

Keysight E3631A Triple Output DC Power Supply

NOTICE: This document contains references to Agilent Technologies. Agilent's former Test and Measurement business has become Keysight Technologies. For more information, go to www.keysight.com.



The Keysight Technologies E3631A is a high performance 80 watt-triple output DC power supply with GPIB and RS-232 interfaces. The combination of bench-top and system features in this power supply provides versatile solutions for your design and test requirements.

Convenient bench-top features

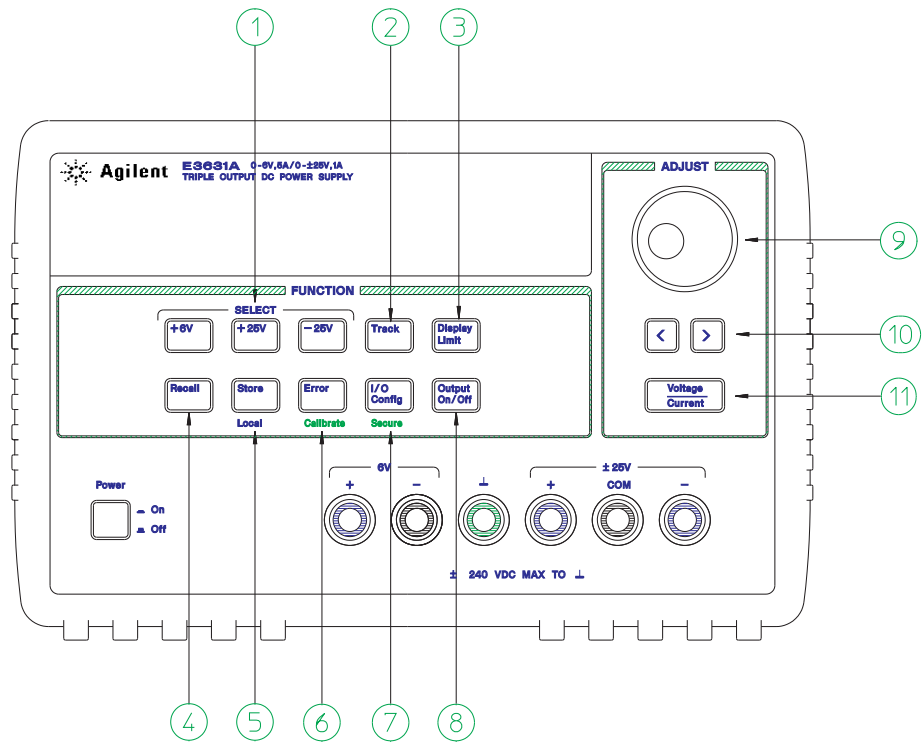
- Triple output
- Easy-to-use knob control for voltage and current settings
- Highly visible vacuum-fluorescent display for voltage and current meters
- Tracking operation for $\pm 25\text{V}$ outputs
- Excellent load and line regulation and low ripple and noise
- Operating states storage
- Portable, ruggedized case with non-skid feet

Flexible system features

- GPIB (IEEE-488) and RS-232 interfaces are standard
- SCPI (Standard Commands for Programmable Instruments) compatibility
- I/O setup easily done from front-panel

Keysight E3631A Triple Output DC Power Supply

The Front Panel at a Glance



-
- | | |
|-------------------------------------|---|
| 1 Meter and adjust selection keys | 7 I/O Configuration / Secure key |
| 2 Tracking enable/disable key | 8 Output On/Off key |
| 3 Display limit key | 9 Control knob |
| 4 Recall operating state key | 10 Resolution selection keys |
| 5 Store operating state / Local key | 11 Voltage/current adjust selection key |
| 6 Error / Calibrate key | |

- 1 Meter and adjust selection keys** Select the output voltage and current of any one supply (+6V, +25V, or -25V output) to be monitored on the display and allow knob adjustment of that supply.
- 2 Tracking enable / disable key** Enables / disables the track mode of $\pm 25V$ supplies.
- 3 Display limit key** Shows the voltage and current limit values on the display and allows knob adjustment for setting limit values.
- 4 Recall operating state key** Recalls a previously stored operating state from location "1", "2", or "3".
- 5 Store operating state / Local key¹** Stores an operating state in location "1", "2", or "3" / or returns the power supply to local mode from remote interface mode.
- 6 Error / Calibrate key²** Displays error codes generated during operations, self-test and calibration / or enables calibration mode (the power supply must be *unsecured* before performing calibration).
- 7 I/O Configuration / Secure key³** Configures the power supply for remote interfaces / or secure and unsecure the power supply for calibration.
- 8 Output On/Off key** Enables or disables all three power supply outputs. This key toggles between two states.
- 9 Control knob** Increases or decreases the value of the blinking digit by turning clockwise or counter clockwise.
- 10 Resolution selection keys** Move the flashing digit to the right or left.
- 11 Voltage/current adjust selection key** Selects the knob function to voltage control or current control.

¹The key can be used as the "Local" key when the power supply is in the remote interface mode.

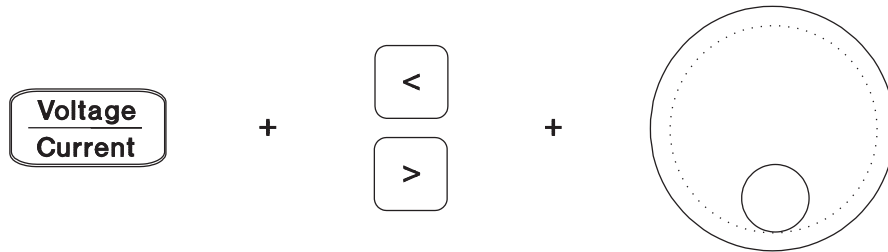
²You can enable the "calibration mode" by holding down this key when you turn on the power supply.

³You can use it as the "Secure" or "Unsecure" key when the power supply is in the calibration mode.

Front-Panel Voltage and Current Settings

You can set the voltage and current from the front panel using the following method.

Use the voltage/current adjust selection key, the resolution selection keys, and the control knob to change the limiting or limitings value of voltage or current.

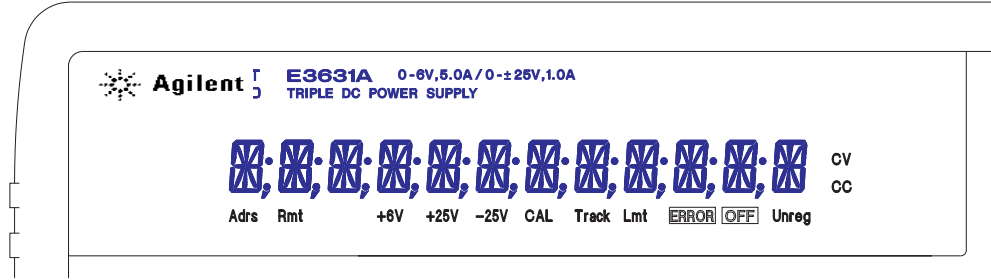


- 1 Press the `Display Limit` key after turning on the power supply.
- 2 Set the knob to the voltage control mode or current control mode using the voltage/current adjust selection key.
- 3 Move the blinking digit to the appropriate position using the resolution selection keys.
- 4 Change the blinking digit to the desired value using the control knob.
- 5 Press the `Output On/Off` key to enable the output. After about 5 seconds, the display will go to the output monitor mode automatically to display the voltage and current at the output.

Note

All front panel keys and controls can be disabled with remote interface commands. The Keysight E3631A must be in "Local" mode for the front panel keys and controls to function.

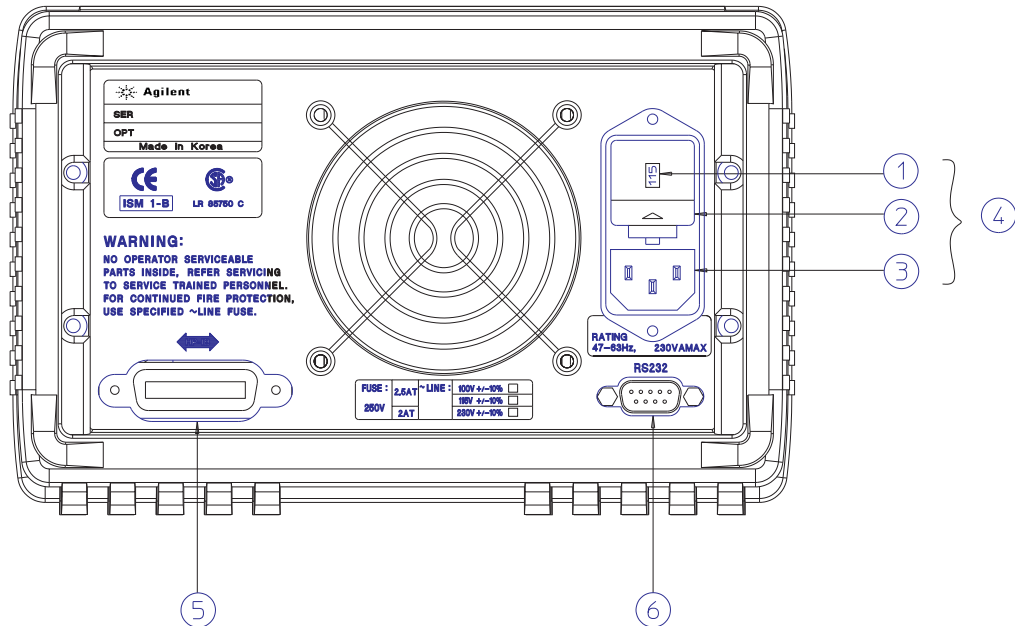
Display Annunciators



| | |
|--------------|---|
| Adrs | Power supply is addressed to listen or talk over a remote interface. |
| Rmt | Power supply is in remote interface mode. |
| +6V | Displays the output voltage and current for +6V supply. Knob is active for 6V supply. |
| +25V | Displays the output voltage and current for +25V supply. Knob is active for +25V supply. |
| -25V | Displays the output voltage and current for -25V supply. Knob is active for -25V supply. |
| CAL | Power supply is in the calibration mode. |
| Track | The output of +25V and -25V supplies are in track mode. |
| Lmt | The display shows the voltage and current limit values of a selected supply. |
| ERROR | Hardware or remote interface command errors are detected and also the error bit has not been cleared. |
| OFF | The three output of the power supply is disabled. |
| Unreg | The displayed output is unregulated (output is neither CV nor CC). |
| CV | The displayed output is in constant-voltage mode. |
| CC | The displayed output is in constant-current mode. |

To review the display annunciators, hold down **Display Limit** key as you turn on the power supply.

The Rear Panel at a Glance



- | | |
|-----------------------------------|---------------------------------------|
| 1 Power-line voltage setting | 4 Power-line module |
| 2 Power-line fuse-holder assembly | 5 GPIB (IEEE-488) interface connector |
| 3 AC inlet | 6 RS-232 interface connector |

Use the front-panel `I/O Config` key to:

- Select the GPIB or RS-232 interface (see chapter 3 in User's Guide).
- Set the GPIB bus address (see chapter 3 in User's Guide).
- Set the RS-232 baud rate and parity (see chapter 3 in User's Guide).

In This Book

Specifications Chapter 1 lists the power supply's specifications and describes how to interpret these specifications.

Quick Start Chapter 2 prepares the power supply for use and helps you get familiar with the front-panel features.

Calibration Procedures Chapter 3 provides performance verification and calibration procedures.

Theory of Operation Chapter 4 describes block and circuit level theory related to the operation of the power supply.

Service Chapter 5 provides guidelines for returning your power supply to Keysight Technologies for servicing, or for servicing it yourself.

Component Locator Diagrams Chapter 6 contains the component locator diagrams.

If you have questions relating to the operation of the power supply, call 1-800-829-4444 in the United States, or contact your nearest Keysight Technologies Sales Office.

Environmental Conditions

This instrument is designed for indoor use and in an area with low condensation. The table below shows the general environmental requirements for this instrument.

| Environmental condition | Requirements |
|--------------------------------|--|
| Temperature | Operating condition • 0 °C to 40 °C Storage condition • -20 °C to 70 °C |
| Humidity | Up to 80% RH |
| Altitude | Up to 2000 m |
| Installation category | II |
| Pollution degree | 2 |

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Specifications

Specifications

The *performance* specifications are listed in the following pages. Specifications are warranted in the temperature range of 0 to 40°C with a resistive load. *Supplemental* characteristics, which are not warranted but are descriptions of performance determined either by design or testing. Chapter 3 "Calibration Procedures" contains procedures for verifying the performance specifications. All specifications apply to the three outputs unless otherwise specified.

Performance Specifications

Output Ratings (@ 0°C - 40°C)

| | |
|-------------|-----------------------|
| +6V Output | 0 to +6 V ; 0 to 5 A |
| +25V Output | 0 to +25 V ; 0 to 1 A |
| -25V Output | 0 to -25 V ; 0 to 1 A |

Programming Accuracy^[1] 12 months (@ 25°C ± 5°C), ±(% of output + offset)

| | <u>+6V Output</u> | <u>+25V Output</u> | <u>-25V Output</u> |
|---------|-------------------|--------------------|--------------------|
| Voltage | 0.1% + 5 mV | 0.05% + 20 mV | 0.05% + 20 mV |
| Current | 0.2% + 10 mA | 0.15% + 4 mA | 0.15% + 4 mA |

Readback Accuracy^[1] 12 months (over GPIB and RS-232 or front panel with respect to actual output @ 25°C ± 5°C), ±(% of output + offset)

| | <u>+6V Output</u> | <u>+25V Output</u> | <u>-25V Output</u> |
|---------|-------------------|--------------------|--------------------|
| Voltage | 0.1% + 5 mV | 0.05% + 10 mV | 0.05% + 10 mV |
| Current | 0.2% + 10 mA | 0.15% + 4 mA | 0.15% + 4 mA |

Ripple and Noise (with outputs ungrounded, or with either output terminal grounded, 20 Hz to 20 MHz)

| | <u>+6V Output</u> | <u>+25V Output</u> | <u>-25V Output</u> |
|---------------------|-------------------|--------------------|--------------------|
| Voltage | <0.35 mV rms | <0.35 mV rms | <0.35 mV rms |
| | <2 mV p-p | <2 mV p-p | <2 mV p-p |
| Current | <2 mA rms | <500 µA rms | <500 µA rms |
| Common mode current | <1.5 µA rms | | |

Load Regulation, ±(% of output + offset)

Change in output voltage or current for any load change within ratings

| | |
|---------|-----------------|
| Voltage | <0.01% + 2 mV |
| Current | <0.01% + 250 µA |

Line Regulation, ±(% of output + offset)

Change in output voltage and current for any line change within ratings

| | |
|---------|-----------------|
| Voltage | <0.01% + 2 mV |
| Current | <0.01% + 250 µA |

^[1] Accuracy specifications are after an 1-hour warm-up and calibration at 25°C

Chapter 1 Specifications

Performance Specifications

Programming Resolution

| | <u>+6V Output</u> | <u>+25V Output</u> | <u>-25V Output</u> |
|---------|-------------------|--------------------|--------------------|
| Voltage | 0.5 mV | 1.5 mV | 1.5 mV |
| Current | 0.5 mA | 0.1 mA | 0.1 mA |

Readback Resolution

| | <u>+6V Output</u> | <u>+25V Output</u> | <u>-25V Output</u> |
|---------|-------------------|--------------------|--------------------|
| Voltage | 0.5 mV | 1.5 mV | 1.5 mV |
| Current | 0.5 mA | 0.1 mA | 0.1 mA |

Meter Resolution

| | <u>+6V Output</u> | <u>+25V Output</u> | <u>-25V Output</u> |
|---------|-------------------|--------------------|--------------------|
| Voltage | 1 mV | 10 mV | 10 mV |
| Current | 1 mA | 1 mA | 1 mA |

Transient Response Time

Less than 50 μ sec for output recover to within 15 mV following a change in output current from full load to half load or vice versa

Command Processing Time

Programming Commands : Maximum time for output to change after receipt of APPLy and SOURce commands : <50 msec

Readback Command : Maximum time to readback output by MEASure? command : <100 msec

The Other Commands : < 50 msec

Tracking Accuracy

The \pm 25V outputs track each other within \pm (0.2% of output + 20 mV).

Supplemental Characteristics

Output Programming Range (maximum programmable values)

| | <u>+6V Output</u> | <u>+25V Output</u> | <u>-25V Output</u> |
|---------|-------------------|--------------------|--------------------|
| Voltage | 0 to 6.18 V | 0 to 25.75 V | 0 to -25.75 V |
| Current | 0 to 5.15 A | 0 to 1.03 A | 0 to 1.03 A |

Temperature Coefficient, \pm (% of output + offset)

Maximum change in output/readback per °C after a 30-minute warm-up

| | <u>+6V Output</u> | <u>+25V Output</u> | <u>-25V Output</u> |
|---------|-------------------|--------------------|--------------------|
| Voltage | 0.01% + 2 mV | 0.01% + 3 mV | 0.01% + 3 mV |
| Current | 0.02% + 3 mA | 0.02% + 0.5 mA | 0.02% + 0.5 mA |

Stability, \pm (% of output + offset)

Following a 30-minute warm-up, with the output in the ON state according to the operating mode (CC with load or CV), and with a change in the output over 8 hours under constant load, line, and ambient temperature

| | <u>+6V Output</u> | <u>+25V Output</u> | <u>-25V Output</u> |
|---------|-------------------|--------------------|--------------------|
| Voltage | 0.03% + 1 mV | 0.02% + 2 mV | 0.02% + 2 mV |
| Current | 0.1% + 3 mA | 0.05% + 1 mA | 0.05% + 1 mA |

Voltage Programming Speed

Maximum time required for output voltage to settle within 1% of its total excursion (for resistive load). Excludes command processing time.

| | <u>+6V Output</u> | <u>+25V Output</u> | <u>-25V Output</u> |
|----------------|-------------------|--------------------|--------------------|
| Full load Up | 11 msec | 50 msec | 50 msec |
| Full load Down | 13 msec | 45 msec | 45 msec |
| No load Up | 10 msec | 20 msec | 20 msec |
| No load Down | 200 msec | 400 msec | 400 msec |

Isolation

The 0-6V supply is isolated from the $\pm 25V$ supply up to ± 240 Vdc. Maximum isolation voltage from any terminal to chassis ground ± 240 Vdc.

AC Input Ratings (selectable via rear panel selector)

| | |
|---------|--------------------------------|
| std | 115 Vac \pm 10%, 47 to 63 Hz |
| opt 0E3 | 230 Vac \pm 10%, 47 to 63 Hz |
| opt 0E9 | 100 Vac \pm 10%, 47 to 63 Hz |

Maximum Input Power

350 VA with full load

Chapter 1 Specifications

Supplemental Characteristics

Cooling

Fan cooled

Operating Temperature

0 to 40°C for full rated output. At higher temperatures, the output current is derated linearly to 50% at 55°C maximum temperature.

Output Voltage Overshoot

During turn-on or turn-off of ac power, output plus overshoot will not exceed 1 V if the output control is set to less than 1 V. If the output control is set to 1 V or higher, there is no overshoot.

