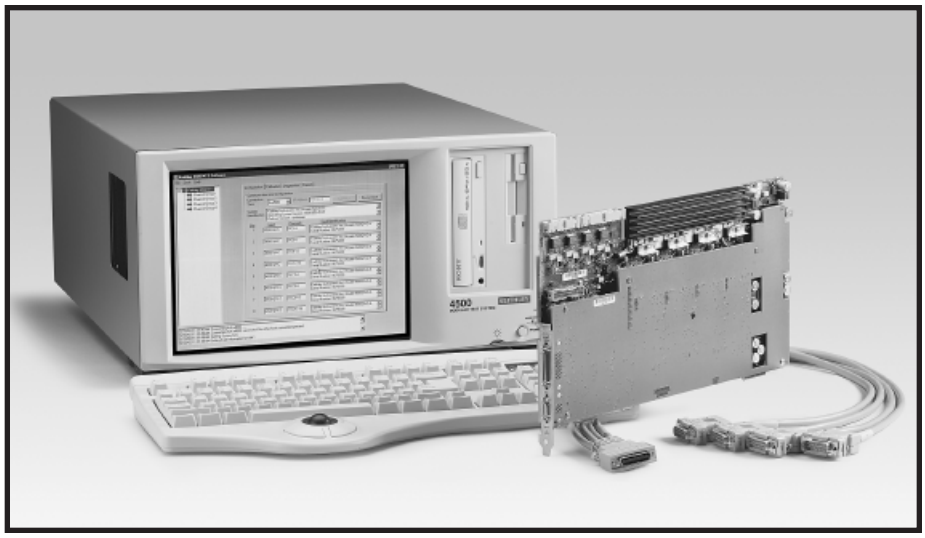
4500-MTS

Multi-Channel I-V Test System

- Configurable from four to 36 source-measure channels
- Programmable DC sources, up to 10V @ 10mA or 1A @ 6V
- Supports parallel testing with up to eight autonomous groups of channels
- Real-time parallel source and measurement sequences
- Fast measurement integration—rates as short as 0.002 NPLC
- Easy-to-program parallel I-V sweeps and step-and-sweep sequences
- Open PC/PCI architecture allows easy integration of software and hardware
- Software drivers optimized for popular test development environments
- Ethernet and Windows 2000 support popular network interfaces that connect to corporate networks and the Internet
- Test applications can be developed and executed on either a remote PC or on the Model 4500-MTS



The Model 4500-MTS Multi-Channel I-V Test System is a DC source-measure test system optimized for high speed parallel testing. It supports up to 36 source-measure channels while managing complex channel coordination tasks automatically, such as inter-channel triggering and communications. It also reduces system complexity by eliminating the need for external trigger control and instrument communications buses.

Unmatched Channel Density

Model 4510-QIVC and 4511-QIVC plug-in cards offer powerful and precise source-measure capability. Each card provides four channels, each of which includes a current source subchannel and a voltage source subchannel, as shown in Figure 1. Each channel includes an instrument-grade A/D converter to ensure the highest possible throughput without compromising precision. With nine available slots, the Model 4500-MTS can be configured for applications that require as few as four channels or as many as 72 subchannels.

A current source subchannel includes a programmable current source with current readback, four-wire voltage measurement, and a programmable voltage clamp. The Model 4510-QIVC has 30mA, 100mA, and 500mA current source ranges, while the Model 4511-QIVC offers 100mA, 300mA, and 1A ranges.

A voltage source subchannel consists of a programmable voltage source of up to 10V with voltage readback and three current measurement ranges: 10μA, 500μA, and 10mA.

Each subchannel has independently controllable output modes, including high impedance and short circuit modes. The high impedance output mode allows both the current and voltage source subchannels to be connected to the same DUT (Device Under Test) and change between current and voltage source tests without using external switching. The short circuit mode provides improved ESD protection for the DUT when the output is turned off.

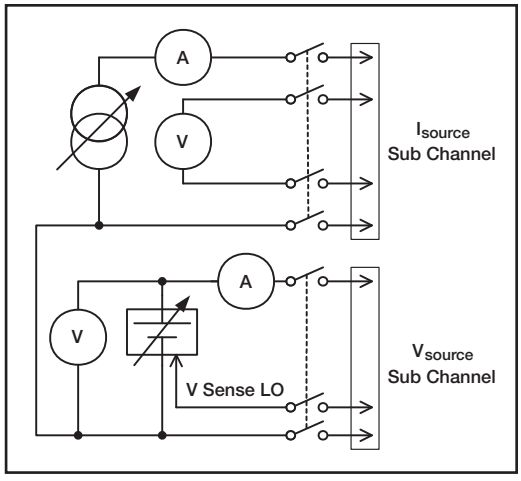


Figure 1. The source and measurement components in one channel of a Model 4500-QIVC card.

