use of DMA and interrupts requires proper hardware and software configuration. For more information, refer to the Sub-Chapter "Installation & Configuration" early in this Chapter.

9I. Operating Modes

For Driver488/SUB, W31, W95, & WNT

Topics

Introduction

There are four types of IEEE 488 bus devices: Active Controllers, Peripherals, Talk-Only devices, and Listen-Always devices:

- In simple systems, *Talk-Only* and *Listen-Always* devices are usually used together, such as a Talk-Only digitizer sending results to a Listen-Always plotter. In these systems, no controller is needed because the talker assumes it is the only talker on the bus, and the listener(s) assume they are all supposed to receive all data sent over the bus. This is a simple and effective method of transferring data from one device to another, but is not adequate for more complex systems where, for example, one computer is controlling many different bus devices.
- In more complex systems, the *Active Controller* sends commands to the various bus *Peripherals*, telling them what to do. The controller sends bus commands such as: **`Unlisten`**, **`Listen Address Group`**, **`Untalk`**, and **`Talk Address Group`** to specify which device(s) send data, and which receive it.

When an IEEE 488 bus system is first turned on, some device must be the Active Controller. This device is the System Controller and always keeps some control of the bus. In particular, the System

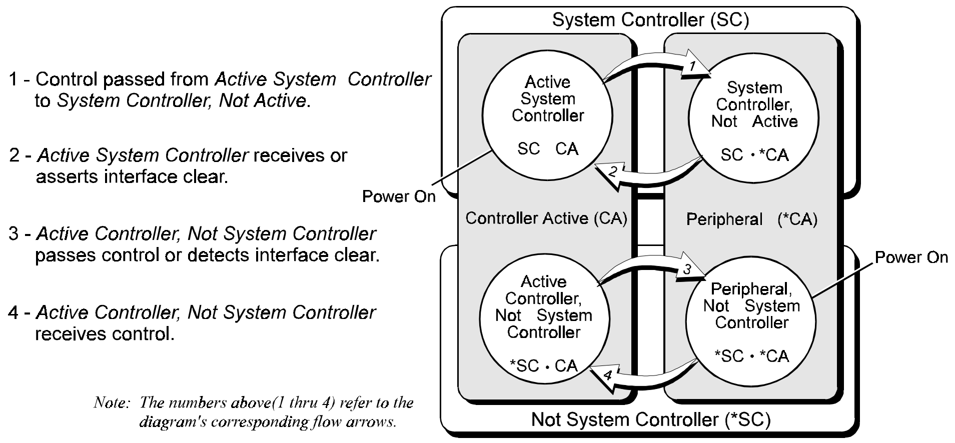
Controller controls the Interface Clear (`IFC`) and Remote Enable (`REN`) bus management lines. By asserting Interface Clear, the System Controller forces all other bus devices to stop their bus operations, and regains control as the Active Controller.

Operating Mode Transitions

The System Controller is initially the Active Controller. It can, if desired, Pass Control to another device and thereby make that device the Active Controller. Notice that the System Controller remains the System Controller even when it is not the Active Controller. Of course, the device to which control is passed must be capable of taking the role of Active Controller. It would make no sense to try to pass control to a printer. Control should only be passed to other computers that are capable, and ready, to become the Active Controller. Note further that there must be exactly one System Controller on the IEEE 488 bus. All other potential controllers must be configured as Peripherals when they power up.

The state diagram which follows, shows the relationships between the various operating modes. The top half of the state diagram shows the two operating states of a System Controller. At power on, it is the Active Controller. It directs the bus transfers by sending the bus commands mentioned previously. It also has control of the Interface Clear and Remote Enable bus lines. The System Controller can pulse Interface Clear to reset all of the other bus devices.

Furthermore, the System Controller can pass control to some other bus device and thereby become a Peripheral to the new Active Controller. If the System Controller receives control from the new Active Controller, then it once again becomes the Active Controller. The System Controller can also force the Active Controller to relinquish control by asserting the Interface Clear signal.


1 - Control passed from *Active System Controller* to *System Controller, Not Active*.
2 - *Active System Controller* receives or asserts interface clear.
3 - *Active Controller, Not System Controller* passes control or detects interface clear.
4 - *Active Controller, Not System Controller* receives control.
Note: The numbers above(1 thru 4) refer to the diagram's corresponding flow arrows.
System Controller (SC)
Active System Controller SC CA
System Controller, Not Active SC • *CA
1
2
Power On
Controller Active (CA)
Peripheral (*CA)
Power On
Active Controller, Not System Controller *SC • CA
Peripheral, Not System Controller *SC • *CA
3
4
Not System Controller (*SC)

IEEE 488 Bus Operating Modes State Diagram

The bottom half of the state diagram shows the two operating states of a Not System Controller device. At power on, it is a Peripheral to the System Controller which is the Active Controller. If it receives control from the Active Controller, it becomes the new Active Controller. Even though it is the Active Controller, it is still not the System Controller. The System Controller can force the Active Controller to give up control by asserting Interface Clear. The Active Controller can also give up control by Passing Control to another device, which may or may not be the System Controller.

In summary, a bus device is set in hardware as either the sole System Controller in the system, or as a non-System Controller. At power on, the System Controller is the Active Controller, and the other devices are Peripherals. The System Controller can give up control by passing control, and can regain control by asserting Interface Clear, or by receiving control. A Peripheral can become the Active Controller by receiving control, and can give up control by Passing Control, or on detecting Interface Clear.

System Controller Mode

The most common Driver488 configuration is as the System Controller, controlling several IEEE 488 bus instruments. In this mode, Driver488 can perform all the various IEEE 488 bus protocols necessary to control and communicate with any IEEE 488 bus devices. As the System Controller in the Active Controller mode, Driver488 can use all the commands available for the Active Controller state, plus control the Interface Clear and Remote Enable lines. The allowed bus commands and their actions are:

Command	Action
`Abort`	Pulse Interface Clear.
`Local`	Unassert Remote Enable, or send Go To Local to selected devices.
`Remote`	Assert Remote Enable, optionally setting devices to Remote.
`Local Lockout`	Prevent local (front-panel) control of bus devices.
`Clear`	Clear all or selected devices.
`Trigger`	Trigger selected devices.
`Enter`	Receive data from a bus device.
`Output`	Send data to bus devices.
`Pass Control`	Give up control to another device which becomes the Active Controller.
`SPoll`	Serial Poll a bus device, or check the Service Request state.
`PPoll`	Parallel Poll the bus.
`PPoll Config`	Configure Parallel Poll responses.
`PPoll Disable`	Disable the Parallel Poll response of selected bus devices.
`PPoll Unconfig`	Disable the Parallel Poll response of all bus devices
`Send`	Send low-level bus sequences.
`Resume`	Unassert Attention. Use to allow Peripheral-to-Peripheral transfers.

System Controller, Not Active Controller Mode

After Passing Control to another device, the System Controller is no longer the Active Controller. It acts as a Peripheral to the new Active Controller, and the allowed bus commands and their actions are modified accordingly. However, it still maintains control of the Interface Clear and Remote Enable lines. The available bus commands and their actions are:

Command	Action
`Abort`	Pulse Interface Clear.
`Local`	Unassert Remote Enable.
`Remote`	Assert Remote Enable.
`Enter`	Receive data from a bus device as directed by the Active Controller.
`Output`	Send data to bus devices as directed by the Active Controller.
`Request`	Set own Serial Poll request (including Service Request) status.
`SPoll`	Get own Serial Poll request status.

As a bus Peripheral, Driver488 must respond to the commands issued by the Active Controller. The controller can, for example, address Driver488 to listen in preparation for sending data. There are two ways to detect our being addressed to listen: through the **`Status`** command, or by detecting an interrupt with the **`Arm`** command.

The **`Status`** command can be used to watch for commands from the Active Controller. The Operating Mode, which is a **`"P"`** while Driver488 is a Peripheral, changes to a **`"C"`** if the Active Controller passes control to Driver488. The Addressed State goes from **`Idle "I"`** to **`Listen "L"`** or **`Talk "T"`** if Driver488 is addressed to listen or to talk, and goes back to **`Idle "I"`** when the Active Controller issues **`Unlisten`** (**`UNL`**), **`Untalk`** (**`UNT`**), or specifies another **`Talker Address Group`** (**`TAG`**). The **`Trigger "T1"`** and **`Clear "C1"`** indicators are set when Driver488 is triggered or cleared, and reset when **`Status`** is read. The Address Change indicator is set to **`Change "G1"`** when the Addressed State changes. These indicators allow the program to sense the commands issued to Driver488 by the Active Controller.

The various **`Status`** indicators and their descriptions are provided in the following table:

Status Indicator	Description
`"P" (Peripheral)`	Driver488 is in the Peripheral (`*CA`) operating mode.
`"C" (Controller)`	Driver488 is the Active Controller (`CA`).
`"T1" (Trigger)`	Driver488, as a Peripheral, has received a `Trigger` bus command.
`"C1" (Clear)`	Driver488, as a Peripheral, has received a `Clear` bus command.
`"T" (Talk)`	Driver488 is in the `Talk` state and can `Output` to the bus.
`"L" (Listen)`	Driver488 is in the `Listen` state and can `Enter` from the bus.
`"I" (Idle)`	Driver488 is in neither the `Talk` nor `Listen` state.
`"G1" (Change)`	An Address Change has occurred, that is, a change between Peripheral and Controller, or among `Talk`, `Listen`, and `Idle` has occurred. This is, perhaps, the most useful interrupt in the Peripheral mode.

The following BASIC program fragment illustrates the use of the Address Change and Addressed State indicators to communicate with the Active Controller.

First check `Status` until it indicates there has been an Address Change:

```
while (1) {
       Status (ieee, &stat);
       if (!stat.addrChange) { continue;}
       if (stat.idle) {continue;)

/* If we are addressed to listen, we ENTER a line from the */
/* controller and print it out. */

       if (stat.listener) {
              Enter (ieee, data);
              printf ("%d", data);
              printf ("\n";
              continue;
       }

/* If we are addressed to talk, we INPUT a line from the keyboard*/
/* and OUTPUT it to the controller.*/

       if (stat.talker) {
              gets (message);
              Output (ieee, message);
              continue;
       }
       printf (Bad addressed state.\n");
       break;
}
```

It is also possible to detect these conditions with the `Arm` command and handle them in an Interrupt Service Routine (ISR). The `Peripheral`, `Controller`, `Talk`, `Listen`, and `Idle` conditions cause interrupts only when the Address Change indicator `"G1"` in the `Status` response is set. The `Change`, `Trigger`, and `Clear` indicators are all reset by the `Status` command. Thus, the `Status` command should be used in the Interrupt Service Routine to prevent re-interruption by an indicator which has not been reset.

The various `Arm` conditions and their descriptions are provided in the following table:

Arm Condition	Description
`SRQ`	The internal Service Request state is set. See the `SPoll` command in "Section III: Command References" for more information.
`Peripheral`	Driver488 is in the Peripheral (`*CA`) operating mode.
`Controller`	Driver488 is the Active Controller (`CA`).
`Trigger`	Driver488, as a Peripheral, has received a `Trigger` bus command.
`Clear`	Driver488, as a Peripheral, has received a `Clear` bus command.
`Talk`	Driver488 is in the `Talk` state and can `Output` to the bus.
`Listen`	Driver488 is in the `Listen` state and can `Enter` from the bus.
`Idle`	Driver488 is in neither the `Talk` nor `Listen` state.
`Bytein`	Driver488 has been received a byte from the IEEE 488 bus.
`Byteout`	Driver488 can output a byte to the IEEE 488 bus.
`Error`	Driver488 has detected an error condition.
`Change`	An Address Change has occurred, that is, a change between Peripheral and Controller, or among `Talk`, `Listen`, and `Idle` has occurred. This is, perhaps, the most useful interrupt in the Peripheral mode.

Not System Controller Mode

If Driver488 is not configured as the System Controller, then at power on, it is a bus Peripheral. It might use a program like the one previously described to communicate with the Active Controller. When Driver488 is not the System Controller and not the Active Controller (`*SC••CA`), the available bus commands and their actions are:

Command	Action
`Enter`	Receive data from a bus device as directed by the Active Controller.
`Output`	Send data to bus devices as directed by the Active Controller.
`Request`	Set own Serial Poll request (including Service Request) status.
`SPoll`	Get own Serial Poll request status.

Active Controller, Not System Controller Mode

If the Active Controller passes control to the Driver488, then it becomes the new Active Controller. This can be detected by the `Status` command or as an `Arm`ed interrupt. As an Active Controller, but not the System Controller, the available bus commands and their actions are:

Command	Action
`Abort`	Assert Attention and send My Talk Address to stop any bus transfers.
`Local`	Send Go To Local to selected devices.
`Local Lockout`	Prevent local (front-panel) control of bus devices.
`Clear`	Clear all or selected devices.
`Trigger`	Trigger selected devices.
`Enter`	Receive data from a bus device.
`Output`	Send data to bus devices.
`Pass Control`	Give up control to another device which becomes the Active Controller.
`SPoll`	Serial Poll a bus device, or check the Service Request state.
`PPoll`	Parallel Poll the bus.
`PPoll Config`	Configure Parallel Poll responses.
`PPoll Disable`	Disable the Parallel Poll response of selected bus devices.
`PPoll Unconfig`	Disable the Parallel Poll response of all bus devices.
`Send`	Send low-level bus sequences.
`Resume`	Unassert Attention. Used to allow Peripheral-to-Peripheral transfers.

9J. Utility Programs

Topics

Printer & Serial Redirection

`IEEELPT` and **`IEEECOM`** are stand-alone utilities (Driver488 need not be installed to use them) that allow programs which are unaware of the IEEE 488 bus to control IEEE 488 bus devices as if they were printer (**`IEEELPT`**) or serial (**`IEEECOM`**) devices. They automatically redirect communications destined for printer or serial ports to specified IEEE 488 bus devices. For example, the command:

```
C> IEEELPT IEEE05
```

will configure IEEE 488 bus device **`5`** to appear as the first parallel printer port (**`LPT1:`**). Any text that is destined for **`LPT1:`** will, instead be send to bus device **`5`**. For example, the **`COPY`** command:

```
C> COPY TEXTFILE.DOC LPT1:
```

will copy the contents of **`TEXTFILE.DOC`** to the IEEE 488 bus. Any software which prints to **`LPT1:`** will now send its data to IEEE 488 bus device **`5`**.

Similarly, the command:

```
C> IEEECOM IEEE12
```

will redirect communications to and from the **`COM1:`** serial port to IEEE 488 bus device **`12`**. Thus, a plotting program which expects a serial plotter can communicate with an IEEE 488 plotter using Power488.

Serial port redirection is often less effective than printer port redirection because many programs control the serial port hardware directly and bypass the redirection program. It is still possible to redirect output from such a program to an IEEE device if that program can be configured to send its output to a disk file rather than directly to the printer or plotter. If a file such as **`\DEV\COM1`** is specified, the program will act as though the data were being written to an actual disk file, while the output will be sent to the IEEE 488 bus device to which **`COM1`** was redirected. The program may even issue a warning message that the specified file exists and will be overwritten. If it does, then the user may tell it that it may delete or overwrite the file. No harm can result from trying to delete a device.

To understand how these programs are used, it is necessary to keep in mind the difference between logical and physical devices. When the computer first boots up, it takes an inventory of the installed hardware. It might, for example, find two parallel printer ports, and one serial communications port. These are the physical devices. The physical device, **`LPT1`** (note the *absence* of the colon) is the printer port first identified by the computer. The logical device **`LPT1:`** (*with* the colon) refers to the device which is currently configured to receive data to be printed. The computer maintains two tables of four entries each to keep track of physical devices by logical device name. In the case of two printer and one serial port, these tables initially appear as:

Printer Port Assignments			
LPT1:	**LPT2:**	**LPT3:**	**LPT4:**
LPT1	LPT2	(none)	(none)

Serial Port Assignments			
COM1:	**COM2:**	**COM3:**	**COM4:**
COM1	(none)	(none)	(none)

The **IEEELPT** command takes up to four optional device arguments. Each argument is of the form **IEEEpp**, **IEEEppss** or **LPTn**, where **pp** is an IEEE 488 bus primary address from **00** to **30**, **ppss** is a bus address composed of a primary address from **00** to **30** followed by a secondary address from **00** to **31**, and **n** is a physical printer port device number, from **1** to **4**.

If **IEEELPT** is executed with no arguments, then it just displays the current logical printer port assignments. If one or more arguments are provided, then the first logical printer port (**LPT1:**) is redirected to the physical device specified by the first argument, the next logical port (**LPT2:**) is redirected to the next specified physical device, and so on. If fewer than four devices are specified, then the remaining logical printers are directed to any unused physical parallel printer ports. For example, on a machine with two physical parallel printer ports these commands have the effects indicated in the following table:

Command	**Printer Port Assignments**			
	LPT1:	**LPT2:**	**LPT3:**	**LPT4:**
(Boot-Up)	LPT1	LPT2	(none)	(none)
IEEELPT (No change)	LPT1	LPT2	(none)	(none)
IEEELPT IEEE05	IEEE05	LPT1	LPT2	(none)
IEEELPT IEEE05 IEEE1201	IEEE05	IEEE1201	LPT1	LPT2
IEEELPT IEEE05 IEEE1201 IEEE17	IEEE05	IEEE1201	IEEE17	LPT1
IEEELPT IEEE05 IEEE1201 IEEE17 IEEE29	IEEE05	IEEE1201	IEEE17	IEEE29
IEEELPT LPT1 IEEE05	LPT1	IEEE05	LPT2	(none)
IEEELPT LPT2 LPT1 IEEE1201	LPT2	LPT1	IEEE1201	(none)

Note that the port assignments are flexible, any order may be used. Also note how the physical printer ports are added to the assignments if there is room for them and if they have not already been specified.

Serial port redirection is accomplished by **IEEECOM**. **IEEECOM** is used identically to **IEEELPT** except that the physical port names (without colons) are **COM1** through **COM4** rather than **LPT1** through **LPT4**. For example, the **IEEECOM** command:

```
IEEECOM IEEE12 COM2 COM1
```

will redirect communications from **COM1:** to IEEE 488 bus device **12**, **COM2:** to **COM2**, and **COM3:** to **COM1**.

In addition to the port specifications, both **IEEELPT** and **IEEECOM** allow two optional parameters. The **/Aioaddr** parameter is used to specify the I/O base address of the IEEE 488 interface board and the **/Baddr** parameter sets its IEEE 488 bus address.

The I/O base address must be specified when the associated IEEE 488 interface board is not at the default I/O address of **02E1 (hex)**. The I/O base address is usually given as a hexadecimal number. For example, to use the default I/O address, the parameter would be **/A&H02E1**. If the hexadecimal I/O address ends in a **0** or an **8** then consecutive I/O addresses will be used. If the address ends in a **1** then I/O addresses will be separated by **&H400**. I/O addresses ending in other than **0**, **1**, or **8** are not allowed. For example, the command:

```
IEEELPT IEEE05 /A&H22E1
```

would configure **LPT1:** for output to IEEE 488 bus address **05** on a second interface card located at **22E1 (hex)**. The I/O base address is usually set by switches or jumpers on the interface card. Refer to the manufacturer's instructions for your IEEE 488 board to determine its I/O address.

The default I/O port base address for **IEEELPT** and **IEEECOM** is **/A&H02E1**.

The **/B** sets the primary IEEE 488 bus address of IEEE 488 interface card. Every IEEE 488 bus device, including the controller must have a unique IEEE 488 address in the range of **00** to **30 (decimal)**. The default address for the interface card is **21**, but must be changed if any IEEE Peripheral uses the same address. For example, the command:

```
IEEECOM IEEE21 /B00
```

sets the interface card bus address to **00** so that **COM1:** may be redirected to an IEEE 488 bus device with an address of **21**.

Removal & Reinstallation

Driver488 is a special type of *terminate-and-stay-resident* (TSR) program that controls Power488, Personal488, and LAN488. When **DRVR488.COM** is executed, it installs itself permanently into memory and connects itself into DOS so that it appears to be a standard device driver that can be used to control IEEE 488 devices. Normally, Driver488 is present in memory whenever the computer is operating, even if it is not being used. Most computers have enough memory so that the amount taken by Driver488 is not critical, but some very large programs need so much memory that they cannot operate if Driver488 is installed.

It is possible to temporarily remove Driver488 by editing the **AUTOEXEC.BAT** file. Once Driver488 is installed, the **AUTOEXEC.BAT** file will contain one or more lines similar to the following:

```
C:\IEEE488\DRVR488
```

These are the commands that install Driver488. They can be disabled by adding the word **REM**, followed by a space, to convert them to remarks:

```
REM C:\IEEE488\DRVR488
```

When the computer is rebooted, these lines will be ignored, Driver488 will not be loaded, and the memory that would have been used for Driver488 will now be available for other programs. If Driver488 is needed later, the **AUTOEXEC.BAT** file must be re-edited to remove the **REM**s and to re-enable Driver488, and then the computer must be rebooted.

A more practical method involves the creation of a separate batch file that holds the **DRVR488** commands. When Driver488 is installed, the **DRVR488** commands are placed in the **AUTOEXEC.BAT** file. By moving these commands to a separate batch file, it is possible to avoid installing Driver488 before it is needed. To create a separate batch file, first copy **AUTOEXEC.BAT** to a new file, perhaps **DRIVER.BAT**. Then edit the **AUTOEXEC.BAT** file, deleting the **DRVR488** commands, and edit **DRIVER.BAT**, leaving only the **DRVR488** commands. When the system is rebooted, Driver488 will no longer be installed because the **AUTOEXEC.BAT** file no longer contains the DRVR488 commands. However, whenever Driver488 is needed, it can be installed by typing **DRIVER** which will execute the **DRVR488** commands in the **DRIVER.BAT** file. Once Driver488 has been installed, it will remain installed until the system is rebooted.

MARKDRVR & REMDRVR

Using the techniques described above, it is possible to install Driver488 only when it is needed. However, it is still necessary to reboot the computer to remove Driver488. The **MARKDRVR** and **REMDRVR** utilities allow Driver488 and other TSR programs, such as **Sidekick** and **Superkey**, to be installed and removed at will, without rebooting.

Before installing the TSR program, the **MARKDRVR** command should be used to “snapshot” the system state:

```
C:> MARKDRVR comment
C:> C:\IEEE488\DRVR488
```

The **MARKDRVR** command is followed by an optional **comment** of up to 119 character that is normally used to note which TSR programs are about to be installed. When the above command is executed it saves internal system information including the interrupt vectors, the device driver chain, and the free memory pointer. This information, along with the specified comment, is saved for use by **REMDRVR**.

The **`MARKDRVR`** command is then followed by the commands needed to install the TSR programs. When using Driver488, these would be the **`DRVR488`** commands. When these commands have completed, Driver488 is installed and ready for use.

When Driver488 is no longer needed, it can be removed by using the **`REMDRVR`** command:

```
C:> REMDRVR
```

`REMDRVR` prints out the **`comment`** that was saved by **`MARKDRVR`** and then uses the information that **`MARKDRVR`** saved to restore the system to the state it had before **`MARKDRVR`** had been executed. This removes Driver488 and any other TSR programs that had been loaded in the interim and recovers their memory for reuse.

If several different TSR programs are being used, then it might be appropriate to use **`MARKDRVR`** more than once. Then, when **`REMDRVR`** is used, it will only remove the TSR programs that were installed after the last **`MARKDRVR`** command. Each time **`REMDRVR`** is used, it will remove one more "layer" of TSR programs. The comment saved by **`MARKDRVR`** can help keep track of which TSR programs are removed at each step.

Note that the most recently installed programs are always removed first. It is not possible to remove a program until all the more recently installed programs have been removed.

When working with Power488, it is good practice to create a **`DRIVER.BAT`** file that includes the **`DRVR488`** commands as described above. Then a **`MARKDRVR`** command, such as **`MARKDRVR Driver488`** can be added to the beginning of the **`DRIVER.BAT`** file. Then, Driver488 can be installed by typing **`DRIVER`** and removed by typing **`REMDRVR`**. Driver488 can thus be installed and removed as desired, without rebooting the computer.

Moving Files from an IEEE 488 (HP-IB) Controller to a PC

Included on the Driver488 release disk is a utility program that allows files to be transferred from any IEEE controller to the PC in which Driver488 resides. This utility program configures the PC as a Peripheral on the IEEE network, much like a standard IEEE 488 printer. Any controller capable of sending information to an IEEE 488 printer, including controllers like the HP 9000 series computers, can send any type of data to the PC.

Once launched to the PC, the file transfer utility allows the operator to redirect the incoming data either to the PC screen, a PC disk file, or a printer attached to the PC.

PRNTEMUL Files

In the **`\UTILS`** subdirectory of the Driver488 diskette, there are 2 files:

- **`PRNTEMUL.EXE:`** This file is the MS-DOS executable version of the program. This is all that you will need to emulate an IEEE 488 printer on a PC/AT or PS/2 computer.
- **`PRNTEMUL.C:`** This is the C source code of the **`PRNTEMUL.EXE`** program. It uses a C subroutine interface of Driver488, which is located in the **`\SUBAPI`** directory of the main Driver488 directory. Refer to the corresponding language support section on how to compile this code.

Configuration of the IEEE Interface for PRNTEMUL

The **`PRNTEMUL`** program requires the Driver488 to be configured as a Peripheral (same as an IEEE printer). Make sure that the IEEE interface is configured at a unique IEEE address.

Once Driver488 is configured properly, reboot the computer and connect your PC/AT to your IEEE controller.

Running PRNTEMUL

After the IEEE interfaces of each computer has been configured and connected, run the **`PRNTEMUL`** program from the **`\UTILS`** directory by typing one of the following commands at the DOS prompt:

Command	Description
`PRNTEMUL <ENTER>`	Prints information received from the IEEE 488 bus to the screen.
`PRNTEMUL > MYPROG.BAS <ENTER>`	Redirects information to a file called `MYPROG.BAS`
`PRNTEMUL > LPT1 <ENTER>`	Redirects information to the printer port (`LPT1`).

Once the `PRNTEMUL` program is started, it will continue to send any information received from the IEEE bus to the specified destination until any key is pressed. Once a key is pressed, the `PRNTEMUL` program will return to DOS at which time it can be run again, with a different destination specified, if so desired.

Data Transfer

Data is transferred to the computer running `PRNTEMUL` the same way information is sent to an IEEE printer. For a description of how to print information out, refer to the documentation of your IEEE controller.

For example, the following commands might be used on an HP 9000 computer running HP BASIC:

Command	Description
`LOAD "MYPROG.BAS"`	Load a program to print out.
`PRINTER IS 710`	Set the current printer to address `10` of the IEEE bus.
`LIST`	List the current program to the selected printer (computer running `PRNTEMUL`).

The output of the `PRNTEMUL` program could be redirected to a datafile to transfer source files from the IEEE controller to a PC/AT or PS/2.

9K. Command Descriptions

For Driver488/SUB, W31, W95, & WNT

Topics

Introduction

There are two types of commands: Bus commands and system commands. *Bus commands* communicate with the IEEE 488 bus. *System commands* configure or request information from Driver488. This Sub-Chapter contains a detailed description of the bus and system command formats available for Driver488/SUB and Driver488/W31. The commands for Driver488/W95 and Driver488/WNT are provided as guides, pending current software revisions. Refer to your operating system header file for the latest available information specific to your application.

A double-lined banner box similar to the following:

Driver488/XXX Only

indicates differences among these Driver488 versions. For more detail on the individual system commands, see "Section III: Command References."

Format

The format for the Driver488/SUB, W31, W95, and WNT command descriptions consists of several sections which together define the command. Using the C language, this format is implemented for the system commands found in Sub-Chapter 15B: "Driver488/SUB, W31, W95 & WNT Commands" of the "Section III: Command References" in this manual.

Syntax

The Syntax section of the system command description describes the proper command syntax that must be sent to Driver488. To define the specific command function, *syntax parameters* accompany each of the system commands. For five detailed listings of syntax parameters for Driver488/SUB and Driver488/W31, turn to the topic "Syntax Parameters" found in each of the five Sub-Chapters of Chapter 14 "Command Summaries."

Returns

The Returns section describes the return of the function completed. Note that most functions return a value of `-1` to indicate an error. Where no other return value is needed, a `0` indicates normal completion. Some functions can also return specific values such as the number of bytes of data successfully transferred.

Note: This format section differs from the Response section of the Driver488/DRV.

Mode

This section of the command description format specifies the operating modes in which the command is valid. Driver488 may be configured as the System Controller in which case it is initially the Active Controller, or as a Not System Controller in which case it is initially in the Peripheral state. The Driver488 configuration as System Controller or Not System Controller can be changed by the **`INSTALL`** program.

Note: Even if Driver488 is not configured as the System Controller, it can still become the Active Controller if another controller on the IEEE 488 bus passes control to Driver488.

The modes are referred to by their names and states as shown below:

Mode Name	State
System Controller	**`SC`**
Active Controller	**`CA`**
Active System Controller	**`SC•CA`**
Not System Controller, Active Controller	**`*SC•CA`**

Mode Name	State
Not System Controller	**`*SC`**
Peripheral (Not Active Controller)	**`*CA`**
System Controller, Not Active	**`SC•*CA`**
Not System Controller, Not Active Controller	**`*SC•*CA`**

Bus States

This section of the command description format indicates the state of the bus device. The mnemonics abbreviations for these bus states, as well as the relevant bus lines and bus commands, are listed in the following two tables:

Bus State	**Bus Lines**	**Data Transfer (DIO) Lines**							
		8	**7**	**6**	**5**	**4**	**3**	**2**	**1**
	Hex Value (QuickBASIC)	&H80	&H40	&H20	&H10	&H08	&H04	&H02	&H01
	Decimal Value	128	64	32	16	8	4	2	1
	Bus Management Lines								
IFC	Interface Clear								
REN	Remote Enable								
	IEEE 488 Interface: Bus Management Lines								
ATN	Attention (&H04)	0	0	0	0	0	1	0	0
EOI	End-Or-Identify (&H80)	1	0	0	0	0	0	0	0
SRQ	Service Request (&H40)	0	1	0	0	0	0	0	0
	IEEE 488 Interface: Handshake Lines								
DAV	Data Valid (&H08)	0	0	0	0	1	0	0	0
NDAC	Not Data Accepted (&H10)	0	0	0	1	0	0	0	0
NRFD	Not Ready For Data (&H20)	0	0	1	0	0	0	0	0
	Serial Interface: Bus Management Lines								
DTR	Data Terminal Ready (&H02)	0	0	0	0	0	0	1	0
RI	Ring Indicator (&H10)	0	0	0	1	0	0	0	0
RTS	Request To Send (&H01)	0	0	0	0	0	0	0	1
	Serial Interface: Handshake Lines								
CTS	Clear To Send (&H04)	0	0	0	0	0	1	0	0
DCD	Data Carrier Detect (&H08)	0	0	0	0	1	0	0	0
DSR	Data Set Ready (&H20)	0	0	1	0	0	0	0	0

Bus State (IEEE 488)	**Bus Commands** (ATN is asserted "1")	**Data Transfer (DIO) Lines**							
		8	**7**	**6**	**5**	**4**	**3**	**2**	**1**
	Hex Value (QuickBASIC)	&H80	&H40	&H20	&H10	&H08	&H04	&H02	&H01
	Decimal Value	128	64	32	16	8	4	2	1
DCL	Device Clear (&H14)	x	0	0	1	0	1	0	0
GET	Group Execute Trigger (&H08)	x	0	0	0	1	0	0	0
GTL	Go To Local (&H01)	x	0	0	0	0	0	0	1
LAG	Listen Address Group (&H20-3F)	x	0	1	a	d	d	r	n
LLO	Local Lock Out (&H11)	x	0	0	1	0	0	0	1
MLA	My Listen Address	x	0	1	a	d	d	r	n
MTA	My Talk Address	x	1	0	a	d	d	r	n
PPC	Parallel Poll Config	x	1	1	0	S	P2	P1	P0
PPD	Parallel Poll Disable (&H70)	x	1	1	1	0	0	0	0
PPU	Parallel Poll Unconfig (&H15)	x	0	0	1	0	1	0	1
SCG	Second. Cmd. Group (&H60-7F)	x	1	1	c	o	m	m	d
SDC	Selected Device Clear (&H04)	x	0	0	0	0	1	0	0
SPD	Serial Poll Disable (&H19)	x	0	0	1	1	0	0	1
SPE	Serial Poll Enable (&H18)	x	0	0	1	1	0	0	0
TAG	Talker Address Group (&H40-5F)	x	1	0	a	d	d	r	n
TCT	Take Control (&H09)	x	0	0	0	1	0	0	1
UNL	Unlisten (&H3F)	x	0	1	1	1	1	1	1
UNT	Untalk (&H5F)	x	1	0	1	1	1	1	1
	(x = "don't care")								

If a command is preceded by an asterisk (**`*`**), that command is unasserted. For example, **`*REN`** states that the remote enable line is unasserted. Conversely, **`REN`** without the asterisk states that the line becomes asserted.

For a further description of these bus states and their bus lines, turn to the topic "Bus States" found in the Sub-Chapter "Command Descriptions" of Chapter 8, and to "Section V: Appendix" in this manual.

Examples

The Examples section of the command description format lists one or more short examples of the command's normal use. These and additional programs can be found in language or example subdirectories of the Driver488 installation directory.

Data Types

Driver488 uses a number of data bit masks, data constants, and data structures. The following constructions have been defined for the C language. Other languages are shown in their respective language sections of this manual.

Arm Condition Bit Masks

Defined bit masks used in the Arm and Disarm functions:

```
acError        acChange       acIdle         acSRQ
acByteIn       acClear        acListen       acTalk
acByteOut      acController   acPeripheral   acTrigger
```

Control Line Bit Masks

The following **`Control Line`** functions for IEEE 488 devices:

```
clEOI    clSRQ    clNRFD    clNDAC    clDAV    clATN
```

return the following defined bit masks, as shown in the table:

Control Line Bit Masks	**Data Transfer (DIO) Lines**							
	8	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Hex Value (QuickBASIC)	&H80	&H40	&H20	&H10	&H08	&H04	&H02	&H01
Decimal Value	128	64	32	16	8	4	2	1
Bit Mask	**EOI**	**SRQ**	**NRFD**	**NDAC**	**DAV**	**ATN**	**0**	**0**

The following **`Control Line`** functions for serial devices:

```
clDSR    clRI    clDCD    clCTS    clDTR    clRTS
```

return the following defined bit masks, as shown in the table:

Control Line Bit Masks	**Data Transfer (DIO) Lines**							
	8	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Hex Value (QuickBASIC)	&H80	&H40	&H20	&H10	&H08	&H04	&H02	&H01
Decimal Value	128	64	32	16	8	4	2	1
Bit Mask	**0**	**0**	**DSR**	**RI**	**DCD**	**CTS**	**DTR**	**RTS**

For more information on the **`Control Line`** command, turn to "Section III: Command References" in this manual.

Terminator Structures

Structure used by **`Enter`**, **`Output`**, and **`Term`**:

```
typedef struct {
      bool EOI;            /* Do we care about or send EOI?*/
      int nChar;           /* 0,1, or 2 characters to match*/
      bool EightBits;      /* 7 (False) or 8 (True) bit terminator match*/
      int termChar [2];    /* The actual terminating character*/
} TermT;
```

Status Structure

Structure used by `Status`:

```
typedef struct {           /* These flags are TRUE (non-zero) if: */
      bool SC;             /* we are System Controller */
      bool CA;             /* we are Active Controller */
      char Primaddr;       /* our primary bus address */
      char Secaddr;        /* our secondary bus address */
      bool SRQ;            /* SRQ is active (CA) or rsv is active (-CA) */
      bool addrChange;     /* we detected an address status change */
      bool talker;         /* we are an active talker */
      bool listener;       /* we are an active listener */
      bool triggered;      /* we have been triggered */
      bool cleared;        /* we have been cleared */
      bool transfer;       /* we have a transfer in progress */
      bool byteIn;         /* we have an input byte to read */
      bool byteOut;        /* we may be able to output a byte */
} IeeeStatusT;
typedef IeeeStatusT*IeeeStatusPT;
```

Completion Code Bit Masks

Structure used by all the `Enter` and `Output` functions:

```
typedef enum {
      ccCount   = 0x0001  /* specified number of characters transferred */
      ccBuffer  = 0x0002  /* buffer count exhausted */
      ccTerm    = 0x0004  /* terminator character(s) detected */
      ccEnd     = 0x0008  /* End signal (EOI) detected */
      ccChange  = 0x0010  /* unexpected change of I/O signals */
      ccStop    = 0x0020  /* transfer terminated by program cmd */
      ccDone    = 0x4000  /* transfer has terminated */
      ccError   = 0x8000  /* details in error code field */
} CompCodeT;
typedef CompCodeT far *CompCodePT;
```

Miscellaneous Constants

The following constants are defined and are required as parameters in several functions:

```
IN          OUT          ON          OFF          FILL_OFF     FILL_ERROR
```

9L. Command Reference

For Driver488/SUB, W31, W95, & WNT

To obtain a detailed description of the command references for Driver488/SUB and Driver488/W31, turn to Section III in this manual entitled “Command References.” The commands for Driver488/W95 and Driver488/WNT are provided as guides, pending current software revisions. Refer to your operating system header file for the latest available information specific to your application. The commands are presented in alphabetical order for ease of use.

10. Driver488/W31

Sub-Chapters

10A. Introduction

Note: Driver488/WIN from previous manuals, has been renamed Driver488/W31.

Driver488/W31 includes a Windows Dynamic Link Library (`DLL`) for integrating IEEE 488.2 control into Microsoft Windows applications. Driver488/W31 transfers data at up to 1M byte/second. It uses HP-style IEEE 488 commands for high- and low-level IEEE 488.1 bus control, and offers additional commands that support the IEEE 488.2 standard. Furthermore, Driver488/W31 conforms to Windows' standard application architecture, allowing Windows to link with the IEEE 488 driver during run time, and to manage its memory requirements, interrupts and messages.

Because Microsoft Windows enables multitasking, multiple test applications may concurrently require access to the same network of IEEE 488 instruments. Driver488/W31 automatically arbitrates among test applications, letting multiple applications run concurrently without the risk of data loss.

Microsoft Windows provides access to Dynamic Data Exchange (DDE), a mechanism by which unrelated applications can exchange data during run time. Driver488/W31 lets you use this inter-application communication technique to transfer data acquired from instruments to any other compatible application. For example, with Driver488/W31, an application program can collect data from an instrument and automatically transfer it to a concurrently running Excel spreadsheet.

Driver488/W31 provides language interfaces for Microsoft C, Quick C on Windows, Visual Basic, Turbo C and Borland C++. Driver488/W31 makes IEEE events in your C or C++ applications conform to Windows' standard event handling scheme, passing IEEE events such as bus errors and `SRQ`s to Windows as standard messages. This assures consistent handling of IEEE and user events.

Visual Basic lets you easily develop full-featured Windows applications. Unlike DOS-based test-system development environments, which merely code for insertion into an application, Visual Basic greatly simplifies the task of adding a user interface to your application. In addition, Visual Basic contains a tool palette for designing your application's user interface, letting you use point-and-click operations to design and test your interface.

Driver488/W31 augments this tool palette with an IEEE *Event Custom Control* tool. When you include this *Event Custom Control* tool in your application, it creates service routines for IEEE events such as bus errors and instruments interrupts (`SRQ`), letting your application handle asynchronous bus events with ease. At run time, the IEEE *Event Custom Control* traps IEEE events which are then automatically dispatched to the appropriate service routines.

Driver488/W31 supports up to four IEEE 488 interfaces. These can be multiple external devices on each interface up to the limits imposed by either electrical loading (14 devices), or with a product such as Expander488, to the limits of the IEEE 488 addressing protocols.

Driver488/W31 supports the GP488B, AT488, MP488, MP488CT, GP488/MM, and NB488 series of IEEE 488.2 interface hardware (with the exception of the Digital I/O and Counter/Timer functions). All interaction between the application and the driver takes place via subroutine calls. Note that Counter/Timer support is available in the **IOTTIMER.DLL** package included on the Driver488/W31 diskette. Refer to your appropriate manuals for more information.

10B. Installation & Configuration

Topics

Before You Get Started

Prior to Driver488/W31 software installation, configure your interface board by setting the appropriate jumpers and switches as detailed in the “Section I: Hardware Guides.” Note the configuration settings used, as they must match those used within the Driver488/W31 software installation.

Once the IEEE 488 interface hardware is installed, you are ready to proceed with the steps outlined within this Sub-Chapter to install and configure the Driver488/W31 software. The Driver488/W31 software disk(s) include the driver files themselves, installation tools, example programs, and various additional utility programs. A file called **README.TXT**, if present, is a text file containing new material that was not available when this manual went to press.

NOTICE

1. **The Driver488/W31 software, including all files and data, and the diskette on which it is contained (the "Licensed Software"), is licensed to you, the end user, for your own internal use. You do not obtain title to the licensed software. You may not sublicense, rent, lease, convey, modify, translate, convert to another programming language, decompile, or disassemble the licensed software for any purpose.**
2. **You may:**
   - **only use the software on one single machine;**
   - **copy the software into any machine-readable or printed form for backup in support of your use of the program on the single machine; and,**
   - **transfer the programs and license to use to another party if the other party agrees to accept the terms and conditions of the licensing agreement. If you transfer the programs, you must at the same time either transfer all copies whether in printed or in machine-readable form to the same party and destroy any copies not transferred.**

The first thing to do, before installing the software, is to make a backup copy of the Driver488/W31 software disks onto blank disks. To make the backup copy, follow the instructions given below.

Making Backup Disk Copies

1. Boot up the system according to the manufacturer's instructions.
2. Find the MS-DOS icon, and open the DOS window.
3. Type the command **`CD\`** to go back to your system's root directory.
4. Place the first Driver488/W31 software disk into drive **`A:`**.
5. Type **`DISKCOPY A: A:`** and follow the instructions given by the **`DISKCOPY`** program. (You may need to swap the original (source) and blank (target) disks in drive **`A:`** several times to complete the **`DISKCOPY`**. If your blank disk is unformatted, the **`DISKCOPY`** program allows you to format it before copying.)
6. When the copy is complete, remove the backup (target) disk from drive **`A:`** and label it to match the original (source) Driver488/W31 software disk just copied.
7. Store the original Driver488/W31 software disk in a safe place.
8. Place the next Driver488/W31 software disk into drive **`A:`** and repeat steps 4-6 for each original (source) disk included in the Driver488/W31 package.
9. Place the backup copy of the Installation disk into drive **`A:`**, type **`A:INSTALL`**, then follow the instructions on the screen.

Driver Installation

There are two steps involved in installing Driver488/W31 onto your working disk. The batch file must first be used to copy the required files from the distribution disk to your working disk, and then the configuration must be established by using the Driver488/W31 configuration utility or modifying the supplied Windows-style initialization file.

Note: Driver488/W31 requires about 2.5MB of hard disk space.

Driver488/W31 should normally be installed on a hard disk. Installing Driver488/W31 on a floppy disk, while possible, is not recommended. The installation batch file will install **`DRVR488W.INI`** into your Windows directory and all other files into a new subdirectory, named **`\IEEE488`**, within your Windows directory. Three subdirectories exist within the **`\IEEE488`** subdirectory which include the language interfaces, example program(s), and utility programs: **`\LANGS`**, **`\EXAMPLES`**, and **`\UTILS`**, respectively.

Assuming that the Driver488/W31 disk is in drive `A:`, specify the full path of your Windows directory. For example, if your Windows directory is `C:\WINDOWS`, you would copy all required files by entering the following command at the DOS prompt:

```
INSTALL C:\WINDOWS
```

The language support files can be copied to any location accessible to your compiler and other development tools. If you wish to have the Driver488/W31 support reside with your application, simply copy or move the files from the `\LANGS\xxx` directory appropriate to your development environment:

- For Borland C compilers: `\LANGS\BC`
- For Microsoft C compilers: `\LANGS\MC`
- For Visual Basic: `\LANGS\VB`

Alternatively, you can place the files where your compiler expects its own files, which may involve placing include files in one place and library files in another.

Example programs are contained in individual subdirectories of `\EXAMPLES` with a precompiled executable made from the provided source files, allowing you to run the example and compare the source code without necessarily needing to compile the program.

The utilities subdirectory `\UTILS` contains two utility programs: `WINTEST` and `QUIKTEST`. These programs were designed as an exercise in order to see the functionality contained within Driver488/W31, to test that your hardware is properly installed and working correctly, and to experiment with command sequences that might be used in your application. For more information on these programs, refer to the Sub-Chapter “Utility Programs” found later in this Chapter.

Note: Before using Driver488/W31, the `C:\WINDOWS\IEEE488` subdirectory must be added to your path. To do so, you may wish to add the following line to your `AUTOEXEC.BAT` file:

```
set PATH=C:\WINDOWS\IEEE488;%PATH%
```

or simply add the following segment to your path statement:

```
;C:\WINDOWS\IEEE488
```

Note if any error messages display when trying to load Driver488/W31 in memory. If so, refer to “Section IV: Troubleshooting” in this manual..

Enhanced Mode DMA Transfers

Driver488/W31 contains an option to use Direct Memory Access (DMA) transfers which provides the highest data transfer rate of the interface hardware. Due to the fact the Microsoft-supplied enhanced-mode DMA device-driver does not allow Driver488/W31 to properly interrogate the DMA controller, you must instruct Windows to use the DMA device driver. If you wish to use DMA transfers, perform the following additional installation steps:

1. In `C:\WINDOWS\SYSTEM.INI`, change the line: `device=*vdmad`
   to: `device=vdmad.386`
2. Next, copy `VDMAD.386` from the `C:\WINDOWS\IEEE488` directory into the `C:\WINDOWS` directory: `COPY\WINDOWS\IEEE488\VDMAD.386 \WINDOWS`

Note: The device driver `vdmad.386` can be used in Windows 3.1 only. **DO NOT use any other operating system.**

Configuration Utility

The Driver488/W31 startup configuration is specified in a Windows-style initialization file named **`DRVR488W.INI`**, which resides in the **`\WINDOWS`** directory. The first screen of the **`CONFIG`** program is used to enter the configuration settings so the Driver488/W31 software can be correctly modified to reflect the state of the hardware.

An alternative to using the configuration utility, is to modify the initialization file directly (either using a text editor or from an application program). For more information on this process, refer to the last topic "Modification of the Initialization File" found in this Sub-Chapter.

The driver can be reconfigured at any time by running the **`CONFIG`** program. If the driver is currently loaded (the Driver488/W31 icon is present), any changes made will not take affect until the driver is closed and reloaded.

Interfaces

The minimum requirement for configuring your system is to make certain that your IEEE 488.2 interface board or module is selected under "Device Type." The default settings in all of the other fields match those of the interface as shipped from the factory. If you are unsure of a setting, it is recommended that you leave it as is.

External Devices

Within your IEEE 488.2 application program, devices on the bus are accessed by name. These names must be created and configured within the **`CONFIG`** program. After configuring your interface parameters, press **`<F5>`** to open the External Devices window. All configured devices will be accessible in your application program via the **`OpenName`** command. For more details, refer to the topic "Configuration of IEEE 488 External Devices" found later in this Sub-Chapter.

Opening the Configuration Utility

In general, all Driver488/W31 configuration utility screens have three main windows: the "name" of the interfaces or devices on the left, the "configuration" window on the right, and the "instruction" window at the bottom of the screen. Based on current cursor position, the valid keys for each window will display in the Instructions box.

To begin the interface configuration, move the cursor in the name window to select an interface description for modification. (Interfaces can be added or deleted using **`<F3>`** and **`<F4>`**.) Notice moving the cursor up and down the list of interfaces or devices in the left window changes the parameters in the configuration window. The configuration fields always correspond with the currently selected interface and device type.

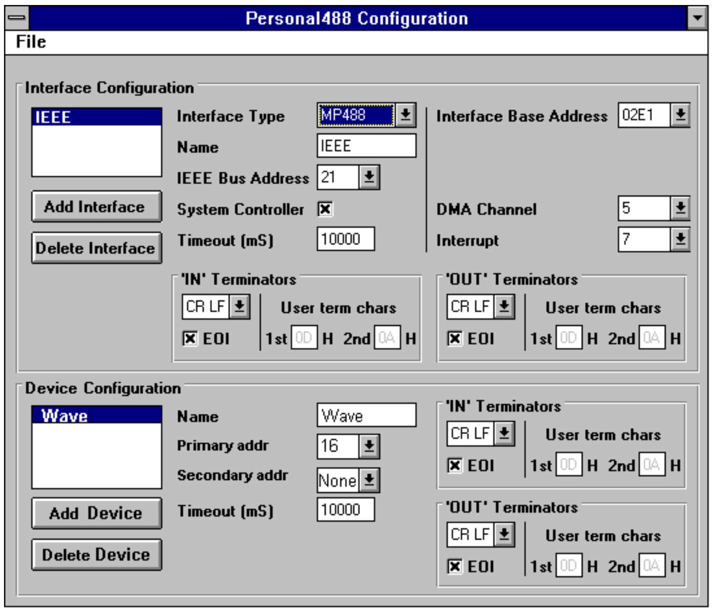
Once all modifications have been made to the configuration screen, **`<F10>`** must be pressed to accept the changes made or **`<F9>`** can be pressed to exit without making any change. Additional function keys allow the user to continue onto the configuration of external devices via **`<F5>`** or to view a graphic representation of the interface card with the selected settings via **`<F7>`**.

Configuration of IEEE 488 Interfaces

Note: The Driver488/W31 supports only the IEEE interface.

The following Driver488/W31 figure displays the configuration of: An MP488 IEEE 488.2 interface in the upper screen section, and a **`WAVE`** external device in the lower screen section.

For additional information on using more than one interface, refer to the final topic "Multiple Interface Management" in the Sub-Chapter "Installation & Configuration" of Chapter 8.



Interface Configuration

IEEE

Interface Type: MP488
Name: IEEE
IEEE Bus Address: 21
System Controller: ☒
Timeout (mS): 10000
Interface Base Address: 02E1
DMA Channel: 5
Interrupt: 7

'IN' Terminators: CR LF, ☒ EOI, User term chars 1st 0D H 2nd 0A H
'OUT' Terminators: CR LF, ☒ EOI, User term chars 1st 0D H 2nd 0A H

Device Configuration

Wave

Name: Wave
Primary addr: 16
Secondary addr: None
Timeout (mS): 10000

'IN' Terminators: CR LF, ☒ EOI, User term chars 1st 0D H 2nd 0A H
'OUT' Terminators: CR LF, ☒ EOI, User term chars 1st 0D H 2nd 0A H

Configuration Utility Screen with MP488 Board

Once an interface is selected, the fields and default entries which display in the configuration window depend on the device type specified. The configuration parameters of the IEEE interface, shown in the figure, are as follows:

Configuration Parameters

- **Name:** This field is a descriptive instrument name which is manually assigned by the user. This must be a unique name. Typically, IEEE is used.
- **IEEE Bus Address:** This is the setting for the IEEE bus address of the board. It will be checked against all the instruments on the bus for conflicts. It must be a valid address from `0` to `30`.
- **DMA:** A *direct memory access* (DMA) channel can be specified for use by the I/O interface card. If DMA is to be used, select a channel as per the hardware setting. If no DMA is to be used, select NONE. The NB488 does not support DMA, therefore the DMA field will not display if this device type is used. Valid settings are displayed in the table.

I/O Board	Specified DMA Channel
GP488B	1, 2, 3 or none
AT488	1, 2, 3, 5, 6, 7 or none
MP488	1, 2, 3, 5, 6, 7 or none
MP488CT	1, 2, 3, 5, 6, 7 or none
NB488	Not applicable
CARD488	Not applicable

- **Interrupt:** A hardware interrupt level (IRQ) can be specified to improve the efficiency of the I/O adapter control and communication using Driver488/W31. For DMA operation or any use of **`OnEvent`** and **`Arm`** functions, an interrupt level must be selected. Boards may share the same interrupt level. If no interrupt level is to be used, select NONE. Valid interrupt levels depend on the type of interface. Possible settings are shown in the table.

I/O Board	Specified Interrupt Level
GP488B	levels 2-7 or none
AT488	levels 3-7, 9-12, 14-15 or none
MP488	levels 3-7, 9-12, 14-15 or none
MP488CT	levels 3-7, 9-12, 14-15 or none
NB488	level 7 for LPT1, level 5 for LPT2
CARD488	levels 3-7, 9-12, 14-15 or none

- **SysController:** This field determines whether or not the IEEE 488 interface card is to be the System Controller. The System Controller has ultimate control of the IEEE 488 bus, and the ability of asserting the Interface Clear (**`IFC`**) and Remote Enable (**`REN`**) signals. Each IEEE 488 bus can have only one System Controller. If the board is a Peripheral, it may still take control of the IEEE 488 bus if the Active Controller passes control to the board. The board may then control the bus and, when it is done, pass control back to the System Controller or another computer, which then becomes the Active Controller. If the board will be operating in Peripheral mode (not System Controller), select NO in this field.

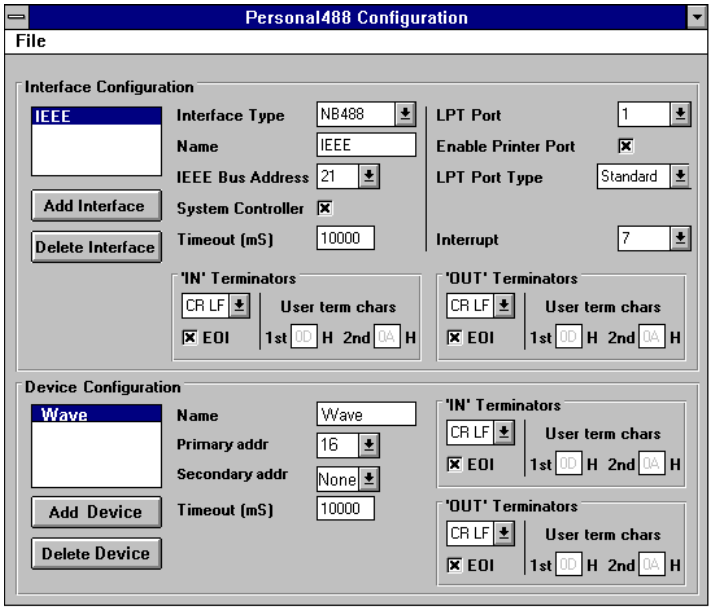
- **Timeout (ms):** The time out period is the amount of time that data transfers wait before assuming that the device does not transfer data. If the time out period elapses while waiting to transfer data, an error signal occurs. This field is the default timeout for any bus request or action, measured in milliseconds. If no timeout is desired, the value may be set to zero.
- **Device Type:** This field specifies the type of device represented by the IEEE device name selected.

I/O Address

- **IEEE 488:** This field is the I/O base address which sets the addresses used by the computer to communicate with the IEEE interface hardware on the board. The address is specified in hexadecimal and can be `02E1`, `22E1`, `42E1` or `62E1`.

  Note: This field does not apply to the NB488. Instead, the NB488 uses the I/O address of the data register (the first register) of the LPT port interface, typically `0x0378`.
- **Bus Terminators:** The IEEE 488 bus terminators specify the characters and/or end-or-identify (`EOI`) signal that is to be appended to data that is sent to the external device, or mark the end of data that is received from the external device.

This second Driver488/W31 example displays the configuration of an NB488 IEEE interface module, specified in the upper screen section. This screen resembles the previous IEEE interface example with the exception of 3 different configuration parameters which are described below.


Personal488 Configuration
File

Interface Configuration
IEEE
Interface Type: NB488
Name: IEEE
IEEE Bus Address: 21
System Controller: ☒
Timeout (mS): 10000
LPT Port: 1
Enable Printer Port: ☒
LPT Port Type: Standard
Interrupt: 7
'IN' Terminators: CR LF; ☒ EOI; User term chars 1st 0D H 2nd 0A H
'OUT' Terminators: CR LF; ☒ EOI; User term chars 1st 0D H 2nd 0A H

Device Configuration
Wave
Name: Wave
Primary addr: 16
Secondary addr: None
Timeout (mS): 10000
'IN' Terminators: CR LF; ☒ EOI; User term chars 1st 0D H 2nd 0A H
'OUT' Terminators: CR LF; ☒ EOI; User term chars 1st 0D H 2nd 0A H

Configuration Utility Screen for NB488

Configuration Parameters

- **LPT Port:** The LPT port is the external parallel port to be connected to the NB488. Valid selections are: `LPT1`, `LPT2`, or `LPT3`. This field takes the place of the I/O Address field.
- **Enable Printer Port:** Because most laptop and notebook PCs provide only one LPT port, the NB488 offers LPT pass-through for simultaneous IEEE 488 instrument control and printer operation. If this option is selected, a printer connected to the NB488 will operate as if it were connected directly to the LPT port. If not enabled, then the printer will not operate when the NB488 is active. The disadvantage of pass-through printer support is that it makes communications with the NB488 about 20% slower.

  Note: If this option is in use, it is important to note that printing will not occur while any IEEE devices are open. If you attempt to print while IEEE 488 devices are open, the program responds as if printing were accomplished. However, Windows actually spools the printer output but then waits until all IEEE 488 devices are closed before printing.

To print through the NB488 printer port, you can either close all IEEE 488 devices, print as necessary and then reopen all instruments on the bus or allow Windows to spool the printer data until the driver devices are closed.

- **LPT Port Type:** This field is used to specify whether the LPT port is a standard IBM PC/XT/AT/PS/2 compatible port. Valid options are Standard or 4-bit. The slower 4-bit option is provided for those computers which do not fully implement the IBM standard printer port. These computers can only read 4 bits at a time from the NB488 making communication with the NB488 up to 30% slower.

  A test program has been provided with NB488 to help identify the user's LPT port type. Once the NB488 is installed, type: **`NBTEST.EXE`**. This program will determine if your computer can communicate with the NB488 and what type of LPT port is installed (Standard or 4-bit).

  It is important to note there are four different versions of the NB488 driver. The **`CONFIG`** utility determines which is to be used based on the user-defined parameters. If both pass-through printer support and the 4-bit LPT port support are selected, then the communication with the IEEE 488 bit may be slowed as much as 40% compared with the fastest case in which neither option is selected. The actual performance will very depending on the exact type and speed of the computer used.

To save your changes to disk, pull down the File menu item and double-click on the Save option. Or to exit without making any changes, double-click on the Exit option. All changes will be saved in the directory where you installed Driver488/W31. If at any time you wish to alter your Driver488/W31 configuration, simply rerun **`CONFIG`**.

Configuration of IEEE 488 External Devices

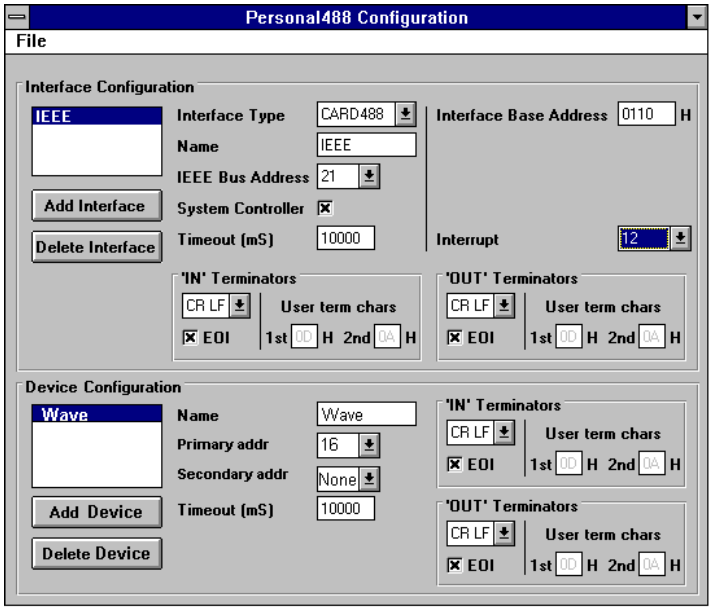
Configuration of IEEE 488 external devices under Driver488/W31 is done by editing an initialization file that stores the specific configuration information about all of the configured external devices. The configuration for each device is set when the Driver488/W31 loads itself into memory and is present at the start of the application program.

Each external device requires a handle to communicate with Driver488/W31. An external device handle is a means of maintaining a record about 3 configurable items: its IEEE 488 bus address, its IEEE 488 bus terminators and its time out period. Any communication with the external device uses these three items. The different configurable items, which define the external device, are listed in the following figure. All external devices have either a default value or a user supplied value for the different fields. All fields can be changed by Driver488/W31 commands during program execution.

Like the first two configuration screen figures, this third figure displays the configuration of an external device named **`WAVE`**, specified in the lower screen section. The following parameters are available for modification:

Configuration Parameters

- **Name:** This field specifies the type of device represented by the IEEE device name selected. External device names are user defined names which are used to convey the configuration information about each device, from the initialization file to the application program. Each external device must have a name to identify its configuration to



Interface Configuration
IEEE
Interface Type: CARD488
Name: IEEE
IEEE Bus Address: 21
System Controller: [X]
Timeout (mS): 10000
Interface Base Address: 0110 H
Interrupt: 12
'IN' Terminators: CR LF; [X] EOI; User term chars 1st 0D H 2nd 0A H
'OUT' Terminators: CR LF; [X] EOI; User term chars 1st 0D H 2nd 0A H

Device Configuration
Wave
Name: Wave
Primary addr: 16
Secondary addr: None
Timeout (mS): 10000
'IN' Terminators: CR LF; [X] EOI; User term chars 1st 0D H 2nd 0A H
'OUT' Terminators: CR LF; [X] EOI; User term chars 1st 0D H 2nd 0A H

Configuration Utility Screen for External Devices

Driver488/W31. The name can then be used to obtain a handle to that device which will be used by all the Driver488/W31 commands. External device names consist of 1 to 32 characters, and the first character must be a letter. The remaining characters may be letters, numbers, or underscores (_). External device names are case insensitive; upper and lower case letters are equivalent. **`ADC`** is the same device as **`adc`**.