Programming Language

SCPI (Standard Commands for Programmable Instruments)

State Storage Memory

Three (3) user-configurable stored states

Recommended Calibration Interval

1 year

Dimensions*

212.6 mmW x 132.6 mmH x 348.2 mmD (8.4 x 5.2 x 13.7 in)

**See the next page for detailed information.*

Weight

| | |
|----------|----------------|
| Net | 8.2 kg (18 lb) |
| Shipping | 11 kg (24 lb) |

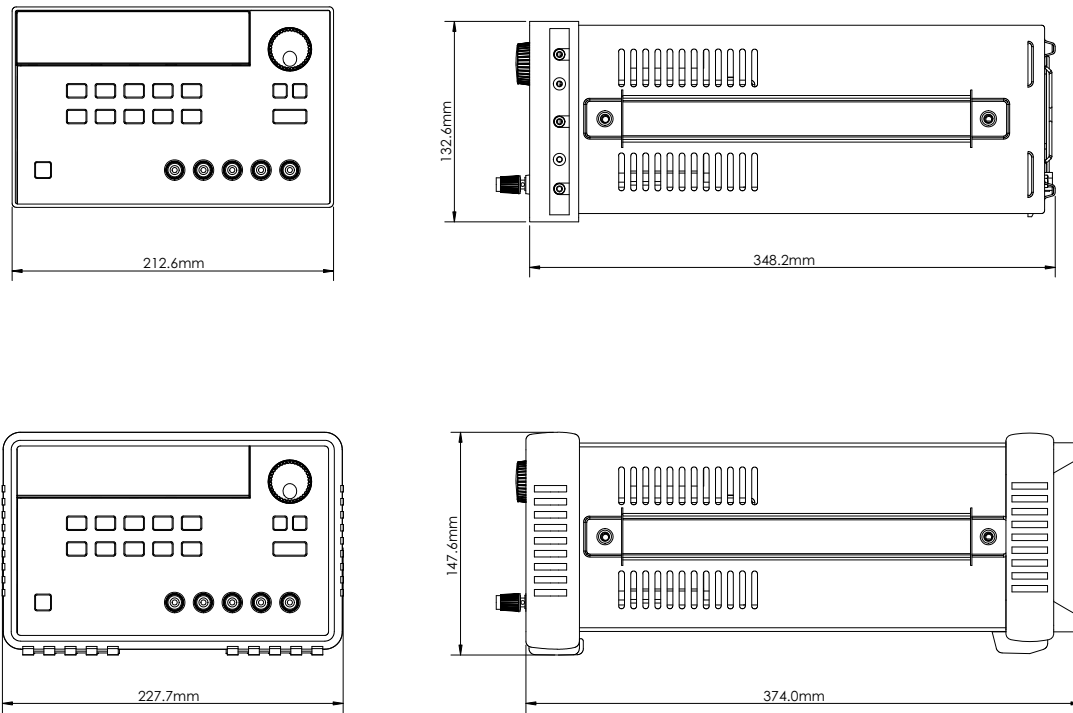


Figure 1-1. Dimensions of Keysight E3631A Power Supply

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Quick Start

Quick Start

One of the first things you will want to do with your power supply is to become acquainted with its front panel. Written procedures in this chapter prepare the power supply for use and familiarize you with most front-panel operations.

- The power supply is shipped from the factory configured in the *front-panel* operation mode. At power-on, the power supply is automatically set to operate in the front-panel operation mode. When in this mode, the front-panel keys can be used. When the power supply is in *remote* operation mode, you can return to front-panel operation mode at any time by pressing the `[Local]` key if you did not previously send the front-panel lockout command. A change between front-panel and remote operation modes will *not* result in a change in the output parameters.
- When you press the `[Display Limit]` key (the **Lmt** annunciator blinks), the display of the power supply goes to the *limit* mode and the present limit values of the selected supply will be displayed. In this mode, you can also observe the change of the limit values when adjusting the knob. If you press the `[Display Limit]` key again or let the display time-out after several seconds, the power supply will return the display to the *meter* mode (the **Lmt** annunciator turns off). In this mode, the actual output voltage and current will be displayed.
- All outputs of the power supply can be enabled or disabled from the front panel using the `[Output On/Off]` key. When the output of the power supply is off, the **OFF** annunciator turns on and the three outputs are disabled.
- The display provides the present operating status of the power supply with annunciators and also informs the user of error codes. For example, the +6V supply is operating in CV mode and controlled from the front panel, then the **CV** and **+6V** annunciators will turn on. If, however, the power supply is remotely controlled, the **Rmt** annunciator will also turn on, and when the power supply is being addressed over GPIB interface, the **Adrs** annunciator will turn on. [see “Display Annunciators”, on page 5](#) for more information.

Throughout this chapter the key to be pressed is shown in the left margin.

To prepare the power supply for use

The following steps help you verify that the power supply is ready for use.

1 Check the list of supplied items.

Verify that you have received the following items with your power supply. If anything is missing, contact your nearest Keysight Technologies Sales Office.

- One appropriate power cord for your location.
- One *User's Guide*.
- This *Service Guide*.
- Certificate of Calibration.

2 Verify that the correct power-line voltage setting is selected and that the correct power-line fuse is installed.

The line voltage is set to 100, 115 or 230 Vac from the factory according to the input power option selected when you ordered the power supply. Change the voltage setting if it is not correct for your location (see the next page for detailed information). For 100 or 115 Vac operation, the correct fuse is 2.5 AT (Keysight part number 2110-0913) and for 230 Vac operation, the correct fuse is 2 AT (Keysight part number 2110-0587).

Power

3 Connect the power cord and turn on the power supply.

A *power-on self-test* occurs automatically when you turn on the power supply. The front-panel display will light up while the power supply performs its power-on self-test. After performing the self-test, the power supply will go into the *power-on / reset* state; all outputs are disabled (the **OFF** annunciator turns on); the display is selected for the +6V supply (the +6V annunciator turns on); the knob is selected for *voltage* control.

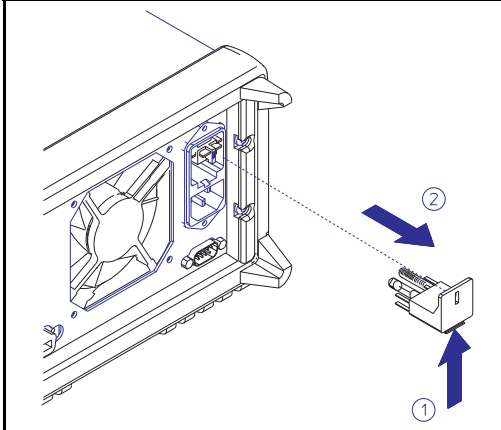
Output On/Off

4 Enable the outputs

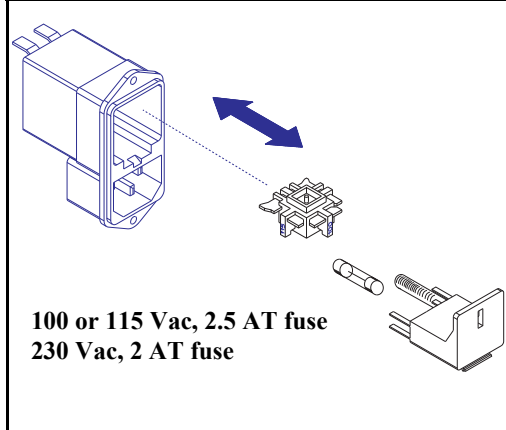
Press the `Output On/Off` key to enable the outputs. The **OFF** annunciator turns off and the +6V and CV annunciators are lit. The *blinking* digit can be adjusted by turning the knob. Notice that the display is in the meter mode. "Meter mode" means that the display shows the actual output voltage and current.

Chapter 2 Quick Start
To prepare the power supply for use

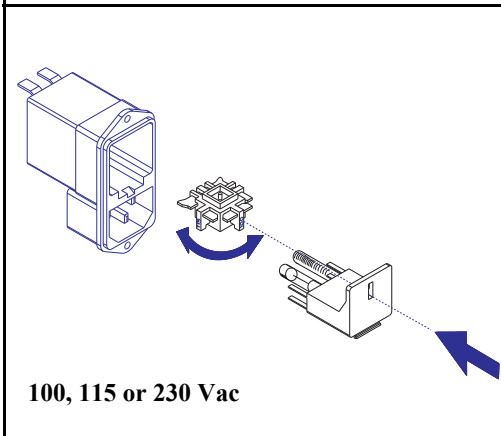
1 Remove the power cord. Remove the fuse-holder assembly with a flat-blade screwdriver from the rear panel.



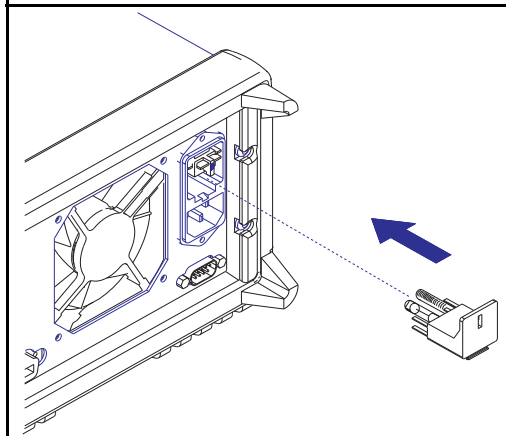
2 Install the correct line fuse. Remove the power-line voltage selector from the power-line module.



3 Rotate the power-line voltage selector until the correct voltage appears.



4 Replace the power-line voltage selector and the fuse-holder assembly in the rear panel.



Install the correct fuse and verify that the correct line voltage appears in the window.

To check the rated voltages of the power supply

The following procedures check to ensure that the power supply develops its rated voltage outputs with no load and properly responds to operation from the front panel. *For each step, use the keys shown on the left margins.*

Power

1 Turn on the power supply.

The power supply will go into the *power-on / reset* state; all outputs are disabled (the **OFF** annunciator turns on); the display is selected for the **+6V** supply (the **+6V** annunciator turns on); and the knob is selected for *voltage* control.

Output On/Off

2 Enable the outputs.

The **OFF** annunciator turns off and the **+6V** and **CV** annunciators are lit. The *blinking* digit can be adjusted by turning the knob. Notice that the display is in the meter mode. "Meter mode" means that the display shows the actual output voltage and current.

3 Check that the front-panel voltmeter properly responds to knob control for +6V supply.

Turn the knob clockwise or counter clockwise to check that the voltmeter responds to knob control and the ammeter indicates nearly zero.

4 Ensure that the voltage can be adjusted from zero to the maximum rated value.

 ¹

Adjust the knob until the voltmeter indicates 0 volts and then adjust the knob until the voltmeter indicates 6.0 volts.

¹You can use the resolution selection keys to move the blinking digit to the right or left when setting the voltage.

+25V

5 Check the voltage function for the +25V supply.

Select the meter and adjust selection key for the +25V supply. The CV annunciator is still lit and the +25V annunciator will turn on. Repeat steps (3) and (4) to check the voltage function for the +25V supply.

-25V

6 Check the voltage function for the -25V supply.

Select the meter and adjust selection key for the -25V supply. The CV annunciator is still lit and the -25V annunciator will turn on. Repeat steps (3) and (4) to check the voltage function for the -25V supply.

To check the rated currents of the power supply

The following procedures check to ensure that the power supply develops its rated current outputs with a short and properly responds to operation from the front panel. *For each step, use the keys shown on the left margin.*

Power

1 Turn on the power supply.

The power supply will go into the *power-on / reset* state; all outputs are disabled (the **OFF** annunciator turns on); the display is selected for the *+6V* supply (the **+6V** annunciator turns on); and the knob is selected for *voltage* control.

2 Connect a short across (+) and (-) output terminals of +6V supply with an insulated test lead.

Output On/Off

3 Enable the outputs.

The **OFF** annunciator turns off and the **+6V** annunciator turns on. The **CV** or **CC** annunciator is lit depending on the resistance of the test lead. The *blinking* digit can be adjusted by turning the knob. Notice that the display is in the meter mode. "Meter mode" means that the display shows the actual output voltage and current.

Display Limit

4 Adjust the voltage limit value to 1.0 volt.

Set the display to the *limit* mode (the **Lmt** annunciator will be *blinking*). Adjust the voltage limit to 1.0 volt to assure **CC** operation. The **CC** annunciator will light.

Vol/Cur

5 Check that the front-panel ammeter properly responds to knob control for the +6V supply.

Set the knob to the *current* control, and turn the knob clockwise or counter clockwise when the display is in the meter mode (the **Lmt** annunciator is off). Check that the ammeter responds to knob control and the voltmeter indicates nearly zero (actually, the voltmeter will show the voltage drop caused by the test lead).

6 Ensure that the current can be adjusted from zero to the maximum rated value.



Adjust the knob until the ammeter indicates 0 amps and then until the ammeter indicates 5.0 amps.

+25V

7 Check the current function for the +25V supply.

Disable the outputs by pressing the `Output On/Off` key and connect a short across (+) and (COM) output terminals of the $\pm 25\text{V}$ supply with an insulated test lead. Repeat steps (3) through (6) after selecting the meter and adjust selection key for the +25V supply.

-25V

8 Check the current function for the -25V supply.

Disable the outputs by pressing the `Output On/Off` key and connect a short across (-) and (COM) output terminals of the $\pm 25\text{V}$ supply with an insulated test lead. Repeat steps (3) through (6) after selecting the meter and adjust selection key for the -25V supply.

Note

If an error has been detected during the output checkout procedures, the ERROR annunciator will turn on. See "Error Messages" for more information, starting on page 113 in chapter 5 of the User's Guide.

¹You can use the resolution selection keys to move the blinking digit to the right or left when setting the current.

To use the power supply in constant voltage mode

To set up the power supply for constant voltage (CV) operation, proceed as follows.
For each step, use the keys shown on the left margin.

1 Connect a load to the desired output terminals.

With power-off, connect a load to the desired output terminals.

Power

2 Turn on the power supply.

The power supply will go into the *power-on / reset* state; all outputs are disabled (the **OFF** annunciator turns on); the display is selected for the **+6V** supply (the **+6V** annunciator turns on); and the knob is selected for *voltage* control.

Output On/Off

3 Enable the outputs.

The **OFF** annunciator turns off and the **+6V** and **CV** annunciators are lit. The *blinking* digit can be adjusted by turning the knob. Notice that the display is in the meter mode. "Meter mode" means that the display shows the actual output voltage and current.

To set up the power supply for +25V supply or -25V supply operation, you should press the **+25V** or **-25V** key to select the display and adjust for +25V supply or -25V supply before proceeding to the next step.


Display Limit

4 Set the display for the limit mode.

Notice that the **Lmt** annunciator blinks, indicating that the display is in the limit mode. When the display is in the *limit* mode, you can see the voltage and current limit values of the selected supply.


In constant voltage mode, the voltage values between meter mode and limit mode are the same, but the current values are not. Further if the display is in the meter mode, you cannot see the change of current limit value when adjusting the knob. We recommend that you should set the display to "limit" mode to see the change of current limit value in constant voltage mode whenever adjusting the knob.

Vol/Cur

5 Adjust the knob for the desired current limit.  ¹

Check that the **Lmt** annunciator still blinks. Set the knob for *current* control. The second digit of ammeter will be *blinking*. Adjust the knob to the desired current limit.

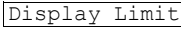
Vol/Cur

6 Adjust the knob for the desired output voltage.  ¹

Set the knob for *voltage* control. The second digit of the voltmeter will be *blinking*. Adjust the knob to the desired output voltage.

Display Limit

7 Return to the meter mode.

 key or let the display time-out after several seconds to return to the meter mode. Notice that the **Lmt** annunciator turns off and the display returns to the meter mode. In the *meter* mode, the display shows the actual output voltage and current of the selected supply.

8 Verify that the power supply is in the constant voltage mode.

If you operate the +6V supply in the constant voltage (CV) mode, verify that **CV** and **+6V** annunciators are lit. If you operate the power supply for +25V supply or -25V supply, the **+25V** or **-25V** annunciator will turn on. If the **CC** annunciator is lit, choose a *higher* current limit.

Note

During actual CV operation, if a load change causes the current limit to be exceeded, the power supply will automatically crossover to constant current mode at the preset current limit and the output voltage will drop proportionately.

¹You can use the resolution selection keys to move the blinking digit to the right or left when setting the voltage and current.

To use the power supply in constant current mode

To set up the power supply for constant current (CC) operation, proceed as follows.
For each step, use the keys shown on the left margin.

1 Connect a load to the output terminals of the desired supply.

With power-off, connect a load to the desired output terminals.

Power

2 Turn on the power supply.

The power supply will go into the *power-on / reset* state; all outputs are disabled (the **OFF** annunciator turns on); the display is selected for the **+6V** supply (the **+6V** annunciator turns on); and the knob is selected for *voltage* control.

Output On/Off

3 Enable the outputs

The **OFF** annunciator turns off and the **+6V** and **CV** annunciators are lit. The *blinking* digit can be adjusted by turning the knob. Notice that the display is in the meter mode. "Meter mode" means that the display shows the actual output voltage and current.


To set up the power supply for +25V supply or -25V supply operation, you should press the **+25V** or **-25V** key to select the display and adjust for +25V supply or -25V supply before proceeding to the next step.

Display Limit

4 Set the display for the limit mode.


Notice that the **Lmt** annunciator blinks, indicating that the display is in the limit mode. When the display is in the *limit* mode, you can see the voltage and current limit values of the selected supply.

In constant current mode, the current values between meter mode and limit mode are the same, but the voltage values are not. Further if the display is in the meter mode, you cannot see the change of voltage limit value when adjusting the knob. We recommend that you should set the display to "limit" mode to see the change of voltage limit value in constant current mode whenever adjusting the knob.

5 Adjust the knob for the desired voltage limit. ¹

Check that the knob is still selected for voltage control and the **Lmt** annunciator blinks. Adjust the knob for the desired voltage limit.

Vol/Cur

6 Adjust the knob for the desired output current. ¹

Set the knob for *current* control. The second digit of the ammeter will be *blinking*. Adjust the knob to the desired current output.

Display Limit

7 Return to the meter mode.

Press the `Display Limit` key or let the display time-out after several seconds to return the meter mode. Notice that the **Lmt** annunciator turns off and the display returns to the meter mode. In the *meter* mode, the display shows the actual output voltage and current of the selected supply.

8 Verify that the power supply is in the constant current mode.

If you operate the +6V supply in the constant current (CC) mode, verify that **CC** and **+6V** annunciators are lit. If you operate the power supply for +25V supply or -25V supply, the **+25V** or **-25V** annunciator will turn on. If the **CV** annunciator is lit, choose a *higher* voltage limit.

Note

During actual CC operation, if a load change causes the voltage limit to be exceeded, the power supply will automatically crossover to constant voltage mode at the preset voltage limit and the output current will drop proportionately.

¹You can use the resolution selection keys to move the blinking digit to the right or left when setting the voltage and current.

To use the power supply in track mode

The $\pm 25\text{V}$ supplies provide 0 to $\pm 25\text{ V}$ tracking outputs. In the track mode, two voltages of the $\pm 25\text{V}$ supplies track each other to within $\pm(0.2\%$ of output + 20 mV) for convenience in varying the symmetrical voltages needed by operational amplifiers and other circuits using balanced positive and negative inputs.

To operate the power supply in the track mode, proceed as follows:

- 1 Set the +25V supply to the desired voltage as described in previous section "To use the power supply in constant voltage mode" (see page 30 for detailed information).**

Track

- 2 Enable the track mode.**

The **Track** key must be depressed for *at least 1 second* to enable the track mode. When the track mode is first enabled, the -25V supply will be set to the same voltage level as the +25V supply. Once enabled, any change of the voltage level in either the +25V supply or the -25V supply will be reflected in other supply. The current limit is independently set for each of the +25V or the -25V supply and is not affected by the track mode.

- 3 Verify that $\pm 25\text{V}$ supplies track each other properly.**

You can verify that the voltage of the -25V supply tracks that of the +25V supply within $\pm(0.2\%$ of output + 20 mV) from the front-panel display by comparing the voltage values of the +25V supply and the -25V supply.

In the track mode, if the CC annunciator is lit when the display is selected for the +25V supply, choose a higher current limit for the +25V supply. If the CC annunciator is lit when the display is selected for the -25V supply, choose a higher current limit for the -25V supply.

To store and recall the instrument state

You can store up to three different operating states in *non-volatile* memory. This also enables you to recall the entire instrument state with just a few key presses from the front panel.

The memory locations are supplied from the factory for front panel operation with the following states: *display and knob selection for +6V output; *RST values of voltage and current limits for three outputs; output disabled; and track off state. *RST values for +6V supply are 0 V and 5 A and 0 V and 1 A for the ±25V supplies.*

The following steps show you how to store and recall an operating state.