APPLICATIONS

Multi-site parallel testing, including:

- Wafer-level HiB LED
- Photonic integrated circuit
- MEMS/MOEMS life test
- Used in RFIC test as intelligent power supply subsystem
- Wafer- and package-level VCSEL test
- Laser diode characterization
- Multi-section tunable laser diode test

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4500-MTS

Multi-Channel I-V Test System

Ordering Information

4500-MTS/F
MTS Chassis with Flat Panel Option

4500-MTS/C
MTS Chassis without Flat Panel Option

Note: 4500-MTS must be purchased with one or more QIVC cards:

4510-QIVC
Low Power Quad I/V Card

4511-QIVC
High Power Quad I/V Card

ACCESSORIES SUPPLIED WITH 4500-MTS

4500 User's Manual

4510/11-QIVC Drivers (Installed)

ACCESSORIES SUPPLIED WITH 451X-QIVC

4500-950-00	CD Manual
4500-CQIV-*	QIVC Cable (*=0.5, 1, 2, 3m length – choice of one)
4500-CILK-*	QIVC Interlock Cable (*=0.5, 1, 2, 3m length – choice of one)
4500-CIV-KIT-1	15-pin female D-sub, solder cup, mates with 4500-CQIV-* (Qty of 4)
4500-ILK-PLUG	QIVC Interlock override plug, mates to 4500-CILK-*
4500-QIVC-TLS	QIVC Test lead set, 15-pin D-sub to 8 alligator clips

ACCESSORIES AVAILABLE

4510-QIVC	Low Power Quad I/V Card
4511-QIVC	High Power Quad I/V Card
4500-CQIV-*	QIVC Cable (* = 0.5, 1, 2, 3m length)
4500-CILK-*	QIVC Interlock Cable (* = 0.5, 1, 2, 3m length)
4500-CIV-KIT-1	15 pin female D-sub, solder cup, mates with 4500-CQIV-*
4500-ILK-KIT-1	14 pin MDR connector and shell for 451x-QIVC
4500-ILK-PLUG	QIVC Interlock override plug, mates to 4500-CILK-*
4500-QIVC-TLS	QIVC Test lead set, 15-pin D-sub to 8 alligator clips

Precise Timing Performance

Complex tests, such as nested sweeps, can easily be performed with precise timing, without the latencies normally associated with multi-channel systems. The real-time controller (RTC) embedded in each Series 4500 card makes this possible by managing test execution independently from the PC in the mainframe. The RTCs, in conjunction with the trigger bus, allow groups of channels spanning one or more cards to act synchronously, yet independently of other groups of channels. The RTCs also record sweep measurement results during a test sequence for transfer via the PCI bus once the test is complete. RTCs can also execute preprogrammed sequences like linear sweeps and list sweeps.

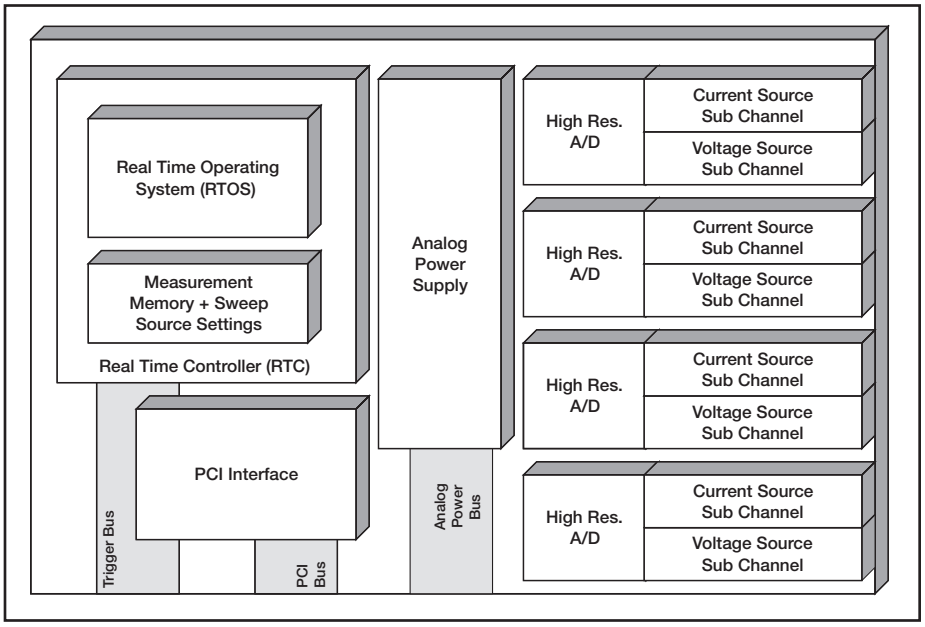


Figure 2. 4510/11-QIVC block diagram showing the RTC (real-time controller), as well as the four channels with dedicated, independent, high resolution analog-to-digital converters.

