KEITHLEY
A Tektronix Company

KTE Integrated Test System

Administrative Guide

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System description

The S500 Integrated Test System is an instrument-based system configuration from Keithley Instruments used primarily for semiconductor parametric characterization testing. The S500 has a wide degree of hardware flexibility, allowing you to configure a system best suited for your applications. The following tables list general S500 configuration options and configurations used specifically for high-voltage or high-current testing of high-power semiconductor devices.

S500 system configuration choices

Series 2600 System SourceMeter® Instruments	■ 0 to 22* ■ Any combination of 2612 or 2636 source-measure units (SMUs)
Model 4200A-SCS/C Semiconductor Characterization System	■ 0 to 4* ■ With 4200-SMUs, 4210-SMUs, 4210-CVU, 4220-PGUs, 4225-PMUs, or 4200-PAs ■ /F or /C chassis (with or without flat-panel display, respectively)
Switching	One of the following four choices: 1. None 2. 0 to 4 each 708B;* choice of switching card: a. 1 each 7072 b. 1 each 7072-HV c. 1 each 7174A 3. 0 to 3 each 707B;* choice of switching cards: a. 1 to 6 each 7072 b. 45541 to 6 each 7072-HV c. 1 to 6 each 7174A 4. 0 to 6 each 3706A;* choice of switching cards (per mainframe): a. 1 to 6 each 3720 b. 1 to 6 each 3721 c. 1 to 6 each 3722 d. 1 to 6 each 3723 e. 1 to 6 each 3730 f. 1 to 6 each 3740
Cabinet selection	■ 37U with or without vented front door ■ 37U with or without advanced seismic securement ■ 23U with or without partially-vented front door
Computer selection – Industrial PC with RAID Linux® or Microsoft Windows® operating system	■ None ■ Internal computer

Flat-panel display selection	■ None ■ Monitor with support arm ■ Monitor installed externally
Other options	■ Adjustable cable support arm

*Maximum number depends on system cabinet height of 37U and other items selected

S500 high-power semiconductor testing configuration choices

Series 2600 System SourceMeter® Instruments	■ 0 to 3 ■ Either 2612 or 2636 SMUs
2657A High-Power SourceMeter® Instruments	■ 0 to 2 ■ (not in series or parallel)
2651A High-Power SourceMeter® Instruments	■ 0 to 2 ■ (2 units allow 100 A parallel operation)
C-V Meter (4200A-SCS-NOSMU with 4210-CVU)	■ 0 to 1 ■ /F or /C chassis (with or without flat-panel display, respectively)
8020 High-Power Interface Panel	■ 0 to 2 ■ Optional 3 kV C-V hardware ■ Choice of output connectors (Keithley high-voltage triaxial, standard triaxial, SHV, or Keysight Technologies® high-voltage triaxial) ■ Optional unit support arm
8010 High Power Device Test Fixture	■ 0 to 2
Cabinet selection	■ 23U with or without vented front door
Computer selection – Industrial PC with RAID **(Linux or Windows operating system)**	■ 0 to 1. Note that if the 4200A-SCS (Semiconductor Characterization System) is included, this unit serves as the system computer. ■ Internal or external computer
Flat-panel display selection	■ None (with 4200A-SCS/F-NOSMU option) ■ Monitor with support arm ■ Monitor installed externally

Optional accessories

Optional items and accessories that may accompany the S500 system:

- Cables to connect to the test fixture or the probe card adapter
- 9139A-PCA (probe card adapter)
- Advanced seismic securement kit

System software options for the S500

- Keithley Instruments offers the Automated Characterization Suite (ACS) software for test and prober automation and parametric device characterization. For Series 2600 wafer-level reliability (WLR) testing, the optional ACS-2600-RTM can be used with ACS for single device or parallel device testing.
- ACS Basic Edition can be used when prober automation is not required.
- Independently-developed software can also be used.

Systems documentation

Documentation for your system is available at tek.com. Following is a list of documentation for your system, including the document part numbers.

- S500 Parametric Test System Administrative Guide (PA-939)

Unpacking the S500 system

The Keithley field service engineer (FSE) is responsible for unpacking the S500 system cabinet and the accessories. However, we recommend that you move the crate and the accessories box to the area where the system is going to be used.

Here is a list of tools needed for unpacking:

- Safety glasses
- Gloves
- Standard screwdriver
- Socket wrench
- Socket head: 19 mm (3/4 in.)

The following information will help the FSE unpack the system. Series 500 systems are shipped in a wooden crate (see the following figure).

Figure 1: S500 system cabinet in shipping crate

Unpacking system components

Inspect the shock sensor on the outside of the shipping crate (see the following figure). If the shock sensor indicates a shock condition, do a thorough inspection of all components in the system cabinet.

Figure 2: S500 crate shock sensor

Also, check the "TIP N TELL" indicator to ensure that the crate has not been tipped over (see the following figure).

Figure 3: S500 crate tipping indicator

Carefully remove all system components from the crate. While unpacking, make sure there is no component damage. Report any damage to the shipping agent immediately. Please reuse or recycle packaging materials in accordance with your local requirements.

NOTE

You need at least two people to unpack and move the S500 system cabinet.

To unpack the system components:

1. Remove the crate clamps from the crate using a standard screwdriver.

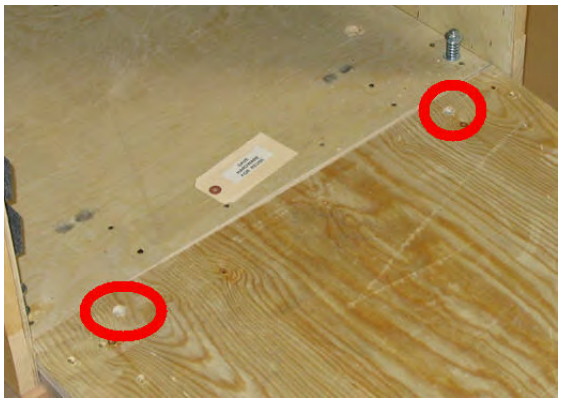
Figure 4: Removing the crate clamps

2. Open the front of the crate. The front is identified by the wooden ramp support attached across the panel (see the following figure).
3. Make sure the ramp support is pulled away from the crate. It is held in place with hook and loop fasteners (such as Velcro®).

Figure 5: Opening the front of the crate

4. Attach the ramp using the two bolts that are attached to the bottom front of the crate.

Figure 6: Front of the crate with ramp down



5. Remove the padding from the front of the S500 system cabinet.

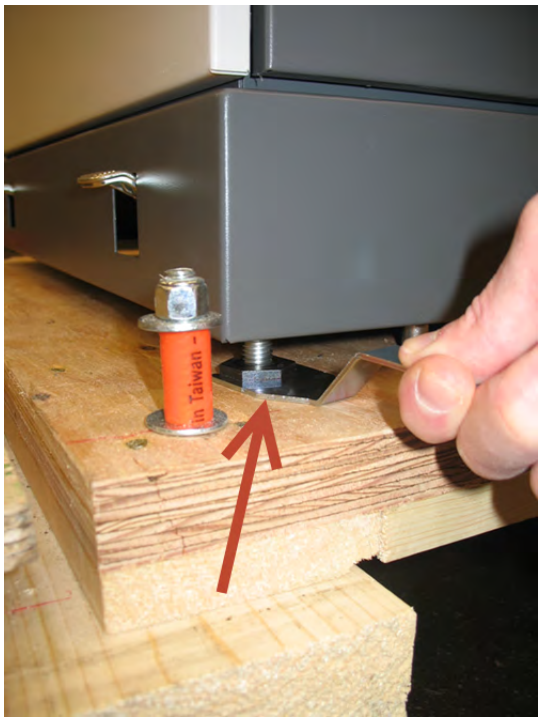
Figure 7: Removing the padding

6. Remove the crate clamps and slide the outer box cover off the crate.

Figure 8: Sliding the outer box off the crate

7. Make sure that you retract the leveling feet on the bottom of the system (next to the casters) to put weight on the casters and prepare the system to be rolled down the ramp.

Figure 9: Leveling feet



8. Remove the four bolts from the bottom of the crate that are attached to the bottom of the S500 system cabinet using a 19 mm socket head on a socket wrench.

Figure 10: System bolted to the crate

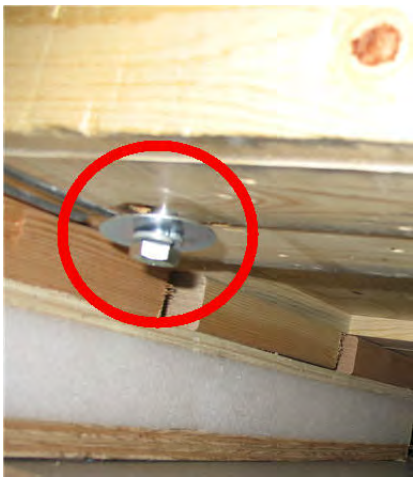


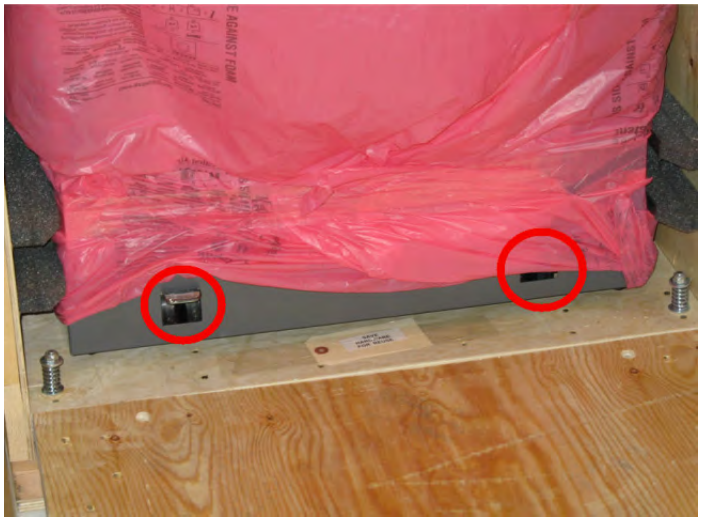
Figure 11: Removing the bolts from the crate

9. Save the hardware (the four bolts and washers) that you remove from the bottom of the crate.

Figure 12: System crate hardware

10. Unlock the two casters that are on the front of the S500 system cabinet by moving the locks up.

Figure 13: System caster brakes



11. With two people, slide the S500 system cabinet down the ramp.

Figure 14: Rolling the system down the ramp

12. Remove the tape from the packing material using scissors, taking care not to scratch the S500 system cabinet.

Figure 15: Cutting the wrap off the system

13. Move the S500 system cabinet to its final destination.

The system cabinet is shipped from the factory with all of the instruments installed. Most equipment connections and wiring of instruments in the system cabinet was done at the factory.

Unpacking the S500 system accessories

The accessories are shipped in a separate box or in multiple boxes, depending on how many accessories are ordered.

Figure 16: S500 system accessories

The accessories box contains a computer monitor, keyboard, and mouse. It also includes required installation hardware, USB extension cables, cable support arm, connectors for the keyboard and mouse, and any other accessories that may have been ordered with the system (for example, probe card adapter, cables to connect to the test fixture or probe card adapter, or advanced seismic securement kit). You will also find all of the documentation that is shipped with your order. Please reuse or recycle packaging materials in accordance with your local requirements.

NOTE

The following figures are examples of system accessories that may be included in your shipment. What you receive may be different depending on your system configuration.

Figure 17: Typical system accessories

Figure 18: Monitor arm accessory

Figure 19: Keyboard tray and arm accessory

Figure 20: Cable support arm accessory

Chuck cables for optional probe card adapter

A set of chuck cables is included with the optional 9139A-PCA probe card adapter. Model numbers of cables vary based on the prober you are using. For example, the Keithley Field Service Engineer (FSE) will install the cables shown in the following table for Tel P8 probers.

Model	Quantity	Description
CA-63-12	2	12 ft three-lug triaxial cables
237-TRX-T	1	Three-slot male to dual three-lug female triaxial tee adapter
237-BNC-TRX	1	High-voltage two-slot BNC to three-lug female triaxial adapter

NOTE

If a different cable termination scheme is required, a customer-supplied solution can be used.

Optional probe card adapter vacuum requirement

9139A-PCA probe card adapter requirement: A 50.80 cm (20 in.) Hg (which is the same as 40.73 PSI) vacuum supply, with a hose connection of 0.64 cm (1/4 in.) outside diameter and 0.32 cm (1/8 in.) inside diameter.

For detailed information about the 9139A-PCA probe card adapter, see the *9139A-PCA Probe Card Adapter Instruction Manual* (part number 9139A-901-01). This manual is available for download at tek.com/keithley.