1 Set up the power supply for the desired operating state.

The storage feature "remembers" the display and knob selection state, the limit values of voltage and current for three outputs, output on/off state, and track mode state.

Store

2 Turn on the storage mode.

Three memory locations (numbered 1, 2, and 3) are available to store the operating states. The operating states are stored in *non-volatile* memory and are remembered when being recalled.

STORE 1

This message appears on the display for approximately 3 seconds.

3 Store the operating state in memory location "3".

Turn the knob to the right to specify the memory location 3.

STORE 3

To cancel the store operation, let the display time-out after 3 seconds or press any other function key except the Store key. The power supply returns to the normal operating mode and to the function pressed.

Store

4 Save the operating state.

The operating state is now stored. To recall the stored state, go to the following steps.

DONE

This message appears on the display for approximately 1 second.


Recall

5 Turn on the recall mode.

Memory location "1" will be displayed in the recall mode.

RECALL 1

This message appears on the display for approximately 3 seconds.

6 Recall the stored operating state. 

Turn the knob to the right to change the displayed storage location to "3".

RECALL 3

If this setting is not followed within 3 seconds with a **Recall** key stroke, the power supply returns to normal operating mode and will not recall the instrument state 3 from memory.

Recall

7 Restore the operating state.

The power supply should now be configured in the same state as when you stored the state on the previous steps.

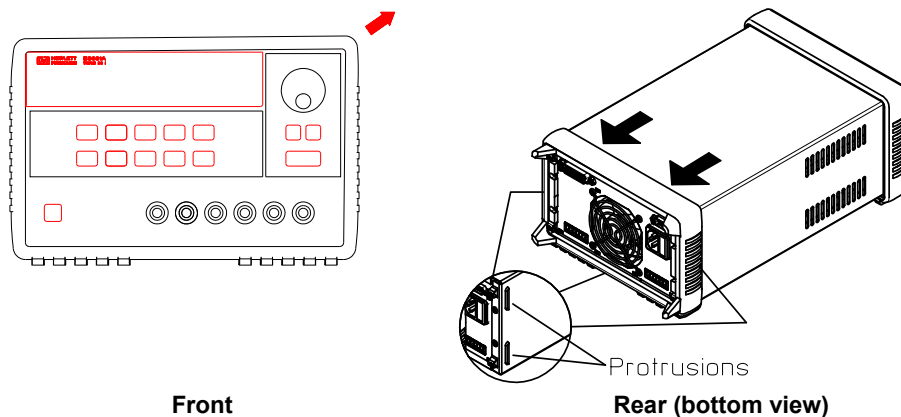
DONE

This message appears on the display for approximately 1 second.

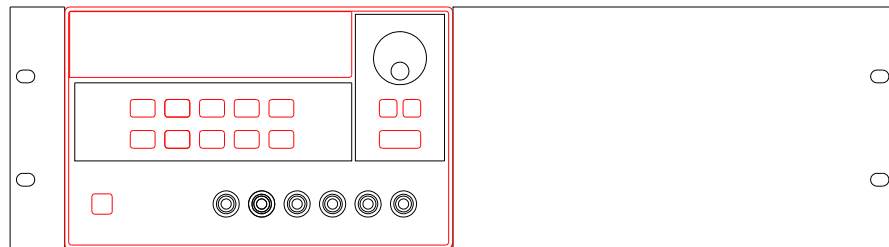
To rack mount the power supply

The power supply can be mounted in a standard 19-inch rack cabinet using one of three optional kits available. A rack-mounting kit for a single instrument is available as Option 1CM (P/N 5062-3957). Installation instructions and hardware are included with each rack-mounting kit. Any Keysight Technologies System II instrument of the same size can be rack-mounted beside the Keysight E3631A power supply. To rack mount the power supply, follow these procedures.

Remove the front and rear bumpers before rack-mounting the power supply.



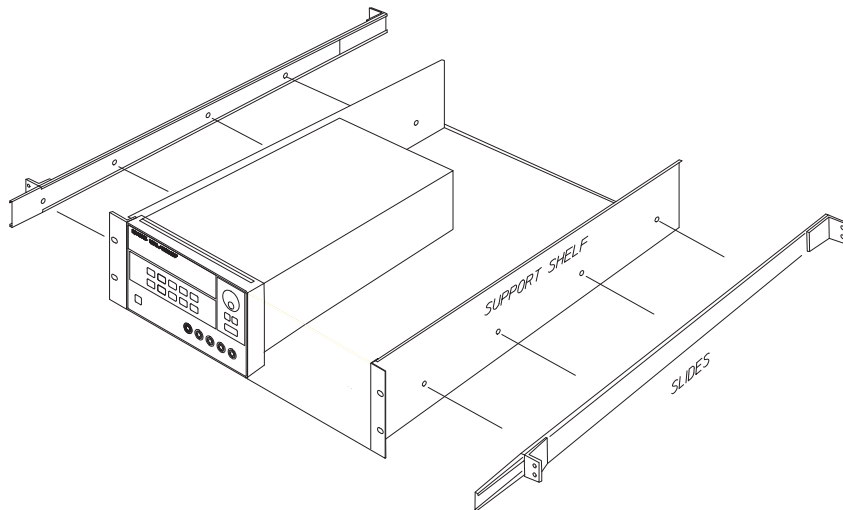
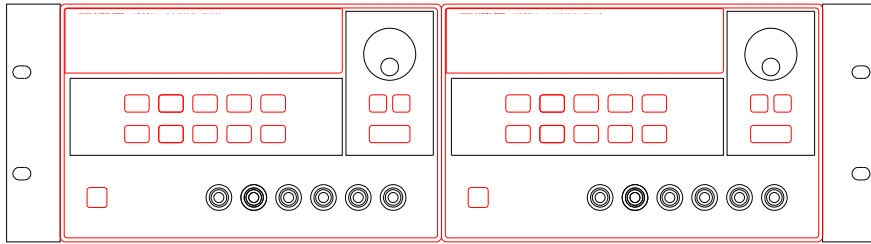
To remove the rear bumper, pull the bumper off from the top as there are protrusions on the sides and bottom of the cover."



To rack mount a single instrument, order adapter kit 5063-9243.

Chapter 2 Quick Start
To rack mount the power supply

2



To rack mount two instruments of the same depth side-by-side, order lock-link kit 5061-9694 and flange kit 5063-9214.

To install two instruments in a sliding support shelf, order support shelf 5063-9256, and slide kit 1494-0015.

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Calibration Procedures

Calibration Procedures

This chapter contains procedures for verification of the power supply's performance and calibration (adjustment). The chapter is divided into the following sections:

- [Keysight Technologies Calibration Services, page 42](#)
- [Calibration Interval, page 42](#)
- [Automating Calibration Procedures, page 43](#)
- [Recommended Test Equipment, page 43](#)
- [Test Considerations, page 44](#)
- [Performance Verification Tests, page 45](#)
- [Measurement Techniques, page 46](#)
- [Constant Voltage \(CV\) Verifications, page 49](#)
- [Constant Current \(CC\) Verifications, page 57](#)
- [Performance Test Record for Keysight E3631A, page 62](#)
- [Calibration Security Code, page 64](#)
- [Calibration Count, page 68](#)
- [Calibration Message, page 68](#)
- [General Calibration/Adjustment Procedure, page 69](#)
- [Aborting a Calibration in Progress, page 74](#)
- [Calibration Record for Keysight E3631A, page 75](#)
- [Error Messages, page 76](#)
- [Calibration Program, page 78](#)

The performance verification tests for constant voltage (CV) and constant current (CC) operations use the power supply's specifications listed in chapter 1, [Specifications, starting on page 14](#).

Closed-Case Electronic Calibration The power supply features closed-case electronic calibration since no internal mechanical adjustments are required for normal calibration. The power supply calculates correction factors based upon the input reference value you enter. The new correction factors are stored in non-volatile memory until the next calibration adjustment is performed. (Non-volatile memory does not change when power has been off or after a remote interface reset.)

Keysight Technologies Calibration Services

When your power supply is due for calibration, contact your local Keysight Technologies Service Center for a low-cost calibration. The Keysight E3631A power supply is supported on calibration processes which allow Keysight Technologies to provide this service at competitive prices.

3

Calibration Interval

The power supply should be calibrated on a regular interval determined by the accuracy requirements of your application. A 1-year interval is adequate for most applications. Keysight Technologies does not recommend extending calibration intervals beyond 1 year for any application. Keysight Technologies recommends that complete re-adjustment should always be performed at the calibration interval. This will increase your confidence that the Keysight E3631A will remain within specification for the next calibration interval. This criteria for re-adjustment provides the best long-term stability.

Automating Calibration Procedures

You can automate the complete verification procedures outlined in this chapter if you have access to programmable test equipment. You can program the instrument configurations specified for each test over the remote interface. You can then enter readback verification data into a test program and compare the results to the appropriate test limit values.

You can also enter calibration constants from the remote interface. Remote operation is similar to the local front-panel procedure. You can use a computer to perform the adjustment by first selecting the required setup. The calibration value is sent to the power supply and then the calibration is initiated over the remote interface. The power supply must be unsecured prior to initiating the calibration procedure. A Keysight BASIC program for calibration over the GPIB interface is listed at the end of this chapter.

For further details on programming the power supply, see chapters 3 and 4 in the *Keysight E3631A User's Guide*.

Recommended Test Equipment

The test equipment recommended for the performance verification and adjustment procedures is listed below. If the exact instrument is not available, use the accuracy requirements shown to select substitute calibration standards.

Table 3-1. Recommended Test Equipment

| Instrument | Requirements | Recommended Model | Use |
|-------------------------------------|--|--------------------------------|--|
| GPIB Controller | Full GPIB capabilities | Keysight 82341C interface card | Programming and readback accuracy |
| Oscilloscope | 100 MHz real time digitizing scope with a 400 MSa/s minimum sampling rate Probe: single-ended | Keysight 54602A | Display transient response and ripple & noise waveform |
| RMS Voltmeter | 20 MHz | | Measure rms ripple & noise |
| Digital Voltmeter | Resolution: 0.1 mV Accuracy: 0.01% | Keysight 34401A | Measure dc voltages |
| Electronic Load | Voltage Range: 50 Vdc Current Range: 10 Adc Open and Short Switches Transient On/Off | Keysight 6063A | Measure load and line regulations and transient response time. |
| Resistive Loads (R_L) | 1.2 Ω , 100 W 25 Ω , 100 W | | Measure ripple and noise |
| Current monitoring Resistor (Shunt) | 0.1 Ω , 0.01% | | Constant current test setup |

Test Considerations

To ensure proper instrument operation, verify that you have selected the correct power-line voltage prior to attempting any test procedure in this chapter. See [page 25](#) in chapter 2 for more information.

- Ensure the calibration ambient temperature is stable and between 20°C and 30°C.
- Ensure ambient relative humidity is less than 80%.
- Allow a 1-hour warm-up period before verification or calibration.
- Keep cables and test leads as short as possible, consistent with the impedance requirements.
- Use shielded cables to connect the monitoring device such as oscilloscope or RMS voltmeter to the power supply.
- Ensure all the devices are firmly connected. The alligator or crocodile clip is not recommended for use in device connection.

3

Caution

The tests should be performed by qualified personnel. During performance verification tests, hazardous voltages may be present at the outputs of the power supply.

Performance Verification Tests

The performance verification tests use the power supply's specifications listed in [chapter 1, "Specifications", starting on page 14](#).

You can perform two different levels of performance verification tests:

- **Self-Test** A series of internal verification tests that provide high confidence that the power supply is operational.
- **Performance Verification Tests** These tests can be used to verify the power supply's specifications following repairs to specific circuits. The performance test procedures must be performed on each output.

Self-Test

A *power-on* self-test occurs automatically when you turn on the power supply. This limited test assures you that the power supply is operational.

The *complete* self-test is enabled by pressing the `[Recall]` key (actually any front panel keys except the `[Error]` key) and the power-line switch simultaneously and then continuing to press the `[Recall]` key for 5 seconds. The complete self-test will be finished in 2 more seconds.

You can also perform a self-test from the remote interface (*see chapter 3 in the Keysight E3631A User's Guide*).

- If the self-test is successful, "PASS" is displayed on the front panel.
- If the self-test fails, "FAIL" is displayed and the **ERROR** annunciator turns on. If repair is required, see [chapter 5, "Service", starting on page 94](#), for further details.
- If self-test passes, you have a high confidence that the power supply is operational.

Performance Verification Tests

These tests can be used to verify the power supply's specifications following repairs to specific circuits. The following sections explain all verification procedures in detail. All of the performance test specifications are shown in each test.

Measurement Techniques

Setup for Most Tests

Most tests are performed at the front terminals as shown in the following figure. Measure the dc voltage directly at the (+) and (-) terminals on the front panel.

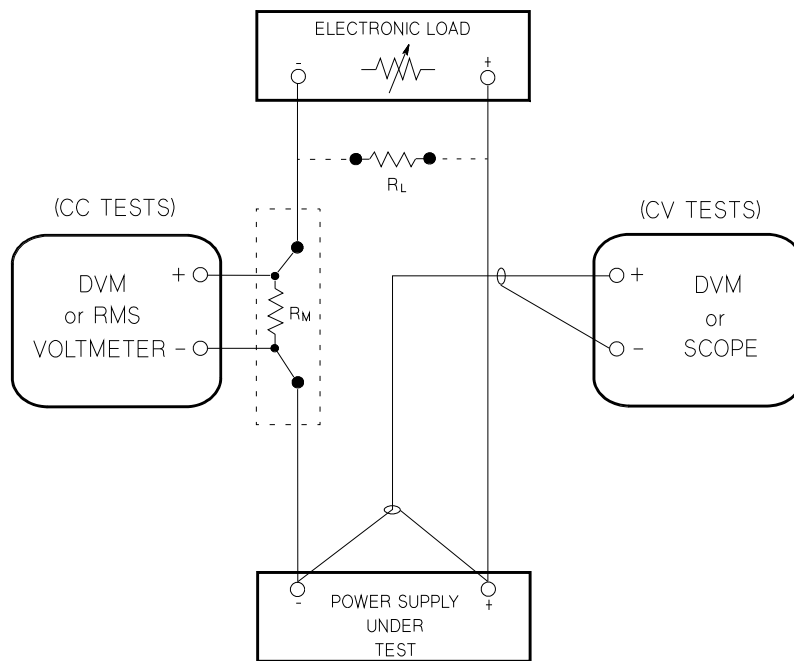


Figure 3-1. Performance Verification Test Setup

General Measurement Techniques

To achieve best results when measuring load regulation, peak-to-peak voltage, and transient response time of the power supply, measuring devices must be connected through the hole in the neck of the binding post at (A) while the load resistor is plugged into the front of the output terminals at (B). A measurement made across the load includes the impedance of the leads to the load. The impedance of the load leads can easily be several orders of the magnitude greater than the power supply impedance and thus invalidate the measurement. To avoid mutual coupling effects, each measuring device must be connected directly to the output terminals by separate pairs of leads.

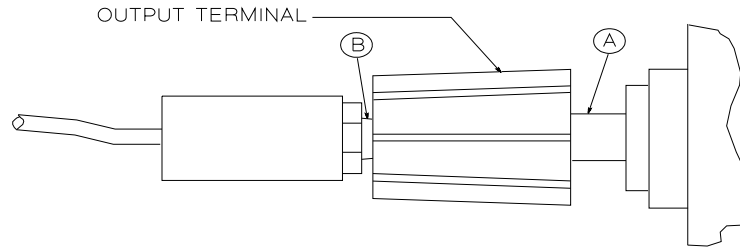


Figure 3-2. Front Panel Terminal Connection

Electronic Load

Many of the test procedures require the use of a variable load resistor capable of dissipating the required power. Using a variable load resistor requires that switches be used to connect, disconnect, and short the load resistor. An electronic load, if available, can be used in place of a variable load resistor and switches. The electronic load is considerably easier to use than load resistors. It eliminates the need for connecting resistors or rheostats in parallel to handle power, it is much more stable than carbon-pile load, and it makes easy work of switching between load conditions as is required for the load regulation and load transient response tests. Substitution of the electronic load requires minor changes to the test procedures in this chapter.

Current-Monitoring Resistor

To eliminate output current measurement error caused by the voltage drops in the leads and connections, connect the current monitoring resistor between the (-) output terminal and the load as a four-terminal device. Connect the current-monitoring leads inside the load-lead connections directly at the monitoring points on the resistor element (see R_M in [Figure 3-1](#)).

Programming

Most performance tests can be performed only from the front panel. However, a GPIB or RS-232 controller is required to perform the voltage and current programming accuracy and readback accuracy tests.

The test procedures are written assuming that you know how to program the power supply either from the front panel or from an GPIB or RS-232 controller. Complete instructions on front panel and remote programming are given in the *Keysight E3631A User's Guide*.

Voltage and Current Values

The full-scale and maximum values of each supply are listed below. You can use this table when you test CV and CC performance verification tests.

Table 3-2. Power Supply Voltage and Current Values

| Output | Full-Scale Voltage | Max. Prog. Voltage | Full-Scale Current | Max. Prog. Current |
|-------------|--------------------|--------------------|--------------------|--------------------|
| +6V Output | +6 V | +6.18 V | 5 A | 5.15 A |
| +25V Output | +25 V | +25.75 | 1 A | 1.03 A |
| -25V Output | -25 V | -25.75 | 1 A | 1.03 A |



Constant Voltage (CV) Verifications

Constant Voltage Test Setup

If more than one meter or a meter and an oscilloscope are used, connect each to the (+) and (-) terminals by a separate pair of leads to avoid mutual coupling effects. Use coaxial cable or shielded 2-wire cable to avoid noise pick-up on the test leads.

Voltage Programming and Readback Accuracy

This test verifies that the voltage programming and GPIB or RS-232 readback functions are within specifications. Note that the readback values over the remote interface should be identical to those displayed on the front panel.

You should program the power supply over the remote interface for this test to avoid round off errors.

- 1 Turn off the power supply and connect a digital voltmeter between the (+) and (-) terminals of the output to be tested as shown in [Figure 3-1](#).
- 2 Turn on the power supply. Enable the outputs and select the desired output to be tested by sending the commands:

```
OUTP ON  
INST {P6V|P25V|N25V}
```

- 3 Program the selected output to zero volts and maximum programmable current (see [Table 3-2](#)) by sending the commands:

```
VOLT 0  
CURR 5.15           for the +6V supply or  
CURR 1.03           for the ±25V supply
```

- 4 Record the output voltage reading on the digital voltmeter (DVM). The readings should be within the limits specified below for each output tested. Also, note that the CV, Adrs, Lmt, and Rmt annunciators are on.

| Output | Programming Accuracy |
|--------|----------------------|
| +6V | 0 ± 5 mV |
| +25V | 0 ± 20 mV |
| -25V | 0 ± 20 mV |

Chapter 3 Calibration Procedures Constant Voltage (CV) Verifications

- 5 Readback the output voltage of the selected output over the remote interface by sending the command:

```
MEAS:VOLT? {P6V|P25V|N25V}
```

- 6 Record the value displayed on the controller. This value should be within the limits specified below for each output tested.

| Output | Readback Accuracy |
|--------|--------------------|
| +6V | DVM \pm 5 mV |
| +25V | DVM \pm 10 mV |
| -25V | -(DVM \pm 10 mV) |

- 7 Program the selected output's voltage to full scale value by sending the commands.

```
VOLT 6.0 for the +6V supply or  
VOLT 25.0 for the  $\pm$  25V supply
```

- 8 Record the output voltage reading on the digital voltmeter (DVM). The readings should be within the limits specified below for each output tested.

| Output | Programming Accuracy |
|--------|-----------------------|
| +6V | 6 V \pm 11 mV |
| +25V | 25 V \pm 32.5 mV |
| -25V | -(25 V \pm 32.5 mV) |

- 9 Readback the output voltage of the selected output over the remote interface by sending the command:

```
MEAS:VOLT? {P6V|P25V|N25V}
```

- 10 Record the value displayed on the controller. This value should be within the limits specified below for the output to be tested.

| Output | Readback Accuracy |
|--------|----------------------|
| +6V | DVM \pm 11 mV |
| +25V | DVM \pm 22.5 mV |
| -25V | -(DVM \pm 22.5 mV) |

- 11 Repeat steps (1) through (10) for the remaining outputs.