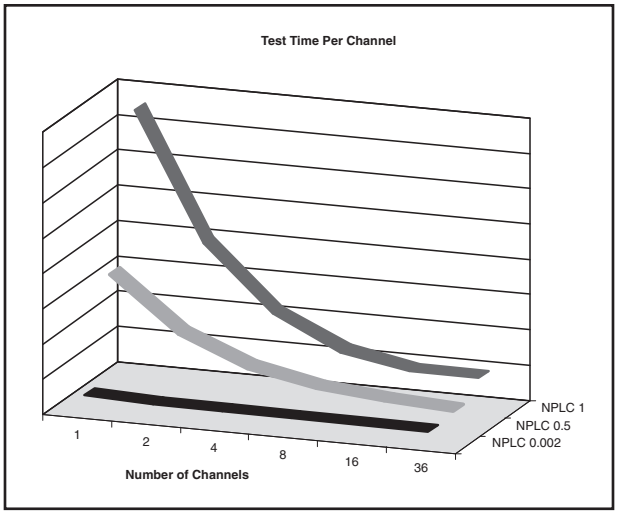


Figure 3. When test configuration and test execution occur in parallel, adding more channels doesn't increase the test time—it only increases the download time of the test results. Here, the test results download time is a fraction of the configuration and test time. As a result, adding more channels actually increases the average speed per channel.

Parallel Test Maximizes Throughput

Parallel test is used when throughput is a high priority and the test execution time is significant compared to the component handling times. **Figure 3** illustrates how throughput improves when the number of channels dedicated to a synchronous parallel test system increases. In this case, the test time per channel actually decreases with the addition of channels. This is because channel configuration and test occur in parallel, while only test results are downloaded sequentially. **Figure 4** shows a concurrent test environment, where groups of channels execute asynchronously. In this case, the RTCs in the Series 4500 cards execute completely independently of other groups and of the embedded PC. This allows the PC embedded in the mainframe to manage coordination between the channel groups and the component handling system.

Simplified Programming

The Model 4500-MTS software architecture allows the unit to be used either as an instrument, being controlled by a remote PC, or as a self contained system. The architecture allows the same application code to be executed either on a remote PC or on the Model 4500-MTS without any changes. **Figure 5** shows the communications flow between the software and hardware components of the system.

Series 4500 card drivers communicate with the 4500 Real-Time Manager via TCP/IP. This communication layer allows the application code to communicate with the 4500 Real-Time Manager locally or over the Ethernet. In addition to allowing remote control, the 4500 Real-Time Manager also:

- Manages groups of channels—Coordinates groups of channels that execute tests as an organized group. It supports up to eight channel groups. Each channel group executes independently of all other channel groups.
- Channel configuration—Configures each channel based on input from the Series 4500 card driver. The 4500 Real-Time Manager greatly reduces the programming complexity by configuring the inter- and intra-card sequencing. It also eliminates complex trigger model programming.
- Manages access among multiple users—Allows multiple users to connect to the Model 4500-MTS through the Ethernet connection. The 4500 Real-Time Manager ensures each user has access to unused hardware resources and doesn't interfere with other users. It also ensures that the test data produced by a channel group is sent to that channel group's owner.

Open System Architecture

The Model 4500-MTS's architecture is based on standard PC technology, including Windows 2000, the PCI bus, and the ISA bus. While the Model 4500-MTS can be used as a remotely controlled instrument, it can also be used as a self-contained system.

Application development environments such as Microsoft Visual Basic or LabVIEW can be loaded directly onto the Model 4500-MTS, then used to build control applications for the Model 4500-MTS and external instruments. Third-party PCI cards can be installed in the chassis to provide a broad range of capabilities, such as a GPIB interface for controlling external instruments, digital I/O to interface with component handlers and robots, etc.

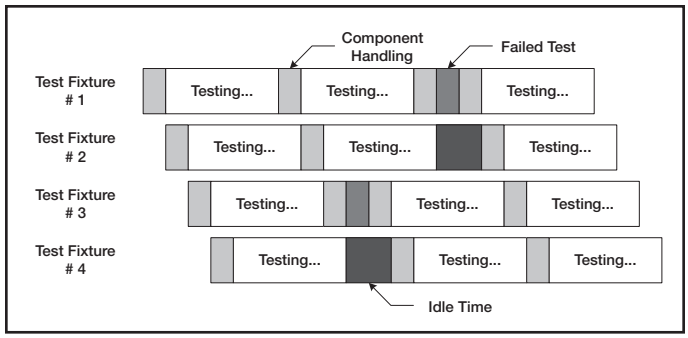


Figure 4. The architecture of the Model 4500-MTS allows channel groups to execute autonomously. Here, four DUTs are being tested concurrently. Each DUT is tested by a different group of channels working independently. Each channel group's test sequencing is offloaded to the Series 4500 cards' RTCs.