- **IEEE Bus Address:** This is the setting for the IEEE 488 bus address of the board. It will be checked against all the devices on the bus for conflicts. The IEEE 488 bus address consists of a primary address from **`00`** to **`30`**, and an optional secondary address from **`00`** to **`31`**. Where required, Driver488/W31 accepts a secondary address of **`-1`** to indicate "NONE."
- **Timeout (ms):** The time out period is the amount of time that data transfers wait before assuming that the device does not transfer data. If the time out period elapses while waiting to transfer data, an error signal occurs. This field is the default timeout for any bus request or action, measured in milliseconds. If no timeout is desired, the value may be set to zero.
- **Device Type:** This field specifies the type of device represented by the external device name selected.
- **Bus Terminators:** The IEEE 488 bus terminators specify the characters and/or end-or-identify (**`EOI`**) signal that is to be appended to data that is sent to the external device, or mark the end of data that is received from the external device.

Note: Because secondary addresses and bus terminators are specified by each handle, it may be useful to have several different external devices defined for a single IEEE 488 bus device. For example, separate device handles would be used to communicate with different secondary addresses within a device. Also, different device handles might be used for communication of command and status strings (terminated by carriage return/line feed) and for communication of binary data (terminated by **`EOI`**).

Note: If installation or configuration problems exist, refer to "Section IV: Troubleshooting."

To save your changes to disk, pull down the File menu item and double-click on the Save option. Or to exit without making any changes, double-click on the Exit option. All changes will be saved in the directory where you installed Driver488/W31. If at any time you wish to alter your Driver488/W31 configuration, simply rerun **`CONFIG`**.

Modification of the Initialization File

If instead of using the configuration utility you wish to modify the initialization file directly, (either using a text editor or from an application program), the following text describes the required contents.

The example initialization file **`DRVR488W.INI`** provides a default setup with one 16-bit IEEE 488 interface at bus address **`21`**, and one external device called **`WAVE`** at bus address **`16`**. This file can be modified to define other configurations, as described in the following paragraphs. Fields not described, should be left as in the example. The order of the fields within the file is significant and should be preserved. If your application will modify the initialization file, note that per Microsoft recommendations for future compatibility, it should be accessed only through the **`GetPrivateProfileString`** and **`SetPrivateProfileString`** functions.

Refer to the supplied **`DRVR488W.INI`** while reviewing the following material:

- The field labeled "Driver" in each section, is the filename of the driver file for a particular layer of the driver. This can be just the filename if the driver file is present in the Windows directory or in the DOS search path, or this can include a full path to the file.
- To support multiple IEEE 488 interfaces, duplicate the driver core sections labeled **`IEEE_3`**, **`IEEE_4`**, and **`IEEE`** for each additional interface, changing the names as required to avoid duplicate names. For instance, **`IEEE_3`** might be changed to **`IEEE2_3`**. These names follow the rules given for device names under **`MakeDevice`** found in "Section III: Command References" of this manual. Also, for more information on multiple interfaces, see the last topic "Multiple Interface Management" in the Sub-Chapter "Installation & Configuration" of Chapter 8.

- Terminators refer to the particular characters or other signals which indicate the end of a data transfer. For instance, a carriage return (`CR`) and line feed (`LF`) pair typically indicates the end of a line of text to a printer. However, some printers may use just `CR` or just `LF` to indicate the end of a line. Other devices may use one of these combinations or some other character, with or without the IEEE 488 end-or-identify (`EOI`) signal, to indicate the end of a transfer.

  Driver488/W31 provides for automatic insertion and detection of these terminators, with the exact terminator to be used, configurable for each interface and external device. Terminators are indicated in the initialization file as a quoted string containing any combination of the following, which indicates no more than 2 characters plus an optional `EOI`:

  `CR` : Carriage return (decimal 13, hex 0D)

  `LF` : Line feed (decimal 10, hex 0A)

  `$char` : A specific character as indicated in decimal

  `‘X` : A specific printable character such as X

  `EOI` : The IEEE 488 End Or Identify signal

  For example, to specify terminators of carriage return followed by line feed with `EOI`, the specification would be `CR LF EOI`. To specify a terminator of the character `X` (decimal 88, hex 58) without `EOI`, you could use either `’X` or `$88`.

Driver Core Sections

Drivers Section

This section contains the names of all active succeeding driver core sections. Any given section can be disabled by removing or commenting out the corresponding line in this section, as has been done with the support for a second IEEE 488 interface in the supplied initialization file.

Router Section

The Router section refers to the driver core section responsible for communications among the other parts of the driver.

Message Handling Section

The Message Handling section refers to the section responsible for error reporting.

Interrupt Section

The Interrupt section refers to the section responsible for coordination of interrupts and event handling.

DMA Section

The DMA section refers to the section responsible for data transfers via Direct Memory Access.

IEEE_3 Section

The `IEEE_3` section concerns the lowest-level access to the interface board and is responsible for directly controlling the hardware. Its components include the following:

- **IOaddr:** `&H02E1`, `&H22E1`, `&H42E1`, `&H62E1`, `&H0378`, `&W0278` or `&W03BC` according to the hardware configuration.
- **DMA:** The DMA channel number to be used (such as `1`, `3`, `5`, etc.) as selected on the interface hardware. If DMA is not desired for any reason, the entry NONE in place of a channel number indicates this fact. For more information on enhanced mode DMA transfers, see the topic “Driver Installation” in the Sub-Chapter “Installation & Configuration” of this Chapter.
- **Interrupt:** The interrupt channel to be used (such as `2`, `7`, `15`, etc.) as selected on the interface hardware. If interrupt support is not desired, the word NONE replaces the channel number.

- **Subset:** MP488CT, MP488, AT488, GP488BP, GP488B or NB488 depending on the type of interface which is present. Also, note that a section defining a GP488B interface must follow a section defining one of the other interfaces.

IEEE_4 Section

The **`IEEE_4`** section concerns components which are common to all IEEE 488 interfaces but not necessarily all types of communications. These components include the following:

- **Slave:** Name of the slave device. With multiple interfaces, this allows the specification of which interface is in this particular chain. The slave must be a device using the **`IOTMP488.EXE`** driver.
- **IEEE Bus Address:** The IEEE 488 Bus Address to be assigned to the interface. This must be a one- or two-digit decimal address between **`0`** and **`30`**.
- **System Controller:** The digit **`1`** indicates System Controller, and **`0`** indicates not System Controller.

IEEE Section

The **`IEEE`** section, which is the device visible to applications as the interface device, concerns components which are common to all types of communication. These components include the following:

- **Slave:** Name of the slave device. With multiple interfaces, this allows the specification of which interface is in this particular chain. The slave must be a device using the **`IOTIEEE4.EXE`** driver.
- **Timeout:** Timeout interval in milliseconds.
- **Termin:** Input terminator (**`Enter`**) following the format specified for terminators, as described above.
- **Termout:** Output terminator (**`Output`**) following the format specified for terminators, as described above.

IEEEDEV Section

The **`IEEEDEV`** section is used for predefined external devices, such as a digital multimeter (**`DMM`**), oscilloscope (**`SCOPE`**), or analog-to-digital converter (**`ADC`**), and is visible to applications as an external device. The name can be changed to suit the application and will be the name referenced by the **`OpenName`** command. There must be at least one external device defined in the initialization file in order to use the **`MakeDevice`** command. There may be multiple external devices on each interface, up to the limits imposed by IEEE 488, but the total number of devices (interfaces plus external devices) may not exceed 56 at any one time. The components for this section, include the following:

- **Slave:** Name of the slave device. With multiple interfaces, this allows the specification of which interface serves this external device. The slave must be a device using the **`IOTGNRCD.EXE`** driver. As noted above, several external devices can specify the same slave when multiple devices are physically connected to the same interface.
- **Termin:** Input terminator (**`Enter`**) following the format specified for terminators, as described above.
- **Termout:** Output terminator (**`Output`**) following the format specified for terminators, as described above.
- **IEEE Bus Address:** IEEE 488 Bus Address (decimal) to be assigned to the device. If this address is one or two digits, it is interpreted as a primary address with no secondary address. With three digits, it is interpreted as a one-digit primary address followed by a two-digit secondary address. With four digits, it is interpreted as a two-digit primary address followed by a two-digit secondary address.
- **Timeout:** Timeout interval in milliseconds.

Additional external devices on the same IEEE 488 interface can be configured by duplicating the **`IEEEDEV`** section and modifying the bus address and other parameters as required.

10C. External Device Interfacing

Topics

Introduction

This Sub-Chapter is a technical review of external device interfacing. It contains information on how to use external devices and multiple interfaces.

Driver488/W31 controls I/O adapters and their attached external devices. In turn, Driver488/W31 is controlled via *subroutine calls*.

Driver488/W31 communicates directly with I/O adapters such as an IEEE 488 interface board. More than one I/O adapter may reside on a single plug-in board. For example, the IEEE 488 interface board contains the IEEE 488 I/O adapter.

I/O adapters connect to external devices such as digitizers, multimeters, plotters, and oscilloscopes (IEEE 488 interface); and serial devices such as printers, plotters, and modems. However, Driver488/W31 allows direct control of IEEE 488 external devices only.

Note: To reiterate, Driver488/W31 supports IEEE 488 external devices, and does not support serial external devices.

Driver488/W31 is controlled by sending data and commands, and receiving responses and status by *subroutine calls*. This method is the only Application Program Interface, API, available to connect the application (user's) program to Driver488/W31.

Subroutine Calls

The subroutine API is a library of subroutines linked to the application program that are invoked like any other subroutines in that programming language. Once invoked, these routines can control Driver488/W31.

Configuration of Named Devices

Named devices provide a method to maintain a permanent record of an external device's configuration that does not change between application programs. Once the configuration of a particular external device is established, its Driver488/W31 configuration for that device will remain the same until the next time you reconfigure it or unload and reload the driver. The external devices supported by Driver488/W31 are IEEE 488 external devices only.

External devices are most easily configured at installation. For Driver488/W31, the device names, terminators, timeout period, and bus addresses may be entered into a configuration file (either manually or using the **`CONFIG`** utility) which contains the device configuration information. This configuration file is automatically read during driver load to install the configured named devices. The application program can then refer to the external device by name and have all of the configuration information automatically set.

Every device to be accessed by Driver488/W31 must have a valid device name. Driver488/W31 comes with several device and interface names preconfigured for use. Among those already configured for the GP488B board, for example, are: **`IEEE`** and **`WAVE`**. You can configure up to 32 external devices for each IEEE 488 interface.

It is also possible to configure new named devices by using the Driver488/W31 command **`MakeDevice`**. The **`MakeDevice`** command creates a temporary device that is an identical copy of an already existing Driver488/W31 device. The new device has default configuration settings identical to those of the existing device. The new device can then be reconfigured by calling the proper functions, such as **`BusAddress`**, **`IntLevel`**, and **`TimeOut`**. When Driver488/W31 is closed, the new device is forgotten unless the **`KeepDevice`** command is used to make it permanent.

The following code illustrates how the subroutine API version of the **`MakeDevice`** command could be used to configure several new named devices. Using the C language subroutine interface, three named devices can be configured as follows:

```
wave = OpenName("WAVE")
dmm = MakeDevice(WAVE,"DMM");
if (dmm == -1) { process error...}
err = BusAddress(dmm,16,-1);
if (err == -1) { processerror...}
term.EOI = TRUE;
term.nChars = 2;
term.termChar[0] = '\r';
term.termChar[1] = '\n';
err = Term(dmm,&term,BOTH);
if (err == -1) {process error...}

adc = MakeDevice(WAVE,"ADC");
if (a == -1) { process error...}
err = BusAddress(adc,14,00);
if (err == -1) { process error...}
term.EOI = FALSE;
term.nChars = 1;
term.termChar[0] = '\n';
err = Term(adc,&term,BOTH);
if (err == -1) { process error...}

scope = MakeDevice(WAVE,"SCOPE");
if (scope == -1) { process error...}
err = BusAddress(scope,12,01);
if (err == -1) { process error...}
term.EOI = TRUE;
term.nChars = 0;
err = Term(scope,&term,BOTH);
if (err == -1) { process error...}
```

The above example defines the following: An external device named **`DMM`** (digital multimeter) as device **`16`** with bus terminators of carriage return (**`\r`**), line feed (**`\n`**), and **`EOI`**; a second external device named **`ADC`** (analog-to-digital converter) as device **`14`** with bus terminators of carriage return and line feed (together as **`\n`**); and a third external device named oscilloscope (**`SCOPE`**) as device **`12`** with bus terminators of **`EOI`** only.

External devices defined in a configuration file are permanent. Their definitions last until they are explicitly removed or until the configuration file is changed and Driver488/W31 is restarted. Devices defined after installation are normally temporary. They are forgotten as soon as the program finishes. The **`KeepDevice`** command can be used to make these devices permanent. The **`RemoveDevice`** command removes the definitions of devices even if they are permanent. These commands are described in further detail in the "Section III: Command Reference" of this manual.

Use of External Devices

When using subroutine Application Program Interface (API) functions, it is first necessary to obtain a device handle for the device(s) with which you wish to interact.

When using Driver488/W31, the **`OpenName`** function must be the first function called in the program. It takes the name of the device to open and returns a handle for the specified interface board or device. Every other function can then use that handle to access the device.

The following program illustrates how Driver488/W31 might communicate with an analog-to-digital converter (**`adc`**) and an oscilloscope (**`scope`**):

```
DevHandleT ieee;              // handle to access the interface board ieee
DevHandleT adc;               // handle to access a ADC488
DevHandleT scope;             // handle to access the scope
DevHandleT deviceList[5];     // array containing a list of device handles;
int err;
```

Communication with a single device:

```
adc = OpenName ("ADC");
```

If you use several devices, you must open each one.

```
ieee = OpenName("IEEE");
scope = OpenName("SCOPE");    // Add adc to the list of devices
deviceList[0] = adc;          // Add oscilloscope to the list of devices
deviceList[1] = scope         // End of list marker
deviceList[2] = -1;

Abort(ieee);                  // Send Interface Clear (IFC)

Output(scope,"SYST:ERR?");    // Read SCOPE error status
Enter(scope,data);
printf(data);

Output(adc,"A0 C1 G0 R3 T0 X");      // Set up ADC488
Enter(adc,data);
printf(data);

ClearList (deviceList) ;      // Send a Selected Device Clear (SDC) to a list
Close (adc) ;                 // Close ADC488. Handle is now unavailable for
                              // access.
```

If we tried to call **`Output`** by sending the handle **`adc`** without first opening the name **`ADC`**, an error would result and **`Output`** would return a **`-1`** as shown below:

```
result = Output (adc, "A0 C1 G0 R3 T0 X");
printf ("Output returned: %d.\n",result);
```

should print:

```
Output returned: -1.
```

As mentioned above, named devices have another advantage: they automatically use the correct bus terminators and time out. When a named device is defined, it is assigned bus terminators and a time out period. When communicating with that named device occurs, Driver488/W31 uses these terminators and time out period automatically. Thus **`Term`** commands are not needed to reconfigure the bus terminators for devices that cannot use the default terminators (which are usually carriage-return line-feed **`EOI`**). It is still possible to override the automatic bus terminators by explicitly specifying the terminators in an **`Enter`** or **`Output`** command, or to change them semi-permanently via the **`Term`** command. For more information, see the **`Enter`**, **`Output`**, and **`Term`** commands described in "Section III: Command References."

Extensions For Multiple Interfaces

Driver488/W31 allows the simultaneous control of multiple interfaces each with several attached devices. To avoid confusion, external devices may be referred to by their "full name" which consists of two parts. The "first name" is the hardware interface **`name`**, followed by a colon separator (**`:`**). The "last name" is the external device **`name`** on that interface. For example, the "full name" of **`DMM`** might be **`IEEE:DMM`**.

Duplicate Device Names

Duplicate device names are most often used in systems that consist of several identical sets of equipment. For example, a test set might consist of a signal generator and an oscilloscope. If three test sets were controlled by a single computer using three separate IEEE 488 interfaces, then each signal generator and each oscilloscope might be given the same name and the program would specify which test set to use by opening the correct interface (**`OpenName("IEEE")`** for one, **`OpenName("IEEE2")`** for the other), or by using the interface names when opening the devices (**`OpenName("IEEE:GENERATOR")`** for one and **`OpenName("IEEE2:GENERATOR")`** for the other).

Unique names are appropriate when the devices work together, even if more than one interface is used. If two different oscilloscopes, on two different interfaces are used as part of the same system, then they would each be given a name appropriate to its function. This avoids confusion and eliminates the need to specify the interface when opening the devices.

Access of Multiple Interfaces

If the computer only has one IEEE 488 interface, then there is no confusion; for every external device is known to be on that interface. As noted above, duplicate device names on one interface are not recommended; if they exist, the most recently defined device with the requested name will be used. When more than one interface is available and duplicate names appear on different interfaces, the following rules apply.

1. If the external device name is specified without its interface name, then any external device with that name may be used. If more than one external device has that name, then the choice of which particular external device is not defined.
2. If the external device name is specified with its interface name prefixed, then that external device on that hardware interface is used. If that external device is not attached to the specified hardware interface, then an error occurs.

Example

Assume there are three IEEE 488 interfaces: **`IEEE`**, **`IEEE2`**, and **`IEEE3`** controlling multiple devices: **`SCOPE`** (on **`IEEE`**), **`DA`** (on **`IEEE2`**) and **`DA`** (on **`IEEE3`**). Since there are two external devices, both named **`DA`**, their full name must be used to specify them.

We can communicate with the external devices, according to the two rules above.

```
scope = OpenName ("SCOPE") ;          // SCOPE on IEEE (Rule 1)
da = OpenName ("DA")                  // DA on IEEE2 or IEEE3 (not specified)
da = OpenName ("IEEE2:DA") ;          // DA on IEEE2 (Rule 2)
scope = OpenName ("IEEE2:SCOPE");     // Error (not IEEE:SCOPE) (Rule 2)
```

10D. Getting Started

Topics

Introduction

C Languages

Driver488/W31 provides support for Microsoft C, Quick C and Borland C++. In addition, Driver488/W31 features an IEEE 488 *Event Message*. The IEEE *Event Message* can be used to trap IEEE 488 events such as bus errors and instrument interrupts (**`SRQ`**) letting your application handle asynchronous bus events. At run time, the IEEE 488 Message Handler traps IEEE 488 events, which are then automatically dispatched to the appropriate service routines.

The following text outlines the steps necessary to produce an application program that communicates with Driver488/W31. For more details on using C languages to develop a basic data acquisition program and on how to use the IEEE 488 *Event Message* with Driver488/W31, turn to the next Sub-Chapter "C Languages" in this Chapter. All of the examples described in that Sub-Chapter were developed using Quick C for Windows. For details on using the **`WINTEST`** and **`QUIKTEST`** utility programs, turn to the following Sub-Chapter "Utility Programs" in this Chapter. Additional functions provided by Driver488/W31 are described in "Section III: Command References" of this manual.

Visual Basic

Driver488/W31 provides support for Microsoft's Visual Basic. Visual Basic includes a tool palette for designing your application's user interface, letting you use point-and-click operations to design and test your entire user interface. For example, to place a button in one of your application's windows, you simply select the button tool from the tool palette, then click and drag in the desired window to place and size the button.

In addition, Driver488/W31 adds to the tool palette with an IEEE 488 *Event Custom Control*. Including the *Event Custom Control* in your application creates service routines for IEEE 488 events such as bus errors and instrument interrupts (**`SRQ`**), letting your application handle asynchronous bus events with unparalleled ease. At run time, the IEEE 488 *Event Custom Control* traps IEEE 488 events, which are then automatically dispatched to the appropriate service routines.

The following text outlines the steps necessary to produce an application program that communicates with Driver488/W31. For more details on using Visual Basic to develop a basic data acquisition program, how to use the IEEE 488 *Event Custom Control*, and performing Dynamic Data Exchange with Driver488/W31, turn to the following Sub-Chapter "Visual Basic" in this Chapter. For details on using the **`WINTEST`** and **`QUIKTEST`** utility programs, turn to the following Sub-Chapter "Utility Programs" in this Chapter. Additional functions provided by Driver488/W31 are described in "Section III: Command References" of this manual.

C Languages

To successfully operate Driver488/W31, several declarations must be included in the user's application program. These declarations are found in two headers which must be included in the main module of your C program. The two required headers can be found in the language-specific subdirectory at the end of the path **`\IEEE488\LANGUAGE`**, if installed under the default conditions.

In the same directory as the headers is the library that must be linked with your C project to resolve Driver488/W31 external references.

Note: For proper configuration, the C compiler must have byte alignment when using term structure.

Required Headers

For Microsoft C and Quick C Users:

- All programs need to include the following header files to run with Driver488/W31:

```
iot_main.h
iotmc60w.h
```

- These header files must be included in your test program. To do so, insert the following lines:

```
#include "iot_main.h"
#include "iotmc60w.h"
```

These lines must be included at the top of your program before any calls to the Driver488/W31 subroutine functions are made. Notice that the header file **iot_main.h** must be in the module containing your **main()** function and may not appear in any other modules.

For Borland C Users:

- All programs need to include the following header files to run with Driver488/W31:

```
iot_main.h
iotbc20w.h
```

- These header files must be included in your test program. To do so, insert the following lines:

```
#include "iot_main.h"
#include "iotbc20w.h"
```

These lines must be included at the top of your program before any calls to the Drvier488/W31 subroutine functions are made. Notice that the header file **iot_main.h** must be in the module containing your **main()** function and may not appear in any other modules.

Required Libraries

For Microsoft C & Quick C Users:

- All programs need to include the following library in the link process to run with Driver488/W31:

```
drvr488.lib
```

This file must be included in your test program's makefile or link process. Due to the complexity of makefiles, this discussion will not attempt to build a makefile but does include sample makefiles for each of the examples used within the next Sub-Chapter "C Languages" in this Chapter.

For Borland C Users:

- All programs need to include the following library in the link process to run with Driver488/W31:

```
drvr488.lib
```

This file must be included in your test program's project file or link process. Due to the complexity of project files, this discussion will not attempt to build a project file but does include sample project files for each of the examples used within the next Sub-Chapter "C Languages" in this Chapter.

Visual Basic

To successfully operate Driver488/W31, a text file must be included in the user's application program. The required library can be found in the language-specific subdirectory at the end of the path **\IEEE488\WINAPI**, if installed under the default conditions.

Required Files

In order to have access to all the Driver488/W31 functions, you must include the following file:

```
IOTVB10.TXT
```

You can accomplish this through the Add File item under the File menu. Type ***.TXT** into the selection field to find the file in your project.

Certain functions provided by Driver488/W31 require that data structures be passed in a particular format which is not easily generated from a VB application. Conversion functions are provided in:

```
IOTVB10.BAS
```

This file should be included in the Project Window. Using the VB File menu, select the item Add File and select **IOTVB10.BAS**. At this point, all Driver488/W31 functions should be accessible.

If you require event handling support, use the custom control written for event handling. The IEEE 488 *Event Custom Control* support is included in the following file:

```
IOTEVENT.VBX
```

This file should be included in the Project Window. For more information on using the IEEE *488 Event Custom Control*, turn to the topic “IEEE 488 Event Custom Control” found in the following Sub-Chapter “Visual Basic” in this Chapter.

10E. C Languages

Topics

Accessing from a Windows Program

The structure of a Windows program generally dictates that actions take place in response to messages such as an operator key press, mouse action, menu selection, etc. This discussion covers the basic actions needed to control Driver488/W31. How these actions are combined and coordinated in response to Windows messages, is up to the application designer.

Opening & Closing the Driver

The first Driver488/W31 programming example is designed for simplicity. Its sole purpose is to verify proper communication with the driver, and upon closing, remove the driver from memory.

In every C program using Driver488/W31, header files of declarations must be merged into the program. In the following example, those declarations have been omitted from the listing for the sake of brevity.

With the associated source files, the following program can be built using the file **`EXAMPLE1.MAK`** (for Microsoft C or Quick C users) or **`EXAMPLE1.PRJ`** (for Borland C users) found on the Driver488/W31 disk.

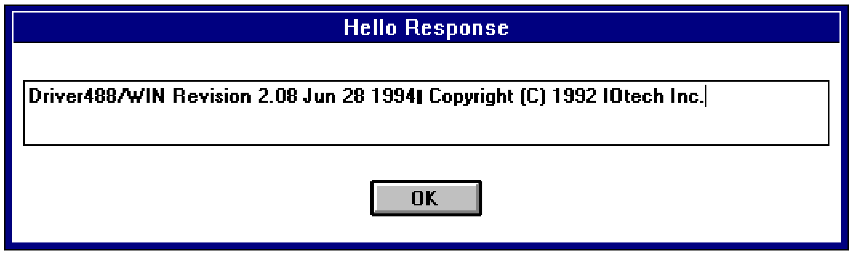
This example has several declarations that will be used later:

```
HWND hDriver              /* handle for Driver488/W31 */
DevHandleT ieee;          /* handle for the IEEE board * /
char hellomsg[256];       /* string to hold the hello response */
```

The program only has one menu with two selections: *Go* and *Quit*. When Go is selected, the service routine for Go opens Driver488/W31. Then the **`Hello`** function is called, using the handle returned from the **`OpenName`** function:

```
case WM_INITDIALOG:
      cwCenter(hWndDlg, 0);
      /* initialize working variables */
      ieee=OpenName("IEEE");
      Hello(ieee, hellomsg);
      SetDlgItemText(hWndDlg, 101, (LPSTR)hellomsg);
      Close(ieee);
      break; /* End of WM_INITDIALOG */
```

After the *Hello Message* window is displayed, as shown in the figure, the driver handle is closed. Since in this application the handle is created every time Go is selected, a potential conflict could arise if that handle is not closed as we exit this subroutine. Clicking the OK button will close this window.


Hello Response

Driver488/WIN Revision 2.08 Jun 28 1994| Copyright (C) 1992 IOtech Inc.

Hello Message Window

When the application is closed by selecting Quit, the **`WM_DESTROY`** message is sent to Driver488/W31:

```
case WM_CLOSE:                          /* close the window */
      hDriver=FindWindow((LPSTR)"Driver488Loader",
      (LPSTR)"Driver488/W31");
      SendMessage(hDriver, WM_DESTROY, 0, 0L);
      DestroyWindow(hWnd);
      if (hWnd == hWndMain)
            PostQuitMessage(0);         /* Quit the application */
      break;
```

Establishing Communications

The following program contains most of the function calls of Driver488/W31. The user interface of this program is intentionally simple to highlight the Driver488/W31 operations. To centralize all of the Driver488/W31-related code, the architecture of this example is not typical of a C program. This example operates the multi-channel 16-bit analog-to-digital converter; the ADC488.

In every C program using Driver488/W31, header files of declarations must be merged into the program. In the next example, those declarations are omitted from the listing for the sake of brevity.

With the associated source files, the following program can be built using the file **`EXAMPLE2.MAK`** (for Miscrosoft C or Quick C users) or **`EXAMPLE2.PRJ`** (for Borland C users) found on the Driver488/W31 disk.

This example has several declarations that will be used later:

```
HWND hDriver                        /* handle for Driver488/W31 */
DevHandleT ieee, adc, devhandle;    /* handles for the IEEE board * /
char textstr[2048], response[64];   /* string for Driver488responses */
double sum, voltage;                /* variables for ADC488 responses */
```

For the sake of this discussion, assume that Driver488/W31 has been configured to start with a configuration including the devices **`IEEE`** (IEEE 488 interface) and **`ADC`** (ADC488/8S connected to the IEEE 488 interface). Additional interfaces and/or devices may also have been defined, as the driver can support up to 4 interfaces and 56 devices simultaneously. To open the two devices of interest, we use the following statements:

```
/* Open Driver488/W31 */
if ((ieee=OpenName("IEEE"))<0) {
        MessageBox(hWndDlg,(LPSTR)"Cannot initialize IEEE system",
        NULL,MB_OK);
        EndDialog(hWndDlg, TRUE);
        return TRUE;
}

/* Open or create the device named ADC */
Error(ieee, OFF);
switch (adc=OpenName("ADC")) {
        case -2:
                MessageBox(hWndDlg,(LPSTR)"ADC device already open",NULL,
                MB_OK);
                EndDialog(hWndDlg, TRUE);
                return TRUE;
        case -1:
                /* Create the device ADC by copying the default device WAVE*/
                switch (devhandle=OpenName("WAVE")) {
                        case -2:
                                MessageBox(hWndDlg,(LPSTR)"WAVE device already
                                open",NULL,MB_OK);
                                EndDialog(hWndDlg, TRUE);
                                return TRUE;
                        case -1:
                                MessageBox(hWndDlg,(LPSTR)"Cannot open WAVE
                                device",NULL,MB_OK);
                                EndDialog(hWndDlg, TRUE);
                                return TRUE;
                        default:
                                break;
        }
        if ((adc=MakeDevice(devhandle, "ADC"))) {
                MessageBox(hWndDlg, (LPSTR)"Cannot create ADC device", NULL,
                MB_OK);
                EndDialog(hWndDlg, TRUE);
                return TRUE;
        }
        Close(devhandle);
                break;
        default:
                break;
}
GetError(ieee, textstr);
BusAddress(adc, 14, -1);
```

If the **ADC** was not configured within Driver488/W31, it can be optionally created "on the fly", as shown above. First **Error** was used to turn **OFF** automatic error reporting so that our application can trap the error instead. If opening the name **ADC** failed, the handle of the device **IEEE**, which is always available within Driver488/W31, is used to clone a new device called **ADC** using the **MakeDevice** command. **GetError** is then called to clear the internal error registered within Driver488/W31. Lastly, the IEEE bus address **14** is assigned to the **ADC**.

If other devices were needed for the application at hand, they could either be defined in the startup configuration for Driver488/W31 or they could be created "on the fly" from the application:

```
adc2 = MakeDevice(adc, "ADC2")
BusAddress (adc2,10,-1)
```

The new device **ADC2** is configured to reside at a different bus address so that the two devices may be distinguished. There is one other important difference between **ADC** and **ADC2** at this point. **ADC2** is a temporary device; that is, as soon as the creating application closes, **ADC2** ceases to exist. If our intent was to create a device that could be accessed after this application ends, we must tell Driver488/W31 this:

```
KeepDevice (adc2)
```

After executing the previous statement, **ADC2** is marked as being permanent; that is, the device will not be removed when the creating application exits. If we later wish to remove the device, however, we can do so explicitly:

```
RemoveDevice (adc2)
```

Confirming Communications

With or without an open device handle, the application can, if desired, confirm communication with Driver488/W31 via the **`Hello`** function:

```
Hello(ieee, textstr);
strcat(textstr, "\r\n");
```

The function also fills in a string, from which information can be extracted if it is desirable to display facts about the driver in use.

IEEE 488 Event Message

The IEEE 488 *Event Message* feature of Driver488/W31 allows a C program to respond to IEEE 488 bus events. Driver488/W31 will send the Windows Message **`WM_IEEE488EVENT`** to the application when an enable event occurs. A listing of available events is shown in the table:

Event	Description
`SRQ`	The Service Request bus line is asserted.
`Peripheral`	An addressed status change has occurred and the interface is a Peripheral.
`Controller`	An addressed status change has occurred and the interface is an Active Controller.
`Trigger`	The interface has received a device **`Trigger`** command.
`Clear`	The interface has received a device **`Clear`** command.
`Talk`	An addressed status change has occurred and the interface is a Talker.
`Listen`	An addressed status change has occurred and the interface is a Listener.
`Idle`	An addressed status change has occurred and the interface is neither a Talker nor a Listener.
`ByteIn`	The interface has received a data byte.
`ByteOut`	The interface has been configured to output a data byte.
`Error`	A Driver488/W31 error has occurred.
`Change`	The interface has changed its addressed state. The Controller/Peripheral or Talker/Listener/Idle states of the interface have changed.

Note: This *Event* table mirrors the *Arm Condition* table found under the topic "System Controller, Not Active Controller Mode" in the Sub-Chapter "Operating Modes" of Chapter 9.

To trap the IEEE 488 *Event Message*: Simply check for the **`WM_IEEE488EVENT`** message in the default switch of the application's window handler. If the IEEE 488 *Event Message* is detected, execute code to handle the event.

The following example uses the capability of the ADC488 to issue an IEEE 488 **`SRQ`** when it needs servicing. The IEEE 488 *Event Message* will be issued and trapped on the **`SRQ`** and the ADC488 will be serviced.

In every C program using Driver488/W31, header files of declarations must be merged into the program. In the following example, those declarations have been omitted from the listing for the sake of brevity.

With the associated source files, the following program can be built using the file **`EXAMPLE3.MAK`** (for Microsoft C or Quick C users) or **`EXAMPLE3.PRJ`** (for Borland C users) found on the Driver488/W31 disk.

This example has several declarations that will be used later:

```
HWND hDriver                          /* handle for Driver488/W31 */
DevHandleT ieee;                      /* handle for the IEEE board * /
char textstr[2048], response[64];     /* string for Driver488responses */
char hellomsg[256];                   /* string to hold the hello response */
int i, hundred[100];                  /* general counter and data buffer */
TermT noterm;                         /* structure for disabling terminators */
```

Starting out like the previous example, this program then differs by adding an **`Error`** line to turn **`ON`** the automatic error reporting:

```
/* open Driver488/W31 */
if ((ieee=OpenName(“IEEE”))) {
        MessageBox(hWndDlg, (LPSTR)"Cannot initialize IEEE system",
        NULL, MB_OK);
        EndDialog(hWndDlg, TRUE);
        return TRUE;
}

/* open device named ADC */
Error(ieee, OFF);
switch (adc=OpenName(“ADC”)) {
        case -2:
                MessageBox(hWndDlg, (LPSTR)"ADC device already open", NULL,
                MB_OK);
                EndDialog(hWndDlg, TRUE);
                return TRUE;
        case -1:
                /* Create the device ADC by copying the default device WAVE*/
                switch (devhandle=OpenName(“WAVE”)) {
                        case -2:
                                MessageBox(hWndDlg, (LPSTR)"WAVE device already
                                open", NULL, MB_OK);
                                EndDialog(hWndDlg, TRUE);
                                return TRUE;
                        case -1:
                                MessageBox(hWndDlg, (LPSTR)"Cannot open WAVE
                                device",NULL, MB_OK);
                                EndDialog(hWndDlg, TRUE);
                                return TRUE;
                        default:
                                break;
        }
        if ((adc=MakeDevice(devhandle, “ADC”))) {
                MessageBox(hWndDlg, (LPSTR)"Cannot create ADC device", NULL,
                MB_OK);
                EndDialog(hWndDlg, TRUE);
                return TRUE;
        }
        Close(devhandle);
                break;
        default:
                break;
}
GetError(ieee, response);
Error(ieee, ON);
BusAddress(adc, 14, -1);
```

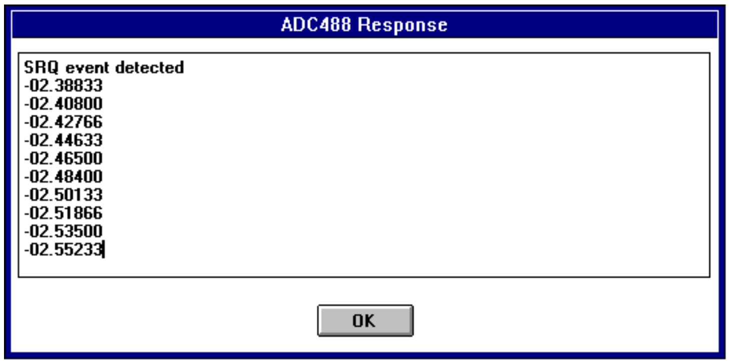
When the IEEE 488 *Event Message* has been passed to the application, the following service routine is executed. The particular subroutine is invoked when the ADC generates an **SRQ** on “acquisition complete.”

```
default:
        if (Message==WM_IEEE488EVENT) {
                strcpy(textstr,"SRQ event detected\r\n");
                SetDlgItemText(hWndDlg, 201, (LPSTR)textstr);
        }

        /* Clear the SRQ condition */
        SPoll(adc);

        /* Reset the buffer pointer of the ADC488 */
        Output(adc, “B0X”);

        /* Get 100 readings from the ADC488 */
        for (i=0;id;i++) {
                Enter(adc,response);
                strcat(textstr, response);
                strcat(textstr, “\r\n”);
        }

        SetDlgItemText(hWndDlg, 201, (LPSTR)textstr);
}
return FALSE;
```

To enable the **`WM_IEEE488EVENT`** message, Driver488/W31 must be told to which window to send the message using the **`OnEvent`** command. It must also enable the message on an **`SRQ`** with the **`Arm`** command.

```
/* Setup event handling for trapping the SRQ */
OnEvent(ieee, hWndDlg, (OpaqueP)0L);
Arm(ieee, acSRQ);
```

Note that upon closing the handle, all event handling associated with this control is disabled. You must keep the device open during the time in which its events are of interest. That is, with an ADC488, you would open the device, assign the device handle, configure the **`adc`** with **`Output`** commands, and then wait for the **`SRQ`** event to be triggered. The **`SRQ`** event handler would read data from the ADC488 and then close the device, allowing other tasks access, and eliminating the event notification. The data read from the ADC488, is displayed in the *ADC488 Response* window, as shown in the figure.



```
SRQ event detected
-02.38833
-02.40800
-02.42766
-02.44633
-02.46500
-02.48400
-02.50133
-02.51866
-02.53500
-02.55233
```

Data read from the ADC488

Finally, the ADC488 is setup to complete an acquisition and assert **`SRQ`**.

```
/* Clear the ADC488 */
Clear(adc);

/* Setup the ADC488 to SRQ on acquisition complete */
Output(adc, "M128X");

/* Setup the ADC488:
       100 uSec scan interval (I3)
       No pre-trigger scans, 100 post-trigger scans (N100)
       Continuous trigger on GET (T1)
*/
Output(adc, "I3N100T1X");

/* Wait for the ready bit of the ADC488 to be asserted */
while ((SPoll(adc) & 32) == 0);

/* Trigger the ADC488 */
Trigger(adc);
```

Reading Driver Status

Your application may interrogate Driver488/W31 at any time to determine its status and other information. **`Status`** information is returned in a structure provided by the application and can be displayed by the **`showstat`** function shown below.

```
Status(ieee, &substat);
showstat(&substat, textstr);
```

Another function to display the information contained in the **`Status`** structure could be:

```
void showstat(IeeeStatusT *substat, char *textstr) {
char response[64];

sprintf(response, "SC            :%d\r\n", substat->SC);
strcat(textstr, response);
sprintf(response, "CA            :%d\r\n", substat->CA);
strcat(textstr, response);
sprintf(response, "PrimAddr      :%d\r\n", substat->Primaddr);
strcat(textstr, response);
sprintf(response, "SecAddr       :%d\r\n", substat->Secaddr);
strcat(textstr, response);
sprintf(response, "SRQ           :%d\r\n", substat->SRQ);
strcat(textstr, response);
sprintf(response, "addrChange    :%d\r\n", substat->addrChange);
strcat(textstr, response);
sprintf(response, "talker        :%d\r\n", substat->talker);
strcat(textstr, response);
sprintf(response, "listener      :%d\r\n", substat->listener);
strcat(textstr, response);
sprintf(response, "triggered     :%d\r\n", substat->triggered);
strcat(textstr, response);
sprintf(response, "cleared       :%d\r\n", substat->cleared);
strcat(textstr, response);
sprintf(response, "transfer      :%d\r\n", substat->transfer);
strcat(textstr, response);
sprintf(response, "byteIn        :%d\r\n", substat->byteIn);
strcat(textstr, response);
sprintf(response, "byteOut       :%d\r\n", substat->byteOut);
strcat(textstr, response);
}
```

External Device Initialization

Refer to the device manufacturer's documentation on specific requirements for initializing your IEEE 488 instrument. In the case of the ADC488, appropriate initialization involves sending it a **`Clear`** command and placing it into **`Remote`** mode:

```
Clear (adc) ;
Remote (adc) ;
```

For our hypothetical application, we also wish to have the ADC488 generate a service request should it detect a command error. This involves sending a command string consisting of textual data to the ADC488:

```
Output (adc, "M8X") ;
```

We may also wish to perform other initialization and configuration. In this case, we set up the ADC488 (**`adc`**) in the following configuration:

```
/* Setup the ADC488
      Differential inputs (A0)
      Scan group channel 1 (C1)
      Compensated ASCII floating-point output format (G0)
      Channel 1 range to +/- 10V (R3)
      One-shot trigger on talk (T6)
*/
```

The command to perform this configuration combines the above strings and adds the **`Execute`** (**`X`**) command for the ADC488:

```
Output(adc, "A0C1G0R3T6X");
```

Basic Data Acquisition

With both Driver488/W31 and the external device ready for action, we next might try taking a simple reading using the ADC488. Here, we use the serial poll (**`SPoll`**) capabilities of Driver488/W31 to determine when a response is ready and to format the reply.

```
/* Wait for the ready bit of the ADC488 to be asserted */
while ((SPoll(adc) & 32) == 0);

/* Display the reading */
Enter(adc, response);
strcat(textstr, "ADC488 channel #1 reading value is ");
strcat(textstr, response);
strcat(textstr, "\r\n");
```

```
/* Now acquire and display the average of 10 readings */
sum = 0.0;
for (i=0;i<10;i++) {
      Enter(adc,response);
      sscanf(response,"%lf",&voltage);
      sum+=voltage;
}
sum/=10.0;

sprintf(response, "The average of 10 readings is %lf\r\n", sum);
strcat(textstr, response);
```

Block Data Acquisition

First, we set up the ADC488 (**`adc`**) in the following configuration:

```
/* Setup the ADC488:
      Compensated binary output format (G10)
      100 uSec scan interval (I3)
      No pre-trigger scans, 100 post-trigger scans (N100)
      Continuous trigger on GET (T1)
*/
```

We then wait for the ADC488 to start the acquisition process. Once the acquisition is complete, which is determined by the MSB of the ADC488's serial poll response, the buffer pointer of the ADC488 is reset (**`B0`**).

```
Output(adc, "G10I3N100T1X");

/* wait for the ready bit of the ADC488 to be asserted */
while ((SPoll(adc) & 32) == 0);

/* Trigger the ADC488 */
Trigger(adc);

/* wait for the acquisition complete bit of ADC488 to be asserted */
while ((SPoll(adc) & 128) == 0);

/* Reset the buffer pointer of the ADC488 */
Output(adc, "B0X");
```

Next, we fill the buffer with 100 readings from the ADC488. Since the data being returned from the ADC488 is in a binary format, the **`noterm`** terminator structure is used to disable scanning for terminators such as carriage return and line feed.

```
noterm.EOI = 0;
noterm.nChar = 0;
EnterX(adc, (char *)hundred, 200, 1, &noterm, 1, 0);
```

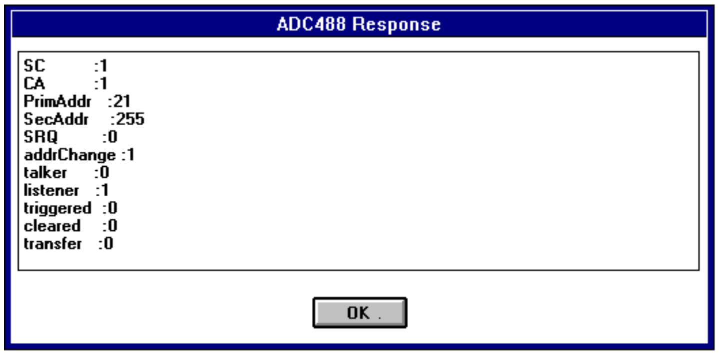
The **`EnterX`** function will use a DMA transfer if available. Because DMA transfers are performed entirely by the hardware, the program can continue with other work while the DMA transfer function occurs. For example, the program will process the previous set of data while collecting a new set of data into a different buffer. However, before processing the data we must wait for the transfer to complete. For illustration purposes, we query the Driver488/W31 status both before and after waiting.

```
/* Display DRIVER488/W31 status */
Status(ieee, &substat);
showstat(&substat, textstr);

/* Wait for completion of input operation*/
Wait(adc);

/* Display DRIVER488/W31 status */
Status(ieee, &substat);
showstat(&substat, textstr);
```

Now we process the buffer:

```
/* Print the received characters */
for (i=0;i<100;i++) {
       sprintf(response, "%6d ", hundred[i]);
       strcat(textstr, response);
       if ((i%8)==7) {
              strcat(textstr,"\r\n");
       }
}
strcat(textstr,"\r\n");
SetDlgItemText(hWndDlg, 201, (LPSTR)textstr);
```

The readings are stored in the local variable **textstr** in the above example. They could, however be placed into a text-type control. Refer to the Driver488/W31 status display in the *ADC488 Response* window, shown in the following figure:



```
SC          :1
CA          :1
PrimAddr    :21
SecAddr     :255
SRQ         :0
addrChange  :1
talker      :0
listener    :1
triggered   :0
cleared     :0
transfer    :0
```

Driver488/W31 Status Display

The functions described so far in this Sub-Chapter provide enough functionality for a *basic data acquisition* program. The following program listing covers the examples used. Additional functions provided by Driver488/W31 are described in the “Section III: Command References” of this manual.

Sample Programs

Data Acquisition Sample Programs

The following examples were developed using Quick C for Windows. Additional example programs are included on the Driver488/W31 disk.

Source Code (Example 2.c)

```
/* QuickCase:W KNB Version 1.00 */
#include "EXAMPLE2.h"
#include "iot_main.h"
#include "iotmc60w.h"
#include "stdio.h"

/* function prototypes */
void showstat(IeeeStatusT *substat, char *textstr);

int PASCAL WinMain(HANDLE hInstance, HANDLE hPrevInstance, LPSTR
lpszCmdLine, int nCmdShow)
{

/*********************************************************************/
/* HANDLE hInstance;       handle for this instance                  */
/* HANDLE hPrevInstance; handle for possible previous instances     */
/* LPSTR lpszCmdLine;      long pointer to exec command line         */
/* int nCmdShow;           Show code for main window display         */
/*********************************************************************/
MSG  msg;           /* MSG structure to store your messages       */
int  nRc;     /* return value from Register Classes          */

strcpy(szAppName, "EXAMPLE2");
hInst = hInstance;
if (!hPrevInstance) {
  /* register window classes if first instance of application      */
 if ((nRc = nCwRegisterClasses()) == -1) {
        /* registering one of the windows failed                   */
  LoadString(hInst,IDS_ERR_REGISTER_CLASS,szString,
        sizeof(szString));
        MessageBox(NULL, szString, NULL, MB_ICONEXCLAMATION);
        return nRc;
  }
 }

 /* create application's Main window                               */
 hWndMain = CreateWindow(
             szAppName           /* Window class name              */
       "Driver488/W31 Simple Example"    , /* Window's title       */
       WS_CAPTION |        /* Title and Min/Max                    */
       WS_SYSMENU                 /* Add system menu box           */
       WS_MINIMIZEBOX |           /* Add minimize box              */
       WS_MAXIMIZEBOX |           /* Add maximize box              */
       WS_THICKFRAME |                   /* thick sizeable frame   */
       WS_CLIPCHILDREN |   /* don't draw in child windows areas*/
       WS_OVERLAPPED,
       CW_USEDEFAULT, 0,          /* Use default X, Y              */
       CW_USEDEFAULT, 0,          /* Use default X, Y              */
       NULL,        /* Parent window's handle                      */
       NULL,        /* Default to Class Menu                       */
       hInst,              /* Instance of window                   */
       NULL);              /* Create struct for WM_CREATE          */

if (hWndMain == NULL) {
   LoadString(hInst, IDS_ERR_CREATE_WINDOW, szString,
     sizeof(szString));
   MessageBox(NULL, szString, NULL, MB_ICONEXCLAMATION);
     return IDS_ERR_CREATE_WINDOW;
 }

ShowWindow(hWndMain, nCmdShow)     /* display main window          */

while (GetMessage(&msg, NULL, 0, 0)) { /* Until WM_QUIT message    */
     TranslateMessage(&msg);
     DispatchMessage(&msg);
 }

 /* Do clean up before exiting from the application                */
 CwUnRegisterClasses();
 return msg.wParam;
} /* End of WinMain                                                */

/*******************************************************************/
/*                                                                 */
/* Main Window Procedure                                           */
/*                                                                 */
/* This procedure provides service routines for the Windows events */
/* (messages)that Windows sends to the window, as well as the user */
/* initiated events (messages) that are generated when the user    */
/* selectsthe action bar and pulldown menu controls or the         */
/* corresponding keyboard accelerators.                            */
/*                                                                 */
/*******************************************************************/

LONG FAR PASCAL WndProc(HWND hWnd, WORD Message, WORD wParam, LONG
lParam)
```

```
{
HMENU  hMenu=0;      /* handle for the menu                              */
HBITMAP       hBitmap=0     /* handle for bitmaps                        */
 HDC   hDC;          /* handle for the display device                    */
 PAINTSTRUCT ps;     /* holds PAINT information                          */
 int   nRc=0;        /* return code                                      */
HWND hDriver;

switch (Message) {
 case WM_COMMAND:
  /* The Windows messages for action bar and pulldown menu items   */
       /* are processed here.                                        */
       switch (wParam) {
        case IDM_F_GO:

/* Place User Code to respond to the                                 */
       /* Menu Item Named "&Go" here.                                */
       {
       FARPROC lpfnEX2DLGMsgProc;

       lpfnEX2DLGMsgProc = MakeProcInstance((FAPROC)EX2DLGMsgProc,
hInst);
       nRc = DialogBox(hInst, MAKEINTRESOURCE(200), hWnd,
       lpfnEX2DLGMsgProc);
       FreeProcInstance(lpfnEX2DLGMsgProc);
       }
       break;

 case IDM_F_QUIT:
              /* Place User Code to respond to the                   */
       /* Menu Item Named "&Quit" here.                              */
              SendMessage(hWnd, WM_CLOSE, 0, 0L);
              break;
        default:
       return DefWindowProc(hWnd, Message, wParam, lParam);
              }
              break; /* End of WM_COMMAND                            */
case WM_CREATE:
       break;        /* End of WM_CREATE                             */
case WM_MOVE: /* code for moving the window                          */
              break;
case WM_SIZE: /* code for sizing client area                         */
       break;        /* End of WM_SIZE                               */
case WM_PAINT: /* code for the window's client area                  */
       /* Obtain a handle to the device context                      */
       /* BeginPaint will sends WM_ERASEBKGND if appropriate */
 memset(&ps, 0x00, sizeof(PAINTSTRUCT));
 hDC = BeginPaint(hWnd, &ps);

/* Included in case the background is not a pure color               */
       SetBkMode(hDC, TRANSPARENT);

/* Inform Windows painting is complete                               */
       EndPaint(hWnd, &ps);
       break; /* End of WM_PAINT                                     */
 case WM_CLOSE: /* close the window                                  */
       /* Destroy child windows, modeless dialogs, then,this window */
       hDriver=FindWindow((LPSTR)"Driver488/W31 Loader",
       (LPSTR)"Driver488/W31");
SendMessage(hDriver, WM_DESTROY, 0, 0L);
       DestroyWindow(hWnd);
       if (hWnd == hWndMain)
        PostQuitMessage(0); /* Quit the application                  */
       break;
default:
       /* For any message for which you don't specifically provide */
       /* a service routine, you should return the message to      */
```

```
      /* Windows for default message processing.                 */
      return DefWindowProc(hWnd, Message, wParam, lParam);
 }

 return 0L;
} /* End of WndProc                                              */

/****************************************************************/
/*                                                               */
/* Dialog Window Procedure                                       */
/*                                                               */
/* This procedure is associated with the dialog box that is      */
/* included in the function name of the procedure. It provides the */
/* service routines for the events (messages) that occur because  */
/* the end user operates one of the dialog box's buttons, entry   */
/* fields, or controls.                                           */
/****************************************************************/

BOOL FAR PASCAL EX2DLGMsgProc(HWND hWndDlg, WORD Message, WORD wParam,
LONG lParam)
{
DevHandleT ieee, adc, devhandle; /* handles for the IEEE devices   */
IeeeStatusT substat;  /* structure for the Driver488/W31 Status*/
chartextstr[2048],response[64];
                           /* strings for Driver488/W31 responses  */
 double sum, voltage;      /* variables for ADC488 responses       */
 int i, hundred[100];      /* general counter and data buffer      */
 TermT noterm;             /* structure for disabling terminators  */

switch(Message)
{
case WM_INITDIALOG:
  cwCenter(hWndDlg, 0);
  /* initialize working variables                               */

  /* open Driver488/W31                                         */
 if ((ieee=OpenName("IEEE"))<0) {
  MessageBox(hWndDlg, (LPSTR)"Cannot initialize IEEE system",
      NULL,  MB_OK);
      EndDialog(hWndDlg, TRUE);
      return TRUE;
}

/* open or create the device named ADC                            */
Error(ieee, OFF);
switch (adc=OpenName("ADC")) {
 case -2:
      MessageBox(hWndDlg, (LPSTR)"ADC device already open", NULL,
      MB_OK);
             EndDialog(hWndDlg, TRUE);
      return TRUE;
 case -1:
      /* Create the device ADC by copying the default device WAVE */
      switch (devhandle=OpenName("WAVE")) {
 case -2:
             MessageBox(hWndDlg, (LPSTR)"WAVE device already open",
             NULL, MB_OK);
             EndDialog(hWndDlg, TRUE);
             return TRUE;
        case -1:
             MessageBox(hWndDlg, (LPSTR)"Cannot open WAVE device",
             NULL, MB_OK);
             EndDialog(hWndDlg, TRUE);
             return TRUE;
        default:
             break;
 }
 if ((adc=MakeDevice(devhandle, “ADC”))<0) {
  MessageBox(hWndDlg, (LPSTR)"Cannot create ADC device", NULL,
       MB_OK);
       EndDialog(hWndDlg, TRUE);
       return TRUE;
 }
 Close(devhandle);
 break;
 default:
 break;
 }
 GetError(ieee, textstr);
BusAddress(adc, 14, -1);
/* get Driver488/W31 hello response                              */
Hello(ieee, textstr);
strcat(textstr, “\r\n”);

/* get Driver488/W31 status response                             */
Status(ieee, &substat);
showstat(&substat, textstr);

/* Clear the ADC488                                              */
Clear(adc);

/* Setup the ADC488
 Differential inputs (A0)
 Scan group channel 1 (C1)
 Compensated ASCII floating-point output format (G0)
 Channel 1 range to +/- 10V (R3)
 One-shot trigger on talk (T6)
*/
Output(adc, “A0C1G0R3T6X”);

/* wait for the ready bit of the ADC488 to be asserted           */
while ((SPoll(adc) & 32) == 0);

/* display the reading */
Enter(adc, response);
strcat(textstr, “ADC488 channel #1 reading value is ”);
strcat(textstr, response);
strcat(textstr, “\r\n”);

/* Now aquire and display the average of 10 readings             */
sum = 0.0;
for (i=0;i<0;i++) {
 Enter(adc,response);
 sscanf(response,"%lf",&voltage);
 sum+=voltage;
 }
sum/=10.0;
sprintf(response, “The average of 10 readings is %lf\r\n”, sum);
strcat(textstr, response);

/* Setup the ADC488:
 Compensated binary output format (G10)
 100 uSec scan interval (I3)
 No pre-trigger scans, 100 post-trigger scans (N100)
 Continuous trigger on GET (T1)
*/
Output(adc, “G10I3N100T1X”);

/* wait for the ready bit of the ADC488 to be asserted           */
while ((SPoll(adc) & 32) == 0);
/* Trigger the ADC488 */
Trigger(adc);
```

```
/* wait for the acquisition complete bit of ADC488 to be asserted  */
while ((SPoll(adc) & 128) == 0);

/* Reset the buffer pointer of the ADC488 */
Output(adc, "B0X");
/* Take 100 readings from the ADC488 */
noterm.EOI = 0;
noterm.nChar = 0;
EnterX(adc, (char *)hundred, 200, 1, &noterm, 1, 0);

/* Display DRIVER488/W31 status                                    */
Status(ieee, &substat);
showstat(&substat, textstr);

/* Wait for completion of input operation                          */
Wait(adc);

/* Display DRIVER488/W31 status                                    */
Status(ieee, &substat);
showstat(&substat, textstr);

/* Print the received charcters                                    */
for (i=0;i<100;i++) {
 sprintf(response, "%6d ", hundred[i]);
 strcat(textstr, response);
 if ((i%8)==7) {
 strcat(textstr,"\r\n");
 }
}
strcat(textstr,"\r\n");
SetDlgItemText(hWndDlg, 201, (LPSTR)textstr);

Close(ieee);
Close(adc);

 break; /* End of WM_INITDIALOG                                    */

case WM_CLOSE:
 /* Closing the Dialog behaves the same as Cancel                  */
 PostMessage(hWndDlg, WM_COMMAND, IDCANCEL, 0L);
 break; /* End of WM_CLOSE                                         */

case WM_COMMAND:
 switch(wParam)
 {
 case 201: /* Edit Control                                         */
       break;
 case IDOK:
       EndDialog(hWndDlg, TRUE);
       break;
 case IDCANCEL:
       /* Ignore data values entered into the controls             */
       /* and dismiss the dialog window returning FALSE            */
       EndDialog(hWndDlg, FALSE);
       break;
 }
 break; /* End of WM_COMMAND                                       */

default:
 return FALSE;
 }
 return TRUE;
} /* End of EX2DLGMsgProc                                          */
```

```
/*****************************************************************/
/*                                                               */
/* nCwRegisterClasses Function                                   */
/*                                                               */
/* The following function registers all the classes of all the  */
/* windows associated with this application. The function returns */
/* an error code if unsuccessful, otherwise it returns 0.        */
/*                                                               */
/*****************************************************************/
int nCwRegisterClasses(void)
{
 WNDCLASS wndclass; /* struct to define a window class          */
 memset(&wndclass, 0x00, sizeof(WNDCLASS));

 /* load WNDCLASS with window's characteristics                 */
 wndclass.style = CS_HREDRAW | CS_VREDRAW | CS_BYTEALIGNWINDOW;
 wndclass.lpfnWndProc = WndProc;
 /* Extra storage for Class and Window objects                  */
 wndclass.cbClsExtra = 0;
 wndclass.cbWndExtra = 0;
 wndclass.hInstance = hInst;
 wndclass.hIcon = LoadIcon(hInst, "EXAMPLE2");
 wndclass.hCursor = LoadCursor(NULL, IDC_ARROW);
 /* Create brush for erasing background                         */
 wndclass.hbrBackground = (HBRUSH)(COLOR_WINDOW+1);
 wndclass.lpszMenuName = szAppName;     /* Menu Name is App Name   */
 wndclass.lpszClassName = szAppName;     /* Class Name is App Name*/
 if (!RegisterClass(&wndclass))
 return -1;
return(0);
} /* End of nCwRegisterClasses                                   */

/*****************************************************************/
/* cwCenter Function                                             */
/*                                                               */
/* centers a window based on the client area of its parent       */
/*                                                               */
/*****************************************************************/
void cwCenter(hWnd, top)
HWND hWnd;
int top;
{
POINT pt;
RECT swp;
RECT rParent;
int iwidth;
int iheight;

/* get the rectangles for the parent and the child              */
GetWindowRect(hWnd, &swp);
GetClientRect(hWndMain, &rParent);

/* calculate the height and width for MoveWindow                */
iwidth = swp.right - swp.left;
iheight = swp.bottom - swp.top;

/* find the center point and convert to screen coordinates      */
pt.x = (rParent.right - rParent.left) / 2;
pt.y = (rParent.bottom - rParent.top) / 2;
ClientToScreen(hWndMain, &pt);

/* calculate the new x, y starting point                        */
pt.x = pt.x - (iwidth / 2);
pt.y = pt.y - (iheight / 2);
/* top will adjust the window position, up or down              */

if (top)
```

```
 pt.y = pt.y + top;

/* move the window                                              */
 MoveWindow(hWnd, pt.x, pt.y, iwidth, iheight, FALSE);
}

/****************************************************************/
/* CwUnRegisterClasses Function                                 */
/*                                                              */
/* Deletes any refrences to windows resources created for this  */
/* application, frees memory, deletes instance, handles and does */
/* clean up prior to exiting the window                         */
/*                                                              */
/****************************************************************/
void CwUnRegisterClasses(void)
{
WNDCLASS wndclass; /* struct to define a window class           */
 memset(&wndclass, 0x00, sizeof(WNDCLASS));

UnregisterClass(szAppName, hInst);
} /* End of CwUnRegisterClasses                                  */

void showstat(IeeeStatusT *substat, char *textstr) {
 char response[64];

sprintf(response, "SC      :%d\r\n", substat->SC);
strcat(textstr, response);
sprintf(response, "CA      :%d\r\n", substat->CA);
strcat(textstr, response);
sprintf(response, "PrimAddr       :%d\r\n", substat->Primaddr);
strcat(textstr, response);
sprintf(response, "SecAddr        :%d\r\n", substat->Secaddr);
strcat(textstr, response);
sprintf(response, "SRQ            :%d\r\n", substat->SRQ);
strcat(textstr, response);
sprintf(response, "addrChange     :%d\r\n", substat->addrChange);
strcat(textstr, response);
sprintf(response, "talker  :%d\r\n", substat->talker);
strcat(textstr, response);
sprintf(response, "listener       :%d\r\n", substat->listener);
strcat(textstr, response);
sprintf(response, "triggered      :%d\r\n", substat->triggered);
strcat(textstr, response);
sprintf(response, "cleared        :%d\r\n", substat->cleared);
strcat(textstr, response);
sprintf(response, "transfer       :%d\r\n", substat->transfer);
strcat(textstr, response);
sprintf(response, "byteIn  :%d\r\n", substat->byteIn);
strcat(textstr, response);
sprintf(response, "byteOut        :%d\r\n", substat->byteOut);
strcat(textstr, response);
}
```