CV Load Regulation

This test measures the immediate change in the output voltage resulting from a change in the output current from full to no load.

- 1 Turn off the power supply and connect a digital voltmeter between the (+) and (-) terminals of the output to be tested as shown in [Figure 3-1](#).
- 2 Turn on the power supply and select the desired output to be tested using the meter and adjust selection key on the front panel. Enable the outputs and set the display to the limit mode. When the display is in the limit mode, program the current of the selected output to the maximum programmable value and the voltage to the full rated value (see [Table 3-2](#)).
- 3 Operate the electronic load in constant current mode and set its current to the full rated value of the output to be tested (see [Table 3-2](#)). Check that the front panel CV annunciator remains lit. If not lit, adjust the load so that the output current drops slightly until the CV annunciator lights. Record the output voltage reading on the digital voltmeter.
- 4 Operate the electronic load in open mode (input off). Record the output voltage reading on the digital voltmeter immediately. The difference between the digital voltmeter readings in steps (3) and (4) is the CV load regulation. The difference of the readings during the immediate change should be within the limit specified below for each output tested.

| Output | Difference |
|---------------|-------------------|
| +6V | 2.6 mV |
| +25V | 4.5 mV |
| -25V | 4.5 mV |

- 5 Repeat steps (1) through (4) for the remaining outputs.

CV Line Regulation

This test measures the immediate change in output voltage that results from a change in ac line voltage from the minimum value (10% below the nominal input voltage) to maximum value (10% above the nominal input voltage).

- 1 Turn off the power supply and connect a digital voltmeter between the (+) and (-) terminals of the output to be tested as shown in [Figure 3-1](#).
- 2 Connect the ac power line through a variable voltage transformer.
- 3 Turn on the power supply and select the desired output to be tested using the meter and adjust selection key on the front panel. Enable the outputs and set the display to the limit mode. When the display is in the limit mode, program the current of the selected output to the maximum programmable value and the voltage to full rated value (see [Table 3-2](#)).
- 4 Operate the electronic load in constant current mode and set its current to the full rated value (see [Table 3-2](#)) of the output to be tested. Check that the front panel CV annunciator remains lit. If not lit, adjust the load so that the output current drops slightly until the CV annunciator lights.
- 5 Adjust the transformer to low line voltage limit (104 Vac for nominal 115 Vac, 90 Vac for nominal 100 Vac, or 207 Vac for nominal 230 Vac). Record the output reading on the digital voltmeter.
- 6 Adjust the autotransformer to high line voltage (127 Vac for nominal 115 Vac, 110 Vac for nominal 100 Vac, or 253 Vac for nominal 230 Vac). Record the voltage reading on the digital voltmeter immediately. The difference between the digital voltmeter readings in steps (5) and (6) is the CV line regulation. The difference of the readings during the immediate change should be within the limit specified below for each output tested.

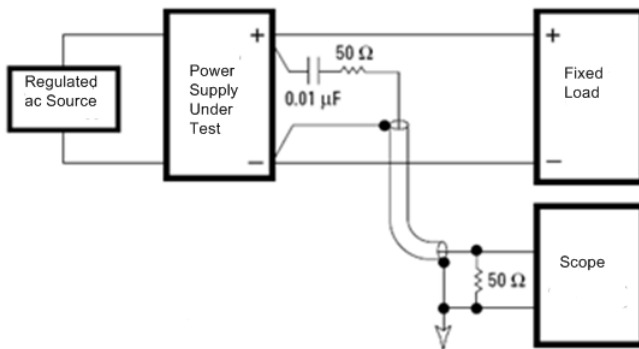
| Output | Difference |
|--------|------------|
| +6V | 2.6 mV |
| +25V | 4.5 mV |
| -25V | 4.5 mV |

- 7 Repeat steps (1) through (6) for the remaining outputs.

Normal Mode Voltage Noise (CV Ripple and Noise)

The normal mode voltage noise is in the form of ripple related to the line frequency plus some random noise. The normal mode voltage noise is specified as the RMS or peak-to-peak output voltage in a frequency range from 20 Hz to 20 MHz.

- 1** Turn off the power supply and connect the output to be tested as shown in [Figure 3-3](#) to an oscilloscope (ac coupled) between (+) and (-) terminals.
- 2** Turn on the oscilloscope. Configure the oscilloscope as shown below:
 - Set the oscilloscope to AC mode and bandwidth limit to 20 MHz.
 - Set the vertical sensitivity to 3 mV/div.
 - Set the horizontal sweep speed to 10 ms/div.
 - Enable auto/continuous triggering.
 - Enable V_{pp} measurement function.
- 3** Connect a resistive load (1.2 Ω for +6 V supply and 25 Ω for ±25 V supplies) as shown in [Figure 3-3](#) (see [Table 3-2](#)).
- 4** Turn on the power supply and select the output to be tested using the meter and adjust selection key on the front panel. Enable the outputs and set the display to the limit mode. When the display is in the limit mode, program the current of the selected output to the maximum programmable value and the voltage to the full-scale value (see [Table 3-2](#)).
- 5** Check that the front panel CV annunciator remains lit. If not lit, adjust the load down slightly.
- 6** Note that the waveform on the oscilloscope does not exceed the peak-to-peak limit of 2 mV for each of the three outputs.
- 7** Disconnect the oscilloscope and connect a RMS voltmeter in its place as shown in [Figure 3-4](#). The RMS voltage reading does not exceed the RMS limit of 0.35 mV for each of the three outputs.
- 8** Repeat steps (1) through (7) for the remaining outputs.



3

Figure 3-3. Peak-to-Peak Ripple/Noise Measurement Setup

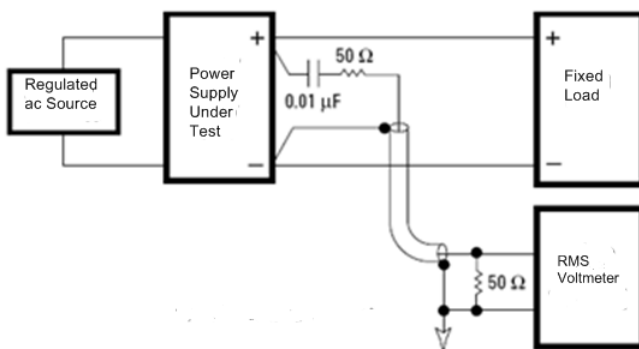


Figure 3-4. RMS Ripple/Noise Measurement Setup

Common Mode Current Noise

The common mode current is that ac current component which exists between any or all outputs or output lines and chassis ground. Common mode noise can be a problem for very sensitive circuitry that is referenced to earth ground. When a circuit is referenced to earth ground, a low level line-related ac current will flow from the output terminals to earth ground. Any impedance to earth ground will create a voltage drop equal to the output current flow multiplied by the impedance.

- 1** Turn off the power supply and connect a 100 k Ω resistor (R_S) and a 2200 pF capacitor in parallel between the (-) terminal and chassis ground for +6V output or between the (COM) terminal and chassis ground for ± 25 V outputs.
- 2** Connect a digital voltmeter across R_S .
- 3** Turn on the power supply and select the output to be tested using the meter and adjust selection key on the front panel. Enable the outputs and set the display to the limit mode. When the display is in the limit mode, program the current of the selected output to the maximum programmable value and the voltage to the full-scale value (see [Table 3-2](#)).
- 4** Record the voltage across R_S and convert it to current by dividing by the resistance (DVM reading/100 k Ω). Note that the current is less than 1.5 μ A for each of the three outputs.
- 5** Repeat steps (1) through (4) for the remaining outputs.

Load Transient Response Time

This test measures the time for the output voltage to recover to within 15 mV of nominal output voltage following a load change from full load to half load, or half load to full load.

- 1 Turn off the power supply and connect the output to be tested as shown in [Figure 3-1](#) with an oscilloscope. Operate the electronic load in constant current mode.
- 2 Turn on the power supply and select the output to be tested using the meter and adjust selection key on the front panel. Enable the outputs and set the display to the limit mode. When the display is in the limit mode, program the current to the maximum programmable value and the voltage to the full-scale value (see [Table 3-2](#)).
- 3 Set the electronic load to transient operation mode between one half of the output's full scale value and the output's full scale value at a 1 kHz rate with 50% duty cycle.
- 4 Set the the oscilloscope for ac coupling, internal sync, and lock on either the positive or negative load transient.
- 5 Adjust the the oscilloscope to display transients as shown in [Figure 3-5](#). Note that the pulse width (t_2-t_1) of the transients at 15 mV from the base line is no more than 50 μsec for each of the three outputs.
- 6 Repeat steps (1) through (5) for the remaining outputs.

3

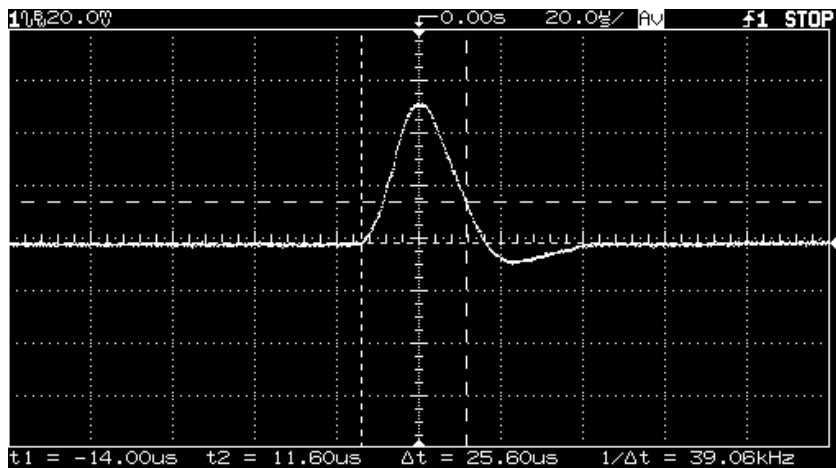


Figure 3-5. Transient Response Time

Constant Current (CC) Verifications

Constant Current Test Setup

Follow the general setup instructions in the "Measurement Techniques" section starting on page 46 and the specific instructions will be given in the following paragraphs.

Current Programming and Readback Accuracy

This test verifies that the current programming and GPIB or RS-232 readback functions are within specifications. Note that the readback values over the remote interface should be identical to those displayed on the front panel. The accuracy of the current monitoring resistor must be 0.1% or better.

You should program the power supply over the remote interface for this test to avoid round off errors.

- 1 Turn off the power supply and connect a 0.1 Ω current monitoring resistor (R_M) across the output to be tested and a digital voltmeter across the current monitoring resistor (R_M).
- 2 Turn on the power supply. Enable the outputs and select the desired output to be tested by sending the commands:

```
OUTP ON  
INST {P6V|P25V|N25V}
```

- 3 Program the selected output voltage to 5.0 volts and the current to 0 amps by sending the commands:

```
VOLT 5  
CURR 0
```

- 4 Divide the voltage drop (DVM reading) across the current monitoring resistor (R_M) by its resistance to convert to amps and record this value (I_O). This value should be within the limits specified below for each output tested. Also, note that the **CC**, **Adrs**, **Lmt**, and **Rmt** annunciators are on.

| Output | Programming Accuracy |
|--------|----------------------|
| +6V | 0 A \pm 10 mA |
| +25V | 0 A \pm 4 mA |
| -25V | 0 A \pm 4 mA |

Chapter 3 Calibration Procedures
Constant Current (CC) Verifications

- 5 Readback the output current from the selected output over the remote interface by sending the command:

```
MEAS:CURR? {P6V|P25V|N25V}
```

- 6 Record the value displayed on the controller. This value should be within the limits specified below for each output tested.

| Output | Readback Accuracy |
|--------|-------------------------|
| +6V | $I_O \pm 10 \text{ mA}$ |
| +25V | $I_O \pm 4 \text{ mA}$ |
| -25V | $I_O \pm 4 \text{ mA}$ |

- 7 Program the selected output current to the full scale value (see [Table 3-2](#)) by sending the commands:

```
CURR 5.0           for the +6V supply or
CURR 1.0           for the ±25V supply
```

- 8 Divide the voltage drop (DVM reading) across the current monitoring resistor (R_M) by its resistance to convert to amps and record this value (I_O). This value should be within the limits specified below for each output tested.

| Output | Programming Accuracy |
|--------|----------------------------------|
| +6V | $5 \text{ A} \pm 20 \text{ mA}$ |
| +25V | $1 \text{ A} \pm 5.5 \text{ mA}$ |
| -25V | $1 \text{ A} \pm 5.5 \text{ mA}$ |

- 9 Readback the output current from the selected output over the remote interface by sending the command:

```
MEAS:CURR? {P6V|P25V|N25V}
```

- 10 Record the value displayed on the controller. This value should be within the limits specified below for each output tested.

| Output | Readback Accuracy |
|--------|--------------------------|
| +6V | $I_O \pm 20 \text{ mA}$ |
| +25V | $I_O \pm 5.5 \text{ mA}$ |
| -25V | $I_O \pm 5.5 \text{ mA}$ |

- 11 Repeat steps (1) through (10) for the remaining outputs.



CC Load Regulation

This test measures the immediate change in output current resulting from a change in the load from full rated output voltage to short circuit.

- 1 Turn off the power supply and connect the output to tested as shown in [Figure 3-1](#) with the digital voltmeter connected across the 0.1Ω current monitoring resistor (R_M).
- 2 Turn on the power supply and select the desired output to be tested using the meter and adjust selection key on the front panel. Enable the outputs and set the display to the limit mode. When the display is in the limit mode, program the voltage to the maximum programmable value and the current to the full rated value (see [Table 3-2](#)).
- 3 Operate the electronic load in constant voltage mode and set its voltage to the full rated value of the output to be tested (see [Table 3-2](#)). Check that the CC annunciator is on. If it is not, adjust the load so that the output voltage drops slightly. Record the current reading by dividing the voltage reading on the digital voltmeter by the resistance of the current monitoring resistor.
- 4 Operate the electronic load in short (input short) mode. Record the current reading within two seconds by dividing the voltage reading on the digital voltmeter by the resistance of the current monitoring resistor. The difference between the current readings in step (3) and (4) is the load regulation current. The difference of the readings during the immediate change should be within the limit specified below for each output tested.

| Output | Difference |
|--------|------------|
| +6V | 0.75 mA |
| +25V | 0.35 mA |
| -25V | 0.35 mA |

- 5 Repeat steps (1) through (4) for the remaining outputs.

CC Line Regulation

This test measures the immediate change in output current that results from a change in ac line voltage from the minimum value (10% below the nominal input voltage) to the maximum value (10% above nominal voltage).

- 1 Turn off the power supply and connect the output to be tested as shown in [Figure 3-1](#) with the digital voltmeter connected across the current monitoring resistor (R_M).
- 2 Connect the ac power line through a variable voltage transformer.
- 3 Turn on the power supply and select the desired output to be tested using the meter and adjust selection key on the front panel. Enable the outputs and set the display to the limit mode. When the display is in the limit mode, program the voltage to the maximum programmable value and the current to the full rated value (see [Table 3-2](#)).
- 4 Operate the electronic load in constant voltage mode and set its voltage to the full rated value of the output to be tested (see [Table 3-2](#)). Check that the CC annunciator remains lit. If not lit, adjust the load so that the output voltage drops slightly until the CC annunciator lights.
- 5 Adjust the transformer to low line voltage limit (104 Vac for nominal 115 Vac, 90 Vac for nominal 100 Vac, or 207 Vac for nominal 230 Vac). Record the output current reading by dividing the voltage reading on the digital voltmeter by the resistance of the current monitoring resistor.
- 6 Adjust the transformer to 10% above the nominal line voltage (110 Vac for a 100 Vac nominal input, 127 Vac for a 115 Vac nominal input or 253 Vac for a 230 Vac nominal input). Record the current reading immediately by dividing the voltage reading on the digital voltmeter by the resistance of the current monitoring resistor. The difference between the current readings in step (5) and (6) is the load regulation current. The difference of the readings during the immediate change should be within the limit specified below for each output tested.

| Output | Difference |
|--------|------------|
| +6V | 0.75 mA |
| +25V | 0.35 mA |
| -25V | 0.35 mA |

- 7 Repeat steps (1) through (6) for the remaining outputs.

Normal Mode Current Noise (CC Ripple and Noise)

The normal mode current noise is specified as the rms output current in a frequency range 20 Hz to 20 MHz with the power supply in constant current operation.

- 1** Turn off the power supply and connect the output to be tested as shown in **Figure 3-1** with a load resistor (1.2 Ω for +6V supply and 25 Ω for \pm 25V supplies) across output terminals to be tested. Connect a rms voltmeter across the load resistor. Use only a resistive load for this test.
- 2** Turn on the power supply and select the output to be tested using the meter selection key on the front panel. Enable the outputs and set the display to the limit mode. When the display is in the limit mode, program the current to full-scale value and the voltage to the maximum programmable value.
- 3** The output current should be at the full-scale rating with the **CC** annunciator on. If not lit, adjust the load so that the output voltage drops slightly until the **CC** annunciator lights.
- 4** Divide the reading on the rms voltmeter by the load resistance to obtain rms current. The readings should be within the limit specified below for each output tested.

| Output | Specification |
|---------------|----------------------|
| +6V | 2 mA |
| +25V | 0.5 mA |
| -25V | 0.5 mA |

- 5** Repeat steps (1) through (4) for the remaining outputs.

Performance Test Record for Keysight E3631A

CV Performance Test Record

| Test Description | Actual Result | Specifications | |
|--|---------------|---|---|
| | | Upper Limit | Lower Limit |
| CV Programming Accuracy @ 0 volts (DVM reading) +6V supply +25V supply -25V supply | | +0.0050 V +0.0200 V +0.0200 V | -0.0050 V -0.0200 V -0.0200 V |
| CV Readback Accuracy @ 0 volts +6V supply +25V supply -25V supply | | DVM + 0.0050 V DVM + 0.0100 V -(DVM + 0.0100) V | DVM - 0.0050 V DVM - 0.0100 V -(DVM - 0.0100) V |
| CV Programming Accuracy @ Full Scale (DVM reading) +6V supply +25V supply -25V supply | | 6.0110 V 25.0325 V -25.0325 V | 5.9890 V 24.9675 V -24.9675 V |
| CV Readback Accuracy @ Full Scale +6V supply +25V supply -25V supply | | DVM + 0.0110 V DVM + 0.0225 V -(DVM + 0.0225) V | DVM - 0.0110 V DVM - 0.0225 V -(DVM - 0.0225) V |
| CV Load Regulation +6V supply +25V supply -25V supply | | Maximum change: <2.6 mV <4.5 mV <4.5 mV | |
| CV Line Regulation +6V supply +25V supply -25V supply | | Maximum change: <2.6 mV <4.5 mV <4.5 mV | |
| CV Ripple/Noise +6V supply +25V supply -25V supply | | <2 mV p-p, 0.35 mV rms for each of the three outputs | |
| CV Current Noise (Common Mode) +6V supply +25V supply -25V supply | | <1.5 μ A for each of the three outputs | |
| Load Transient Response Time +6V supply +25V supply -25V supply | | <50 μ sec for each of three outputs | |



CC Performance Test Record

| Test Description | Actual Result | Specifications | |
|--|---------------|--|--|
| | | Upper Limit | Lower Limit |
| CC Programming Accuracy @ 0 amps (I_O) +6V supply +25V supply -25V supply | | +0.0100 A +0.0040 A +0.0040 A | -0.0100 A -0.0040 A -0.0040 A |
| CC Readback Accuracy @ 0 amps +6V supply +25V supply -25V supply | | $I_O + 0.0100$ A $I_O + 0.0040$ A $I_O + 0.0040$ A | $I_O - 0.0100$ A $I_O - 0.0040$ A $I_O - 0.0040$ A |
| CC Programming Accuracy @ Full Scale (I_O) +6V supply +25V supply -25V supply | | 5.0200 A 1.0055 A 1.0055 A | 4.9800 A 0.9945 A 0.9945 A |
| CC Readback Accuracy @ Full Scale +6V supply +25V supply -25V supply | | $I_O + 0.0200$ A $I_O + 0.0055$ A $I_O + 0.0055$ A | $I_O - 0.0200$ A $I_O - 0.0055$ A $I_O - 0.0055$ A |
| CC Load Regulation +6V supply +25V supply -25V supply | | Maximum change: <0.75 mA <0.35 mA <0.35 mA | |
| CC Line Regulation +6V supply +25V supply -25V supply | | Maximum change: <0.75 mA <0.35 mA <0.35 mA | |
| CC Ripple/Noise +6V supply +25V supply -25V supply | | <2 mA <0.5 mA <0.5 mA | |

Calibration Security Code

This feature allows you to enter a security code (electronic key) to prevent accidental or unauthorized calibrations of the power supply. When you first receive your power supply, it is secured. Before you can calibrate the power supply, you *must* unsecure it by entering the correct security code. A procedure to unsecure the power supply is given on the following page.