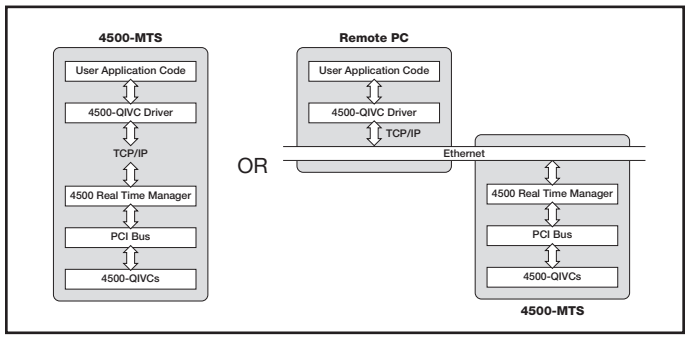


Figure 5. The software architecture allows executing programs locally or remotely without modifying application code.

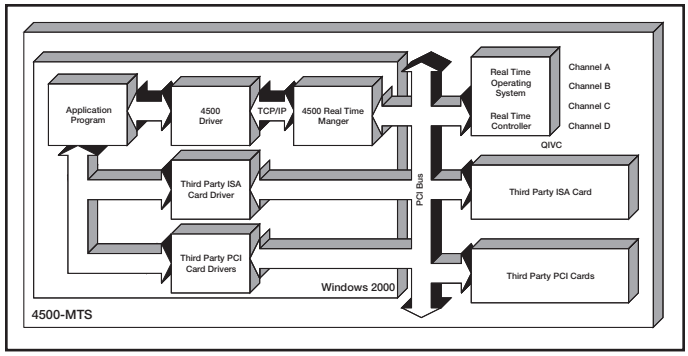


Figure 6. The open system architecture of the Model 4500-MTS allows it to operate as the test system controller.

Multi-Channel I-V Test System

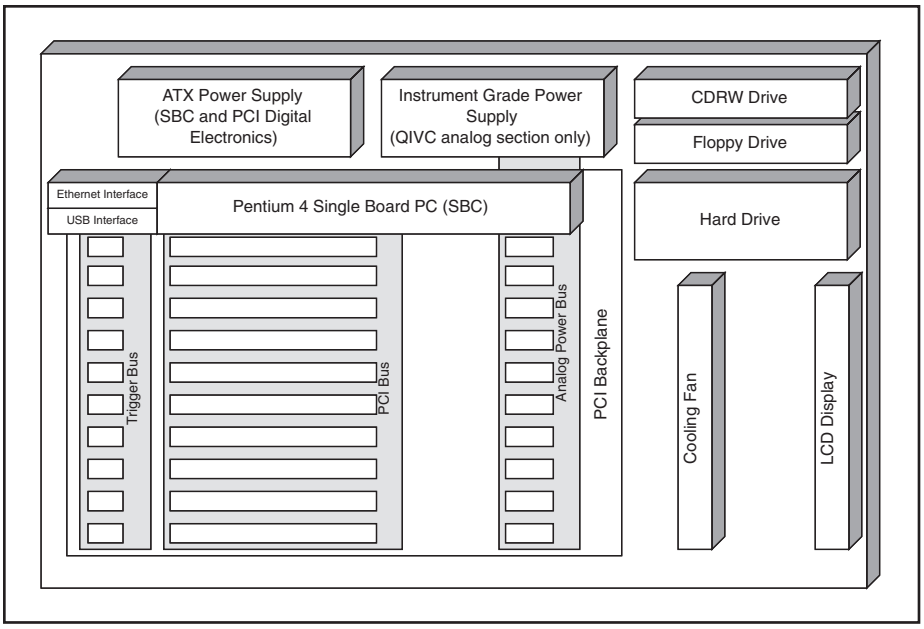


Figure 7. The 4500-MTS is an instrument-grade PC with special features, including an instrument-grade power supply, analog power bus, trigger bus, and additional electrical shielding.

Instrument-Grade PC

The 4500-MTS mainframe provides a hardware platform for both source/measure hardware and test system software and software development. As **Figure 7** shows, the chassis includes a 2GHz Pentium 4-based PC running Windows 2000, a nine-slot chassis, etc.

The 4500-MTS Mainframe has all the features of an instrument-grade PC:

- Instrument-grade power supply—This supply is isolated from the ATX (standard PC power supply) to ensure the lowest possible power supply noise.
- Instrument power bus—A dedicated instrument power bus carries high current, low noise power from the instrument power supply to the QIVC cards. This bus is located far away from the PCI digital signals.
- Electrical shielding—The chassis is designed to stop external signals from penetrating the all-metal enclosure.
- Special cooling fans—These fans maintain a cool operating environment for the source/measure hardware.