Header File   (Example2.h)

```
/* QuickCase:W KNB Version 1.00 */
#include <windows.h>
#include <string.h>
#define IDM_FILE 1000
#define IDM_F_GO 1050
#define IDM_F_QUIT 1150

#define IDS_ERR_REGISTER_CLASS 1
#define IDS_ERR_CREATE_WINDOW 2

char szString[128]; /* variable to load resource strings    */
char szAppName[20]; /* class name for the window            */
HWND hInst;
HWND hWndMain;
void cwCenter(HWND, int);

LONG FAR PASCAL WndProc(HWND, WORD, WORD, LONG);
BOOL FAR PASCAL EX2DLGMsgProc(HWND, WORD, WORD, LONG);
int nCwRegisterClasses(void);
void CwUnRegisterClasses(void);
```

Resource Script (Example2.rc)

```
#include "EXAMPLE2.h"
EXAMPLE2 ICON 488.ICO

EXAMPLE2 MENU
 BEGIN
   POPUP "&File"
     BEGIN
    MENUITEM "&Go", IDM_F_GO
    MENUITEM SEPARATOR
    MENUITEM "&Quit", IDM_F_QUIT
   END
 END

#include "EXAMPLE2.DLG"

STRINGTABLE
BEGIN
 IDS_ERR_CREATE_WINDOW, "Window creation failed!"
 IDS_ERR_REGISTER_CLASS, "Error registering window class"
END
```

Dialog Script (Example2.dlg)

```
DLGINCLUDE RCDATA DISCARDABLE
BEGIN
 "EXAMPLE2.H\0"
END

200 DIALOG 27, 40, 293, 138
STYLE DS_MODALFRAME | WS_POPUP | WS_VISIBLE | WS_CAPTION
CAPTION "ADC488 Response"
FONT 8, "Helv"
BEGIN
 EDITTEXT 201, 3, 6, 287, 99, ES_MULTILINE | ES_AUTOVSCROLL |
 ES_AUTOHSCROLL
 PUSHBUTTON "OK", IDS_ERR_REGISTER_CLASS, 127, 117, 40, 14
END
```

Definition (Example2.def)

```
NAME   EXAMPLE2
EXETYPE      WINDOWS
STUB   'WINSTUB.EXE'
CODE   PRELOAD MOVEABLE
DATA   PRELOAD MOVEABLE MULTIPLE
HEAPSIZE     4096
STACKSIZE 5110
EXPORTS      WndProc @1
                    EX2DLGMsgProc @2
```

IEEE 488 Event Message Sample Programs

Source Code (Example3.c)

```
/* QuickCase:W KNB Version 1.00 */
#include "EXAMPLE3.h"
#include "iot_main.h"
```

```
#include "iotmc60w.h"
#include "stdio.h"

/* Global variables */
DevHandleT ieee, adc, devhandle; /* handles for IEEE devices */
char textstr[2048], response[64];

                            /* strings for Driver488/W31 responses*/

int PASCAL WinMain(HANDLE hInstance, HANDLE hPrevInstance, LPSTR
lpszCmdLine, int nCmdShow)
{

/*******************************************************************/
/* HANDLE hInstance;              handle for this instance         */
/* HANDLE hPrevInstance;   handle for possible previous instances  */
/* LPSTR lpszCmdLine;             long pointer to exec command line*/
/* int nCmdShow;           Show code for main window display       */
/*******************************************************************/

MSG msg;            /* MSG structure to store your messages        */
int nRc;            /* return value from Register Classes          */

strcpy(szAppName, "EXAMPLE3");
hInst = hInstance;
if (!hPrevInstance) {
/* register window classes if first instance of application        */
if ((nRc = nCwRegisterClasses()) == -1) {
  /* registering one of the windows failed                         */
  LoadString(hInst, IDS_ERR_REGISTER_CLASS, szString,
  sizeof(szString));
  MessageBox(NULL, szString, NULL, MB_ICONEXCLAMATION);
  return nRc;
 }
 }

/* create application's Main window                                */
hWndMain = CreateWindow(
  szAppName                /* Window class name                    */
       "Driver488/W31 Simple Example", /* Window's title           */
       WS_CAPTION | /* Title and Min/Max                           */
       WS_SYSMENU | /* Add system menu box                         */
       WS_MINIMIZEBOX |    /* Add minimize box                     */
       WS_MAXIMIZEBOX |    /* Add maximize box                     */
       WS_THICKFRAME |     /* thick sizeable frame                 */
       WS_CLIPCHILDREN |   /* don't draw in child windows areas    */
       WS_OVERLAPPED,
       CW_USEDEFAULT, 0,   /* Use default X, Y                     */
       CW_USEDEFAULT, 0,   /* Use default X, Y                     */
       NULL,  /* Parent window's handle                            */
       NULL,  /* Default to Class Menu                             */
       hInst,       /* Instance of window                          */
       NULL);       /* Create struct for WM_CREATE                 */

if (hWndMain == NULL) {
  LoadString(hInst, IDS_ERR_CREATE_WINDOW, szString,
  sizeof(szString));
  MessageBox(NULL, szString, NULL, MB_ICONEXCLAMATION);
  return IDS_ERR_CREATE_WINDOW;
 }

ShowWindow(hWndMain, nCmdShow);         /* display main window     */

while (GetMessage(&msg, NULL, 0, 0)) {  /* Until WM_QUIT message   */
 TranslateMessage(&msg);
  DispatchMessage(&msg);
 }
```

```
/* Do clean up before exiting from the application              */
 CwUnRegisterClasses();
 return msg.wParam;
} /* End of WinMain                                             */

/******************************************************************/
/*                                                              */
/* Main Window Procedure                                        */
/* This procedure provides service routines for the Windows     */
/* events(messages) that Windows sends to the window, as well as   */
/* the user initiated events (messages) that are generated when    */
/* the user selects the action bar and pulldown menu controls or   */
/* the corresponding keyboard accelerators.                     */
/******************************************************************/

LONG FAR PASCAL WndProc(HWND hWnd, WORD Message, WORD wParam, LONG
lParam)
{
HMENU hMenu=0;      /* handle for the menu                      */
HBITMAP hBitmap=0;  /* handle for bitmaps                       */
HDC hDC;            /* handle for the display device            */
PAINTSTRUCT ps;     /* holds PAINT information                  */
int nRc=0;          /* return code                              */
HWND hDriver;

 switch (Message) {
   case WM_COMMAND:
     /* The Windows messages for action bar and pulldown menu items */
  /* are processed here.                                        */
     switch (wParam) {
     case IDM_F_GO:
              /* Place User Code to respond to the              */
              /* Menu Item Named "&Go" here.                    */
              {
        FARPROC lpfnEX3DLGMsgProc;

        lpfnEX3DLGMsgProc = MakeProcInstance((FARPROC)EX3DLGMsgProc,
        hInst);
        nRc = DialogBox(hInst, MAKEINTRESOURCE(200), hWnd,
        lpfnEX3DLGMsgProc);
        FreeProcInstance(lpfnEX3DLGMsgProc);
}
break;
case IDM_F_QUIT:
 /* Place User Code to respond to the                           */
 /* Menu Item Named "&Quit" here.                               */
SendMessage(hWnd, WM_CLOSE, 0, 0L);
break;
default:
return DefWindowProc(hWnd, Message, wParam, lParam);
}
 break; /* End of WM_COMMAND                                    */
case WM_CREATE:
 break; /* End of WM_CREATE                                     */
case WM_MOVE: /* code for moving the window                     */
 break;
case WM_SIZE: /* code for sizing client area                    */
 break; /* End of WM_SIZE                                       */
case WM_PAINT: /* code for the window's client area             */
 /* Obtain a handle to the device context                       */
 /* BeginPaint will sends WM_ERASEBKGND if appropriate          */
 memset(&ps, 0x00, sizeof(PAINTSTRUCT));
 hDC = BeginPaint(hWnd, &ps);

 /* Included in case the background is not a pure color         */
 SetBkMode(hDC, TRANSPARENT);
```

```
/* Inform Windows painting is complete                          */
 EndPaint(hWnd, &ps);
 break; /* End of WM_PAINT                                      */
case WM_CLOSE: /* close the window                              */

/* Destroy child windows, modeless dialogs, then, this window      */
 hDriver=FindWindow((LPSTR)"Driver488/W31 Loader",
 (LPSTR)"Driver488/W31");
 SendMessage(hDriver, WM_DESTROY, 0, 0L);
 DestroyWindow(hWnd);
 if (hWnd == hWndMain)
 PostQuitMessage(0); /* Quit the application                    */
 break;
default:
/* For any message for which you don't specifically provide a      */
 /* service routine, you should return the message to Windows      */
 /* for default message processing.                                */
 return DefWindowProc(hWnd, Message, wParam, lParam);
 }
 return 0L;
} /* End of WndProc                                                 */

/*******************************************************************/
/*                                                                  */
/* Dialog Window Procedure                                          */
/*                                                                  */
/* This procedure is associated with the dialog box that is        */
/* included inthe function name of the procedure. It provides the  */
/* service routines for the events (messages) that occur because   */
/* the end user operates one of the dialog box's buttons, entry    */
/* fields, or controls.                                             */
/*******************************************************************/

BOOL FAR PASCAL EX3DLGMsgProc(HWND hWndDlg, WORD Message, WORD wParam,
LONG lParam)
{
 double sum, voltage;
int i, hundred[100];
 TermT noterm;

switch(Message) {
 case WM_INITDIALOG:
 cwCenter(hWndDlg, 0);
 /* initialize working variables                                   */

 /* open Driver488/W31                                             */
 if ((ieee=OpenName("IEEE"))<0) {
  MessageBox(hWndDlg, (LPSTR)"Cannot initialize IEEE system", NULL,
       MB_OK);
       EndDialog(hWndDlg, TRUE);
       return TRUE;
 }

/* open device named ADC                                            */
Error(ieee, OFF);
switch (adc=OpenName("ADC")) {
 case -2:
       MessageBox(hWndDlg, (LPSTR)"ADC device already open", NULL,
              MB_OK);
       EndDialog(hWndDlg, TRUE);
       return TRUE;
 case -1:
 switch (devhandle=OpenName("WAVE")) {
       case -2:
  MessageBox(hWndDlg, (LPSTR)"WAVE device already open", NULL, MB_OK);
    EndDialog(hWndDlg, TRUE);
```

```
     return TRUE;
    case -1:
   MessageBox(hWndDlg, (LPSTR)"Cannot open WAVE device",
   NULL, MB_OK);
   EndDialog(hWndDlg, TRUE);
   return TRUE;
default:
   break;
  }
  if ((adc=MakeDevice(devhandle, "ADC"))<0) {
   MessageBox(hWndDlg, (LPSTR)"Cannot create ADC device", NULL,
   MB_OK);
   EndDialog(hWndDlg, TRUE);
   return TRUE;
  }
  Close(devhandle);
        break;
  default:
        break;
  }
GetError(ieee, response);
Error(ieee, ON);
BusAddress(adc, 14, -1);

/* Setup event handling for trapping the SRQ                          */
OnEvent(ieee, hWndDlg, (OpaqueP)0L);
Arm(ieee, acSRQ);

/* Clear the ADC488                                                   */
Clear(adc);

/* Setup the ADC488 to SRQ on acquisition complete                    */
Output(adc, "M128X");
/* Setup the ADC488:

100 uSec scan interval (I3)
No pre-trigger scans, 100 post-trigger scans (N100)
Continuous trigger on GET (T1)
*/
Output(adc, "I3N100T1X");

/* Wait for the ready bit of the ADC488 to be asserted                */
while ((SPoll(adc) & 32) == 0);

/* Trigger the ADC488                                                 */
 Trigger(adc);
 strcpy(textstr,"Waiting for SRQ event\r\n");
 SetDlgItemText(hWndDlg, 201, (LPSTR)textstr);
 break; /* End of WM_INITDIALOG                                       */
case WM_CLOSE:
      /* Closing the Dialog behaves the same as Cancel                */
            PostMessage(hWndDlg, WM_COMMAND, IDCANCEL, 0L);
            break; /* End of WM_CLOSE                                 */
case WM_COMMAND:
 switch(wParam) {
  case 201: /* Edit Control                                           */
      break;
  case IDOK:
      Close(ieee);
      Close(adc);
      EndDialog(hWndDlg, TRUE);
      break;
  case IDCANCEL:
      /* Ignore data values entered into the controls                 */
      /* and dismiss the dialog window returning FALSE                */
      EndDialog(hWndDlg, FALSE);
      break;
```

```
             }
       break; /* End of WM_COMMAND                                     */
 default:
 if (Message==WM_IEEE488EVENT) {
   strcpy(textstr,"SRQ event detected\r\n");
   SetDlgItemText(hWndDlg, 201, (LPSTR)textstr);

 /* Clear the SRQ condition                                            */
 SPoll(adc);

 /* Reset the buffer pointer of the ADC488                             */
 Output(adc, "B0X");
 /* Get 100 readings from the ADC488                                   */
 for (i=0;i<100;i++) {
  Enter(adc,response);
  strcat(textstr, response);
  strcat(textstr, "\r\n");
 }
 SetDlgItemText(hWndDlg, 201, (LPSTR)textstr);
}
return FALSE;
}
return TRUE;
} /* End of EX3DLGMsgProc                                              */

/*********************************************************************/
/*                                                                   */
/* nCwRegisterClasses Function                                       */
/*                                                                   */
/* The following function registers all the classes of all the       */
/* windows associated with this application. The function returns    */
/* an error code if unsuccessful, otherwise it returns 0.            */
/*                                                                   */
/*********************************************************************/

int nCwRegisterClasses(void)
{
 WNDCLASS wndclass; /* struct to define a window class                 */
 memset(&wndclass, 0x00, sizeof(WNDCLASS));
 /* load WNDCLASS with window's characteristics                        */
 wndclass.style = CS_HREDRAW | CS_VREDRAW | CS_BYTEALIGNWINDOW;
 wndclass.lpfnWndProc = WndProc;
 /* Extra storage for Class and Window objects                         */
 wndclass.cbClsExtra = 0;
 wndclass.cbWndExtra = 0;
 wndclass.hInstance = hInst;
 wndclass.hIcon = LoadIcon(hInst, "EXAMPLE3");
 wndclass.hCursor = LoadCursor(NULL, IDC_ARROW);
 /* Create brush for erasing background                                */
 wndclass.hbrBackground = (HBRUSH)(COLOR_WINDOW+1);
 wndclass.lpszMenuName = szAppName; /* Menu Name is App Name           */
 wndclass.lpszClassName = szAppName; /* Class Name is App Name         */
 if (!RegisterClass(&wndclass))
 return -1;

 return(0);
} /* End of nCwRegisterClasses                                         */

/*********************************************************************/
/* cwCenter Function                                                 */
/*                                                                   */
/* centers a window based on the client area of its parent           */
/*                                                                   */
/*********************************************************************/

void cwCenter(hWnd, top)
HWND hWnd;
```

```
int top;

{
POINT pt;
RECT swp;
RECT rParent;
int iwidth;
int iheight;

/* get the rectangles for the parent and the child                */
GetWindowRect(hWnd, &swp);
GetClientRect(hWndMain, &rParent);

/* calculate the height and width for MoveWindow                  */
iwidth = swp.right - swp.left;
iheight = swp.bottom - swp.top;

/* find the center point and convert to screen coordinates        */
pt.x = (rParent.right - rParent.left) / 2;
pt.y = (rParent.bottom - rParent.top) / 2;
ClientToScreen(hWndMain, &pt);

/* calculate the new x, y starting point                          */
pt.x = pt.x - (iwidth / 2);
pt.y = pt.y - (iheight / 2);

/* top will adjust the window position, up or down                */
if (top)
 pt.y = pt.y + top;

/* move the window                                                */
MoveWindow(hWnd, pt.x, pt.y, iwidth, iheight, FALSE);
}

/*****************************************************************/
/* CwUnRegisterClasses Function                                   */
/*                                                                */
/* Deletes any refrences to windows resources created for this    */
/* application, frees memory, deletes instance, handles and does  */
/* clean up prior to exiting the window                           */
/*                                                                */
/******************************************************************/

void CwUnRegisterClasses(void)
{
WNDCLASS wndclass; /* struct to define a window class             */
memset(&wndclass, 0x00, sizeof(WNDCLASS));

UnregisterClass(szAppName, hInst);
} /* End of CwUnRegisterClasses                                   */
```

Header File (Example3.h)

```
/* QuickCase:W KNB Version 1.00                                   */
#include windows.h
include
g.h
#define IDM_FILE 1000
#define IDM_F_GO 1050
#define IDM_F_QUIT 1150
#define IDS_ERR_REGISTER_CLASS 1
#define IDS_ERR_CREATE_WINDOW 2

char szString[128]; /* variable to load resource strings          */

char szAppName[20]; /* class name for the window                  */
HWND hInst;
HWND hWndMain;
```

```
void cwCenter(HWND, int);

LONG FAR PASCAL WndProc(HWND, WORD, WORD, LONG);
BOOL FAR PASCAL EX3DLGMsgProc(HWND, WORD, WORD, LONG);
int nCwRegisterClasses(void);
void CwUnRegisterClasses(void);
```

Resource Script (Example3.rc)

```
#include "EXAMPLE3.h"
EXAMPLE3 ICON 488.ICO

EXAMPLE3 MENU
BEGIN
 POPUP "&File"
   BEGIN
   MENUITEM "&Go", IDM_F_GO
   MENUITEM SEPARATOR
   MENUITEM "&Quit", IDM_F_QUIT
 END
 END

#include "EXAMPLE3.DLG"

STRINGTABLE
BEGIN
 IDS_ERR_CREATE_WINDOW, "Window creation failed!"
 IDS_ERR_REGISTER_CLASS, "Error registering window class"
END
```

Dialog Script (Example3.dlg)

```
DLGINCLUDE RCDATA DISCARDABLE
BEGIN
 "EXAMPLE3.H\0"
END

200 DIALOG 27, 40, 293, 138
STYLE DS_MODALFRAME | WS_POPUP | WS_VISIBLE | WS_CAPTION
CAPTION "ADC488 Response"
FONT 8, "Helv"
BEGIN
  EDITTEXT   201, 3, 6, 287, 99, ES_MULTILINE | ES_AUTOVSCROLL |
       ES_AUTOHSCROLL
       PUSHBUTTON "OK", IDS_ERR_REGISTER_CLASS, 127, 117, 40, 14
END
```

Definition (Example3.def)

```
NAME   EXAMPLE3
EXETYPE      WINDOWS
STUB   'WINSTUB.EXE'
CODE   PRELOAD MOVEABLE
DATA   PRELOAD MOVEABLE MULTIPLE
HEAPSIZE     4096
STACKSIZE 5110
EXPORTS      WndProc @1
       EX3DLGMsgProc @2
```

Command Summary

To obtain a summary of the C language commands for Driver488/W31, turn to the "Section III: Command References" of this manual.

10F. Visual Basic

Topics

Accessing from a Windows Program

The structure of a Windows program generally dictates that actions take place in response to messages such as an operator key press, mouse action, menu selection, etc. This discussion covers the basic actions needed to control Driver488/W31. How these actions are combined and coordinated in response to Windows messages is up to the application designer.

The interface between Visual Basic (VB) and Driver488/W31 consists of three pieces:

- **`IOTVB10.TXT`:** A file containing the required external declarations
- **`IOTVB10.BAS`:** A set of interface functions to handle structure conversions
- **`IOTEVENT.VBX`:** An IEEE 488 *Event Custom Control*

Your application can call all Driver488/W31 functions as documented in the “Section III: Command References.” The following functions found in that Section, as shown in the table, are renamed to avoid conflicts with VB reserved words:

Driver488/W31 Command	Visual Basic Name
`Clear`	`ioClear`
`Close`	`ioClose`
`Error`	`ioError`
`Local`	`ioLocal`
`Output`	`ioOutput`
`Reset`	`ioReset`
`Resume`	`ioResume`
`Stop`	`ioStop`
`Wait`	`ioWait`

In order to have access to all the Driver488/W31 functions, you must include the file **`IOTVB10.TXT`**. You can accomplish this through the Add File item under the file menu. Type **`*.TXT`** into the selection field to find the file in your project.

Certain functions provided by Driver488/W31 require that data structures be passed in a particular format which is not easily generated from a VB application. Conversion functions are provided in **`IOTVB10.BAS`**, which should be included in the

Project window. Using the VB File menu, select the item Add File and select **`IOTVB10.BAS`**. At this point, all Driver488/W31 functions should be accessible.

If you require event handling support, use the custom control written for event handling. The IEEE 488 *Event Custom Control* support is included in the file **`IOTEVENT.VBX`**, which should be included in the Project window. For more information on using the IEEE 488 *Event Custom Control*, turn to the following topic "IEEE 488 Event Custom Control" in this Sub-Chapter.

Opening & Closing the Driver

The first Driver488/W31 programming example is designed for simplicity. Its sole purpose is to verify proper communication with the driver, and upon closing, remove the driver from memory.

In every Visual Basic program using Driver488/W31, a file of declarations must be merged into the program, typically to the **`GLOBAL.BAS`** file. In the following example, those declarations have been omitted from the listing for the sake of brevity.

With the associated source files, the following program can be built using the file **`EXAMPLE1.MAK`** found on the Driver488/W31 disk.

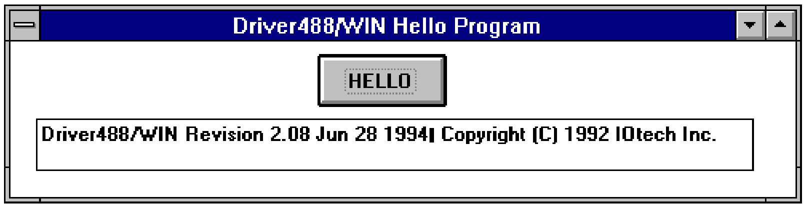
This example has two declarations that will be used later:

```
Declare Function FindWindow Lib "User" (ByVal data1$, ByVal data2$)As
    Integer
Declare Function SendMessage Lib "User" (ByVal winHandle%, ByVal
    message%, ByVal wp%, ByVal lp As Long) As Integer
```

The form has only one text box with one button . When the button is pressed, the service routine for **`Command1_Click`** opens the driver. Then the **`Hello`** function is called, using the handle returned from the **`OpenName`** function.

```
Sub Command1_Click ()
      Dim ieee As Integer
      Dim hellomsg As String * 247
      ieee = OpenName ("IEEE")
      errcode = Hello (ieee, ByVal hellomsg)
      Response.Text = hellomsg
      errcode = ioClose(ieee)
End Sub
```

After the *Hello Message* window is displayed, as shown in the figure, the driver handle is closed. Since in this application, the handle is created every time the form button is pressed, a potential conflict could arise if that handle is not closed as we exit this subroutine. Clicking the HELLO button will close this window.



```
Driver488/WIN Revision 2.08 Jun 28 1994| Copyright (C) 1992 IOtech Inc.
```

Hello Message Window

When the application is closed by the user, the **`Unload`** event is sent to the form. Our service routine for **`Unload`** uses the functions that were declared earlier in the **`GLOBAL.BAS`** file.

```
Sub Form_Unload (Cancel As Integer)
      'Unload the IEEE driver
      loaderName$ = "Driver488Loader"
      winName$ = "Driver488/W31"
      Hdriver% = FindWindow (loaderName$, winName$)
      asdf = SendMessage (Hdriver%, &H2, 0, 0)
End Sub
```

Establishing Communications

The following program contains most of the function calls of Driver488/W31. The user interface of this program is intentionally simple to highlight the Driver488/W31 operations. To centralize all of the Driver488/W31-related code, the architecture of this example is not typical of a Visual Basic program. This example operates the multichannel, 16-bit analog to digital converter; the ADC488.

In every Visual Basic program using Driver488/W31, a file of declarations must be merged into the program, typically to the **`GLOBAL.BAS`** file. In the following example, those declarations have been omitted from the listing for the sake of brevity.

With the associated source files, the following program can be built using the file **`EXAMPLE2.MAK`** found on the Driver488/W31 disk.

This example has two declarations that will be used later:

```
Declare Function FindWindow Lib "User" (ByVal data1$, ByVal data2$)As
    Integer

Declare Function SendMessage Lib "User" (ByVal winHandle%,
    ByValmessage%, ByVal wp%, ByVal lp As Long) As Integer
```

The following declarations are included in the General section of the form, and are assumed through the remainder of the discussion:

```
Dim nl As String * 2
Dim mystring As String
Dim substat As IeeeStatus
Dim adc As Integer
Dim response As String * 256
Dim intResp(500) As Integer
Dim voltage As Single
Dim sum As Single
Dim noterm As terms
Dim sample As String * 7
```

For the sake of this discussion, assume that Driver488/W31 has been configured to start with a configuration including the devices **`IEEE`** (IEEE 488 interface) and **`ADC`** (ADC488/8S connected to the IEEE 488 interface). Additional interfaces and/or devices may also have been defined, as the driver can support up to 4 interfaces and 56 devices simultaneously. To open the two devices of interest, we use the following statements:

```
'Open Driver488/W31
ieee% = OpenName("IEEE")
If (ieee% = -1) Then
       MsgBox "Cannot initialize IEEE system"
       End
End If

'Open device named ADC
rv% = ioError (ieee%, TURNOFF)
devhandle% = OpenName ("wave")
adc = OpenName("ADC")
If (adc = -1) Then
       adc = MakeDevice(devhandle%, "ADC")
       If (adc = -1) Then
              MsgBox "Can not initialize device ADC"
              End
       End If
End If

response = ""
rv% = GetError (1eee%, response)
rv% = BusAddress (adc, 14, -1)
```

If the **`ADC`** was not configured within Driver488/W31, it can be optionally created "on the fly", as shown above. First **`ioError`** was used to **`TURNOFF`** automatic error reporting so that our application can trap the error instead. If opening the name **`ADC`** failed, the handle of the device **`wave`**, which is always available within Driver488/W31, is used to clone a new device called **`ADC`** using the **`MakeDevice`** command. **`GetError`** is then called to clear the internal error registered within Driver488/W31. Lastly, the IEEE bus address **`14`** is assigned to the **`ADC`**.

If other devices were needed for the application at hand, they could either be defined in the startup configuration for Driver488/W31 or they could be created “on the fly” from the application:

```
adc2% = MakeDevice(adc, “ADC2")
rv% = BusAddress(adc2, 10, -1)
```

The new device **`ADC2`** is configured to reside at a different bus address so that the two devices may be distinguished. There is one other important difference between **`ADC`** and **`ADC2`** at this point. **`ADC2`** is a temporary device; that is, as soon as the creating application closes, ADC2 ceases to exist. If our intent were to create a device that could be accessed after this application ends, we must tell Driver488/W31 this:

```
rv%=KeepDevice (adc2)
```

After executing the above statement, **`ADC2`** is marked as being permanent; that is, the device will not be removed when the creating application exits. If we later wish to remove the device, however, we can do so explicitly:

```
rv%=RemoveDevice (adc2)
```

Confirming Communications

With or without an open device handle, the application can, if desired, confirm communication with Driver488/W31 via the Hello function:

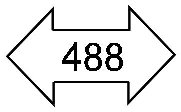
```
rv% = Hello(ieee%, response)
mystring = “”
```

The function also fills in a string, from which information can be extracted if it is desirable to display facts about the driver in use.

IEEE 488 Event Custom Control

The IEEE 488 *Event Custom Control* feature of Driver488/W31 allows a Visual Basic program to respond to IEEE 488 bus events. This feature is represented by a tool icon in the toolbox containing “488” within a double arrow which appears when the **`IOTEVENT.VBX`** file is included in the Project window. To begin this program from the VB File menu, select the tool icon and then select **`IOTEVENT.VBX`**.

The IEEE 488 *Event Custom Control* has properties that correspond to IEEE 488 bus events that can be enabled or disabled. If an IEEE 488 *Event Custom Control* property is enabled, the Visual Basic program will call a user written function associated with the specified event when the event occurs. The IEEE 488 *Event Custom Control* has two other properties: the **`Handle`** property and the **`CtrlName`** property. The **`Handle`** property specifies the device that the events describe. The **`CtrlName`** property stores space for the name of an application text box. For more information on **`CtrlName`**, refer to the topic “Dynamic Data Exchange (DDE)” found later in this Sub-Chapter.



IEEE 488 Event Custom Control Icon

The IEEE 488 bus events that Driver488/W31 supports are shown in the following table:

Event	**Description**
`SRQ`	The Service Request bus line is asserted.
`Peripheral`	An addressed status change has occurred and the interface is a Peripheral.
`Controller`	An addressed status change has occurred and the interface is an Active Controller.
`Trigger`	The interface has received a device `Trigger` command.
`Clear`	The interface has received a device `Clear` command.
`Talk`	An addressed status change has occurred and the interface is a Talker.
`Listen`	An addressed status change has occurred and the interface is a Listener.
`Idle`	An addressed status change has occurred and the interface is neither a Talker nor a Listener.
`ByteIn`	The interface has received a data byte.
`ByteOut`	The interface has been configured to output a data byte.
`Error`	A Driver488/W31 error has occurred.
`Change`	The interface has changed its addressed state. The Controller/Peripheral or Talker/Listener/Idle states of the interface have changed.

Note: This *Event* table mirrors the *Arm Condition* table found under the topic “System Controller, Not Active Controller Mode” in the Sub-Chapter “Operating Modes” of Chapter 9.

To use an IEEE 488 *Event Custom Control*:

1. Click on the IEEE 488 tool in the toolbox and insert it on the form.
2. Enable the properties that specify the events you wish to trap.
3. Open the Code window for the IEEE 488 *Event Custom Control*.
4. For each property you enabled, open the Procedure window that corresponds to the property and write code enabling the program to perform the actions needed when the IEEE 488 event occurs. When the IEEE 488 event occurs during program execution, the function associated with that event will be called.

The upcoming example uses the programs of the ADC488 to issue an IEEE 488 **`SRQ`** when it needs servicing. The IEEE 488 *Event Custom Control* will be programmed to trap the **`SRQ`** and the ADC488 will be serviced.

In every Visual Basic program using Driver488/W31, a file of declarations must be merged into the program, typically to the **`GLOBAL.BAS`** file. In the following example, those declarations have been omitted from the listing for the sake of brevity.

With the associated source files, the following program can be built using the file **`EXAMPLE3.MAK`** found on the Driver488/W31 disk.

This example has several declarations that will be used later:

```
Declare Function FindWindow Lib “User” (ByVal data1$, ByVal data2$) As
   Integer
Declare Function SendMessage Lib “User” (ByVal winHandle%, ByVal
   message%, ByVal wp%, ByVal lp As Long) As Integer
```

The following declarations are included in the General section of the form, and are assumed through the remainder of the discussion:

```
Dim nl As String * 2
Dim mystring As String
Dim substat As IeeeStatus
Dim adc As Integer
Dim response As String * 256
Dim intResp(500) As Integer
Dim voltage As Single
Dim sum As Single
Dim noterm As terms
Dim sample As String * 7
```

When the IEEE 488 *Event Custom Control* has been placed in your application, the following service routine is made available. The particular subroutine is invoked when the ADC generates an **SRQ** on "acquisition complete".

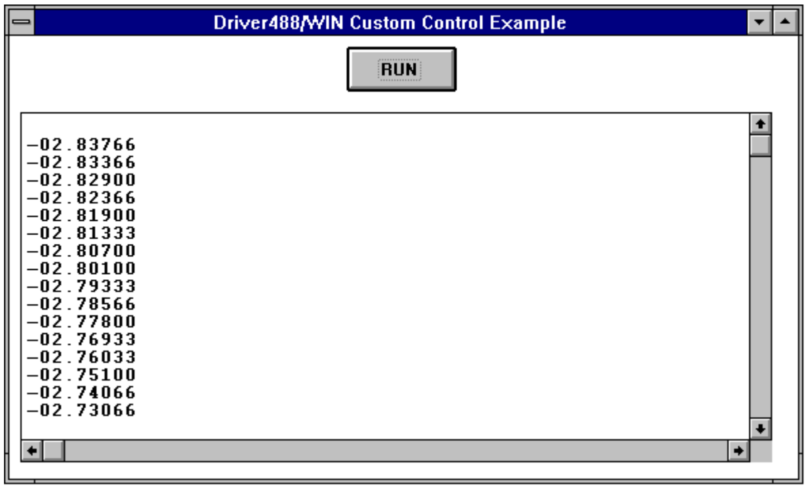
```
Sub Event4881_Srq ()
       'Clear SRQ condition
       rv% = spoll (adc)

       'Reset the buffer pointer of the ADC488
       rv% = ioOutput (adc, "B0X")

       'Get 100 readings from the ADC488
       TextWindow.Text = ""
       For i% = 1 to 100
              rv% = Enter(adc, response)
              TextWindow.Text = TextWindow.Text + response
       Next i%
End Sub
```

The sole button on the form opens the pre-configured ADC then initializes it by clearing it. Next, the IEEE 488 event handling is setup by affiliating the **Handle** property of the **Event4881** control to the newly opened ADC handle. For the bus event to be captured and sent to the custom control, the ADC handle must be left open.

```
Sub Command1_Click ()
       'Now opening a device named ADC
       adc = OpenName ("ADC")
       If (adc = -1) Then
              MsgBox "Cannot initialize device ADC"
              End
       End If
```

To activate this event (**SRQ**), the **SRQ** property of the IEEE controller must be set to **True**. At design-time, select the IEEE 488 tool icon on your form, then select **SRQ** in the properties area. Set the **SRQ** property to **True**.

Note that upon closing the handle, all event handling associated with this control is disabled. You must keep the device open during the time in which its events are of interest. That is, with an ADC488, you would open the device, assign the handle to the *Event Custom Control*'s **Handle** property, configure the **adc** with **ioOutput** commands, and then wait for the **SRQ** event to be triggered. The **SRQ** event handler would read data from the ADC488 and then close the device, allowing other tasks access, and eliminating the event notification. The data read from the ADC488, is displayed in the *Driver488/W31 Custom Control Example* window, as shown in the figure.



```
-02.83766
-02.83366
-02.82900
-02.82366
-02.81900
-02.81333
-02.80700
-02.80100
-02.79333
-02.78566
-02.77800
-02.76933
-02.76033
-02.75100
-02.74066
-02.73066
```

Data read from the ADC488

Finally, the ADC488 is setup to complete an acquisition and assert **`SRQ`**.

```
'Clear ADC
rv% = ioClear (adc)

'Set up event handling for trapping the SRQ
Event4881.Handle = adc
Event4881.SRQ = -1

"Enable ADC to SRQ on acquisition complete
rv% = ioOutput (adc, "M128X")

'Setup the ADC488:
'100 uSec scan interval (I3)
'No pre-trigger scans, 100 post-trigger scans (N100)
'Continuous trigger on GET (T1)
rv% = ioOutput (adc, "13N100T1X")

'Trigger the ADC488
rv% = Trigger (adc)
```

Reading Driver Status

Your application may interrogate Driver488/W31 at any time to determine its status and other information. **`Status`** information is returned in a structure provided by the application and can be displayed by the function shown below.

```
rv% = Status(ieee%, substat)
Call showstat (substat)
```

Another function to display the information contained in the **`Status`** structure could be:

```
Sub showstat (substat As IeeeStatus)
       nl = Chr$(13) + Chr$(10)
       mystring = ""
       mystring = mystring + "SC:" + Str$ (substat.SC) + nl
       mystring = mystring + "CA:" + Str$ (substat.CA) + nl
       mystring = mystring + "PrimAddr:" + Str$ (substat.PrimAddr) + nl
       mystring = mystring + "SecAddr:" + Str$ (substat.SecAddr) + nl
       mystring = mystring + "SRQ:" + Str$ (substat.SRQ) + nl
       mystring = mystring + "addrChange:" + Str$ (substat.addrChange) + nl
       mystring = mystring + "talker :" + Str$ (substat.talker) + nl
       mystring = mystring + "listener:" + Str$ (substat.listener) + nl
       mystring = mystring + "triggered:" + Str$ (substat.triggered) + nl
       mystring = mystring + "cleared:" + Str$ (substat.cleared) + nl
       mystring = mystring + "transfer:" + Str$ (substat.transfer) + nl
       mystring = mystring + "byteIn :" + Str$ (substat.byteIn) + nl
       mystring = mystring + "byteOut        :" + Str$ (substat.byteOut) + nl
       TextWindow.Text = TextWindow.Text + RTrim$ (mystring)
End Sub
```

External Device Initialization

Refer to the device manufacturer's documentation for specific requirements for initializing your IEEE 488 instrument. In the case of the ADC488, appropriate initialization involves sending it a **`ioClear`** command and placing it into **`Remote`** mode:

```
rv% = ioClear(adc)
rv% = Remote(adc)
```

For our hypothetical application, we also wish to have the ADC488 generate a service request should it detect a command error. This involves sending a command string consisting of textual data to the ADC488:

```
rv% = ioOutput (adc, "M8X")
```

We may also wish to perform other initialization and configuration. In this case, we set up the ADC488 (**`adc`**) in the following configuration:

```
'Setup the ADC488:
'Differential inputs (A0)
'Scan group channel 1 (C1)
'Compensated ASCII floating point output format (G0)
'Channel 1 range to +/ 10V (R3)
'One shot trigger on talk (T6)
```

The command to perform this configuration combines the above strings and adds the **`Execute`** (**`X`**) command for the ADC488:

```
rv% = ioOutput(adc, "A0C1G0R3T6X")
```

Basic Data Acquisition

With both Driver488/W31 and the external device ready for action, we next might try taking a simple reading using the ADC488. Here, we use the serial poll (**`SPoll`**) capabilities of Driver488/W31 to determine when a response is ready and to format the reply. The reply is appended to the existing contents of the control **`TextWindow`** so that it will not erase previous responses.

```
'Wait for the ready bit of the ADC488 to be asserted
While ((spoll(adc) And 32) = 0)
Wend

'Display the reading
response = ""
mystring = ""
rv% = enter(adc, response)
voltage = Val(response)
mystring = mystring + "ADC488 channel #1 reading value is " +
Str$(voltage) + nl
TextWindow.Text = TextWindow.Text + mystring

'Now acquire and display an average of 10 readings
sum = 0
For I% = 0 to 9
       response = ""
       rv% = enter (adc, response)
       voltage = Val (response)
       sum = sum + voltage
Next I%
sum = sum / 10

mystring = ""
mystring = mystring + "The average of 10 readings is" + Str$(sum) + nl
TextWindow.Text = TextWindow.Text + mystring
```

Block Data Acquisition

First, we set up the ADC488 (**`adc`**) in the following configuration:

```
'Setup the ADC488:
'Compensated binary output format (G10)
'100 uSec scan interval (I3)
'No pre-trigger scans, 100 post-trigger scans (N100)
'Continuous trigger on GET (T1)
```

We then wait for the ADC488 to start the acquisition process. Once the acquisition is complete, which is determined by the MSB of the ADC488's serial poll response, the buffer pointer of the ADC488 is reset (**`B0`**).

```
rv% = iooutput(adc, "G10I3N100T1X")

'Wait for the ready bit of the ADC488 to be asserted
While ((spoll(adc) And 32) = 0)
Wend

'Trigger the ADC488
rv% = Trigger(adc)

'Wait for the acquisition complete bit of the ADC488 to be asserted
```

```
While ((Spoll(adc) And 128) = 0)
Wend

'Reset the buffer pointer of the ADC488
rv% = ioOutput(adc, "B0X")
```

Next, we fill the buffer with 100 readings from the ADC488. Since the data being returned from the ADC 488 is in a binary format, the noterm terminator structure is used to disable scanning for terminators such as carriage return and line feed.

```
noterm.eoi = 0
noterm.nChar = 0
rv% = EnterXI(adc, intResp(0), 200, 1, noterm, 0, 0)
```

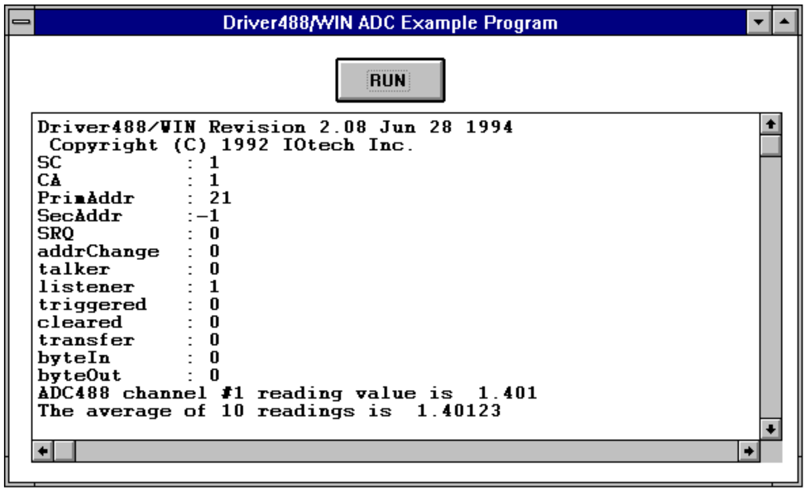
The `EnterX` function will use a DMA transfer if available. Because DMA transfers are performed entirely by the hardware, the program can continue with other work while the DMA transfer function occurs. For example, the program will process the previous set of data while collecting a new set of data into a different buffer. However, before processing the data we must wait for the transfer to complete. For illustration purposes, we query the Driver488/W31 status both before and after waiting.

```
'Display DRIVER488/W31 status
rv% = Status(ieee%, substat)
Call showstat(substat)

'Wait for completion of input operation
rv% = ioWait(adc)

'Display DRIVER488/W31 status
rv% = Status(ieee%, substat)
Call showstat(substat)
```

Now we process the buffer:

```
'Print the received characters
mystring = ""
For i% = 0 To 99
       mystring = mystring + Str$(intResp(i%))+nl
Next i%
```

The readings are stored in the local variable `mystring` in the above example. They could, however be placed into a text-type control. Refer to the Driver488/W31 status display in the *Driver488/W31 ADC Example Program* window, shown in the following figure:



```
Driver488/WIN Revision 2.08 Jun 28 1994
 Copyright (C) 1992 IOtech Inc.
SC           :  1
CA           :  1
PrimAddr     :  21
SecAddr      : -1
SRQ          :  0
addrChange   :  0
talker       :  0
listener     :  1
triggered    :  0
cleared      :  0
transfer     :  0
byteIn       :  0
byteOut      :  0
ADC488 channel #1 reading value is  1.401
The average of 10 readings is  1.40123
```

Driver488/W31 Status Display

The functions described so far in this Sub-Chapter provide enough functionality for a *basic data acquisition* program. The program listing which appears at the end of this Sub-Chapter, covers the examples used. Additional functions provided by Driver488/W31 are described in the "Section III: Command References" of this manual

Dynamic Data Exchange (DDE)

Dynamic Data Exchange (DDE) is a feature built into Microsoft Windows where by unrelated application programs can communicate.

In test and measurement, there are several potential applications for DDE. For example, a very small program can be written to collect data for another specialized program to process, like a spreadsheet program. Programs such as Microsoft Excel have a wide variety of graphics, analysis, and report writing capabilities. Supplying data to Excel directly from an instrument can be a very powerful solution to a laboratory application.

This example will explain the concept of DDE from a programmer's perspective using Visual Basic as the development environment. Driver488/W31 will be used to collect instrument data that will be automatically transferred to an unrelated application program.

Application

Data that is transferred from one application to another, first goes through the clipboard. This is important to know when debugging a DDE application. To see what is being transferred from application to application at run time, just open the Clipboard in the Windows Program Manager.

Every DDE data transfer requires a Client and a Server; the Client receives the data while the Server supplies it. Visual Basic has three controls that can act as a client: A picture box, a text box, and a label. Most controls on a form can act as a source for data, but only a form can act as a server.

Windows provides two kinds of application links: *Hot links* and *cold links*. Hot links update the data in the client application as soon as the data is available on the server. Cold links require the operator to request that the client be updated. Cold links give more control to the operator as to when the data transfer takes place.

Let us see how Microsoft Excel and Microsoft Word for Windows set up a DDE link:

1. If you have them, start them both.
2. In Word, type in a short string of text.
3. Select the text, then click the Copy item under the Edit menu.
4. Bring the Excel spreadsheet into the foreground by clicking on its window.
5. Select a cell, then click Paste Link under its Edit menu. The link is now complete, and any changes made in the string in the word processor will be reflected in the spreadsheet cell.

Server Links

Visual Basic provides two methods by which its applications can be linked to other applications: *Design-time* and *run-time* links. A design-time link is performed while in the Visual Basic development environment. Meanwhile, a run-time link is performed when your Visual Basic program is running. Run-time links are more flexible than design-time links in that the application which will be linked does not need to be chosen at design time.

Design-Time Links

To create a design-time link between your application and Microsoft Excel:

1. Place a text box in your application's form.
2. Select the text box by clicking on it with the mouse cursor.
3. Now go up into the Visual Basic Edit menu and select Copy.
4. If Excel is not running, start it now.
5. Select a cell in the Excel spreadsheet, then select Paste Link under the Edit menu. The hot link is now complete. Anything typed into your application's text box will also show up in the spreadsheet cell. This link will be maintained when your application is running.

During this process, some properties of the controls in your application were altered by Visual Basic. These include the **`LinkMode`** and the **`LinkTopic`**. For more information on the use and meaning of Link properties, consult your Visual Basic User Manual or Help system.

Run-Time Links

To create a run-time link:

1. Your program must set itself up as a server via the **`LinkMode`** property. Your application may have several forms, the form which contains the control that will supply the data must have its **`LinkMode`** property set to **`SERVER`**. This property can be set at design time by selecting the **`LinkMode`** property of your form and setting it to **`SERVER`**, or at run time by placing the following command in the Load event service routine of your form:

   ```
   LinkMode = SERVER
   ```

   Note: The string **`SERVER`** is defined in **`CONSTANT.TXT`** which should be added to your project if you wish to use it.

2. To take your application out of server mode at run time, issue the following command in the service routine of your choice:

   ```
   LinkMode = NONE
   ```

3. After your application has been setup as a server, the data in its controls is immediately accessible to other applications.

4. Start your application then launch Excel.

5. Select a cell in the spreadsheet. We can now type in an application link by specifying: the application to link, the form within the application, and the control within the form.

   For example, if your application is named **`PROJECT1`**, with one form named **`FORM1`**, containing one text box named **`TEXT1`**, type the following into a cell in your Excel spreadsheet:

   ```
   =PROJECT1|FORM1!TEXT1
   ```

   You have now formed a hot link Anything typed in text box **`TEXT1`** will appear in the spreadsheet cell.

Posting Link Information

One drawback to this run-time linking approach is that a user of your program would need to know the names of your application's controls (like **`TEXT1`**) to complete the link. To eliminate this requirement, your application can be programmed to post the link information in the clipboard. When programs like Excel recognize the presence of this information in the clipboard, they enable a command called Paste Link under their Edit menu. Paste Link will automatically place the string that we typed above into the selected cell.

To program your application to post the link information:

1. In your application, create a button or a menu item called Copy Link. Under your new control's Click event, type in the following:

   ```
   ClipBoard.Clear
   ClipBoard.SetText "PROJECT1|Form1!text1", &HBF00
   ```

   The first line clears the present contents of the clipboard. The second line places the control identifier which includes the application name, the form name and the control name, into the clipboard and tags it as a link specifier via the last parameter (**`&HBF00`**).

2. After starting your application, click the Copy Link control.

3. Select a cell in the Excel spreadsheet and click the Paste Link item under the Edit menu. The following string:

   ```
   =PROJECT1|Form1!text1
   ```

   is automatically placed in the cell completing the link.

Posting Link Information with Focus

If your application has several text boxes from which DDE information can be sourced, you will want to allow your Copy Link control to post the name of the text box that presently has the Focus.

To do this, here is one way:

1. Declare a global string called **`CtrlName`** as a storage space for the name of the text box that presently has the Focus.
2. Under the **`GotFocus`** event for each of the text boxes, type the following commands:

```
Sub Text1_GotFocus()
       CtrlName = "text1"
       CopyLink.Enabled = TRUE
End Sub

Sub Text2_GotFocus()
       CtrlName = "text2"
       CopyLink.Enabled = TRUE
End Sub

Sub Text3_GotFocus()
       CtrlName = "text3"
       CopyLink.Enabled = TRUE
End Sub
```

   These service routines will maintain the global variable **`CtrlName`** with the name of the presently selected text box. They also allow user access to your Copy Link button.

3. Under the **`LostFocus`** event for each of the text boxes, type the following commands:

```
Sub Text1_LostFocus()
       CtrlName = "text1"
       CopyLink.Enabled = FALSE
End Sub

Sub Text2_LostFocus()
       CtrlName = "text2"
       CopyLink.Enabled = FALSE
End Sub

Sub Text3_LostFocus()
       CtrlName = "text3"
       CopyLink.Enabled = FALSE
End Sub
```

   These service routines will disable user access to your Copy Link control when no text boxes have the Focus.

4. In your Copy Link service routine, type the following:

```
Sub CopyLink_Click ()
       ClipBoard.Clear
       ClipBoard.SetText "PROJECT1|Form1!" + CtrlName, &HBF00
End Sub
```

   This service routine will post the name of the text box that presently has the Focus. When you move to the Excel spreadsheet and perform a Paste Link, the proper text box specification will appear.

Acquisition Engine

One of the most common DDE applications in the data acquisition world, is sending collected data from an instrument directly to a spreadsheet or analysis package.

Since spreadsheets and analysis programs typically do not have any means by which to setup instruments and collect data, an independent program must be written to perform those functions, namely, the Acquisition Engine. Using Driver488/W31, we will write a program that controls the 16-channel digitizer, the ADC488/16A.

The ADC488/16A Acquisition Engine will have one form that sets up some of the parameters of the instrument and provides a means of collecting and displaying the data. We will also include a means for posting a server link specification in the clipboard, so Excel can perform a Paste Link operation.

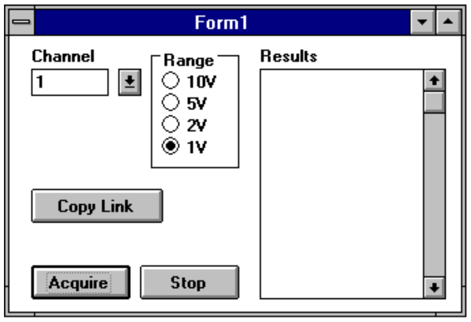
Note: A similar example is also used within the **`QUIKTEST`** utility. For more information on this utility, turn to the next Sub-Chapter “Utility Programs” in this Chapter.

All of the initialization happens in the following **`Form_Load`** service routine.

```
Sub Form_Load ()
      LinkMode = 1
      Chan.AddItem “1"
      Chan.AddItem ”2"
      Chan.AddItem “3"
      Chan.AddItem ”4"
      Chan.AddItem “5"
      Chan.AddItem ”6"
      Chan.AddItem “7"
      Chan.AddItem ”8"
      Chan.AddItem “9"
      Chan.AddItem ”10"
      Chan.AddItem “11"
      Chan.AddItem ”12"
      Chan.AddItem “13"
      Chan.AddItem ”14"
      Chan.AddItem “15"
      Chan.AddItem ”16"
      Chan.ListIndex = 0
      Range(0).value = -1
      text1.text = “”
      StartFlag = 0
      NL = Chr$(13) + Chr$(10)
End Sub
```

First the **`LinkMode`** is set to **`SERVER (1)`**. Then the combo box is initialized with the channel numbers available from the ADC488/16A. After some form control initialization, the constant **`NL`** (new line) is defined as a string consisting of a carriage return and line feed. This will be used to put a new line between readings.

Although the ADC488/16A has many programmable features, for the sake of brevity, this application will only exercise a few. This application provides controls to adjust the channel voltage range and the desired channel. The control where the collected data is returned is a text box with its **`Multiline`** and **`ScrollBar`** properties set to **`TRUE`** at design time.



Channel 1

Range 10V 5V 2V [✓ 1V]

ADC488/16A Acquisition Engine Form

A very small bit of code resides behind the option buttons. The option buttons are configured as a control array. The **`Click`** event is serviced by the same code which sets the value of the global variable **`Rng`** to the index number of the option control.

```
Sub Range_Click (index As Integer)
      Rng = index
End Sub
```

When the Acquire button is pressed, executing the **`Acquire_Click`** routine, the pre-configured device ADC488 is opened and cleared. Then a string of ADC488 commands are sent to the device using the settings from the combo box and the variable **`Rng`**. Lastly, the global variable **`StartFlag`** is set to **`1`** (start).

```
Sub Acquire_Click ()
      Handle = OpenName("ADC488")
      Err = ioClear(Handle)
      cmd$ = "C" + Str$(Chan.ListIndex + 1) + "R" + Str$(Rng) + "T0X"
      Err = ioOutput(Handle, cmd$)
      StartFlag = 1
End Sub
```

The acquisition actually takes place in the `Timer` service routine. If the acquisition took place in the `Acquire_Click` service routine, it might never relinquish control to the user again, collecting readings forever.

At design time, the timer interval was set to `500` which translates to a `500 ms` period. The service routine for the timer checks the `StartFlag`. If the value is `1`, the routine collects data from the ADC488/16A via the `Enter` command. After getting a reading, the new reading is appended to the existing string using `NL` as a data separator:

```
Sub Timer1_Timer ()
      If StartFlag = 1 Then
            Err = Enter(Handle, resp)
            text1.text = text1.text + NL + resp
      End If
End Sub
```

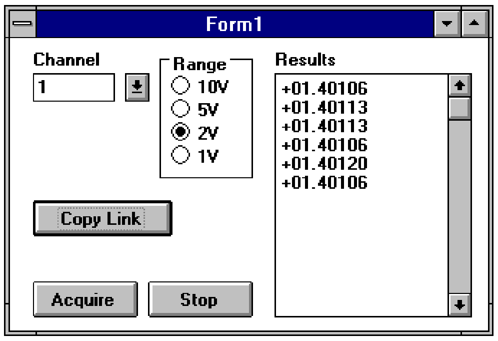
The Stop button executes the `Stopper_Click` routine, setting the `StartFlag` back to `0`, ending the acquisition, then closes the device ADC488 via its `Handle`:

```
Sub Stopper_Click ()
      StartFlag = 0
      Err = ioClose(Handle)
End Sub
```

The Copy Link button executes the `CopyLink_Click` routine, posting the server link information in the clipboard. First the clipboard is cleared, then the link information is inserted.

```
Sub CopyLink_Click ()
      Clipboard.Clear
      Clipboard.SetText "ADC488|Form1|text1"' &HBF00
End Sub
```

While this application is running, pressing the Copy Link button seems to have no effect. After starting the Excel program, we select several cells in a column, then click Paste Link under the Edit menu. Returning to the application, we click the Acquire button. The data immediately begins flowing into the text box. Soon after, the Excel spreadsheet column begins to reflect the new data from the application, as indicated in the following two screens.



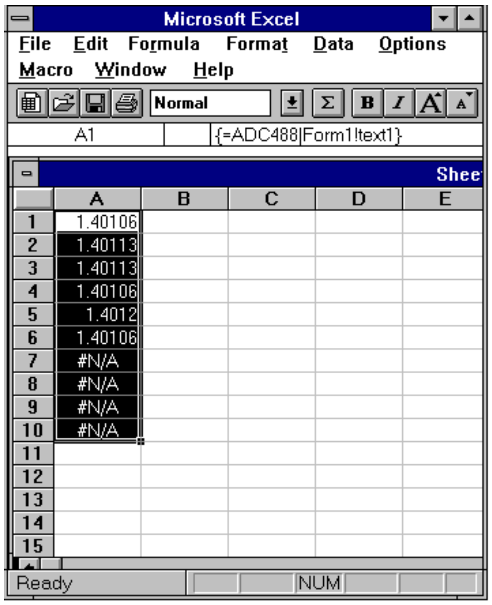
```
+01.40106
+01.40113
+01.40113
+01.40106
+01.40120
+01.40106
```

Acquisition Engine Form with Data

From Excel, this can be turned into a cold link, where the column of the spreadsheet is updated only when the user requests an update. In Excel, click Links... under the File menu. A list of the present links is displayed. Selecting the newly active link and clicking the option button, brings up a dialog box with a check box for enabling and disabling automatic link updates.

If the ADC488 application is terminated, the data in the spreadsheet will become static. If we ask for the data to be updated, the Excel spreadsheet will make an attempt to start the application.

The following program listing includes the ADC488 Acquisition Engine program. This program was designed to outline the basic concepts of DDE. For further information on DDE, consult your Visual Basic User Manual or Help system.



	A	B	C	D	E
1	1.40106				
2	1.40113				
3	1.40113				
4	1.40106				
5	1.4012				
6	1.40106				
7	#N/A				
8	#N/A				
9	#N/A				
10	#N/A				
11					
12					
13					
14					
15					

Excel Spreadsheet with ADC488/16A Data

Sample Programs

Data Acquisition Sample Program

GLOBAL.BAS Declarations

```
Declare Function FindWindow Lib "User" (ByVal data1$, ByVal data2$)
As Integer

Declare Function SendMessage Lib "User" (ByVal winHandle%, ByVal
message%, ByVal wp%, ByVal lp As Long) As Integer
```

Declarations included in Form

```
Dim nl As String * 2
Dim mystring As String
Dim substat As IeeeStatus
Dim adc As Integer
Dim response as String * 256
Dim intResp(500) As Integer
Dim voltage As Single
Dim noterm As terms
Dim sample As String * 7
```

Source Code

```
Sub Command1_Click ()
nl = Chr$(13) + Chr$(10)
  TextWindow.Text = ""

  'open driver . . .
  ieee% = OpenName ("IEEE")
  If (ieee% = -1) Then
        MsgBox "Cannot initialize IEEE system"
        End
  End If

  'Open device named ADC
  rv% = ioError (ieee%, TURNOFF)
  devhandle% = OpenName ("wave")
  adc = OpenName ("ADC")
  If (adc = -1) Then
         adc = MakeDevice (devhandle%, "ADC")
         If (adc = -1) Then
              MsgBox "Can not initialize device ADC"
              End
          End If
  End If

  response = ""
  rv% = GetError (ieee%, response)
  rv% = BusAddress (adc, 14, -1)

  'Get DRIVER488/W31 status
  rv% = Hello (ieee%, response)
  mystring = ""

  For i% = 1 To Len (RTrim$ (response))
         If Asc (Mid$(response, i%, 1)) = 10 Then
              mystring = mystring + nl
         Else
              mystring = mystring + Mid% (response, i%, 1)
         End If
Next i%
mystring = mystring + nl

TextWindow.Text = TextWindow.Text + RTrim$ (mystring)
TextWindow.Text = TextWindow.Text + nl

'Display DRIVER488/W31 status
rv% = Status (ieee%, substat)
Call showstat (substat)

'Clear ADC
response = ""
rv% = ioClear (adc)

'Setup the ADC488:
'Differential inputs (A0)
'Scan group channel 1 (C1)
'Compensated ASCII floating-point output format (G0)
'Channel 1 range to +/- 10V (R3)
'One-shot trigger on talk (T6)
'rv% = iooutput (adc, "A0C1G0R3T6X")

'Wait for the ready bit of the ADC488 to be asserted
While ((spoll (adc) And 32) = 0)
Wend

'Display the reading
response = ""
mystring = ""
rv% = enter(adc, response)
voltage = Val (response)
mystring = mystring + "ADC488 channel #1 reading value is " +
Str$(voltage) + nl
TextWindow.Text = TextWindow.Text + mystring

'Now acquire and display an average of 10 readings
sum = 0
For i% = 0 To 9
  response = ""
  rv% = enter (adc, response)
  voltage = Val (response)
  sum = sum + voltage
```

```
Next i%
sum = sum / 10

mystring = ""
mystring = mystring + "The average of 10 readings is " + Str$(sum) +
nl
TextWindow.Text = TextWindow.Text + mystring

'Setup the ADC488:
'Compensated binary output format (G10)
'100 uSec scan interval (I3)
'No pre-trigger scans, 100 post-trigger scans (N100)
'Continuous trigger on GET (T1)
rv% = iooutput (adc, "G10I3N100T1X")

'Wait for ready bit of the ADC488 to be asserted
While ((spoll (adc) And 32) = 0)
Wend

'Trigger the ADC488
rv% = Trigger (adc)

'Wait for the ready bit of the ADC488 to be asserted
While ((spoll (adc) And 32) = 0)
Wend

'Reset the buffer pointer of the ADC488
rv% = iooutput (adc, "B0X")

'Take 100 readings from the ADC488
noterm.eoi = 0
noterm.nChar = 0
rv% = EnterXI(adc, intResp(0), 200, 1, noterm, 0, 0)
If rv% = -1 Then
TextWindow.Text = TextWindow.Text + "Error in data transfer!"
End
End If

'Display DRIVER488/W31 status
rv% = Status (ieee%, substat)
Call showstat (substat)

'Wait for completion of input operation
rv% = ioWait (adc)

'Display DRIVER488/W31 status
rv% = Status (ieee%, substat)
Call showstat (substat)
'Print the received characters
  mystring = ""
  For i% = 0 to 99
       mystring = mystring + Str$(intResp(i%) + nl
  'Next i%
  mystring = mystring + nl
  TextWindow.Text = TextWindow.Text + mystring
End Sub

Sub Form_Unload (Cancel As Integer)
  'Unload the IEEE driver
  loaderName$ = "Driver488/W31 Loader"
  winName$ = "Driver488/W31"
  Hdriver% = FindWindow(loaderName$, winName$)
  asdf = SendMessage (Hdriver%, &H2, 0, 0)
End Sub

Sub showstat (substat As IeeeStatus)
  nl = Chr$(13) + Chr$(10)
  mystring = “”
  mystring = mystring + “SC       :” + Str$ (substat.SC) + nl
  mystring = mystring + “CA       :” + Str$ (substat.CA) + nl
  mystring = mystring + “PrimAddr :” + Str$ (substat.PrimAddr) + nl
  mystring = mystring + “SecAddr  :” + Str$ (substat.SecAddr) + nl
  mystring = mystring + “SRQ      :” + Str$ (substat.SRQ) + nl
  mystring = mystring + “addrChange:” + Str$(substat.addrChange)+ nl
  mystring = mystring + “talker   :” + Str$ (substat.talker) + nl
  mystring = mystring + “listener :” + Str$ (substat.listener) + nl
  mystring = mystring + “triggered:” + Str$ (substat.triggered) + nl
  mystring = mystring + “cleared  :” + Str$ (substat.cleared) + nl
  mystring = mystring + “transfer :” + Str$ (substat.transfer) + nl
  mystring = mystring + “byteIn   :” + Str$ (substat.byteIn) + nl
  mystring = mystring + “byteOut  :” + Str$ (substat.byteOut) + nl
  TextWindow.Text = TextWindow.Text + RTrim$ (mystring)
End Sub

Function cvi (stringarg$) As Single
  Static hb As Integer
  Static lb As Integer
  Static temp As Single
  hb = Asc(Right$(stringarg$, 1)
       lb = Asc(Left$(stringarg$, 1)
  temp = ((hb And &H7F) * 256) + lb
  If (hb And &H80) Then
         temp = -temp
  End If
  cvi = temp
End Function
```

IEEE 488 Event Custom Control Sample Program

Declarations Included with Form

```
Dim adc As Integer
Dim response As String * 256
```

Source Code

```
Sub Event4881_SRQ ()
  ‘Clear SRQ condition
  rv% = spoll(adc)

  ‘Reset the buffer pointer of the ADC488
  rv% = ioOutput(adc, “B0X”)

  ‘Get 100 readings from the ADC488
  TextWindow.Text = “”
  For i% = 1 To 100
  rv% = Enter(adc, response)
  TextWindow.Text = TextWindow.Text + Chr$(13) + Chr$(10) + response
  Next i%
  rv% = ioClose(adc)
End Sub

Sub Command1_Click ()
  ‘Now opening a device named ADC
  adc = OpenName(“ADC”)
  If (adc = -1) Then
       MsgBox “Can not initialize device ADC”
        End
End If

‘Clear ADC
```

```
rv% = ioClear(adc)

'Set up event handling for trapping the SRQ
Event4881.Handle = adc
Event4881.SRQ = -1

'Enable ADC to SRQ on acquisition complete
rv% = ioOutput(adc, "M128X")

'Setup the ADC488:
'100 uSec scan interval (I3)
'No pre-trigger scans, 100 post-trigger scans (N100)
'Continuous trigger on GET (T1)
rv% = ioOutput(adc, "I3N100T1X")

'Trigger the ADC488
rv% = Trigger(adc)
End Sub
```

Acquisition Engine Sample Program

GLOBAL.BAS Declarations

```
Global NL As String
Global resp As String * 255
Global StartFlag As Integer
Global Handle As Integer
Global Rng As Integer
```

Source Code

```
Sub Form_Load ()
  LinkMode = 1
  Chan.AddItem "1"
  Chan.AddItem "2"
  Chan.AddItem "3"
  Chan.AddItem "4"
  Chan.AddItem "5"
  Chan.AddItem "6"
  Chan.AddItem "7"
  Chan.AddItem "8"
  Chan.AddItem "9"
  Chan.AddItem "10"
  Chan.AddItem "11"
  Chan.AddItem "12"
  Chan.AddItem "13"
  Chan.AddItem "14"
  Chan.AddItem "15"
  Chan.AddItem "16"
  Chan.ListIndex = 0
  Range(0).value = -1
  text1.text = ""
  StartFlag = 0
  NL = Chr$(13) + Chr$(10)
End Sub

Sub Acquire_Click ()
  Handle = OpenName("ADC")
  Err = ioClear(Handle)
  cmd$ = "C" + Str$(Chan.ListIndex + 1) + "R" + Str$(Rng) + "T0X"
  Err = ioOutput(Handle, cmd$)
  StartFlag = 1
End Sub

Sub CopyLink_Click ()
```

```
  ClipBoard.Clear
  ClipBoard.SetText "ADC488|Form1!text1", &HBF00
End Sub

Sub Range_Click (index As Integer)
  Rng = index
End Sub

Sub Stopper_Click ()
  StartFlag = 0
  Err = ioClose(Handle)
End Sub

Sub Timer1_Timer ()
  If StartFlag = 1 Then
         Err = Enter(Handle, resp)
         text1.text = text1.text + NL + resp
  End If
End Sub
```

Command Summary

To obtain a summary of the Visual Basic commands for Driver488/W31, turn to the "Section III: Command References" of this manual.