- *The security code is set to "HP003631" when the power supply is shipped from the factory.* The security code is stored in *non-volatile* memory, and *does not* change when power has been off or after a remote interface reset.
- To secure the power supply from the *remote interface*, the security code may contain up to 12 alphanumeric characters as shown below. The first character *must* be a letter, but the remaining characters can be letters or numbers. You do not have to use all 12 characters but the first character must always be a *letter*.

A _ _ _ _ _ _ _ _ _ _ (12 characters)

- To secure the power supply from the remote interface so that it can be unsecured from the front panel, use the eight-character format shown below. The first two characters must be "H P" and the remaining characters must be numbers. Only the last six characters are recognized from the front panel, but all eight characters are required. *To unsecure the power supply from the front panel, omit the "H P" and enter the remaining numbers as shown on the following pages.*

H P _ _ _ _ _ (8 characters)

- *If you forget your security code, you can disable the security feature by adding a jumper inside the power supply, and then entering a new code. See the procedure on page 67.*



To Unsecure the Power Supply for Calibration

The power supply can use a calibration security code to prevent unauthorized or accidental calibration. This procedure shows you how to unsecure the power supply for calibration from the front panel.

Calibrate

Power

1 Turn on the front-panel calibration mode.

SECURED

Turn on the calibration mode by pressing the "Calibrate" key while simultaneously turning on the power supply then continue to hold the "Calibrate" key for about 5 seconds until a beep is heard.

If the power supply is secured, you will see the above message from the front panel for approximately one second. The "CAL MODE" message is then displayed on the front panel.

Secure

2 Move to the security code by pressing the "Secure" key.

000000 CODE

3 Enter the security code using the knob and resolution selection keys.

003631 CODE

The security code is set to "HP003631" when the power supply is shipped from the factory. The security code is stored in *non-volatile* memory and *does not* change when the power has been off or after a remote interface reset.

To enter the security code from the front panel, enter only the last six digits. To enter the security code from the remote interface, you may enter up to 12 characters.

Use the resolution selection keys to move left or right between digits. Use the knob to change the digits. Notice that the security code may be different if the security code has been changed from the default setting.

Secure

4 Unsecure the power supply.

UNSECURED

The power supply is unsecured when you press the Secure key. You will see the above message from the front panel for one second. The "CAL MODE" message is displayed on the front panel after above message.

Power

5 Turn off the calibration mode.

Turn off the power supply to exit the calibration mode.

To re-secure the power supply (following calibration), perform this procedure again.

3

To Unsecure the Power Supply Without the Security Code

To unsecure the power supply without the correct security code (when you forget the security code), follow the steps below. See "[Electrostatic Discharge \(ESD\) Precautions](#)" in [chapter 5](#) before beginning this procedure.

- 1 Disconnect the power cord and *all* load connections from front terminals.
- 2 Remove the instrument cover.
- 3 Connect the power cord and turn on the *calibration mode* by pressing the "Calibrate" key while simultaneously turning on the power supply then continue to hold the "Calibrate" key for about 5 seconds until a beep is heard. Be careful not to touch the power line connections.
- 4 Apply a short between the two exposed metal pads on JP1^[1] (located near the main controller U17 on the top board). The exposed metal pads are outlined with a small rectangular silkscreen. (See the component locator drawing for the E3631-60002 top PC board [on page 108](#).)
- 5 While maintaining the short, move to the security code and enter any unsecure code in the calibration mode. The power supply is now unsecured.
- 6 Remove the short at JP1^[2]. (An error occurs if not removed.)
- 7 Turn off and reassemble the power supply.

Now you can enter a new security code. Be sure you take note of the new security code.

[1]For serial MY53xx6xxx, apply the short at JP2 (located near the main controller U10 on the top board). See the component locator drawing for the top PC board (MY53xx6xxx) [on page 111](#).

[2]For serial MY53xx6xxx, remove the short at JP2.

Calibration Count

The calibration count feature provides an independent "serialization" of your calibrations. You can determine the number of times that your power supply has been calibrated. By monitoring the calibration count, you can determine whether an unauthorized calibration has been performed. Since the value increments by one for each *calibration parameter* (see [Table 3-3](#) on the next page), a complete calibration increases the value by 6 counts.

- The calibration count is stored in *non-volatile* memory and *does not* change when power has been off or after a remote interface reset. Your power supply was calibrated before it left the factory. When you receive the power supply, read the calibration count to determine its value.
- The calibration count increments up to a maximum of 32,767 after which it wraps around to 0. No way is provided to program or reset the calibration count.

3

Calibration Message

You can use the calibration message feature to record calibration information about your power supply. For example, you can store such information as the last calibration date, the next calibration due date, the power supply's serial number, or even the name and phone number of the person to contact for a new calibration.

You can record and read information in the calibration message from the remote interface only.

- The calibration message may contain up to 40 characters.
- The calibration message is stored in *non-volatile* memory and *does not* change when power has been off or after a remote interface reset.

General Calibration/Adjustment Procedure

The calibration procedures from the front panel are described in this section. For output *voltage* calibration, disconnect all loads from the power supply and connect a DVM across the output terminals to be calibrated. For output *current* calibration, disconnect all loads from the power supply, connect an appropriate current monitoring resistor across the output terminals to be calibrated, and connect a DVM across the terminals of the monitoring resistor.

The following table shows calibration parameters and points which should be used to calibrate the output voltage and current for each of the three outputs.

Table 3-3. Parameters for Calibration

| Output | Calibration Parameter | Voltage/ Current | Calibration Point mnemonic |
|-------------|-----------------------|---------------------|-------------------------------|
| +6V output | CAL SETUP 1 | Voltage | V LO |
| | | | V HI |
| | CAL SETUP 2 | Current | I LO |
| | | | I HI |
| +25V output | CAL SETUP 3 | Voltage | V LO |
| | | | V HI |
| | CAL SETUP 4 | Current | I LO |
| | | | I HI |
| -25V output | CAL SETUP 5 | Voltage | V LO |
| | | | V HI |
| | CAL SETUP 6 | Current | I LO |
| | | | I HI |

Note

You can terminate any CAL SETUP without changing its calibration constants by turning off power.

Chapter 3 Calibration Procedures General Calibration/Adjustment Procedure

To calibrate the output voltages and currents of the power supply from the front panel, proceed as follows:

1 Unsecure the power supply.

To calibrate the output voltage and current, you must *unsecure* the power supply according to the procedure given [on page 65](#).

2 Disconnect all loads from the power supply and connect a DVM across output terminals of the +6V output.

Calibrate

Power

3 Turn on the calibration mode.

CAL MODE

Turn on the calibration mode by pressing the "Calibrate" key while simultaneously turning on the power supply then continue to hold the "Calibrate" key for about 5 seconds until a beep is heard.

Make sure that the power supply is in "CV" mode. If the power supply is not in "CV" mode, an error occurs.

Calibrate

4 Move down a level to the voltage calibration mode for the +6V supply.

CAL SETUP 1

The display shows the above message to indicate that the power supply is ready for the voltage calibration of +6V supply.

Calibrate

5 Select the first voltage calibration point for the +6V supply.

V LO +0.1000 V

The display shows the first voltage calibration point for the +6V supply.

6 Read the DVM and change the first voltage value on the display to match the measured voltage.

For example, if the DVM reading is 0.0860 V, adjust the voltage to 0.0860 V using the knob and resolution selection keys.

V LO +0.0860 V

Calibrate

- 7 Pressing the "Calibrate" key saves the change and selects the second voltage calibration point for the +6V supply.**

V HI +5.7000 V

If the entered number is within an acceptable range, an "ENTERED" message appears for one second. The display now shows the second voltage calibration point for the +6V supply. If the entered number is not correct, an "INVALID DATA" message appears for one second and the display shows the first voltage calibration point again.

- 8 Read the DVM and change the second voltage value on the display to match the measured voltage.**

For example, if the DVM reads 5.9990 V, adjust the voltage to 5.9990 V using the knob and arrow keys.

V HI +5.9990 V

Calibrate

- 9 Pressing the "Calibrate" key saves the new calibration constants for the +6V output voltage and goes to the current calibration mode for the +6V supply.**

CAL SETUP 2

If the entered number is within an acceptable range, a "CALIBRATING" message appears for one second to indicate that the calibration is successful and that new calibration constants of "SETUP 1" are stored. Then, the display shows the above message to indicate that the power supply is ready for the current calibration for +6V supply.

If the entered number is not correct, an "INVALID DATA" message appears for one second and the display shows the second voltage calibration point again. If the calibration fails, a "CAL FAIL" message appears for one second and the display shows the "CAL SETUP 1" for the voltage calibration of the +6V supply again.

Connect an appropriate shunt (see [Table 3-1 on page 43](#)) across the +6V supply's output terminals, and connect a digital voltmeter across the shunt resistor for the current calibration.

Calibrate

- 10 Select the first current calibration point for the +6V supply.**

I LO +0.100 A

The display shows the first current calibration point for the +6V supply.

- 11 Read the DVM and change the first current value on the display to match the computed current (DVM reading \div by shunt resistance).**

For example, if the computed value is 0.099 A, adjust the current to 0.099 A using the knob and arrow keys.

Notice that you should wait for the DVM reading to stabilize for accurate calibration.

I LO +0.099 A

Calibrate

- 12 Pressing the "Calibrate" key saves the change and selects the second current calibration point for the +6V supply.**

I HI +4.750 A

If the entered number is within an acceptable range, an "ENTERED" message appears for one second. The display now shows the second current calibration point for the +6V supply. If the entered number is not correct, an "INVALID DATA" message appears for one second and the display shows the first current calibration point again.

- 13 Read the DVM and change the second current value on the display to match the computed current (DVM reading \div by shunt resistance).**

For example, if the computed value is 4.999 A, adjust the current to 4.999 A using the knob and arrow keys.

Notice that you should wait for the DVM reading to stabilize for accurate calibration.

I HI +4.999 A

Calibrate

- 14 Pressing the "Calibrate" key saves the new calibration constants for the +6V output current and goes to the voltage calibration mode for the +25V supply.**

CAL SETUP 3

If the entered number is within an acceptable range, a "CALIBRATING" message appears for one second to indicate that the calibration is successful and that new calibration constants of "SETUP 2" are stored. Then, the display shows the above message to indicate that the power supply is ready for the voltage calibration for +25V supply.

If the entered number is not correct, an "INVALID DATA" message appears for one second and the display shows the second voltage calibration point again. If the calibration fails, a "CAL FAIL" message appears for one second and the display shows the "CAL SETUP 2" for the current calibration of the +6V supply again.

- 15 Repeat steps (5) through (14) for the voltage and current calibration of the +25V supply (replace +6V with +25V in all the text).**

You can calibrate the output voltage and current of the +25V supply easily in the same manner. Notice that you should connect a shunt across (+) and (COM) terminals of the $\pm 25V$ supply for the +25V supply current calibration.

- 16 Repeat steps (5) through (14) for the voltage and current calibration of the -25V supply (replace +6V with -25V in all the text).**

You can also calibrate the output voltage and current of the -25V supply easily in the same manner. Notice that you should connect a shunt across (-) and (COM) terminals of the $\pm 25V$ supply for the -25V supply current calibration.

Aborting a Calibration in Progress

Sometimes it may be necessary to abort a calibration after the procedure has already been initiated. You can abort a calibration at any time by turning the power supply off from the front panel. When performing a calibration from the remote interface, you can abort a calibration by issuing a remote interface device clear message or by pressing the front-panel "Local" key.

Calibration Record for Keysight E3631A

| Step | Calibration Description | Measurement Mode (DVM) | Supply being Adjusted |
|------|--|------------------------|-----------------------|
| 1 | Unsecure the power supply (see page 65). | | |
| 2 | Turn on "CAL MODE"(simultaneously press "Calibrate" and "Power" keys) until a beep is heard. | | |
| 3 | Move down menu to "CAL SETUP 1" (press "Calibrate" key). | | +6 supply |
| 4 | "V LO 0.1000 V" appears on the display (change the display to match the DVM reading; then press "Calibrate" key). | V | +6 supply |
| 5 | "V HI +5.7000 V" appears on the display (change the display to match the DVM reading; then press "Calibrate" key). | V | +6 supply |
| 6 | "CAL SETUP 2" now appears on the display (press "Calibrate" key). | | +6 supply |
| 7 | "I LO 0.100 A" appears on the display (change the display to match the computed current through 0.1Ω resistor; then press "Calibrate" key). | A | +6 supply |
| 8 | "I HI +4.750 A" appears on the display (change the display to match the computed current through 0.1Ω resistor; then press "Calibrate" key). | A | +6 supply |
| 9 | "CAL SETUP 3" now appears on the display (press "Calibrate" key). | | +25 supply |
| 10 | "V LO 0.5000 V" appears on the display (change the display to match the DVM reading; then press "Calibrate" key). | V | +25 supply |
| 11 | "V HI +24.750 V" appears on the display (change the display to match the DVM reading; then press "Calibrate" key). | V | +25 supply |
| 12 | "CAL SETUP 4" now appears on the display (press "Calibrate" key). | | +25 supply |
| 13 | "I LO 0.100 A" appears on the display (change the display to match the computed current through 0.1Ω resistor; then press "Calibrate" key). | A | +25 supply |
| 14 | "I HI +0.950 A" appears on the display (change the display to match the computed current through 0.1Ω resistor; then press "Calibrate" key). | A | +25 supply |
| 15 | "CAL SETUP 5" now appears on the display (press "Calibrate" key). | | -25 supply |
| 16 | "V LO -0.5000 V" appears on the display (change the display to match the DVM reading; then press "Calibrate" key). | V | -25 supply |
| 17 | "V HI -24.750 V" appears on the display (change the display to match the DVM reading; then press "Calibrate" key). | V | -25 supply |
| 18 | "CAL SETUP 6" now appears on the display (press "Calibrate" key). | | -25 supply |
| 19 | "I LO 0.100 A" appears on the display (change the display to match the computed current through 0.1Ω resistor; then press "Calibrate" key). | A | -25 supply |
| 20 | "I HI +0.950 A" appears on the display (change the display to match the computed current through 0.1Ω resistor; then press "Calibrate" key). | A | -25 supply |

Error Messages

The following tables are abbreviated lists of error messages for the E3631A. The errors listed are the most likely errors to be encountered during calibration and adjustment. A more complete list of error messages and descriptions is contained in chapter 5 of the E3631A User's Guide.

System Error Messages

| Error | Error Message |
|--------------------|--|
| -330 | Self-test failed |
| -350 | Too many errors |
| 501 | Isolator UART framing error |
| 502 | Isolator UART overrun error |
| 503 ^[1] | SPI data error |
| 511 | RS-232 framing error |
| 512 | RS-232 overrun error |
| 513 | RS-232 parity error |
| 514 | Command allowed only with RS-232 |
| 521 | Input buffer overflow |
| 522 | Output buffer overflow |
| 550 | Command not allowed in local |
| 800 | P25V and N25V coupled by track system |
| 801 | P25V and N25V coupled by trigger subsystem |

[1] This error message is only applicable for serial MY53xx6xxx.

Self-Test Error Messages

| Error | Error Message |
|--------------------|--------------------------------------|
| 601 | Front panel does not respond |
| 602 | RAM read/write failed |
| 603 | A/D sync stuck |
| 604 | A/D slope convergence failed |
| 605 | Cannot calibrate rundown gain |
| 606 | Rundown gain out of range |
| 607 | Rundown too noisy |
| 608 | Serial configuration readback failed |
| 609 ^[1] | System ADC test failed |
| 624 | Unable to sense line frequency |
| 625 | I/O processor does not respond |
| 626 | I/O processor failed self-test |
| 630 | Fan test failed |
| 631 | System DAC test failed |
| 632 | P6V hardware test failed |
| 633 | P25V hardware test failed |
| 634 | N25V hardware test failed |

[1] This error message is only applicable for serial MY53xx6xxx.