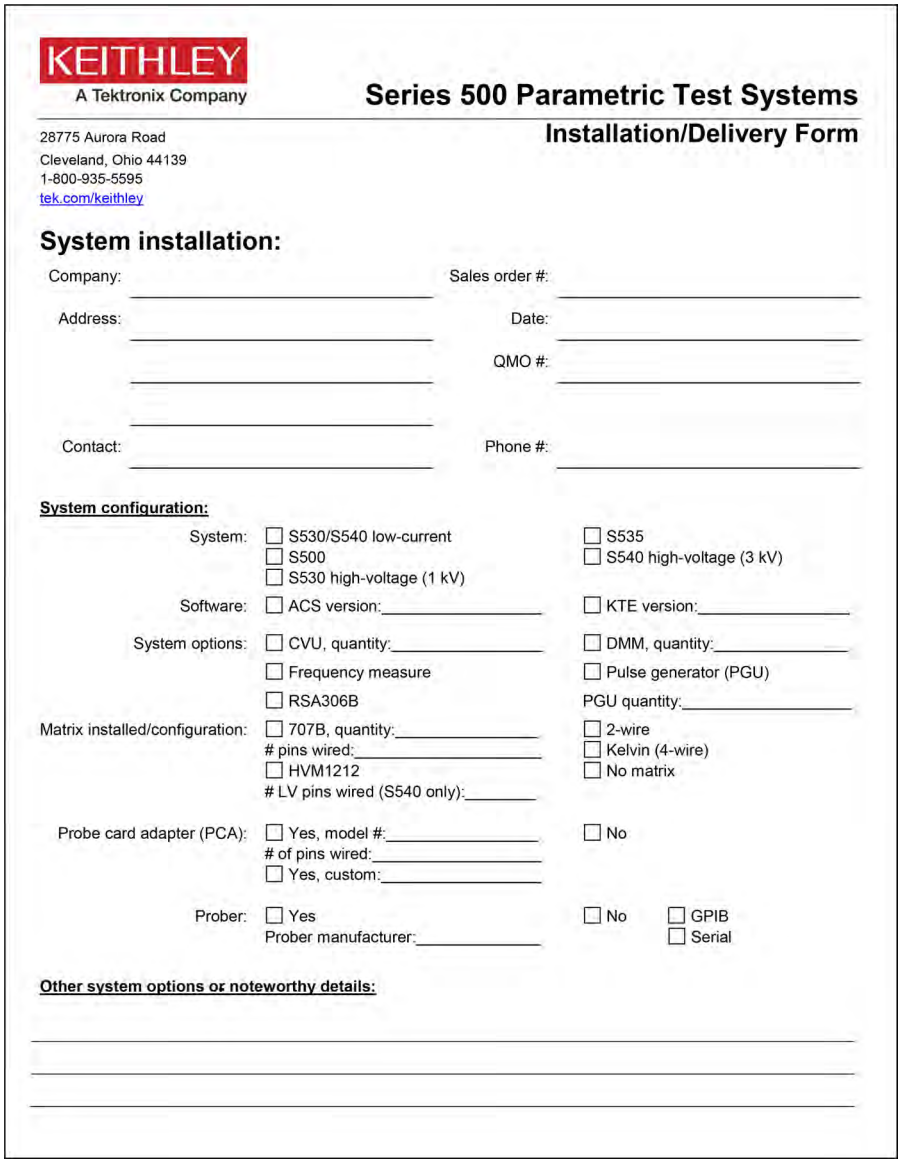
Keithley field service engineer installation tasks

The Keithley field service engineer (FSE) will perform the following tasks:

- Unpack the system components and accessories.
- Attach the keyboard arm and monitor arm to the system.
- Install the keyboard and the mouse on the keyboard arm, and the monitor on the monitor arm.
- Install the cable support arm to the system.
- Install the Model 8020 High-Power Interface Panel.
- Install the Model 8020 support arm (high-power S500 units only).
- Install the probe card assembly (PCA) (if ordered) on the back of the system cabinet, and the 60190-PCA (probe card assembly) to the correct prober plate (customer-supplied from the prober company). The prober plate is attached to the prober.
- Plug in the system to your power facilities (supplied by your facilities department at the final location for the S500 system cabinet) and power up the entire cabinet.
- Verify communications of all instruments and with the properly configured prober.
- Perform diagnostics and system verification tests of the entire S500 system, to include the 60190-PCA (if ordered).
- Record all the information on the System Installation Form.

Example Series 500 System Installation Form

Figure 21: Example Series 500 System Installation Form page 1



KEITHLEY
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Series 500 Parametric Test Systems
Installation/Delivery Form

28775 Aurora Road
Cleveland, Ohio 44139
1-800-935-5595
tek.com/keithley

System installation:

Company: _____ Sales order #: _____

Address: _____ Date: _____

_____ QMO #: _____

_____

Contact: _____ Phone #: _____

System configuration:

System: ☐ S530/S540 low-current ☐ S535
☐ S500 ☐ S540 high-voltage (3 kV)
☐ S530 high-voltage (1 kV)

Software: ☐ ACS version:_____ ☐ KTE version:_____

System options: ☐ CVU, quantity:_____ ☐ DMM, quantity:_____
☐ Frequency measure ☐ Pulse generator (PGU)
☐ RSA306B PGU quantity:_____

Matrix installed/configuration: ☐ 707B, quantity:_____ ☐ 2-wire
pins wired:_____ ☐ Kelvin (4-wire)
☐ HVM1212 ☐ No matrix
LV pins wired (S540 only):_____

Probe card adapter (PCA): ☐ Yes, model #:_____ ☐ No
# of pins wired:_____
☐ Yes, custom:_____

Prober: ☐ Yes ☐ No ☐ GPIB
Prober manufacturer:_____ ☐ Serial

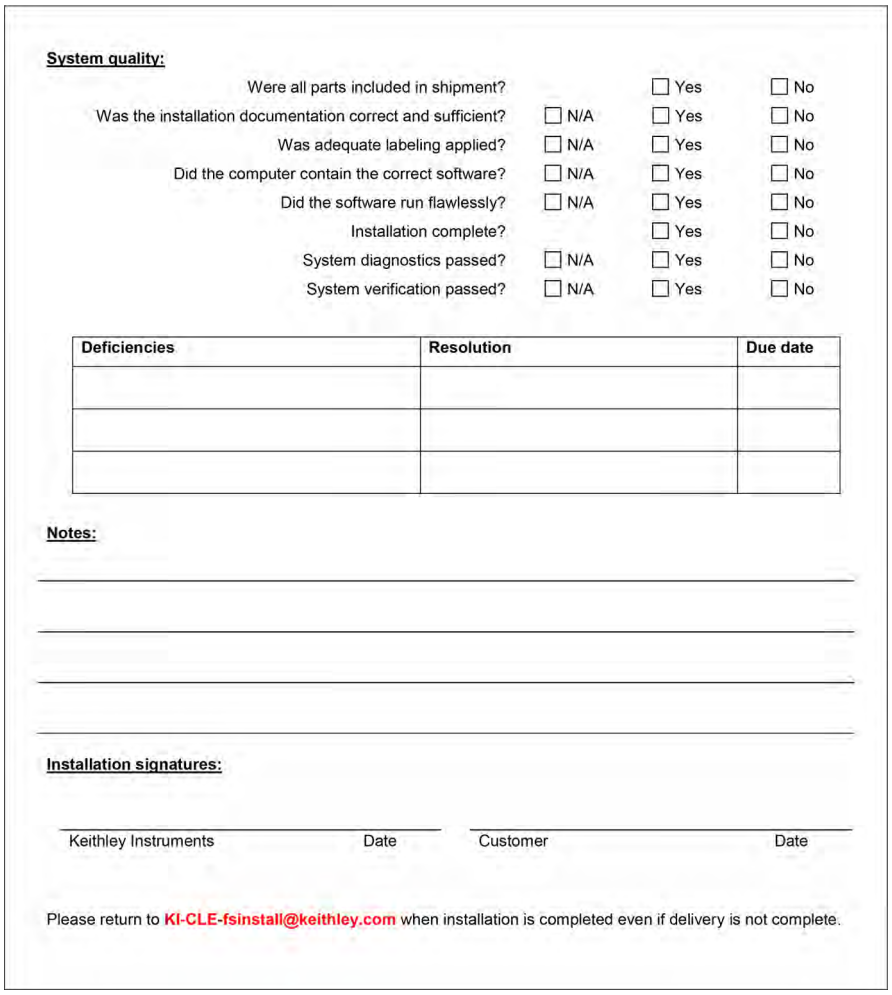
Other system options or noteworthy details:

_____

_____

_____

Figure 22: Example Series 500 System Installation Form page 2



System quality:

Were all parts included in shipment?		☐ Yes	☐ No
Was the installation documentation correct and sufficient?	☐ N/A	☐ Yes	☐ No
Was adequate labeling applied?	☐ N/A	☐ Yes	☐ No
Did the computer contain the correct software?	☐ N/A	☐ Yes	☐ No
Did the software run flawlessly?	☐ N/A	☐ Yes	☐ No
Installation complete?		☐ Yes	☐ No
System diagnostics passed?	☐ N/A	☐ Yes	☐ No
System verification passed?	☐ N/A	☐ Yes	☐ No

Deficiencies	Resolution	Due date

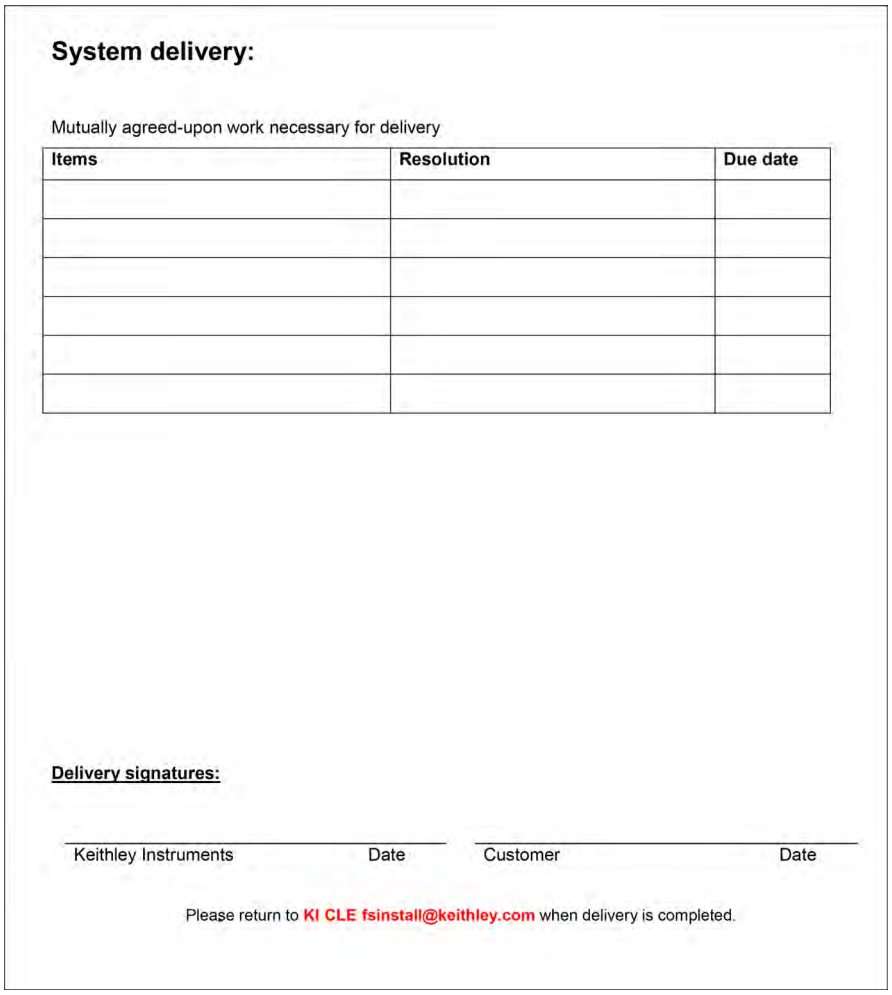
Notes:

Installation signatures:

Keithley Instruments Date Customer Date

Please return to KI-CLE-fsinstall@keithley.com when installation is completed even if delivery is not complete.

Figure 23: Example Series 500 System Installation Form page 3



System delivery:

Mutually agreed-upon work necessary for delivery

Items	Resolution	Due date

Delivery signatures:

Keithley Instruments Date Customer Date

Please return to KI CLE fsinstall@keithley.com when delivery is completed.