10G. Utility Programs

Topics

Introduction

The Driver488/W31 software disk includes two utility programs: **`WINTEST`** and **`QUIKTEST`**. These programs were designed as an exercise for the user and to verify proper installation of the driver. **`WINTEST`** uses the Driver488/W31 C syntax while **`QUIKTEST`** uses Visual Basic. This Sub-Chapter describes each utility in detail.

WINTEST

`WINTEST` is a utility program included with Driver488/W31. Its primary application is to exercise the driver and instruments on the bus via Driver488/W31 commands, which are accessible from the menu bar. Since the lines of code that are generated and executed by **`WINTEST`** use the Driver488/W31 C language syntax, **`WINTEST`** is most useful for C programmers.

Under the menu items of the `WINTEST` application are all of the commands in Driver488/W31. The commands are categorized in 8 groups:

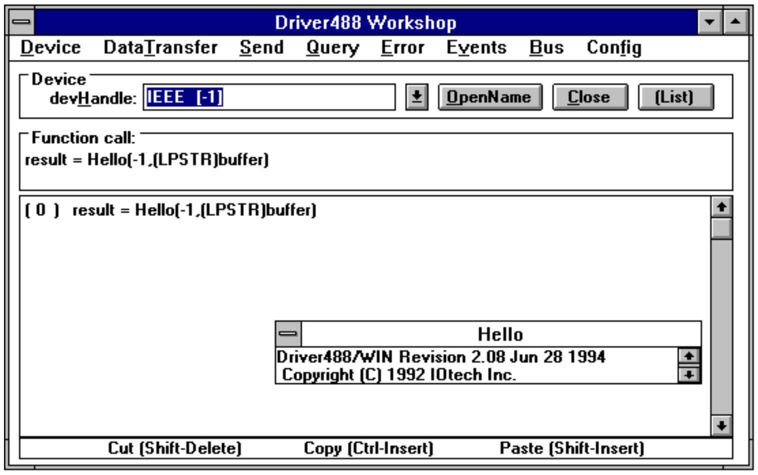
Menu Item	Group Description
Device	Commands dealing with accessing and configuring instruments
DataTransfer	Commands that send and receive data from instruments
Send	Low-level commands for sending commands and data to instruments
Query	Polling commands
Error	Driver query and error handling commands
Events	Commands dealing with enabling and disabling bus events
Bus	Bus and instrument management commands
Config	Driver configuration commands

As the application's main window opens on the screen, a response window is also opened with the response from Driver488/W31's `Hello` command placed in it. This window returns the response from any input command used during the session.

Note: **DO NOT close this response window for the duration of your `WINTEST` session**. *There is no mechanism in the application to re-open this window*.

Opening a Device Handle for Communication

To perform any of the commands under the menu items, it is first necessary to open a device. Within the `WINTEST` main window is a menu item labeled Device, as shown in the figure. The field labeled `devHandle` holds a table of all of the devices that were configured during the driver configuration process. Next to each device name, is a number in brackets `[ ]`. This number corresponds to the present value of the handle associated with the device name. A value of `-1` means that the device has not been opened. Any positive value means that the device is open and available.



result = Hello(-1,(LPSTR)buffer)

(0) result = Hello(-1,(LPSTR)buffer)

Driver488/WIN Revision 2.08 Jun 28 1994
Copyright (C) 1992 IOtech Inc.

Selecting a Device Handle

To open a device, select the desired device, then click the OpenName button. All of the commands under the menus will use the presently selected device handle shown in the `devHandle` field. If the selected device is not open, an error will be returned. To close the selected device, click the Close button.

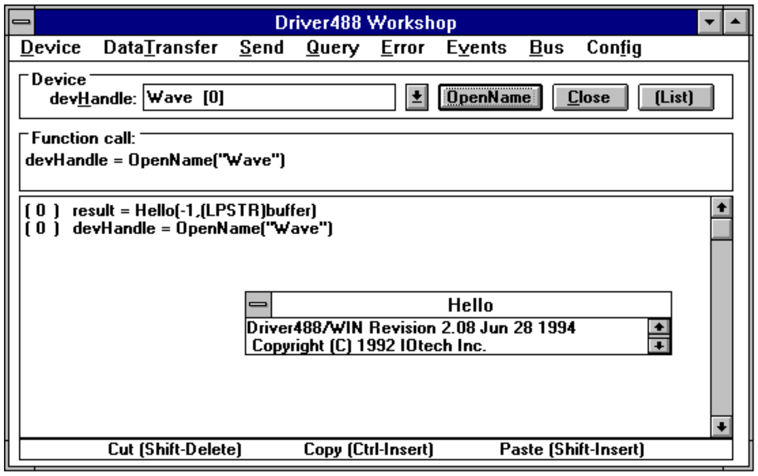
Handle Lists

Several of the Driver488/W31 commands operate on lists of handles (i.e. `ClearList`). To create a list, select a device in the `devHandle` field that you wish to place in the list, then click the List button. Repeat this process for all of the devices that you want in the list.

Non-list commands will still use the handle of the device that is presently showing in the `devHandle` field, but list-type commands will use the handles of all of the devices tagged as list handles. All of the devices tagged as list items must be open to successfully complete a list command.

WINTEST Session

Start **`WINTEST`**. In the **`devHandle`** field is the table of preconfigured devices. If no changes were made to the factory default, the table should include **`IEEE`** and **`Wave`**. The handle **`IEEE`** is always in the device table for interface-related commands.



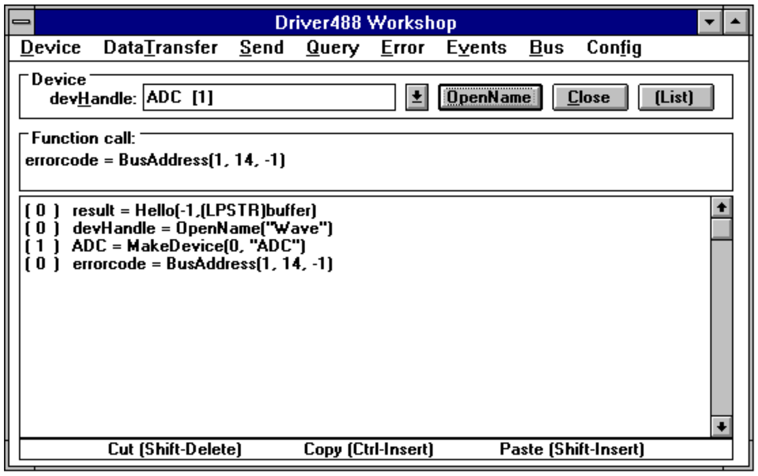
```
Wave  [0]
devHandle = OpenName("Wave")
( 0 )  result = Hello(-1,(LPSTR)buffer)
( 0 )  devHandle = OpenName("Wave")
Driver488/WIN Revision 2.08 Jun 28 1994
 Copyright (C) 1992 IOtech Inc.
```

Opening a Device

As shown in the following figure, select **`Wave`** in the **`devHandle`** field, then click the OpenName button. The number in brackets next to the name **`Wave`** changes from **`-1`** to a positive number as the command is executed and the device is opened. The complete function call appears in the **`Function Call`** field and the call also appears in the executed command list.

In the executed command list, the number to the left in parenthesis, is the value returned by the function call during execution. Generally, if the command completed successfully, the number is `0`, and if the command caused an error, the number is **`-1`**. For more information on the command return values, refer to the "Section III: Command References" of this manual.

To clear the device named **`Wave`**, select Clear under the Bus menu item. Then, create a new device using the **`MakeDevice`** command under the Device menu item. A dialog box will pop up that shows the C structure for the required user input. In this case, the name of the new device is required. Fill in the name and click OK. The command and the returned value will now be in the command list, as shown in the figure. Your new device now appears in the **`devHandle`** field. Select BusAddress under the Config menu item to set the address of your newly created device.

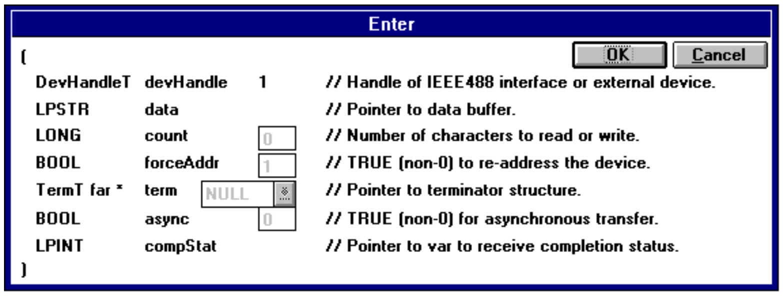


```
ADC  [1]
errorcode = BusAddress(1, 14, -1)
( 0 )  result = Hello(-1,(LPSTR)buffer)
( 0 )  devHandle = OpenName("Wave")
( 1 )  ADC = MakeDevice(0, "ADC")
( 0 )  errorcode = BusAddress(1, 14, -1)
```

Creating a New Device

As you fill in the pop-up dialog boxes, **`WINTEST`** uses your input to adjust the parameters in the function call. These completed syntactically-correct lines of C code can be selected, cut and pasted into your C editor at any time.

To get data from your new device, select Enter Commands under the DataTransfer menu item. A sub menu showing the controls for the **`Enter`** commands will display a dialog box, as indicated in the figure. Since the **`Enter`** command uses a subset of the parameters of the **`EnterX`** command, the dialog box displays all of the controls for the **`EnterX`** command, while disabling those not appropriate for the **`Enter`** command.



```
{
  DevHandleT  devHandle   1     // Handle of IEEE488 interface or external device.
  LPSTR       data              // Pointer to data buffer.
  LONG        count       0     // Number of characters to read or write.
  BOOL        forceAddr   1     // TRUE (non-0) to re-address the device.
  TermT far * term        NULL  // Pointer to terminator structure.
  BOOL        async       0     // TRUE (non-0) for asynchronous transfer.
  LPINT       compStat          // Pointer to var to receive completion status.
}
```

Displaying the Enter Commands

Click OK to get a reading. A dialog box pops up showing the results. The **`Enter`** command returns the number of bytes successfully transferred. Notice the byte count in parenthesis to the left of the command in the command list.

For a complete explanation of the Driver488/W31 commands and their uses, refer to the “Section III: Command References” of this manual.

QUIKTEST

`QUIKTEST` is a simple application designed to exercise Driver488/W31, and the instruments connected to the interface card. **`QUIKTEST`** is a good tool for verifying that your driver and interface card are properly installed. **`QUIKTEST`** can also be used to experiment with your instruments to see how they respond to different sequences of commands. Included on the disk, is an executable version of **`QUIKTEST`** and the Visual Basic source code files, form files, and makefile.

Application Files

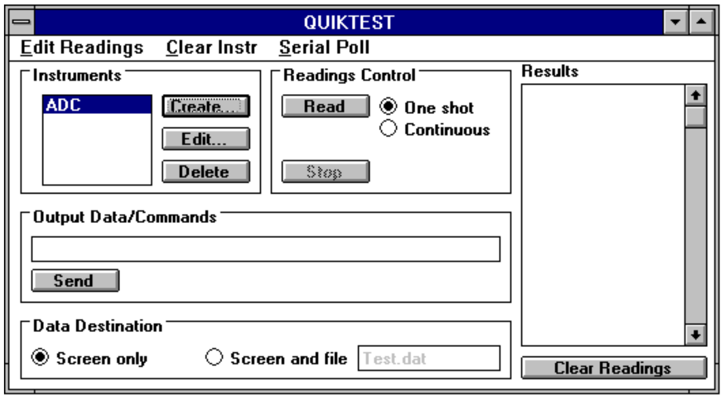
The executable version of **`QUIKTEST`** includes the following: The source code files, the form files, the make file, and the Visual Basic (VB) run-time Dynamic Link Library (DLL), as shown in the table:

File Name	Description
`QUIKTEST.EXE`	The executable version of the application
`QUIKTEST.MAK`	The VB makefile, used to build the executable
`QUIKTEST.FRM`	A VB form file, which generates the main window of the application
`DEVICE.FRM`	A VB form file, which generates the pop-up window used to create and edit bus devices
`GLOBAL.BAS`	A VB source code file containing global declarations and variables
`IOTVB10.BAS`	A VB interface file included with Driver488/W31
`MYCODE.BAS`	A VB source code file containing application-specific routines
`VBRUN100.DLL`	The VB run-time DLL supplied by Microsoft

Installation

To run the application, only the **`QUIKTEST.EXE`** and **`VBRUN100.DLL`** files are required. Copy the **`VBRUN100.DLL`** file into your **`\WINDOWS`** directory. The **`QUIKTEST`** file can be copied anywhere or run from the floppy. However, the application will generally respond quicker if it is executed from the hard drive.

Operation of the Application

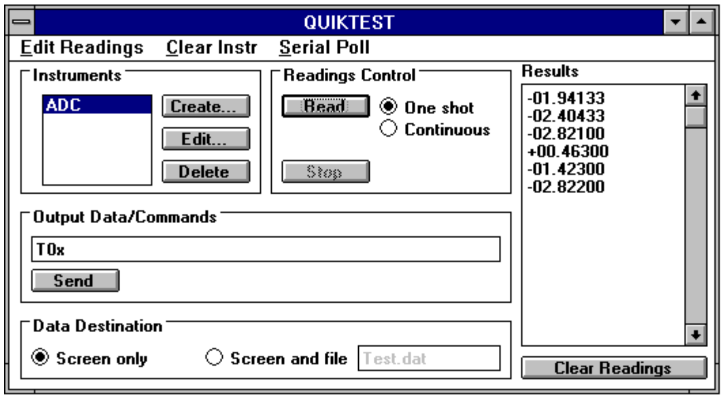


Creating a Device

Designed for simplicity, the application has very few controls. To begin communicating with your instruments, you must first create a device. When creating a device, you can either use a device name that you have pre-configured or a new name. Press the Create button, as shown in the figure, then fill in the parameters in the pop-up Device Window.

After a device has been created, most of the main window controls will be enabled. If your instrument has data available, pressing the Read button will collect the data and place it in the adjacent Results window. Commands can be sent to the selected device at any time. Simply type in the command string into the Output Data/Commands field, then click on the Send button, or hit **`<Enter>`**.

When collecting data via the Read button, the data is placed at the destination selected in the Data Destination field. If the destination is a file, it is usually a good idea to specify the entire path. The example in the following figure, shows the Data Destination for Screen and file as **`Test.dat`**. A more complete destination for Screen and file would be **`C:\Test.dat`**.



```
-01.94133
-02.40433
-02.82100
+00.46300
-01.42300
-02.82200
```

Output Data/Commands: T0x

Collecting Data

As additional devices are created, they will be added to the Instruments list. No two instruments can be created using the same name. Only one instrument in the Instruments list can be selected at any one time. All of the controls in the main window pertain directly to the selected instrument. For example, after creating create two devices, the last device created will be selected. Now click on the Serial Poll menu item. The response will immediately pop-up on the screen. Now select the other device and repeat the Serial Poll. The response of that device will now be on the screen.

Cutting & Pasting to Other Applications

The Results field of the **`QUIKTEST`** main window supports many of the features of a standard text editor. The cursor can be placed anywhere in the text, text can be added or deleted, and text can be selected, cut or copied. Under the Edit Readings menu item, is the **`Copy`** command for copying selected text to the clipboard. Text sent the clipboard can subsequently be pasted into almost any Windows application.

Dynamic Data Exchange (DDE)

The **`QUIKTEST`** application has the ability to send collected instrument results directly to other Windows applications via the Windows Dynamic Data Exchange (DDE) capabilities.

For example, to send collected data to a Microsoft Excel spreadsheet:

1. Select Copy under the Edit Results menu item.
2. Start the Excel application, then select a range of cells within a column.
3. Within the Excel application, select Paste Link under the Edit menu item. The DDE "link" is now complete.
4. Next, click on the **`QUIKTEST`** application window to bring it to the foreground.
5. Finally, send the necessary commands to your instrument for it to supply readings continuously, by selecting Continuous in the Readings Control field, and clicking on the Read button. As the readings appear in the Results field of the **`QUIKTEST`** window, they should also appear in the selected cells of the Excel spreadsheet.

For detailed information on performing Dynamic Data Exchange, refer to the topic "Dynamic Data Exchange (DDE)" found in the previous Sub-Chapter "Visual Basic" of this Chapter.

Loading the Project into Visual Basic

To inspect the source code of this application or change its functionality, the Visual Basic development package from Microsoft is required.

Start the Visual Basic application. Select Open Project under the File menu item. Select the makefile **`QUIKTEST.MAK`**. All of the forms and source files will now be accessible for inspection and/or change.

The majority of the source code pertains to the managing of the device table. Operating the action buttons is typically quite simple. However, it is important to understand how the application performs the collection of data:

- The Read button merely sets a flag when it is clicked.
- A Timer control actually collects the readings.
- If the readings were actually collected by the clicking of the Read button, continuous data collection would never service the mouse, since the act of collecting data would not allow any user events to ever be serviced.

  For more information on data collection, see the topic "Dynamic Data Exchange (DDE)" found in the previous Sub-Chapter "Visual Basic" of this Chapter. Or more specifically, this information is found under the sub-topic "Acquisition Engine."

Licensing

You may copy, change, and paste from these utility programs freely. Although owned by IOtech, purchasers of Driver488/W31 are granted unlimited privileges for copying and/or altering **`WINTEST`** and/or **`QUIKTEST`**. All other parts of Driver488/W31, however, are licensed software and cannot be copied or reproduced without the expressed written consent from IOtech, Inc.

10H. Command Reference

For Driver488/SUB, W31, W95, & WNT

To obtain a detailed description of the command references for Driver488/SUB and Driver488/W31, turn to Section III in this manual entitled "Command References." The commands for Driver488/W95 and Driver488/WNT are provided as guides, pending current software revisions. Refer to your operating system header file for the latest available information specific to your application. The commands are presented in alphabetical order for ease of use.

11. Driver488/W95

Note: Driver488/WIN95 and Driver488/NT from previous manuals, have been renamed Driver488/W95 and Driver488/WNT, respectively.

Note: The differences among Driver488 for Windows 3.x, Windows 95 and Windows NT are slight. However, because additional changes are being made to Driver488/W95 and Driver488/WNT at the time this manual is being revised, *refer to your operating system header file* (and `README.TXT` text file, if present) *to obtain the current material on these driver versions.*

To obtain a detailed description of the command references for Driver488/SUB and Driver488/W31, turn to Section III in this manual entitled "Command References." The commands for Driver488/W95 and Driver488/WNT are provided as guides, pending current software revisions. Refer to your operating system header file for the latest available information specific to your application. The commands are presented in alphabetical order for ease of use.

12. Driver488/WNT

Note: Driver488/WIN95 and Driver488/NT from previous manuals, have been renamed Driver488/W95 and Driver488/WNT, respectively.

Note: The differences among Driver488 for Windows 3.x, Windows 95 and Windows NT are slight. However, because additional changes are being made to Driver488/W95 and Driver488/WNT at the time this manual is being revised, *refer to your operating system header file* (and `README.TXT` text file, if present) *to obtain the current material on these driver versions.*

To obtain a detailed description of the command references for Driver488/SUB and Driver488/W31, turn to Section III in this manual entitled “Command References.” The commands for Driver488/W95 and Driver488/WNT are provided as guides, pending current software revisions. Refer to your operating system header file for the latest available information specific to your application. The commands are presented in alphabetical order for ease of use.

Section III:

COMMAND REFERENCES

III. COMMAND REFERENCES

Chapters

13. Overview

This Section on the Driver488 "Command References" contains the detailed descriptions of the Application Program Interface (API) command references pertaining to Driver488/DRV, Driver488/SUB, Driver488/W31, Driver488/W95, and Driver488/WNT. Although changes are currently being made to Driver488/W95 and to Driver488/WNT, the commands which apply to these drivers are close to those that apply to Driver488/W31. The Driver488/W31 command reference may be used as a detailed reference for these other two drivers. But for accuracy, refer to your operating system file header to obtain the actual syntax for your particular driver.

14. Command Summaries

Sub-Chapters

14A. Driver488/SUB, C Languages

Topics

Function Descriptions

Command	Description
`Abort (IntfHandle)`	Assert IFC
`Arm (IntfHandle,Condition)`	Arm OnEvent for specified event(s)
`AutoRemote (IntfHandle,Flag)`	Assert REN on Output
`Buffered (IntfHandle)`	Return number of buffered bytes
`BusAddress (Handle,Prim,Sec)`	Set IEEE address of interface or device
`CheckListener (IntfHandle Prim, Sec)`	Check for device at specified bus address
`Clear (Handle)`	Issue Selected Device Clear (SDC) or Device Clear (DCL)
`ClearList (DevHandles)`	Clear devices in list
`Clock Frequency (IntfHandle, Freq)`	Specify clock interface frequency
`Close (Handle)`	Close specified handle
`ControlLine (IntfHandle)`	Get bus line status from IEEE 488 or serial bus
`Disarm (IntfHandle, Condition)`	Disarm event handling for specified condition
`DmaChannel (IntfHandle, DmaChan)`	Specify DMA channel
`Enter (IntfHandle,Data)`	Read data from specified device
`EnterMore (IntfHandle,Data)`	Read data from specified device without forcing address
`EnterN (IntfHandle,Data,Count)`	Read count bytes from specified device
`EnterNMore (IntfHandle,Data,Count)`	Read count bytes without forcing address
`EnterX (DevHandle, Data, Count, ForceAddr, Term, Async,`	Read data adjusting all parameters

`CompStat)`	
`Error (Handle, Display)`	Control display of error messages
`FindListeners (IntfHandle, Prim, Listener, Limit)`	Find devices configurable to listen at specific address
`Finish (IntfHandle)`	Reassert ATN (see Resume)
`GetError (Handle, ErrText)`	Get error code and error text
`GetErrorList (DevHandles, ErrText, ErrHandle)`	Find device in error and identify
`Hello (IntfHandle, Message)`	Verify communication and get revision number
`IntLevel (IntfHandle,IntLev)`	Specify hardware interrupt level of I/O adapter
`IOAddress (IntfHandle, IOAddr)`	Specify I/O port base address of I/O adapter
`KeepDevice (DevHandle)`	Make specified external device permanent
`LightPen (IntfHandle, LightPen)`	Enable or disable detection of interrupts via light pen status
`Listen (IntfHandle, Prim, Sec)`	Send Listen Address
`Local (Handle)`	Unassert REN (IntfHandle) or issue GTL (DevHandle)
`LocalList (DevHandles)`	Issue GTL to devices in list
`Lol (IntfHandle)`	Issue LLO bus command
`MakeDevice (DevHandle, Name)`	Create identical copy of existing device
`MyListenAddr (IntfHandle)`	Send My Listen Address
`MyTalkAddr (IntfHandle)`	Send My Talk Address
`OnEvent (IntfHandle,Handler,Argument)`	Specify function to be called upon Armed event
`OepnName (Name)`	Open specified device and return device handle
`Output (DevHandle,Data)`	Send data to specified device
`OutputN (DevHandle,Data,Count)`	Send count bytes to specified device
`OutputMore (DevHandle,Data)`	Send count bytes to specified device without forcing address
`OutputNMore (DevHandle,Data,Count)`	Send count bytes without forcing address
`OutputX (DevHandle,Data,Count, LastForceAddr,Term,Async,CompStat)`	Send data to specified device adjusting all parameters
`PassControl (DevHandle)`	Allow Interface to give control to another controller on bus
`PPoll (IntfHandle)`	Perform IEEE 488 parallel poll operation
`PPollConfig (DevHandle,PPresponse)`	Configure Parallel Poll response of bus device
`PPollDisable (DevHandle)`	Disable Parallel Poll response of a bus driver
`PPollDisableList (DevHandles)`	Disable Parallel Poll response of several bus devices
`PPollUnconfig (IntfHandle)`	Disable the Parallel Poll response of all bus devices
`Remote (Handle)`	Assert REN if IntfHandle, address to Listen if DevHandle
`RemoteList (DevHandles)`	Address specified external devices to Listen
`RemoveDevice (DevHandle)`	Remove Driver488 device
`Request (IntfHandle, SPstatus)`	Request service from Active Controller by asserting SRQ
`Reset (IntfHandle)`	Provide warm start of interface, clear all error conditions
`Resume (IntfHandle,Monitor)`	Unassert ATN
`SendCmd (IntfHandle,Bytes,Length)`	Send command strings with ATN asserted
`SendData (DevHandle,Bytes,Length)`	Send command strings with ATN unasserted
`SendEoi (IntfHandle,Bytes,Length)`	Same as SendData with eoi on last byte
`SPoll (DevHandle)`	Serial Poll device
`SPoll (IntfHandle)`	Get SRQ state
`SPollList`	Serial Poll devices until parameters are met

`(DevHandles,SPResult,UntilFlag)`	
`Status (IntfHandle,StatusVal)`	Return details of state of the driver
`Stop (IntfHandle)`	Halt any asynchronous transfer that may be in progress
`SysController (IntfHandle,SysCont)`	Specify if interface is to be System Controller
`Talk (IntfHandle,Prim,Sec)`	Send specified Talk Address
`Term (Handle,TermP,TermType)`	Set terminators for interface or device
`TimeOut (Handle, Timeout)`	Set time that must elapse before time out error declared
`Trigger (Handle)`	Issue Group Execute Trigger
`TriggerList (DevHandles)`	Issue GET to devices in list
`UnListen (IntfHandle)`	Send the Unlisten (UNL) command
`UnTalk (IntfHandle)`	Send the Untalk (UNT) command
`Wait (IntfHandle)`	Wait until asynchronous transfer has completed

The Commands

To obtain a more detailed description of the command references for Driver488/SUB, turn to Chapter 15 “Command References” in this Section. The commands are presented in alphabetical order for ease of use.

Syntax Parameters

The symbol `*` (asterisk) refers to a Pointer.

Name	Type	Description
`Argument`	`void far *`	32-bit argument
`Async`	`bool`	Flag to indicate async transfer
`Bytes`	`unsigned char *`	Pointer to characters to transfer
`CompStat`	`int *`	Completion status from Driver
`Condition`	`ArmCondT`	Arm/Disarm bit mask
`Count`	`long`	Long count specifier
`Data`	`char far *`	Pointer to a character array
`DevHandle`	`DevHandleT`	External device handle
`DevHandles`	`DevHandleT *`	Pointer to array of handles
`Display`	`bool`	Error message display is ON or OFF
`DmaChan`	`int`	Hardware DMA channel
`ErrHandle`	`DevHandleT *`	Pointer to handle that caused error
`ErrText`	`char *`	Pointer to error text
`Flag`	`bool`	ON or OFF specifier
`ForceAddr`	`bool`	Force address flag
`Freq`	`int`	Clock frequency
`Handle`	`DevHandleT`	Either a DevHandle or an IntfHandle
`Handler`	`UserHandlerFP`	Pointer to OnEvent Handler
`IntLev`	`int`	Hardware Interrupt level
`IntfHandle`	`DevHandleT`	Interface handle
`Last`	`bool`	Terminator on last byte indicator
`Length`	`int`	Number of Bytes
`LightPen`	`bool`	Light Pen emulation is ON or OFF
`Limit`	`short`	Max number of listeners
`Listener`	`unsigned short *`	Pointer to listener list
`Message`	`char *`	Pointer to character array
`Monitor`	`bool`	Data monitor ON or OFF
`Name`	`char *`	Pointer to name string
`Ppresponse`	`int`	Configuration byte

`Prim`	`char`	IEEE 488 primary address
`SPResult`	`unsigned char *`	Array of SPOLL results
`Sec`	`char`	IEEE 488 secondary address
`SPstatus`	`int`	Service request status
`StatusVal`	`IeeeStatusT *`	Pointer to status structure
`SysCont`	`bool`	System Controller flag for IEEE 488 interface
`TermP`	`TermT *`	Pointer to terminator structure
`TermType`	`int`	Terminator type: TERMIN or TERMOUT
`Timeout`	`long`	Timeout value in milliseconds
`UntilFlag`	`char`	SpollList operating mode

Defined Constants

Bus Command Constants	
`bcUNT`	1
`bcUNL`	2
`bcMTA`	3
`bcMLA`	4
`bcTALK`	5
`bcLISTEN`	6

Miscellaneous Constants	
`IN`	1
`OUT`	2
`ON`	1
`OFF`	0
`ALL`	-1
`SAME`	-2
`WHILE_SRQ`	-2
`UNTIL_RSV`	-3
`TRUE`	1
`FALSE`	0
`MAXHANDLES`	50
`NOIEEEADRESS`	-1
`NODEVICE`	-1
`NONODE`	NULL
`TERMIN`	1
`TERMOUT`	2

Structure Definitions

```
typedef struct {
      bool   SC;
      bool   CA;
      uchar  Primaddr;
      uchar  Secaddr;
      bool   SRQ;
      bool   addrChange;
      bool   talker;
      bool   listener;
      bool   triggered;
      bool   cleared;
      bool   transfer;
      bool   byteIn;
      bool   byteOut;
} IeeeStatusT;
```

```
typedef struct {
      bool   EOI;
      int    Char;  bool
      EightBits;
      int    termChar[2];
} TermT;
```

14B. Driver488/SUB, QuickBASIC

Topics

Function Descriptions

Command	Description
`ioAbort% (IntfHandle%)`	Assert IFC
`ioAddress% (IntfHandle%,IOAddr%)`	Specify I/O port base address of I/O adapter
`ioArm% (IntfHandle%,Condition%)`	Arm OnEvent for specified event(s)
`ioAutoRemote% (IntfHandle%,Flag%)`	Assert REN on Output
`ioBuffered& (IntfHandle%)`	Return number of buffered bytes
`ioBusAddress% (Handle%,Prim%,Sec%)`	Set IEEE address of interface or device
`ioCheckListener% (IntfHandle%,Prim%, Sec%)`	Check for device at specified bus address
`ioClear% (Handle%)`	Issue Selected Device Clear (SDC) or Device Clear (DCL)
`ioClearList% (IntHandles%)`	Clear devices in list
`ioClockFrequency% (IntfHandle%, Freq%)`	Specify clock interface frequency
`ioClose% (Handle%)`	Close specified handle
`ioControlLine% (IntfHandle%)`	Get bus line status from IEEE 488 or serial bus
`ioDisarm% (IntfHandle%,Condition%)`	Disarm event handling for specified condition
`ioDmaChannel% (IntfHandle%,DmaChan%)`	Specify DMA channel
`ioEnter% (IntfHandle%,Data$)`	Read data from specified device
`ioEnterMore& (IntfHandle%,Data$)`	Read data from specified device without forcing address
`ioEnterN& (IntfHandle%,Data$,Count&)`	Read count bytes from specified device
`ioEnterNMore& (IntfHandle%,Data$,Count&)`	Read count bytes without forcing address
`ioEnterX& (DevHandle%,Data$,Count&, ForceAddr%,Term,Async%,CompStat%)`	Read data adjusting all parameters
`ioError% (Handle%,Display%)`	Control display of error messages
`ioFindListeners% (IntfHandle%, Prim%, Listener%,Limit%)`	Find devices configurable to listen at specific address
`ioFinish% (IntfHandle%)`	Reassert ATN (see Resume)
`ioGetError (Handle%,ErrText$)`	Get error code and error text
`ioGetErrorList% (DevHandles%(),ErrText$,ErrHandle%)`	Find device in error and identify
`ioHello% (IntfHandle%,Message$)`	Verify communication and get revision number
`ioIntLevel% (IntfHandle%,IntLev%)`	Specify hardware interrupt level of I/O adapter
`ioKeepDevice% (DevHandle%)`	Make specified external device permanent
`ioLightPen% (IntfHandle%,LightPen%)`	Enable or disable detection of interrupts via light pen status
`ioListen% (IntfHandle%,Prim%,Sec%)`	Send Listen Address

`ioLocal% (DevHandle%)`	Unassert REN (IntfHandle) or issue GTL (DevHandle)
`ioLocalList% (DevHandles%)`	Issue GTL to devices in list
`ioLol% (IntfHandle%)`	Issue LLO bus command
`ioMakeDevice% (DevHandle%,Name$)`	Create identical copy of existing device
`ioMyListenAddr% (IntfHandle%)`	Send My Listen Address
`ioMyTalkAddr% (IntfHandle%)`	Send My Talk Address
`ioOpenName% (Name$)`	Open specified device and return device handle
`ioOutput (DevHandle%,Data$)`	Send data to specified device
`ioOutputN (DevHandle%,Data$,Count&)`	Send count bytes to specified device
`ioOutputMore (DevHandle%,Data$)`	Send count bytes to specified device without forcing address
`ioOutputNMore (DevHandle%,Data$,Count&)`	Send count bytes without forcing address
`ioOutputX (DevHandle%,Data$,Count&, Last%,ForceAddr%,Term,Async%, CompStat%)`	Send data to specified device adjusting all parameters
`ioPassControl (DevHandle%)`	Allow Interface to give control to another controller on bus
`ioPPoll% (IntfHandle%)`	Perform IEEE 488 parallel poll operation
`ioPPollConfig% (DevHandle%,Ppresponse%)`	Configure Parallel Poll response of bus device
`ioPPollDisable% (DevHandle%)`	Disable Parallel Poll response of a bus driver
`ioPPollDisableList% (DevHandles%)`	Disable Parallel Poll response of several bus devices
`ioPPollUnconfig% (IntfHandle%)`	Disable the Parallel Poll response of all bus devices
`ioRemote% (DevHandle%)`	Assert REN if IntfHandle, address to Listen if DevHandle
`ioRemoteList% (DevHandle%)`	Address specified external devices to Listen
`ioRemoveDevice% (DevHandle%)`	Remove Driver488 device
`ioRequest% (IntfHandle%, Spstatus%)`	Request service from Active Controller by asserting SRQ
`ioReset% (IntfHandle%)`	Provide warm start of interface, clear all error conditions
`ioResume% (UntfHandle%,Monitor%)`	Unassert ATN
`ioSendCmd% (IntfHandle%,Bytes$,Length%)`	Send command strings with ATN asserted
`ioSendData% (DevHandle%,Bytes$,Length%)`	Send command strings with ATN unasserted
`ioSendEoi% (IntfHandle%,Bytes$,Length%)`	Same as SendData with EOI on last byte
`ioSPoll% (DevHandle%)`	Serial Poll device
`ioSPoll% (IntfHandle%)`	Get SRQ state
`ioSPollList% (DevHandles%(), SPResult%(),UntilFlag%)`	Serial Poll devices until parameters are met
`ioStatus% (IntfHandle%,StatusVal)`	Return details of state of the driver
`ioStop% (IntfHandle%)`	Halt any asynchronous transfer that may be in progress
`ioSysController% (IntfHandle%,SysCont%)`	Specify if interface is to be System Controller
`ioTalk% (IntfHandle,Prim%,Sec%)`	Send specified Talk Address
`ioTerm% (Handle%,TermP,TermType%)`	Set terminators for interface or device
`ioTimeOut% (Handle%,Timeout&)`	Set time that must elapse before time out error declared
`ioTrigger% (Handle%)`	Issue Group Execute Trigger

`ioTriggerList% (DevHandles%())`	Issue GET to devices in list
`ioUnListen% (IntfHandle%)`	Send the Unlisten (UNL) command
`ioUnTalk% (IntfHandle%)`	Send the Untalk (UNT) command
`ioWait% (IntfHandle%)`	Wait until asynchronous transfer has completed

The Commands

To obtain a more detailed description of the command references for Driver488/SUB, turn to Chapter 15 “Command References” in this Section. The commands are presented in alphabetical order for ease of use.

Syntax Parameters

Name	Type	Description
`Async%`	`integer`	Flag to indicate async transfer
`Bytes$`	`string`	String containing characters to transfer
`CompStat%`	`integer`	Completion status from Driver
`Condition%`	`integer`	Arm/Disarm bit mask
`Count&`	`long`	Long count specifier
`Data$`	`string`	Buffer used to send or receive data
`DevHandle%`	`integer`	External device handle
`DevHandles%()`	`integer array`	Array of handles
`Display%`	`integer`	Error message display is ON or OFF
`DmaChan%`	`integer`	Hardware DMA channel
`ErrHandle%`	`integer`	Handle that caused error
`ErrText$`	`string`	Buffer containing error text
`Flag%`	`integer`	ON or OFF specifier
`ForceAddr%`	`integer`	Force address flag
`Freq%`	`integer`	Clock frequency
`Handle%`	`integer`	Either a DevHandle or an IntfHandle
`IntLev%`	`integer`	Hardware Interrupt level
`IntfHandle%`	`integer`	Interface handle
`IOAddr%`	`integer`	I/O base address
`Last%`	`integer`	Terminator on last byte indicator
`Length%`	`integer`	Number of Bytes
`LightPen%`	`integer`	Light Pen emulation is ON or OFF
`Limit%`	`integer`	Max number of listeners
`Listener%()`	`integer array`	Array of FindListener results
`Message$`	`string`	Buffer used to receive data
`Monitor%`	`integer`	Data monitor ON or OFF
`Name$`	`string`	Name of external device or DOS device
`Ppresponse%`	`integer`	Configuration byte
`Prim%`	`integer`	IEEE 488 primary address
`SPResult%()`	`integer array`	Array of SPOLL results
`Sec%`	`integer`	IEEE 488 primary address
`Spstatus%`	`integer`	Service request status
`StatusVal`	`IeeeStatus`	Status structure
`SysCont%`	`integer`	System Controller flag for IEEE 488 interface
`TermP`	`terms`	Terms TYPE
`TermType%`	`integer`	Terminator type: TERMIN or TERMOUT
`Timeout&`	`integer`	Timeout value in milliseconds
`UntilFlag%`	`integer`	SpollList operating mode

Defined Constants

Arm/Disarm Bit Mask	
`acError`	&H800
`acSRQ`	&H400
`acPeripheral`	&H200
`acController`	&H100
`acTrigger`	&H080
`acClear`	&H040
`acTalk`	&H020
`acListen`	&H010
`acIdle`	&H008
`acByteIn`	&H004
`acByteOut`	&H002
`acChange`	&H001

Completion Status Bit Mask	
`ccCount`	&H001
`ccBuffer`	&H002
`ccTerm`	&H004
`ccEnd`	&H008
`ccChange`	&H0010
`ccStop`	&H0020
`ccDone`	&H4000
`ccError`	&H8000

ControlLine Bit Mask for IEEE 488 Bus	
`clEOI`	&H80
`clSRQ`	&H40
`clNRFD`	&H20
`clDAC`	&H10
`clDAV`	&H08
`clATN`	&H04

ControlLine Bit Mask for Serial Bus	
`clDSR`	&H20
`clRI`	&H10
`clDCD`	&H08
`clCTS`	&H04
`clDTR`	&H02
`clRTS`	&H01

Bus Commands	
`bcUNT`	1
`bcUNL`	2
`bcMTA`	3
`bcMLA`	4
`bcTALK`	5
`bcLISTEN`	6

Miscellaneous	
`IN`	1
`OUT`	2
`ON`	1
`OFF`	0
`ALL`	-1
`SAME`	-2
`WHILE_SRQ`	-2
`UNTIL_RSV`	-3
`TRUE`	1
`FALSE`	0
`MAXHANDLES`	50
`NOIEEEADRESS`	-1
`NODEVICE`	-1
`NONODE`	NULL
`TERMIN`	1
`TERMOUT`	2

Structure Definitions

```
TYPE IeeeStatus
       SC            AS integer
       CA            AS integer
       Primaddr      AS integer
       Secaddr       AS integer
       SRQ           AS integer
       addrChange    AS integer
       talker        AS integer
       listener      AS integer
       triggered     AS integer
       cleared       AS integer
       transfer      AS integer
       byteIn        AS integer
       byteOut       AS integer
END TYPE
```

```
TYPE terms
       EOI;          AS integer
       Char;         AS integer
       EightBits;    AS integer
       term1         AS integer
       term2         AS integer
END TYPE
```

14C. Driver488/SUB, Pascal

Topics

Function Descriptions

Command	Description
`ioAbort (IntfHandle)`	Assert IFC
`ioAddress (IntfHandle, IOAddr)`	Specify I/O port base address of I/O adapter
`ioArm (IntfHandle,Condition)`	Arm OnEvent for specified event(s)
`ioAutoRemote (IntfHandle,Flag)`	Assert REN on Output
`ioBuffered (IntfHandle)`	Return number of buffered bytes
`ioBusAddress (Handle,Prim,Sec)`	Set IEEE address of interface or device
`ioCheckListener (IntfHandle Prim, Sec)`	Check for device at specified bus address
`ioClockFrequency (IntfHandle, Freq)`	Specify clock interface frequency
`ioClose (Handle)`	Close specified handle
`ioControlLine (IntfHandle)`	Get bus line status from IEEE 488 or serial bus
`ioDisarm (IntfHandle, Condition)`	Disarm event handling for specified condition
`ioDmaChannel (IntfHandle, DmaChan)`	Specify DMA channel
`ioEnter (IntfHandle,Data)`	Read data from specified device
`ioEnterMore (IntfHandle,Data)`	Read data from specified device without forcing address
`ioEnterN (IntfHandle,Data,Count)`	Read count bytes from specified device
`ioEnterNMore (IntfHandle,Data,Count)`	Read count bytes without forcing address
`ioEnterX (DevHandle, Data, Count, ForceAddr, Term, Async, CompStat)`	Read data adjusting all parameters
`ioError (Handle, Display)`	Control display of error messages
`ioFindListeners (IntfHandle, Prim, Listener, Limit)`	Find devices configurable to listen at specific address
`ioFinish (IntfHandle)`	Reassert ATN (see Resume)
`ioGetError (Handle, ErrText)`	Get error code and error text
`ioGetErrorList (DevHandles, ErrText, ErrHandle)`	Find device in error and identify
`ioHello (IntfHandle, Message)`	Verify communication and get revision number
`ioIntLevel (IntfHandle,IOAddr)`	Specify hardware interrupt level of I/O adapter
`ioKeepDevice (DevHandle)`	Make specified external device permanent
`ioLightPen (IntfHandle, LightPen)`	Enable or disable detection of interrupts via light pen status
`ioListen (IntfHandle, Prim, Sec)`	Send Listen Address
`ioLocal (Handle)`	Unassert REN (IntfHandle) or issue GTL (DevHandle)
`ioLocalList (DevHandles)`	Issue GTL to devices in list
`ioLol (IntfHandle)`	Issue LLO bus command

`ioMakeDevice (DevHandle, Name)`	Create identical copy of existing device
`ioMyListenAddr (IntfHandle)`	Send My Listen Address
`ioMyTalkAddr (IntfHandle)`	Send My Talk Address
`ioOnEvent (IntfHandle,Handler,Argument)`	Specify function to be called upon Armed event
`ioOpenName (Name)`	Open specified device and return device handle
`ioOutput (DevHandle,Data)`	Send data to specified device
`ioOutputN (DevHandle,Data,Count)`	Send count bytes to specified device
`ioOutputMore (DevHandle,Data)`	Send count bytes to specified device without forcing address
`ioOutputNMore (DevHandle,Data,Count)`	Send count bytes without forcing address
`ioOutputX (DevHandle,Data,Count, Last ForceAddr, Term, Async, CompStat)`	Send data to specified device adjusting all parameters
`ioPassControl (DevHandle)`	Allow Interface to give control to another controller on bus
`ioPPoll (IntfHandle)`	Perform IEEE 488 parallel poll operation
`ioPPollConfig (DevHandle,PPresponse)`	Configure Parallel Poll response of bus device
`ioPPollDisable (DevHandle)`	Disable Parallel Poll response of a bus driver
`ioPPollDisableList (DevHandles)`	Disable Parallel Poll response of several bus devices
`ioPPollUnconfig (IntfHandle)`	Disable the Parallel Poll response of all bus devices
`ioRemote (Handle)`	Assert REN if IntfHandle, address to Listen if DevHandle
`ioRemoteList (DevHandle)`	Address specified external devices to Listen
`ioRemoveDevice (DevHandle)`	Remove Driver488 device
`ioRequest (IntfHandle, SPstatus)`	Request service from Active Controller by asserting SRQ
`ioReset (IntfHandle)`	Provide warm start of interface, clear all error conditions
`ioResume (UntfHandle,Monitor)`	Unassert ATN
`ioSendCmd (IntfHandle,Bytes,Length)`	Send command strings with ATN asserted
`ioSendData (DevHandle,Bytes,Length)`	Send command strings with ATN unasserted
`ioSendEoi (IntfHandle,Bytes,Length)`	Same as SendData with eoi on last byte
`ioSPoll (DevHandle)`	Serial Poll device
`ioSPoll (IntfHandle)`	Get SRQ state
`ioSPollList (DevHandles,SPResult,UntilFlag)`	Serial Poll devices until parameters are met
`ioStatus (IntfHandle,StatusVal)`	Return details of state of the driver
`ioStop (IntfHandle)`	Halt any asynchronous transfer that may be in progress
`ioSysController (IntfHandle,SysCont)`	Specify if interface is to be System Controller
`ioTalk (IntfHandle,Pri,Sec)`	Send specified Talk Address
`ioTerm (Handle,TermP,TermType)`	Set terminators for interface or device
`ioTimeOut (Handle,TermP,TermType)`	Set time that must elapse before time out error declared
`ioTrigger (Handle)`	Issue Group Execute Trigger
`ioTriggerList (DevHandles)`	Issue GET to devices in list
`ioUnListen (IntfHandle)`	Send the Unlisten (UNL) command
`ioUnTalk (IntfHandle)`	Send the Untalk (UNT) command
`ioWait (IntfHandle)`	Wait until asynchronous transfer has completed

The Commands

To obtain a more detailed description of the command references for Driver488/SUB, turn to Chapter 15 “Command References” in this Section. The commands are presented in alphabetical order for ease of use.

Syntax Parameters

Name	Type	Description
`Argument`	`var (untyped)`	32 bit argument
`Async`	`boolean`	Flag to indicate async transfer
`BuffString`	`string`	Buffer containing characters to transfer
`Bytes`	`var (untyped)`	Pointer to characters to transfer
`CompStat`	`var (untyped)`	Completion status from Driver
`Condition`	`integer`	Arm/Disarm bit mask
`Count`	`longint`	Long count specifier
`Data`	`var (untyped)`	Pointer to a character array
`DataString`	`var string`	
`DevHandle`	`integer`	External device handle
`DevHandles`	`DevPtr`	Pointer to array of handles
`Display`	`boolean`	Error message display is ON or OFF
`DmaChan`	`integer`	Hardware DMA channel
`ErrHandle`	`var integer`	Pointer to handle that caused error
`ErrText`	`var string`	Pointer to error text
`Flag`	`boolean`	ON or OFF specifier
`ForceAddr`	`boolean`	Force address flag
`Freq`	`integer`	Clock frequency
`Handle`	`integer`	Either a DevHandle or an IntfHandle
`Handler`	`HandlerProcPtr`	Pointer to OnEvent Handler
`IntLev`	`integer`	Hardware Interrupt level
`IntfHandle`	`integer`	Interface handle
`IOAddr`	`integer`	
`Last`	`boolean`	Terminator on last byte indicator
`Length`	`integer`	Number of Bytes
`LightPen`	`boolean`	Light Pen emulation is ON or OFF
`Limit`	`integer`	Max number of listeners
`Listener`	`var (untyped)`	Pointer to listener list
`Message`	`var string`	Pointer to character array
`Monitor`	`boolean`	Data monitor ON or OFF
`Name`	`string`	Pointer to name string
`Ppresponse`	`integer`	Configuration byte
`Prim`	`integer`	IEEE 488 primary address
`SPResult`	`var (untyped)`	Array of SPOLL results
`Sec`	`integer`	IEEE 488 primary address
`SPstatus`	`integer`	Service request status
`StatusVal`	`var (untyped)`	Pointer to status structure
`SysCont`	`boolean`	System Controller flag for IEEE 488 interface
`Term`	`var (untyped)`	Terminator structure
`TermType`	`integer`	Terminator type: TERMIN or TERMOUT
`Timeout`	`longint`	Timeout value in milliseconds
`UntilFlag`	`integer`	SpollList operating mode

Defined Constants

Arm/Disarm Bit Mask	
`acError`	$800
`acSRQ`	$400
`acPeripheral`	$200
`acController`	$100
`acTrigger`	$080
`acClear`	$040
`acTalk`	$020
`acListen`	$010
`acIdle`	$008
`acByteIn`	$004
`acByteOut`	$002
`acChange`	$001

ControlLine Bit Mask for Serial Bus	
`clDSR`	$20
`clRI`	$10
`clDCD`	$08
`clCTS`	$04
`clDTR`	$02
`clRTS`	$01

Bus Commands	
`bcUNT`	1
`bcUNL`	2
`bcMTA`	3
`bcMLA`	4
`bcTALK`	5
`bcLISTEN`	6

Completion Status Bit Mask	
`ccCount`	$0001
`ccBuffer`	$0002
`ccTerm`	$0004
`ccEnd`	$0008
`ccChange`	$0010
`ccStop`	$0020
`ccDone`	$4000
`ccError`	$8000

Miscellaneous Commands	
`IN`	1
`OUT`	2
`ON`	1
`OFF`	0
`ALL`	-1
`SAME`	-2
`WHILE_SRQ`	-2
`UNTIL_RSV`	-3
`TRUE`	1
`FALSE`	0
`MAXHANDLES`	50
`NOIEEEADRESS`	-1
`NODEVICE`	-1
`NONODE`	NULL
`TERMIN`	1
`TERMOUT`	2

ControlLine Bit Mask for IEEE 488 Bus	
`clEOI`	$80
`clSRQ`	$40
`clNRFD`	$20
`clDAC`	$10
`clDAV`	$08
`clATN`	$04

Structure Definitions

```
type
IeeeStatusRec = record
       SC            :boolean;
       CA            :boolean;
       Primaddr      :integer;
       Secaddr       :integer;
       SRQ           :boolean;
       addrChange    :boolean;
       talker        :boolean;
       listener      :boolean;
       triggered     :boolean;
       cleared       :boolean;
       transfer      :boolean;
       byteIn        :boolean;
       byteOut       :boolean;
end;
```

```
type
termrec = packed record
       EOI          :boolean;
       nChar        :integer;
       EightBits    :boolean;
       termChar     :termsvals;
end;
```

14D. Driver488/W31, C Languages

Topics

Function Descriptions

Command	Description
`Abort (IntfHandle)`	Assert IFC
`Arm (IntfHandle,Condition)`	Arm OnEvent for specified event(s)
`AutoRemote (IntfHandle,Flag)`	Assert REN on Output
`Buffered (IntfHandle)`	Return number of buffered bytes
`BusAddress (Handle,Prim,Sec)`	Set IEEE address of interface or device
`CheckListener (IntfHandle Prim, Sec)`	Check for device at specified bus address
`Clear (Handle)`	Issue Selected Device Clear (SDC) or Device Clear (DCL)
`ClearList (DevHandles)`	Clear devices in list
`Clock Frequency (IntfHandle, Freq)`	Specify clock interface frequency
`Close (Handle)`	Close specified handle
`ControlLine (IntfHandle)`	Get bus line status from IEEE 488 or serial bus
`Disarm (IntfHandle, Condition)`	Disarm event handling for specified condition
`DmaChannel (IntfHandle, DmaChan)`	Specify DMA channel
`Enter (IntfHandle,Data)`	Read data from specified device
`EnterMore (IntfHandle,Data)`	Read data from specified device without forcing address
`EnterN (IntfHandle,Data,Count)`	Read `count` bytes from specified device
`EnterNMore (IntfHandle,Data,Count)`	Read `count` bytes without forcing address
`EnterX (DevHandle, Data, Count, ForceAddr, Term, Async, CompStat)`	Read data adjusting all parameters
`Error (Handle, Display)`	Control display of error messages
`FindListeners (IntfHandle, Prim, Listener, Limit)`	Find devices configurable to listen at specific address
`Finish (IntfHandle)`	Reassert ATN (see Resume)
`GetError (Handle, ErrText)`	Get error code and error text
`GetErrorList (DevHandles, ErrText, ErrHandle)`	Find device in error and identify
`Hello (IntfHandle, Message)`	Verify communication and get revision number
`IntLevel (IntfHandle,IntLev)`	Specify hardware interrupt level of I/O adapter
`IOAddress (IntfHandle, IOAddr)`	Specify I/O port base address of I/O adapter
`KeepDevice (DevHandle)`	Make specified external device permanent
`LightPen (IntfHandle, LightPen)`	Enable or disable detection of interrupts via light pen status
`Listen (IntfHandle, Prim, Sec)`	Send Listen Address
`Local (Handle)`	Unassert REN (IntfHandle) or issue GTL (DevHandle)

`LocalList (DevHandles)`	Issue GTL to devices in list
`Lol (IntfHandle)`	Issue LLO bus command
`MakeDevice (DevHandle, Name)`	Create identical copy of existing device
`MyListenAddr (IntfHandle)`	Send My Listen Address
`MyTalkAddr (IntfHandle)`	Send My Talk Address
`OnEvent (IntfHandle,Handler,Argument)`	Specify function to be called upon Armed event
`OpenName (Name)`	Open specified device and return device handle
`Output (DevHandle,Data)`	Send data to specified device
`OutputN (DevHandle,Data,Count)`	Send `count` bytes to specified device
`OutputMore (DevHandle,Data)`	Send `count` bytes to specified device without forcing address
`OutputNMore (DevHandle,Data,Count)`	Send `count` bytes without forcing address
`OutputX (DevHandle,Data,Count, LastForceAddr, Term, Async, CompStat)`	Send data to specified device adjusting all parameters
`PassControl (DevHandle)`	Allow Interface to give control to another controller on bus
`PPoll (IntfHandle)`	Perform IEEE 488 parallel poll operation
`PPollConfig (DevHandle,PPresponse)`	Configure Parallel Poll response of bus device
`PPollDisable (DevHandle)`	Disable Parallel Poll response of a bus driver
`PPollDisableList (DevHandles)`	Disable Parallel Poll response of several bus devices
`PPollUnconfig (IntfHandle)`	Disable the Parallel Poll response of all bus devices
`Remote (Handle)`	Assert REN if IntfHandle, address to Listen if DevHandle
`RemoteList (DevHandles)`	Address specified external devices to Listen
`RemoveDevice (DevHandle)`	Remove Driver488 device
`Request (IntfHandle, SPstatus)`	Request service from Active Controller by asserting SRQ
`Reset (IntfHandle)`	Provide warm start of interface, clear all error conditions
`Resume (IntfHandle,Monitor)`	Unassert ATN
`SendCmd (IntfHandle,Bytes,Length)`	Send command strings with ATN asserted
`SendData (DevHandle,Bytes,Length)`	Send command strings with ATN unasserted
`SendEoi (IntfHandle,Bytes,Length)`	Same as SendData with EOI on last byte
`SPoll (DevHandle)`	Serial Poll device
`SPoll (IntfHandle)`	Get SRQ state
`SPollList (DevHandles,SPResult,UntilFlag)`	Serial Poll devices until parameters are met
`Status (IntfHandle,StatusVal)`	Return details of state of the driver
`Stop (IntfHandle)`	Halt any asynchronous transfer that may be in progress
`SysController (IntfHandle,SysCont)`	Specify if interface is to be System Controller
`Talk (IntfHandle,Prim,Sec)`	Send specified Talk Address
`Term (Handle,TermP,TermType)`	Set terminators for interface or device
`TimeOut (Handle, Timeout)`	Set time that must elapse before time out error declared
`Trigger (Handle)`	Issue Group Execute Trigger
`TriggerList (DevHandles)`	Issue GET to devices in list
`UnListen (IntfHandle)`	Send the Unlisten (UNL) command
`UnTalk (IntfHandle)`	Send the Untalk (UNT) command
`Wait (IntfHandle)`	Wait until asynchronous transfer has completed

The Commands

To obtain a more detailed description of the command references for Driver488/W31, turn to Chapter 15 “Command References” in this Section. The commands are presented in alphabetical order for ease of use.

Syntax Parameters

The symbol `*` (asterisk) refers to a Pointer.