4500-MTS Multi-Channel I-V Test System

Series 451x-QIVC Card Specifications

The 451x-QIVC cards incorporate four independent, isolated measurement channels on a single card. Each channel consists of a:

- Programmable multi-range current source with programmable voltage clamp, source read-back, and precision voltage measurement.
- Programmable voltage source with source read-back and precision multi-range current measurement.

The 451x-QIVC cards are recommended for use only with the 4500-MTS Product.

CURRENT SOURCE

RANGE	MODEL	PROGRAMMING RESOLUTION	PROGRAMMING ACCURACY (1 Year) (23°C ±5°C) ±(%rdg. + amps + amps * $\lvert(\lvert V_O/V_{fs}\rvert - \lvert I_O/I_{fs}\rvert)\rvert$)[5]			PROGRAMMING ACCURACY (24 Hour)[1] (23°C ±1°C) ±(%rdg. + amps + amps * $\lvert(\lvert V_O/V_{fs}\rvert - \lvert I_O/I_{fs}\rvert)\rvert$)[5]			NOISE TYPICAL (peak to peak) 0.1Hz – 150kHz
±30.0000 mA	4510	2 µA	0.08%	7.4 µA	4.3 µA	0.065%	3.5 µA	4.3 µA	100 µA
±100.000 mA	4510/11	5 µA	0.08%	25 µA	14.3 µA	0.065%	13 µA	14.3 µA	100 µA
±300.000 mA	4511	15 µA	0.08%	75 µA	43 µA	0.065%	40 µA	43 µA	200 µA
±500.000 mA	4510	25 µA	0.08%	122 µA	72 µA	0.065%	42 µA	72 µA	250 µA
± 1.000 A	4511	50 µA	0.08%	250 µA	144 µA	0.065%	84 µA	144 µA	500 µA

RANGE	MODEL	DEFAULT MEASUREMENT RESOLUTION	MEASUREMENT ACCURACY (1 Year) (23°C ±5°C) ±(%rdg. + amps + amps * $\lvert(\lvert V_O/V_{fs}\rvert - \lvert I_O/I_{fs}\rvert)\rvert$)[5]			MEASUREMENT ACCURACY (24 Hour)[1] (23°C ±1°C) ±(%rdg. + amps + amps * $\lvert(\lvert V_O/V_{fs}\rvert - \lvert I_O/I_{fs}\rvert)\rvert$)[5]			TYPICAL[7] OUTPUT SLEW RATE mA/µs
±30.0000 mA	4510	0.1 µA	0.065%	2.5 µA	4.3 µA	0.065%	1.5 µA	4.3 µA	0.3
±100.000 mA	4510/11	1 µA	0.065%	8 µA	14.3 µA	0.065%	4 µA	14.3 µA	1
±300.000 mA	4511	3 µA	0.065%	12 µA	43 µA	0.065%	9 µA	43 µA	3
±500.000 mA	4510	5 µA	0.065%	20 µA	72 µA	0.065%	10 µA	72 µA	5
± 1.000 A	4511	10 µA	0.065%	40 µA	143 µA	0.065%	20 µA	143 µA	10

CURRENT OUTPUT SETTLING TIME: 150µs to 0.1% of final value typical, resistive load after command is processed[3].

CURRENT SOURCE SHORTING RELAY: Shorts load when output is turned off or when interlock condition exists.

CURRENT SOURCE OVERSHOOT: <0.1%, full-scale step, resistive load.

CURRENT SOURCE LONG TERM STABILITY: ±20ppm/hour typical, ±1°C ambient, 30 minute warm-up required.

OVER TEMPERATURE PROTECTION: Internally sensed temperature overload puts unit in standby mode.

LOAD INDUCTANCE: 200µH maximum[4].

CURRENT SOURCE LOAD VOLTAGE MEASUREMENT

RANGE	MEASUREMENT ACCURACY (1 Year) (23°C ±5°C) ±(%rdg. + volts)	MEASUREMENT ACCURACY (24 Hour)[1] (23°C ±1°C) ±(%rdg. + volts)	DEFAULT MEASUREMENT RESOLUTION
±6.0000 V	0.06% + 2 mV	0.025% + 250 µV	10 µV

REMOTE/LOCAL SENSE: Automatic; remote sense and proper zero are required to meet rated accuracy.

REMOTE SENSE: Up to 0.5V drop from card bracket to DUT.

CURRENT SOURCE VOLTAGE COMPLIANCE

RANGE	PROGRAMMING RESOLUTION	PROGRAMMING ACCURACY (1 Year) (23°C ±5°C) ±(%rdg. + volts)	PROGRAMMING ACCURACY (24 Hour)[1] (23°C ±1°C) ±(%rdg. + volts)
±6.000 V	200 µV	0.1% + 4.7 mV	0.07% + 3.7 mV

MINIMUM COMPLIANCE VOLTAGE: 100mV.