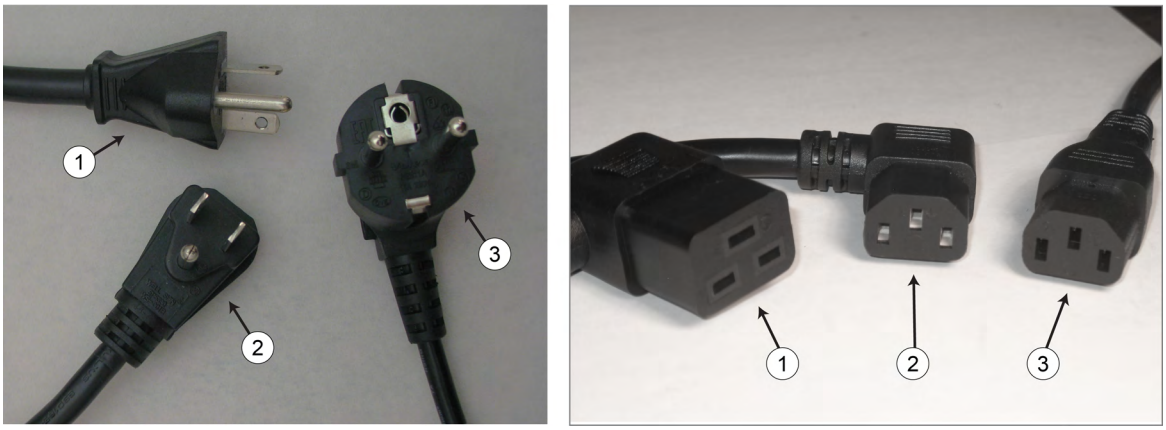
Power and operating conditions

The following topics contain information about power and operating environment conditions.

Supplied power cords

Keithley Instruments provides power cords that match the power requirements of the system. The following figure and table describe these cords.

Figure 24: Supplied power cables



Number	Description
1	20 A, 125 V American
2	15 A, 125 V American
3	16 A, 250 V Eurostyle cord

If power cords with different cord ends are needed, you must provide those cords.

Line power requirements

Nominal input line voltage: 100 VAC, 115 VAC, 220 VAC, 240 VAC (50 Hz, 60 Hz)

Short-circuit current rating: 5 kA

Power consumption: Rated at 2.4 kVA for the 2 kW power distribution unit (PDU)

Heat generation: Quiescent heat of 1720 BTU (1815 kJ) to maximum heat of 8191 BTU (8642 kJ)

WARNING

Severe personal injury or death due to electric shock or electrocution or equipment damage may occur if you do not have the correct circuit amperage.

S500 systems that are configured to operate between 100 VAC and 120 VAC must use a 20 A circuit; systems that are configured to operate between 200 VAC and 240 VAC must use a 15 A circuit.

System power dissipation

The total power dissipated by the S500 depends on the type and number of instruments in the test system. The power distribution unit (PDU) limit the incoming power to these instruments.

Though the PDU ensures electrical safety and compliance to the required standards, it does not prevent the system from overheating.

When a Series 2600B instrument detects an excessive heat condition, the instrument turns the output off to minimize power dissipation. This safeguard prevents damage to individual Series 2600B instruments, but may result in test instability. For instance, if you continuously source more than 1 A from all the source-measure units (SMUs) for more than 100 seconds, it may trigger a temperature error in one or more of the Series 2600B instruments. However, an average output of less than 1 A for an indefinite period will not cause a temperature error.

For additional information about the Keithley Instruments Series 2600B SourceMeter® instruments, refer to the documentation on the DVD that was shipped with your purchase.

Operating environment conditions

To ensure operation within specifications, the S500 must be operated inside of the following environmental conditions.

Temperature: 23 °C ±5 °C

Operating humidity: 30% to 60% relative humidity, noncondensing, after a two-hour warm up time

Vibration: High ambient vibration levels may require isolation pads or the repositioning of equipment

Air quality: The S500 system is compatible for use in a Class 10 clean room

Audible system noise: Decibel level is 65 dBA in optimal environmental conditions

Airflow: The S500 system is configured for top to bottom airflow

Altitude: Less than 2000 m (6,561 feet) above sea level

Noise interference: To prevent electrical noise from interfering with measurements, the ambient AC magnetic field must not exceed 2×10^{-3} G (2×10^{-7} T):

- Avoid locating the S500 next to plasma etchers, large motors, magnets, RF transmitters, equipment with flash lamps, and other potential sources of interference
- Position equipment to avoid routing signal and power cables near sources of electrical noise

Triaxial connector handling and avoiding contamination

Keep source-measure triaxial cable connectors (if applicable) clean and free of any foreign contaminants. Do not touch the connector pins of the triaxial connectors. Contamination can cause current leakage in the source-measure signal paths to the device under test (DUT), which can significantly degrade the test results.

CAUTION

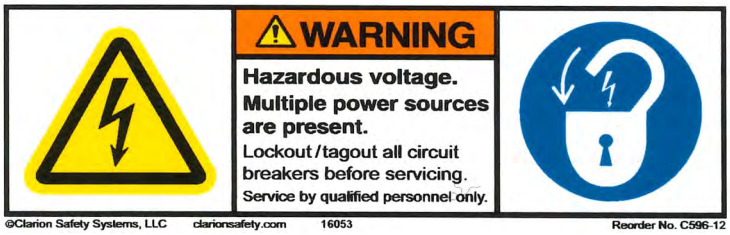
Do not touch any connector pins or the areas adjacent to the electrical contacts of the triaxial connectors; contamination will degrade the performance of the test system.

Cleaning: Use lint-free swabs moistened with methanol or isopropyl alcohol to clean contaminated connectors and then blow-dry them with nitrogen gas. After blowing dry, wait several minutes before using.

Lockout and tagout

For maximum safety while power is applied, always perform a lockout and tagout procedure. Remove power from the entire test system and discharge capacitors before connecting or disconnecting cables or any instrument, including the device under test. When you perform lockout and tagout procedures, make sure that you read all warning labels on the cabinet and instruments (see the following figure).

Figure 25: Hazardous warning label



WARNING

Severe personal injury or death due to electric shock or electrocution may result if power is not removed before working inside the cabinet. Always perform the lockout and tagout procedure before opening the system cabinet. Also, never turn on the system until all connections and safety grounds are installed.

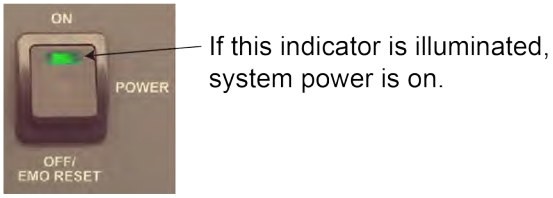
To remove system power:

You must shut down the software and remove all power from the computer and the system (see **Error! Hyperlink reference not valid.** (on page 34).

⚠ WARNING

Before proceeding, you must make sure the power indicator on the front door is not illuminated. See the following figure for an example of what the indicator looks like when illuminated.

Figure 26: Indicator showing system power is still on



1. Place the breaker for the power distribution unit (PDU) in the OFF position. The PDU is at the back of the cabinet below the rear door. See the figure in **Error! Hyperlink reference not valid.** (on page 46) for a simplified drawing of the PDU.
2. If you are working in the system cabinet, disconnect the system cabinet line cord from the AC line power receptacles.
3. Verify that all power has been removed and discharged from the system cabinet by switching the main power switch (on the front door of the cabinet) to the ON position and verify that the green light does not illuminate. If the light does not come on, the power is off. Turn the main power switch back to the OFF position.
4. With the PDU breaker in the OFF position, lockout and tagout the system source power connection by locking a padlock through the hasp that surrounds the PDU breaker.

Installation and connections

⚠ WARNING

The following installation and connection procedures should be performed by trained site installers who are familiar with the associated physical and electrical hazards. Also, you should never turn on the system until all connections and safety grounds are installed.

Position the system cabinet

The system cabinet contains the controller and instrumentation for the test system. The cabinet is on casters, which allows you to easily roll it on a hard floor surface. The two steering casters in the rear are swivel type, and the two casters at the front are in fixed positions.

To position the system cabinet:

1. Carefully roll the system cabinet to its location next to the prober, allowing a minimum distance of 15 cm (6 in.) up to a maximum distance of 122 cm (48 in.). Allow approximately 60 cm (23.5 in.) (nominal) of clearance between the cabinet and other instrumentation.
2. Lock the casters by pushing down on the caster-locking mechanisms near the front-bottom of the cabinet.
3. Adjust the height of the four legs so that the weight of the cabinet is on the legs and not on the casters. Adjust the legs so that the cabinet is level and does not move (see **Error! Hyperlink reference not valid.** (on page 28)).

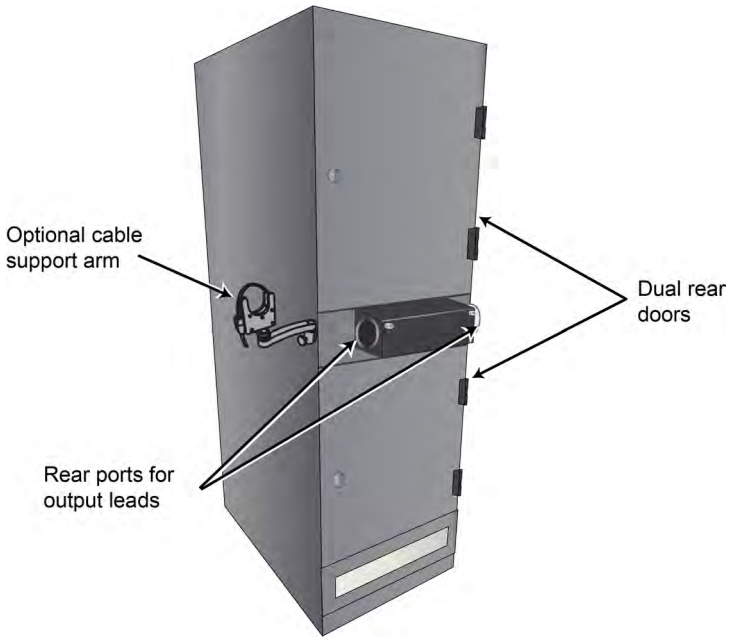
⚠ WARNING

System securement is required for safety of the S500 system and for personnel. You must bolt the legs adjacent to the four casters to the floor. See Error! Hyperlink reference not valid. **(on page 28) for details.**

Cable harness routing

The S500 has a dual-door rear portal for output leads. Cables can be routed from the cable harness at the rear portal to either the right or left of the cabinet.

Figure 27: S500 cabinet rear doors and cable portal



You can mount cable support arms on either side of the cabinet to suspend cables off the floor and prevent a tripping hazard.

Floor plan

NOTE

The following floor plan information is for the system cabinet only. Refer to the documentation for the prober or other test fixture equipment to determine its floor space requirements.

The system cabinet requires a floor space of approximately 1.2 m × 2.1 m (4 ft × 7 ft). The following figures show a top view of the floor plan for the S500 37U and 23U and an overall cabinet dimension diagram for both units.