Name	Type	Description
`Argument`	`void far *`	32 bit argument
`Async`	`bool`	Flag to indicate async transfer
`Bytes`	`unsigned char *`	Pointer to characters to transfer
`CompStat`	`int *`	Completion status from Driver
`Condition`	`ArmCondT`	Arm/Disarm bit mask
`Count`	`long`	Long count specifier
`Data`	`char far *`	Pointer to a character array
`DevHandle`	`DevHandleT`	External device handle
`DevHandles`	`DevHandleT *`	Pointer to array of handles
`Display`	`bool`	Error message display is ON or OFF
`DmaChan`	`int`	Hardware DMA channel
`ErrHandle`	`DevHandleT *`	Pointer to handle that caused error
`ErrText`	`char *`	Pointer to error text
`Flag`	`bool`	ON or OFF specifier
`ForceAddr`	`bool`	Force address flag
`Freq`	`int`	Clock frequency
`Handle`	`DevHandleT`	Either a DevHandle or an IntfHandle
`Handler`	`UserHandlerFP`	Pointer to OnEvent Handler
`IntLev`	`int`	Hardware Interrupt level
`IntfHandle`	`DevHandleT`	Interface handle
`Last`	`bool`	Terminator on last byte indicator
`Length`	`int`	Number of Bytes
`LightPen`	`bool`	Light Pen emulation is ON or OFF
`Limit`	`short`	Max number of listeners
`Listener`	`unsigned short *`	Pointer to listener list
`Message`	`char *`	Pointer to character array
`Monitor`	`bool`	Data monitor ON or OFF
`Name`	`char *`	Pointer to name string
`Ppresponse`	`int`	Configuration byte
`Prim`	`char`	IEEE 488 primary address
`SPResult`	`unsigned char *`	Array of SPOLL results
`Sec`	`char`	IEEE 488 secondary address
`SPstatus`	`int`	Service request status
`StatusVal`	`IeeeStatusT *`	Pointer to status structure
`SysCont`	`bool`	System Controller flag for IEEE 488 interface
`TermP`	`TermT *`	Pointer to terminator structure
`TermType`	`int`	Terminator type: TERMIN or TERMOUT
`Timeout`	`long`	Timeout value in milliseconds
`UntilFlag`	`char`	SpollList operating mode

Defined Constants

Bus Command Constants	
`bcUNT`	1
`bcUNL`	2
`bcMTA`	3
`bcMLA`	4
`bcTALK`	5
`bcLISTEN`	6

Miscellaneous Constants:	
`IN`	1
`OUT`	2
`ON`	1
`OFF`	0
`ALL`	-1
`SAME`	-2
`WHILE_SRQ`	-2
`UNTIL_RSV`	-3
`TRUE`	1
`FALSE`	0
`MAXHANDLES`	50
`NOIEEEADRESS`	-1
`NODEVICE`	-1
`NONODE`	NULL
`TERMIN`	1
`TERMOUT`	2

Structure Definitions

```
typedef struct {
       bool   SC;
       bool   CA;
       uchar  Primaddr;
       uchar  Secaddr;
       bool   SRQ;
       bool   addrChange;
       bool   talker;
       bool   listener;
       bool   triggered;
       bool   cleared;
       bool   transfer;
       bool   byteIn;
       bool   byteOut;
} IeeeStatusT;
```

```
typedef struct {
       bool   EOI;
       int    Char;  bool
       EightBits;
       int    termChar[2];
} TermT;
```

14E. Driver488/W31, Visual Basic

Topics

Function Descriptions

Command	**Description**
`Abort (IntfHandle)`	Assert IFC
`Arm (IntfHandle,Condition)`	Arm OnEvent for specified event(s)
`AutoRemote (IntfHandle,Flag)`	Assert REN on Output
`Buffered (IntfHandle)`	Return number of buffered bytes
`BusAddress (Handle,Prim,Sec)`	Set IEEE 488 address of interface or device
`CheckListener (IntfHandle Prim, Sec)`	Check for device at specified bus address
`Clear (Handle)`	See ioClear
`ClearList (ListFirstElement (0))`	Clear devices in list
`Clock Frequency (IntfHandle, Freq)`	Specify clock interface frequency
`Close (Handle)`	See ioClose
`ControlLine (IntfHandle)`	Get bus line status from IEEE 488 or serial bus
`Disarm (IntfHandle, Condition)`	Disarm event handling for specified condition
`DmaChannel (IntfHandle, DmaChan)`	Specify DMA channel
`Enter (IntfHandle,Data)`	See ioEnter
`EnterI (IntfHandle,Data)`	Read binary data from specified device
`EnterMore (IntfHandle,Data)`	Read data from specified device without forcing address
`EnterN (IntfHandle,Data,Count)`	Read `count` bytes from specified device
`EnterNI (IntfHandle,Data,Count)`	Read `count` bytes from specified device (binary)
`EnterNMore (IntfHandle,Data,Count)`	Read `count` bytes without forcing address
`EnterNMoreI (IntfHandle,Data,Count)`	Read `count` bytes without forcing address (binary)
`EnterXI(DevHandle, Data, Count, ForceAddr, Term, Async, CompStat)`	Read binary data adjusting all parameters
`Error (Handle, Display)`	See ioError
`FindListeners (IntfHandle, Prim, ListFirstElement (0), Limit)`	Find devices configurable to listen at specific address
`Finish (IntfHandle)`	Reassert ATN (see Resume)
`GetError (Handle, ByValErrText)`	Get error code and error text
`GetErrorList (ListFirstElement(0), ByValErrText, ErrHandle)`	Find device in error and identify
`Hello (IntfHandle, ByValMessage)`	Verify communication and get revision number
`IntLevel (IntfHandle,IntLev)`	Specify hardware interrupt level of I/O adapter
`IOAddress (IntfHandle, IOAddr)`	Specify I/O port base address of I/O adapter
`ioClear (Handle)`	Issue Selected Device Clear (SDC) or Device Clear (DCL)
`ioClose (Handle)`	Close specified handle

`ioEnter ()`	Read data from specified device
`ioError (Handle, Display)`	Control display of error messages
`ioLocal (Handle)`	Unassert REN (IntfHandle) or issue GTL (DevHandle)
`ioOutput (DevHandle, Data)`	Send data to specified device
`ioReset (IntfHandle)`	Provide warm start of interface, clear all error conditions
`ioResume (IntfHandle, Monitor)`	Unassert ATN
`ioStop (IntfHandle)`	Halt any asynchronous transfer that may be in progress
`ioWait (IntfHandle)`	Wait until asynchronous transfer has completed
`KeepDevice (DevHandle)`	Make specified external device permanent
`Listen (IntfHandle, Prim, Sec)`	Send Listen Address
`Local (Handle)`	See ioLocal
`LocalList (ListFirstElement)`	Issue GTL to devices in list
`Lol (IntfHandle)`	Issue LLO bus command
`MakeDevice (DevHandle, ByValName)`	Create identical copy of existing device
`MyListenAddr (IntfHandle)`	Send My Listen Address
`MyTalkAddr (IntfHandle)`	Send My Talk Address
`OpenName (ByValName)`	Open specified device and return device handle
`Output (DevHandle,Data)`	See ioOutput
`OutputI (DevHandle,Data)`	Send binary data to the specified device
`OutputN (DevHandle,Data,Count)`	Send `count` bytes to specified device
`OutputNI (DevHandle,Data,Count)`	Send `count` bytes to specified device (Binary)
`OutputMore (DevHandle,Data)`	Send `count` bytes to specified device without forcing address
`OutputNMore (DevHandle,Data,Count)`	Send `count` bytes without forcing address
`OutputNMoreI (DevHandle,Data,Count)`	Send `count` bytes without forcing address (Binary)
`OutputX (DevHandle,Data,Count, LastForceAddr, Term, Async, CompStat)`	Send data to specified device adjusting all parameters
`OutputXI (DevHandle,Data,Count, LastForceAddr, Term, Async, CompStat)`	Send binary data to specified device adjusting all parameters
`PassControl (DevHandle)`	Allow Interface to give control to another controller on bus
`PPoll (IntfHandle)`	Perform IEEE 488 parallel poll operation
`PPollConfig (DevHandle,PPresponse)`	Configure Parallel Poll response of bus device
`PPollDisable (DevHandle)`	Disable Parallel Poll response of a bus driver
`PPollDisableList (ListFirstElement (0))`	Disable Parallel Poll response of several bus devices
`PPollUnconfig (IntfHandle)`	Disable the Parallel Poll response of all bus devices
`Remote (Handle)`	Assert REN if IntfHandle, address to Listen if DevHandle
`RemoteList (ListFirstElement (0))`	Address specified external devices to Listen
`RemoveDevice (DevHandle)`	Remove Driver488 device
`Request (IntfHandle, SPstatus)`	Request service from Active Controller by asserting SRQ
`Reset (IntfHandle)`	See ioReset
`Resume (IntfHandle,Monitor)`	See ioResume
`SendCmd (IntfHandle,Bytes,Length)`	Send command strings with ATN asserted
`SendData (DevHandle,Bytes,Length)`	Send command strings with ATN unasserted
`SendEoi (IntfHandle,Bytes,Length)`	Same as SendData with EOI on last byte
`SPoll (DevHandle)`	Serial Poll device

`SPoll (IntfHandle)`	Get SRQ state
`SPollList (ListFirstElement(0), ResultFirstElement(0),UntilFlag )`	Serial Poll devices until parameters are met
`Status (IntfHandle,StatusVal)`	Return details of state of the driver
`Stop (IntfHandle)`	See ioStop
`SysController (IntfHandle,SysCont)`	Specify if interface is to be System Controller
`Talk (IntfHandle,Prim,Sec)`	Send specified Talk Address
`Term (Handle,TermVal,TermType)`	Set terminators for interface or device
`TimeOut (Handle, Timeout)`	Set time that must elapse before time out error declared
`Trigger (Handle)`	Issue Group Execute Trigger
`TriggerList (ListFirstElement (0))`	Issue GET to devices in list
`UnListen (IntfHandle)`	Send the Unlisten (UNL) command
`UnTalk (IntfHandle)`	Send the Untalk (UNT) command
`Wait (IntfHandle)`	See ioWait

The Commands

To obtain a more detailed description of the command references for Driver488/W31, turn to Chapter 15 “Command References” in this Section. The commands are presented in alphabetical order for ease of use.

Syntax Parameters

Name	**Type**	**Description**
`Async`	`integer`	Flag to indicate async transfer
`Bytes`	`string`	String containing characters to transfer
`ByVal ErrText`	`string`	Buffer containing error text
`ByVal Message`	`string`	Buffer used to receive Hello message
`ByVal Name`	`string`	Name of external device or DOS device
`CompStat`	`integer`	Completion status from Driver
`Count`	`long`	Long count specifier
`Data`	`string`	Buffer used to send or receive data
`DevHandle`	`integer`	External device handle
`Display`	`integer`	Error message display is TURN ON or TURN OFF
`DmaChan`	`integer`	Hardware DMA channel
`ErrHandle`	`integer`	Handle that caused error
`Flag`	`integer`	ON or OFF specifier
`ForceAddr`	`integer`	Force address flag
`Freq`	`integer`	Clock frequency
`Handle`	`integer`	Either a DevHandle or an IntfHandle
`IntLev`	`integer`	Hardware Interrupt level
`IntfHandle`	`integer`	Interface handle
`IOAddr`	`integer`	I/O base address
`Last`	`integer`	Terminator on last byte indicator
`Length`	`integer`	Number of Bytes
`Limit`	`integer`	Max number of listeners
`ListFirstElement(0)`	`integer array`	First element of the array of handles
`Monitor`	`integer`	Data monitor ON or OFF
`PPresponse`	`integer`	Configuration byte
`Prim`	`integer`	IEEE 488 primary address
`ResultFirstElement(0)`	`integer`	First element of the array of results
`Sec`	`integer`	IEEE 488 secondary address

`SPstatus`	`integer`	Service request status
`StatusVal`	`IeeeStatus`	Status TYPE
`TermType`	`integer`	Terminator type: TERMIN or TERMOUT
`TermVal`	`terms`	Terminator TYPE
`Timeout`	`integer`	Timeout value in milliseconds
`UntilFlag`	`integer`	SpollList operating mode

Defined Constants

Completion Status Bit Mask	
`ccCount`	&H0001
`ccBuffer`	&H0002
`ccTerm`	&H0004
`ccEnd`	&H0008
`ccChange`	&H0010
`ccStop`	&H0020
`ccDone`	&H4000
`ccError`	&H8000

ControlLine Bit Mask for IEEE 488 Bus	
`clEOI`	&H80
`clSRQ`	&H40
`clNRFD`	&H20
`clNDAC`	&H10
`clDAV`	&H08
`clATN`	&H04

ControlLine Bit Mask for Serial Bus	
`clDSR`	&H20
`clRI`	&H10
`clDCD`	&H08
`clCTS`	&H04
`clDTR`	&H02
`clRTS`	&H01

Miscellaneous Commands	
`TURNON`	1
`TURNOFF`	2
`ALL`	-1
`WHILESRQ`	-2
`UNTILRSV`	-3
`NOIEEEADRESS`	-1
`NODEVICE%`	-1
`TERMIN`	1
`TERMOUT`	2

Bus Commands	
`bcUNT`	1
`bcUNL`	2
`bcMTA`	3
`bcMLA`	4
`bcTALK`	5
`bcLISTEN`	6

Structure Definitions

```
TYPE IeeeStatus
       SC             AS Integer
       CA             AS Integer
       Primaddr       AS Integer
       Secaddr        AS Integer
       SRQ            AS Integer
       addrChange     AS Integer
       talker         AS Integer
       listener       AS Integer
       triggered      AS Integer
       cleared        AS Integer
       transfer       AS Integer
       byteIn         AS Integer
       byteOut        AS Integer
END TYPE
```

```
TYPE Terms
       EOI            AS Integer
       nChar          AS Integer
       EightBits      AS Integer
       term1          AS Integer
       term2          AS Integer
END TYPE
```

15. Command References

Sub-Chapters

15A. Driver488/DRV Commands

This Sub-Chapter contains the command references for Driver488/DRV, *using the QuickBASIC language*. The commands are presented in alphabetical order on the following pages for ease of use. For more information on the format of the command descriptions, turn to the Sub-Chapter "Command Descriptions" of Chapter 8.

Bus Management Commands	Page
ABORT	III-283
AUTO REMOTE	III-284
CHECK LISTENER	III-285
CONTROL LINE	III-286
FIND LISTENERS	III-292
PASS CONTROL	III-301
PPOLL CONFIG or PPC	III-301
PPOLL DISABLE or PPD	III-302
PPOLL UNCONFIG or PPU	III-302
REQUEST	III-303
RESET	III-304

Instrument Management Commands	Page
CLEAR	III-285
LOCAL	III-296
LOCAL LOCKOUT or LOL	III-296
REMOTE	III-302
TRIGGER	III-310

Device Management Commands	Page
BUS ADDRESS	III-284
KEEP DEVICE	III-295
KEEP DOS NAME	III-295
MAKE DEVICE	III-297
MAKE DOS NAME	III-297
REMOVE DEVICE	III-303
REMOVE DOS NAME	III-303

Device I/O Commands	Page
ENTER (Controller Mode)	III-287
ENTER # count BUFFER (Controller)	III-288
ENTER (Peripheral Mode)	III-288
ENTER # count BUFFER (Peripheral)	III-289
OUTPUT (Controller Mode)	III-297
OUTPUT # count BUFFER (Control.)	III-298
OUTPUT (Peripheral Mode)	III-298
OUTPUT # count BUFFER (Periph.)	III-300
PPOLL	III-301
SPOLL	III-306
SPOLLLIST	III-307

Low-Level Bus Commands	Page
SEND	III-305

Event Handling Commands	Page
ARM	III-283
DISARM	III-286

I/O Management Commands	Page
BUFFERED	III-284
FINISH	III-293
RESUME	III-304
STOP	III-309
WAIT	III-311

Interface Management Commands	Page
CLOCK FREQUENCY	III-285
DMA CHANNEL	III-287
EOL	III-290
INT LEVEL	III-293
IO ADDRESS	III-293
SYS CONTROLLER	III-309
TERM	III-309
TIME OUT	III-310

Error Management Commands	Page
ERROR	III-291
FILL	III-291

Miscellaneous Commands	Page
HELLO	III-293
IOCTL (BASIC Statement)	III-294
IOCTL$ (BASIC Statement)	III-294
LIGHT PEN	III-296
STATUS	III-307

ABORT

SYNTAX	`ABORT[addr]`
RESPONSE	`None`
MODE	`SC` or `*SC•CA`
BUS STATES	`IFC, *IFC (SC mode)`
	`ATN, MTA (*SC•CA mode)`
SEE ALSO	`SYS CONTROLLER`
EXAMPLE	`PRINT#1,"ABORT"`

As the System Controller (**SC**), whether Driver488 is the Active Controller or not, the **ABORT** command causes the Interface Clear (**IFC**) bus management line to be asserted for at least 500 microseconds. By asserting **IFC**, Driver488 regains control of the bus even if one of the devices has locked it up during a data transfer. Asserting **IFC** also makes Driver488 the Active Controller. If a Non System Controller was the Active Controller then it is forced to relinquish control to Driver488. **ABORT** forces all IEEE 488 device interfaces into a quiescent state.

If Driver488 is a Non System Controller in the Active Controller state (***SC•CA**), it asserts attention (**ATN**), which stops any bus transactions, and then sends its Talk address to "Untalk" any other Talkers on the bus. It does not (and cannot) assert **IFC**.

ARM

SYNTAX	`ARM interrupt [[,]interrupt...]`	
RESPONSE	`None`	
MODE	`Any`	
BUS STATES	`None`	
SEE ALSO	`DISARM, LIGHT PEN; OnEvent (Sub-Chapter 15B)`	
EXAMPLE	`100 ON PEN GOSUB 1000`	Set up service routine.
	`110 PEN ON`	Enable interrupt polling.
	`PRINT#1,"ARMSRQ"`	Detect Service Request
	`1000 PRINT#1,"SPOLL16"`	Get Serial Poll status from
	`1010 INPUT#2,STATUSBYTE`	device and act accordingly.
	`1999 RETURN`	Done with interrupt.

The following **ARM** conditions are supported:

Condition	Description
`SRQ`	The Service Request bus line is asserted.
`Peripheral`	An addressed status change has occurred and the interface is a Peripheral.
`Controller`	An addressed status change has occurred and the interface is an Active Controller.
`Trigger`	The interface has received a device **Trigger** command.
`Clear`	The interface has received a device **Clear** command.
`Talk`	An addressed status change has occurred and the interface is a Talker.
`Listen`	An addressed status change has occurred and the interface is a Listener.
`Idle`	An addressed status change has occurred and the interface is neither a Talker nor a Listener.
`ByteIn`	The interface has received a data byte.
`ByteOut`	The interface has been configured to output a data byte.
`Error`	A Driver488 error has occurred.
`Change`	The interface has changed its addressed state. The Controller/Peripheral or Talker/Listener/Idle states of the interface have changed.

The **ARM** command allows Driver488 to signal to the user specified function when one or more of the specified conditions occurs. **ARM** sets a flag corresponding to each implementation of the conditions indicated by the user.

Once an interrupt is **`ARM`**ed, it remains **`ARM`**ed until it is **`DISARM`**ed, or until Driver488 is reset. BASIC automatically suppresses light pen interrupt detection during the execution of an interrupt service routine, so the interrupt service routine is never re-entrantly invoked. In languages that explicitly poll the light pen status, polling should not be done during the interrupt service routine.

AUTO REMOTE

SYNTAX	`AUTO REMOTE [{ON|OFF}]`
RESPONSE	`None`
MODE	`SC`
BUS STATES	`None`
SEE ALSO	`LOCAL, REMOTE, ENTER, OUTPUT`
EXAMPLE	`PRINT#1,"AUTO REMOTE ON"`

The **`AUTO REMOTE`** command enables or disables the automatic assertion of the Remote Enable (**`REN`**) line by **`OUTPUT`**. When **`AUTO REMOTE`** is enabled, **`OUTPUT`** automatically asserts **`REN`** before transferring any data. When **`AUTO REMOTE`** is disabled, there is no change to the **`REN`** line. **`AUTO REMOTE`** is on by default.

BUFFERED

SYNTAX	`BUFFERED`
RESPONSE	Integer from 0 to 1,048,575 (or 2^{20}-1)
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`ENTER, OUTPUT`

EXAMPLE	`PRINT#1,"ENTER16#1024 BUFFER &H1000:0 EOI"`
	`PRINT#1,"BUFFERED"`
	`INPUT#2,N`
	`PRINT N,"bytes were actually received."`

The **`BUFFERED`** command returns the number of characters transferred by the latest **`ENTER`**, **`OUTPUT`**, **`SEND DATA`**, or **`SEND EOI`** command. If a **`CONTINUE`** transfer is in progress, then the result is the number of characters that have been transferred at the moment the command is issued. This command is most often used after an **`ENTER #count BUFFER`** term to determine if the full number of characters was received, or if the transfer terminated upon detection of **`TERM`**. It is also used to find out how many characters have currently been sent during an asynchronous DMA transfer.

BUS ADDRESS

SYNTAX	`BUS ADDRESS [name] prim-addr[sec-addr]`
	`name` is the name of an external device. If **`name`** is not specified, then **`BUS ADDRESS`** sets the bus address of the interface.
	`primary` is the IEEE 488 bus primary address of the specified device.
	`secondary` is the IEEE 488 bus secondary address of the specified device.
RESPONSE	`None`
MODE	`Any`
BUS STATE	`None`
SEE ALSO	`MakeDevice`
EXAMPLE	`PRINT#1, "BUS ADDRESS DMM 1400"`

The **`BUS ADDRESS`** command sets the IEEE 488 bus address of the IEEE 488 hardware interface or an external device. Every IEEE 488 bus device has an address that must be unique within any single IEEE 488 bus system. The default IEEE 488 bus address for Driver488 is **`21`**, but this may be changed if it conflicts with some other device.

CHECK LISTENER

SYNTAX	`CHECK LISTENER pri-addr[sec-addr]`
	`pri-addr` is a primary device address in the range `0` to `30`.
	`Sec-addr` is an optional two-digit secondary device address in the range `00` to `31`.
RESPONSE	`1 if listener found`
	`0 if listener not found`
MODE	`CA`
BUS STATES	`ATN•MTA, UNL, LAG, (check for NDAC asserted)`
SEE ALSO	`FIND LISTENER, BUS ADDRESS`

EXAMPLE	`PRINT#1”CHECKLISTENER 1501”`
	`INPUT#2,N`
	`IF N=1 THEN PRINT “LISTENER FOUND”`
	`IF N=0 THEN PRINT “LISTENER NOT FOUND”`

The **`CHECK LISTENER`** command checks for the existence of a device on the IEEE 488 bus at the specified address.

CLEAR

SYNTAX	`CLEAR [addr[,addr…]]`	
	`addr` is a device address (primary with optional secondary) or an external device name.	
RESPONSE	`None`	
MODE	`CA`	
BUS STATES	`ATN•DCL (all devices)`	
	`ATN•UNL, MTA, LAG, SDC (selected devices)`	
SEE ALSO	`RESET`	
EXAMPLES	`PRINT#1,CLEAR”`	Issue a Device Clear to all devices.
	`PRINT#1,”CLEAR12,18”`	Issue a Selected Device Clear to devices 12 and 18.
	`PRINT#1,”CLEAR DMM”`	Issue a Selected Device Clear to the device DMM.

The **`CLEAR`** command causes the Device Clear (**`DCL`**) bus command to be issued by Driver488. If the optional addresses are included, the Selected Device Clear (**`SDC`**) command is issued to all specified devices. IEEE 488 bus devices that receive a Device Clear or Selected Device Clear command normally reset to their power-on state.

CLOCK FREQUENCY

SYNTAX	`[CLOCK]FREQUENCY frequency`
	`frequency` is the actual clock rate in megahertz rounded up to the nearest whole number of megahertz.
RESPONSE	`None`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`RESET`
EXAMPLE	`PRINT#1, “CLOCK FREQUENCY 8”`

The **`CLOCK FREQUENCY`** command specifies the IEEE 488 adapter internal clock frequency. The clock frequency depends upon the design and jumper settings of the interface board. The specified clock frequency must be the actual clock rate in megahertz rounded up to the nearest whole number of megahertz. For example, the MP488 and MP488CT boards use a fixed clock frequency of 8 MHz.

CONTROL LINE

SYNTAX	`CONTROL LINE`
RESPONSE	`Bit-mapped number from 0 to 255 representing the state of the control lines.`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`TIME OUT`
EXAMPLE	`PRINT#1,"CONTROL LINE"` `INPUT#2,"CL"`

The `CONTROL LINE` command may be used on either IEEE 488 devices or Serial devices. If the device specified is an IEEE 488 device, this command returns the status of the IEEE 488 bus control lines as an 8-bit unsigned value (bits 2 and 1 are reserved for future use), as shown below:

8	7	6	5	4	3	2	1
`EOI`	`SRQ`	`NRFD`	`NDAC`	`DAV`	`ATN`	`0`	`0`

If the device refers to a Serial device, this command returns the status of the Serial port control lines as an 8-bit unsigned value (bits 8 and 7 are reserved for future use), as shown below:

8	7	6	5	4	3	2	1
`0`	`0`	`DSR`	`RI`	`DCD`	`CTS`	`DTR`	`RTS`

A fuller description of the above bus line abbreviations are provided below:

Bus State	**Bus Lines**	**Data Transfer (DIO) Lines**							
		8	**7**	**6**	**5**	**4**	**3**	**2**	**1**
	IEEE 488 Interface								
`ATN`	Attention (&H04)	0	0	0	0	0	1	0	0
`EOI`	End-Or-Identify (&H80)	1	0	0	0	0	0	0	0
`SRQ`	Service Request (&H40)	0	1	0	0	0	0	0	0
`DAV`	Data Valid (&H08)	0	0	0	0	1	0	0	0
`NDAC`	Not Data Accepted (&H10)	0	0	0	1	0	0	0	0
`NRFD`	Not Ready For Data (&H20)	0	0	1	0	0	0	0	0
	Serial Interface								
`DTR`	Data Terminal Ready (&H02)	0	0	0	0	0	0	1	0
`RI`	Ring Indicator (&H10)	0	0	0	1	0	0	0	0
`RTS`	Request To Send (&H01)	0	0	0	0	0	0	0	1
`CTS`	Clear To Send (&H04)	0	0	0	0	0	1	0	0
`DCD`	Data Carrier Detect (&H08)	0	0	0	0	1	0	0	0
`DSR`	Data Set Ready (&H20)	0	0	1	0	0	0	0	0

DISARM

SYNTAX	`DISARM[interrupt[,interrupt…]]`	
	`interrupt` is one of the following events: `SRQ`, `Peripheral`, `Controller`, `Trigger`, `Clear`, `Talk`, `Listen`, `Idle`, `Bytein`, `Byteout`, or `Change`.	
RESPONSE	`None`	
MODE	`Any`	
BUS STATES	`None`	
SEE ALSO	`ARM, LIGHT PEN; OnEvent (Sub-Chapter 15B)`	
EXAMPLES	`PRINT#1,"DISARM"`	Disable all interrupts
	`PRINT#1,"DISARM SRQ"`	Do not respond to SRQ

The `DISARM` command prevents Driver488 from setting the light pen status or invoking an event handle and interrupting the computer system, even when the specified conditions occur. The user's program can still check for the conditions by using the **`STATUS`** command. If the **`DISARM`** command is invoked without specifying any interrupts, then all interrupts are disabled. The **`ARM`** command may be used to re-enable interrupt detection.

DMA CHANNEL

SYNTAX	`DMA CHANNEL {channel|NONE}`
	`channel` is the DMA channel to be used by the I/O adapter.
RESPONSE	`None`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`INT LEVEL, TIME OUT`
EXAMPLE	`PRINT#1,"DMA CHANNEL 5"`

The **`DMA CHANNEL`** command specifies which DMA channel, if any, is to be used by the I/O interface card. The PC has four DMA channels, but channel **`0`** is used for memory refresh and is not available for peripheral data transfer. Channel **`2`** is usually used by the floppy-disk controller and is also unavailable. Channel **`3`** is used by the hard disk controller in PCs, but is usually not used in AT compatible machines. So, channel **`1`** (and possibly channel **`3`**) is available for DMA transfers. The AT compatible computers have three 16-bit DMA channels: **`5`**, **`6`**, and **`7`**. The MP488CT can use these channels for high speed transfer. The **`DMA CHANNEL`** value must match the hardware switch settings on the I/O adapter card.

ENTER (Controller Mode)

SYNTAX	`ENTER[addr][;][#count][;][term][term][EOI]`	
	`addr` is a device address (primary with optional secondary) or external device name.	
	`count` is the number of characters to read.	
	`Term` and `EOI` override the normal bus input terminator.	
RESPONSE	`Device-dependent data. If count is specified, then the exact count of characters is returned without EOL being appended. If not, the response ends when the input terminator is detected and EOL is appended to the returned data.`	
MODE	`CA`	
BUS STATES	`ATN•UNL, MLA,TAG, *ATN, data   (With addr)`	
	`*ATN, data   (Without addr)`	
SEE ALSO	`OUTPUT, TERM, EOL, BUFFERED`	
EXAMPLES	`PRINT#1,"ENTER16"` `INPUT#2,A$`	Read data from device 16
	`PRINT#1,"ENTER16"LINE` `INPUT#2,A$`	Read an entire line of data from device 16 even if it contains commas or other punctuations
	`PRINT#1,"ENTER16;CR"` `INPUT#2,A$`	Read data from device 16 until CR is detected
	`PRINT#1,"ENTER16$000"` `INPUT#2,A$`	Read data until a NULL is detected
	`PRINT#1,"ENTER16LFEOI"` `INPUT#2,A$`	Read data until LF or EOI is detected.
	`PRINT#1,"ENTER0702` `INPUT#2,A$`	Read data from device 7
	`PRINT#1,"ENTER12#5"` `A$=INPUT$(5,#2)`	Read 5 bytes from device 12. INPUT$ returns 5 bytes from file #2
	`PRINT#1,"ENTER#20"` `A$=INPUT$(20,#2)`	Read 20 more bytes. INPUT$ returns 20 bytes from file #2
	`PRINT#1,"ENTER DMM"` `INPUT#2,VOLTAGE`	Read data from device DMM
	`PRINT#1,"ENTER COM1"` `INPUT#2,A$`	Read data from device COM1

The **`ENTER`** command reads data from the I/O adapter. If a device address (with optional secondary address) or name is specified, then Driver488 is addressed to Listen, and that device is addressed to Talk. If no address is specified, then Driver488 must already be configured to receive data, either as a result of an immediately preceding **`ENTER`** command, or as a result of one of the **`SEND`** commands. If the character count **`count`** is specified, then that exact number of characters is read from the device. Otherwise, **`ENTER`** terminates reception on detection of the input terminator, that may be overridden by specifying the terminator in the **`ENTER`** command. The received terminator is then replaced with the **`EOL IN`** terminator before being returned to the user's program.

ENTER (Peripheral Mode)

SYNTAX	`ENTER[;][#count][;][term][term][EOI]`	
	`count` is the number of characters to read.	
	`Term` and `EOI` override the normal bus input terminator.	
RESPONSE	`Device-dependent data. If count is specified, then exactly count characters are returned without EOL being appended. Otherwise the response ends when the input terminator is detected at which time EOL is appended to the returned data.`	
MODE	`*CA`	
BUS STATES	`Determined by the Controller`	
SEE ALSO	`OUTPUT, TERM, EOL, BUFFERED`	

EXAMPLES	`PRINT#1,"ENTER"`
	`INPUT#2,A$`
		Read data into A$ until the default bus input terminator is detected

	`PRINT#1,"ENTER CR"`
	`INPUT#2,A$`
		Read data until CR is detected

	`PRINT#1,"ENTER$00"`
	`INPUT#2,A$`
		Read data until a NULL is detected

	`PRINT#1,"ENTER LFEOI"`
	`INPUT#2,A$`
		Read data until LF or EOI is detected

	`PRINT#1,"ENTER#10"`
	`A$=INPUT$(10,#2)`
		Read 10 bytes. INPUT$ returns 10 bytes from file #2

In Peripheral mode, the **`ENTER`** command receives data from the I/O adapter under control of the Active Controller. The Active Controller must put Driver488 into the **`Listen`** state and configure some bus device to provide Driver488 with data. The **`Listen`** state can be checked with the **`STATUS`** command, or can cause an interrupt with the **`ARM`** command. A time-out error occurs (if enabled) if Driver488 does not receive a data byte within the time out period after issuing the **`ENTER`** command.

ENTER #count BUFFER (Controller Mode)

SYNTAX	`ENTER[addr][;]#count[;]BUFFER buf-addr [CONTINUE] [term] [term][EOI]`
	`addr` is a device address (primary with optional secondary) or external device name.
	`count` is the number of characters to read.
	`CONTINUE` specifies asynchronous transmission.
	`Buf-addr` is the memory buffer address.
	`Term` and `EOI` override the normal bus input terminators.
RESPONSE	`None, returned data is placed directly into the specified memory buffer.`
MODE	`CA`
BUS STATES	`ATN•UNL, MLA, TAG, *ATN, data   (With addr)`
	`*ATN, data   (Without addr)`
SEE ALSO	`OUTPUT, TERM, EOL, BUFFERED`
EXAMPLES	`See next page.`

EXAMPLES	`PRINT#1,"ENTER16#100 BUFFER &H2000:0"`	Read 100 characters into memory at &H20000.
	`PRINT#1, "ENTER16#100 BUFFER &H20100 EOI"`	Read 100 characters, or until EOI is detected into memory at absolute location 20100.
	`PRINT#1,"BUFFERED"` `INPUT#2,N`	
	`PRINT#1, "ENTER16#100 BUFFER 262144 CONTINUE"`	Read 100 characters as before, but allow the program to continue while the transfer is taking place.
	`PRINT#1, "WAIT"`	Wait until the transfer has completed.
	`PRINT#1, "ENTER16#100 BUFFER 262144 CONTINUE EOI"`	Read 100 characters as before, but stop if the EOI (end or identify) signal is encountered.
	`PRINT#1,"WAIT"`	Wait until the transfer has completed.
	`PRINT#1,"BUFFERED"` `INPUT#2,NBUFFERED`	Get the number of characters actually read.

The **ENTER #count BUFFER** command reads data from the I/O adapter into a user-supplied memory region. If a device address (with optional secondary address) or name is specified, Driver488 is addressed to Listen, and that device is addressed to Talk. If no address is specified, Driver488 must already be configured to receive data, either as a result of an immediately preceding **ENTER** command, or as a result of one of the **SEND** commands.

The character count **count** must be specified and is the maximum number of characters that is transferred. **ENTER #count BUFFER** does not detect the input terminator unless it is explicitly specified in the command. Otherwise the specified number of characters is received. The number of characters actually received can be checked with the **BUFFERED** command. The terminator characters, if received, are placed into the memory buffer.

If **CONTINUE** is specified, Driver488 returns control to the user's program as soon as possible, without waiting for the transfer to be completed. It does, however, wait for the first byte to check for time-out unless a time-out value of **0** had been specified by a **TIMEOUT** command. Because of hardware limitations, the **CONTINUE** may not return until a substantial portion of the transfer is complete, if configured for no interrupts.

CONTINUE transfers are not finished until Driver488 has had an opportunity to "clean up" and complete the transfer. This "clean up" is usually automatic: Driver488 implicitly performs a **WAIT** command before performing any bus command. The program can itself use the **WAIT** command to guarantee that the transfer is complete.

All characters read, including the bus terminator, if any, are placed in the memory buffer; no terminator translation is performed. The **EOL IN** terminator is not put into the memory buffer.

ENTER #count BUFFER (Peripheral mode)

SYNTAX	`ENTER[;] #count[;]BUFFERbuf-addr[CONTINUE][term][term][EOI]`
	count is the number of characters to **ENTER**.
	buf-addr is the memory buffer address.
	CONTINUE specifies asynchronous transmission.
	term and **EOI** override the normal bus input terminators.
RESPONSE	`None, returned data is placed directly into the specified memory buffer.`
MODE	`*CA`
BUS STATES	`Determined by the Controller.`
SEE ALSO	`OUTPUT, TERM, EOL, BUFFERED`
EXAMLES	`See next page.`

EXAMPLES	`PRINT#1,"ENTER#100 BUFFER &H2000:0"`	Read 100 characters into memory at &H20000.
	`PRINT#1,"ENTER#100 BUFFER &H20100 EOI"`	Read 100 characters, or until EOI is detected into memory at absolute location 20100.
	`PRINT#1,"BUFFERED"` `INPUT#2,NBUFFERED`	
	`PRINT#1,"ENTER# 100 BUFFER 262144 CONTINUE"`	Read 100 characters as before, but allow the program to continue while the transfer is taking place.
	`PRINT#1,"WAIT"`	Wait until the transfer has completed.
	`PRINT#1,"ENTER#100 BUFFER 262144CONTINUE EOI"`	Read 100 characters as before, but stop if the EOI (end or identify) signal is encountered.
	`PRINT#1,"WAIT"`	Wait until the transfer has completed.
	`PRINT#1,"BUFFERED"` `INPUT#2,NBUFFERED`	Get the number of characters actually read.

In Peripheral mode, the **`ENTER #count BUFFER`** command receives data from the bus under control of the Active Controller. The Active Controller must put Driver488 into the **`Listen`** state and configure some other device to provide it with data. The **`Listen`** state can be checked with the **`STATUS`** command, or can cause an interrupt via the **`ARM`** command. A time-out error occurs (if enabled) if Driver488 does not receive a data byte within the time out period after issuing the **`ENTER #count BUFFER command`**. The character count **`count`** must be specified, and is the maximum number of characters that is transferred.

`ENTER #count BUFFER` does not detect the input terminator unless it is explicitly specified in the command. Otherwise the specified number of characters is received. The number of characters actually received can be checked with the **`BUFFERED`** command.

If **`CONTINUE`** is specified, then Driver488 returns control to the user's program as soon as possible, without waiting for the transfer to be completed. It does, however, wait for the first byte to check for time-out unless a time-out value of **`0`** had been specified by a **`TIMEOUT`** command. Because of hardware limitations, the **`CONTINUE`** may not return until a substantial portion of the transfer is complete if Driver488 is configured for no interrupts.

`CONTINUE` transfers are not finished until Driver488 has had an opportunity to "clean up" and complete the transfer. This "clean up" is usually automatic: Driver488 implicitly performs a **`WAIT`** command before performing any bus command. The program can itself use the **`WAIT`** command to guarantee that the transfer is complete.

All characters read, including the bus terminator, if any, are placed in the memory buffer. No terminator translation is performed. The **`EOL IN`** terminator is not put into the memory buffer.

EOL

SYNTAX	`EOL [name][IN|OUT] {term [term]|NONE}`
	`name` is the name of an External Device. If name is not specified, then EOL acts on the I/O adapter.
	`IN` or **`OUT`** specifies whether the input or output terminators are being set. If neither **`IN`** nor **`OUT`** is specified, then both terminators are set identically.
	`term` is one of **`CR`**, **`LF`**, **`$char`**, or **`'X`**, specifying a terminator character.
	`NONE` may be specified instead of term to indicate that no **`EOL`** terminators are used.
RESPONSE	`None`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`TERM, ENTER, OUTPUT`
EXAMPLES	`See next page.`

EXAMPLES	`PRINT#1,"EOL DMM CR LF"`	Set both input and output terminators to carriage-return line-feed.
	`PRINT#1,"EOLTIMER OUT CR LF"`	Set output terminator to CR LF.
	`PRINT#1,"EOLTIMER IN CR"`	Set input terminator to CR only.
	`PRINT#1,"EOL DVM $0"`	Set both terminators to an ASCII NULL.
	`PRINT#1,"EOL WAVE IN NONE"`	Configure for no input terminator.

The **`EOL`** command sets the end-of-line terminators for input to the user's program, output to Driver488, or both. All output to Driver488, except **`OUTPUT #count`**, must be terminated by the **`EOL`** output terminator. All input to the user's program, except **`ENTER #count`**, is terminated by the **`EOL`** input terminator. The default terminators for both input and output are set by **`INSTALL`** and are normally **`CR LF`**, which is appropriate for most languages.

ERROR

SYNTAX	`ERROR {ON|OFF}`	
RESPONSE	`None`	
MODE	`Any`	
BUS STATES	`None`	
SEE ALSO	`STATUS; OnEvent, GetError, GetErrorList (Sub-Chapter 15B)`	
EXAMPLES	`PRINT#1,"ERROR OFF"`	Disable on-screen error message display.
	`PRINT#1,"ERROR ON"`	Re-enable error message display.

The **`ERROR`** command enables or disables automatic on-screen display of Driver488 error messages. **`ERROR ON`** enables error message display, and **`ERROR OFF`** disables it. **`ERROR ON`** is the default condition.

FILL

SYNTAX	`FILL [name] {OFF|ERROR|CR|LF|$char|'X}`	
	`name` is the name of an external device. If name is not specified, then **`EOL`** acts on the I/O adapter	
	`OFF` prevents response if none is available.	
	`ERROR` enables **`SEQUENCE - NO DATA AVAILABLE`** errors.	
	`CR, LF, $char,` or **`'X`** specify the character with which to "fill" the response.	
RESPONSE	`None`	
MODE	`Any`	
BUS STATES	`None`	
SEE ALSO	`ENTER, OUTPUT, EOL`	
EXAMPLES	`PRINT#1,"FILL OFF"`	Do not detect NO DATA AVAILABLE errors. Do not return fill characters.
	`INT#1,"FILL ERROR"`	Detect NO DATA AVAILABLE errors.Do not return fill characters.
	`PRINT#1,"FILL $000"`	Do not detect NO DATA AVAILABLE errors. Fill requests with nulls.

The **`FILL`** command controls the response of Driver488 to a request for data when none is available. This type of request can occur in three ways: (1) a program error, such as a missing **`ENTER`** command, results in a request for a response without first setting up Driver488 to provide that response; (2) the I/O procedures supplied with the user's programming language request more data than is actually available; or (3) the **`OPEN`** command for input from Driver488 tries to read one character from Driver488 to confirm that data is available even before any commands have been issued.

When such a request occurs, Driver488 can respond in three ways: (1) it can respond to the calling routine that no data is available, (2) it can immediately signal an error, or (3) it can satisfy the request by returning some specified character repeated as many times as necessary. The **`FILL`** command selects which response is to be used. In general, when Driver488 receives a request for data, it is provided with the address in memory of a buffer that is to hold the response, and with the buffer length.

If **`FILL OFF`** is specified, then the buffer is filled with any available response, and the remainder of the buffer (if it is larger than the response) is not changed. If no response is available, then the entire buffer is left unchanged, but no error is indicated.

If **`FILL ERROR`** is specified, then the buffer is filled with any available response, and the remainder of the buffer (if it is larger than the response) is not be changed. If no response is available, then the entire buffer is left unchanged and a **`SEQUENCE - NO DATA AVAILABLE`** error occurs.

If **`FILL`** term is specified, where term is one of **`CR`**, **`LF`**, **`$char`**, or **`'X`**, the buffer is filled with any available response, and the remainder of the buffer (if it is larger than the response) is filled with the specified character. If no response is available, the entire buffer is filled with that character.

If the error is due to an actual programming error, it is to the user's advantage to have Driver488 automatically detect this error. In this case, error detection should be enabled with the **`FILL ERROR`** command. Normal I/O with Driver488 in both BASIC and Turbo Pascal 3.0 is performed on a character-by-character basis and so neither language reads more data than is available. Thus, **`FILL ERROR`** is appropriate for both languages. Note, however, that the **`OPEN`** for input command in some versions of BASIC does try to read one character upon opening the file. For this reason, the files should be opened in the following sequence:

```
100 OPEN "\DEV\IEEEOUT" FOR OUTPUT AS #1
110 IOCTL#1,"BREAK"
120 PRINT#1,"RESET"
130 OPEN "\DEV\IEEEIN" FOR INPUT AS #2
140 PRINT#1,"FILL OFF"
```

The **`RESET`** command guarantees that **`FILL$000`** (the default condition, **`FILL`** with the null character) is in effect when the **`OPEN`** statement tries to read the first character from Driver488. Driver488 responds with a null character that BASIC ignores so that the first real response from Driver488 will be corrupted.

In some languages, such as C, the I/O routines may try to read a fixed length block from Driver488. Use of the BASIC **`GET`** file I/O also has this effect. The size of the block requested varies. It may be as much as several thousand bytes, or it may be the record size or buffer length defined for the file. In any case, if **`FILL`** is **`OFF`**, then no error is signaled, and the returned characters are placed into the first bytes of the buffer. The remainder of the block is not modified. It is, though, sometimes useful to fill the remainder of the block with some specific byte value. This is accomplished with the **`FILL term`** command. **`FILL term`** forces Driver488 to return as many characters as are requested by the I/O routines, even if they are dummy fill characters.

FIND LISTENERS

SYNTAX	`FIND LISTENERS pri-addr`	
RESPONSE	`The number of active listeners found, followed by those addresses, separated by commas.`	
MODE	`Any`	
BUS STATES	`UNL, LAG`	
SEE ALSO	`CHECK LISTENER, BUS ADDRESS, STATUS`	
EXAMPLES	`PRINT#1,"FIND LISTENERS 12"` `LINE INPUT#1,A$`	
	`0`	No Listeners Found
	`1,12`	Primary Address Listener Found
	`2,1200,1201`	Secondary Address Listeners Found

The **`FIND LISTENERS`** command finds all of the devices configured to listen at the specified primary address on the IEEE 488 bus. It takes the primary address to check, and returns the number of listeners found and their addresses.

FINISH

SYNTAX	`FINISH`
RESPONSE	`None`
MODE	`CA`
BUS STATES	`ATN`
SEE ALSO	`RESUME, PASS CONTROL`
EXAMPLE	`PRINT#1, “FINISH”`

The **`FINISH`** command asserts **`ATN`** and releases any pending holdoffs after a **`RESUME`** function is called with the monitor flag set. **`FINISH`** everything necessary for Driver488 to be ready for the next operation.

HELLO

SYNTAX	`HELLO`	
RESPONSE	`Driver488 Revision X.X (C)199X IOtech, Inc.`	
MODE	`Any`	
BUS STATES	`None`	
SEE ALSO	`Status; OpenName, GetError (Sub-Chapter 15B)`	

EXAMPLE	`PRINT#1,"HELLO"`
	`INPUT#2,A$`
	`PRINT A$`
		Get the HELLO response and display it.

The **`HELLO`** command is used to verify communication with Driver488, and to read the software revision number. When the command is sent, Driver488 returns a string similar to the following:

```
Driver488 Revision X.X (C)199X IOtech, Inc.
```

where **`X`** is the appropriate revision or year number.

INT LEVEL

SYNTAX	`INT LEVEL [channel│NONE]`
	`channel` is a valid interrupt channel.
RESPONSE	`None`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`DMA CHANNEL, TIME OUT`
EXAMPLES	`PRINT#1, “INT LEVEL 3"`

The **`INT LEVEL`** command specifies the hardware interrupt level that is used by the I/O adapter. Driver488 uses hardware interrupts, if available, to improve the efficiency of I/O adapter control and communication. The interrupt level is specified by an integer in the range **`2`** through **`15`**, where channel availability within this range is determined by the system bus type and the adapter type. The interrupt level value must match the hardware settings on the I/O adapter card.

IO ADDRESS

SYNTAX	`IO ADDRESS[io-addr]`
	`ioaddr` is the I/O base address to set.
RESPONSE	`None`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`INT LEVEL, DMA CHANNEL, TIME OUT`
EXAMPLES	`PRINT#1,"IOADDRESS &H02E1"`

The `IO ADDRESS` command specifies the I/O port base address of the I/O adapter. The base address is set by a sixteen-bit integer, `ioaddr`, that is usually given as a hexadecimal number. For example, to use the default I/O address, the command would be `IO ADDRESS &H02E1`.

The default I/O port base address for the IEEE 488 hardware interface is `&H02E1` for the first interface, `&H22E1` for the second, `&H42E1` for the third, and `&H62E1` for the fourth interface. The default I/O port base addresses for the serial hardware interface is `&H03F8`. Other standard I/O port base addresses are `&H02F8`, `&H03E8`, `&H02E8`. The `IO ADDRESS` value must match the hardware switch settings on the I/O adapter.

IOCTL (BASIC Statement)

SYNTAX	`IOCTL#2,"BREAK"`
RESPONSE	`None`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`IOCTL$`
EXAMPLE	`IOCTL#2,"BREAK"` Send the IOCTL message "BREAK" to the Driver488

The `IOCTL` command is a BASIC statement that can be used to reset Driver488 unconditionally. When the message `"BREAK"` is sent to Driver488 via the `IOCTL Write` DOS function (`&H4403`, accessible via the `IOCTL` BASIC statement), Driver488 stops any command currently executing, and prepares to accept a new command. This can be used even when Driver488 is not expecting a command, but is transferring data. Commands such as `ABORT` or `RESET` may then be used to reset the entire IEEE 488 bus.

`IOCTL` resets the `EOL OUT` terminators to their default values to guarantee that Driver488 is able to recognize the next command correctly. No `IOCTL` commands other than `BREAK` are supported by Driver488. The `IOCTL` command can be accomplished in other languages by using MS-DOS function calls.

IOCTL$ (BASIC Statement)

SYNTAX	`A$=IOCTL$(#2)`
	`A$` is a string variable that is set to one of the following: `0` if there is nothing to read, `1` if there is something to read, `2` if data should be written, `3` if the remainder of a command is expected.
RESPONSE	`None`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`IOCTL`

EXAMPLE	`100 PRINT#1,"ENTER16"`
	`110 A$=IOCTL$(#2)`
	`120 IF A$="1" THEN PRINT INPUT$(1,#2): GOTO 110`
	`130 PRINT "NO INPUT READY"`

The `IOCTL$` command is a BASIC statement that can be used to determine the communication state of Driver488. When data is read from Driver488 using the `IOCTL Read` DOS command (`&H4402`, access via the `IOCTL$` BASIC function), Driver488 returns a single ASCII character, either `0`, `1`, `2`, or `3`. The meaning of these responses is:

- `0:` A response of `0` indicates that Driver488 is ready to receive a command. It has no data to read, nor is it expecting data for output to the IEEE 488 bus.

- **`1:`** A response of `1` indicates that Driver488 has a response ready to be read by the user's program. The program must read the response before sending a new command (except **`IOCTL "BREAK"`**) or a **`SEQUENCE - DATA HAS NOT BEEN READ`** error occurs.
- **`2:`** A response of `2` indicates that Driver488 is waiting for data to **`OUTPUT`** to the I/O adapter. The user's program must send the appropriate data with terminators as needed to Driver488 with **`PRINT`** statements (or their equivalent in other languages). Attempting to read from Driver488 while it is waiting for data, causes a **`SEQUENCE - NO DATA AVAILABLE`** error.
- **`3:`** A response of `3` indicates that Driver488 is waiting for the completion of a command. This is similar to a response of `2` except that Driver488 is waiting for a command rather than for data to **`OUTPUT`**.

The **`IOCTL$`** command has two primary uses: In the Keyboard Controller Program it allows the program to know when Driver488 has data available to read, and in BASIC Interrupt Service Routines it prevents interrupts from being serviced while Driver488 is busy finishing a command.

Notice that **`IOCTL$`** suppresses light pen interrupt emulation, so that the next time light pen status is requested, it responds with a "no interrupt" status. Normal light pen interrupt emulation is then restored. This is required to allow the BASIC **`ON PEN`** function to operate normally. The **`IOCTL$`** command can be accomplished in other languages by using MS-DOS function calls.

KEEP DEVICE

SYNTAX	**`KEEP DEVICE name`**
	`name` is the name of an external device.
RESPONSE	**`None`**
MODE	**`Any`**
BUS STATES	**`None`**
SEE ALSO	**`MAKE DEVICE, REMOVE DEVICE`**
EXAMPLES	**`PRINT#1, "KEEP DEVICE SCOPE"`**

The **`KEEP DEVICE`** command makes the specified Driver488 device permanent. Permanent Driver488 devices are not removed when Driver488 is closed. Driver488 devices are created by **`MAKE DEVICE`** and are initially temporary. Unless **`KEEP DEVICE`** is used, all temporary Driver488 devices are forgotten when Driver488 is closed. The only way to remove the device once it has been made permanent by the **`KEEP DEVICE`** command, is to use the **`REMOVE DEVICE`** command.

KEEP DOS NAME

SYNTAX	**`KEEP DOS NAME dosname`**
	`dosname` is the name of the Driver488 DOS device.
RESPONSE	**`None`**
MODE	**`Any`**
BUS STATES	**`None`**
SEE ALSO	**`MAKE DOS NAME, REMOVE DOS NAME, KEEP DEVICE`**
EXAMPLES	**`PRINT#1, "KEEP DOS NAME PLOTTER"`**

The **`KEEP DOS NAME`** command makes the specified Driver488 DOS device permanent. Permanent Driver488 DOS devices are not removed when Driver488 is closed. Driver488 DOS devices are created by **`MAKE DOS NAME`** and are initially temporary. Unless **`KEEP DOS NAME`** is used, all temporary Driver488 DOS devices are forgotten when Driver488 is closed. The only way to remove the DOS device once it has been made permanent by the **`KEEP DOS NAME`** command, is to use the **`REMOVE DOS NAME`** command.

The Driver488 DOS device is attached to a Driver488 device that was specified when the Driver488 DOS device was created by **`MAKE DOS NAME`**. If that Driver488 device is not permanent, then **`KEEP DOS NAME`** makes it permanent, and then makes the Driver488 DOS device permanent.

LIGHT PEN

SYNTAX	`LIGHT PEN [ON|OFF]`
RESPONSE	`None`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`ARM, DISARM; OnEvent (Sub-Chapter 15B)`
EXAMPLES	`PRINT#1, "LIGHT PEN ON"`

The **`LIGHT PEN`** command enables or disables the detection of interrupts via setting the light pen status. The default is light pen interrupt enabled.

LOCAL

System Controller Mode		
SYNTAX	`LOCAL`	
RESPONSE	`None`	
MODE	`SC`	
BUS STATES	`*REN`	
SEE ALSO	`REMOTE, AUTO REMOTE`	
EXAMPLE	`PRINT#1,"LOCAL"`	Unassert the Remote Enable Line

Active Controller Mode		
SYNTAX	`LOCAL addr[,addr...]`	
	`addr` is a bus device address (primary with optional secondary) or a device name.	
RESPONSE	`None`	
MODE	`CA`	
BUS STATES	`ATNUNL, MTA, LAG,GTL`	
SEE ALSO	`REMOTE, AUTO REMOTE`	
EXAMPLE	`PRINT#1,"LOCAL 12,16"`	Send Go To Local to devices 12 and 16.

In the System Controller mode, the **`LOCAL`** command without optional addresses causes Driver488 to unassert the Remote Enable (**`REN`**) line. This causes devices on the bus to return to manual operation. As the Active Controller, with bus addresses specified, bus devices are placed in the local mode by the Go To Local (**`GTL`**) bus command. If addresses are specified, then the Remote Enable line is not unasserted.

LOCAL LOCKOUT or LOL

SYNTAX	`LOCAL LOCKOUT` or `LOL`	
RESPONSE	`None`	
MODE	`CA`	
BUS STATES	`ATN•LLO`	
SEE ALSO	`LOCAL, LOCAL LIST, REMOTE`	
EXAMPLES	`PRINT#1,"LOCAL LOCKOUT"`	Send Local Lockout bus command.
	`PRINT#1,"LOL"`	Same as above.

The **`LOCAL LOCKOUT`** command causes Driver488 to issue a Local Lockout (**`LOL`**) IEEE 488 bus command. Bus devices that support this command are thereby inhibited from being controlled manually from their front panels.

MAKE DEVICE

SYNTAX	`MAKE DEVICE name = oldname`	
	`name` is the name of the device that is created with the same configuration as the existing device oldname.	
RESPONSE	`None`	
MODE	`Any`	
BUS STATES	`None`	
SEE ALSO	`KEEP DEVICE, REMOVE DEVICE`	

EXAMPLE	`PRINT#1,"MAKE DEVICE DMM=SCOPE"`
	`PRINT#1,"BUS ADDRESS DMM 16`
		Create a device named DMM, attached to the same I/O adapter as SCOPE and set its IEEE 488 bus address to 16.

The **`MAKE DEVICE`** command creates a new, temporary Driver488 device that is an identical copy of an already existing Driver488 device. The new device is attached to the same I/O adapter of the existing device and has the same terminators, timeouts, and other characteristics. If there are no appropriate Driver488 devices, then the **`INSTALL`** program must be used to create one. The newly created device is temporary, and is forgotten when Driver488 is closed. **`KEEP DEVICE`** may be used to make the device permanent.

MAKE DOS NAME

SYNTAX	`MAKE DOS NAME dosname = devicename`
	`dosname` is the name of the newly created Driver488 DOS device that is configured to communicate with the Driver488 device `devicename`
RESPONSE	`None`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`KEEP DOS NAME, REMOVE DOS NAME, MAKE DEVICE`

EXAMPLES	`PRINT#1, "MAKE DOS NAME METER = DMM"`
	`OPEN "METER" FOR OUTPUT AS #3`

The **`MAKE DOS NAME`** command creates a new, temporary Driver488 DOS device that is configured to communicate with an already existing Driver488 device. The newly created DOS device is temporary, and is forgotten when Driver488 is closed. **`KEEP DOS NAME`** may be used to make the device permanent.

OUTPUT (Controller Mode)

SYNTAX	`OUTPUT [addr][#count][term][term][EOI];data`
	`addr` is a device address (primary with optional secondary) or external device name.
	`count` is the number of characters to output.
	`Term` and `EOI` override the normal IEEE 488 bus output terminator
	`data` is a string of characters to output, terminated by the `EOL` output terminator (unless count is specified in which case no terminator is needed).
RESPONSE	`None`
MODE	`CA`
BUS STATES	`REN (if SC and AUTO REMOTE), *ATN, data (without addr)`
	`REN (if SC and AUTO REMOTE), ATN•MTA, UNL, LAG, *ATN, data (with addr)`
SEE ALSO	`ENTER, TERM, TIME OUT, EOL, BUFFERED`
EXAMPLES	`See next page.`

EXAMPLES	`PRINT#1,"OUTPUT22;R0C0T1X"`	Send "R0C0T1X" to device 22.
	`PRINT#1,"OUTPUT;XYZ"`	And send it "XYZ".
	`PRINT#1,"OUTPUT0602;DEF"`	Send "DEF" to device 6, secondary address 2.
	`PRINT#1,"OUTPUT06#26; abcdefghijklmnopqrstuvwxyz"`	Send the 26 letters of the alphabet without terminators to device 6.
	`PRINT#1,"OUTPUT DMM;DC VOLTS"`	Send "DCVOLTS" to device DMM.

The **`OUTPUT`** command sends data to the I/O adapter. The Remote Enable (**`REN`**) line is first asserted if Driver488 is the System Controller and **`AUTO REMOTE`** is enabled. Then, if a device address (with optional secondary address) is specified, Driver488 is addressed to Talk and that device is addressed to Listen. If no address is specified, Driver488 must already be configured to send data, either as a result of an immediately preceding **`OUTPUT`** command or as the result of a **`SEND`** command. If the character count **`count`** is specified, that exact number of characters is sent to the bus devices. Otherwise, **`OUTPUT`** terminates data transfer upon detection of the **`EOL`** output terminator from the user's program. The **`EOL`** output terminator is replaced with the bus output terminator before being sent to the bus devices.

OUTPUT (Peripheral Mode)

SYNTAX	`OUTPUT [#count][term][term][EOI];data`	
	`count` is the number of characters to **`OUTPUT`**.	
	`term` and **`EOI`** override the normal IEEE 488 bus output terminators.	
	`data` is a string of characters to **`OUTPUT`** terminated by the **`EOL`** output terminator unless **`count`** is specified.	
RESPONSE	`None`	
MODE	`*CA`	
BUS STATES	`Determined by the Controller.`	
	`REN asserted if SYS CONTROLLER and AUTO REMOTE are enabled.`	
SEE ALSO	`ENTER, TERM, TIME OUT, BUFFERED`	
EXAMPLES	`PRINT#1,"OUTPUT;DCVOLTS"`	Send "DC VOLTS"
	`PRINT#1,"OUTPUT#5;ABCDE"`	Send "ABCDE" without bus terminators.

In Peripheral mode, the **`OUTPUT`** command sends data to the I/O adapter under control of the Active Controller. The Active Controller must put Driver488 into the **`Talk`** state and configure some bus device to accept the transferred data. The **`Talk`** state can be checked with the **`STATUS`** command, or can cause an interrupt via the **`ARM`** command. A time-out error occurs, if enabled, if no bus device accepts the data within the time out period after issuing the **`OUTPUT`** command. If the character count **`count`** is specified, that exact number of characters is sent to the bus device. Otherwise, **`OUTPUT`** terminates data transfer upon detection of the **`EOL`** output terminator from the user's program. The **`EOL`** output terminator is replaced with the bus output terminator before being sent to the bus devices. Even as a Peripheral, Driver488 might be the System Controller. If it is and **`AUTO REMOTE`** is enabled, it asserts Remote Enable (**`REN`**) before sending any data.

OUTPUT #count BUFFER (Controller Mode)

SYNTAX	`OUTPUT [addr]#count BUFFER buf-addr [CONTINUE] [term] [term] [EOI]`	
	`addr` is a device address (primary with optional secondary) or an external device name.	
	`count` is the number of bytes to `OUTPUT`.	
	`buf-addr` is the memory buffer address.	
	`CONTINUE` specifies asynchronous transmission.	
	`term` and `EOI` override the normal IEEE 488 bus output terminator	
RESPONSE	`None`	
MODE	`CA`	
BUS STATES	`REN (if SC), *ATN, data (without addr)`	
	`REN (if SC), ATN•MTA, UNL, LAG, *ATN, data (with addr)`	
SEE ALSO	`ENTER, TERM, TIME OUT, EOL, BUFFERED`	
EXAMPLES	`PRINT#1,"OUTPUT16#100 BUFFER &H2000:0”`	Send 100 characters from memory at &H20000.
	`PRINT#1,"OUTPUT16#100 BUFFER &H20100 EOI”`	Send 100 characters from memory at &H20100 asserting EOI with the last character.
	`PRINT#1,"OUTPUT0701 #100 BUFFER &H1000:0 EOI”`	Send 100 characters to bus device 07.
	`PRINT#1,"OUTPUT16#100 BUFFER &H2000:0 CONTINUE EOI”`	Send 100 characters and allow the program to continue while the transfer is taking place.
	`PRINT#1,"WAIT"`	Wait for the transfer to complete.
	`PRINT#1,"OUTPUT16#100 BUFFER &H2000:100”`	And send the next 100 bytes.

The **`OUTPUT #count BUFFER`** command sends data to I/O adapter devices from a user- supplied memory region. The Remote Enable (**`REN`**) line is first asserted if Driver488 is the System Controller. Then, if a device address (with optional secondary address) is specified, Driver488 is addressed to Talk and that device is addressed to Listen. If no address is specified, Driver488 must already be configured to send data, either as a result of an immediately preceding **`OUTPUT`** command, or as the result of a **`SEND`** command.