Series 451x-QIVC Specifications (continued)

VOLTAGE SOURCE

FULL SCALE	PROGRAMMING RESOLUTION	PROGRAMMING[6] ACCURACY (1 Year) (23°C ±5°C) ±(%rdg. + volts)	PROGRAMMING ACCURACY (24 Hour)[1] (23°C ±1°C) ±(%rdg. + volts)	DEFAULT MEASUREMENT RESOLUTION	MEASUREMENT[2] ACCURACY (1 Year) (23°C ±5°C) ±(%rdg. + volts)	MEASUREMENT ACCURACY (24 Hour)[1] (23°C ±1°C) ±(%rdg. + volts)
±10.000 V	400 µV	0.1% +6 mV	0.07% +4 mV	10 µV	0.1% + 1 mV	0.06% +540 µV

VOLTAGE OUTPUT SETTLING TIME: <300µs to 0.1% typical, resistive load after command is processed[3].

VOLTAGE OUTPUT SLEW RATE: <0.5V/µs typical, resistive load after command is processed.

VOLTAGE NOISE: 10µV rms, 0.1Hz to 10Hz typical.

CURRENT LIMIT: 25mA typical[3, 8].

MAXIMUM CAPACITIVE LOAD: 20nF on 10µA and 500µA range; 35nF on 10mA range.

MISCELLANEOUS

AUTOMATIC OFFSET COMPENSATION: The user can command the 451x-QIVC to disconnect itself from the device under test and measure and store any offsets in the source and measure circuitry so that future measurements are appropriately compensated.

OUTPUT RELAY ISOLATION

The GUARD signal is not is isolated with a relay.

The information below applies when the output state is set to OFF-OPEN (Hi-Impedance).

TYPICAL ISOLATION LEAKAGE CURRENT: 30nA.

MAXIMUM ISOLATION VOLTAGE: 12V DC.

MAXIMUM ISOLATION RELAY SETTLING TIME: 10ms.

VOLTAGE SOURCE CURRENT MEASUREMENT

Range	MEASUREMENT ACCURACY (1 Year) (23°C ±5°C) ±(%rdg. + current)	MEASUREMENT ACCURACY (24 Hour)[1] (23°C ±1°C) ±(%rdg. + current)	DEFAULT MEASUREMENT RESOLUTION
±10.000 µA	0.1% + 15 nA	0.063% + 12 nA	0.1 nA
±500 µA	0.1% + 70 nA	0.063% + 55 nA	5 nA
±10.0000 mA	0.1% + 1.4 µA	0.063% + 1.1 µA	100 nA

VOLTAGE BURDEN: <14mV[3].

GENERAL SPECIFICATIONS

DIGITAL INTERFACE:

Safety Interlock:

- Customer provided closed contact on a per-channel basis, to enable output.
- On a channel group basis, opening of customer provided contacts disconnects the sources from loads on the Voltage Source and Current Source. 5-volt level, 500Ω input impedance.

Supplies: +5V (fused ¾ amp) and Ground.

OVERRANGE: 105% of Range (Source Functions), 110% of Measure (Measure Functions).

COMMON MODE VOLTAGE: ±20V DC maximum.

WARM-UP TIME: 1 hour.

OVER-TEMPERATURE: Two on-board over-temperature detectors.

ENVIRONMENT: Accuracy specifications are multiplied by one of the following factors, depending upon the ambient temperature and humidity.

	% RELATIVE HUMIDITY	
TEMPERATURE	5–60	60–70
10° – <18°C	×3	×3
18° – 28°C	×1	×3
>28° – 40°C	×3	×5

WEIGHT (approx.): 0.9kg (2 lbs).

NOTES

1. The 24 hour specification applies only for the 24 hour period immediately following an Auto-Offset, and ±1°C of the temperature at which the Auto-Offset was performed, and within 1 year of calibration.
2. When I-SOURCE-LO and V-SOURCE-LO share a common connection, current flow through V-SOURCE-LO's parasitic ground resistance may cause up to 150mV of measurement error. This error is limited to measurement only and does not affect voltage source accuracy.
3. As guaranteed by design.
4. Includes cable inductance.
5. For example, the total uncertainty of a current source of 1A on the 1A range into a perfect short of 0V would be:
   $(0.08\% \times 1A) + (250\mu A) + (144\mu A) \times |(|0V/6V| - |1A/1A|)|$
   $= (80\mu A) + (250\mu A) + (144\mu A)$
   $= 474\mu A$
   The generic equation of the third error term is:
   $$\text{Amps} \times \left|\left(\left|\frac{V_{out}}{V_{FS}}\right| - \left|\frac{I_{out}}{I_{FS}}\right|\right)\right|$$
6. Includes 2 meter accessory cable while excluding IR drop in DUT leads.
7. Slew rates apply for resistive loads: Rload <200Ω for 30mA range, Rload <60Ω for 100mA range, Rload <12Ω for 500mA range, and Rload <6Ω for 1A range.
8. Hardware limited.