Figure 28: 37U system floor plan, top view

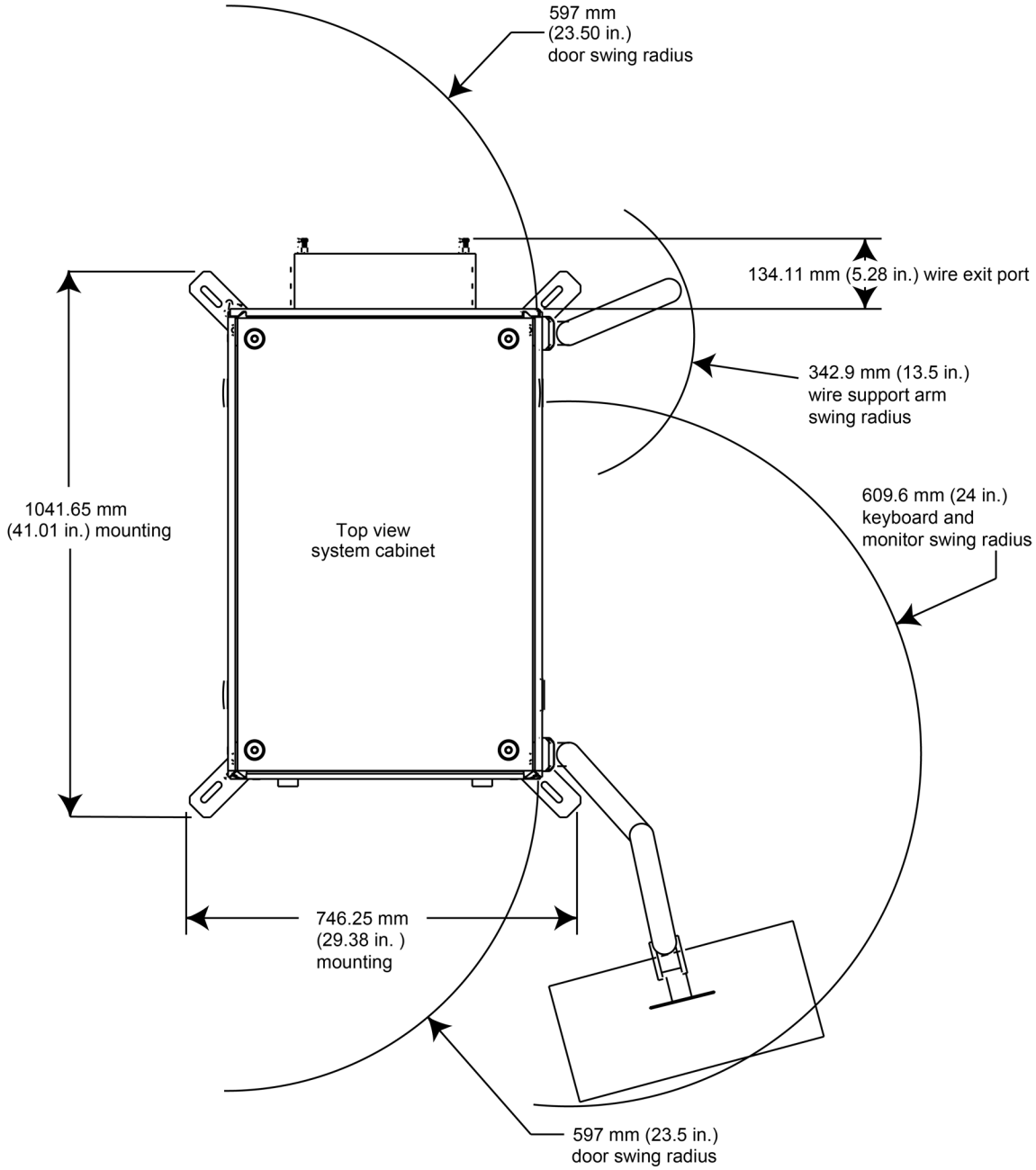


Figure 29: 23U system floor plan top view

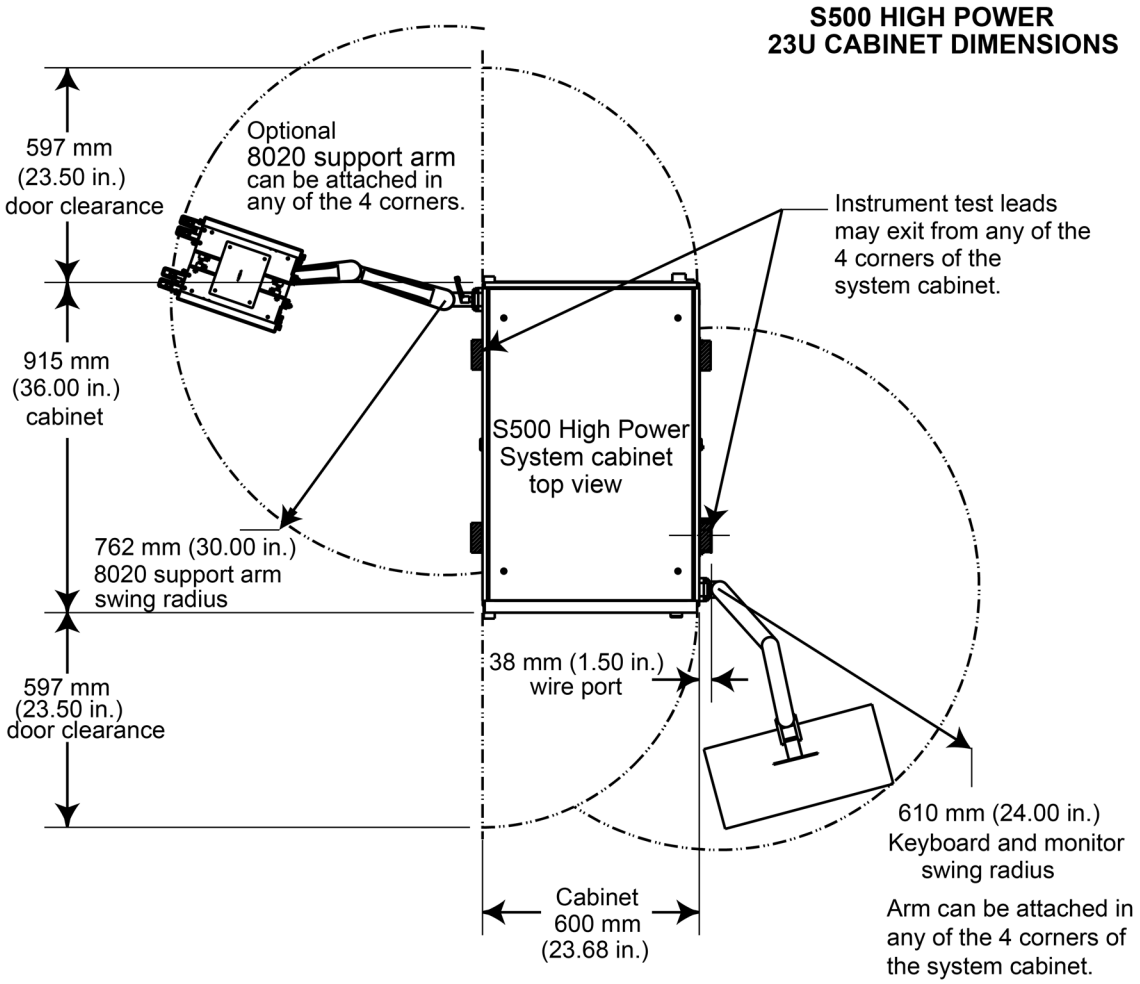


Figure 30: 37U cabinet dimensions

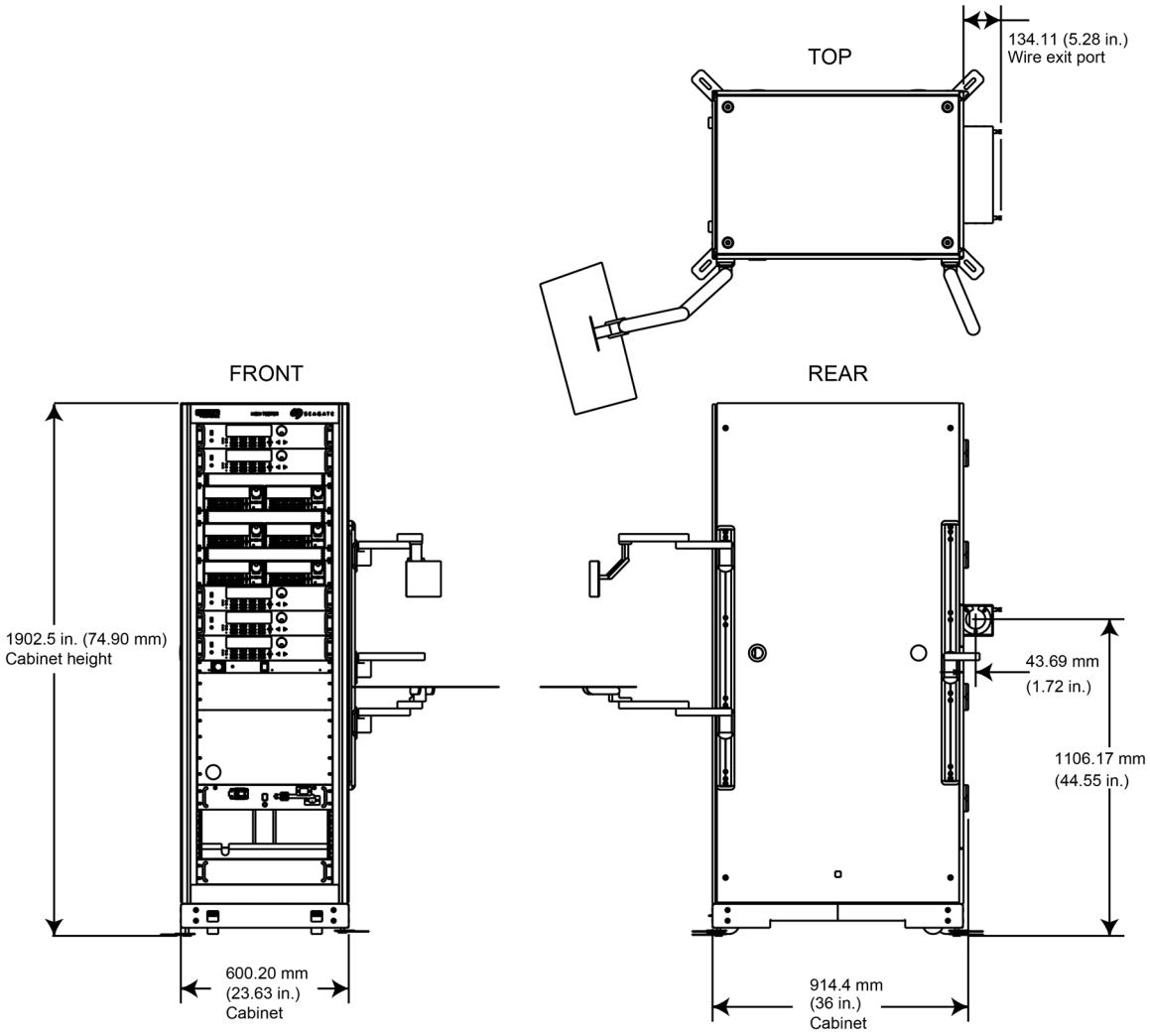
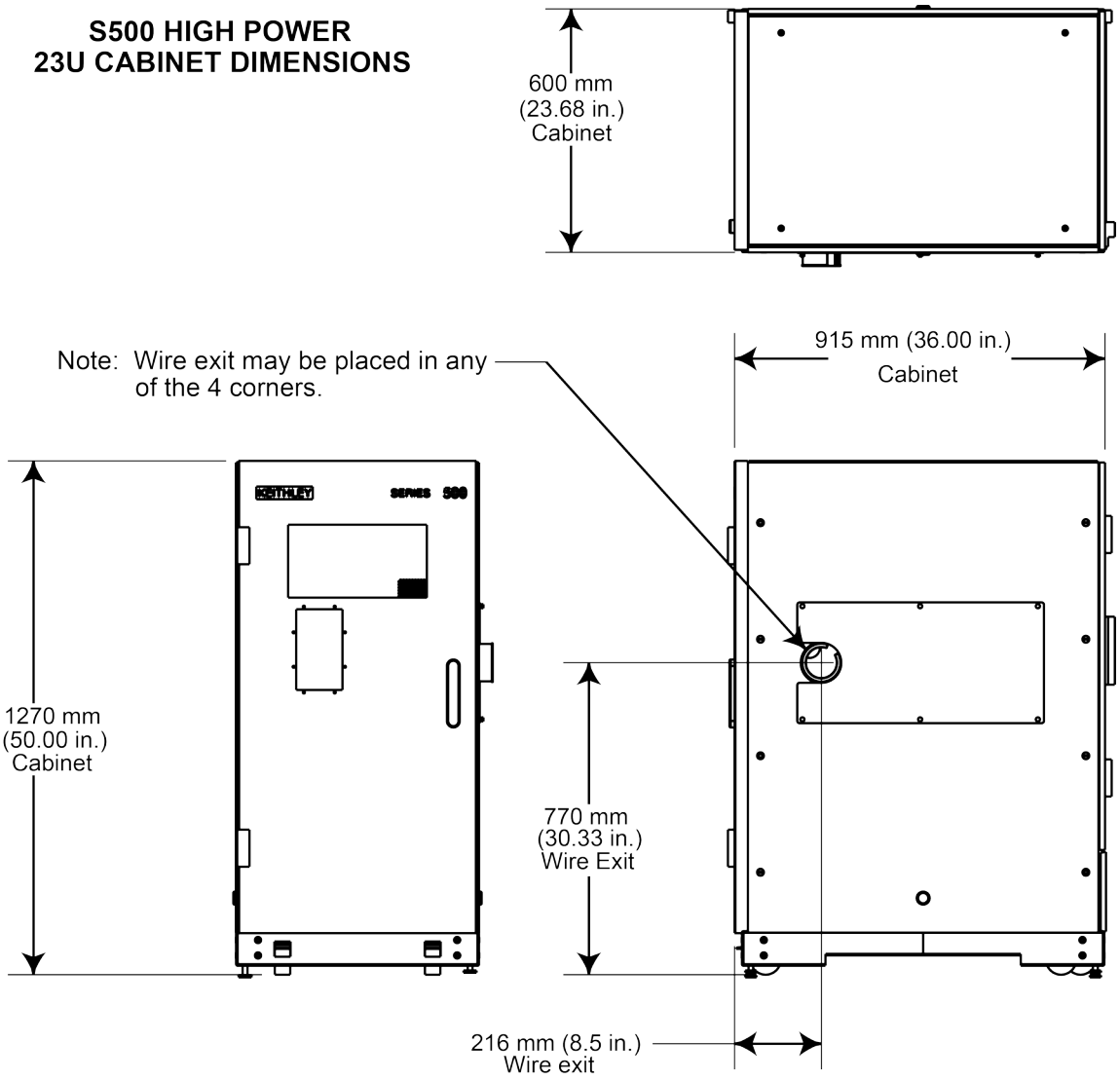


Figure 31: High Power 23U cabinet dimensions



System cabinet size and weight

The size and weight specifications for the system cabinet are listed in the following table. See **Error! Hyperlink reference not valid.** (on page 24) for details about designing a floor plan for the system cabinet.