The character count **`count`** must be specified and is the number of characters that is transferred. **`OUTPUT #count BUFFER`** does not send any bus output terminators unless they are specified. The number of characters actually sent can be checked with the **`BUFFERED`** command.

If **`CONTINUE`** is specified, then Driver488 returns control to the user’s program as soon as possible without waiting for the transfer to be completed. It does, however, wait for the first byte to check for time-out unless a time-out value of **`0`** had been specified by a **`TIME OUT`** command. Because of hardware limitations, the **`CONTINUE`** may not return until a substantial portion of the transfer is complete.

`CONTINUE` transfers are not finished until Driver488 has had an opportunity to “clean up” and complete the transfer. This “clean up” is usually automatic: Driver488 implicitly performs a **`WAIT`** command before performing any bus command. The program can itself use the **`WAIT`** command to guarantee that the transfer is complete.

All characters in the memory buffer are sent exactly as stored. No detection of the **`EOL`** output terminator is performed, and no terminator translation takes place.

OUTPUT #count BUFFER (Peripheral Mode)

SYNTAX	`OUTPUT #count BUFFER buf-addr [CONTINUE] [term] [term] [EOI]`	
	`count` is the number of characters to `OUTPUT`.	
	`buf-addr` is the memory buffer address.	
	`CONTINUE` specifies an asynchronous data transfer.	
	`term` and `EOI` override the normal IEEE 488 bus output terminators.	
RESPONSE	`None`	
MODE	`*CA`	
BUS STATES	`Determined by the Controller.`	
	`REN asserted if SYS CONTROLLER and AUTO REMOTE are enabled.`	
SEE ALSO	`ENTER, TERM, TIME OUT, BUFFERED`	
EXAMPLES	`PRINT#1,"OUTPUT#100 BUFFER &H2000:0"`	Send 100 characters from memory at &H20000.
	`PRINT#1,"OUTPUT#100 BUFFER &H20100 EOI"`	Send 100 characters from memory at &H20100 asserting EOI with the last character.
	`PRINT#1,"OUTPUT#100 BUFFER &H1000:0 EOI"`	Send 100 characters, asserting EOI on the last character.
	`PRINT#1,"OUTPUT#100 BUFFER &H2000:0 CONTINUE EOI"`	Send 100 characters and allow the program to continue while the transfer is taking place.
	`PRINT#1,"WAIT"`	Send 100 characters and allow the program to continue while the transfer is taking place.

In Peripheral mode, the **`OUTPUT #count BUFFER`** command sends data to the I/O adapter under control of the Active Controller. The Active Controller must put Driver488 into the **`Talk`** state and configure some bus device to accept the data that is transferred. The **`Talk`** state can be checked with the **`STATUS`** command or it can cause an interrupt via the **`ARM`** command. A time-out error occurs, if enabled, if the Controller does not accept the data within the time out period after issuing the **`OUTPUT #count BUFFER`** command.

The character count **`count`** must be specified and is the number of characters that is transferred. **`OUTPUT #count BUFFER`** does not send any bus output terminators unless they are specified. The number of characters actually sent can be checked with the **`BUFFERED`** command.

If **`CONTINUE`** is specified, then Driver488 returns control to the user's program as soon as possible without waiting for the transfer to be completed. It does, however, wait for the first byte to check for time-out unless a time-out value of **`0`** had been specified by a **`TIME OUT`** command. Because of hardware limitations, the **`CONTINUE`** may not return until a substantial portion of the transfer is complete, if Driver488 is configured for no interrupts.

`CONTINUE` transfers are not finished until Driver488 has had an opportunity to "clean up" and complete the transfer. This "clean up" is usually automatic: Driver488 implicitly performs a **`WAIT`** command before performing any bus command. The program can itself use the **`WAIT`** command to guarantee that the transfer is complete. If **`EOI`** is specified, the last byte is not transferred until Driver488 has the opportunity to perform this clean up.

All characters in the memory buffer are sent exactly as stored. No detection of the **`EOL`** output terminator is performed, and no terminator translation takes place.

Even as a Peripheral, Driver488 might be the System Controller. If it is and if **`AUTO REMOTE`** is enabled, then it asserts RemoteEnable (**`REN`**) before sending any data.

PASS CONTROL

SYNTAX	`PASS CONTROL addr`	
	`addr` is a device address (primary with optional secondary) or the external device name of the device to which control is passed.	
RESPONSE	`None`	
MODE	`CA`	
BUS STATES	`ATN•UNL, MLA, TAG, UNL, TCT, *ATN`	
SEE ALSO	`ABORT, RESET, SEND`	
EXAMPLE	`100 PRINT#1, "PASS CONTROL 22"`	Control is passed to device 22.
	`110 PRINT#1,"STATUS"`	Use STATUS to check control.
	`120 INPUT#1,A$`	Wait until we are controller again
	`130 IF LEFT$(A$,1)"C" THEN 110`	

The `PASS CONTROL` command allows Driver488 to give control to another controller on the bus. After passing control, Driver488 enters the Peripheral mode. If Driver488 was the System Controller, then it remains the System Controller, but it is no longer the Active Controller. The Controller now has command of the bus until it passes control to another device or back to Driver488. The System Controller can regain control of the bus at any time by issuing an `ABORT` command.

PPOLL

SYNTAX	`PPOLL`	
RESPONSE	`Number in the range 0 to 255.`	
MODE	`CA`	
BUS STATES	`ATN•EOI <parallel poll response>, *EOI`	
SEE ALSO	`PPOLL CONFIG, PPOLL UNCONFIG, PPOLL DISABLE, SPOLL`	
EXAMPLE	`PRINT#1,"PPOLL"`	Conduct a Parallel Poll
	`INPUT#2,PPSTAT`	Receive the PPOLL status

The `PPOLL` (Parallel Poll) command is used to request status information from many bus devices simultaneously. If a device requires service, it responds to a Parallel Poll by asserting one of the eight IEEE 488 bus data lines (`DIO1` through `DIO8`, with `DIO1` being the least significant). In this manner, up to eight devices may simultaneously be polled by the controller. More than one device can share any particular `DIO` line. In this case, it is necessary to perform further Serial Polling to determine which device actually requires service.

Parallel Polling is often used upon detection of a Service Request (`SRQ`), though it may also be performed periodically by the controller. In either case, `PPOLL` responds with a number from `0` to `255` corresponding to the eight binary `DIO` lines. Refer to the manufacturer's documentation for each device to determine whether or not Parallel Poll capabilities are supported.

PPOLL CONFIG or PPC

SYNTAX	`PPOLL CONFIG addr;response` or `PPC addr;response`
	`addr` is a device address (primary with optional secondary) or an external device name.
	`response` is the decimal equivalent of the four binary bits `S`, `P2`, `P1`, and `P0` where `S` is then Sense bit, while `P2`, `P1`, and `P0` assign the `DIO` bus data line used for the response.
RESPONSE	`None`
MODE	`CA`
BUS STATES	`ATN•UNL, MTA, LAG, PPC`
SEE ALSO	`PPOLL, PPOLL UNCONFIG, PPOLL DISABLE`
EXAMPLE	`See next page.`

EXAMPLE	`PRINT#1, "PPC23;&H0D"`	Configure device 23 to assert DIO6 when it desires service (ist = 1) and it is Parallel Polled (&H0D = 1101 binary; S=ist=1, P2=1, P1=0, P0=1; 101 binary = 5 decimal = DIO6).

The `PPOLL CONFIG` command configures the Parallel Poll response of a specified bus device. Not all devices support Parallel Polling and, among those that do, not all support the software control of their Parallel Poll response. Some devices are configured by internal switches.

The Parallel Poll response is set by a four-bit binary number response: `S`, `P2`, `P1`, and `P0`. The most significant bit of response is the *Sense* (`S`) bit. The Sense bit is used to determine when the device will assert its Parallel Poll response. Each bus device has an internal individual status (`ist`). The Parallel Poll response is asserted when this `ist` equals the Sense bit value `S`. The `ist` is normally a logic `1` when the device requires attention, so the `S` bit should normally also be a logic `1`. If the `S` bit is `0`, then the device asserts its Parallel Poll response when its `ist` is a logic `0`. That is, it does not require attention. However, the meaning of `ist` can vary between devices, so refer to your IEEE 488 bus device documentation. The remaining 3 bits of response: `P2`, `P1`, and `P0`, specify which `DIO` bus data line is asserted by the device in response to a Parallel Poll. These bits form a binary number with a decimal value from `0` through `7`, specifying data lines `DIO1` through `DIO8`, respectively.

PPOLL DISABLE or PPD

SYNTAX	`PPOLL DISABLE addr[,addr...]` or `PPD addr[,addr...]`
	`addr` is a device address (primary with optional secondary) or an external device name.
RESPONSE	`None`
MODE	`CA`
BUS STATES	`ATN•UNL, MTA, LAG, PPC, PPD`
SEE ALSO	`PPOLL, PPOLL CONFIG, PPOLL UNCONFIG`
EXAMPLE	`PRINT#1,"PPOLL DISABLE 18,06,13"` Disable Parallel Poll of devices 18, 6, and 13.

The `PPOLL DISABLE` command disables the Parallel Poll response of selected bus devices.

PPOLL UNCONFIG or PPU

SYNTAX	`PPOLL UNCONFIG` or `PPU`
RESPONSE	`None`
MODE	`CA`
BUS STATES	`ATN•PPU`
SEE ALSO	`PPOLL, PPOLL CONFIG, PPOLL DISABLE`
EXAMPLE	`PRINT#1,"PPOLL UNCONFIG"`

The `PPOLL UNCONFIG` command disables the Parallel Poll response of all bus devices.

REMOTE

Bus Addresses Not Specified

SYNTAX	`REMOTE`
RESPONSE	`None`
MODE	`SC`
BUS STATES	`REN`
SEE ALSO	`Remote (Sub-Chapter 15B)`
EXAMPLES	`PRINT#1,"REMOTE"` Assert Remote Enable

Bus Addresses Specified		
SYNTAX	`REMOTE addr[,addr...]`	
	`addr` is a device address (primary with optional secondary) or an external device name.	
RESPONSE	`None`	
MODE	`SC•CA`	
BUS STATES	`REN, ATN•UNL, MTA, LAG`	
SEE ALSO	`LOCAL, LOCAL LOCKOUT, Remote (Sub-Chapter 15B)`	
EXAMPLES	`PRINT#1,"REMOTE16,28"`	Assert REN and address devices 16 and 28 to listen.

The **`REMOTE`** command asserts the Remote Enable (**`REN`**) bus management line. If the optional bus addresses are specified, **`REMOTE`** also address those devices to listen, placing them in the Remote state.

REMOVE DEVICE

SYNTAX	`REMOVE DEVICE [[,]name...]`
	`name` is the external device to remove.
RESPONSE	`None`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`MAKE DEVICE, KEEP DEVICE, REMOVE DOS NAME`
EXAMPLES	`PRINT#1, "REMOVE DEVICE DMM"`

The **`REMOVE DEVICE`** command removes the specific temporary or permanent Driver488 device that was created with either the **`MAKE DEVICE`** command or the **`INSTALL`** program. This command also removes a device that was made permanent through a **`KEEP DEVICE`** command. Notice that **`REMOVE DEVICE`** cannot be used to remove devices having DOS names. The **`REMOVE DOS NAME`** command must first be used to remove any associated DOS names from such devices before the devices are removed via the **`REMOVE DEVICE`** command.

REMOVE DOS NAME

SYNTAX	`REMOVE DOS NAME dosname`
	`dosname` is the name of the Driver488 DOS device to remove.
RESPONSE	`None`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`MAKE DOS NAME, KEEP DOS NAME, REMOVE DEVICE`
EXAMPLES	`PRINT#1, "REMOVE DOS NAME METER"`

The **`REMOVE DOS NAME`** command removes the temporary or permanent Driver488 DOS device that was created by either the **`MAKE DOS NAME`** command or the **`INSTALL`** program.

REQUEST

SYNTAX	`REQUEST[;] status`
	status is the service **`REQUEST`** status in the range `0` to `255`.
RESPONSE	`None`
MODE	`*CA`
BUS STATES	`SRQ if rsv is set`
	`*SRQ if rsv is not set`
SEE ALSO	`STATUS, CONTROL LINE, PPOLL CONFIG`

EXAMPLES	`See next page.`	
EXAMPLES	`PRINT#1,"REQUEST";64+2+4`	Generate an SRQ (decimal 64) with DIO2 (decimal 2) and DIO3 (decimal 4) set in the Serial Poll Response.
	`PRINT#1,"REQUEST 0"`	Clear SRQ and Serial Poll Response.

In Peripheral mode, Driver488 is able to request service from the Active Controller by asserting the Service Request (**`SRQ`**) bus signal. The **`REQUEST`** command sets or clears the Serial Poll status (including Service Request) of Driver488. **`REQUEST`** takes a numeric argument in the decimal range **`0`** to **`255`** (hex range **`&H0`** to **`&HFF`**) that is used to set the Serial Poll status. When Driver488 is Serial Polled by the Controller, it returns this byte on the **`DIO`** data lines.

The data lines are numbered **`DIO8`** through **`DIO1`**. **`DIO8`** is the most significant line and corresponds to a decimal value of **`128`** (hex **`&H80`**). **`DIO7`** is the next most significant line and corresponds to a decimal value of **`64`** (hex **`&H40`**). **`DIO7`** has a special meaning: It is the *Request for Service* (**`rsv`**) bit. If **`rsv`** is set, then Driver488 asserts the Service Request (**`SRQ`**) bus signal. If **`DIO7`** is clear (a logic **`0`**), then Driver488 does not assert **`SRQ`**. When Driver488 is Serial Polled, all eight bits of the Serial Poll status are returned to the Controller. The **`rsv`** bit is cleared when Driver488 is Serial Polled by the Controller. This causes Driver488 to stop asserting **`SRQ`**.

RESET

SYNTAX	`RESET`
RESPONSE	`None`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`ABORT, TERM, TIME OUT`
EXAMPLE	`PRINT#1,”RESET”`

The **`RESET`** command provides a warm start of the interface. It is equivalent to issuing the following command process, including clearing all error conditions:

1. **`STOP`**
2. **`DISARM`**
3. Reset hardware. (Resets to Peripheral if not System Controller)
4. **`ABORT`** (if System Controller)
5. **`ERROR ON`**
6. **`FILL$0`**
7. **`LOCAL`**
8. **`REQUEST 0`** (if Peripheral)
9. Clear **`Change`**, **`Trigger`**, and **`Clear`** event conditions.
10. Reset I/O adapter settings to installed values. (**`TIME OUT`**, **`INT LEVEL`**, and **`DMA CHANNEL`**)

RESUME

SYNTAX	`RESUME [MONITOR] [name]`	
	`name` is either an I/O adapter or an external device. If **`name`** is an external device, then the device’s output terminators are used. If **`name`** is a hardware interface, then the default input terminators are used. If **`name`** is not specified, then **`RESUME`** acts as if the hardware interface was specified.	
	`MONITOR` is a flag that when specified, Driver488 monitors the data.	
RESPONSE	`None`	
MODE	`CA`	
BUS STATES	`*ATN`	
SEE ALSO	`FINISH`	
EXAMPLE	`PRINT#1,"RESUME"`	Unassert Attention Line.

The **RESUME** command unasserts the Attention (**ATN**) bus signal. Attention is normally kept asserted by Driver488, but it must be unasserted to allow transfers to take place between two peripheral devices. In this case, Driver488 sends the appropriate **Talk** and **Listen** addresses, and then must unassert Attention with the **RESUME** command.

If **MONITOR** is specified, then Driver488 monitors the handshaking process but does not participate in it. Driver488 takes control synchronously when the last terminator or **EOI** is encountered. At that point, the transfer of data stops. The **FINISH** command must be called to assert Attention and release any pending holdoffs to be ready for the next action.

SEND

SYNTAX	`SEND[;] subcommand[subcommand...]`
RESPONSE	`None`
MODE	`CA (any subcommands)`
	`Any (DATA and EOI subcommands only)`
BUS STATES	`User-defined`
SEE ALSO	`OUTPUT`
EXAMPLES	`PRINT#1,"SEND MTA UNL LISTEN16 DATA 'T1S0R2X'"` is the same as `PRINT#1,"OUTPUT16;T1S0R2X"`
	`PRINT#1,"SEND CMD 128,0,10 DATA 156,35 EOI 'ABC'"` sends the following byte sequence: (see below)

```
Data        ATN     EOI
10000000    ATN     *EOI
00000000    ATN     *EOI
00001010    *ATN    *EOI
10011100    *ATN    *EOI
00100011    *ATN    *EOI
01000001    *ATN    *EOI
01000010    *ATN    *EOI
01000011    *ATN    EOI
```

The **SEND** command provides byte-by-byte control of data and command transfers on the bus and gives greater flexibility than the other commands. This command can specify exactly which operations Driver488 executes. The following subcommands are available within the **SEND** command:

SEND Subcommand	Operation (Bus Command or Data Transfer)
`UNT`	Send the Untalk bus command. ATN is asserted.
`UNL`	Send the Unlisten bus command. ATN is asserted.
`MTA`	Send the My Talk Address bus command. ATN is asserted.
`MLA`	Send the My Listen Address bus command. ATN is asserted.
`TALK addr`	Send the Talk Address Group (TAG) bus command. ATN is asserted.
`LISTEN addr[,addr...]`	Send the Listen Address Group (LAG) bus command. ATN is asserted.
`DATA {'data'|number} [,{'data'|number}...]`	Send character strings data or characters with numeric ASCII values char. ATN unasserted.
`EOI {'data'|number} [,{'data'|number}...]`	Send character strings data or characters with numeric ASCII values char. ATN unasserted. EOI is asserted on the last character.
`CMD {'data'|number} [,{'data'|number}...]`	Send character strings data or characters with numeric ASCII values char. ATN asserted.

The **DATA**, **EOI** and **CMD** subcommands send data bytes or characters over the bus. The characters to be sent are specified either as a quoted string (**'data'**) or as individual ASCII values (**number[,number...]**). For example, **DATA'R0X'** sends the characters **R**, **0**, and **X** to the active listeners, while **DATA13,&H0A** sends the carriage return and line feed. Multiple quoted strings or ASCII valued bytes may be specified by separating them with commas. The **EOI** subcommand is identical to the **DATA** subcommand except that the End-Or-Identify (**EOI**) signal is asserted on the transfer of the last character.

The `CMD` subcommand sends the data bytes with Attention (`ATN`) asserted. This `ATN` tells the bus devices that the characters are to be interpreted as IEEE 488 bus commands, rather than as data. `EOI` is not asserted during `CMD` transfers. For example, `CMD &H3F` is the same as UnListen (`UNL`). Note that it is not possible to assert `EOI` during the transfer of a command byte, because `EOI` and `ATN` together specify Parallel Poll (`PPOLL`).

The maximum length of the `SEND` command, including any subcommands, is `255` characters. If large amounts of data must be transferred using the `SEND` command, then multiple `SEND` commands must be used so that they are each less than `255` characters long. For example:

```
PRINT#1,"SEND UNT UNL MTA LISTEN 16 DATA 1,2,3,4,5,6"
```

is equivalent to:

```
PRINT#1,"SEND UNT UNL MTA LISTEN 16"
PRINT#1,"SEND DATA 1,2,3"
PRINT#1,"SEND DATA 4,5,6"
```

In this way, a long `SEND` command can be broken up into shorter commands.

SPOLL

SYNTAX	`SPOLL [addr]`	
	`addr` is a device address (primary with optional secondary) or an external device name.	
RESPONSE	`0 or 64 (without addr)`	
	`Number in the range 0 to 255 (with addr)`	
MODE	`CA`	
BUS STATES	`ATN•UNL, MLA, TAG, SPE, *ATN, ATN•SPD, UNT`	
SEE ALSO	`SPOLL LIST, PPOLL`	
EXAMPLES	`PRINT#1,"SPOLL 16"`	Serial Poll device 16
	`INPUT#2,SPSTAT`	Receive the SPOLL status
	`IF SPSTAT AND 64 THEN`	Test rsv...
	`PRINT#1,"SPOLL"`	Check the SRQ status
	`INPUT#2,SRQ`	Receive the SRQ status
	`IF SRQ<>0 THEN`	If SRQ is asserted then ...

In Active Controller mode, the `SPOLL` (Serial Poll) command performs a Serial Poll of the bus device specified and responds with a number from `0` to `255` representing the decimal equivalent of the eight-bit device response. If `rsv` (`DIO7`, decimal value `64`) is set, then that device is signaling that it requires service. The meanings of the other bits are device-specific.

Serial Polls are normally performed in response to assertion of the Service Request (`SRQ`) bus signal by some bus device. In Active Controller mode, with no bus address specified, the `SPOLL` command returns the internal `SRQ` status. If the internal `SRQ` status is set, it usually indicates that the `SRQ` line is asserted. Driver488 then returns a `64`. If it is not set, indicating that `SRQ` is not asserted, then Driver488 returns a `0`.

In Peripheral mode, the `SPOLL` command is issued without an address, and returns the Serial Poll status. If `rsv` (`DIO7`, decimal value `64`) is set, then Driver488 has not been Serial Polled since the issuing last `REQUEST` command. The `rsv` is reset whenever Driver488 is Serial Polled by the Controller.

SPOLL LIST

SYNTAX	`SPOLL LIST [UNTIL_RSV|WHILE_SRQ|ALL] addr[, addr...]`	
	`addr` is a device name (primary with optional secondary) or an external device name to be Serial Polled.	
RESPONSE	`Number of devices serial polled followed by their responses which are numbers in the range 0 to 255, separated by commas.`	
MODE	`CA`	
BUS STATES	`ATN•UNL, MLA, TAG, SPE, *ATN, data, ATN•SPD, UNT`	
SEE ALSO	`SPOLL, PPOLL`	
EXAMPLES	`PRINT#1,"SPOLL LIST ALL 16,17"`	Serial Poll devices 16 and 17.
	`INPUT#2,SPSTAT`	Receive the SPOLL status.
	`2,64,12`	Device 16 responded with 64, and 17 responded with 12.
	`PRINT#1 "SPOLL LIST UNTIL_RSV 16,17"`	Serial Poll first device 16.
	`INPUT#2, SPSTAT`	Receive the SPOLL status.
	`1,64`	Device 16 responded with 64.

`SPOLL LIST` performs a Serial Poll of one or more bus devices, and responds with the number of devices actually polled and their individual responses. An optional flag specifies the criteria Driver488 should use to terminate scanning the list of devices.

If **`UNTIL_RSV`** is chosen, Driver488 Serial Polls the devices until the first device whose **`rsv`** bit is set, is found. If **`WHILE_SRQ`** is chosen, Driver488 Serial Polls the devices until the **`SRQ`** bus signal becomes unasserted. If **`ALL`** is chosen, all the devices are Serial Polled. The default is **`ALL`**.

STATUS

SYNTAX	`STATUS [name]`	
RESPONSE	`Character string as described below.`	
MODE	`Any`	
BUS STATES	`None`	
SEE ALSO	`ARM, SPOLL, GetError (Sub-Chapter 15B)`	
EXAMPLE	`PRINT#1,"STATUS"`	Read Driver488 status.
	`INPUT#2,A$`	Receive status.
	`PRINT A$`	Display status.

The **`STATUS`** command returns various items detailing the current state of Driver488/DRV. They are returned as one long character string, based on the following table:

STATUS Item (Starting Col., No. of Cols.)	**Values and Description**
`Operating model (1,1)`	**`C`**: Controller; **`P`**: Peripheral
`System Controller (2,1)`	**`S`**: System Controller; **`N`**: Not System Controller
`Primary Bus Address (3,2)`	**`00`** to **`30`**: Two-digit decimal number
`Secondary Bus Address (5,2)`	**`00`** to **`31`**: Two-digit decimal number, or blank if no secondary address
`Address Change (7,1)`	**`0`**: Address change has not occurred; **`1`**: Address change has occured
`Addressed State (9,1)`	**`T`**: Talker; **`L`**: Listener; **`I`**:Idle
`ByteIn (10,1)`	**`0`**: No byte in; **`1`**: Byte in
`ByteOut (11,1)`	**`0`**: No byte out; **`1`**: Byte out
`Service Request (12,1)`	**`0`**: SRQ is not asserted.; **`1`**: SRQ is asserted.
`Error Code (14,3)`	**`nnn`**: Three-digit error code
`Triggered (18,2)`	**`T0`**: Trigger command not received; **`T1`**: Trigger command received
`Cleared (21,2)`	**`C0`**: Clear command not received; **`C1`**: Clear command received.
`Transfer in Progress (24,2)`	**`P0`**: No transfer in progress; **`P1`**: Transfer in progress
`Error Message (27,x)`	Text of error message (**`x`** = variable text)

These **STATUS** items are more-fully described in the following paragraphs:

- The *Operating Mode* (**C** or **P**) indicates whether or not Driver488 is the Active Controller. If Driver488 passes control to another device, the Operating Mode indicator changes from **C** to **P**. When Driver488 regains control, the indicator is **C** again. If Driver488 is not the System Controller, it is initially a Peripheral and thus the indicator is **P**. It does, of course, become **C** when Driver488 receives control from the Active Controller.
- The *System Controller Mode* (**S** or **N**) indicates whether or not Driver488 is the System Controller. If Driver488 is System Controller, the System Controller Mode indicator is **S**. If Driver488 is not System Controller, then the System Controller Mode indicator is **N**. The System Controller Mode may be configured from the **INSTALL** program or with the **SYS CONTROLLER** command.
- The *Primary Bus Address* (**00** to **30**) is the IEEE 488 bus device primary address assigned to Driver488 or the specified device. The *Secondary Bus Address* (**00** to **31**) is the IEEE 488 bus device secondary address assigned to the specified device. If there is no secondary address, this field is blank.
- The *Address Change* (**0** or **1**) indicator is set whenever Driver488 become a Talker, Listener, or the Active Controller, or when it becomes no longer a Talker, Listener, or the Active Controller. It is reset when **STATUS** is read. The *Addressed State* (**T**, **L**, or **I**) is the current Talker/Listener state of Driver488. As a Peripheral, Driver488 can check this status to see if it has been addressed to **Talk** or addressed to **Listen** by the Active Controller. In this way, the desired direction of data transfer can be determined.
- The *ByteIn* (**0** or **1**) indicator is set when the I/O adapter has received a byte that can be read by an **ENTER** command. The *ByteOut* (**0** or **1**) indicator is set when the I/O adapter is ready to output data. The *Service Request* (**0** or **1**) field, as an Active Controller, reflects the IEEE 488 bus **SRQ** line signal. As a peripheral, this status reflects the **rsv** bit that can be set by the **REQUEST** command and is cleared when the Driver488 is Serial Polled (**SPOLL**).
- The *Error Code* (**000**) indicator appears when no error has occurred. If it is non-zero, then the Error Message (see below) is appended to the **STATUS** response. The Error Code is reset to **000** when **STATUS** is read.
- The *Triggered* (**T0** or **T1**) and *Cleared* (**C0** or **C1**) indicators are set when, as a Peripheral, Driver488 is triggered or cleared. These two indicators are cleared when **STATUS** is read. The *Transfer in Progress* (**P1**) indicator is set when a **CONTINUE** transfer is in progress. The Triggered and Cleared indicators are not updated while **CONTINUE** transfers (**P1**) are in progress.
- The *Error Message* is a variable text description of the error status. For more details about the individual errors, refer to Chapter 19 “Error Messages.”

The standard default setting yields the following power-up status response:

```
CS21 1 I000 000 T0 C0 P0 OK
```

where the following indicators describe each component of the Driver488/DRV status:

Indicator	Driver488/DRV Status
C	It is in the Controller state.
S	It is the System Controller.
21	The value of its IEEE 488 bus address.
1	An Address Change has occurred.
I	It is Idle (neither a Talker nor a Listener).
0	There is no **ByteIn** available.
0	It is not ready to send a **ByteOut**.
0	Service Request (**SRQ**) is not asserted.
000	There is no outstanding error.
T0	It has not received a bus device **TRIGGER** command (only applicable in the Peripheral mode).
C0	It has not received a **CLEAR** command (only applicable in the Peripheral mode).
P0	No **CONTINUE** transfer is in progress.
OK	The error message is “OK”.

STOP

SYNTAX	`STOP[name]`
RESPONSE	`None`
MODE	`Any`
BUS STATES	`ATN (Controller)`
	`None (Peripheral)`
SEE ALSO	`ENTER, OUTPUT, BUFFERED, STATUS`
EXAMPLE	`PRINT#1,"STOP"`

The **`STOP`** command halts any **`CONTINUE`** transfer that may be in progress. If the transfer has completed already, then **`STOP`** has no effect. The actual number of characters transferred is available from the **`BUFFERED`** command.

SYS CONTROLLER

SYNTAX	`SYS CONTROLLER [OFF|ON]`
RESPONSE	`None`
MODE	`Any`
BUS STATES	`IFC if System Controller`
SEE ALSO	`ABORT, RESET`
EXAMPLES	`PRINT#1"SYS CONTROLLER OFF"`

The **`SYS CONTROLLER`** command specifies whether or not the IEEE 488 interface card is to be the System Controller. The System Controller has ultimate control of the IEEE 488, and there may be only one System Controller on a bus.

If Driver488 is a Peripheral (that is, not System Controller), it may still take control of bus transactions if the Active Controller passes control to Driver488. Driver488 may then control the bus and, when it is done, pass control back to the System Controller or other computer, which then becomes the Active Controller.

TERM

SYNTAX	`TERM[;] [devicename] [IN|OUT]term[term][EOI]`	
	`devicename` refers to an external device name.	
	`IN` or **`OUT`** specifies whether the input or output terminators are being set. If neither **`IN`** nor **`OUT`** is specified, then both terminators are set identically.	
	`term` is one of **`CR`**, **`LF`**, **`$char`**, or **`'X`**, specifying a terminator character.	
RESPONSE	`None`	
MODE	`Any`	
BUS STATES	`None`	
SEE ALSO	`EOL, ENTER, OUTPUT, STATUS`	
EXAMPLES	`PRINT#1,"TERM CR LF EOI"`	Set both input and output bus terminators to carriage return line feed, with EOI sent on output and detected on input.
	`PRINT#1,"TERM OUT LF EOI"`	Set output term to LF with EOI.
	`PRINT#1,"TERM IN 'Z"`	Set bus input term to the letter "Z".
	`PRINT#1,"TERM OUT $0 EOI"`	Set output term to NULL with EOI.

The **`TERM`** command sets the end-of-line (**`EOL`**) terminators for input from, and output to, the I/O adapter devices. All output to I/O adapter devices, except **`OUTPUT #count`** and **`OUTPUT #count BUFFER`**, is terminated by the bus output terminator. All **`ENTER`** input from I/O adapter devices, except **`ENTER #count`** and **`ENTER #count BUFFER`**, must be terminated by the bus input terminator.

During **`OUTPUT`**, Driver488 takes the **`EOL`** terminator it receives from the user's program, and replaces it with the bus output terminator before sending it to the I/O adapter device. Conversely, when Driver488 receives the bus input terminator, it replaces it with the **`EOL`** input terminator before returning it to the user's program. The default terminators for both input and output are normally **`CR LF EOI`**, which is appropriate for most bus devices.

`EOI` has a different meaning when specified for input than when it is specified for output. During input, **`EOI`** specifies that input is terminated on detection of the **`EOI`** bus signal, regardless of which characters have been received. During output, **`EOI`** specifies that the **`EOI`** bus signal is to be asserted during the last byte transferred.

TIME OUT

SYNTAX	`TIME OUT [devicename] n[.[n][n][n]]`	
	`devicename` is the name of the external device.	
	`n[.[n][n][n]]`, the time out value, is the number of seconds to allow in the range of `0.000` to `65535.999`. If zero is specified, ignore time outs. A leading `0` must be used for time out intervals below `1.000` second.	
RESPONSE	`None`	
MODE	`Any`	
BUS STATES	`None`	
SEE ALSO	`RESET, MAKE DEVICE`	
EXAMPLES	`PRINT#1,"TIME OUT10"`	Reset to default (10 seconds).
	`PRINT#1,"TIME OUT0.5"`	Set time out interval to one-half second.
	`PRINT#1,"TIME OUT3600"`	Wait an hour before a time out error.
	`PRINT#1,"TIME OUT0"`	Ignore time outs.

The **`TIME OUT`** command sets the number of seconds that Driver488 waits for a transfer before declaring a time out error. Driver488 checks for time out errors on every byte it transfers, except in the case of **`CONTINUE`** transfers. While the first byte of a **`CONTINUE`** transfer is checked for time out errors, subsequent bytes are not. The user's program must check for timely completion of a **`CONTINUE`** transfer.

Time out checking may be suppressed by specifying time out after zero seconds. The default time out is `10` seconds. The time out interval may be specified to the nearest `0.001` seconds. However, due to the limitations of the computer, the actual interval is always a multiple of `0.055` seconds (55 milliseconds) and there is an uncertainty of `0.055` seconds in the actual time out interval. Time out intervals from `0.010` to `0.110` seconds are rounded to `0.110` seconds. Larger intervals are rounded to the nearest multiple of `0.055` seconds (e.g., `0.165`, `0.220`, `0.275` seconds, etc.).

TRIGGER

SYNTAX	`TRIGGER [addr[,addr...]]`	
	`addr` is a device address (primary with optional secondary) or an external device name to be triggered.	
RESPONSE	`None`	
MODE	`CA`	
BUS STATES	`ATN•GET (without addr)`	
	`ATN•UNL, MTA, LAG, GET (with addr)`	
SEE ALSO	`STATUS, SEND, TriggerList (Sub-Chapter 15B)`	
EXAMPLES	`PRINT#1,"TRIGGER"`	Trigger all current listeners.
	`PRINT#1,"TRIGGER02,04,16"`	Issue Group Execute Trigger (GET) to devices 2, 4, and 16.

The **`TRIGGER`** command issues a Group Execute Trigger (**`GET`**) bus command to the specified devices. If no addresses are specified, then the **`GET`** only affects those devices that are already in the Listen state as a result of a previous **`OUTPUT`** or **`SEND`** command.

WAIT

SYNTAX	`WAIT`
RESPONSE	`None`
MODE	`Any`
BUS STATES	`Determined by previous ENTER or OUTPUT command`
SEE ALSO	`ENTER, OUTPUT, BUFFERED, STATUS`
EXAMPLE	`PRINT#1,"WAIT"` Wait for CONTINUE transfer to be done.

The **`WAIT`** command causes Driver488 to wait until any **`CONTINUE`** transfer has completed, before returning to the user's program. It can be used to guarantee that the data has actually been received before beginning to process it, or that it has been sent before overwriting the buffer. It is especially useful with **`ENTER`** when a terminator has been specified. In that case, the amount that is actually received is unknown, and so the user's program must check with Driver488 to determine when the transfer is done. Time out checking, if enabled, is performed while **`WAIT`**ing.

15B. Driver488/SUB, W31, W95, & WNT Commands

This Sub-Chapter contains command reference for Driver488/SUB, Driver488/W31, Driver488/W95, and Driver488/WNT, *using the C language*. The commands are presented in alphabetical order on the following pages for ease of use. For more information on the format of the command descriptions, turn to the Sub-Chapter "Command Descriptions" of Chapter 9.

Note: The differences among Driver488 for Windows 3.x, Windows 95 and Windows NT are slight. However, because additional changes are being made to Driver488/W95 and Driver488/WNT at the time this manual is being revised, *refer to your operating system header file* (and `README.TXT` text file, if present) *to obtain the current material on these driver versions.*

Bus Management Commands	Page
Abort	III-313
AutoRemote	III-314
CheckListener	III-315
ControlLine (Driver488/SUB only)	III-317
ControlLine (Driver488/W31, W95)	III-318
FindListeners	III-325
Lol	III-330
PassControl	III-340
PPollConfig	III-340
PPollDisable	III-341
PPollDisableList	III-341
PPollUnconfig	III-341
Request	III-343
Reset	III-343

Instrument Management Commands	Page
Clear	III-316
ClearList	III-316
Local	III-329
LocalList	III-329
Remote	III-342
RemoteList	III-342
Trigger	III-350
TriggerList	III-351

Device Management Commands	Page
BusAddress	III-315
Close	III-317
KeepDevice	III-328
MakeDevice	III-330
MakeNewDevice	III-330
OpenName	III-334
RemoveDevice	III-342

Device I/O Commands	Page
Enter (Controller Mode)	III-319
Enter (Peripheral Mode)	III-321
EnterI (Controller Mode)	III-322
EnterI (Peripheral Mode)	III-324
Output (Controller Mode)	III-334
Output (Peripheral Mode)	III-336
OutputI (Controller Mode)	III-337
OutputI (Peripheral Mode)	III-339
PPoll	III-340
SPoll	III-345
SPollList	III-346

Low-Level Bus Commands	Page
Listen	III-329
MyListenAddr	III-331
MyTalkAddr	III-331
SendCmd	III-344
SendData	III-344
SendEoi	III-345
Talk	III-348
UnListen	III-351
UnTalk	III-351

Event Handling Commands	Page
Arm	III-313
Disarm	III-318
OnEvent (Driver488/SUB only)	III-331
OnEvent (Driver488/W31, W95)	III-332
OnEventVDM (Driver488/W95)	III-333

I/O Management Commands	Page
Buffered	III-314
Finish	III-325
Resume	III-344
Stop	III-348
Wait	III-352

Interface Management Commands	Page
ClockFrequency	III-316
DmaChannel	III-319
IntLevel	III-327
IOAddress	III-328
LightPen	III-328
SysController	III-348
Term	III-349
TermQuery	III-349
TimeOut	III-350
TimeOutQuery	III-350

Error Management Commands	Page
Error	III-324
GetError	III-326
GetErrorList	III-326

Miscellaneous Commands	Page
Hello	III-327
Status	III-346

Abort

SYNTAX	`int pascal Abort(DevHandleT devHandle);`
	`devHandle` refers to either an IEEE 488 hardware interface or an external device. If `devHandle` refers to an external device, the `Abort` command will act on the hardware interface to which the external device is attached.
RETURNS	`-1 if error`
MODE	`SC or *SC•CA`
BUS STATES	`IFC, *IFC (SC)`
	`ATN•MTA (*SCCA)`
SEE ALSO	`SysController`
EXAMPLE	`errorflag = Abort(ieee);`

As the System Controller (`SC`), whether Driver488 is the Active Controller or not, the `Abort` command causes the Interface Clear (`IFC`) bus management line to be asserted for at least 500 microseconds. By asserting `IFC`, Driver488 regains control of the bus even if one of the devices has locked it up during a data transfer. Asserting `IFC` also makes Driver488 the Active Controller. If a Non System Controller was the Active Controller, it is forced to relinquish control to Driver488. `Abort` forces all IEEE 488 device interfaces into a quiescent state.

If Driver488 is a Non System Controller in the Active Controller state (`*SC•CA`), it asserts Attention (`ATN`), which stops any bus transactions, and then sends its My Talk Address (`MTA`) to "Untalk" any other Talkers on the bus. It does not (and cannot) assert `IFC`.

Arm

SYNTAX	`int pascal Arm(DevHandleT devHandle, ArmCondT condition);`
	`devHandle` refers to either an IEEE 488 hardware interface or an external device. If `devHandle` refers to an external device, the `Arm` command acts on the hardware interface to which the external device is attached.
	`condition` is one of the following: `acError, acSRQ, acPeripheral, acController, acTrigger, acClear, acTalk, acListen, acIdle, acByteIn, acByteOut,` or `acChange`.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`Disarm, OnEvent, LightPen`
EXAMPLE	`errorflag = Arm(ieee, acSRQ|acTrigger|acChange);`

The following `Arm` conditions are supported:

Condition	Description
`acSRQ`	The Service Request bus line is asserted.
`acPeripheral`	An addressed status change has occurred and the interface is a Peripheral.
`acController`	An addressed status change has occurred and the interface is an Active Controller.
`acTrigger`	The interface has received a device `Trigger` command.
`acClear`	The interface has received a device `Clear` command.
`acTalk`	An addressed status change has occurred and the interface is a Talker.
`acListen`	An addressed status change has occurred and the interface is a Listener.
`acIdle`	An addressed status change has occurred and the interface is neither Talker nor Listener.
`acByteIn`	The interface has received a data byte.
`acByteOut`	The interface has been configured to output a data byte.
`acError`	A Driver488 error has occurred.
`acChange`	The interface has changed its addressed status. Its Controller/Peripheral or Talker/Listener/Idle states of the interface have changed.

The **`Arm`** command allows Driver488 to signal to the user specified function when one or more of the specified conditions occurs. **`Arm`** sets a flag corresponding to each implementation of the conditions indicated by the user. **`Arm`** conditions may be combined using the bitwise **`OR`** operator.

Once an interrupt is **`Arm`**ed, it remains **`Arm`**ed until it is **`Disarm`**ed, or until Driver488 is reset. BASIC automatically suppresses light pen interrupt detection during the execution of an interrupt service routine, so the interrupt service routine is never re-entrantly invoked. In languages that explicitly poll the light pen status, polling should not be done during the interrupt service routine.

If Pascal or C is being used, the **`OnEvent`** function must be called. This function acts similar to the **`ON PEN`** command in BASIC. When the **`Arm`**ed condition occurs, the **`OnEvent`** function calls a function specified by the user.

AutoRemote

SYNTAX	`int pascal AutoRemote(DevHandleT devHandle, bool flag);`
	`devHandle` refers to either an IEEE 488 hardware interface or an external device. If **`devHandle`** refers to an external device, the **`AutoRemote`** command acts on the hardware interface to which the external device is attached.
	`flag` may be either **`OFF`** or **`ON`**
RETURNS	`-1 if error.`
	`When the flag is non-zero, AutoRemote is enabled; a zero flag disables the function.`
MODE	`SC`
BUS STATES	`None`
SEE ALSO	`Local, Remote, Enter (see EnterX), Output (see OutputX)`
EXAMPLE	`errorcode = AutoRemote(ieee,ON);`

The **`AutoRemote`** command enables or disables the automatic assertion of the Remote Enable (**`REN`**) line by **`Output`**. When **`AutoRemote`** is enabled, **`Output`** automatically asserts **`REN`** before transferring any data. When **`AutoRemote`** is disabled, there is no change to the **`REN`** line. **`AutoRemote`** is on by default.

Buffered

SYNTAX	`long pascal Buffered(DevHandleT devHandle);`
	`devHandle` refers to either an IEEE 488 hardware interface or an external device. If devHandle refers to an external device, the **`Buffered`** command acts on the hardware interface to which the external device is attached.
RETURNS	`-1 if error, otherwise long integer from 0 to 1,048,575(`2^{20}`-1)`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`Enter (see EnterX), Output (see OutputX)`

EXAMPLE	`result = Buffered(ieee);`
	`printf("%ld bytes were received.",result);`

The **`Buffered`** command returns the number of characters transferred by the latest **`Enter`**, **`Output`**, **`SendData`**, or **`SendEoi`** command. If an asynchronous transfer is in progress, the result is the number of characters that have been transferred at the moment the command is issued. This command is most often used after a **`counted`** **`Enter`**, **`EnterN`**, **`EnterNMore`**, etc., to determine if the full number of characters was received, or if the transfer terminated upon detection of **`term`**. It is also used to find out how many characters have currently been sent during an asynchronous DMA transfer.

BusAddress

SYNTAX	`int pascal BusAddress (DevHandleT devHandle, char primary, char secondary);`
	`devHandle` refers to either an IEEE 488 hardware interface or an external device.
	`primary` is the IEEE 488 bus primary address of the specified device.
	`secondary` is the IEEE 488 bus secondary address of the specified device. If the specified device is an IEEE 488 hardware interface, this value must be `-1` since there are no secondary addresses for the IEEE 488 hardware interface. For no secondary address, a `-1` must be specified.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`MakeDevice`
EXAMPLE	`errorcode = BusAddress(dmm,14,0);`

The **`BusAddress`** command sets the IEEE 488 bus address of the IEEE 488 hardware interface or an external device. Every IEEE 488 bus device has an address that must be unique within any single IEEE 488 bus system. The default IEEE 488 bus address for Driver488 is `21`, but this may be changed if it conflicts with some other device.

CheckListener

SYNTAX	`int pascal CheckListener(DevHandleT devHandle, char primary, char secondary);`
	`devHandle` refers to either an IEEE 488 hardware interface or an external device. If **`devHandle`** refers to an external device, the **`CheckListener`** command acts on the hardware interface to which the external device is attached.
	`primary` is the primary bus address to check for a Listener (`00` to `30`)
	`secondary` is the secondary bus address to check for a Listener (`00` to `31`). For no secondary address, a `-1` must be specified
RETURNS	`-1 if error,`
	`otherwise it returns a 1 if a listener was found at the specified address and a 0 if a listener was not found at the specified address.`
MODE	`CA`
BUS STATES	`ATN•MTA, UNL, LAG, (check for NDAC asserted)`
SEE ALSO	`FindListener, BusAddress`

EXAMPLE	`result = CheckListener(ieee,15,4);`
	`if (result == 1)`
	`{`
	`printf("Device found at specified address.\n");`
	`}`
	`if (result == 0)`
	`{`
	`printf("Device not found at specified address.\n");`
	`}`

The **`CheckListener`** command checks for the existence of a device on the IEEE 488 bus at the specified address.

Clear

SYNTAX	`int pascal Clear(DevHandleT devHandle);`	
	`devHandle` refers to either an IEEE 488 hardware interface or an external device. If `devHandle` refers to a hardware interface, then a Device Clear (`DCL`) is sent. If `devHandle` refers to an external device, a Selected Device Clear (`SDC`) is sent.	
RETURNS	`-1 if error`	
MODE	`CA`	
BUS STATES	`ATN•DCL (all devices)`	
	`ATN•UNL, MTA, LAG, SDC (selected device)`	
SEE ALSO	`Reset, ClearList`	
EXAMPLES	`errorcode = Clear(ieee);`	Sends the Device Clear (DCL) command to the interface board
	`errorcode = Clear(wave)`	Sends the Selected Device Clear (SDC) command to the WAVE
	`errorcode = Clear(dmm)`	Sends the Selected Device Clear (SDC) command to the DMM

The `Clear` command causes the Device Clear (`DCL`) bus command to be issued to an interface or a Selected Device Clear (`SDC`) command to be issued to an external device. IEEE 488 bus devices that receive a Device Clear or Selected Device Clear command normally reset to their power-on state.

ClearList

SYNTAX	`int pascal ClearList(DevHandlePT devHandles);`	
	`devHandles` is a pointer to a list of device handles that refer to external devices. If a hardware interface is in the list, `DCL` is sent instead of `SDC`.	
RETURNS	`-1 if error`	
MODE	`CA`	
BUS STATES	`ATN•DCL (all devices)`	
	`ATN•UNL, MTA, LAG, SDC (selected device)`	
SEE ALSO	`Clear, Reset`	

EXAMPLES	`deviceList[0] = wave;`
	`deviceList[1] = scope;`
	`deviceList[2] = dmm;`
	`deviceList[3] = NODEVICE;`
	`errorcode = ClearList(deviceList);`
		Sends the Selected Device Clear (SDC) command to a list of devices.

The `ClearList` command causes the Selected Device Clear (`SDC`) command to be issued to a list of external devices. IEEE 488 bus devices that receive a Selected Device Clear command normally reset to their power-on state.

ClockFrequency

Driver488/SUB and Driver488/W31 only

SYNTAX	`int pascal ClockFrequency(DevHandleT devHandle,int freq);`
	`devHandle` refers to either an IEEE 488 Interface or an external device. If `devHandle` refers to an external device, the `ClockFrequency` command acts on the hardware interface to which the external device is attached.
	`freq` is the actual clock rate rounded up to the nearest whole number of MHz.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`Reset`

EXAMPLE	`errorcode = ClockFrequency(ieee, 8);`

The `ClockFrequency` command specifies the IEEE 488 adapter internal clock frequency. The clock frequency depends upon the design and jumper settings of the interface board. The specified clock frequency must be the actual clock rate in megahertz (MHz) rounded up to the nearest whole number of megahertz. The MP488 and MP488CT boards use a fixed clock frequency of 8 MHz.

Note: This command is not applicable to the NB488.

Close

SYNTAX	`int pascal Close(DevHandleT devHandle);`
	`devHandle` refers to either an IEEE 488 interface or an external device.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`Completion of any pending I/O activities`
SEE ALSO	`OpenName, MakeDevice, Wait`
EXAMPLE	`errorcode = Close(wave);`

The `Close` command waits for I/O to complete, flushes any buffers associated with the device that is being closed, and then invalidates the handle associated with the device.

ControlLine

Driver488/SUB only

SYNTAX	`int pascal ControlLine(DevHandleT devHandle);`
	`ControlLine` returns a bit mapped number.
	`devHandle` refers to the I/O adapter. If `devHandle` refers to an external device, the `ControlLine` command acts on the hardware interface to which the external device is attached.
RESPONSE	`-1 if error,`
	`otherwise, a bit mapped integer indicating the value of the control lines.`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`TimeOut`

EXAMPLES	`result = ControlLine(ieee);`
	`printf("The response is %X\n",result);`

The `ControlLine` command may be used on either IEEE 488 devices or Serial devices. If the device specified is an IEEE 488 device, this command returns the status of the IEEE 488 bus control lines as an 8-bit unsigned value (bits 2 and 1 are reserved for future use), as shown below:

8	**7**	**6**	**5**	**4**	**3**	**2**	**1**
`EOI`	`SRQ`	`NRFD`	`NDAC`	`DAV`	`ATN`	`0`	`0`

If the device refers to a Serial device, this command returns the status of the Serial port control lines as an 8-bit unsigned value (bits 8 and 7 are reserved for future use), as shown below:

8	**7**	**6**	**5**	**4**	**3**	**2**	**1**
`0`	`0`	`DSR`	`RI`	`DCD`	`CTS`	`DTR`	`RTS`

A fuller description of the above bus line abbreviations are provided below:

Bus State	**Bus Lines**	**Data Transfer (DIO) Lines**							
		8	**7**	**6**	**5**	**4**	**3**	**2**	**1**
	IEEE 488 Interface								
`ATN`	Attention (&H04)	0	0	0	0	0	1	0	0
`EOI`	End-Or-Identify (&H80)	1	0	0	0	0	0	0	0
`SRQ`	Service Request (&H40)	0	1	0	0	0	0	0	0
`DAV`	Data Valid (&H08)	0	0	0	0	1	0	0	0
`NDAC`	Not Data Accepted (&H10)	0	0	0	1	0	0	0	0
`NRFD`	Not Ready For Data (&H20)	0	0	1	0	0	0	0	0
	Serial Interface								
`DTR`	Data Terminal Ready (&H02)	0	0	0	0	0	0	1	0
`RI`	Ring Indicator (&H10)	0	0	0	1	0	0	0	0
`RTS`	Request To Send (&H01)	0	0	0	0	0	0	0	1
`CTS`	Clear To Send (&H04)	0	0	0	0	0	1	0	0
`DCD`	Data Carrier Detect (&H08)	0	0	0	0	1	0	0	0
`DSR`	Data Set Ready (&H20)	0	0	1	0	0	0	0	0

ControlLine

Driver488/W31 and Driver488/W95 only

SYNTAX	`int pascal ControlLine(DevHandleT devHandle);`
	`ControlLine` returns a bit mapped number.
	`devHandle` refers to the I/O adapter. If `devHandle` refers to an external device, the `ControlLine` command acts on the hardware interface to which the external device is attached.
RESPONSE	`-1 if error,`
	`otherwise, a bit mapped integer indicating the value of the control lines.`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`TimeOut, ControlLine (Driver488/SUB only)`

EXAMPLES	`result = ControlLine(ieee);`
	`printf("The response is %X\n",result);`

The `ControlLine` command applies to IEEE 488 devices only. It returns the status of the IEEE 488 bus control lines as an 8-bit unsigned value (bits 2 and 1 are reserved for future use), as shown below:

8	**7**	**6**	**5**	**4**	**3**	**2**	**1**
`EOI`	`SRQ`	`NRFD`	`NDAC`	`DAV`	`ATN`	`0`	`0`

Disarm

SYNTAX	`int pascal Disarm(DevHandleT devHandle, ArmCondT condition);`
	`devHandle` refers to either an IEEE 488 interface or an external device. If `devHandle` refers to an external device, then the `Disarm` command acts on the hardware interface to which the external device is attached.
	`condition` specifies which of the conditions are no longer to be monitored. If condition is `0`, then all conditions are `Disarm`ed.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`Arm, OnEvent, LightPen`
EXAMPLES	`errorcode=Disarm(ieee,acTalk|acListen|acChange);`

	`errorcode=Disarm(ieee,0);`

The `Disarm` command prevents Driver488 from setting the light pen status or invoking an event handler and interrupting the PC, even when the specified condition occurs. The user's program can still check for the condition by using the `Status` command. If the `Disarm` command is invoked without specifying any conditions, then all conditions are disabled. The `Arm` command may be used to re-enable interrupt detection.

DmaChannel

Driver488/SUB and Driver488/W31 only

SYNTAX	`int pascal DmaChannel(DevHandleT devHandle, int channel);`
	`devHandle` refers to either an IEEE 488 interface or an external device. If `devHandle` refers to an external device, the `DmaChannel` command acts on the hardware interface to which the external device is attached.
	`channel` is the DMA channel to be used by the I/O adapter, or `-1` for NONE.
RESPONSE	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`IntLevel, TimeOut`
EXAMPLE	`errorcode = DmaChannel(ieee, 5);`

The `DmaChannel` command specifies which DMA channel, if any, is to be used by the I/O interface card. The PC has four DMA channels, but channel `0` is used for memory refresh and is not available for peripheral data transfer. Channel `2` is usually used by the floppy-disk controller and is also unavailable. Channel `3` is used by the hard disk controller in PCs, but is usually not used in AT compatible machines. So, channel `1` (and possibly channel `3`) is available for DMA transfers. The AT compatible computers have three 16-bit DMA channels: `5`, `6`, and `7`. The MP488CT, MP488, and AT488 interfaces can use these channels for high speed transfer. The `DmaChannel` value must match the hardware jumper settings on the I/O adapter card.

Note: This command is not applicable to the NB488.

Enter (Controller Mode)

EnterX

SYNTAX	`long pascal EnterX(DevHandleT devHandle, char *data,long count,bool forceAddr,TermT*term,bool async,int *compStat);`
	`devHandle` refers to either an IEEE 488 interface or an external device.
	`data` is a pointer to the buffer into which the data is read.
	`count` is the number of characters to read.
	`forceAddr` is used to specify whether the addressing control bytes are to be issued for each `EnterX` command.
	`term` is a pointer to a terminator structure that is used to set up the input terminators. If `term` is set to `0`, the default terminator is used.
	`async` is a flag that allows asynchronous data transfer.
	`compStat` is a pointer to an integer containing completion status information.
RETURNS	`-1 if error,`
	`otherwise, the number of bytes transferred. The memory buffer pointed to by the data parameter is filled in with the information read from the device.`
MODE	`CA`
BUS STATES	`ATN•UNL, MLA, TAG, *ATN, data   (With external device handle)`
	`*ATN, data   (With interface handle)`
SEE ALSO	`OutputX, Term, EOL, Buffered`
EXAMPLE	`See next page.`

EXAMPLE	`term.EOI = TRUE;`
	`term.nChar = 1;`
	`term.EightBits = TRUE;`
	`term.termChar[0] = '\r';`
	`bytecount=EnterX(timer,data,1024,0,&term,1,&stat);`

The **`EnterX`** command reads data from the I/O adapter. If an external device is specified, then Driver488 is addressed to Listen, and that device is addressed to Talk. If an interface is specified, then Driver488 must already be configured to receive data and the external device must be configured to Talk, either as a result of an immediately preceding **`EnterX`** command or as a result of one of the **`Send`** commands. **`EnterX`** terminates reception on either the specified count of bytes transferred, or the specified or default terminator being detected. Terminator characters, if any, are stripped from the received data before the **`EnterX`** command returns to the calling application.

The **`forceAddr`** flag is used to specify whether the addressing control bytes are to be issued for each **`EnterX`** command. If the device handle refers to an I/O adapter, then **`forceAddr`** has no effect and command bytes are not sent. For an external device, if **`forceAddr`** is **`TRUE`** then Driver488 always sends the **`UNL`**, **`MLA`**, and **`TAG`** command bytes. If **`forceAddr`** is **`FALSE`**, then Driver488 compares the current device with the previous device that used that interface adapter board for an **`EnterX`** command. If they are the same, then no command bytes are sent. If they are different, then **`EnterX`** acts as if the **`forceAddr`** flag were **`TRUE`** and sends the command bytes. The **`forceAddr`** flag is usually set **`TRUE`** for the first transfer of data from a device, and then set **`FALSE`** for additional transfers from the same block of data from that device.

Additional Enter Functions

Driver488 provides additional **`Enter`** routines that are short form versions of the **`EnterX`** function. The additional **`Enter`** functions are: **`Enter`**, **`EnterN`**, **`EnterMore`**, and **`EnterNMore`**. These functions are discussed in detail below:

Enter	
SYNTAX	`long pascal Enter(DevHandleT devHandle, char *data)`
REMARKS	**`Enter`** is equivalent to the following call to **`EnterX`**: `EnterX(devHandle,data,sizeof(data),1,0L,0,0L);`

The **`Enter`** function passes the device handle and a pointer to the data buffer to the **`EnterX`** function. It determines the size of the data buffer provided by the user and passes that value as the **`count`** parameter. It specifies **`forceAddr`** is **`TRUE`**, causing Driver488 to re-address the device. The default terminators are chosen by specifying a **`0`** as the **`term`** parameter. Asynchronous transfer is turned off by sending **`0`** for the **`async`** parameter, and the completion status value is ignored by sending **`0`** for the **`compStat`** parameter.

EnterN	
SYNTAX	`long pascal EnterN(DevHandleT devHandle,char *data,int count)`
REMARKS	**`EnterN`** is equivalent to the following call to **`EnterX`**: `EnterX(devHandle,data,count,1,0L,0,0L);`

The **`EnterN`** function passes the device handle, the pointer to the data buffer, and the size of the data buffer to the **`EnterX`** function. It specifies **`forceAddr`** is **`TRUE`**, causing Driver488 to re-address the device. The default terminators are chosen by specifying a **`0`** pointer as the **`term`** parameter. Asynchronous transfer is turned off by sending **`0`** for the **`async`** parameter, and the completion status value is ignored by sending **`0`** for the **`compStat`** parameter.

EnterMore	
SYNTAX	`long pascal EnterMore(DevHandleT devHandle,char *data)`
REMARKS	**`EnterMore`** is equivalent to the following call to **`EnterX`**: `EnterX(devHandle,data,sizeof(data),0,0L,0,0L);`

The **EnterMore** function passes the device handle and the pointer to the data buffer to the **EnterX** function. It determines the size of the data buffer provided by the user and passes that value as the **count** parameter. It specifies **forceAddr** is **FALSE**, therefore Driver488 does not address the device if it is the same device as previously used. The default terminators are chosen by specifying a **0** as the **term** parameter. Asynchronous transfer is turned off by sending **0** for the **async** parameter, and the completion status value is ignored by sending **0** for the **compStat** parameter.

EnterNMore	
SYNTAX	`long pascal EnterNMore(DevHandleT devHandle,char *data,int count);`
REMARKS	**EnterNMore** is equivalent to the following call to **EnterX**: `EnterX(devHandle,data,count,0,0L,0,0L);`

The **EnterNMore** function passes the device handle, the pointer to the data buffer, and the size of the data buffer to the **EnterX** function. It specifies **forceAddr** is **FALSE**; therefore, Driver488 does not address the device if it is the same device as previously used. The default terminators are chosen by specifying a **0** as the **term** parameter. Asynchronous transfer is turned off by sending **0** for the **async** parameter, and the completion status value is ignored by sending **0** for the **compStat** parameter.

Enter (Peripheral Mode)

EnterX	
SYNTAX	`long pascal EnterX(DevHandleT devHandle, char *data, long count,bool forceAddr,TermT*term,bool async,int *compStat);`
	devHandle refers to either an IEEE 488 interface or an external device.
	data is a pointer to the buffer into which the data is read.
	count is the number of characters to read.
	forceAddr is ignored.
	term is a pointer to a terminator structure that is used to set up the input terminators. If **term** is set to **0**, the default terminators are used.
	async is a flag that allows asynchronous data transfer.
	compStat is a pointer to an integer containing completion status information.
RETURNS	`-1 if error,`
	`otherwise, the number of bytes transferred. The memory buffer pointed to by the data parameter is filled in with the information read from the device.`
MODE	`*CA`
BUS STATES	`Determined by the Controller`
SEE ALSO	`Output, Term, Buffered, EOL (Sub-Chapter 15A)`

EXAMPLE	`term.EOI = TRUE;`
	`term.nChar = 1;`
	`term.EightBits = TRUE;`
	`term.termChar[0] = '\r';`
	`bytecount=EnterX(timer,data,1024,0,&term,1,&stat);`

In Peripheral mode, the **EnterX** command receives data from the I/O adapter under control of the Active Controller. The Active Controller must put Driver488 into the Listen state and configure some bus device to provide Driver488 with data. The Listen state can be checked with the **Status** command, or can cause an interrupt with the **Arm** command. A time-out error occurs (if enabled) if Driver488 does not receive a data byte within the time out period after issuing the **EnterX** command.

Additional Enter Functions

Driver488 provides additional **Enter** routines that are short form versions of the **EnterX** function. The additional **Enter** functions are: **Enter** and **EnterN**. In Peripheral mode, the device handle must always refer to an I/O adapter, and the **`forceAddr`** flag is ignored. Thus, **`EnterMore`** is equivalent to **`Enter`**, and **`EnterNMore`** is equivalent to **`EnterN`**.