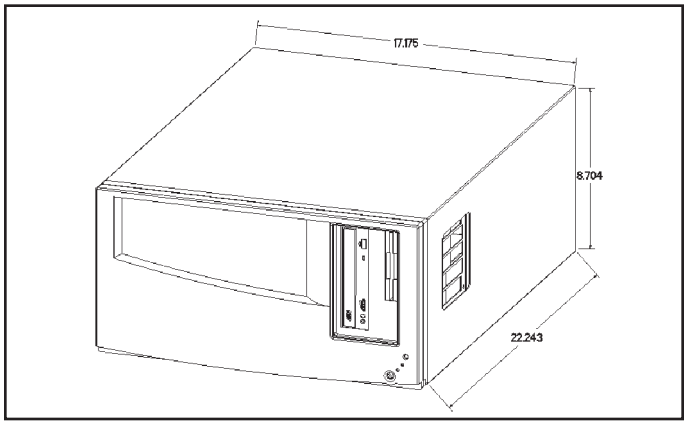
4500-MTS Multi-Channel I-V Test System

Model 4500-MTS Mainframe Specifications

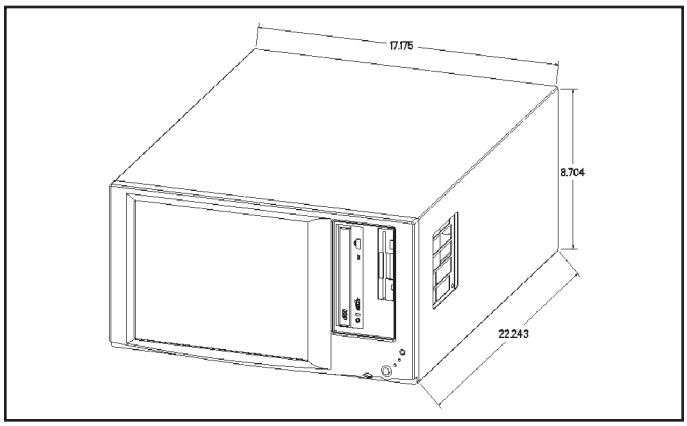
DESCRIPTION

The 4500-MTS is a fully integrated, instrument grade industrial computer with the following features:

- Total of 10 PCI slots, 9 PCI instrument slots available to user. 1 ISA instrument slot. 1 PICMG CPU slot.
- Sideband/trigger bus for cross-card measurement synchronization. Dedicated connector on each instrument slot.
- High-power, low-noise instrument grade power supply. Dedicated connector on each instrument slot.
- Embedded PC with Windows operating system.
- SVGA interface for driving an external monitor.
- 10/100 Base-T LAN interface.
- USB interface.
- RS-232 interface.
- Printer interface.
- Hard disk drive.
- CD-RW disk drive.
- Floppy disk drive.
- Steel chassis with enhanced cooling, painted cover, and plastic front bezel.
- Optional integrated Flat Panel Display.
- Full size keyboard with integrated pointing device.



4500-MTS/C



4500-MTS/F

ACCESSORIES

The following instruments were specifically designed for use with the 4500-MTS mainframe:

- 4511-QIVC – 1A, Quad IV instrument card.
- 4510-QIVC – 500mA, Quad IV instrument card.

The following is a current list of Keithley products that have been validated with the 4500-MTS:

- KPCI-PIO32IOA and KPCI-PDISO8A (16I/16O and 8I/8O Isolated Digital IO)
- KPCI-3130 and KPCI-3132 (8 and 2 channel Analog Output)
- KPCI-3110 (1.25MHz Multifunction AIO PCI Card)
- KPCI-3116 (250kHz Low Gain AIO PCI Card)
- KPCI-3108 and KPCI-3107 (100kHz Multifunction AIO (3108) AI (3107))
- KPCI-488.2 GPIB PCI Card

Other Keithley PCI and ISA cards could be used with the 4500-MTS but have not been verified at the time of this printing.

SYSTEM BACKPLANE

PCI
Slots: Ten total. Nine slots are available for PCI instrumentation. One slot reserved.
Compliance: PCI 2.1–2.3 (determined by embedded PC).

ISA
Slots: 1, 16 bit slot.
Compliance: PICMG 2.0

PCI/ISA
Slots: 1
Compliance: PICMG 2.0

SIDEBAND/TRIGGER BUS: Reserved for use by 45XX instrument cards.