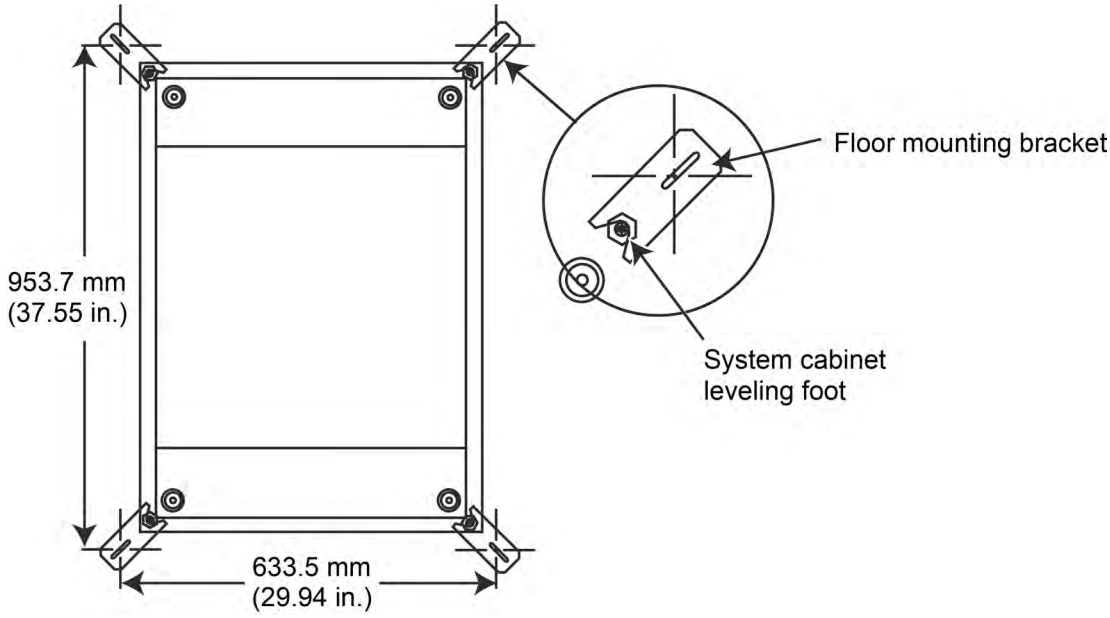
		Weight (typical)	
Model	**Size (width×depth×height)**	**Minimum configuration**	**Maximum configuration**
37U	60.1 cm x 92 cm x 192 cm 23.7 in. x 36.2 in. x 75.7 in.	273.3 kg 600 lbs.	364.4 kg 800 lbs.

Physically securing the system

You must bolt the S500 system cabinet to the floor for safety purposes and to ensure the cabinet will not tip over.

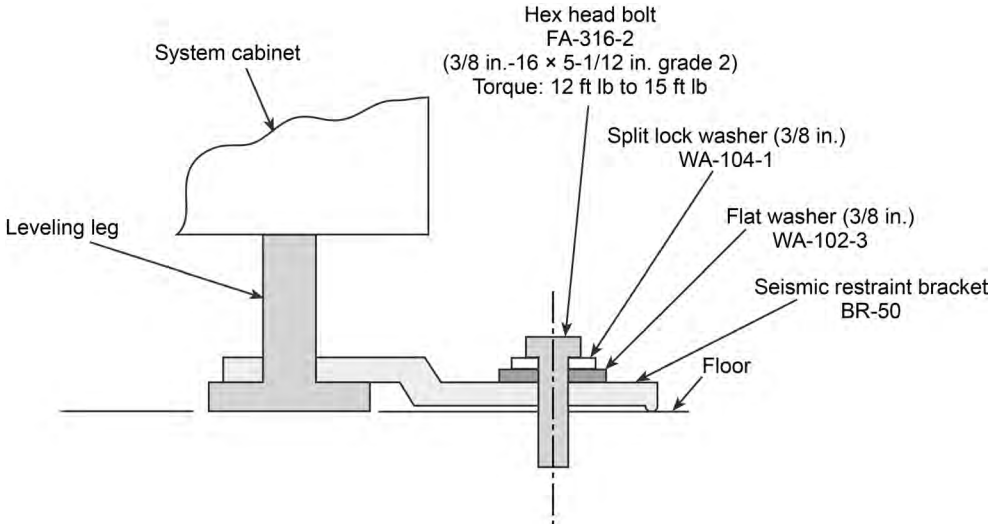
The following figure shows the restraint brackets and bolt installation dimensions for the system cabinet.

Figure 32: S500 system securement dimensions



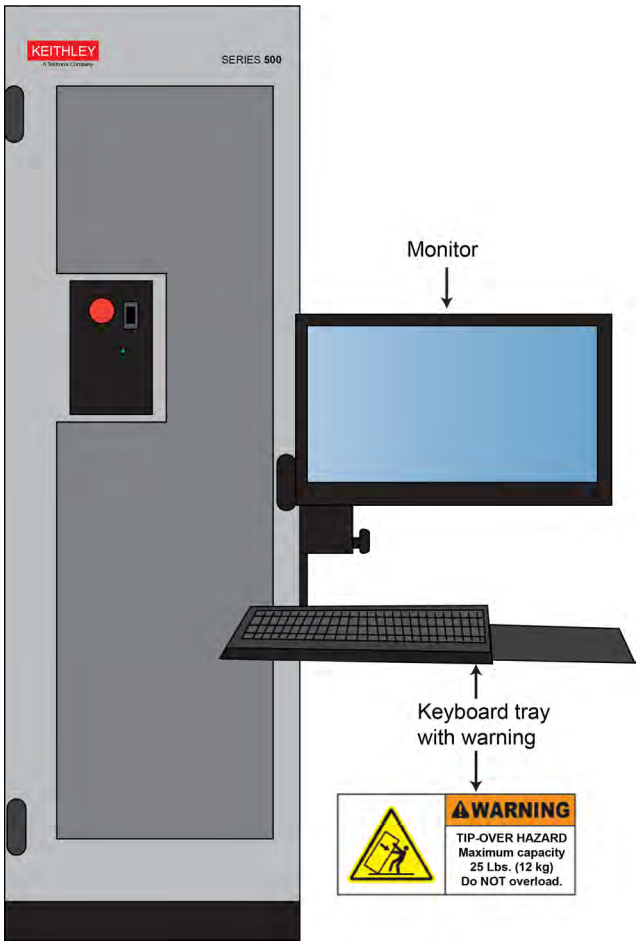
The following figure shows how a floor-mounting bracket is installed. Keithley part numbers are included for the required hardware.

Figure 33: S500 system cabinet floor mount



The following figure shows a label on the keyboard tray that indicates a tip-over hazard. The maximum weight capacity for the keyboard tray is 12 kg (25 lb).

Figure 34: S500 tip-over hazard warning label on keyboard tray



Optional advanced seismic securement

The S500 system can be ordered with an advanced seismic fastening option that has been tested and certified to the standards stated in IEC 61587-2 Ed. 2.0 Mechanical structures for electronic equipment — Tests for IEC 60917 and 60297 Part 2: Seismic tests for cabinets and racks.

If your system has this option, use the following installation instructions.

To install advanced seismic securement:

NOTE

You must supply the washers (flat and lock), threaded insert anchors, and mounting bolts that attach the mounting brackets to the floor (16 of each). The bolts should be at least grade-five bolts.

1. Position the cabinet where needed on a smooth, level floor.
2. Place the floor mounting brackets at the corners and make sure you have enough room for proper placement.
3. To properly place the mounting brackets, lift the cabinet by the leveling legs.

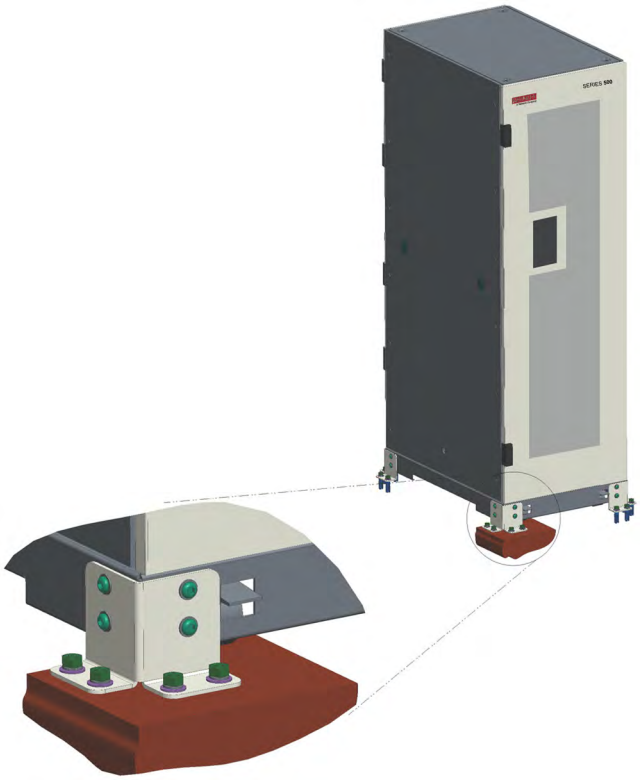
NOTE

Lifting the cabinet allows the holes in the mounting brackets to line up with the holes in the lower frame of the cabinet.

4. Temporarily attach the mounting brackets to each corner with the provided screws.

   The following figure shows the restraint brackets and bolt installation for the system cabinet.

Figure 35: S500 seismic restraints



5. Mark the position of the mounting holes to the floor with a marker.
6. Remove the mounting brackets and also mark the location of the cabinet leveling legs.
7. Lower the cabinet and move as needed for drilling and installing the customer-supplied floor anchors.

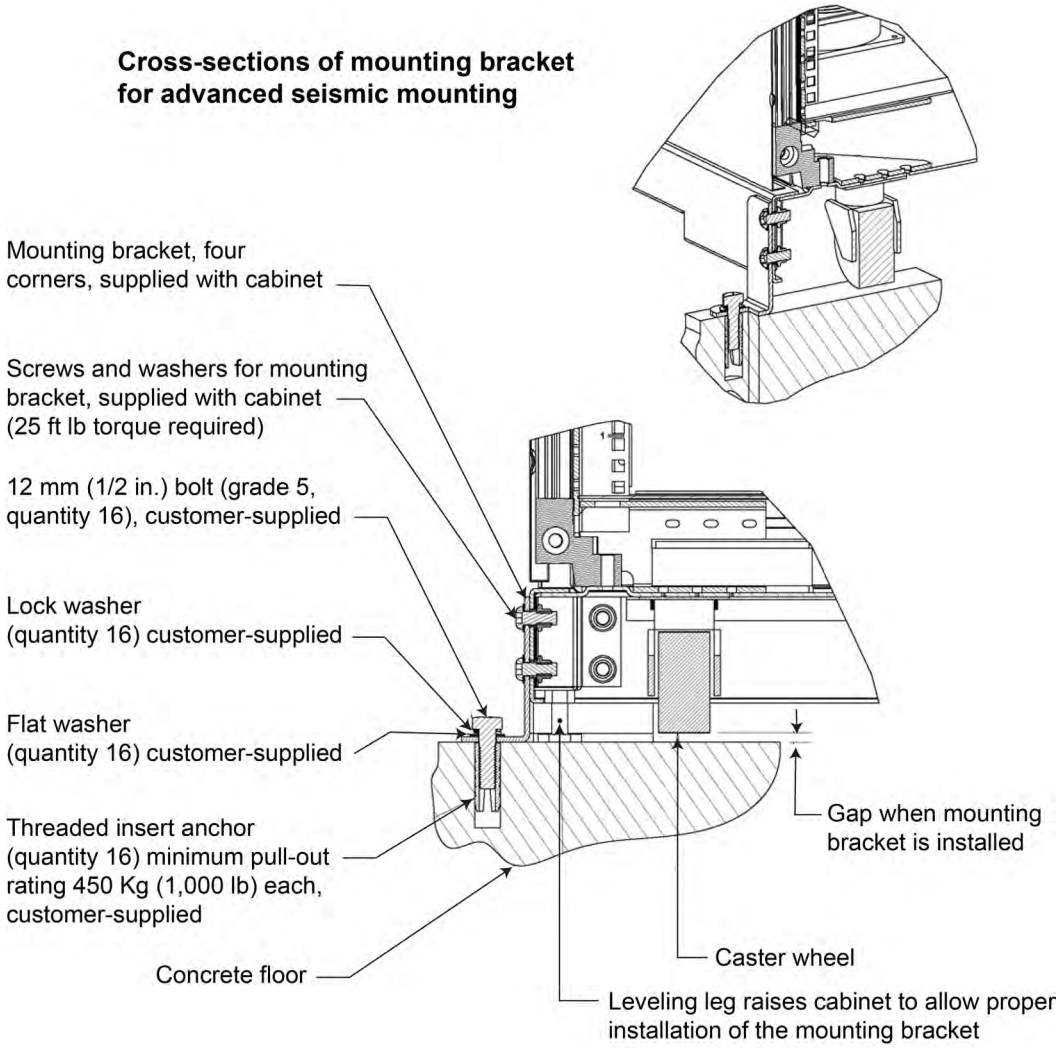
NOTE

Anchors should have a minimum pullout rating of 450 kg (1000 lb) each. Install 16 anchors for maximum protection.