EnterI (Controller Mode)

Driver488/W31 (Visual Basic only)

EnterXI	
SYNTAX	`EnterXI (ByVal devHandle% ,data%, ByVal count&, ByVal forceAddr%, Term As terms, ByVal async%, compStat%)As Long`
	`devHandle%` refers to either an IEEE 488 interface or an external device.
	`data%` is the first element in an integer array into which the data is read.
	`count&` is the number of characters to read.
	`forceAddr%` is used to specify whether the addressing control bytes are to be issued for each **`EnterXI`** command.
	`term` is a pointer to a terminator structure that is used to set up the input terminators. If **`term`** is set to **`0`**, the default terminator is used.
	`async%` is a flag that allows asynchronous data transfer.
	`compStat%` is a pointer to an integer containing completion status information.
RETURNS	`-1 if error,`
	`otherwise the number of bytes transferred. The memory buffer pointed to by the data parameter is filled in with the information read from the device.`
MODE	`CA`
BUS STATES	`ATN•UNL, MLA, TAG, *ATN, data (With external device handle)`
	`*ATN, data (With interface handle)`
SEE ALSO	`Output, Term, Buffered, EOL (Sub-Chapter 15A)`

EXAMPLE	`term.EOI = TRUE`
	`term.nChar = 1`
	`term.EightBits = TRUE`
	`term.term1 = &HA`
	`bytecount=EnterXI(timer,data%(0),1024,0,term,1,stat)`

These **`EnterI`** commands for Visual Basic are identical to the standard **`Enter`** commands with the exception of the return values being placed in integer variables rather than string variables.

The **`EnterXI`** command reads data from the I/O adapter. If an external device is specified, then Driver488 is addressed to Listen, and that device is addressed to Talk. If an interface is specified, then Driver488 must already be configured to receive data and the external device must be configured to Talk, either as a result of an immediately preceding **`EnterXI`** command or as a result of one of the **`Send`** commands. **`EnterXI`** terminates reception on either the specified count of bytes transferred, or the specified or default terminator being detected. Terminator characters, if any, are stripped from the received data before the **`EnterXI`** command returns to the calling application.

The **`forceAddr%`** flag is used to specify whether the addressing control bytes are to be issued for each **`EnterXI`** command. If the device handle refers to an I/O adapter, then **`forceAddr%`** has no effect and command bytes are not sent. For an external device, if **`forceAddr%`** is **`TRUE`** then Driver488 always sends the **`UNL`**, **`MLA`**, and **`TAG`** command bytes. If **`forceAddr%`** is **`FALSE`**, then Driver488 compares the current device with the previous device that used that interface adapter board for an **`EnterXI`** command. If they are the same, then no command bytes are sent. If they are different, then **`EnterXI`** acts as if the **`forceAddr%`** flag were **`TRUE`** and sends the command bytes. The **`forceAddr%`** flag is usually set **`TRUE`** for the first transfer of data from a device, and then set **`FALSE`** for additional transfers from the same block of data from that device.

Additional EnterI Functions

Driver488 provides additional **`EnterI`** routines that are short form versions of the **`EnterXI`** function. The additional **`EnterI`** functions are: **`EnterI`**, **`EnterNI`**, **`EnterMoreI`**, and **`EnterNMoreI`**. These functions are discussed in detail below:

EnterNI	
SYNTAX	**`EnterNI(ByVal devHandle%,data%,By Val count& ) As Long`**
REMARKS	**`EnterNI`** is equivalent to the following call to **`EnterXI`**: **`EnterXI(devHandle%,data%,count&, 1, 0, 0, 0)`**

The **`EnterNI`** function passes the device handle, the pointer to the data buffer, and the size of the data buffer to the **`EnterXI`** function. It specifies **`forceAddr%`** is **`TRUE`**, causing Driver488 to re-address the device. The default terminators are chosen by specifying a **`0`** pointer as the **`term`** parameter. Asynchronous transfer is turned off by sending **`0`** for the **`async%`** parameter, and the completion status value is ignored by sending **`0`** for the **`compStat%`** parameter.

EnterNMoreI	
SYNTAX	**`EnterNMoreI(ByVal devHandle%,data%,ByVal count&)As Long`**
REMARKS	**`EnterNMoreI`** is equivalent to the following call to **`EnterXI`**: **`EnterXI(devHandle%,data%,count&,0,0,0,0);`**

The **`EnterNMoreI`** function passes the device handle, the pointer to the data buffer, and the size of the data buffer to the **`EnterXI`** function. It specifies **`forceAddr%`** is **`FALSE`**; therefore, Driver488 does not address the device if it is the same device as previously used. The default terminators are chosen by specifying a **`0`** as the **`term`** parameter. Asynchronous transfer is turned off by sending **`0`** for the **`async%`** parameter, and the completion status value is ignored by sending **`0`** for the **`compStat%`** parameter.

Note: All forms of the **`EnterI`** commands (except **`EnterXI`**) use **`EOI`** as the only terminator. Also, **`EnterI`** and **`EnterMoreI`** must be passed to the entire array (i.e. **`intarray()`**, not the starting location: **`intarray (0)`**).

The following table describes the differences between the various forms of **`EnterI`**. It outlines the variables passed to each function and how many bytes the functions read.

EnterI Function	**Reads Until**	**Variable**
`EnterXI (ADC,IResp (0),1000,1,Term,1,1)`	**`n`** bytes or terminators	Pass starting location

`EnterI (ADC, IResp())`
`EnterMoreI (ADC, IResp ())`
	Array full or **`EOI`**	Pass entire array

`EnterNI (ADC< IResp (0), 1000)`
`EnterNMoreI (ADC, IResp (0), 1000)`
	`n` bytes or **`EOI`**	Pass starting location

where: **`SResp`** is **`String * 1000`**, and **`IResp(1000)`** is **`integer`**.

EnterI (Peripheral Mode)

Driver488/W31 (Visual Basic only)

EnterXI

SYNTAX	`EnterXI (ByVal devHandle% ,data%, ByVal count&, ByVal forceAddr%, Term As terms, ByVal async%, compStat%)As Long`
	`devHandle%` refers to either an IEEE 488 interface or an external device.
	`data%` is the first element in an integer array into which the data is read.
	`count&` is the number of characters to read.
	`forceAddr%` is ignored.
	`term` is a pointer to a terminator structure that is used to set up the input terminators. If `term` is set to `0`, the default terminators are used.
	`async%` is a flag that allows asynchronous data transfer.
	`compStat%` is a pointer to an integer containing completion status information.
RETURNS	`-1 if error,`
	`otherwise, the number of bytes transferred. The memory buffer pointed to by the data parameter is filled in with the information read from the device.`
MODE	`*CA`
BUS STATES	`Determined by the Controller`
SEE ALSO	`OutputX, Term, Buffered, EOL (Sub-Chapter 15A)`

EXAMPLE	`term.EOI = TRUE`
	`term.nChar = 1`
	`term.EightBits = TRUE`
	`term.term1 = &HA`
	`bytecount=EnterXI(timer,data%(0),1024,0,term,1,&stat)`

These **`EnterI`** commands for Visual Basic are identical to the standard **`Enter`** commands with the exception of the return values are placed in integer variables rather than string variables.

In Peripheral mode, the **`EnterXI`** command receives data from the I/O adapter under control of the Active Controller. The Active Controller must put Driver488 into the Listen state and configure some bus device to provide Driver488 with data. The Listen state can be checked with the **`Status`** command, or can cause an interrupt with the **`Arm`** command. A time-out error occurs (if enabled) if Driver488 does not receive a data byte within the time out period after issuing the **`EnterXI`** command.

Additional EnterI Functions

Driver488 provides additional **`EnterI`** routines that are short form versions of the **`EnterXI`** function. The additional **`EnterI`** functions are: **`EnterI`** and **`EnterNI`**. In Peripheral mode, the device handle must always refer to an I/O adapter, and the **`forceAddr%`** flag is ignored. Thus, **`EnterMoreI`** is equivalent to **`EnterI`**, and **`EnterNMoreI`** is equivalent to **`EnterNI`**.

Error

SYNTAX	`int pascal Error(DevHandleT devHandle, bool display);`
	`devHandle` refers to either an IEEE 488 interface or an external device.
	`display` indicates whether the error message display should be **`ON`** or **`OFF`**.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`

SEE ALSO	`OnEvent, GetError, GetErrorList, Status`
EXAMPLE	`errorcode = Error(ieee, OFF);`

The **`Error`** command enables or disables automatic on-screen display of Driver488 error messages. Specifying **`ON`** enables the error message display, while specifying **`OFF`** disables the error message display. **`Error ON`** is the default condition.

FindListeners

SYNTAX	`int pascal FindListeners(DevHandleT devHandle, char primary, unsigned short *listener, short limit);`
	`devHandle` refers to either an IEEE 488 interface or an external device. If **`devHandle`** refers to an external device, then the **`FindListeners`** command acts on the hardware interface to which the external device is attached.
	`primary` is the primary IEEE 488 bus address to check.
	`listener` is a pointer to a list that contains all Listeners found on the specified interface board. The user must allocate enough memory to accommodate all of the possible Listeners up to the limit that he specified.
	`limit` is the maximum number of Listeners to be entered into the Listener list.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`ATN•MTA, UNL, LAG`
SEE ALSO	`CheckListener, BusAddress, Status`
EXAMPLE	`DevHandleT listeners[5];` `errorcode = FindListeners(ieee,10,listeners,5)`

The **`FindListeners`** command finds all of the devices configured to Listen at the specified primary address on the IEEE 488 bus. The command first identifies the primary address to check and returns the number of Listeners found and their addresses. Then, it fills the user supplied array with the addresses of the Listeners found. The number of Listeners found is the value returned by the function. The returned values include the secondary address in the upper byte, and the primary address in the lower byte. If there is no secondary address, then the upper byte is set to **`255`**; hence, a device with only a primary address of **`16`** and no secondary address, is represented as **`0xFF10`**, or **`-240`** decimal.

Finish

SYNTAX	`int pascal Finish(DevHandleT devHandle);`
	`devHandle` refers to either an IEEE 488 interface or an external device. If **`devHandle`** refers to an external device, the **`Finish`** command acts on the hardware interface to which the external device is attached.
RETURNS	`-1 if error`
MODE	`CA`
BUS STATES	`ATN`
SEE ALSO	`Resume, PassControl`
EXAMPLE	`errorcode = Finish(ieee);`

The **`Finish`** command asserts Attention (**`ATN`**) and releases any pending holdoffs after a **`Resume`** function is called with the monitor flag set.

GetError

SYNTAX	`ErrorCodeT pascal`
	`GetError(DevHandleT devHandle, char *errText);`
	`devHandle` refers to either the IEEE 488 interface or the external device that has the associated error.
	`errText` is the string that will contain the error message. If **`errText`** is non-null, the string must contain at least 247 bytes.
RETURNS	`-1 if error,`
	`otherwise, it returns the error code number associated with the error for the specified device.`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`Error, GetErrorList, Status`

EXAMPLE	`errnum = GetError(ieee,errText);`
	`printf("Error number:%d;%s \n"errnum,errText);`

The **`GetError`** command is called by the user after another function returns an error indication. The device handle sent to the function that returned the error indication, is sent to **`GetError`** as its **`devHandle`** parameter. **`GetError`** finds the error associated with that device, and returns the error code associated with that error. If a non-null error text pointer is passed, **`GetError`** also fills in up to 247 bytes in the string. The application must ensure that sufficient space is available.

GetErrorList

SYNTAX	`ErrorCodeT pascal GetErrorList(DevHandlePT devHandles, char *errText, DevHandlePT errHandle);`
	`devHandles` is a pointer to a list of external devices that was returned from a function, due to an error associated with one of the external devices in the list.
	`errText` is the text string that contains the error message. The user must ensure that the string length is at least 247 bytes.
	`errHandle` is a pointer to the device handle that caused the error.
RETURNS	`-1 if error`
	`otherwise, it returns the error number associated with the given list of devices.`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`Error, GetError, Status`

EXAMPLE	`char errText[329];`
	`int errHandle;`
	`int errnum;`
	`result = ClearList(list);`
	`if (result == -1) {`
	`     errnum=GetErrorList(list,errText,&errHandle);`
	`     printf("Error %d;%s,at handle %d\n", errnum, errText,`
	`     errHandle);`
	`}`

The **`GetErrorList`** command is called by the user, after another function identifying a list of device handles, returns an error indication. The device handle list sent to the function that returned the error indication, is sent to **`GetErrorList`**. **`GetErrorList`** finds the device which returned the error indication, returning the handle through **`errHandle`**, and returns the error code associated with that error. If a non-null error text pointer is passed, **`GetError`** also fills in up to 247 bytes in the string. The application must ensure that sufficient space is available.

Hello

SYNTAX	`int pascal Hello(DevHandleT devHandle, char *message);`
	`devHandle` refers to either an IEEE 488 interface or an external device. If `devHandle` refers to an external device, the `Hello` command acts on the hardware interface to which the external device is attached.
	`message` is a character pointer that contains the returned message.
RETURNS	`-1 if error.`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`Status, OpenName, GetError`

EXAMPLE	`char message[247];`
	`result = Hello(ieee,message);`
	`printf("%s\n",message);`

The **`Hello`** command is used to verify communication with Driver488, and to read the software revision number. If a non-null string pointer is passed, **`Hello`** fills in up to 247 bytes in the string. The application must ensure that sufficient space is available. When the command is sent, Driver488 returns a string similar to the following:

```
Driver488 Revision X.X (C)199X IOtech, Inc.
```

where **`X`** is the appropriate revision or year number.

IntLevel

Driver488/SUB and Driver488/W31 only

SYNTAX	`int pascal IntLevel(DevHandleT devHandle, int channel);`
	`devHandle` refers to either an IEEE 488 interface or an external device. If `devHandle` refers to an external device, then the `IntLevel` command acts on the hardware interface to which the external device is attached.
	`channel` is a valid interrupt channel, or `-1` to specify `NONE`.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`DmaChannel, TimeOut`
EXAMPLE	`errorcode = IntLevel(ieee, 7);`

The **`IntLevel`** command specifies the hardware interrupt level that is used by the I/O adapter. Driver488 uses hardware interrupts, if available, to improve the efficiency of I/O adapter control and communication. The interrupt level is specified by an integer in the range 2 through 15 as appropriate to the host computer bus and interface card type. The interrupt level value must match the hardware settings on the interface card.

IOAddress

Driver488/SUB and Driver488/W31 only

SYNTAX	`int pascal IOAddress(DevHandleT devHandle, uint ioaddr);`
	`devHandle` refers to either an interface or an external device. If `devHandle` refers to an external device, then the `IOAddress` command acts on the hardware interface to which the external device is attached.
	`ioaddr` is the I/O base address to set.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`IntLevel, DmaChannel, TimeOut`
EXAMPLE	`errorcode = IOAddress(ieee,0x02E1);`

The `IOAddress` command specifies the I/O port base address of the I/O adapter. The base address is set by a 16-bit integer, `ioaddr`, that is usually given as a hexadecimal number. The default I/O port base address for the IEEE 488 hardware interface is `0X02E1` for the first interface, `0X22E1` for the second, and `0X42E1` and `0X62E1` for the third and fourth interfaces. The default I/O port base addresses for the serial hardware interface is `0X03F8`. Other standard I/O port base addresses are `0X02F8`, `0X03E8`, `0X02E8`. The `IOAddress` value must match the hardware switch settings on the I/O adapter.

KeepDevice

SYNTAX	`int pascal KeepDevice(DevHandleT devHandle);`
	`devHandle` refers to an external device.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`MakeDevice, RemoveDevice, OpenName`
EXAMPLE	`errorcode = KeepDevice(scope);`

The `KeepDevice` command changes the indicated temporary Driver488 device to a permanent device, visible to all applications. Permanent Driver488 devices are not removed when Driver488 is closed. Driver488 devices are created by `MakeDevice` and are initially temporary. Unless `KeepDevice` is used, all temporary Driver488 devices are forgotten when Driver488 is closed. The only way to remove the permanent device once it has been made permanent by the `KeepDevice` command, is to use the `RemoveDevice` command.

LightPen

Driver488/SUB only

SYNTAX	`int pascal LightPen(DevHandleT devHandle, bool flag);`
	`devHandle` refers to either an IEEE 488 interface or an external device. If `devHandle` refers to an external device, then the `LightPen` command acts on the hardware interface to which the external device is attached.
	`flag` may be either `ON` (`LightPen` enabled), or `OFF` (`LightPen` disabled).
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`OnEvent, Arm, Disarm`
EXAMPLE	`errorcode = LightPen(ieee,ON);`

The **`LightPen`** command disables the detection of interrupts via setting the light pen status. The default is light pen interrupt enabled.

Listen

SYNTAX	`int pascal Listen(DevHandleT devHandle, char pri, char sec);`
	`devHandle` refers to either an IEEE 488 interface or an external device. If `devHandle` refers to an external device, the command acts on the associated interface.
	`pri` and `sec` specify the primary and secondary addresses of the device which is to be addressed to listen.
RETURNS	`-1 if error`
MODE	`CA`
BUS STATES	`ATN, LAG`
SEE ALSO	`Talk, SendCmd, SendData, SendEoi, FindListeners`
EXAMPLES	`errorcode = Listen (ieee, 12, -1);`

The **`Listen`** command addresses an external device to Listen.

Local

SYNTAX	`int pascal Local(DevHandleT devHandle);`	
	`devHandle` refers to either an IEEE 488 interface or an external device.	
RETURNS	`-1 if error`	
MODE	`SC`	
BUS STATES	`*REN`	
SEE ALSO	`Remote, AutoRemote`	
EXAMPLES	`errorcode = Local(ieee);`	To unassert the Remote Enable (REN) line, the IEEE 488 interface is specified.
	`errorcode = Local(wave);`	To send the Go To Local (GTL) command, an external device is specified.

In the System Controller mode, the **`Local`** command issued to an interface device, causes Driver488 to unassert the Remote Enable (**`REN`**) line. This causes devices on the bus to return to manual operation. A **`Local`** command addressed to an external device, places the device in the local mode via the Go To Local (**`GTL`**) bus command.

LocalList

SYNTAX	`int pascal LocalList(DevHandlePT devHandles);`	
	`devHandles` refers to a pointer to a list of external devices.	
RETURNS	`-1 if error`	
MODE	`CA`	
BUS STATES	`ATN•UNL, MTA, LAG,GTL`	
SEE ALSO	`Local, Remote, RemoteList, AutoRemote`	

EXAMPLES	`deviceList[0] = wave;`
	`deviceList[1] = timer;`
	`deviceList[2] = dmm;`
	`deviceList[3] = NODEVICE;`
	`errorcode = LocalList(deviceList);`
		To send the Go To Local (GTO) bus command to a list of external devices.

In the System Controller mode, the **`LocalList`** command issued to an interface device, causes Driver488 to unassert the Remote Enable (**`REN`**) line. This causes devices on the bus to return to manual operation. A **`LocalList`** command addressed to an external device, places the device in the local mode via the Go To Local (**`GTL`**) bus command.

Lol

SYNTAX	`int pascal Lol(DevHandleT devHandle);`
	`devHandle` refers to either an IEEE 488 interface or an external device. If `devHandle` refers to an external device, the `Lol` command acts on the hardware interface to which the external device is attached.
RETURNS	`-1 if error`
MODE	`CA`
BUS STATES	`ATN•LLO`
SEE ALSO	`Local, LocalList, Remote, RemoteList`
EXAMPLES	`errorcode = Lol(ieee);`

The `Lol` command causes Driver488 to issue an IEEE 488 LocalLockout (`LLO`) bus command. Bus devices that support this command are thereby inhibited from being controlled manually from their front panels.

MakeDevice

SYNTAX	`int pascal MakeDevice(DevHandleT devHandle, char *name);`	
	`devHandle` refers to an existing external device.	
	`name` is the device name of the device that is to be made and takes the configuration of the device given by devHandle.	
RETURNS	`Device handle, or -1 if error`	
MODE	`Any`	
BUS STATE	`None`	
SEE ALSO	`KeepDevice, RemoveDevice, OpenName, Close`	
EXAMPLE	`dmm=MakeDevice(scope,"DMM");` `BusAddress(dmm,16,-1);`	Create a device named DMM, attached to the same I/O adapter as SCOPE and set its IEEE 488 bus address to 16.

The `MakeDevice` command creates a new temporary Driver488 device that is an identical copy of an already existing Driver488 external device. The new device is attached to the same I/O adapter of the existing device and has the same bus address, terminators, timeouts, and other characteristics. The newly created device is temporary and is removed when Driver488 is closed. `KeepDevice` may be used to make the device permanent. To change the default values assigned to the device, it is necessary to call the appropriate configuration functions such as `BusAddress`, `IOAddress`, and `TimeOut`.

MakeNewDevice

Driver488/W95 only

SYNTAX	`DevHandleT pascal MakeNewDevice(LPSTR iName, LPSTR aName,BYTE primary,BYTE secondary,TermPT In,TermPT Out,DWORD tOut);`
	`devHandle` refers to the new external device.
	`Name` is the device name of the device that is to be made and takes the configuration of the device based on the parameters specified.
	`primary` and `secondary` are the secondary and primary bus addresses to be specified. For no secondary address, a `-1` must be specified.
	`In` and `Out` are pointers to terminator structures specified to set up the respective input and output terminators of the device.
	`tOut` is the timeout parameter to be specified.
RETURNS	`Device handle, or -1 if error`
MODE	`Any`
BUS STATE	`None`
SEE ALSO	`MakeDevice, KeepDevice, RemoveDevice, OpenName, Close`

This is a new function in Driver488/W95. This function is similar to the **`MakeDevice`** function except that **`MakeNewDevice`** will create a new device based on the parameters specified, instead of simply cloning an existing device. To change the default values assigned to the device, it is necessary to call the appropriate configuration functions such as **`BusAddress`**, **`IOAddress`**, and **`TimeOut`**.

MyListenAddr

SYNTAX	`int pascal MyListenAddr (DevHandleT devHandle);`
	`devHandle` refers to either an interface or an external device. If **`devHandle`** refers to an external device, the command acts on the associated interface.
RETURNS	`-1 if error`
MODE	`CA`
BUS STATES	`ATN, MLA`
SEE ALSO	`MyTalkAddr, Talk, Listen, SendCmd`
EXAMPLES	`errorcode = MyListenAddr (ieee);`

The **`MyListenAddr`** command addresses the interface to Listen.

MyTalkAddr

SYNTAX	`int pascal MyTalkAddr (DevHandleT devHandle);`
	`devHandle` refers to either an interface or an external device. If **`devHandle`** refers to an external device, the command acts on the associated interface.
RETURNS	`-1 if error`
MODE	`CA`
BUS STATES	`ATN, MTA`
SEE ALSO	`MyListenAddr, Listen, SendCmd`
EXAMPLES	`errorcode = MyTalkAddr (ieee);`

The **`MyTalkAddr`** command addresses the interface to Talk.

OnEvent

Driver488/SUB only

SYNTAX	`int pascal OnEvent(DevHandleT devHandle,UserHandleFP handler,OpaqueP argument);`
	`devHandle` refers to either an interface or an external device.
	`handler` is a user-specified interrupt-handler function that is to perform some function, defined by the user, when one of the **`Arm`**ed conditions occur.
	`argument` is the 32-bit argument passed to the **`handler`** function. It may be used to point to information used by the **`handler`** function.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`Arm, Disarm, LightPen`

EXAMPLE	`void`
	`Handler(OpaqueP arg)`
	`{`
	`printf("Interrupt handler got arg = %ld\n",arg);`
	`}`
	`errorcode = OnEvent(ieee,Handler,(OpaqueP)(15));`

The **`OnEvent`** command specifies the function to be called when an **`Arm`**ed event occurs. The function **`handler`** is passed the specified 32-bit argument entry. The **`handler`** can use the argument to identify the portion of the program that set up the **`OnEvent`**, and then use **`Status`** and other commands to determine the state of Driver488 and take appropriate action. **`OnEvent`** is most often used to respond to Service Requests (**`SRQ`**).

OnEvent

Driver488/W31 (C only) and Driver488/W95 only

SYNTAX	`int pascal OnEvent(DevHandleT devHandle, HWND hWnd, OpaqueP lParam);`
	`devHandle` refers to either an interface or an external device.
	`hWnd` is the window handle to receive the event notification.
	`lParam` value will be passed in the notification message.
RETURNS	`-1 if error`
MODE	`Any`
SEE ALSO	`Arm, Disarm`
BUS STATES	`None`

EXAMPLE	`ieee = OpenName ("ieee");`
	`OnEvent (ieee, hWnd, (OpaqueP) 12345678L);`
	`Arm (ieee, acSRQ | acError);`
	`break;`

The **`OnEvent`** command causes the event handling mechanism to issue a message upon occurrence of an **`Arm`**ed event. The message will have a type of **`WM_IEEE488EVENT`**, whose value is retrieved via:

```
RegisterWindowMessage ((LPSTR) "WM_IEEE488EVENT");
```

The associated **`wParam`** is an event mask indicating which **`Arm`**ed event(s) caused the notification, and the **`lParam`** is the value passed to **`OnEvent`**. Note that although there is a macro for **`WM_IEEE488EVENT`** in the header file for each language, this macro resolves to a function call and therefore cannot be used as a case label. The preferred implementation is to include a default case in the message handling case statement and directly compare the message ID with **`WM_IEEE488EVENT`**. The following is a full example of a program using the **`OnEvent`** function:

```
LONG FAR PASCAL export
WndProc(HWND hWnd, unsigned iMessage, WORD wParam, LONG lParam);
{
HANDLE
ieee;
switch (iMessage)
        {
        case WM_CREATE:
                ieee = OpenName ("ieee");
                OnEvent (ieee, hWnd, (OpaqueP) 12345678L);
                Arm (ieee, acSRQ | acError);
                break;
        default:
                if (iMessage == WM_IEEE488EVENT) {
                        char buff [80];
                        wsprintf (buff, "Condition = %04X, Param = %081X",
                        wParam, lParam);
                        MessageBox (hWnd, (LPSTR) buff,(LPSTR) "Event
                        Noted", MB OK);
                        return TRUE;
                }
        }
}
```

OnEventVDM

Driver488/W95 (Console Mode Applications only)

SYNTAX	`INT pascal OnEventVDM(DevHandleT devHandle, EventFuncT func);`
	`devHandle` refers to either an interface or an external device.
	`func` is a user-specified interrupt-handler function that is to perform some function, defined by the user, when one of the `Arm`ed conditions occur.
RETURNS	`-1 if error`
MODE	`Any`
SEE ALSO	`OnEvent, Arm, Disarm`
BUS STATES	`None`
EXAMPLE	`qsk(x,Arm(ieee0, acSRQ));` `qsk(x,OnEventVDM(ieee0, srqHandler));` Arm SRQ detection and set up SRQ function handler

This function is new in Driver488/W95. The `OnEventVDM` (`VDM` refers to Virtual DOS Machine) allows a call back to a user-specified function in a console mode application. The following is a full example of a console mode program using the `OnEventVDM` function:

```
#include <windows.h>
#include <stdio.h>
#include “iotieee.h”

// For debugging
#define qsk(v,x) (v=x, printf(#x “ returned %d/n, v))

void
srqHandler(DevHandlerT devHandle, UINT mask)
{
       LONG xfered;
       printf(“\007\n\nEVENT-FUNCTION on %d mask 0x%04x\n”,devHandle,
       mask);
       qsk(xfered, Spoll(devHandle));
       printf(“\n\n”);
}

void
main(void)
{
       LONG result, xfered;
       int ioStatus, x;
       DevHandleT ieee0, wave14, wave16;
       TermT myTerm;
       UCHAR buffer[500];
       printf(“\n\nSRQTEST program PID %d\n”,GetCurrentProcessId ());
       qsk(ieee0, OpenName(“ieee0”));
       qsk(wave14, OpenName(“Wave14”));
       qsk(wave16, OpenName(“Wave16”));
       qsk(result, Abort(wave14));
       qsk(result, Abort(wave16));
       qsk(x, Hello(ieee0, buffer));
       printf(“\n%s\n\n”, buffer);
       myTerm.EOI = 1;
       myTerm.nChar = 0;
       myTerm.termChar[0] = ‘\r’;
       myTerm.termChar[1] = ‘\n’;

       // Arm SRQ detection and set up SRQ function handler
       qsk(x, Arm(ieee0, acSRQ));
       qsk(x, OnEventVDM(ieee0, srqHandler));

       // Tell the Wave to assert SRQ in 3 seconds
       qsk(xfered,Output(wave16,“t3000x”,6L,1,0,&myTerm,0,&ioStatus));
       printf(“Completion code: 0x%04x\n”, ioStatus);
```

```
                // Normally, your program would be off doing other work, for
                // this example we will just hold here for a short time.
                For(result = 0; result 30000; result++) {
                      printf("Result is %06d\r", result);
                }
                printf("\n\n");

                qsk(xfered, Spoll(wave16));
                qsk(x, Close(wave14));
                qsk(x, Close(wave16));
                qsk(x, Close(ieee0));
        }
```

OpenName

SYNTAX	`DevHandleT pascal OpenName(char *name);`	
	`name` is the name of an interface or external device.	
RETURNS	`Device handle associated with the given name, or -1 if error.`	
MODE	`Any`	
BUS STATE	`None`	
SEE ALSO	`MakeDevice, Close`	
EXAMPLES	`dmm = OpenName("DMM");`	Open the external device DMM
	`dmm = OpenName("IEEE:DMM");`	Specify the interface to which the external device is connected

The `OpenName` command opens the specified interface or external device and returns a device handle for use in accessing that device.

Output (Controller Mode)

OutputX	
SYNTAX	`long pascal OutputX(DevHandleT devHandle, char *data, long count, bool last, bool forceAddr, TermT *terminator, bool async, int *compStat);`
	`devHandle` refers to either an interface or an external device. If `devHandle` refers to an external device, the `OutputX` command acts on the hardware interface to which the external device is attached.
	`data` is a string of bytes to send.
	`count` is the number of bytes to send.
	`last` is a flag that forces the device output terminator to be sent with the data.
	`forceAddr` is used to specify whether the addressing control bytes are to be issued for each Output command.
	`terminator` is a pointer to a terminator structure that is used to set up the input terminators. If `terminator` is set to `0`, the default terminator is used.
	`async` is a flag that allows asynchronous data transfer.
	`compStat` is a pointer to an integer containing completion status information.
RETURNS	`-1 if error, otherwise, the number of characters transferred`
MODE	`CA`
BUS STATES	`With interface handle: REN (if SC and AutoRemote), *ATN, ATN`
	`With external device handle: REN (if SC and AutoRemote), ATN•MTA, UNL, LAG, *ATN, ATN`
SEE ALSO	`Enter, Term, TimeOut, Buffered, EOL (Sub-Chapter 15A)`
EXAMPLES	`term.EOI = TRUE;` `term.nChar = 1;` `term.EightBits = TRUE;` `term.termChar[0] = '\r';` `data = "U0X";` `count = strlen(data);` `bytecnt=Output(timer,data,count,1,0,&term,0,&stat);`

The **`OutputX`** command sends data to an interface or external device. The Remote Enable (**`REN`**) line is first asserted if Driver488 is the System Controller and **`AutoRemote`** is enabled. Then, if a device address (with optional secondary address) is specified, Driver488 is addressed to Talk and the specified device is addressed to Listen. If no address is specified, then Driver488 must already be configured to send data, either as a result of a preceding **`OutputX`** command, or as the result of a **`Send`** command. Terminators are automatically appended to the output data as specified.

The **`forceAddr`** flag is used to specify whether the addressing control bytes are to be issued for each **`OutputX`** command. If the device handle refers to an interface, **`forceAddr`** has no effect and command bytes are not sent. If the device handle refers to an external device and **`forceAddr`** is **`TRUE`**, Driver488 addresses the interface to Talk and the external device to Listen. If **`forceAddr`** is **`FALSE`**, Driver488 compares the current device with the most recently addressed device on that interface. If the addressing information is the same, no command bytes are sent. If they are different, **`OutputX`** acts as if the **`forceAddr`** flag were **`TRUE`** and sends the addressing information.

The **`terminator`** is a pointer to a terminator structure that is used to set up the input terminators. This pointer may be a null pointer, requesting use of the default terminators for the device, or it may point to a terminator structure requesting no terminators. The **`async`** is a flag that allows asynchronous data transfer. If this flag is **`TRUE`**, the **`OutputX`** command returns to the caller as soon as the data transfer is underway and can be completed under DMA and/or interrupts. **`FALSE`** indicates that the **`OutputX`** command should not return until the transfer is complete. The **`compStat`** is a pointer to an integer containing completion status information. A null pointer indicates that completion status is not requested. In the case of an asynchronous transfer, this pointer must remain valid until the transfer is complete.

Additional Output Functions

Driver488 provides additional **`Output`** functions that are short form versions of the **`OutputX`** function. The additional **`Output`** functions are: **`Output`**, **`OutputN`**, **`OutputMore`**, and **`OutputNMore`**. These functions are discussed in detail below:

Output	
SYNTAX	**`long pascal Output(DevHandleT devHandle,char *data);`**
REMARKS	**`Output`** is equivalent to the following call to **`OutputX`**: **`OutputX(devHandle,data,strlen(data),1,1,0L,0,0L);`**

The **`Output`** function passes the device handle and a pointer to the data buffer to the **`OutputX`** function. It determines the size of the data buffer provided by the user and passes that value as the **`count`** parameter. It specifies that the **`forceAddr`** flag is set **`TRUE`**, which causes Driver488 to address the device if an external device is specified. The default terminators are chosen by specifying a **`0`** pointer as the **`terminator`** parameter. Synchronous transmission is specified by sending **`0`** for the **`async`** parameter, and the completion status value is ignored by sending a **`0`** for the **`compStat`** pointer.

OutputN	
SYNTAX	**`long pascal OutputN(DevHandleT devHandle,char *data,long count);`**
REMARKS	**`OutputN`** is equivalent to the following call to **`OutputX`**: **`OutputX(devHandle,data,count,0,1,0L,0,0L);`**

The **`OutputN`** function passes the device handle and a pointer to the data buffer to the **`OutputX`** function. It specifies that the **`forceAddr`** flag is set **`TRUE`**, which causes Driver488 to address the device if an external device is specified. The default terminators are chosen by specifying a **`0`** pointer as the **`terminator`** parameter. Synchronous transmission is specified by sending **`0`** for the **`async`** parameter, and the completion status value is ignored by sending a **`0`** for the **`compStat`** pointer.

OutputMore	
SYNTAX	**`long pascal OutputMore(DevHandleT devHandle, char *data);`**
REMARKS	**`OutputMore`** is equivalent to the following call to **`OutputX`**:

	`OutputX(devHandle,data,strlen(data),1,0,0L,0,0L);`

The `OutputMore` function passes the device handle and a pointer to the data buffer to the `OutputX` function. It determines the size of the data buffer provided by the user and passes that value as the `count` parameter. It specifies that the `forceAddr` flag is set `FALSE`, so Driver488 does not re-address the device if it is the same device as that previously used. The default terminators are chosen by specifying a `0` pointer as the `terminator` parameter. Synchronous transmission is specified by sending `0` for the `async` parameter, and the completion status value is ignored by sending a `0` pointer for the `compStat` pointer.

OutputNMore	
SYNTAX	`long pascal OutputNMore (DevHandleT devHandle, char *data, long count);`
REMARKS	`OutputNMore` is equivalent to the following call to `OutputX`: `OutputX(devHandle,data,0,0,0L,0,0L);`

The `OutputNMore` function passes the device handle and a pointer to the data buffer to the `OutputX` function. It specifies that the `forceAddr` flag is set `FALSE`, so Driver488 does not re-address the device if it is the same device as that previously used. The default terminators are chosen by specifying a `0` pointer as the `terminator` parameter. Synchronous transmission is specified by sending `0` for the `async` parameter, and the completion status value is ignored by sending a `0` pointer for the `compStat` pointer.

Output (Peripheral Mode)

OutputX	
SYNTAX	`long pascal OutputX(DevHandleT devHandle, char *data, long count, bool last, bool forceAddr, TermT *terminator, bool async, int *compStat);`
	`devHandle` refers to either an interface or an external device.
	`data` points to the bytes to send.
	`count` is the number of characters to send.
	`last` is a flag that forces the device output terminator to be sent with the data.
	`forceAddr` is ignored.
	`terminator` is a pointer to a terminator structure that is used to set up the output terminators. If `terminator` is set to `0`, the default terminator is used.
	`async` is a flag that allows asynchronous data transfer.
	`compStat` is a pointer to an integer containing completion status information.
RETURNS	`-1 if error; otherwise, the number of characters transferred`
MODE	`*CA`
BUS STATES	`Determined by the Controller.`
SEE ALSO	`Enter, Term, TimeOut, Buffered`

In Peripheral mode, the `OutputX` command sends data to the interface under control of the Active Controller. The Active Controller must put the interface into the Talk state and configure some bus device to accept the transferred data. The Talk state can be checked with the `Status` command, or can cause an interrupt via the `Arm` command. A time-out error occurs, if enabled, if no bus device accepts the data within the time out period after issuing the `OutputX` command. Even as a Peripheral, Driver488 might be the System Controller. If Driver488 is the System Controller and `AutoRemote` is enabled, then Driver488 asserts Remote Enable (`REN`) before sending any data. The `OutputX` command in Peripheral mode is otherwise identical to the `OutputX` command in Controller mode.

Additional Output Functions

Driver488 provides additional `Output` routines that are short form versions of the `OutputX` function. The additional `Output` functions are: `Output` and `OutputN`. In Peripheral mode, the device handle must always refer to an I/O adapter, and the `forceAddr` flag is ignored. Thus, `OutputMore` is equivalent to `Output`, and `OutputNMore` is equivalent to `OutputN`.

OutputI (Controller Mode)

Driver488/W31 (Visual Basic only)

OutputXI	
SYNTAX	`OutputXI (ByVal devHandle%, data%, ByVal count&, ByVal last%, ByVal forceAddr%, Term As terms, ByVal async%, compstat%) As Long`
	`devHandle%` refers to either an interface or an external device. If `devHandle%` refers to an external device, the `OutputXI` command acts on the hardware interface to which the external device is attached.
	`data%` is the first element in an integer array which holds the data being sent.
	`count&` is the number of bytes to send.
	`last%` is a flag that forces the device output terminator to be sent with the data.
	`forceAddr%` is used to specify whether the addressing control bytes are to be issued for each `OutputXI` command.
	`terms` is a pointer to a terminator structure that is used to set up the input terminators. If `terms` is set to `0`, the default terminator is used.
	`async%` is a flag that allows asynchronous data transfer.
	`compStat%` is a pointer to an integer containing completion status information.
RETURNS	`-1 if error; otherwise, the number of characters transferred`
MODE	`CA`
BUS STATES	`With interface handle: REN (if SC and AutoRemote), *ATN, ATN`
	`With external device handle: REN (if SC and AutoRemote), ATN•MTA, UNL, LAG, *ATN, ATN`
SEE ALSO	`EnterI, Term, TimeOut, Buffered, EOL (Sub-Chapter 15A)`

EXAMPLES	`term.EOI = TRUE`
	`term.nChar = 1`
	`term.EightBits = TRUE`
	`term.term1 = &HA`
	`data%(0) = 1`
	`data%(1) = 2`
	`data%(2) = 3`
	`bytecount = OutputI(dev, data%(0), 3, 0, term, 1, stat)`

The `OutputI` commands for Visual Basic are identical to the standard `Output` commands except for the variable holding the data to be sent is an integer rather than a string type.

The `OutputXI` command sends data to an interface or external device. The Remote Enable (`REN`) line is first asserted if Driver488 is the System Controller and `AutoRemote` is enabled. Then, if a device address (with optional secondary address) is specified, Driver488 is addressed to Talk and the specified device is addressed to Listen. If no address is specified, then Driver488 must already be configured to send data, either as a result of a preceding `OutputXI` command, or as the result of a `Send` command. Terminators are automatically appended to the output data as specified.

The `forceAddr%` flag is used to specify whether the addressing control bytes are to be issued for each `OutputXI` command. If the device handle refers to an interface, `forceAddr%` has no effect and command bytes are not sent. If the device handle refers to an external device and `forceAddr%` is `TRUE`, Driver488 addresses the interface to Talk and the external device to Listen. If `forceAddr%` is `FALSE`, Driver488 compares the current device with the most recently addressed device on that interface. If the addressing information is the same, no command bytes are sent. If they are different, `OutputXI` acts as if the `forceAddr%` flag were `TRUE` and sends the addressing information.

The `terms` is a pointer to a terminator structure that is used to set up the input terminators. This pointer may be a null pointer, requesting use of the default terminators for the device, or it may point to a terminator structure requesting no terminators. The **`async%`** is a flag that allows asynchronous data transfer. If this flag is **`TRUE`**, the **`OutputXI`** command returns to the caller as soon as the data transfer is underway and can be completed under DMA and/or interrupts. **`FALSE`** indicates that the **`OutputXI`** command should not return until the transfer is complete. The **`compStat%`** is a pointer to an integer containing completion status information. A null pointer indicates that completion status is not requested. In the case of an asynchronous transfer, this pointer must remain valid until the transfer is complete.

Additional OutputI Functions

Driver488 provides additional **`OutputI`** functions that are short form versions of the **`OutputXI`** function. The additional **`OutputI`** functions are: **`OutputNI`**, **`OutputMoreI`**, and **`OutputNMoreI`**. These functions are discussed in detail below:

OutputNI	
SYNTAX	**`OutputNI(ByVal devHandle%, data%, ByVal count&) As Long`**
REMARKS	**`OutputNI`** is equivalent to the following call to **`OutputXI`**: **`OutputXI(devHandle%,data%,count&,0,1,0,0,0)`**

The **`OutputNI`** function passes the device handle and a pointer to the data buffer, to the **`OutputXI`** function. It specifies that the **`forceAddr%`** flag is set **`TRUE`**, which causes Driver488 to address the device if an external device is specified. The default terminators are chosen by specifying a **`0`** pointer as the **`terms`** parameter. Synchronous transmission is specified by sending **`0`** for the **`async`** parameter, and the completion status value is ignored by sending a **`0`** for the **`compStat`** pointer.

OutputMoreI	
SYNTAX	**`OutputMoreI(ByVal devHandle%,data%,By Val count&)As Long`**
REMARKS	**`OutputMoreI`** is equivalent to the following call to **`OutputXI`**: **`OutputXI(devHandle%,data%,count&,1,0,0,0,0)`**

The **`OutputMoreI`** function passes the device handle and a pointer to the data buffer, to the **`OutputXI`** function. It determines the size of the data buffer provided by the user and passes that value as the **`count&`** parameter. It specifies that the **`forceAddr%`** flag is set **`FALSE`**, so Driver488 does not re-address the device if it is the same device as that previously used. The default terminators are chosen by specifying a **`0`** pointer as the **`terms`** parameter. Synchronous transmission is specified by sending **`0`** for the **`async`** parameter, and the completion status value is ignored by sending a **`0`** pointer for the **`compStat`** pointer.

OutputNMoreI	
SYNTAX	**`OutputNMoreI(ByVal devHandle, data%, ByVal count&) As Long`**
REMARKS	**`OutputNMoreI`** is equivalent to the following call to **`OutputXI`**: **`OutputXI(devHandle%,data%,count&,0,0,0,0,0);`**

The **`OutputNMoreI`** function passes the device handle and a pointer to the data buffer, to the **`OutputXI`** function. It specifies that the **`forceAddr%`** flag is set **`FALSE`**, so Driver488 does not re-address the device if it is the same device as that previously used. The default terminators are chosen by specifying a **`0`** pointer as the **`terms`** parameter. Synchronous transmission is specified by sending **`0`** for the **`async`** parameter, and the completion status value is ignored by sending a **`0`** pointer for the **`compStat`** pointer.

Note: The **`OutputNI`** and **`OutputNMoreI`** commands do not send terminators. Also, **`OutputI`** and **`OutputMoreI`** must be passed to the entire array (i.e. **`intarray()`**, not the starting location: **`intarray (0)`**).

The following table describes the differences between the various forms of **`OutputI`**. It outlines the variables passed to each function and how many bytes the functions output.

OutputI Function	Terminators	Variable
`OutputXI(ADC,IResp (0),1000,1,Term,1,1)`	Choice	Pass starting location

`OutputI (ADC, IRESP())`
`OutputMoreI (ADC, IResp ())`
	Yes	Pass entire array

`OutputNI (ADC< IResp (0), 1000)`
`OutputNMoreI (ADC, IResp (0), 1000)`
	No	Pass starting location

where: **`SResp`** is **`String * 1000`**, and **`IResp(1000)`** is **`integer`**.

OutputI (Peripheral Mode)

Driver488/W31 only (Visual Basic only)

OutputXI	
SYNTAX	`OutputXI (ByVal devHandle%, data%, ByVal last%, ByVal forceAddr%, Term As terms, ByVal async%, compstat%) As Long`
	`devHandle%` refers to either an interface or an external device.
	`data%` points to the bytes to send.
	`count&` is the number of characters to send.
	`last%` is a flag that forces the device output terminator to be sent with the data.
	`forceAddr%` is ignored.
	`terms` is a pointer to a terminator structure that is used to set up the output terminators. If **`terms`** is set to **`0`**, the default terminator is used.
	`async%` is a flag that allows asynchronous data transfer.
	`compStat%` is a pointer to an integer containing completion status information.
RETURNS	`-1 if error; otherwise, the number of characters transferred`
MODE	`*CA`
BUS STATES	`Determined by the Controller.`
SEE ALSO	`EnterI, Term, TimeOut, Buffered`

The **`OutputI`** commands for Visual Basic are identical to the standard **`Output`** commands except that they use an integer array for the output data rather than a string.

In Peripheral mode, the **`OutputXI`** command sends data to the interface under control of the Active Controller. The Active Controller must put the interface into the Talk state and configure some bus device to accept the transferred data. The Talk state can be checked with the **`Status`** command, or can cause an interrupt via the **`Arm`** command. A time-out error occurs, if enabled, if no bus device accepts the data within the time out period after issuing the **`OutputXI`** command. Even as a Peripheral, Driver488 might be the System Controller. If Driver488 is the System Controller and **`AutoRemote`** is enabled, then Driver488 asserts Remote Enable (**`REN`**) before sending any data. The **`OutputXI`** command in Peripheral mode is otherwise identical to the **`OutputXI`** command in Controller mode.

Additional OutputI Functions

Driver488 provides additional **`OutputI`** functions that are short form versions of the **`OutputXI`** function. The additional **`OutputI`** functions are: **`OutputI`** and **`OutputNI`**. In Peripheral mode, the device handle must always refer to an I/O adapter, and the **`forceAddr%`** flag is ignored. Thus, **`OutputMoreI`** is equivalent to **`OutputI`**, and **`OutputNMoreI`** is equivalent to **`OutputNI`**.

PassControl

SYNTAX	`int pascal PassControl(DevHandleT devHandle);`
	`devHandle` refers to an external device to which control is passed.
RETURNS	`-1 if error`
MODE	`CA`
BUS STATES	`ATN•UNL, MLA, TAG, UNL, TCT, *ATN`
SEE ALSO	`Abort, Reset, SendCmd`
EXAMPLE	`errorcode = PassControl(scope);`

The **`PassControl`** command allows Driver488 to give control to another controller on the bus. After passing control, Driver488 enters the Peripheral mode. If Driver488 was the System Controller, then it remains the System Controller, but it is no longer the Active Controller. The Controller now has command of the bus until it passes control to another device or back to Driver488. The System Controller can regain control of the bus at any time by issuing an **`Abort`** command.

PPoll

SYNTAX	`int pascal PPoll(DevHandleT devHandle);`
	`devHandle` refers to either an interface or an external device. If **`devHandle`** refers to an external device, then the **`PPoll`** command acts on the hardware interface to which the external device is attached.
RETURNS	`-1 if error; otherwise, a number in the range 0 to 255`
MODE	`CA`
BUS STATES	`ATN•EOI, *EOI`
SEE ALSO	`PPollConfig, PPollUnconfig, PPollDisable, SPoll`
EXAMPLE	`errorcode = PPoll(ieee);`

The **`PPoll`** (Parallel Poll) command is used to request status information from many bus devices simultaneously. If a device requires service then it responds to a Parallel Poll by asserting one of the eight IEEE 488 bus data lines (**`DIO1`** through **`DIO8`**, with **`DIO1`** being the least significant). In this manner, up to eight devices may simultaneously be polled by the controller. More than one device can share any particular **`DIO`** line. In this case, it is necessary to perform further Serial Polling (**`SPoll`**) to determine which device actually requires service.

Parallel Polling is often used upon detection of a Service Request (**`SRQ`**), though it may also be performed periodically by the controller. In either case, **`PPoll`** responds with a number from **`0`** to **`255`** corresponding to the eight binary **`DIO`** lines. Not every device supports Parallel Polling. Refer to the manufacturer's documentation for each bus device to determine if Parallel Poll capabilities are supported.

PPollConfig

SYNTAX	`int pascal PPollConfig(DevHandleT devHandle, int ppresponse);`
	`devHandle` refers to either an interface or an external device to configure for the Parallel Poll.
	`ppresponse` is the decimal equivalent of the four binary bits **`S`**, **`P2`**, **`P1`**, and **`P0`** where **`S`** is the Sense bit, and **`P2`**, **`P1`**, and **`P0`** assign the **`DIO`** bus data line used for the response.
RETURNS	`-1 if error`
MODE	`CA`
BUS STATES	`ATN•UNL, MTA, LAG, PPC`

SEE ALSO	`PPoll, PPollUnconfig, PPollDisable`	
EXAMPLE	`errorcode = PPollConfig (dmm,0x0D);`	Configure device DMM to assert DIO6 when it desires service (ist = 1) and it is Parallel Polled (0x0D = &H0D = 1101 binary; S=1, P2=1, P1=0, P0=1; 101 binary = 5 decimal = DIO6).

The **`PPollConfig`** command configures the Parallel Poll response of a specified bus device. Not all devices support Parallel Polling and, among those that do, not all support the software control of their Parallel Poll response. Some devices are configured by internal switches.

The Parallel Poll response is set by a four-bit binary number response: **`S`**, **`P2`**, **`P1`**, and **`P0`**. The most significant bit of response is the *Sense* (**`S`**) bit. The Sense bit is used to determine when the device will assert its Parallel Poll response. Each bus device has an internal individual status (**`ist`**). The Parallel Poll response is asserted when this **`ist`** equals the Sense bit value **`S`**. The **`ist`** is normally a logic **`1`** when the device requires attention, so the **`S`** bit should normally also be a logic **`1`**. If the **`S`** bit is **`0`**, then the device asserts its Parallel Poll response when its **`ist`** is a logic **`0`**. That is, it does not require attention. However, the meaning of **`ist`** can vary between devices, so refer to your IEEE 488 bus device documentation. The remaining 3 bits of response: **`P2`**, **`P1`**, and **`P0`**, specify which **`DIO`** bus data line is asserted by the device in response to a Parallel Poll. These bits form a binary number with a decimal value from **`0`** through **`7`**, specifying data lines **`DIO1`** through **`DIO8`**, respectively.

PPollDisable

SYNTAX	`int pascal PPollDisable(DevHandleT devHandle);`
	`devHandle` is either an interface or an external device that is to have its Parallel Poll response disabled.
RETURNS	`-1 if error`
MODE	`CA`
BUS STATES	`ATN•UNL, MTA, LAG, PPC, PPD`
SEE ALSO	`PPoll, PPollConfig, PPollUnconfig`
EXAMPLE	`errorcode = PPollDisable(dmm);` Disable Parallel Poll of device DMM.

The **`PPollDisable`** command disables the Parallel Poll response of a selected bus device.

PPollDisableList

SYNTAX	`int pascal PPollDisableList(DevHandlePT devHandles);`
	`devHandles` is a pointer to a list of external devices that are to have their Parallel Poll response disabled.
RETURNS	`-1 if error`
MODE	`CA`
BUS STATES	`ATN•UNL, MTA, LAG, PPC, PPD`
SEE ALSO	`PPoll, PPollConfig, PPollUnconfig`

EXAMPLE	`deviceList[0] = wave;`
	`deviceList[1] = timer;`
	`deviceList[2] = dmm;`
	`deviceList[3] = NODEVICE;`
	`errorcode = PPollDisableList(deviceList);`

The **`PPollDisableList`** command disables the Parallel Poll response of selected bus devices.

PPollUnconfig

SYNTAX	`int pascal PPollUnconfig(DevHandleT devHandle);`
	`devHandle` refers to a hardware interface. If **`devHandle`** refers to an external device, then the **`PPollUnconfig`** command acts on the hardware interface to which the external device is attached.
RETURNS	`-1 if error`

MODE	`CA`
BUS STATES	`ATN•PPU`
SEE ALSO	`PPoll, PPollConfig, PPollDisable`
EXAMPLE	`errorcode = PPollUnconfig(ieee);`

The `PPollUnconfig` command disables the Parallel Poll response of all bus devices.

Remote

SYNTAX	`int pascal Remote(DevHandleT devHandle);`	
	`devHandle` refers to either an interface or an external device. If `devHandle` refers to an interface, then the Remote Enable (`REN`) line is asserted. If `devHandle` refers to an external device, then that device is addressed to Listen and placed into the `Remote` state.	
RETURNS	`-1 if error`	
MODE	`SC`	
BUS STATES	`REN (hardware interface)`	
	`REN, ATN•UNL, MTA, LAG (external device)`	
SEE ALSO	`Local, LocalList, RemoteList`	
EXAMPLES	`errorcode = Remote(ieee);`	Assert the REN bus line.
	`errorcode = Remote(scope);`	Assert the REN bus line and address the SCOPE device specified to Listen, to place it in the Remote state:

The `Remote` command asserts the Remote Enable (`REN`) bus management line. If an external device is specified, then `Remote` will also address that device to Listen, placing it in the `Remote` state.

RemoteList

SYNTAX	`int pascal RemoteList(DevHandlePT devHandles);`	
	`devHandles` is a pointer to a list of devices.	
RETURNS	`-1 if error`	
MODE	`SC•CA`	
BUS STATES	`REN, ATN•UNL, MTA, LAG`	
SEE ALSO	`Remote, Local, LocalList`	

EXAMPLE	`deviceList[0] = wave;`
	`deviceList[1] = timer;`
	`deviceList[2] = dmm;`
	`deviceList[3] = NODEVICE;`
	`errorcode = RemoteList(deviceList);`
		Assert the REN bus line and address a list of specified devices to Listen, to place these specified devices in the Remote state.

The `RemoteList` command asserts the Remote Enable (`REN`) bus management line. If external devices are specified, then `RemoteList` will also address those devices to Listen, placing them in the `Remote` state.

RemoveDevice

SYNTAX	`int pascal RemoveDevice(DevHandleT devHandle);`
	`devHandle` specifies an interface or an external device to remove.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`MakeDevice, KeepDevice, REMOVE DOS NAME (Sub-Chapter 15A)`
EXAMPLE	`errorcode = RemoveDevice(dmm);`

The `RemoveDevice` command removes the specific temporary or permanent Driver488 device that was created with either the `MakeDevice` command or the startup configuration. This command also removes a device that was made permanent through a `KeepDevice` command.

Request

SYNTAX	`int pascal Request(DevHandleT devHandle, int spstatus);`	
	`devHandle` refers to either an interface or an external device. If `devHandle` refers to an external device, the `Request` command acts on the hardware interface to which the external device is attached.	
	`spstatus` is the Service Request status in the range `0` to `255`.	
RETURNS	`-1 if error`	
MODE	`*CA`	
BUS STATES	`SRQ if rsv is set, *SRQ if not.`	
SEE ALSO	`Status, ControlLine`	
EXAMPLES	`errorcode = Request(ieee,0)`	Clear SRQ and Serial Poll Response.
	`errorcode = Request(ieee,64+2+4)`	Generate an SRQ (decimal 64) with DIO2 (decimal 2) and DIO3 (decimal 4) set in the serial poll response.

In Peripheral mode, Driver488 is able to request service from the Active Controller by asserting the Service Request (`SRQ`) bus signal. The `Request` command sets or clears the Serial Poll status (including Service Request) of Driver488. `Request` takes a numeric argument in the decimal range `0` to `255` (hex range `&H0` to `&HFF`) that is used to set the Serial Poll status. When Driver488 is Serial Polled by the Controller, it returns this byte on the `DIO` data lines.

The data lines are numbered `DIO8` through `DIO1`. `DIO8` is the most significant line and corresponds to a decimal value of `128` (hex `&H80`). `DIO7` is the next most significant line and corresponds to a decimal value of `64` (hex `&H40`). `DIO7` has a special meaning: It is the *Request for Service* (`rsv`) bit. If `rsv` is set, then Driver488 asserts the Service Request (`SRQ`) bus signal. If `DIO7` is clear (a logic `0`), then Driver488 does not assert SRQ. When Driver488 is Serial Polled, all eight bits of the Serial Poll status are returned to the Controller. The `rsv` bit is cleared when Driver488 is Serial Polled by the Controller. This causes Driver488 to stop asserting `SRQ`.

Reset

SYNTAX	`int pascal Reset(DevHandleT devHandle);`
	`devHandle` refers to either an interface or an external device. If `devHandle` refers to an external device, the `Reset` command acts on the hardware interface to which the external device is attached.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`Abort, Term, TimeOut`
EXAMPLE	`errorcode=Reset(ieee);`

The `Reset` command provides a warm start of the interface. It is equivalent to issuing the following command process, including clearing all error conditions:

1. `Stop`
2. `Disarm`
3. Reset hardware. (Resets to Peripheral if not System Controller)
4. `Abort` (if System Controller)
5. `Error ON`
6. `Local`
7. `Request 0` (if Peripheral)

8. Clear `Change`, `Trigger`, and `Clear` status.
9. Reset I/O adapter settings to installed values. (`BusAddress`, `TimeOut`, `IntLevel` and `DmaChannel`)

Resume

SYNTAX	`int pascal Resume(DevHandleT devHandle, bool monitor);`	
	`devHandle` refers to either an interface or an external device. If `devHandle` refers to an external device, then the `Resume` command acts on the hardware interface to which the external device is attached.	
	`monitor` is a flag that when it is `ON`, Driver488 monitors the data.	
RETURNS	`-1 if error`	
MODE	`CA`	
BUS STATES	`*ATN`	
SEE ALSO	`Finish`	
EXAMPLES	`errorcode = Resume(ieee,OFF);`	Do not go into monitoring mode.
	`errorcode = Resume(ieee,ON);` `errorcode = Finish(ieee);`	Go into monitoring mode.

The Resume command unasserts the Attention (`ATN`) bus signal. Attention is normally kept asserted by Driver488, but it must be unasserted to allow transfers to take place between two peripheral devices. In this case, Driver488 sends the appropriate Talk and Listen addresses, and then must unassert Attention with the `Resume` command.

If `monitor` is specified, Driver488 monitors the handshaking process but does not participate in it. Driver488 takes control synchronously when the last terminator or `EOI` is encountered. At that point, the transfer of data stops. The `Finish` command must be called to assert Attention and release any pending holdoffs to be ready for the next action.

SendCmd

SYNTAX	`int pascal SendCmd(DevHandleT devHandle, unsigned char *commands, int len);`
	`devHandle` refers to an interface handle.
	`commands` points to a string of command bytes to be sent.
	`len` is the length of the command string.
RESPONSE	`None`
MODE	`CA`
BUS STATES	`User-defined`
SEE ALSO	`SendData, SendEoi`
EXAMPLE	`char command[] = "U?0";` `errorcode = SendCmd(ieee, &command, sizeof command);`

The `SendCmd` command sends a specified string of bytes with Attention (`ATN`) asserted, causing the data to be interpreted as IEEE 488 command bytes.

SendData

SYNTAX	`int pascal SendData(DevHandleT devHandle, unsigned char *data, int len);`
	`devHandle` refers to an interface handle.
	`data` points to a string of data bytes to be sent.
	`len` is the length of the data string.
RESPONSE	`None`
MODE	`Any`
BUS STATES	`User-defined`

SEE ALSO	`SendCmd, SendEoi`

EXAMPLES	`char data[] = "W0X";`
	`errorcode = SendData(ieee, data, strlen (data));`

The **`SendData`** command provides byte-by-byte control of data transfers and gives greater flexibility than the other commands. This command can specify exactly which operations Driver488 executes.

SendEoi

SYNTAX	`int pascal SendEoi(DevHandleT devHandle, unsigned char *data, int len);`
	`devHandle` refers to an interface handle.
	`data` points to a string of data bytes to be sent.
	`len` is the length of the data string.
RESPONSE	`None`
MODE	`Any`
BUS STATES	`User-defined`
SEE ALSO	`SendCmd, SendData`

EXAMPLES	`char data[] = "W0X";`
	`errorcode = SendEoi(ieee, data, strlen (data));`

The **`SendEoi`** command provides byte-by-byte control of data transfers and gives greater flexibility than the other commands. This command can specify exactly which operations Driver488 executes. Driver488 asserts **`EOI`** during the transfer of the final byte.

SPoll

SYNTAX	`int pascal SPoll(DevHandleT devHandle);`	
	`devHandle` refers to either an interface or a specific external device.	
RETURNS	`-1 if error;`	
	`otherwise, 0 or 64 (hardware interface) in the range 0 to 255 (external device)`	
MODE	`Any`	
BUS STATES	`ATN•UNL, MLA, TAG, SPE, *ATN, ATN•SPD, UNT`	
SEE ALSO	`SPollList, PPoll`	
EXAMPLES	`errorcode = SPoll(ieee);`	Return the internal SRQ status
	`errorcode = SPoll(dmm);`	Return the Serial Poll response of the specified device

In Active Controller mode, the **`SPoll`** (Serial Poll) command performs a Serial Poll of the bus device specified and responds with a number from **`0`** to **`255`** representing the decimal equivalent of the eight-bit device response. If **`rsv`** (**`DIO7`**, decimal value **`64`**) is set, then that device is signaling that it requires service. The meanings of the other bits are device-specific.