Calibration Error Messages

| Error | Error Message |
|--------------|--|
| 701 | Cal security disabled by jumper |
| 702 | Cal secured |
| 703 | Invalid secure code |
| 704 | Secure code too long |
| 708 | Cal output disabled |
| 711 | Cal sequence interrupted |
| 712 | Bad DAC cal data |
| 713 | Bad readback cal data |
| 740 | Cal checksum failed, secure state |
| 741 | Cal checksum failed, string data |
| 742 | Cal checksum failed, store/recall data in location 1 |
| 743 | Cal checksum failed, store/recall data in location 2 |
| 744 | Cal checksum failed, store/recall data in location 3 |
| 745 | Cal checksum failed, DAC cal constants |
| 746 | Cal checksum failed, readback cal constants |
| 747 | Cal checksum failed, GPIB address |
| 748 | Cal checksum failed, internal data |

Calibration Program

This section contains a Keysight BASIC program for calibration over the GPIB interface. This program makes software adjustments to the E3631A power supply using a current shunt and a digital multimeter which is connected to the controller. In this program a 0.01 ohm current shunt is used. Be sure to change the value of the variable "Current_shunt" to the value of the current shunt used and the GPIB address for the power supply and the digital voltmeter.

```
10      !
20      ! This program makes software adjustments to the E3631A on the GPIB bus
30      ! using a Keysight 34401A and a current shunt. In the program a 0.01 ohm
40      ! current shunt is used to measure current. Be sure to change the value of
50      ! the variable 'Current_shunt' to the value of the current shunt used.
60      !
70      CLEAR SCREEN
80      DIM Cal_msg$(40), Sec_code$(40),Sec_code$(10]
90      REAL Dmm_rdg, Current_shunt
100     Current_shunt=.01                ! Current Shunt value in Ohms
110     Sec_Code$="HP003631"            ! Assign the security code.
120     ASSIGN @Dmm TO 722              ! Assign address 22 to the Dmm.
130     ASSIGN @Psup TO 705             ! Assign address 5 to the power supply.
140     CLEAR 7                          ! Clear GPIB, Dmm and Power Supply.
150     OUTPUT @Psup;"*CLS"              ! Clear power supply errors.
160     OUTPUT @Dmm;"*RST"              ! Clear Dmm.
170     OUTPUT @Psup;"*RST"            ! Reset power supply.
180     OUTPUT @ Psup;"CAL:STR?"        ! Read the calibration message.
190     ENTER @Psup;Cal_msg$
200     PRINT TABXY(5,2),"Calibration message of Power Supply is: ";Cal_msg$
210     !
220     ! Set the Calibration security to off, and check to be sure
230     ! it is off. If not successful, print message to screen and end.
240     !
250     OUTPUT @Psup;"CAL:SEC:STAT OFF, ";Sec_code$
260     OUTPUT @Psup;"CAL:SEC:STAT?"
270     ENTER @Psup;A
280     IF A=1 THEN
290         PRINT TABXY(5,5),"***** Unable to Unsecure the Power supply *****"
300         GOTO 1430
310     END IF
320     !
330     ! Perform the voltage calibration by stepping through one
340     ! power supply at a time. Alert the operator to hook up the
350     ! connection before calibrating.
360     !
370     FOR I=1 TO 3
380         OUTPUT @Psup;"INST:NSEL ";I !Select the output to be calibrated.
390         ! Alert operator to connect lead
```

Chapter 3 Calibration Procedures Calibration Program

...continued

```
400 PRINT TABXY(10,10), "*****"
410 PRINT TABXY(10,11), " Using the annunciator, note the output selected."
420 PRINT TABXY(10,12), " Connect the selected output to the DMM. Observe"
430 PRINT TABXY(10,13), " Polarity."
440 PRINT TABXY(10,14), "*****"
450 PRINT TABXY(10,15), "Press 'C' to continue, or 'E' to Exist, then"
460 PRINT TABXY(10,16), "press 'Enter'"
470 Ch$="C"
480 INPUT Ch$
490 IF Ch$="E" OR Ch$="e" THEN GOTO 1420
500 OUTPUT @Psup;"OUTP ON" ! Turn on Power supply output.
510 CLEAR SCREEN
520 OUTPUT @Psup;"CAL:VOLT:LEVEL MIN" ! Set output to minimum calibration
530 ! value
540 WAIT 1 ! Allow output to settle.
550 OUTPUT @Dmm;"MEAS:VOLT:DC? " ! Measure output with Dmm.
560 ENTER @Dmm;Dmm_rdg ! Store in variable Dmm_rdg.
570 PRINT Dmm_rdg
580 OUTPUT @Psup;"CAL:VOLT:DATA ";Dmm_rdg ! Send stored value to power
590 ! supply
600 OUTPUT @Psup;"CAL:VOLT:LEVEL MAX" ! Set output to maximum cal value.
610 WAIT 1 ! Allow output to settle.
620 OUTPUT @Dmm;"MEAS:VOLT:DC?" ! Measure output with Dmm.
630 ENTER @Dmm;Dmm_rdg ! Store in variable Dmm_rdg.
640 PRINT Dmm_rdg
650 OUTPUT @Psup;"CAL:VOLT:DATA ";Dmm_rdg ! Send stored value to power
660 ! supply
670 OUTPUT @Psup;"OUTP OFF"
680 OUTPUT @Psup;"SYST:ERR?"
690 ENTER @Psup;Error$
700 !
710 ! Check to see if there is an error. If there is an error,
720 ! display the error and exit the program.
730 !
740 IF Error$="+0,""No error"" THEN
750 PRINT "Voltage calibration completed for Power Supply ";I
760 ELSE
770 PRINT "ERROR: ";Error$; " Power Supply ";I; " Voltage not Calibrated"
780 GOTO 1420
790 END IF
800 NEXT I
810 PRINT TABXY(10,5), "VOLTAGE CALIBRATION COMPLETE"
820 PRINT TABXY(10,7), "BEGIN CURRENT CALIBRATION"
830 !
840 ! Perform the CURRENT calibration by stepping through one
850 ! power supply at a time. Alert the operator to hook up the
860 ! connection before calibrating.
870 !
880 FOR I=1 TO 3
890 OUTPUT @Psup;"INST:NSEL ";I !Select the output to be calibrated.
900 ! Alert operator to connect lead
```

Chapter 3 Calibration Procedures Calibration Program

...continued

```
910 PRINT TABXY(10,9), "*****"
920 PRINT TABXY(10,10), " Connect a CURRENT SHUNT to the Dmm for measuring"
930 PRINT TABXY(59,10), " current."
940 PRINT TABXY(10,11), " Using the annunciator, note the output selected."
950 PRINT TABXY(10,12), " Connect the selected output to the shunt. Observe"
960 PRINT TABXY(60,12), " Polarity"
970 PRINT TABXY(10,13), "*****"
980 PRINT TABXY(10,15), "Press 'C' to continue, or 'E' to Exit, then"
990 PRINT TABXY(10,16), "press 'Enter'"
1000 Ch$="C"
1010 INPUT Ch$
1020 IF Ch$="E" OR Ch$="e" THEN GOTO 1420
1030 OUTPUT @Psup;"OUTP ON" ! Turn on Power supply output.
1040 CLEAR SCREEN
1050 OUTPUT @Psup;"CAL:CURR:LEVel MIN" ! Set output to minimum cal value.
1060 WAIT 1 ! Allow output to settle.
1070 OUTPUT @Dmm;"MEAS:VOLT:DC? " ! Measure output with Dmm.
1080 ENTER @Dmm;Dmm_rdg ! Store in variable Dmm_rdg.
1090 Dmm_rdg=Dmm_rdg/Current_shunt ! Scale reading to amps.
1100 IF I=3 THEN DMM_rdg=-DMM_rdg ! For -25V, Current is positive
1110 PRINT Dmm_rdg
1120 OUTPUT @Psup;"CAL:CURR:DATA ";Dmm_rdg ! Send stored value to power
1130 ! supply
1140 OUTPUT @Psup;"CAL:CURR:LEVel MAX" ! Set output to maximum cal value.
1150 WAIT 1 ! Allow output to settle.
1160 OUTPUT @Dmm;"MEAS:VOLT:DC? " ! Measure output with Dmm.
1170 ENTER @Dmm;Dmm_rdg ! Store in variable Dmm_rdg.
1180 Dmm_rdg=Dmm_rdg/Current_shunt ! Scale reading to amps.
1190 IF I=3 THEN DMM_rdg=-DMM_rdg ! For -25V, Current is positive
1200 PRINT Dmm_rdg
1210 OUTPUT @Psup;"CAL:CURR:DATA ";Dmm_rdg ! Send stored value to power
1220 ! supply.
1230 OUTPUT @Psup;"OUTP OFF" ! Turn off Power supply output.
1240 OUTPUT @Psup;"SYST:ERR?"
1250 ENTER @Psup;Error$
1260 !
1270 ! Check to see if there is an error. If there is an error,
1280 ! display the error and exit the program.
1290 !
1300 IF Error$="+0, No error" THEN
1310 PRINT "Current calibration completed for Power Supply ";I
1320 ELSE
1330 PRINT "ERROR: ";Error$; " Power Supply ";I; " Current not Calibrated"
1340 GOTO 1420
1350 END IF
1360 NEXT I
1370 CLEAR SCREEN
1380 PRINT TABXY(10,5), "CURRENT CALIBRATION COMPLETE"
1390 ! Create a time stamp and output to power supply
1400 Cal_msg$ "Last Calibrated "$DATE$(TIMEDATE)&" "&TIME$(TIMEDATE)
1410 OUTPUT @Psup;"CAL:STR """;Cal_msg$;""
1420 OUTPUT @Psup;"CAL:SEC:STAT ON, ";Sec_code$
1430 END
```

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Theory of Operation

Theory of Operation

This chapter provides block diagram level descriptions of the power supply. The descriptions provide a basic understanding of circuit operation and are intended as an aid in troubleshooting. It is assumed in the following discussions that you are familiar with the operating and programming instructions presented in the E3631A User's Guide. Subjects covered include the following:

- [Block Diagram Overview, page 84](#)
- [AC Input and Bias Supplies, page 86](#)
- [Floating Logic, page 87](#)
- [D-to-A Converter, page 89](#)
- [A-to-D Converter, page 90](#)
- [Power Mesh and Control, page 91](#)
- [Earth-Referenced Logic, page 93](#)
- [Front Panel, page 93](#)

Block Diagram Overview

This discussion pertains to the block diagram on the next page. The power supply's circuitry is divided into two major blocks: the floating circuitry and the ground referenced circuitry. All power mesh and control circuits, display circuit, and digital circuits are contained in the floating circuitry. This circuitry also contains the power supply's main controller. The ground referenced circuitry provides the interface between the user and the power supply.

The floating circuitry can be viewed in four pieces; the DAC system, the digital logic section (floating logic), the power mesh and control section (+6V and $\pm 25V$ power circuits), and the front panel (display and keyboard) section.

The floating logic receives digital signals from the earth-referenced logic and the DAC converts them to analog signals which are sent to the power control circuits in order to program the power supply's output voltage and current. The power supply can also be commanded to send measurement and status data back to the remote interface controller and/or the VFD (vacuum fluorescent display) display on the front panel. The data is processed and sent back via the floating logic and earth-referenced logic.

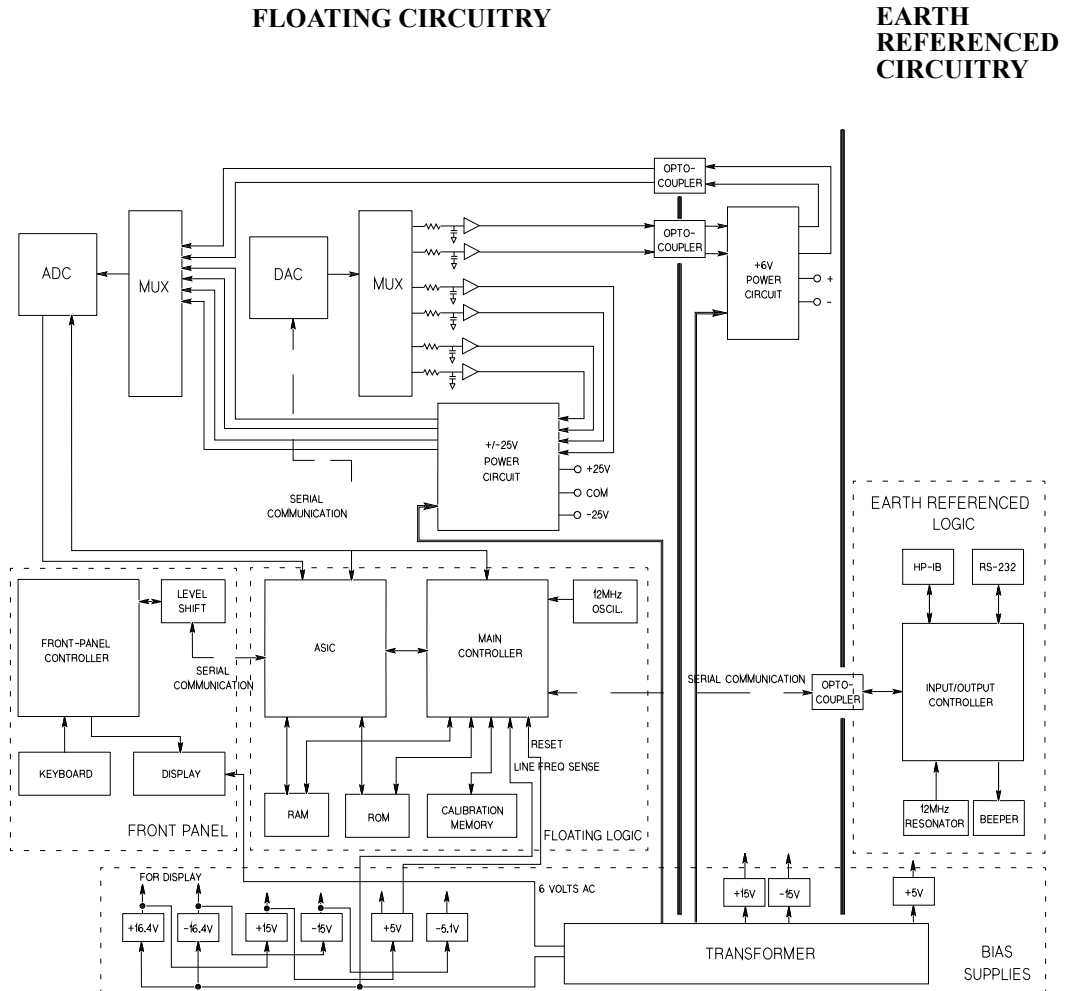
The power mesh and control circuits contains voltage and current control circuits which allows the power supply to operate in either the constant voltage (CV) or constant current (CC) mode. The control circuits compare the power supply's output voltage or current with the programmed value and generates a control signal which varies the conduction of the series pass transistor to raise or lower the output as required.

The front panel circuits consist of VFD control, display high voltage drivers, and keyboard scanning. Communication between the front panel and floating logic circuits is accomplished through a 4-wire bi-directional serial interface.

The ground referenced circuitry uses a controller configured as a slave to the main controller. This controller establishes external I/O communication with the main controller through a bi-directional, optically isolated, serial communications link. The earth referenced controller controls low-level GPIB (IEEE-488) and RS-232 interface operation.

Separate reference and bias supplies are provided for the floating and ground reference circuitry. The front panel operates from the floating circuitry with its logic common different from the main controller logic common.

Block Diagram



AC Input and Bias Supplies

The ac mains are connected by a fused power module. This module incorporates the functions of mains connection, fusing, and line voltage selection (100/115/230 Vac). The line voltage selection function of the module selects which primary winding of power transformer is energized. The transformer secondary windings are connected to the main pc board through connectors.

The bias supplies are consists of four sections; ± 15 Vdc for the +6V power circuits; ± 15 Vdc, +5 Vdc and -5.1 Vdc for the ± 25 V power circuits and floating logic; ± 16.4 Vdc for the display; and +5 Vdc for the earth referenced logic. Power-on reset signals are provided by the +5 Vdc supply of the floating logic.

The ± 15 Vdc for the +6V power circuits are produced by rectifiers CR15 and CR16, filter capacitors C43 and C44, and voltage regulators U24 and U25 on the bottom board. These supplies provide bias voltages for the +6V power circuits.

The ± 16.4 Vdc for the display circuits are produced by rectifier CR20, filter capacitors C44 and C45, and voltage regulators U24 and U25 on the top board. A separate winding of power transformer provides a center tapped 6 Vrms filament supply for the display.

The ± 15 Vdc for the ± 25 V power circuits are derived from ± 16.4 Vdc by diodes CR15 through CR18 on the top board. These supplies provide bias voltages for the ± 25 V power circuits.

The floating +5 Vdc and -5.1 Vdc supplies are produced from ± 16.4 Vdc supplies. VR2 on the top board forms a clamp circuit to provide over voltage protection in the event of a regulator failure. The ADC REF signal is derived from +15 Vdc supply and the TURN_ON RESET signal is derived from +5 Vdc supply. The FAN FAIL signal is asserted when the fan current through R73 on the top board is not detected. The TURN_ON RESET signal holds the main controller and other logic in a reset state until after the +5 Vdc logic power is fully operational. This signal is generally active only following application of line power to the instrument.

The +5V dc earth referenced supply is produced by rectifier CR3, filter capacitor C15, and regulator U11 on the bottom board. The GPIB (IEEE-488) and RS-232 computer interfaces are powered from this supply.

Floating Logic

The floating common logic controls operation of the entire instrument. All output functions and bus command interpretation is performed in the main controller U17. The front panel and the earth referenced logic operate as slaves to U17. The floating common logic is comprised of the main controller U17, custom gate array U16, the program ROM U14, RAM U15, calibration EEPROM U18, and the 12 MHz clock oscillator Y1 on the top board . Non-volatile EEPROM U18 stores calibration constants, calibration secure code, and calibration count. Power-on reset is provided to the main controller by the voltage regulator U1 on the top board.

The main controller U17 is a 16-bit micro controller. It controls such features as receive and transmit serial port, timer/counter ports, an 8-bit pulse width modulated DAC port, and selectable input 10-bit successive approximation a-to-d convert ports. A conventional address/data bus is used to transfer data between the main controller and external ROM and RAM. When the address latch enable (ALE) signal goes high, address data is present on the address/data bus. ASIC U16 latches the address data and decodes the correct chip enable (low true) for external ROM and RAM accesses and for read/write accesses to the internal registers of U16. The system memory map is shown below.

| | | | |
|---------------------------------------|-----|--------|-------------|
| 0000 _H - 1FF7 _H | U15 | 8k x 8 | RAM |
| 1FF8 _H - 1FFF _H | U16 | | Gate Array |
| 2000 _H - FFFF _H | U14 | | Program ROM |

Program ROM U14 contains four 64k x 8 data banks of data. Banks are selected by controlling A16 and A17 ROM address bits directly from the main controller port bits. Custom gate array U16 performs address latching and memory map decoding functions as discussed above. In addition, U16 contains a variety of internal read/write registers. The read (XRD) and write (XWR) signals transfer data out of and into U16 when it is addressed. There are four internal registers in U16: an internal configuration register, an 8 bit counter register, a serial transmit/receive register, and an internal status register.

The counter register is used to capture the ADC slope count at the COMP input. The COMP input functions as both a clocked comparator and the slope counter input for the ADC. In both cases the counter register captures the lower 8 bits of a 24-bit counter. The upper 16 bits of the count are captured by the SYNC input to U17.

The serial register is used to send and receive serial data bytes from the main controller to the DAC system, or to communicate with the front panel controller. The serial register is multiplexed to these two circuits. The transmission rate is selected to 1.5

M bits/second for the DAC system and 93.75 k bits/second for communication with the front panel controller. The general serial interface is a 3-bit interface as shown below.

| U18 Internal Signal | Configuration Signals | Front Panel Signals |
|----------------------------|------------------------------|----------------------------|
| Serial Clock | SERCK | XFPSK |
| Data OUT (send) | SERDAT | FPDI |
| Data IN (receive) | SERRBK | FPDO |

Serial data is received simultaneously as serial data is clocked out. Front panel data is exchanged in both directions whenever a byte is sent from U16 on the top board. The input data of DAC is strobed to outputs by U17 signal SERSTB. Interrupts from the front panel are detected by U16 and signaled to the CHINT. The main controller FPINT signals the front panel controller that U16 has data to send.

The power supply's calibration correction data are stored in a 128 x 16 bit non-volatile electrically erasable ROM U18 on the top board. This non-volatile ROM read/write data is accessed by a 4-bit serial protocol controlled by U17.

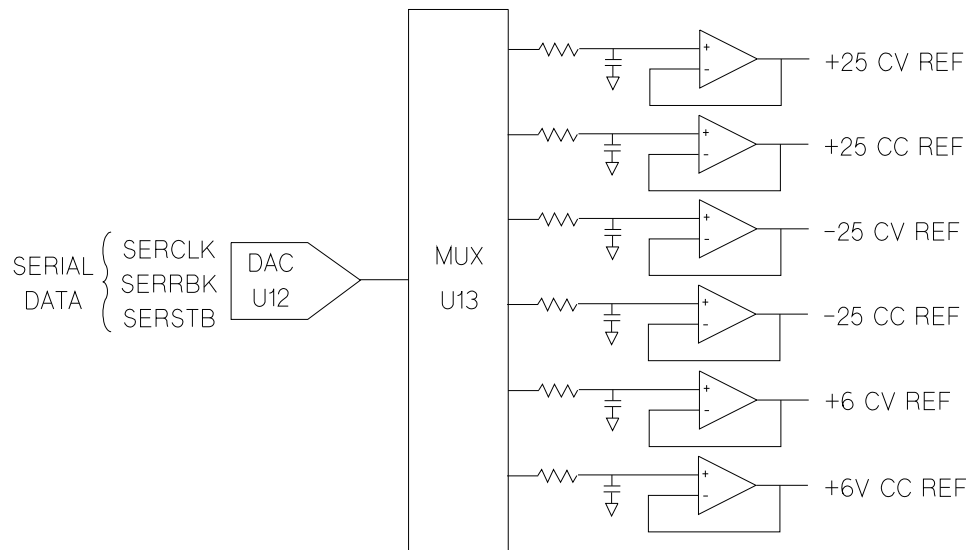
The main controller has an on-chip 10-bit successive approximation ADC. The FLASH input is used to sample the residual charge on the main integrating ADC output of U8 on the top board.

Port bits are also configured to measure the input power line frequency (LSENSE). Frequencies from 55 Hz to 66 Hz are measured as 60 Hz. All other line input frequencies are assumed to be 50 Hz.