8. Return the cabinet to marked locations on the floor and use the leveling legs to lift the cabinet to the proper height.
9. Attach the mounting brackets to the corners with the mounting hardware provided (16 screws and washers; 25 ft lb torque required).
10. Fasten brackets to the floor with user-supplied washers and grade-five (or higher) bolts.

The following figure shows how a floor-mounting bracket is installed.

Figure 36: S500 advanced cabinet floor mount

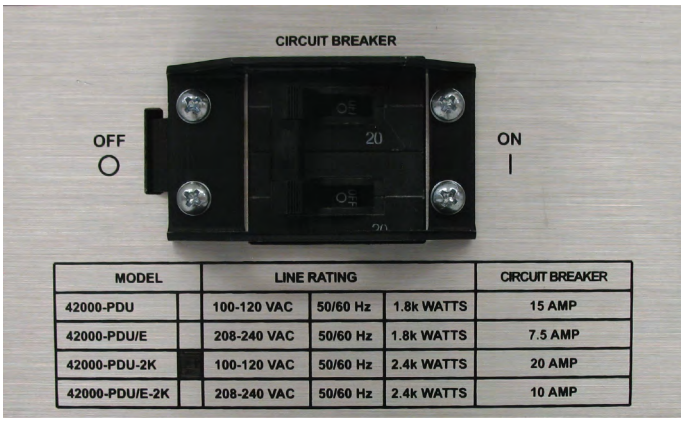


Equipment startup

All of the instruments in the equipment rack are connected to one power distribution unit (PDU), which is in the back of the cabinet.

Follow the instructions in the following topics to start up your system and software.

Figure 37: S500 PDU circuit breaker, OFF position



MODEL	LINE RATING			CIRCUIT BREAKER
42000-PDU	100-120 VAC	50/60 Hz	1.8k WATTS	15 AMP
42000-PDU/E	208-240 VAC	50/60 Hz	1.8k WATTS	7.5 AMP
42000-PDU-2K	100-120 VAC	50/60 Hz	2.4k WATTS	20 AMP
42000-PDU/E-2K	208-240 VAC	50/60 Hz	2.4k WATTS	10 AMP

On the front of the system, turn the POWER switch to the ON position. The POWER switch is on the front door of the cabinet (see the following figure). Make sure the system computer and monitor are also turned on before attempting to use the S500 system and any software.

Figure 38: S500 front view

Initial equipment startup

To begin equipment startup:

1. Check that all power cords for the system cabinet are connected to AC power.
2. Make sure that the circuit breaker on the power distribution unit (PDU) is in the ON position.Press the power/standby button on the computer and monitor.
3. Set the power button on the front door of the system cabinet to the ON position.

Figure 39: S500 power ON switch

System startup

To start up the system:

1. Make sure that the power switch on the power distribution unit (PDU) is set to ON.
2. Set the power button on the front door of the system cabinet to the ON position.
3. If the computer has not started to boot, open the front cabinet door and press the power/standby switch on the host computer.
4. Wait for all of the instruments to power up.
5. Log onto your computer and start the ACS software.

Before starting system software

NOTE

The S500 system includes one of the following system software options:

- Automated Characterization Suite (ACS)

ACS Basic Edition

- You must make sure that all of the instruments are connected with the appropriate interface cable and a TSP-Link® connection between any Series 2600B instruments.
- Assign GPIB or TCP/IP addresses (as appropriate) and node numbers to the hardware and instruments.

ATTENTION

To avoid instrument errors, make sure that all of the instruments in the system are completely powered up and have finished self-testing before starting the system software.

For more information about the ACS software setup procedures, refer to the *Automated Characterization Suite (ACS) Reference Manual* (part number ACS-901-01).

Using Telnet

Telnet is not enabled by default on the S500 system; you must to enable it to use it.

To enable Telnet:

1. From the command prompt (as root user), type `su` and the root password.
2. Type `gedit /etc/xinetd.d/telnet` to open the Telnet server configuration file.
3. In the opened file, change the line that says `disable = yes` to `disable = no` (see the following figure).

Figure 40: Enabling Telnet

4. Save and close the file.
5. At the command prompt (as root user), type the following:

```
service xinetd start
chk config telnet on
chk config xinetd on
```

Start the ACS software

To start the ACS software, log on to the computer and double-click the ACS icon.

For more information about the ACS software setup procedures, refer to the *Automated Characterization Suite (ACS) Reference Manual* (part number ACS-901-01).

Shut down using ACS

To shut down using the Automated Characterization Suite (ACS) software:

NOTE

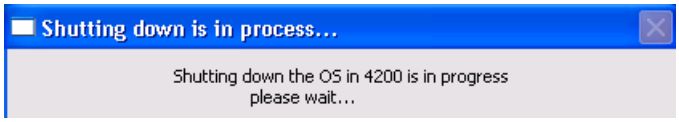
You must have administrator rights in the ACS software to shut down the S500 system.

1. Double-click the **Shutdown** icon on the computer desktop.
2. In the dialog box that opens, click **Yes** that you want to shut down the S500 tester.

NOTE

The message in the following figure opens after you click **Yes** to shut down the S500. You must wait until the 4200A-SCS and the system computer shut down before you press the power button on the system cabinet. It may take several minutes for the system to shut down.

Figure 41: Shut down the S500



3. Once the ACS host computer has shut down, press the power button on the front door of the system cabinet.

Emergency OFF button

An EMERGENCY OFF (EMO) button is on the system cabinet front door (see the following figure). If you push the EMERGENCY OFF button, it removes power to all of the system instruments except the host computer.

Figure 42: EMERGENCY OFF button

The EMO TRIPPED indicator light (on the cabinet door) turns on when the system has undergone an emergency shutdown.

Emergency shutdown procedure

Press the red **EMERGENCY OFF** button on the front of the system cabinet. The instruments power down and the red EMO TRIPPED indicator illuminates.

The red indicator also illuminates when the system recovers from a sudden power loss.

Recovering from an emergency shutdown

To recover after an emergency shutdown:

1. Verify that the hazardous condition or emergency situation is no longer present.
2. Rotate the **EMERGENCY OFF** button to release it.
3. Toggle the power switch from ON to OFF, and then back to ON again. All of the system instruments should power up.
4. Open the front cabinet door and press the power/standby switch on the host computer.

   Call `run_ic.pl` to reinitialize the instrumentation.

Safety interlocks

WARNING

Failure to make sure that the safety interlock and safety shields and guards are properly installed and arranged as indicated will put personnel in severe danger. Severe personal injury or death due to electric shock or electrocution may result.

For the safety interlock to function properly, the device under test (DUT) interlock sensor must be installed near the DUT connections and the interlock magnet must be installed on the safety shield. It must be set up so that when the magnet is near the switch (interlock closed) the operator cannot touch voltage-carrying conductors. If not properly installed, it will render the interlock inoperative and place personnel at severe risk.

For operator safety, the S500 has interlocks on both the front and back cabinet doors and at the DUT. Also, the optional probe card adapter (PCA) has interlocks that provide protection for connections to a prober.

If you open a cabinet door or open the DUT interlock while instruments are sourcing, the interlock activates and disconnects the hazardous voltage from the source-measure instruments, stopping any tests in progress.

An indicator on the front door of the S500 cabinet illuminates, and the ACS software immediately notifies you of the interlock activation.

Figure 43: Interlock indicator

Once the interlock has been activated, you must clear the cause of the interlock activation.

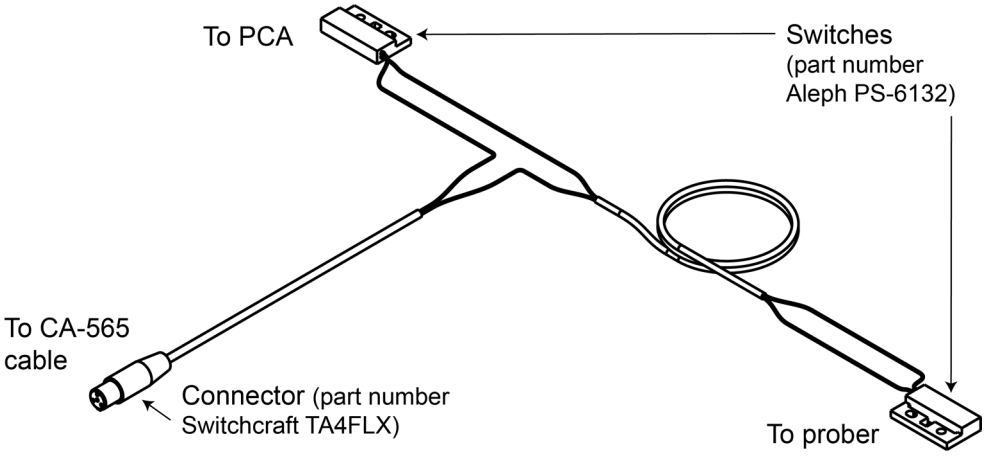
To clear the interlock activation:

1. Follow the instructions on the computer.
2. Make sure the front and rear doors are closed.
3. Make sure the DUT interlock is properly set for safe operation.
4. Close the DUT safety shield.
5. The software must recover before you can continue normal operation. You may need to rerun your tests.

Additional probe card adapter safety interlock cable

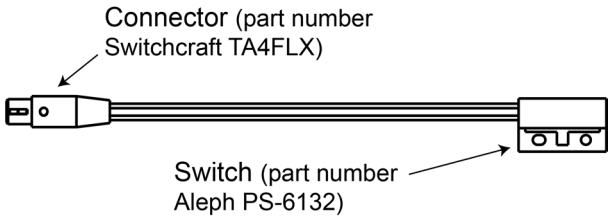
The Model 174-7047-XX Safety Interlock Cable provides additional protection from electric shock at the Keithley probe card adapter (PCA). The cable attaches to the prober top plate and the PCA so that if you unlatch the top plate of the prober and lift it up to change a probe card or take off the PCA, the interlock is tripped.

Figure 44: Model 174-7047-XX Safety Interlock Cable



The Model 174-7037-XX cable can be used with customer-supplied PCA solutions.

Figure 45: Model 174-7037-XX interlock cable



NOTE

The Model 174-7047-XX cable interfaces with your prober interlock through a relay contact. A shorted prober contact engages the interlock circuit. An open contact interrupts the interlock, turning off hazardous voltage.

LO patch panel and 2400-INTRLK

The S500 must have a single, direct connection between instrument lows and protective earth (safety ground). The S500-LOPATCH-3kV panel and 2400-INTRLK safety interlock (systems containing Model 2410 only) provide this common LO connection and protective earth (safety ground) reference.

Figure 46: S500-LOPATCH-3kV

Figure 47: Model 2400-INTRLK

The LO patch panel and 2400-INTRLK provide:

- A common reference point for all the instrument low-side connections
- In 4-wire systems, a common connection for the sense low terminals of the source-measure units (SMUs)
- Connections from low to sense low using a 100 kΩ resistor to enable autosensing

Prober safety

WARNING

Hazardous voltages may be present on the probe card adapter, even after you disengage the interlock. Cables can retain charges after the interlock is disengaged, exposing you to live voltages that, if contacted, may cause personal injury or death. Reset the test equipment to put the probe card adapter in a safe state before touching the prober cables or any connected cables.

Never attempt to touch or change a probe card when tests are running. You must be absolutely certain that all tests have stopped before making contact with anything in the vicinity of the probe card adapter. Also, never run tests without a probe card installed.

Network information

The network connections for the system computer include:

- System controller network interface: Ethernet port (10, 100, or 1000 Base-T capable using RJ-45)
- Supplied cables: One ethernet crossover cable (connects the computer to the tester)
- One 10Base-T patch cable (connects to your network)
- IP address is specified by you

ATTENTION

When setting up the computer for the S500 system, do not change the computer name. Software licenses are tied to the computer name. If you change the computer name, the system software will not work.

Hardware replacement

WARNING

The information in this section is intended only for qualified service personnel, as described in Error! Hyperlink reference not valid. **(on page 51). Because some of these procedures may cause exposure to hazardous voltages that could result in personal injury or death, service personnel must wear personal protective equipment (PPE) suitable for voltages greater than 40 VAC. Do not attempt to perform these procedures unless you are qualified to do so.**

This section contains information about removal and installation of system cabinet components, and instructions for replacing components determined to be faulty.

Handling and cleaning precautions

CAUTION

Always grasp cards by the side edges and shields to avoid contamination that will degrade the performance of the components. Do not touch the connectors, the board surfaces, or components. On plugs and receptacles, do not touch areas adjacent to the electrical contacts.