Serial Polls are normally performed in response to assertion of the Service Request (**`SRQ`**) bus signal by some bus device. In Active Controller mode, with the interface device specified, the **`SPoll`** command returns the internal **`SRQ`** status. If the internal **`SRQ`** status is set, it usually indicates that the **`SRQ`** line is asserted. Driver488 then returns a **`64`**. If it is not set, indicating that **`SRQ`** is not asserted, then Driver488 returns a **`0`**. With an external device specified, **`SPoll`** returns the Serial Poll status of the specified external device.

In Peripheral mode, the **`SPoll`** command is issued only to the interface, and returns the Serial Poll status. If **`rsv`** (**`DIO7`**, decimal value **`64`**) is set, then Driver488 has not been Serial Polled since the issuing last **`Request`** command. The **`rsv`** is reset whenever Driver488 is Serial Polled by the Controller.

SPollList

SYNTAX	`int pascal SPollList(DevHandlePT devHandles, unsigned char *result, char untilflag);`
	`devHandles` is a pointer to a list of external devices.
	`result` is an array that is filled in with the Serial Poll results of the corresponding external devices.
	`untilflag` refers to either `ALL`, `WHILE_SRQ`, or `UNTIL_RSV`.
RETURNS	`-1 if error`
MODE	`*CA`
BUS STATES	`ATN•UNL, MLA, TAG, SPE, *ATN, ATN•SPD, UNT`
SEE ALSO	`SPoll, PPoll`
EXAMPLE	`deviceList[0] = wave;` `deviceList[1] = timer;` `deviceList[2] = dmm;` `deviceList[3] = NODEVICE;` `result = SPollList(deviceList, resultList, ALL);` — Return the Serial Poll response for a list of device handles.

In Active Controller mode, the `SPollList` (Serial Poll) command performs a Serial Poll of the bus devices specified and responds with a number from `0` to `255` (representing the decimal equivalent of the eight-bit device response) for each device on the list. If `rsv` (`DIO7`, decimal value `64`) is set, then that device is signaling that it requires service. The meanings of the other bits are device-specific.

Serial Polls are normally performed in response to assertion of the Service Request (`SRQ`) bus signal by some bus device. In Active Controller mode with the interface device specified, the `SPollList` command returns the internal `SRQ` status for each device. If the internal `SRQ` status is set, it usually indicates that the `SRQ` line is asserted. Driver488 then returns a `64`. If it is not set, indicating that `SRQ` is not asserted, then Driver488 returns a `0`. With an external device specified, `SPollList` returns the Serial Poll status of the specified external device.

In Peripheral mode, the `SPollList` command is issued only to the interface and returns the Serial Poll status. If `rsv` (`DIO7`, decimal value `64`) is set, then Driver488 has not been Serial Polled since the last `Request` command was issued. The `rsv` is reset whenever Driver488 is Serial Polled by the Controller.

The `untilflag` refers to either `ALL`, `WHILE_SRQ`, or `UNTIL_RSV`. If `ALL` is chosen, all the devices are Serial Polled and their results placed into the result array. If `untilflag` is `WHILE_SRQ`, Driver488 Serial Polls the devices until the `SRQ` bus signal becomes unasserted, and the results are put into the result array. If `untilflag` is `UNTIL_RSV`, Driver488 Serial Polls the devices until the first device whose `rsv` bit is set, is found and the results are put into the result array.

Status

SYNTAX	`int pascal Status(DevHandleT devHandle, IeeeStatusT *result);`
	`devHandle` refers to either an IEEE 488 interface or an external device. If `devHandle` refers to an external device, `Status` acts on the hardware interface to which the external device is attached.
	`result` is a pointer to a `Status` structure.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`GetError, SPoll`

EXAMPLE	`result = Status(ieee,&StatusResult);`
	`if (statusResult.transfer == TRUE) {`
	`printf("We have a transfer in progress\n");`
	`} else {`
	`printf("There is no transfer in progress\n");`
	`}`

The **`Status`** command returns various items detailing the current state of Driver488. They are returned in a data structure, based on the following table:

Status Item	Flag	Values and Description
`Controller Active`	`.CA`	**`TRUE`**: Active Controller, **`FALSE`**: Not CA.
`System Controller`	`.SC`	**`TRUE`**: System Controller, **`FALSE`**: Not SC.
`Primary Bus Address`	`.Primaddr`	`0` to `30`: Two-digit decimal number.
`Secondary Bus Address`	`.Secaddr`	`0` to `31`: Two-digit decimal number, or `-1` if no address.
`Address Change`	`.addrChange`	**`TRUE`**: Address change has occured, **`FALSE`**: Not so.
`Talker`	`.talker`	**`TRUE`**: Talker, **`FALSE`**: Not Talker
`Listener`	`.listener`	**`TRUE`**: Listener, **`FALSE`**: Not Listener
`ByteIn`	`.bytein`	**`TRUE`**: Byte in, ready to read, **`FALSE`**: Not so.
`ByteOut`	`.byteout`	**`TRUE`**: Byte out, ready to output, **`FALSE`**: Not so.
`Service Request`	`.SRQ`	**`TRUE`**: SRQ is asserted, **`FALSE`**: SRQ is not asserted
`Triggered`	`.triggered`	**`TRUE`**: Trigger command received, **`FALSE`**: Not so.
`Cleared`	`.cleared`	**`TRUE`**: Clear command received, **`FALSE`**: Not so.
`Transfer in Progress`	`.transfer`	**`TRUE`**: Transfer in progress, **`FALSE`**: Not so.

These **`Status`** items are more-fully described in the following paragraphs:

- The *Controller Active* flag (**`.CA`**) is true if Driver488 is the Active Controller. If Driver488 is not the System Controller, then it is initially a Peripheral and it becomes a controller when Driver488 receives control from the Active Controller.
- The *System Controller* flag (**`.SC`**) is true if Driver488 is the System Controller. The System Controller mode may be configured during installation or by using the SysController command.
- The *Primary Bus Address* (**`.Primaddr`**) is the IEEE 488 bus device primary address assigned to Driver488 or the specified device. This will be an integer from `0` to `30`. The *Secondary Bus Address* (**`.Secaddr`**) is the IEEE 488 bus device secondary address assigned to the specified device. This will be either `-1` to indicate no secondary address, or an integer from `0` to `31`. Note that the interface device can never have a secondary address.
- The *Address Change* indicator (**`.addrChange`**) is set whenever Driver488 become a Talker, Listener, or the Active Controller, or when it becomes no longer a Talker, Listener, or the Active Controller. It is reset when **`Status`** is read. The *Talker* (**`.talker`**) and *Listener* (**`.listener`**) flags reflect the current Talker/Listener state of Driver488. As a Peripheral, Driver488 can check this status to see if it has been addressed to Talk or addressed to Listen by the Active Controller. In this way, the desired direction of data transfer can be determined.
- The *ByteIn* (**`.byteIn`**) indicator is set when the I/O adapter has received a byte that can be read by an **`Enter`** command. The *ByteOut* (**`.byteOut`**) indicator is set when the I/O adapter is ready to output data. The *Service Request* field (**`.SRQ`**), as an active controller, reflects the IEEE 488 bus **`SRQ`** line signal. As a peripheral, this status reflects the **`rsv`** bit that can be set by the **`Request`** command and is cleared when the Driver488 is Serial Polled. For more details, refer to the **`SPoll`** command in this Sub-Chapter.
- The *Triggered* (**`.triggered`**) and *Cleared* (**`.cleared`**) indicators are set when, as a Peripheral, Driver488 is triggered or cleared. These two indicators are cleared when **`Status`** is read. The Triggered and Cleared indicators are not updated while asynchronous transfers are in progress. The *Transfer in Progress* indicator (**`.transfer`**) indicates that an asynchronous transfer is in progress.

Stop

SYNTAX	`int pascal Stop(DevHandleT devHandle);`
	`devHandle` refers to either an interface or an external device. If **`devHandle`** refers to an external device, the **`Stop`** command acts on the hardware interface to which the external device is attached.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`ATN (Controller)`
	`None (Peripheral)`
SEE ALSO	`Enter, Output, Buffered`
EXAMPLE	`errorcode = Stop(ieee);`

The **`Stop`** command halts any asynchronous transfer that may be in progress. If the transfer has completed already, then **`Stop`** has no effect. The actual number of characters transferred is available from the **`Buffered`** command.

SysController

Driver488/SUB and Driver488/W31 only

SYNTAX	`int pascal SysController(DevHandleT devHandle, bool flag);`
	`devHandle` refers to either an interface or an external device. If **`devHandle`** refers to an external device, the **`SysController`** command acts on the hardware interface to which the external device is attached.
	`flag` specifies whether or not Driver488 is to be System Controller. If **`flag`** is **`ON`**, then Driver488 becomes System Controller. If **`flag`** is **`OFF`**, then Driver488 ceases to be System Controller.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATE	`IFC, *IFC (flag TRUE)`
	`None (flag FALSE)`
SEE ALSO	`Abort, Reset`
EXAMPLES	`errorcode = SysController(ieee,ON);`

The **`SysController`** command specifies whether or not the IEEE 488 interface card is to be the System Controller. The System Controller has ultimate control of the IEEE 488 bus, and there may be only one System Controller on a bus. If Driver488 is a Peripheral (that is, not System Controller), it may still take control of bus transactions if the Active Controller passes control to Driver488. Driver488 may then control the bus and, when it is done, pass control back to the System Controller or other computer, which then becomes the Active Controller.

Talk

SYNTAX	`int pascal Talk(DevHandleT devHandle, char pri, char sec);`
	`devHandle` refers to either an interface or an external device. If **`devHandle`** refers to an external device, the **`Talk`** command acts on the associated interface.
	`pri` and **`sec`** specify the primary and secondary addresses of the device which is to be addressed to Talk.

RETURNS	`-1 if error`
MODE	`CA`
BUS STATES	`ATN, TAG`
SEE ALSO	`Listen, SendCmd`
EXAMPLES	`errorcode = Talk (ieee, 12, -1);`

The `Talk` command addresses an external device to Talk.

Term

SYNTAX	`int pascal Term(DevHandleT devHandle, TermT *terminator, int TermType);`
	`devHandle` refers to either an interface or an external device.
	`terminator` is a pointer to the terminator structure.
	`TermType` can be either `IN`, `OUT`, or `IN+OUT`, specifying whether input, output, or both are being set.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`Enter, Output, Status, EOL (Sub-Chapter 15A)`

EXAMPLE	`term.EOI = TRUE;`
	`term.nChar = 1;`
	`term.EightBits = TRUE;`
	`term.termChar[0] = 13;`
	`errorcode = Term(ieee,&term,IN);`

The `Term` command sets the end-of-line (`EOL`) terminators for input from, and output to, I/O adapter devices. These terminators are sent at the end of output data and expected at the end of input data, in the manner of `CR LF` as used with printer data.

During output, `Term` appends the bus output terminator to the data before sending it to the I/O adapter device. Conversely, when Driver488 receives the bus input terminator, it recognizes the end of a transfer and returns the data to the calling application. The terminators never appear in the data transferred to or from the calling application. The default terminators for both input and output are set by the startup configuration and are normally `CR LF EOI`, which is appropriate for most bus devices.

End-Or-Identify (`EOI`) has a different meaning when it is specified for input than when it is specified for output. During input, `EOI` specifies that input is terminated on detection of the `EOI` bus signal, regardless of which characters have been received. During output, `EOI` specifies that the `EOI` bus signal is to be asserted during the last byte transferred.

TermQuery

Driver488/W95 only

SYNTAX	`INT TermQuery(DevHandleT devHandle, TermT *terminator, INT TermType);`
	`devHandle` refers to either an interface or an external device.
	`terminator` is a pointer to the terminator structure.
	`TermType` can be either `IN`, `OUT`, or `IN+OUT`, specifying whether input, output, or both are being set.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`Term, Enter, Output, Status, EOL (Sub-Chapter 15A)`
EXAMPLE	`None provided.`

This is a new function in Driver488/W95. The **`TermQuery`** function queries the terminators setting. Terminators are defined by the **`TermT`** structure.

TimeOut

SYNTAX	`int pascal TimeOut(DevHandleT devHandle, long millisec);`
	`devHandle` refers to either an IEEE 488 interface or an external device.
	`millisec` is a numeric value given in milliseconds.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`Reset`
EXAMPLE	`errorcode = TimeOut(ieee,100);` Set the timeout value to 100 msec.

The **`TimeOut`** command sets the number of milliseconds that Driver488 waits for a transfer before declaring a time out error. Driver488 checks for timeout errors on every byte it transfers, except in the case of asynchronous transfers. While the first byte of an asynchronous transfer is checked for time out, subsequent bytes are not. The user's program must check for timely completion of an asynchronous transfer.

Time out checking may be suppressed by specifying a time out value of zero seconds, which specifies an infinite timeout. The default time out is specified in the startup configuration, normally **`10`** seconds. The time out interval may be specified to the nearest **`0.001`** seconds (1 millisecond). However, due to the limitations of the computer, the actual interval is always a multiple of **`55`** milliseconds and there is an uncertainty of **`55`** msec in the actual interval. Time out intervals from **`1`** to **`110`** milliseconds are rounded to **`110`** milliseconds. Larger intervals are rounded to the nearest multiple of **`55`** msec (e.g. **`165`**, **`220`**, **`275`** msec, etc.).

TimeOutQuery

Driver488/W95 only

SYNTAX	`INT pascal TimeOutQuery(DevHandleT devHandle, DWORD millisec);`
	`devHandle` refers to either an IEEE 488 interface or an external device.
	`millisec` is a numeric value given in milliseconds.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`None`
SEE ALSO	`TimeOut, Reset`
EXAMPLE	`None provided.`

This is a new function in Driver488/W95. The **`TimeOutQuery`** function queries the time out setting, given in milliseconds.

Trigger

SYNTAX	`int pascal Trigger(DevHandleT devHandle);`
	`devHandle` refers to either an IEEE 488 interface or an external device.
RETURNS	`-1 if error`
MODE	`CA`

BUS STATES	`ATN•GET (interface handle)`	
	`ATN•UNL, MTA, LAG, GET (external device handle)`	
SEE ALSO	`TriggerList, Status, SendCmd`	
EXAMPLES	`errorcode = Trigger(ieee);`	Issue a Group Execute Trigger (GET) bus command to those devices that are already in the Listen state as the result of a previous Output or Send command:
	`errorcode = Trigger(dmm);`	Issue a Group Execute Trigger (GET) bus command to the device specified:

The **`Trigger`** command issues a Group Execute Trigger (**`GET`**) bus command to the specified device. If no interface devices are specified, then the **`GET`** only affects those devices that are already in the Listen state as a result of a previous **`Output`** or **`Send`** command.

TriggerList

SYNTAX	`int pascal TriggerList(DevHandlePT devHandles);`	
	`devHandles` is a pointer to a list of external devices.	
RETURNS	`-1 if error`	
MODE	`CA`	
BUS STATES	`ATN•UNL, MTA, LAG, GET`	
SEE ALSO	`Trigger, SendCmd, Status`	

EXAMPLE	`deviceList[0] = wave;`
	`deviceList[1] = timer;`
	`deviceList[2] = dmm;`
	`deviceList[3] = NODEVICE;`
	`errorcode = TriggerList(deviceList);`
		Issue a Group Execute Trigger (GET) bus command to a list of specified devices.

The **`TriggerList`** command issues a Group Execute Trigger (**`GET`**) bus command to the specified devices. If no interface devices are specified, then the **`GET`** affects those devices that are already in the Listen state as a result of a previous **`Output`** or **`Send`** command.

UnListen

SYNTAX	`int pascal UnListen (DevHandleT devHandle);`
	`devHandle` refers to either an interface or an external device. If **`devHandle`** refers to an external device, the **`UnListen`** command acts on the associated interface.
RETURNS	`-1 if error`
MODE	`CA`
BUS STATES	`ATN, UNL`
SEE ALSO	`Listen, UnTalk, SendCmd, Status`
EXAMPLE	`errorcode = UnListen (ieee);`

The **`UnListen`** command unaddresses an external device that was addressed to Listen.

UnTalk

SYNTAX	`int pascal UnTalk (DevHandleT devHandle);`
	`devHandle` refers to either an interface or an external device. If **`devHandle`** refers to an external device, the **`UnTalk`** command acts on the associated interface.
RETURNS	`-1 if error`
MODE	`CA`
BUS STATES	`ATN, UNT`
SEE ALSO	`Talk, UnListen, SendCmd, Status`
EXAMPLE	`errorcode = UnTalk (ieee);`

The `UnTalk` command unaddresses an external device that was addressed to Talk.

Wait

SYNTAX	`int pascal Wait(DevHandleT devHandle);`
	`devHandle` refers to either an interface or an external device. If `devHandle` is an external device, the `Wait` command acts on the hardware interface to which the external device is attached.
RETURNS	`-1 if error`
MODE	`Any`
BUS STATES	`Determined by previous Enter or Output command.`
SEE ALSO	`Enter, Output, Buffered, Status`
EXAMPLE	`errorcode = Wait(ieee);`

The `Wait` command causes Driver488 to wait until any asynchronous transfer has completed before returning to the user's program. It can be used to guarantee that the data has actually been received before beginning to process it, or that it has been sent before overwriting the buffer. It is especially useful with the `Enter` command, when a terminator has been specified. In that case, the amount that is actually received is unknown, and so the user's program must check with Driver488 to determine when the transfer is done. Time out checking, if enabled, is performed while `Wait`ing.

Section IV:

TROUBLESHOOTING

IV. TROUBLESHOOTING

Chapters

16. Overview

This Section consists of basic troubleshooting checklists, steps to correct radio frequency interference problems, as well as a list of error messages for Driver488. The troubleshooting checklists, which pertain to problems resulting from improper software installation or configuration, are nearly identical for each Driver488 version. However, since subtle differences do exist among these drivers, it is important to refer to the correct list.

The “Error Messages” Chapter contains a list of error codes in numerical sequence and a descriptions of the corresponding text for each error message. If a software-related problem exists with your driver, please refer to the following material prior to contacting your service representative.

17. Radio Interference Problems

Personal488 hardware systems generate, use and can radiate radio frequency energy, and if not installed and not used correctly, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

1. Reorient or relocate the receiving antenna.
2. Increase the separation between the equipment and receiver.
3. Connect the equipment to an outlet on a circuit different from that to which the receiver is connected.
4. Consult the dealer of an experienced radio/television technician for help.

The following booklet prepared by the FCC may also be helpful: *How to Identify and Resolve Radio-TV Interference Problems*. This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock Number 004-000-00345-4.

An FCC Radio Frequency Interference Statement appears in the front section of the manual.

18. Troubleshooting Checklists

Sub-Chapters

18A. Introduction

For any type of Personal488 Driver, if during or after installation you notice any of the following:

- Error messages when trying to load **`DRVR488.EXE`** or **`DRVR488W.EXE`** in memory.
- Failures in writing to an instrument using an **`Output`** command.
- Can write but *cannot* read from an instrument using an **`Enter`** command.
- Unusually slow transfer on the IEEE 488 bus.
- General failures of basic Driver488 commands.

Please review the following steps to ensure your Driver488 software is properly configured and installed.

18B. Driver488/DRV

1. Remove the card from the computer and note the selected switch and jumper settings, such as those for: I/O address, DMA channel, and interrupt level. For switch and jumper definitions, refer to “Section I: Hardware Guides” in this manual. If you have an NB488, which is the parallel to IEEE 488 controller interface, verify the interrupt level of your LPT port or run the **`NBTEST`** program.
2. Run the **`CONFIG`** program which acts as an editor of the **`DRVR488.INI`** initialization file. This **`DRVR488.INI`** file is referred to by the **`DRVR488.EXE TSR`** program when loading in memory. If this initialization file is not edited properly, the **`DRVR488.EXE`** program will fail during loading or when communicating on the bus.
3. In the **`CONFIG`** program, first select the **`DEVICE TYPE`** which can be: MP488CT, MP488, AT488, GP488 or NB488. These are 5 different hardware interfaces that are supported by the same Driver488 software. You should select the interface that you are using. To identify your interface, refer to “Section I: Hardware Guides.”

   Note: For GP488 users (which is an 8-bit IEEE 488 controller plug-in card), make sure you have a recent and compatible version of the hardware.
4. Once the **`DEVICE TYPE`** is selected, start selecting the I/O address, DMA channel and interrupt level according to the switch settings determined in *Step 1* above. Make sure none of these parameters are used concurrently somewhere else in the computer, otherwise a system crash is probable. In the case of an NB488, the DMA channel is not applicable.
5. The interface **`NAME`** represents the DOS device name of the controller interface. This **`NAME`** is recommended to be IEEE for direct compatibility with application programs. This **`NAME`** should

not be related to an external instrument unless you are configuring an external device and not the interface itself.

To configure an external device, press **<F5>**. Note that it is not necessary to communicate with instruments, an address number (**0** to **30**) can be used instead.

6. The IEEE bus address should be set to any address between **0** and **30** (preferably **21**) and should not conflict with any addresses on the bus. This is not the address of your instrument and should not be, unless you are configuring an external device and not the interface itself.

   To configure an external device, press **<F5>**. Note that it is not necessary to configure a device in order to communicate with it, an address number (**0** to **30**) can be used instead.

7. **SYS CONTROLLER** and **LIGHT PEN** typically should be checked unless you are using the interface in Peripheral mode.
8. Press **<F7>** to get a picture of the configured board and verify jumper settings.
9. Press **<F10>** to save the **DRVR488.INI** file and exit.
10. If the **DRVR488.EXE** is already loaded in memory, remove it or simply reboot your computer and reload it again because the **DRVR488.EXE** reads the **DRVR488.INI** file only at loading time.
11. Before starting to program in a high-level language, run the **KBC.EXE** program from the **\UTILS** directory and make sure you can read and write, and communicate properly with your instrument by using the **OUTPUT** and **ENTER** commands. For information on the use of the KBC.EXE program, refer to the Sub-Chapter “Getting Started” in Chapter 8 “Driver488/DRV.”
12. If you can write properly to your instrument but you cannot read anything from it, refer to the **TERM** command in “Section III: Command References” in this manual, to match up the terminators sent by the instrument with the terminators expected by the Driver488. Refer to your instrument manual to find the types of terminators appended to its response. Typically, these terminators are **CR** and **LF**.

If problems still persist, consult your service representative for assistance. Once Driver488/DRV is properly installed and configured, you are ready to start programming.

18C. Driver488/SUB

1. Remove the card from the computer and note the selected switch and jumper settings, such as those for: I/O address, DMA channel, and interrupt level. For switch and jumper definitions, refer to “Section I: Hardware Guides” in this manual. If you have an NB488, which is the parallel to IEEE 488 controller interface, verify the interrupt level of your LPT port or run the **NBTEST** program.
2. Run the **CONFIG** program which acts as an editor of the **DRVR488.INI** initialization file. This **DRVR488.INI** file is referred to by the **DRVE488.EXE TSR** program when loading in memory. If this initialization file is not edited properly, the **DRVR488.EXE** program will fail during loading or when communicating on the bus.
3. In the **CONFIG** program, first select the **DEVICE TYPE** which can be: MP488CT, MP488, AT488, GP488 or NB488. These are 5 different hardware interfaces that are supported by the same Driver488 software. You should select the interface that you are using. To identify your interface, refer to “Section I: Hardware Guides.”

   Note: For GP488 users (which is an 8-bit IEEE 488 controller plug-in card), make sure you have a recent and compatible version of the hardware.

4. Once the **DEVICE TYPE** is selected, start selecting the I/O address, DMA channel and interrupt level according to the switch settings determined in *Step 1* above. Make sure none of these parameters are used concurrently somewhere else in the computer, otherwise a system crash is probable. In the case of an NB488, the DMA channel is not applicable.

5. The interface **`NAME`** represents DOS device name of the controller interface. This **`NAME`** is recommended to be IEEE for direct compatibility with application programs. This **`NAME`** should not be related to an external instrument unless you are configuring an external device and not the interface itself.

   To configure an external device, refer to *Step 9* below.

6. The IEEE bus address should be set to any address between **`0`** and **`30`** and should not conflict with any addresses on the bus. This is not the address of your instrument and should not be, unless you are configuring an external device and not the interface itself.

   To configure an external device, refer to *Step 9* below.

7. **`SysController`** and **`LightPen`** typically should be checked unless you are using the interface in Peripheral mode.
8. Press **`<F7>`** to get a picture of the configured board and verify jumper settings.
9. Press **`<F5>`** to configure an external device. The default is two devices: **`DEV`** and **`WAVE`**. At least one known device name should be configured in order to execute the subroutine **`"OpenName"`** successfully. It is not recommended to delete **`DEV`** or **`WAVE`** for compatibility purposes.
10. Press **`<F10>`** to save the **`DRVR488.INI`** file and exit.
11. If the **`DRVR488.EXE`** is already loaded in memory, remove it or simply reboot your computer and reload it again because the **`DRVR488.EXE`** reads the **`DRVR488.INI`** file only at loading time.
12. Start writing a simple program in a high-level language (**`C`**, **`BASIC`**, or **`Pascal`**) using the **`Output`** and **`Enter`** subroutines to make sure you can read and write, and communicate properly with your instrument. For information on how to write a program, refer to the Sub-Chapter “Getting Started” in Chapter 9 “Driver488/SUB.”
13. If you can write properly to your instrument but you cannot read anything from it, refer to the **`Term`** subroutine in “Section III: Command References” in this manual, to match up the terminators sent by the instrument with the terminators expected by the Driver488. Refer to your instrument manual to find the types of terminators appended to its response. Typically, these terminators are **`CR`** and **`LF`**.

If problems still persist, consult your service representative for assistance. Once Driver488/SUB is properly installed and configured, you are ready to start programming..

18D. Driver488/W31

1. Remove the card from the computer and note the selected switch and jumper settings, such as those for: I/O address, DMA channel, and interrupt level. For switch and jumper definitions, refer to “Section I: Hardware Guides” in this manual. If you have an NB488, which is the parallel to IEEE 488 controller interface, verify the interrupt level of your LPT port or run the **`NBTEST`** program.
2. Run the **`CONFIG`** program which acts as an editor of the **`DRVR488W.INI`** initialization file. This **`DRVR488W.INI`** is referred to by the **`DRVR488W.EXE`** program when loading in memory. If this initialization file is not edited properly, the **`DRVR488W.EXE`** program will fail during loading or when communicating on the bus.
3. In the **`CONFIG`** program, first select the **`DEVICE TYPE`** which can be: MP488CT, MP488, AT488, GP488 or NB488. These are 5 different hardware interfaces that are supported by the same Driver488 software. You should select the interface that you are using. To identify your interface, refer to “Section I: Hardware Guides.”

   Note: For GP488 users (which is an 8-bit IEEE 488 controller plug-in card), make sure you have a recent and compatible version of the hardware.

4. Once the **`DEVICE TYPE`** is selected, start selecting the I/O address, DMA channel and interrupt level according to the switch settings determined in *Step 1* above. Make sure none of these

parameters are used concurrently somewhere else in the computer, otherwise a system crash is probable. In the case of NB488, the DMA channel is not applicable.

5. The interface **`NAME`** represents DOS device name of the controller interface. This **`NAME`** is recommended to be IEEE for direct compatibility with application programs. This **`NAME`** should not be related to an external instrument unless you are configuring an external device and not the interface itself.
6. The IEEE bus address should be set to any address between **`0`** and **`30`** and should not conflict with any addresses on the bus. This is not the address of your instrument and should not be, unless you are configuring an external device and not the interface itself.
7. **`SysController`** and **`LightPen`** typically should be checked unless you are using the interface in Peripheral mode.
8. Press **`<F7>`** to get a picture of the configured board and verify jumper settings.
9. Press **`<F10>`** to save the **`DRVR488.INI`** file and exit.
10. If the **`DRVR488W.EXE`** is already loaded in memory, remove it. **`DRVR488W.EXE`** reads the **`DRVR488W.INI`** file only at loading time.
11. Before starting to program in a high-level language, run the **`QUIKTEST`** or **`WINTEST`** program from the **`\UTILS`** directory and make sure you can read and write, and communicate properly with your instrument. For information on the use of **`QUIKTEST`** and **`WINTEST`**, refer to the Sub-Chapter “Getting Started” in Chapter 10 “Driver488/WIN.”
12. If you can write properly to your instrument but you cannot read anything from it, refer to the **`Term`** subroutine in “Section III: Command References” in this manual, to match up the terminators sent by the instrument with the terminators expected by Driver488. Refer to your instrument manual to find the types of terminators appended to its response. Typically, these terminators are **`CR`** and **`LF`**.

If problems still persist, consult your service representative for assistance. Once Driver488/W31 is properly installed and configured, you are ready to start programming.

18E. Driver488/W95 & Driver488/WNT

Note: The differences among Driver488 for Windows 3.x, Windows 95 and Windows NT are slight. However, because additional changes are being made to Driver488/W95 and Driver488/WNT at the time this manual is being revised, *refer to your operating system header file* (and `README.TXT` text file, if present) *to obtain the current material on these driver versions.*

19. Error Messages

Error Number and Message Text		Description
00	OK	No error has occurred.
01	TIME OUT - NOT ADDRESSED TO LISTEN	ENTER as a Peripheral did not receive data within the TIME OUT period.
02	AUTOINITIALIZE MODE NOT ALLOWED	This error message is obsolete in Driver488 Rev.3.0.
03	SYSTEM ERROR - BUFFER MODE NOT SUPPORTED	Internal system error. Report to factory.
04	TIME OUT ERROR ON DATA READ	Expected bus data was not received within the TIME OUT period.
05	SYSTEM ERROR - INVALID INTERNAL MODE	Internal system error. Report to factory.
06	INVALID CHANNEL FOR DMA	This error message is obsolete in Driver488 Rev.4.0.
07	TIME OUT ON DMA TRANSFER	This error message is obsolete in Driver488 Rev.4.0.
08	TIME OUT - NOT ADDRESSED TO TALK	OUTPUT as a Peripheral was not possible within the TIME OUT period.
09	TIME OUT OR BUS ERROR ON WRITE	Error occurred transferring a data byte to a bus service.
10	SEQUENCE - NO DATA AVAILABLE	The user's program attempted to read from Driver488 when no response or data was available.
11	SEQUENCE - DATA HAS NOT BEEN READ	The user's program attempted to write data or commands to Driver488 without reading back the response to a previous command.
12	SYSTEM ERROR - ON PEN INTS ALREADY ON	Internal system error. Report to factory.
13	SYSTEM ERROR - INVALID ON PEN INIT	Internal system error. Report to factory.
14	SYSTEM ERROR - LIKELY MEMORY CORRUPTION	Internal system error. Report to factory.
15	SYSTEM ERROR - ON PEN INTS ALREADY OFF	Internal system error. Report to factory.
16	BOARD DOES NOT RESPOND AT SPECIFIED ADDRESS	Driver488 is unable to communicate with the IEEE interface board. Check the board address configuration, and the software installation.
17	TIME OUT ON COMMAND (MTA)	MyTalkAddress could not be sent within the TIME OUT period.
18	TIME OUT ON COMMAND (MLA)	MyListenAddress could not be sent within the TIME OUT period.
19	TIME OUT ON COMMAND (LAG)	Listen address(es) could not be sent within the TIME OUT period.
20	TIME OUT ON COMMAND (TAG)	Talk address could not be sent within the TIME OUT period.
21	TIME OUT ON COMMAND (UNL)	UnListen could not be sent within the TIME OUT period.
22	TIME OUT ON COMMAND (UNT)	UnTalk could not be sent within the TIME OUT period.

23	ONLY AVAILABLE TO SYSTEM CONTROLLER	Driver488 could not execute a command because it was not the System Controller.
24	RESPONSE MUST BE 0 THROUGH 15	The RESPONSE parameter of the PPOLL CONFIG command must be within the range of 0 to 15.
25	NOT A PERIPHERAL	The REQUEST command is only valid when Driver488 is in the Peripheral (*CA) mode.
26	SYSTEM ERROR - TIMER INTS ALREADY ON	Internal system error. Report to factory.
27	SYSTEM ERROR - INVALID TIMER INIT	Internal system error. Report to factory.
28	SYSTEM ERROR - TIMER INTS ALREADY OFF	Internal system error. Report to factory.
29	ADDRESS REQUIRED	PASS CONTROL requires an address.
30	TIME OUT VALUE MUST BE FROM 0 TO 65535	The TIME OUT period must be within the specified range.
31	MUST BE ADDRESSED TO TALK	DATA or EOI SEND subcommands are invalid unless Driver488 is already addressed to talk by MTA.
32	VALUE MUST BE BETWEEN 0 AND 255	Data bytes specified numerically in the SEND command must be 8-bit integers.
33	INVALID BASE ADDRESS	I/O port base addresses must end in 0, 1, or 8 when expressed in hexadecimal.
34	INVALID BUS ADDRESS	IEEE 488 bus addresses must be in the range of 0 to 30.
35	BAD DMA CHAN NO. OR DMA NOT ENABLED	This error message is obsolete in Driver488 Rev.4.0.
36	NOT AVAILABLE TO A PERIPHERAL	In Peripheral mode Driver488 cannot send bus commands such as device addresses.
37	INVALID PRIMARY ADDRESS	IEEE 488 bus addresses must be in the range of 0 to 30.
38	INVALID SECONDARY ADDRESS	IEEE 488 bus secondary addresses must be in the range of 0 to 31.
39	INVALID - TRANSFER OF ZERO BYTES	A #count of zero bytes is not valid.
40	NOT ADDRESSED TO LISTEN	In Controller mode, ENTER without specifying a bus address is not valid unless Driver488 is already addressed to listen.
41	COMMAND SYNTAX ERROR	Error in specifying command.
42	UNABLE TO CHANGE MODE AFTER BOOTUP	This error message is obsolete in Driver488 Rev.4.0.
43	TIME OUT WAITING FOR ATTENTION	As a Peripheral, executing an ENTER command, Attention did not become unasserted within the TIME OUT period.
44	DEMO VERSION - CAPABILITY EXHAUSTED	The DEMO version of Driver488 is limited to 100 commands per session.
45	DEMO VERSION - ONLY ONE ADDRESS	The DEMO version of Driver488 can control only one instrument at one IEEE 488 bus address.
46	OPTION NOT AVAILABLE	This error message is obsolete in Driver488 Rev.4.0.

47	`VALUE MUST BE BETWEEN 1 AND 8`	The IEEE 488 interface board clock frequency must be between 1 and 8.
48	`TIME OUT - CONTROL NOT ACCEPTED`	No device took control of the IEEE 488 bus after a PASS CONTROL.
49	`UNABLE TO ADDRESS SELF TO TALK OR LISTEN`	A TALK or LISTEN subcommand in a SEND command specified the controller's own address. Use MTA or MLA instead.
50	`TIME OUT ON COMMAND`	A time out error occurred during a SEND command.
51	`CANNOT DMA ON ODD BOUNDARY`	Internal system error. Report to factory.
52	`INTERRUPT %d DOES NOT EXIST`	Invalid interrupt chosen. Check hardware settings.
53	`INTERRUPT %d IS NOT SHAREABLE`	Another device already controls this interrupt.
54	`UNABLE TO ALLOCATE DYNAMIC MEMORY FOR INT %d`	Internal system error. Report to factory.
55	`SHARED INTERRUPT %d CHAIN CORRUPTED`	Internal system error. Report to factory.
56	`TOO MANY ACTIVE TIMEOUTS`	Internal system error. Report to factory.
57	`INVALID DEVICE HANDLE %d`	Device handle was not opened. Must first open device and assign handle.
58	`OUT OF DEVICE HANDLES`	Too many device handles opened. Must close unused handles.
59	`UNKNOWN DEVICE: %s`	Device not configured. Use MakeDevice to create.
60	`DRIVER NOT LOADED`	Driver is not loaded. Must load driver to run.
61	`INVALID LIST OF DEVICE HANDLES`	Array of device handles does not contain valid handles.
62	`INVALID TERMINATOR STRUCTURE`	Terminator structure does not contain valid data.
63	`INVALID DATA POINTER`	Data pointer is NULL or points to invalid data.
64	`INVALID POINTER TO STATUS STRUCTURE`	Status structure address is invalid or NULL.
65	`INVALID NAME POINTER`	Name parameter is empty or address is invalid.
66	`SYSTEM ERROR - INVALID INTERNAL POINTER`	Internal system error. Report to factory.
67	`INVALID STRING FOR ERROR TEXT`	Error text string address is invalid.
68	`UNABLE TO FIND ERROR CODE REPORTER`	Internal system error. Report to factory.
69	`UNABLE TO TRANSLATE ERROR CODE`	Internal system error. Report to factory.
70	`DMA CHANNEL %d DOES NOT EXIST`	Specified DMA channel does not exist. Check hardware settings.
71	`DMA CHANNEL %d NOT AVAILABLE`	Specified DMA channel is not available for use by Driver. Choose another channel.
72	`DMA CHANNEL %d ALREADY IN USE`	Specified DMA channel is already being used by another device. Choose another channel.
73	`UNABLE TO ALLOCATE MEMORY FOR ASYNCHRONOUS I/O`	Internal system error. Report to factory.

74	`UNKNOWN DOS DEVICE NAME`	Driver488 DOS device name not known. Must create Driver488 DOS device name with the Make Dos Name command.
75	`UNABLE TO ALLOCATE MEMORY FOR NEW DEVICE`	Ran out of memory. Remove some devices to restore memory.
76	`UNKNOWN SLAVE DEVICE`	Internal system error. Report to factory.
77	`SLAVE DEVICE NOT SPECIFIED`	Corrupt initialization file. Run the Install program.
78	`UNABLE TO CREATE DOS DEVICE NAME`	Internal system error. Report to factory.
79	`UNABLE TO INITIALIZE DEVICE`	Corrupt initialization file. Run the Install program.
80	`ATTEMPTED TO REMOVE SLAVE DEVICE`	Attempt to remove device which is required for operation by another device.
81	`DATA OVERRUN`	Serial input overflow.
82	`(None)`	(None)
83	`FRAMING ERROR`	Serial data corrupt. Possible incorrect Serial port configuration.
84	`TIME OUT ON SERIAL COMMUNICATION`	Serial device did not respond.
85	`UNKNOWN PARAMETER OF TYPE %d SPECIFIED :\n %s = %s`	Internal system error. Report to factory.
86	`BUS ERROR - NO LISTENERS`	No Listeners found on bus.
87	`TIME OUT ON MONITOR DATA`	Expected terminator was not received.
88	`INVALID VALUE SPECIFIED`	Specified value is invalid for application. See command for proper value types.
89	`NO TERMINATOR SPECIFIED`	Terminator must be specified. Check terminator value.
90	`NOT AVAILABLE IN 8-BIT SLOT`	Specified option is not available when the I/O adapter is fitted into an 8-bit slot.
91	`TOO MANY PENDING EVENTS`	Internal system error. Report to factory.
92	`BREAK ERROR`	Serial receiver detected break.
93	`UNEXPECTED CHANGE OF CONTROL LINES`	Handshake lines changed during transmission.
94	`TIME OUT ON CTS`	Hardware handshake not satisfied within time out. Check cabling and connected device.
95	`TIME OUT ON DSR`	Hardware handshake not satisfied within time out. Check cabling and connected device.
96	`TIME OUT ON DCD`	Hardware handshake not satisfied within time out. Check cabling and connected device.
97	`CANNOT SEND EOI WITHOUT DATA`	Transmission of EOI was requested when no data was available to send.
98	`ADDRESS STATUS CHANGE DURING TRANSFER`	Talker/Listener mode changed during data transfer, possibly due to activity of some other device on the IEEE 488 bus.
99	`UNABLE TO MAKE NEW DEVICE`	MakeDevice or CreateDevice was unable to create a new device, possibly due to the number of devices which already existed.
100	`(None)`	(None)
101	`COMMAND SYNTAX ERROR: %`	Command interpreter was unable to interpret command and no other information was available.

102	`ERROR OPENING DEVICE %s`	Possible loss of electrical or logical connection.
103	`DEVICE %s CURRENTLY LOCKED BY %s`	Device is in use by another processor in a multiprocessing environment. (This does not refer to multitasking environments.)
104	`TIME OUT ON NETWORK COMMUNICATIONS`	Unable to access a remote communications device within the time out interval.
105	`ERROR: DEVICE IS NOT OPEN`	Attempt to access a device which has not been opened or has subsequently been closed.
106	`IPX IS NOT LOADED`	Unable to access device via network communications.
107	`INTERFACE IS BUSY`	Remote IEEE 488 interface is busy.
108	`TIMER/COUNTER REQUIRES INTERRUPTS TO BE CONFIGURED`	Interrupts are required for proper Driver488 function of this device.
109	`INVALID INTERRUPT LEVEL`	Request interrupt level is not supported by this hardware.
110	`MUST REMOVE DOS NAME FIRST`	Attempted to remove a Driver488 device underlying a DOS device.
111	`NO WINDOWS TIMERS AVAILABLE`	Driver488/W31 requires use of a Windows timer which was unavailable. Close other applications using Windows timers and retry.

Section V:

APPENDIX

V. APPENDIX

Bus States, Bus Lines & Bus Commands

Bus State	**Bus Lines**	**Data Transfer (DIO) Lines**							
		8	**7**	**6**	**5**	**4**	**3**	**2**	**1**
	Hex Value (QuickBASIC)	&H80	&H40	&H20	&H10	&H08	&H04	&H02	&H01
	Decimal Value	128	64	32	16	8	4	2	1
	Bus Management Lines								
IFC	Interface Clear								
REN	Remote Enable								
	IEEE 488 Interface: Bus Management Lines								
ATN	Attention (&H04)	0	0	0	0	0	1	0	0
EOI	End-Or-Identify (&H80)	1	0	0	0	0	0	0	0
SRQ	Service Request (&H40)	0	1	0	0	0	0	0	0
	IEEE 488 Interface: Handshake Lines								
DAV	Data Valid (&H08)	0	0	0	0	1	0	0	0
NDAC	Not Data Accepted (&H10)	0	0	0	1	0	0	0	0
NRFD	Not Ready For Data (&H20)	0	0	1	0	0	0	0	0
	Serial Interface: Bus Management Lines								
DTR	Data Terminal Ready (&H02)	0	0	0	0	0	0	1	0
RI	Ring Indicator (&H10)	0	0	0	1	0	0	0	0
RTS	Request To Send (&H01)	0	0	0	0	0	0	0	1
	Serial Interface: Handshake Lines								
CTS	Clear To Send (&H04)	0	0	0	0	0	1	0	0
DCD	Data Carrier Detect (&H08)	0	0	0	0	1	0	0	0
DSR	Data Set Ready (&H20)	0	0	1	0	0	0	0	0

Bus State (IEEE 488)	**Bus Commands** (ATN is asserted "1")	**Data Transfer (DIO) Lines**							
		8	**7**	**6**	**5**	**4**	**3**	**2**	**1**
	Hex Value (QuickBASIC)	&H80	&H40	&H20	&H10	&H08	&H04	&H02	&H01
	Decimal Value	128	64	32	16	8	4	2	1
DCL	Device Clear	x	0	0	1	0	1	0	0
GET	Group Execute Trigger (&H08)	x	0	0	0	1	0	0	0
GTL	Go To Local (&H01)	x	0	0	0	0	0	0	1
LAG	Listen Address Group (&H20-3F)	x	0	1	a	d	d	r	n
LLO	Local Lock Out (&H11)	x	0	0	1	0	0	0	1
MLA	My Listen Address	x	0	1	a	d	d	r	n
MTA	My Talk Address	x	1	0	a	d	d	r	n
PPC	Parallel Poll Config	x	1	1	0	S	P2	P1	P0
PPD	Parallel Poll Disable (&H07)	x	0	0	0	0	1	1	1
PPU	Parallel Poll Unconfig (&H15)	x	0	0	1	0	1	0	1
SCG	Second. Cmd. Group (&H60-7F)	x	1	1	c	o	m	m	d
SDC	Selected Device Clear (&H04)	x	0	0	0	0	1	0	0
SPD	Serial Poll Disable (&H19)	x	0	0	1	1	0	0	1
SPE	Serial Poll Enable (&H18)	x	0	0	1	1	0	0	0
TAG	Talker Address Group (&H40-5F)	x	1	0	a	d	d	r	n
TCT	Take Control (&H09)	x	0	0	0	1	0	0	1
UNL	Unlisten (&H3F)	x	0	1	1	1	1	1	1
UNT	Untalk (&H5F)	x	1	0	1	1	1	1	1
	(x = "don't care")								

ASCII Character Codes & IEEE 488 Bus Line Messages

Box Items

Hex Value	$41	65	Decimal Value
	A		ASCII Character
Bus Message	01		

$00 0 **NUL**	$10 16 **DLE**	$20 32 **SP** 00	$30 48 **0** 16	$40 64 **@** 00	$50 80 **P** 16	$60 96 **‘** SCG	$70 112 **p** SCG
$01 1 **SOH** GTL	$11 17 **DC1** LLO	$21 33 **!** 01	$31 49 **1** 17	$41 65 **A** 01	$51 81 **Q** 17	$61 97 **a** SCG	$71 113 **q** SCG
$02 2 **STX**	$12 18 **DC2**	$22 34 **"** 02	$32 50 **2** 18	$42 66 **B** 02	$52 82 **R** 18	$62 98 **b** SCG	$72 114 **r** SCG
$03 3 **ETX**	$13 19 **DC3**	$23 35 **#** 03	$33 51 **3** 19	$43 67 **C** 03	$53 83 **S** 19	$63 99 **c** SCG	$73 115 **s** SCG
$04 4 **EOT** SDC	$14 20 **DC4** DCL	$24 36 **$** 04	$34 52 **4** 20	$44 68 **D** 04	$54 84 **T** 20	$64 100 **d** SCG	$74 116 **t** SCG
$05 5 **ENQ**	$15 21 **NAK** PPU	$25 37 **%** 05	$35 53 **5** 21	$45 69 **E** 05	$55 85 **U** 21	$65 101 **e** SCG	$75 117 **u** SCG
$06 6 **ACK**	$16 22 **SYN**	$26 38 **&** 06	$36 54 **6** 22	$46 70 **F** 06	$56 86 **V** 22	$66 102 **f** SCG	$76 118 **v** SCG
$07 7 **BEL** PPD	$17 23 **ETB**	$27 39 **’** 07	$37 55 **7** 23	$47 71 **G** 07	$57 87 **W** 23	$67 103 **g** SCG	$77 119 **w** SCG
$08 8 **BS** GET	$18 24 **CAN** SPE	$28 40 **(** 08	$38 56 **8** 24	$48 72 **H** 08	$58 88 **X** 24	$68 104 **h** SCG	$78 120 **x** SCG
$09 9 **HT** TCT	$19 25 **EM** SPD	$29 41 **)** 09	$39 57 **9** 25	$49 73 **I** 09	$59 89 **Y** 25	$69 105 **i** SCG	$79 121 **y** SCG
$0A 10 **LF**	$1A 26 **SUB**	$2A 42 ***** 10	$3A 58 **:** 26	$4A 74 **J** 10	$5A 90 **Z** 26	$6A 106 **j** SCG	$7A 122 **z** SCG
$0B 11 **VT**	$1B 27 **ESC**	$2B 43 **+** 11	$3B 59 **;** 27	$4B 75 **K** 11	$5B 91 **[** 27	$6B 107 **k** SCG	$7B 123 **{** SCG
$0C 12 **FF**	$1C 28 **FS**	$2C 44 **,** 12	$3C 60 **<** 28	$4C 76 **L** 12	$5C 92 **** 28	$6C 108 **l** SCG	$7C 124 **|** SCG
$0D 13 **CR**	$1D 29 **GS**	$2D 45 **-** 13	$3D 61 **=** 29	$4D 77 **M** 13	$5D 93 **]** 29	$6D 109 **m** SCG	$7D 125 **}** SCG
$0E 14 **SO**	$1E 30 **RS**	$2E 46 **.** 14	$3E 62 **>** 30	$4E 78 **N** 14	$5E 94 **^** 30	$6E 110 **n** SCG	$7E 126 **~** SCG
$0F 15 **SI**	$1F 31 **US**	$2F 47 **/** 15	$3F 63 **?** UNL	$4F 79 **O** 15	$5F 95 **_** UNT	$6F 110 **o** SCG	$7F 127 **DEL** SCG
ACG	**UCG**	**LAG**		**TAG**		**SCG**	

ACG = Addressed Command Group
UCG = Universal Command Group
LAG = Listen Address Group

TAG = Talk Address Group
SCG = Secondary Command Group
A "$" preceding numbers indicates hexadecimal

ASCII Control Codes (Table 1)

ASCII Control Codes (Decimal 00 to 31)				
Dec Value	**Hex Value ($ or &H)**	**Character and Abbreviation**	**Name**	**Bus Message**
Addressed Command Group (ACG)				
`00`	`00`	`None / NUL`	Null	None
`01`	`01`	`^A / SOH`	Start of Header	Go To Local
`02`	`02`	`^B / STX`	Start of Text	None
`03`	`03`	`^C / ETX`	End of Text	None
`04`	`04`	`^D / EOT`	End of Transmission	Selected Device Clear
`05`	`05`	`^E / ENQ`	Inquiry	None
`06`	`06`	`^F / ACK`	Acknowledgement	None
`07`	`07`	`^G / BEL`	Bell	Parallel Poll Disable (PPD)
`08`	`08`	`^H / BS`	Backspace	Group Execute Trigger
`09`	`09`	`^I / HT`	Horizontal Tab	Take Control (TCT)
`10`	`0A`	`^J / LF`	Line Feed	None
`11`	`0B`	`^K / VT`	Vertical Tab	None
`12`	`0C`	`^L / FF`	Form Feed	None
`13`	`0D`	`^M / CR`	Carriage Return	None
`14`	`0E`	`^N / SO`	Shift Out	None
`15`	`0F`	`^O / SI`	Shift In	None
Universal Command Group (UCG)				
`16`	`10`	`^P / DLE`	Data Link Escape	None
`17`	`11`	`^Q / DC1`	Device Control 1	Local Lockout (LLO)
`18`	`12`	`^R / DC2`	Device Control 2	None
`19`	`13`	`^S / DC3`	Device Control 3	None
`20`	`14`	`^T / DC4`	Device Control 4	Device Clear (DCL)
`21`	`15`	`^U / NAK`	Negative Acknowledgement	Parallel Poll Unconfig (PPU)
`22`	`16`	`^V / SYN`	Synchronous Idle	None
`23`	`17`	`^W / ETB`	End of Transmission Block	None
`24`	`18`	`^X / CAN`	Cancel	Serial Poll Enable (SPE)
`25`	`19`	`^Y / EM`	End of Medium	Serial Poll Disable (SPD)
`26`	`1A`	`^Z / SUB`	Substitute	None
`27`	`1B`	`^[ / ESC`	Escape	None
`28`	`1C`	`^\ / FS`	File Separator	None
`29`	`1D`	`^] / GS`	Group Separator	None
`30`	`1E`	`^^ / RS`	Record Separator	None
`31`	`1F`	`^_ / US`	Unit Separator	None

Notes: ASCII control codes are sometimes used to "formalize" a communications session between communication devices.

`DC1, DC2, DC3, DC4, FS, GS, RS,` and **`US`** all have user-defined meanings, and may vary in use between sessions or devices.

`DC4` is often used as a general "stop transmission character."

Codes used to control cursor position may be used to control print devices, and move the print head accordingly. However, not all devices support the full set of positioning codes.

ASCII Control Codes (Table 2)

ASCII Control Codes (00 to 31)		
Dec	**Name**	**Description**
Addressed Command Group (ACG)		
00	Null (**NUL**)	Space filler character. Used in output timing for some device drivers.
01	Start of Header (**SOH**)	Marks beginning of message header.
02	Start of Text (**STX**)	Marks beginning of data block (text).
03	End of Text (**ETX**)	Marks end of data block (text).
04	End of Transmission (**EOT**)	Marks end of transmission session.
05	Inquiry (**ENQ**)	Request for identification or information.
06	Acknowledgement (**ACK**)	"Yes" answer to questions or "ready for next transmission." Used in asynchronous protocols for timing.
07	Bell (**BEL**)	Rings bell or audible alarm on terminal.
08	Backspace (**BS**)	Moves cursor position back one character.
09	Horizontal Tab (**HT**)	Moves cursor position to next tab stop on line.
10	Line Feed (**LF**)	Moves cursor position down one line.
11	Vertical Tab (**VT**)	Moves cursor position down to next "tab line."
12	Form Feed (**FF**)	Moves cursor position to top of next page.
13	Carriage Return (**CR**)	Moves cursor to left margin.
14	Shift Out (**SO**)	Next characters do not follow ASCII definitions.
15	Shift In (**SI**)	Next characters revert to ASCII meaning.
Universal Command Group (UCG)		
16	Data Link Escape (**DLE**)	Used to control transmissions using "escape sequences."
17	Device Control 1 (**DC1**)	Not defined. Normally used for ON controls.
18	Device Control 2 (**DC2**)	Usually user defined.
19	Device Control 3 (**DC3**)	Not defined. Normally used for OFF controls.
20	Device Control 4 (**DC4**)	Usually user defined.
21	Negative Acknowledgement (**NAK**)	"No" answer to questions or "errors found, re-transmit." Used in asynchronous protocols for timing.
22	Synchronous Idle (**SYN**)	Sent by asynchronous devices when idle to insure sync.
23	End of Transmission Block (**ETB**)	Marks block boundaries in transmission.
24	Cancel (**CAN**)	Indicates previous transmission should be disregarded.
25	End of Medium (**EM**)	Marks end of physical media, as in paper tape.
26	Substitute (**SUB**)	Used to replace a character known to be wrong.
27	Escape (**ESC**)	Marks beginning of an Escape control sequence.
28	File Separator (**FS**)	Marker for major portion of transmission.
29	Group Separator (**GS**)	Marker for submajor portion of transmission.
30	Record Separator (**RS**)	Marker for minor portion of transmission.
31	Unit Separator (**US**)	Marker for most minor portion of transmission.

ASCII Character Set (Table 1)

ASCII Character Set (Decimal 32 to 79)				
Dec	**Hex**	**Character**	**Name**	**Bus Message**
Listen Address Group (LAG)				
32	20	`<space>`	Space	Bus address 00
33	21	!	Exclamation Point	Bus address 01
34	22	"	Quotation Mark	Bus address 02
35	23	#	Number Sign	Bus address 03
36	24	$	Dollar Sign	Bus address 04
37	25	%	Percent Sign	Bus address 05
38	26	&	Ampersand	Bus address 06
39	27	`	Apostrophe	Bus address 07
40	28	(	Opening Parenthesis	Bus address 08
41	29	)	Closing Parenthesis	Bus address 09
42	2A	*	Asterisk	Bus address 10
43	2B	+	Plus Sign	Bus address 11
44	2C	,	Comma	Bus address 12
45	2D	-	Hyphen or Minus Sign	Bus address 13
46	2E	.	Period	Bus address 14
47	2F	/	Slash	Bus address 15
Listen Address Group (LAG)				
48	30	0	Zero	Bus address 16
49	31	1	One	Bus address 17
50	32	2	Two	Bus address 18
51	33	3	Three	Bus address 19
52	34	4	Four	Bus address 20
53	35	5	Five	Bus address 21
54	36	6	Six	Bus address 22
55	37	7	Seven	Bus address 23
56	38	8	Eight	Bus address 24
57	39	9	Nine	Bus address 25
58	3A	:	Colon	Bus address 26
59	3B	;	Semicolon	Bus address 27
60	3C	<	Less Than Sign	Bus address 28
61	3D	=	Equal Sign	Bus address 29
62	3E	>	Greater Than Sign	Bus address 30
63	3F	?	Question Mark	Unlisten (UNL)
Talk Address Group (TAG)				
64	40	@	At Sign	Bus address 00
65	41	A	Capital A	Bus address 01
66	42	B	Capital B	Bus address 02
67	43	C	Capital C	Bus address 03
68	44	D	Capital D	Bus address 04
69	45	E	Capital E	Bus address 05
70	46	F	Capital F	Bus address 06
71	47	G	Capital G	Bus address 07
72	48	H	Capital H	Bus address 08
73	49	I	Capital I	Bus address 09
74	4A	J	Capital J	Bus address 10
75	4B	K	Capital K	Bus address 11
76	4C	L	Capital L	Bus address 12
77	4D	M	Capital M	Bus address 13
78	4E	N	Capital N	Bus address 14
79	4F	O	Capital O	Bus address 15

ASCII Character Set (Table 2)

ASCII Character Set (80 to 127)				
Dec	**Hex**	**Character**	**Name**	**Bus Message**
Talk Address Group (TAG)				
80	50	P	Capital P	Bus address 16
81	51	Q	Capital Q	Bus address 17
82	52	R	Capital R	Bus address 18
83	53	S	Capital S	Bus address 19
84	54	T	Capital T	Bus address 20
85	55	U	Capital U	Bus address 21
86	56	V	Capital V	Bus address 22
87	57	W	Capital W	Bus address 23
88	58	X	Capital X	Bus address 24
89	59	Y	Capital Y	Bus address 25
90	5A	Z	Capital Z	Bus address 26
91	5B	[	Opening Bracket	Bus address 27
92	5C	\	Backward Slash	Bus address 28
93	5D	]	Closing Bracket	Bus address 29
94	5E	^	Caret	Bus address 30
95	5F	_	Underscore	Untalk (UNT)
Secondary Command Group (SCG)				
96	60	'	Grave	Command 00
97	61	a	Lowercase A	Command 01
98	62	b	Lowercase B	Command 02
99	63	c	Lowercase C	Command 03
100	64	d	Lowercase D	Command 04
101	65	e	Lowercase E	Command 05
102	66	f	Lowercase F	Command 06
103	67	g	Lowercase G	Command 07
104	68	h	Lowercase H	Command 08
105	69	I	Lowercase I	Command 09
106	6A	j	Lowercase J	Command 10
107	6B	k	Lowercase K	Command 11
108	6C	l	Lowercase L	Command 12
109	6D	m	Lowercase M	Command 13
110	6E	n	Lowercase N	Command 14
111	6F	o	Lowercase O	Command 15
Secondary Command Group (SCG)				
112	70	p	Lowercase P	Command 16
113	71	q	Lowercase Q	Command 17
114	72	r	Lowercase R	Command 18
115	73	s	Lowercase S	Command 19
116	74	t	Lowercase T	Command 20
117	75	u	Lowercase U	Command 21
118	76	v	Lowercase V	Command 22
119	77	w	Lowercase W	Command 23
120	78	x	Lowercase X	Command 24
121	79	y	Lowercase Y	Command 25
122	7A	z	Lowercase Z	Command 26
123	7B	{	Opening Brace	Command 27
124	7C	|	Vertical Line	Command 28
125	7D	}	Closing Brace	Command 29
126	7E	~	Tilde	Command 30
127	7F	DEL	Delete	Command 31

Section VI:

INDEX

VI. INDEX

List of ASCII Acronyms & Abbreviations

The following list applies to ASCII Control Codes:

ACK	Acknowledgement
BEL	Bell
BS	Backspace
CAN	Cancel
CR	Carriage Return
DC1	Device Control 1
DC2	Device Control 2
DC3	Device Control 3
DC4	Device Control 4
DEL	Delete
DLE	Data Link Escape
EM	End of Medium
ENQ	Inquiry
EOT	End of Transmission
ESC	Escape
ETB	End of Transmission Block
ETX	End of Text
FF	Form Feed
FS	File Separator
GS	Group Separator
HT	Horizontal Tab
LF	Line Feed
NAK	Negative Acknowledgement
NUL	Null
RS	Record Separator
SI	Shift In
SO	Shift Out
SOH	Start of Header
STX	Start of Text
SUB	Substitute
SYN	Synchronous Idle
US	Unit Separator
VT	Vertical Tab

List of IEEE 488 Acronyms & Abbreviations

The following list of acronyms and abbreviations apply to IEEE 488:

•	(bullet symbol) “and”
*****	(asterisk symbol) “unasserted”
***CA**	Not Controller Active mode
***SC**	Not System Controller mode
ACG	Addressed Command Group
ADC	Analog-to-Digital Converter
API	Application Program Interface
ASCII	American Standard Code for Information Interchange
ATN	Attention line
CA	Controller Active mode
CCL	Character Command Language
CMD	Bus Command interpretation
CTS	Clear To Send line
DAV	Data Valid line
DCD	Data Carrier Detect line
DCL	Device Clear bus command
DDE	Dynamic Data Exchange
DIO	Data Transfer (I/O) line
DLL	Dynamic Link Library
DMA	Direct Memory Access
DMM	Digital Multimeter
DSR	Data Set Ready line
DTR	Data Terminal Ready line
EOI	End-Or-Identify line
EOL	End-Of-Line terminator
GET	Group Execute Trigger bus command
GTL	Go To Local bus command
IEEE	Institute of Electrical & Electronic Engineers
IFC	Interface Clear line
IOCTL	Input/Output Control
ist	Bus Device Individual Status
LAG	Listen Address Group bus command
LLO	Local Lock Out bus command
MLA	My Listen Address
MTA	My Talk Address
NDAC	Not Data Accepted line
NRFD	Not Ready For Data line
PPC	Parallel Poll Configure bus command
PPD	Parallel Poll Disable bus command
PPU	Parallel Poll Unconfig bus command
REN	Remote Enable line
RI	Ring Indicator line
RS	Revised Standard
rsv	Request for Service bit
RTS	Request To Send line
SC	System Controller mode
SCG	Secondary Command Group
SCPI	Standard Command for Programmable Instruments
SDC	Selected Device Clear bus command
SPD	Serial Poll Disable bus command
SPE	Serial Poll Enable bus command
SRQ	Service Request line
TAG	Talk Address Group bus command
TCT	Take Control bus command
UCG	Universal Command Group
UNL	Unlisten bus command
UNT	Untalk bus command