The main controller communicates with the earth referenced controller U10 on the bottom board through an optically isolated (U1 and U2 on the bottom board) asynchronous serial link. Data is sent in an 11-bit frame at a rate of 187.5 k bits/second. When the RS-232 interface is selected, data is sent across the isolated link at 93.75 k bits/second. The 11-bit data frame is configured for one start bit, eight data bits, one control bit, and one stop bit.

D-to-A Converter

All reference voltages of power circuits are derived from the internal voltage reference of system DAC U12 on the top board. The system DAC track/hold amplifier outputs are used to provide controllable reference voltages to three power circuits. The system DAC is programmed and responds to the main controller via internal 3-wire serial data bus SERCLK, SERRBK, and SERSTB. The system DAC is multiplexed to 6 track/hold amplifiers through U13 on the top board. Each track/hold amplifier is refreshed approximately every 13 msec to maintain its output setting. Changes to track/hold amplifier outputs are accomplished by dwelling on that position for an extended period.



A-to-D Converter

The analog-to-digital converter (ADC) is used to change dc voltages into digital information. The circuitry consists of an integrator amplifier (U6 and U8), current steering switch U5, resistors (R5, R4, R15 and R16), voltage reference (U3A and U3B), ADC controller U16, and residue ADC U17 on the top board.

The ADC method used by the Keysight E3631A is called *multislope III*. Multislope III is a charge balancing continuously integrating analog-to-digital converter. The input voltage continuously forces charge onto the integrator capacitors C18 and C19 through R15 on the top board.

Switch U5 steers fixed positive or negative reference currents onto the integrator capacitors to cancel, or balance the accumulated input charge. The level shifted (R19 and R20 on the top board) output of the integrator is checked every $2.66 \mu\text{A}$ by the U16 COMP input. Logic state machines in U16 control the U5 current steering to continuously seek an approximate 2.5 V level on the integrator amplifier output, FLASH. If the ADC input voltage ADC REF is between ± 15 V, the integrator output (FLASH) will remain within the 0 V to 5 V range of the U17 on-chip ADC. An input greater than +15 V may cause the integrator output in U8 at pin 6 (U8-6) to saturate at about -15 V. An input less than -15 V may cause U8 to saturate with an output of about +15 V. The U17 ADC input (FLASH) is clamped to 0 V or 5 V by R21 and CR3 to protect U17.

The integrator amplifier is formed by U6 and U8. Resistors R10 and R11 affect the amplifier stability. Amplifier oscillation may occur if their values are incorrect. Amplifier U6 improves the offset voltage characteristics of integrator amplifier U8 on the top board.

Each analog-to-digital conversion occurs continuously. The ADC starts by clearing the integrator slope count in U16. At the end of the integration period, the slope count is latched. The slope count provides the most significant bits of the input voltage conversion. The least significant bits are converted by the on-chip ADC of U17.

Power Mesh and Control

For the $\pm 25\text{V}$ power mesh and control circuit, a preregulator is added ahead of the series pass transistor to minimize the power dissipated in the series pass transistor by controlling the dc level across the input filter capacitor, depending on the output voltage.

To achieve this, tap switching is accomplished by a TRIAC and one bridge diode and the TRIAC control circuit in each power circuit; Q10 and CR29 on the top board for +25V power circuit, Q3 and CR7 on the top board for -25V power circuit. By turning on or off the TRIAC, these circuits allow the input capacitors (C54, C55, and C56 for +25V power circuit and C34, C35, and C36 for -25V power circuit) to charge to one of two discrete voltage levels, depending on the output voltage required. When the TRIAC is not fired, the bridge diode conducts and the low voltage of two discrete voltage levels is developed across the input filter capacitors.

The TRIAC control circuit determines whether TRIAC is to be fired by monitoring the output voltage and comparing this value against internally derived reference levels.

The series pass transistor is part of a feedback loop which consists of the driver and the Constant Voltage/Constant Current error amplifier. The feedback loop provides "fine and fast" regulation of the output while the preregulator feedback loop handles large, relatively slow, regulation demands.

The series pass transistor is made to alter its conduction to maintain a constant output voltage or current. The voltage developed across the current sampling resistors is the input to the constant current error amplifier. The constant voltage error amplifier obtains its input by sampling the output voltage of the supply. Any changes in output voltage or current are detected and amplified by the constant voltage or constant current error circuit and applied to the series pass transistor in the correct phase and amplitude to counteract the change in output voltage or current.

Two error amplifiers are included in a CV/CC supply, one for controlling output voltage, the other for controlling output current. Since the constant voltage amplifier tends to achieve zero output impedance and alters the output current whenever the load resistance changes, while the constant current amplifier causes the output impedance to be infinite and changes the output voltage in response to any load resistance change, it is obvious that the two amplifiers cannot operate simultaneously. For any given value of load resistance, the power supply must act either as a constant voltage source or as a constant current source - it cannot be both; transfer between these two modes is accomplished at a value of load resistance equal to the ratio of the output voltage control setting to the output current control setting.

Full protection against any overload condition is inherent in the Constant Voltage/Constant Current design principle since there is not any load condition that can cause an output which lies outside the operating region. For either constant voltage or constant current operation, the proper choice of front panel voltage and current limit settings insures optimum protection for the load device as well as full protection for the power supply.

The diodes connected across the output terminals in reverse polarity protect the output electrolytic capacitor and the series pass transistors from the effects of a reverse voltage applied across the output terminals.

The +6V power mesh and control circuits are similar to those of the $\pm 25\text{V}$ power circuits except that the the TRIAC preregulator is not used. The ac input, after passing through power transformer, is rectified and filtered. By feedback action, the series pass transistor alters its conduction to keep the regulated dc output voltage constant. The +6V and the $\pm 25\text{V}$ power mesh and control circuits are isolated from each other and the two outputs of the $\pm 25\text{V}$ power mesh and control circuit share a common output terminal.

Earth-Referenced Logic

Microprocessor U10 on the bottom board handles GPIB (IEEE-488) control through bus interface chip U8 and bus receiver/driver chips U6 and U7 on the bottom board. The RS-232 interface is also controlled through microprocessor U10. RS-232 transceiver chip U12 on the bottom board provides the required level shifting to approximate ± 9 volt logic levels through on-chip charge-pump power supplies using C11 and C12 on the bottom board. Communication between the earth referenced logic interface circuits and the floating logic is accomplished through an optically-isolated bi-directional serial interface. Isolator U2 on the bottom board couples data from U10 to processor U17 on the top board. Isolator U1 on the bottom board couples data from U17 on the top board to microprocessor U10 on the bottom board.

Front Panel

The front panel circuits consist of vacuum fluorescent display control, display high voltage drivers, and keyboard scanning. Communication between the front panel and floating logic circuits is accomplished through a 4-wire bi-directional serial interface. The main controller U17 can cause a hardware reset to front-panel controller by signal IGFPRES. The front panel logic operates from -11.4 volts (logic 1) and -16.4 volts (logic 0). The front panel logic high supply (-11.4 volts) is produced by the -16.4 volts bias supply and the voltage regulator U2 on the front panel board. The four serial communication signals are level shifted by the comparator U8 from the floating logic 0 V to 5 V levels to the -16.4 V to -11.4 V levels present on the front panel assembly. U6 acts as the serial shift register interface for the front-panel controller U7 on the front panel board.

Display anode and grid voltages are +16.4 volts for an "on" segment and -16.4 volts for an "off" segment. The -10.2 V cathode bias for the display is provided by filament winding center tap bias circuit VR3, R43, and C32 on the top board. Keyboard scanning is accomplished through a conventional scanned row-column key matrix. Keys are scanned by outputting data at front-panel controller U7 port pins P0.0 through P0.3 to poll each key column for a key press. Column read-back data are read by the microprocessor at port pins P1.0 through P1.3 for decoding and communication to the floating logic circuits.

Service

Service

This chapter discusses the procedures involved for returning a failed power supply to Keysight Technologies for service or repair. Subjects covered include the following:

- [Operating Checklist, page 96](#)
- [Types of Service Available, page 97](#)
- [Repacking for Shipment, page 98](#)
- [Electrostatic Discharge \(ESD\) Precautions, page 99](#)
- [Surface Mount Repair, page 99](#)
- [To Replace the Power-Line Fuse, page 99](#)
- [Troubleshooting Hints, page 100](#)
- [Self-Test Procedures, page 102](#)

Operating Checklist

Before returning your power supply to Keysight Technologies for service or repair check the following items:

Is the Power Supply Inoperative?

- Verify that the ac power cord is connected to the power supply.
- Verify that the front-panel power switch is depressed.
- Verify that the power-line fuse is installed:
Use the 2.5 AT, 250 V fuse for 100 or 115 Vac operation.
Use the 2 AT, 250 V fuse for 230 Vac operation.
- Verify the power-line voltage setting.
See "To prepare the power supply for use" on page 24.

Does the Power Supply Fail Self-Test?

- Verify that the correct power-line voltage is selected.
See "To prepare the power supply for use" on page 24.
- Remove all load connections to the power supply.
Ensure that all terminal connections are removed while the self-test is performed.

Types of Service Available

If your power supply fails within 3 years of original purchase, Keysight Technologies will repair or replace it free of charge. If your unit fails after your 3-year warranty expires, Keysight will repair or replace it at a very competitive price. Keysight will make the decision locally whether to repair or replace your unit.

Standard Repair Service (worldwide)

Contact your nearest Keysight Technologies Service Center. They will arrange to have your power supply repaired or replaced.

Express Exchange (U.S.A. only)

You can receive a replacement Keysight E3631A via overnight shipment for low downtime.

- 1 Call 1-800-258-5165 and ask for "Express Exchange."
 - You will be asked for your shipping address and a credit card number to guarantee return of your failed power supply.
 - If you do not return your failed power supply within 45 days, your credit card will be billed for a new Keysight E3631A.
 - If you choose not to supply a credit card number, you will be asked to send your failed unit to a designated Keysight Service Center. After the failed unit is received, Keysight will send your replacement unit.
- 2 Keysight Technologies will immediately send a replacement Keysight E3631A to you via overnight shipment.
 - The replacement unit will have a different serial number than your failed unit.
 - If you cannot accept a new serial number for the replacement unit, use the Standard Repair Service option described above.
 - If your failed unit was "in-warranty", your replacement unit continues the original 3-year warranty period. You *will not* be billed for the replacement unit as long as the failed unit is received by Keysight Technologies.
 - If your 3-year warranty has expired, Keysight will bill you for the Keysight E3631A exchange price - less than a new unit price. Keysight warrants exchange units against defects for 90 days.

Repacking for Shipment

For the Express Exchange Service described on the previous page, return your failed Keysight E3631A to the designated Keysight Service Center using the shipping carton of the exchange unit. A shipping label will be supplied. Keysight will notify you when your failed unit has been received.

If the instrument is to be shipped to Keysight Technologies for service or repair, be sure to:

- Attach a tag to the power supply identifying the owner and indicating the required service or repair. Include the instrument model number and full serial number.
- Place the power supply in its original container with appropriate packaging material.
- Secure the container with strong tape or metal bands.

If the original shipping container is not available, place your unit in a container which will ensure at least 4 inches of compressible packaging material around all sides for the power supply. Use static-free packaging materials to avoid additional damage to your unit.

Keysight Technologies suggests that you always insure shipments.

Electrostatic Discharge (ESD) Precautions

Almost all electrical components can be damaged by electrostatic discharge (ESD) during handling. Component damage can occur at electrostatic discharge voltages as low as 50 volts.

The following guidelines will help prevent ESD damage when serving the power supply or any electronic device.

- Disassemble instruments *only* in a static-free work area.
- Use a conductive work area to dissipate static charge.
- Use a conductive wrist strap to dissipate static charge accumulation.
- Minimize handling.
- Keep replacement parts in original static-free packaging.
- Remove all plastic, styrofoam, vinyl, paper, and other static-generating materials from the immediate work area.
- Use *only* anti-static solder suckers.

Surface Mount Repair

Surface mount components should *only* be removed using soldering irons or desoldering stations *expressly* designed for surface mount components. *Use of conventional solder removal equipment will almost always result in permanent damage to the printed circuit board and will void your Keysight Technologies factory warranty.*

To Replace the Power-Line Fuse

The power-line fuse is located within the power supply's fuse-holder assembly on the rear panel (see [on page 25](#)). For 100 or 115 Vac operation, you must use a 2.5 AT slow-blow fuse (Keysight part number 2110-0913). For 230 Vac operation, you must use a 2 AT slow-blow fuse (Keysight part number 2110-0587).

Troubleshooting Hints

This section provides a brief check list of common failures. Before troubleshooting or repairing the power supply, make sure that the failure is in the instrument rather than any external connections. Also make sure that the instrument is accurately calibrated. The power supply's circuits allow troubleshooting and repair with basic equipment such as a digit multimeter and a 100 MHz oscilloscope.

Unit is Inoperative

- Verify that the ac power cord is connected to the power supply.
- Verify that the front-panel power switch is depressed.
- Verify that the power-line fuse is installed:
 - Use the 2.5 AT, 250 V fuse for 100 or 115 Vac operation..*
 - Use the 2 AT, 250 V fuse for 230 Vac operation..*
- Verify the power-line voltage setting.
 - See "To prepare the power supply for use" on page 24.*

Unit Reports Errors 740 to 748

These errors may be produced if you accidentally turn off power the unit during a calibration or while changing a non-volatile state of the instrument. Recalibration or resetting the state should clear the error. If the error persists, a hardware failure may have occurred.

5

Unit Fails Self-Test

Verify that the correct power-line voltage setting is selected. Also, ensure that all terminal connections are removed while the self-test is performed. Failure of the DAC U12^[1] on the top board will cause many self-test failures.

[1]For serial MY53xx6xxx, failure of the DAC U13 on the top board will cause many self-test failures.

Bias Supplies Problems

Check that the input to the voltage regulators of the bias supplies is at least 1 V greater than their output.

Circuit failures can cause heavy loads of the bias supplies which may pull down the regulator output voltages.

Check the voltages of bias supplies as tabulated below.

Table 5-1. Bias Supplies Voltages

| Bias Supply | Minimum | Maximum | Check At |
|-------------------------------------|----------|----------|------------------------------------|
| +5V Floating | 4.75 V | 5.25 V | U1 pin 2 (on the top Board) |
| -5.1V Floating | -4.75 V | -5.25 V | Anode of VR4 (on the top Board) |
| +15V Floating ($\pm 25V$ supplies) | 14.25 V | 15.75 V | Cathode of CR16 (on the top Board) |
| -15V Floating ($\pm 25V$ supplies) | -14.25 V | -15.75 V | Anode of CR18 (on the top Board) |
| +15V Floating (+6V supplies) | 14.25 V | 15.75 V | U25 pin 2 (on the bottom Board) |
| -15V Floating (+6V supplies) | -14.25 V | -15.75 V | U24 pin 3 (on the bottom Board) |
| +5V Ground Ref. | 4.75 V | 5.25 V | U11 pin 3 (on the bottom Board) |

Table 5-2. Bias Supplies Voltages (MY53xx6xxx)

| Bias Supply | Minimum | Maximum | Check At |
|-------------------------------------|----------|----------|-----------------------------------|
| +5V Floating | 4.75 V | 5.25 V | U40 pin 6 (on the top Board) |
| -5.1V Floating | -4.75 V | -5.25 V | Anode of VR1 (on the top Board) |
| +15V Floating ($\pm 25V$ supplies) | 14.25 V | 15.75 V | Cathode of CR4 (on the top Board) |
| -15V Floating ($\pm 25V$ supplies) | -14.25 V | -15.75 V | Anode of CR7 (on the top Board) |
| +15V Floating (+6V supplies) | 14.25 V | 15.75 V | U1 pin 2 (on the bottom Board) |
| -15V Floating (+6V supplies) | -14.25 V | -15.75 V | U2 pin 3 (on the bottom Board) |
| +5V Ground Ref. | 4.75 V | 5.25 V | U3 pin 3 (on the bottom Board) |

Some circuits produce their own local bias supplies from the main bias supplies. Be sure to check that these local bias supplies are active. In particular, the ADC (analog-to-digital converter), ac input, and front panel sections have local bias supplies.

Always check that the power supplies are free of ac oscillations using an oscilloscope. Failure of bias supplies will cause many self-test failures.

Self-Test Procedures

Power-On Self-Test

Each time the power supply is powered on, a set of self-tests are performed. These tests check that the minimum set of logic and measurement hardware are functioning properly. The power-on self-test performs checks 601 through 604 and 624 through 634. For serial MY53xx6xxx, the power-on self-test utilizes the complete self-test, which covers error codes 601 through 634.

Complete Self-Test

Hold any front panel key except the "Error" key for more than 5 seconds while turning on the power to perform a complete self-test. The power supply beeps when the test starts. The tests are performed in the order shown below.

- 601 Front Panel Does not respond** The main controller U17 (U10 for serial MY53xx6xxx) on the top board attempts to establish serial communications with the front panel controller U7 (U602 for serial MY53xx6xxx) on the front panel board. During this test, U7 (U602 for serial MY53xx6xxx) turns on all display segments. Communication must function in both directions for this test to pass. If this error is detected during power-on self-test, the power supply will beep twice. This error is only readable from the remote interface.
- 602 RAM read/write failed** This test writes and reads a 55_h and AA_h checker board pattern to each address of ram U15 (on-chip RAM for serial MY53xx6xxx) on the top board. Any incorrect readback will cause a test failure. This error is only readable from the remote interface.
- 603 A/D sync stuck** The main controller issues an A/D sync pulse to U17 and U16 on the top board to latch the value in the ADC slope counters. A failure is detected when a sync interrupt is not recognized and subsequent time-out occurs.
- 604 A/D slope convergence failed** The input amplifier is configured to the measure zero (MZ) state in the 10 V range. This test checks whether the ADC integrator produces nominally the same number of positive and negative slope decisions ($\pm 10\%$) during a 20 ms interval.

- 605** **Cannot calibrate rundown gain** This test checks the nominal gain between integrating ADC and the U17 on-chip ADC. This error is reported if the procedure cannot run to completion due to a hardware failure.
- 606** **Rundown gain out of range** This test checks the nominal gain between the integrating ADC and the U17 on-chip ADC. The nominal gain is checked to $\pm 10\%$ tolerance.
- 607** **Rundown too noisy** This test checks the gain repeatability between the integrating ADC and the U17 on-chip ADC. The gain test (606) is performed eight times. Gain noise must be less than ± 64 lsb's of the U17 on-chip ADC.
- 608** **Serial configuration readback failed** This test re-sends the last 3 byte serial configuration data to all the serial path (SERDAT, SERBCK, SERCLK). The data is then clocked back into U16 on the top board and compared against the original 3 bytes sent. A failure occurs if the data do not match. This tests checks the serial data path through U11 on the top board.
- 609^[1]** **System ADC test failed** This test checks if the ADC hardware is functional. The main controller U10 establishes communication with the ADC and checks if there are any error bits set for the ADC's status reporting.
- 624** **Unable to sense line frequency** This test checks that the LSENCE logic input U17 on the top board is toggling. If no logic input detected, the power supply will assume a 50 Hz line operation for all future measurements.
- 625** **I/O processor did not respond** This test checks that communications can be established between U16 (U10 for serial MY53xx6xxx) on the top board and U10 (U21 for serial MY53xx6xxx) on the bottom board through the optically isolated (U1 and U2 on the bottom board) (U20 for serial MY53xx6xxx) serial data link. Failure to establish communication in either direction will generate an error. If this condition is detected at power-on self-test, the power supply will beep and the error annunciator will be on.
- 626** **I/O processor failed self-test** This test causes the earth referenced processor U10 (U21 for serial MY53xx6xxx) on the bottom board to execute an internal, ram test. Failure will generate an error.
- 630** **Fan test failed** This test checks if the fan current is flowing. If the current is not detected at power-on self-test, the power supply will beep and the error annunciator will be on.