Take care when handling or servicing to prevent possible contamination in high-impedance areas, which could degrade performance. Take the following precautions when servicing any system component:

- Do not store or operate the system in an environment where dust could settle on the components.
- Use dry nitrogen gas to clean dust off the components, if necessary.
- Handle cards only by the side edges and shields.
- Do not touch any board surfaces, components, or connectors.
- Do not touch areas adjacent to electrical contacts.
- Wear clean-room approved gloves when servicing any component.
- If necessary, make solder repairs on a circuit board using lead-free solder. Remove the solder from the work areas when the repair is complete. Use pure water and clean cotton swabs or a clean, soft brush to remove the solder. Take care not to spread the solder to other areas of the components. Once the solder is removed, use a swab moistened with methanol or isopropyl alcohol to wipe only the repaired area, and then blow-dry the board with dry nitrogen gas.
- After cleaning, place the components in a 50 °C low-humidity environment for several minutes before use.

Special handling of static-sensitive devices

CAUTION

System components can be damaged by electrostatic discharge (ESD). Wear a ground strap and attach the clip lead to the grounding bar in the test head or the system cabinet frame before working on the system. Assume all parts are static sensitive.

High-impedance devices are subject to possible static discharge damage because of the high-impedance levels involved. When handling such devices, assume all parts are static sensitive:

- Static-sensitive components should be transported and handled only in containers designed to prevent or dissipate static buildup. Typically, these components are received in anti-static containers made of plastic or foam. Keep these parts in their original containers until ready for installation or use.
- Remove the components from their protective containers only at a properly grounded workstation. Also, ground yourself with an appropriate wrist strap while working with these components.
- Handle the connectors only by their bodies. Do not touch the boards, pins, or terminals.
- Any printed circuit board into which the device is to be inserted must first be grounded to the bench or table.
- Use only anti-static type desoldering tools and grounded-tip soldering irons.

Electrical hazard tasks

Definitions of electrical hazard tasks (as defined in the SEMI S2-0715a standard) are listed in this section. For S500 systems, Type 2 electrical hazard tasks are typically performed.

For additional information about diagnostics, troubleshooting, or maintenance of specific Keithley instruments, refer to the documentation for that instrument for details before attempting to repair it. Also, refer to the documentation on the DVD that was shipped with your purchase.

Types of electrical hazard tasks

Live circuit type	Description
1	Equipment is fully de-energized.
2	Equipment is energized. Energized circuits are covered or insulated. NOTE 41: Type 2 work includes tasks where the energized circuits are or can be measured by placing probes through suitable openings in the covers or insulators.
3	Equipment is energized. Energized circuits are exposed and inadvertent contact with uninsulated energized parts is possible. Potential exposures are no greater than 30 V_{RMS}, 42.4 V_{peak}, 60 VDC, or 240 VA in dry locations.
4	Equipment is energized. Energized circuits are exposed and inadvertent contact with uninsulated energized parts is possible. Potential exposures are greater than 30 V_{RMS}, 42.4 V_{peak}, 60 VDC, or 240 VA in dry locations. Potential exposures to radio-frequency currents, whether induced or via contact, exceed the limits in SEMI S2, Appendix 3, Table A3-1.

Repair and replacement

Keithley Instruments offers a fee-based service agreement with all S500 systems. Under this agreement, a field service engineer will either repair or replace equipment. For more information about this service agreement, contact Keithley Instruments at 1-800-935-5595.

For additional information about specific parts, operations, and maintenance of Keithley instruments, refer to the documentation for the instrument for details before attempting to replace or repair any equipment. Also, refer to the supplied documentation on the Keithley Instruments DVD that was shipped with your purchase.

Instrument removal and installation

The following topics describe the process for removing or installing instruments in the system, and any special precautions that must be taken.

Remove system power

⚠ WARNING

Severe personal injury or death due to electrical shock or electrocution may result if power is not removed before moving, removing, or installing equipment. Do not attempt to perform these procedures unless you are qualified to do so and are wearing personal protective equipment (PPE) suitable for voltages greater than 40 VAC.

Make sure the system and instruments that are being installed, moved, or removed are turned off with all power source/cables unplugged.

To remove system power before performing maintenance or replacement of components:

CAUTION

Follow precautions for removing hazardous voltage from the probe or other types of test fixtures before handling.

1. Close any software that is open on the computer.
2. Shut down the system computer using the instructions in **Error! Hyperlink reference not valid.** (on page 34).
3. Place the system cabinet power switch on the front-panel door in the OFF position.
4. Place the main circuit breaker on the power distribution unit (PDU) on the back of the cabinet in the OFF position.
5. Disconnect the source power to the S500 system (power cord on back of the PDU).
6. Place a lock and tag on the main circuit breaker of the PDU.
7. Wait five minutes before accessing any high-voltage units.

Heavy instrument removal and installation

Special handling precautions should be taken for heavy instrumentation removal and installation. The following topics describe these precautions.

Moving instruments weighing 20 pounds to 40 pounds

The following instruments require two people to move them. Some of these instruments may require mechanical lifting equipment if they have additional options installed that cause them to weigh more than 40 pounds or if they are located at or near the top of the system cabinet.

NOTE

Some instruments in the S500 system are not heavy enough to require a two-person lift individually, but when put together in a rack, require two people to remove and install them safely.

Instruments in the S500 system that require a two-person lift include:

- 4200A-SCS Parameter Analyzer with only the CVU option installed
- 707B Switch Matrix Mainframe with no cards installed
- Multiple 2636B or 2410 Sourcemeter® Instruments racked together horizontally
- Multiple DMM7510 Digital Multimeters racked together horizontally
- The Comp-41 system computer, if not located near top of the system cabinet

Moving instruments weighing more than 40 pounds

When installing or removing equipment heavier than 40 pounds, use a mechanical lifting device. If there is an instrument mounted below the heavy instrument, it must be removed to provide clearance for the lifting forks. You will also need to allow for additional space outside of the cabinet for the lifting device.

Refer to the lifting device operating manual for proper usage.

Instruments in the S500 system that require a mechanical lifting device include:

- 4200A-SCS Parameter Analyzer with multiple options installed
- 707B Switch Matrix Mainframe with cards installed
- The Comp-41 system computer, if located near top of the system cabinet

General replacement procedure

⚠ WARNING

Severe personal injury or death due to electric shock or electrocution may result if power is not removed before working inside the cabinet. Always disconnect the cabinet line cords from the AC line power receptacles before opening the system cabinet. Also, never turn on the system until all connections and safety grounds are installed.

1. Remove power and place a lock and tag on the main circuit breaker of the power distribution unit (PDU) (see **Error! Hyperlink reference not valid.** (on page 21)).
2. Disconnect and tag cabling to the unit requiring removal. Do not change cable routing or securement.
3. Properly supporting the unit, remove it from the system cabinet.

Adjustment

Keithley Instruments recommends annual adjustment of the individual instruments in your system and offers this as an on-site service. A field service engineer (FSE) will adjust instrumentation and perform system verification according to the warranted system specifications. For more information about adjustment or other S500 services, contact your sales representative.

You can also do system verification as described in the *S500 Reference Manual* (part number S500-901-01).

⚠ WARNING

Hazardous voltages may be present on the probe card adapter, even after you disengage the interlock. Cables can retain charges after the interlock is disengaged, exposing you to live voltages that, if contacted, may cause personal injury or death. Reset the test equipment to put the probe card adapter in a safe state before touching the prober cables or any connected cables.

Never attempt to touch or change a probe card when tests are running. You must be absolutely certain that all tests have stopped before making contact with anything in the vicinity of the probe card adapter. Also, never run tests without a probe card installed.

For information about instrument-level adjustment, refer to documentation for each of the instruments in the system (on the DVD that was shipped with your purchase or available on the Product Support web page (https://www.tek.com/product-support)).

Restore system power

Restore system power after properly performing the required maintenance or replacement of components. Make sure that all connections are secure and connected correctly.

To restore system power:

1. Remove the lock and tag placed on the main circuit breaker of the power distribution unit (PDU).
2. Connect the source power to the S500 system (power cord on the back of the PDU).
3. Place the main circuit breaker on the PDU in the ON position.
4. Close the rear cabinet door.
5. Make sure the system computer and all instrument power switches are in the ON position.
6. Close the front cabinet door.

NOTE

With the system cabinet POWER switch in the OFF position, the EMERGENCY OFF (EMO) light should be off. If the EMO light stays on, the power is not restored to all instruments in the system.

7. Place the system cabinet POWER switch (on the front-panel door) in the ON position.
8. Make sure the computer is turned on.
9. Start the computer and the system software.

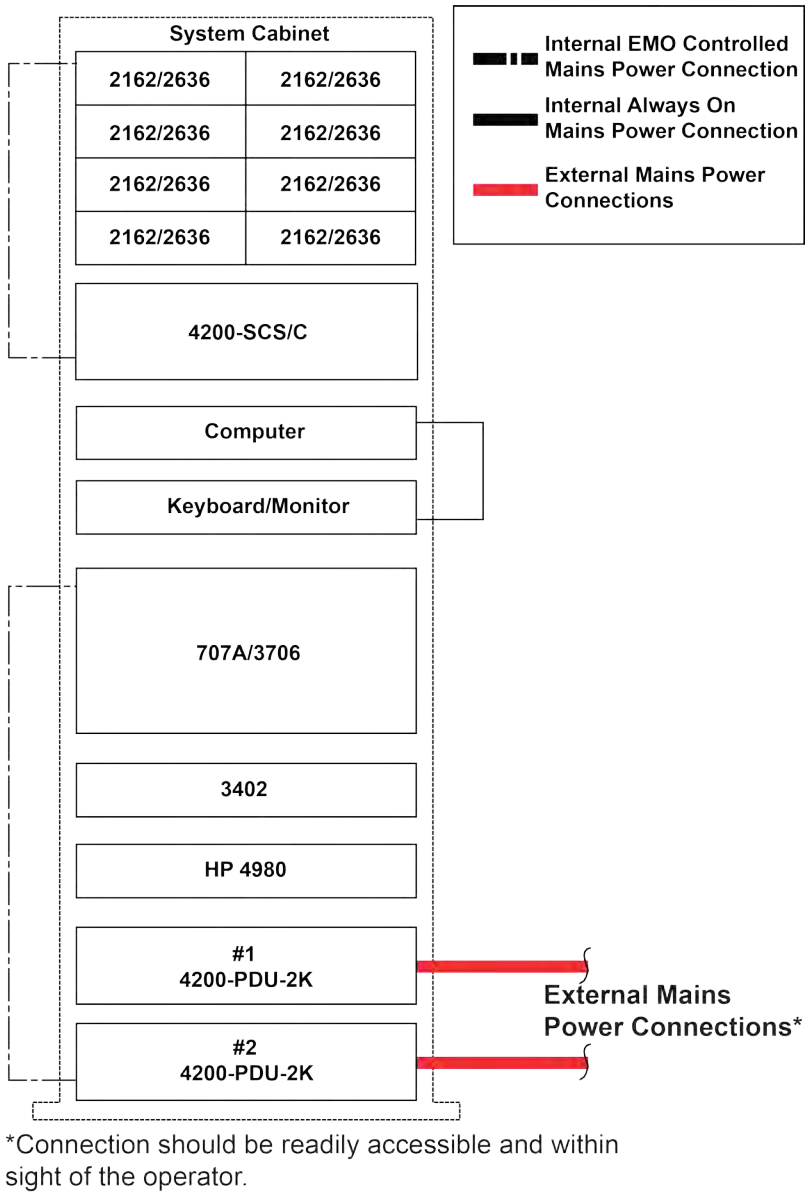
Fuses

Refer to the applicable instrument documentation that is included with the product for fuse replacement.

Power distribution and emergency off

The following figure contains simplified connection schematics for the various components of the S500 (the LO patch panel and the Interlock are shown for reference only; they are located behind the SMUs).

Figure 48: Block diagram of typical S500 configuration



*Connection should be readily accessible and within sight of the operator.