SYSTEM POWER SUPPLIES

The 4500-MTS mainframe utilizes 2 power supplies. The ATX power supply provides power to the computer components (e.g. embedded PC, disk drives, etc.) and PCI bus. The Analog power supply provides 48V power to 45XX instrument card output stages.

ATX POWER SUPPLY: 70 watts maximum.
Output Voltage (Max. Current): +3.3V (14 Amps), +5V (20 Amps), –5V (0.3 Amps), +12V (6 Amps), –12V (0.8 Amps).

ANALOG POWER SUPPLY: +48V (16 Amps max.).

EMBEDDED SINGLE BOARD COMPUTER (SBC)

PROCESSOR: Intel Pentium 4, 2GHz.

CHIPSET: Intel 845.

MEMORY: Up to 2GB, 200/266MHz DDR SDRAM on two 184-pin DIMM sockets.

VIDEO: ATI Mobility M6 graphics controller, 16 Mbytes 200MHz DDR SDRAM display cache. Flat panel LVDS support and simultaneous SVGA support.

LAN: 10/100Base-T. RJ-45 connector on SBC retaining bracket.

USB: One port on SBC retaining bracket. Two ports on 4500-MTS front panel.

SERIAL: One port, 9 pin, COM1.

PARALLEL: One port, 25 pin.

IDE: Two EIDE ports with ULTRA DMA 33/66/100 support.

FLOPPY: One port.

KEYBOARD/MOUSE: One 9-pin DIN connector on SBC retaining bracket. Y-cable provided.

DISK DRIVES

HARD DRIVE: Interface: EIDE. **Capacity:** 40GB.

FLOPPY DISK: Size: 3.5″. **Capacity:** 1.44MB.

CD-RW: Interface: ATAPI, EIDE.

CHASSIS

MATERIAL: Stainless steel inner chassis and rear panel. Painted steel cover.

FAN: High reliability cooling fan.

4500-MTS Multi-Channel I-V Test System

Model 4500-MTS Specifications

SOURCE AND MEASURE

GENERAL SPECIFICATIONS

POWER SUPPLY:
Power Per Slot Max.: 96W for 48V; 8.75W for ATX.
Mains: Push Button ON/OFF switch/fuse/power module combo.

TEMPERATURE: Operating: 0° to +40°C (with no accessory cards) **Storage:** –15° to 60°C.

HUMIDITY: Operating: 5% to 70% RH, non-condensing.

ALTITUDE: Maximum 2000m above sea level. For indoor use only.

POWER REQUIREMENTS: 100–240VAC, 50/60Hz.

INPUT POWER RATING: 1kVA max.

WARM-UP TIME: 1 hour.

REGULATORY COMPLIANCE:
Safety: Conforms to European Union Directive 73/23/EEC, EN61010-1, CAT I.
EMC: Conforms to European Union Directive 89/336/EEC, EN61326-1.

DIMENSIONS: Rack Mounting: 22.3cm high × 43.6cm wide × 56.5cm deep (8.75 in. × 2.17 in. × 22.25 in.).

WEIGHT (approx.): 26.3kg (58 lbs.) for base system (excluding multi-channel cards, cables, keyboard, etc).

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Keithley Instruments, Inc.

Corporate Headquarters • 28775 Aurora Road • Cleveland, Ohio 44139 • 440-248-0400 • Fax: 440-248-6168 • 1-888-KEITHLEY (534-8453) • www.keithley.com

Belgium: Sint-Pieters-Leeuw • 02-363 00 40 • Fax: 02-363 00 64 • www.keithley.nl
China: Beijing • 8610-82251886 • Fax: 8610-82251892 • www.keithley.com.cn
Finland: Helsinki • 09-5306-6560 • Fax: 09-5306-6565 • www.keithley.com
France: Saint-Aubin • 01-64 53 20 20 • Fax: 01-60 11 77 26 • www.keithley.fr
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Great Britain: Theale • 0118 929 7500 • Fax: 0118 929 7519 • www.keithley.co.uk
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Italy: Milano • 02-48 39 16 01 • Fax: 02-48 30 22 74 • www.keithley.it
Japan: Tokyo • 81-3-5733-7555 • Fax: 81-3-5733-7556 • www.keithley.jp
Korea: Seoul • 82-2-574-7778 • Fax: 82-2-574-7838 • www.keithley.com
Netherlands: Gorinchem • 0183-635333 • Fax: 0183-630821 • www.keithley.nl
Singapore: Singapore • 65-6747-9077 • Fax: 65-6747-2991 • www.keithley.com
Sweden: Solna • 08-509 04 600 • Fax: 08-655 26 10 • www.keithley.com
Taiwan: Hsinchu • 886-3-572-9077 • Fax: 886-3-572-9031 • www.keithley.com.tw

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