Power distribution unit connections and power distribution basics

The 42000-PDU consists of:

- 24 VDC output to emergency off (EMO) circuits and cabinet fans with power
- 24 VDC output through banana jacks
- Two specially switched power outlets (factory configuration: Always on)
- Three groups of four switched outlets (off with EMO condition)
- Remote connection to other 42000-PDUs through a 25-pin D-sub connector

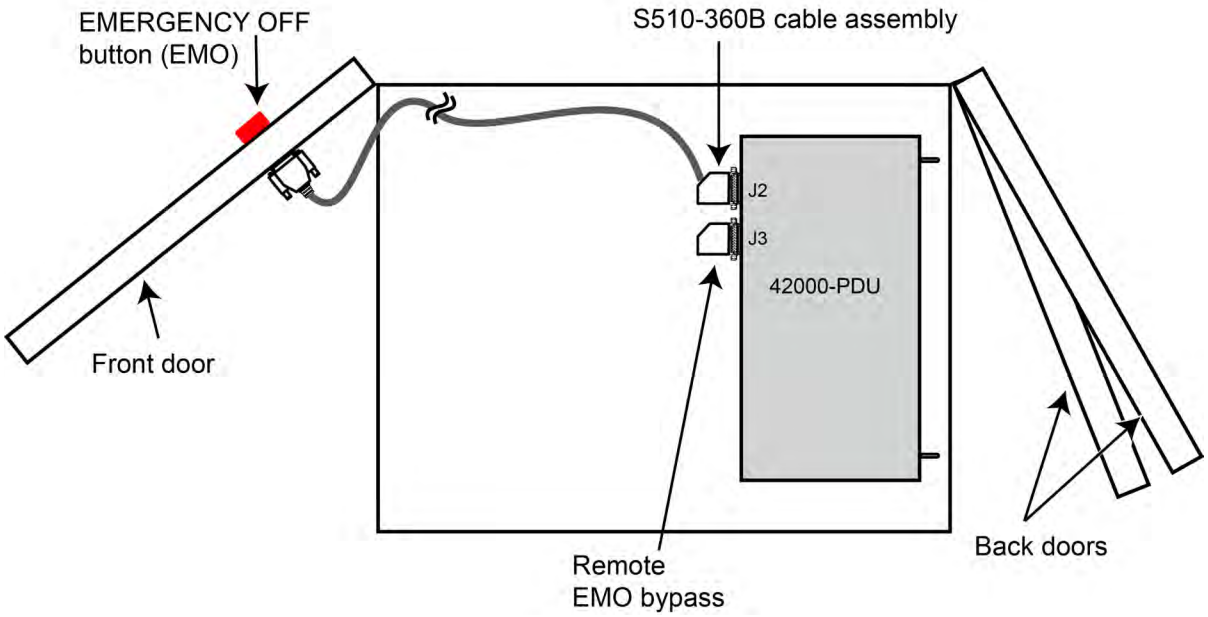
WARNING

Properly lockout and tagout the system before beginning installation or connection. Also, never turn on the system until all connections and safety grounds are installed. Make sure the main circuit breaker on the PDU is placed in the OFF position before making or breaking any connections.

The following figure shows how the PDU is connected to the system EMO circuit.

Figure 49: PDU connection to the EMO circuit

Top view of system cabinet showing PDU at bottom of cabinet



The following table provides a detailed description of the available connections in the 42000-PDU. Information about the EMO circuit connections and operation is also in the table.

42000-PDU connection descriptions

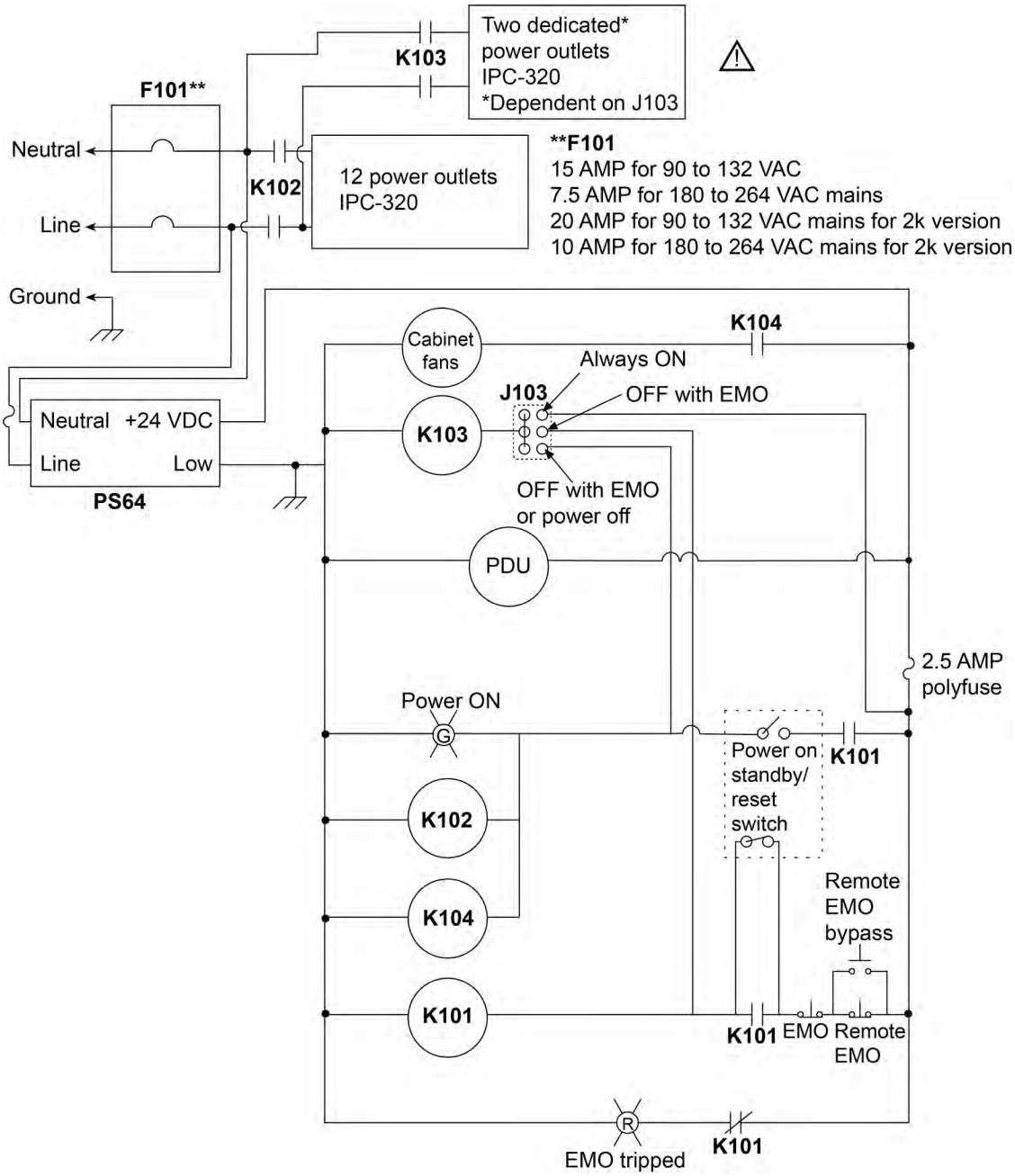
Connection	Description
Specially switched outlets	Two power outlets on the power distribution unit (PDU) rear panel.
	WARNING: Severe personal injury or death due to electric shock or electrocution may result if power is not removed before working inside the cabinet. Do not use power outlets for accessories (for example, a soldering iron or drill). Use for instruments that do not have hazardous voltages and do not need to have power removed through the EMO circuit (for example, a computer). In the factory default configuration, these outlets have dedicated power and will remain live even if power is removed through the EMO circuit.
	The specific configuration is marked on the PDU rear panel.*
To PDU box DB-25 cable connector	Connector providing control of the PDU box. Connect the PDU box to the EMO box with the supplied DB-25 male-to-female cable.
Switched outlets	Twelve power outlets on the PDU rear panel. Do not use power outlets for accessories (for example, soldering iron or drill). Use for equipment with hazardous voltages that need to be removed with the EMO circuitry.*
Ground connection (optional)	Connect to a quality ground within your facility with 18 AWG wire.
External fan connection	Connector providing 24 VDC to cabinet fans.
External EMO/shorting plug connection	DB-25 connector providing connection to external EMO devices. Make sure the shorting plug is installed if the system is not configured for external EMO.
24 VDC (–) banana plug	Banana plug providing 24 VDC (–) power connection.
24 VDC (+) banana plug	Banana plug providing 24 VDC (+) power connection.

* Outlet connector description:
- Class 1 applications (42000-PDU (PDU/E) (PDU/E-2K) 15 A and 42000-PDU-2K 20 A).
- Type: Push-in mount mates with IEC standard 320 C20 (20 A) or the IEC standard 320 C14 (15 A) power cords.

System emergency off circuit

The following figure shows a simplified schematic of the 42000-PDU power distribution unit (PDU) emergency off (EMO) circuit.

Figure 50: 42000-PDU simplified schematic



Editing the icconfig_<QMO>.ini file

The `$KIHOME/IC/icconfig_<QMO>.ini` file is a system configuration file that defines the types of instruments installed in the S500 system, matrix and terminal configuration, and default system settings. Your Keithley field service engineer (FSE) configures this file when your system is installed.

The FSE can edit this file to reflect changes in system hardware or to set different default system settings.

When editing the `icconfig_<QMO>.ini` file (where <QMO> is the system QMO number), follow the guidelines below:

- Make a backup copy of the file before making edits.
- Use only upper case characters.
- Do not use space or tab characters.
- Lines should be terminated with newline characters only (`\n`).
- Avoid duplicate entries and assignments.

Decommissioning an S500 test system

The S500 S500 Integrated Test System does not contain any intentionally released substances, but may contain substances that are potentially hazardous to the environment if not properly recycled.

For example, systems produced before July 22, 2017 and shipped into the European Union may contain lead (Pb) as a part of the solder to connect electronic components and system interconnects. A list of possible hazardous substances is in European Union Directive “Restricting the use of hazardous substances in electrical and electronic equipment” (RoHS) Directive 2011/65/EU or later. This list includes:

- Lead (Pb)
- Mercury (Hg)
- Cadmium (Cd)
- Hexavalent chromium (Cr6+)
- Polybrominated biphenyls (PBB)
- Polybrominated diphenyl ether (PBDE)
- Bis (2-ethylhexyl) phthalate (DEHP)
- Butyl benzyl phthalate (BBP)
- Dibutyl phthalate (DBP)
- Diisobutyl phthalate (DIBP)

For more detailed information, see the European Union Directive.

To minimize environmental impact at system end of life, treat the system, cables and connections, and all subassemblies as waste electrical and electronic equipment (WEEE) category 9. Reference the European Union Directive on waste electrical and electronic equipment (WEEE Directive 2012/19/EU or later).

Follow these directives to minimize environmental impact at any location in the world. Always follow all local, state, and country environmental laws; these take priority over other directives.

Take all product and subassemblies to a reputable electronics recycle company for proper recycling. Several approved recyclers are identified on the Tektronix website at tek.com.

Any cleaning solutions used during the life of the system (such as isopropyl alcohol (IPA)) should be disposed of separately and properly.

The S500 system may be used with other equipment such as automatic probers and third-party probe card adapters. Tektronix is not in control of these products and the original equipment manufacturer should always be contacted for proper recycling procedures.

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A Tektronix Company

Safety precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with nonhazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the user documentation for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product warranty may be impaired.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the user documentation. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, perform safe installations, and repair products. Only properly trained service personnel may perform installation and service procedures.

Keithley products are designed for use with electrical signals that are measurement, control, and data I/O connections, with low transient overvoltages, and must not be directly connected to mains voltage or to voltage sources with high transient overvoltages. Measurement Category II (as referenced in IEC 60664) connections require protection for high transient overvoltages often associated with local AC mains connections. Certain Keithley measuring instruments may be connected to mains. These instruments will be marked as category II or higher.

Unless explicitly allowed in the specifications, operating manual, and instrument labels, do not connect any instrument to mains.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30 V RMS, 42.4 V peak, or 60 VDC are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 V, no conductive part of the circuit may be exposed.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance-limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, ensure that the line cord is connected to a properly-grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

For safety, instruments and accessories must be used in accordance with the operating instructions. If the instruments or accessories are used in a manner not specified in the operating instructions, the protection provided by the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories. Maximum signal levels are defined in the specifications and operating information and shown on the instrument panels, test fixture panels, and switching cards.

When fuses are used in a product, replace with the same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as protective earth (safety ground) connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

The  symbol on an instrument means caution, risk of hazard. The user must refer to the operating instructions located in the user documentation in all cases where the symbol is marked on the instrument.

The  symbol on an instrument means warning, risk of electric shock. Use standard safety precautions to avoid personal contact with these voltages.

The  symbol on an instrument shows that the surface may be hot. Avoid personal contact to prevent burns.

The  symbol indicates a connection terminal to the equipment frame.

If this  symbol is on a product, it indicates that mercury is present in the display lamp. Please note that the lamp must be properly disposed of according to federal, state, and local laws.

The **WARNING** heading in the user documentation explains hazards that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in the user documentation explains hazards that could damage the instrument. Such damage may invalidate the warranty.

The **CAUTION** heading with the  symbol in the user documentation explains hazards that could result in moderate or minor injury or damage the instrument. Always read the associated information very carefully before performing the indicated procedure. Damage to the instrument may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits — including the power transformer, test leads, and input jacks — must be purchased from Keithley. Standard fuses with applicable national safety approvals may be used if the rating and type are the same. The detachable mains power cord provided with the instrument may only be replaced with a similarly rated power cord. Other components that are not safety-related may be purchased from other suppliers as long as they are equivalent to the original component (note that selected parts should be purchased only through Keithley to maintain accuracy and functionality of the product). If you are unsure about the applicability of a replacement component, call a Keithley office for information.

Unless otherwise noted in product-specific literature, Keithley instruments are designed to operate indoors only, in the following environment: Altitude at or below 2,000 m (6,562 ft); temperature 0 °C to 50 °C (32 °F to 122 °F); and pollution degree 1 or 2.

To clean an instrument, use a cloth dampened with deionized water or mild, water-based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., a data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

Safety precaution revision as of June 2017.