[1] This error message is only applicable for serial MY53xx6xxx.

- 631** **System DAC test failed** This test checks if the DAC hardware is functional. The main controller U17 (U10 for serial MY53xx6xxx) sends a reference voltage data to DAC and converts the DAC output to digital data to see if the digital data is within a valid range.
- 632** **P6V hardware test failed** This test checks the the status of voltage and current error amplifiers for +6V power circuit. If both amplifiers are not operational, the power supply will beep and the error annunciator will be on.
- 633** **P25V hardware test failed** This test checks the the status of voltage and current error amplifiers for +25V power circuit. If both amplifiers are not operational, the power supply will beep and the error annunciator will be on.
- 634** **N25V hardware test failed** This test checks the the status of voltage and current error amplifiers for -25V power circuit. If both amplifiers are not operational, the power supply will beep and the error annunciator will be on.

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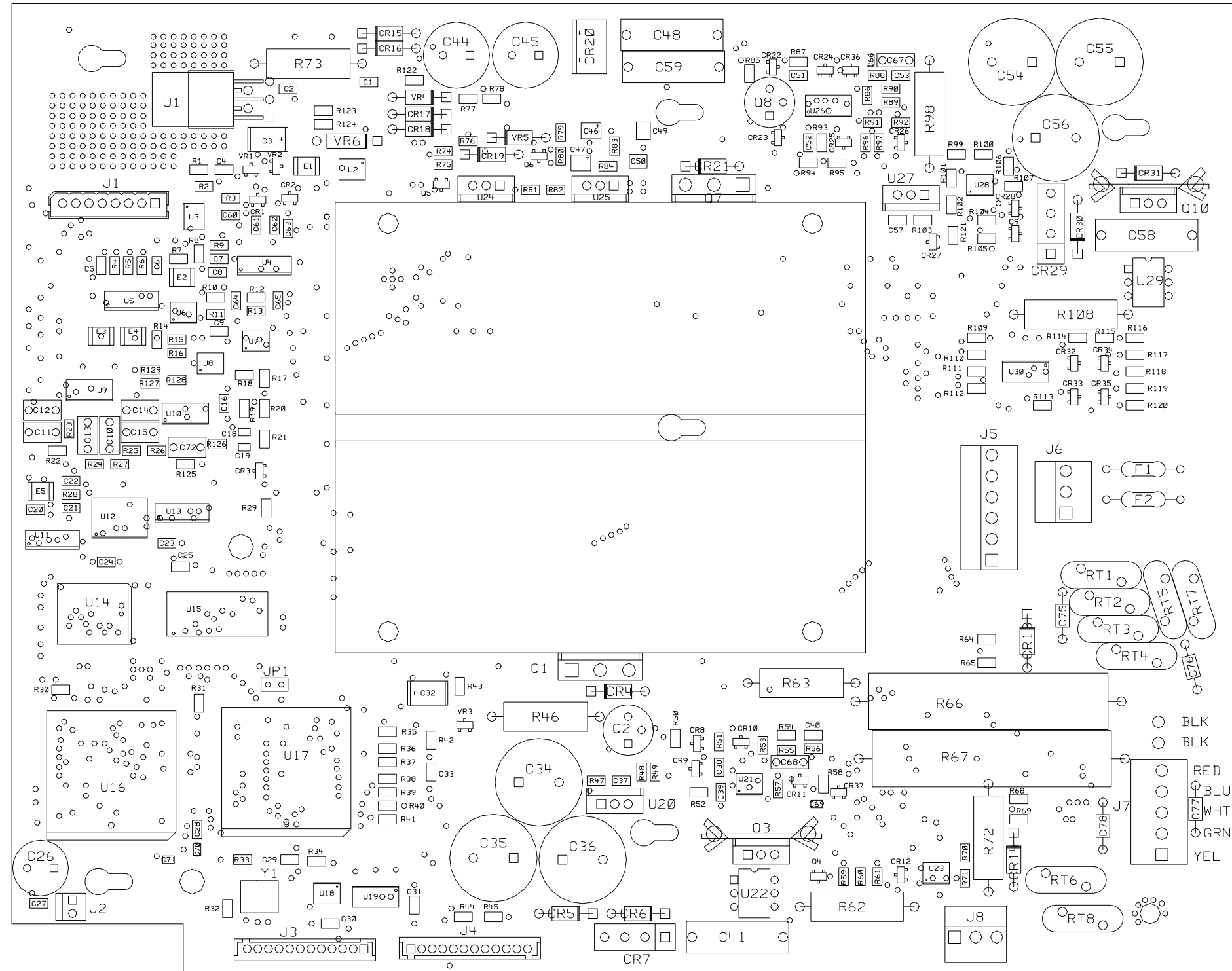
Component Drawings

Component Drawings

This chapter contains component drawings for the power supply. The block diagram is also shown in chapter 4.

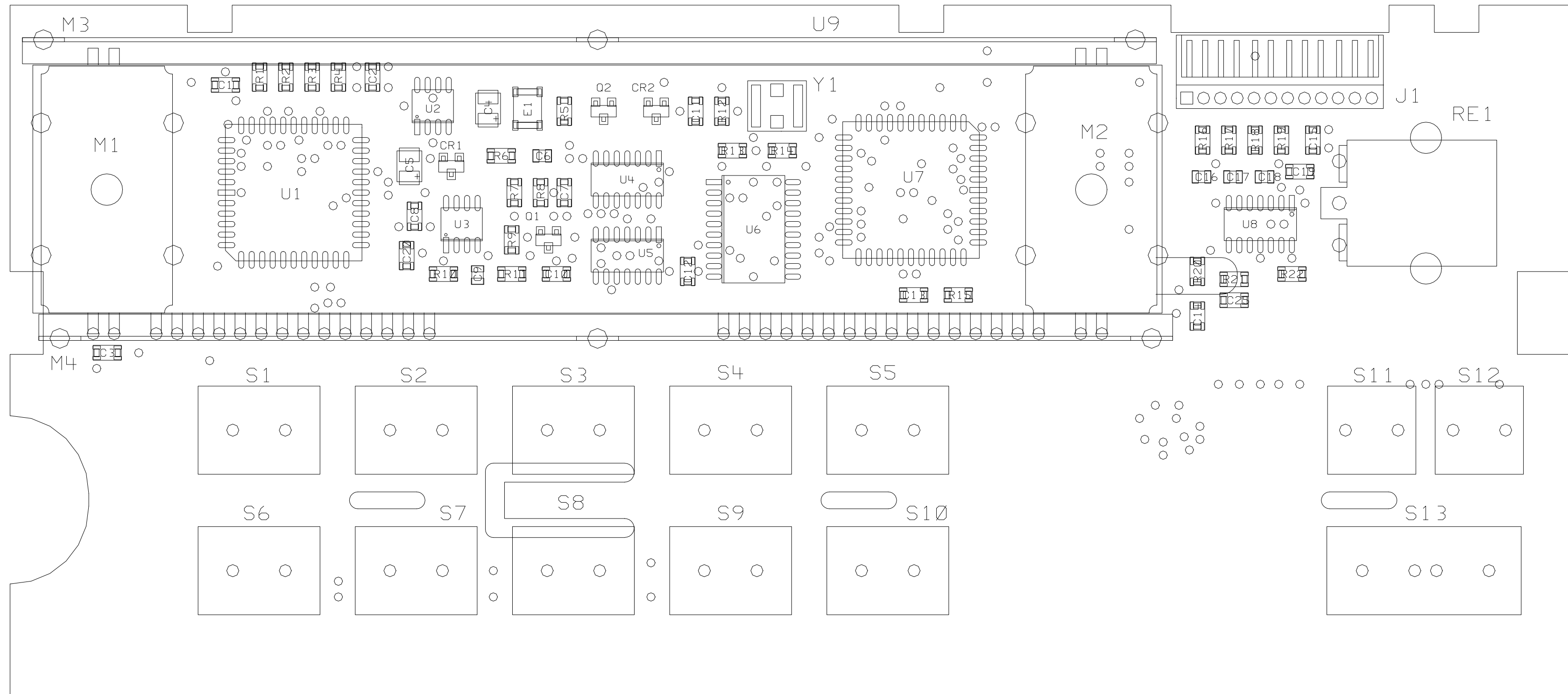
- E3631-60002 Component Locator for the Main Board — Top, page 108
- E3631-60003 Component Locator for the Front Panel, page 109
- E3631-60004 Component Locator for the Main Board — Bottom, page 110
- Component Locator for the Main Board — Top (serial MY53xx6xxx), page 111
- Component Locator for the Front Panel (serial MY53xx6xxx), page 112
- Component Locator for the Main Board — Bottom (serial MY53xx6xxx), page 113

E3631-60002 Component Locator for the Main Board — Top

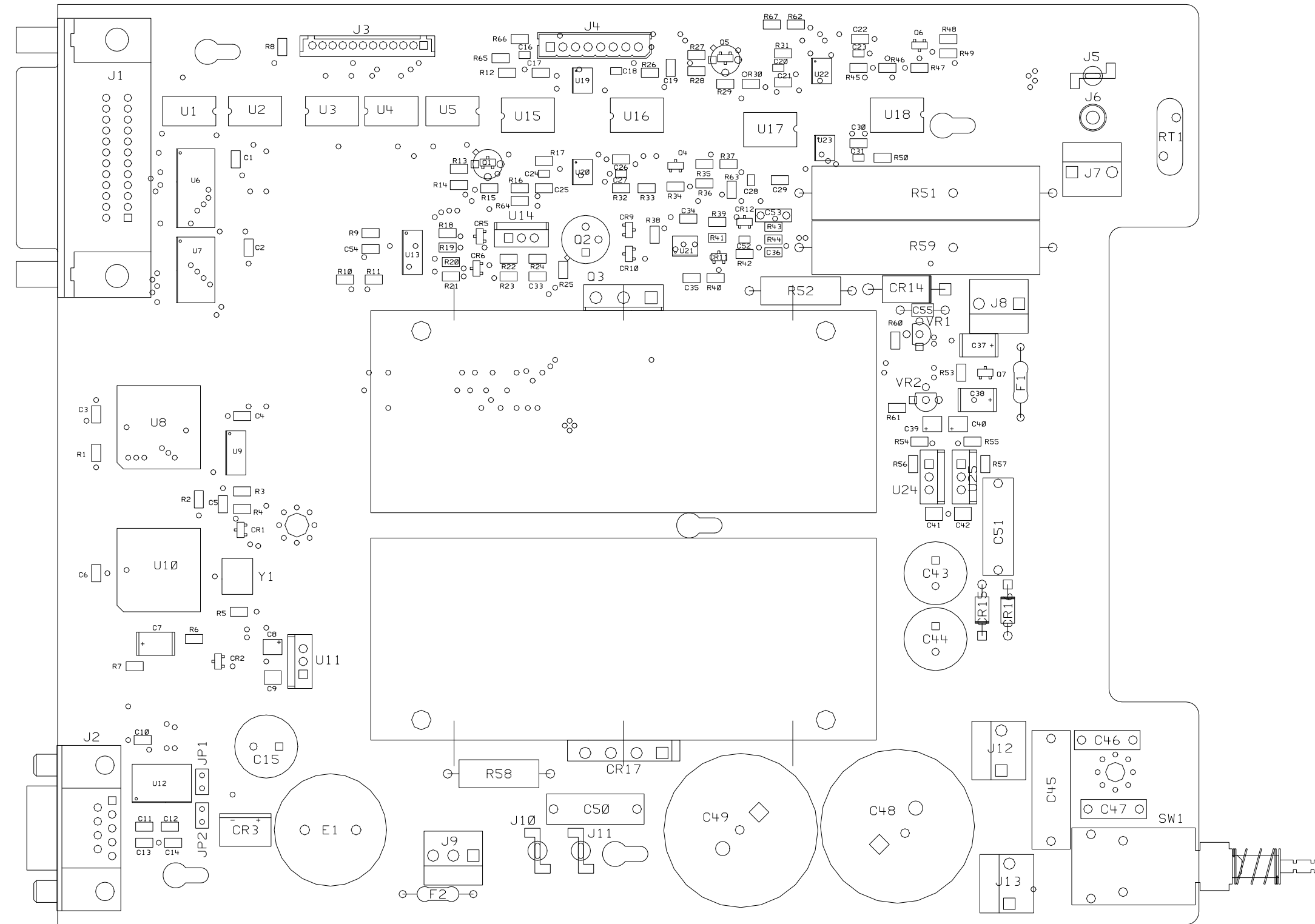


NOT INSERT PARTS (R52, R102, R121, R70, R71, R104, R105, R35, CR27)

E3631-60003 Component Locator for the Front Panel

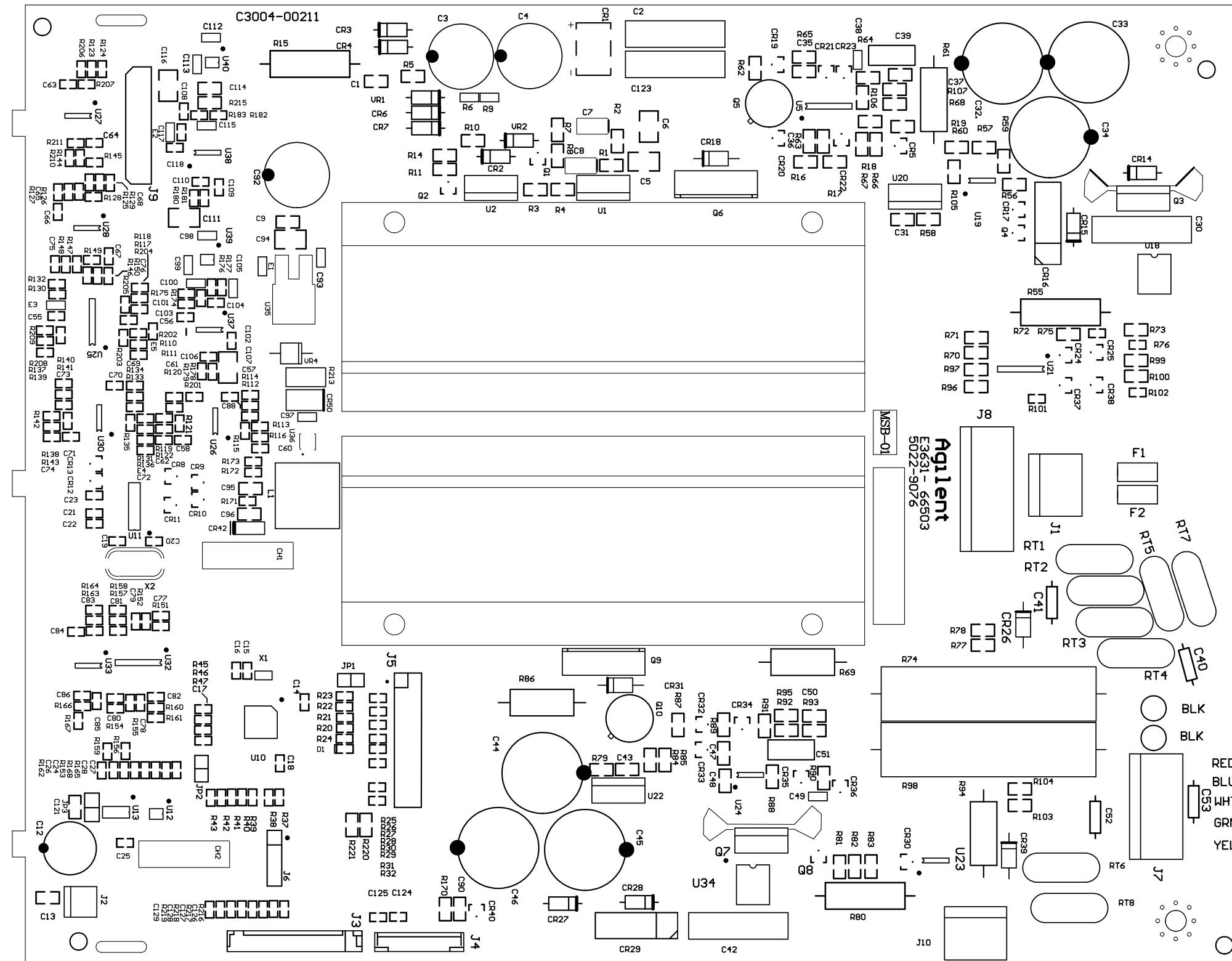


E3631-60004 Component Locator for the Main Board — Bottom

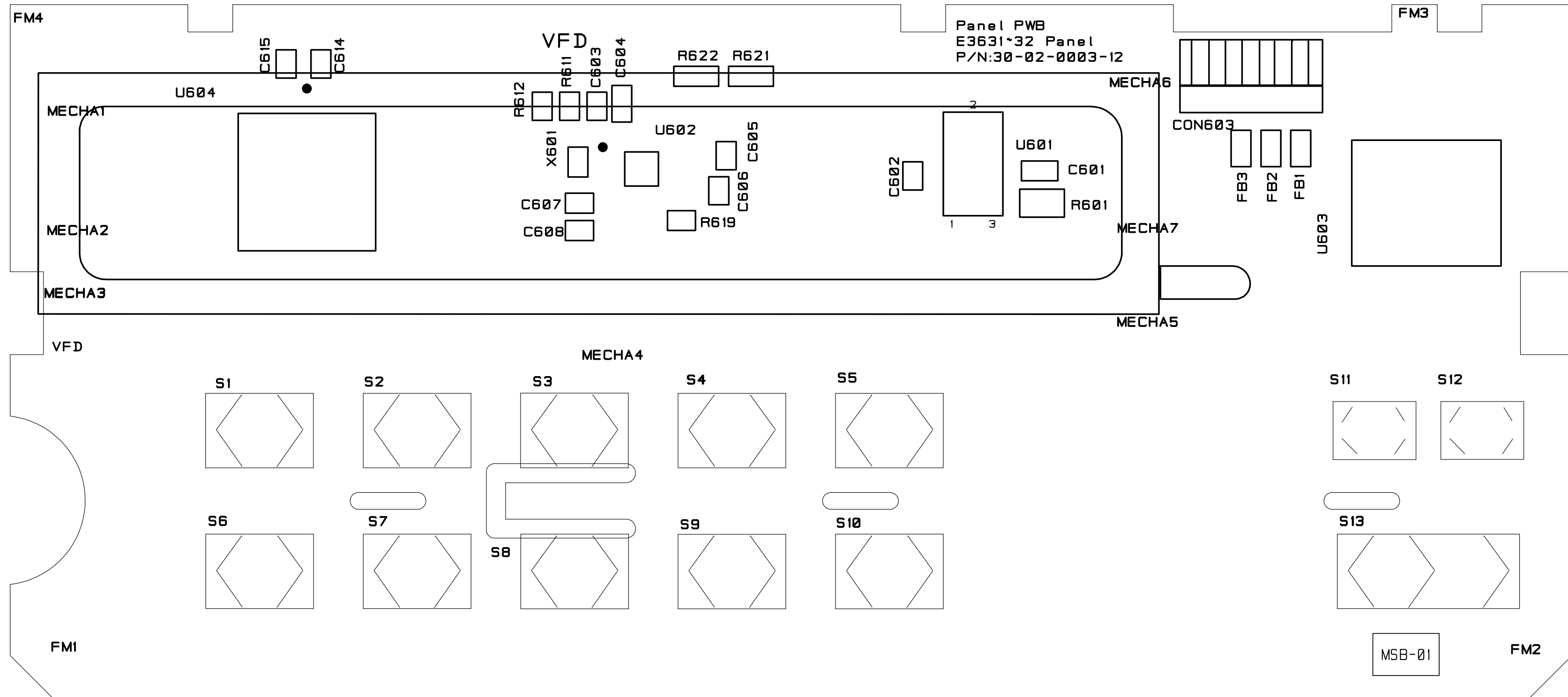


NOT INSERT PARTS (R9, R10, R11, C54, U5)

Component Locator for the Main Board — Top (serial MY53xx6xxx)

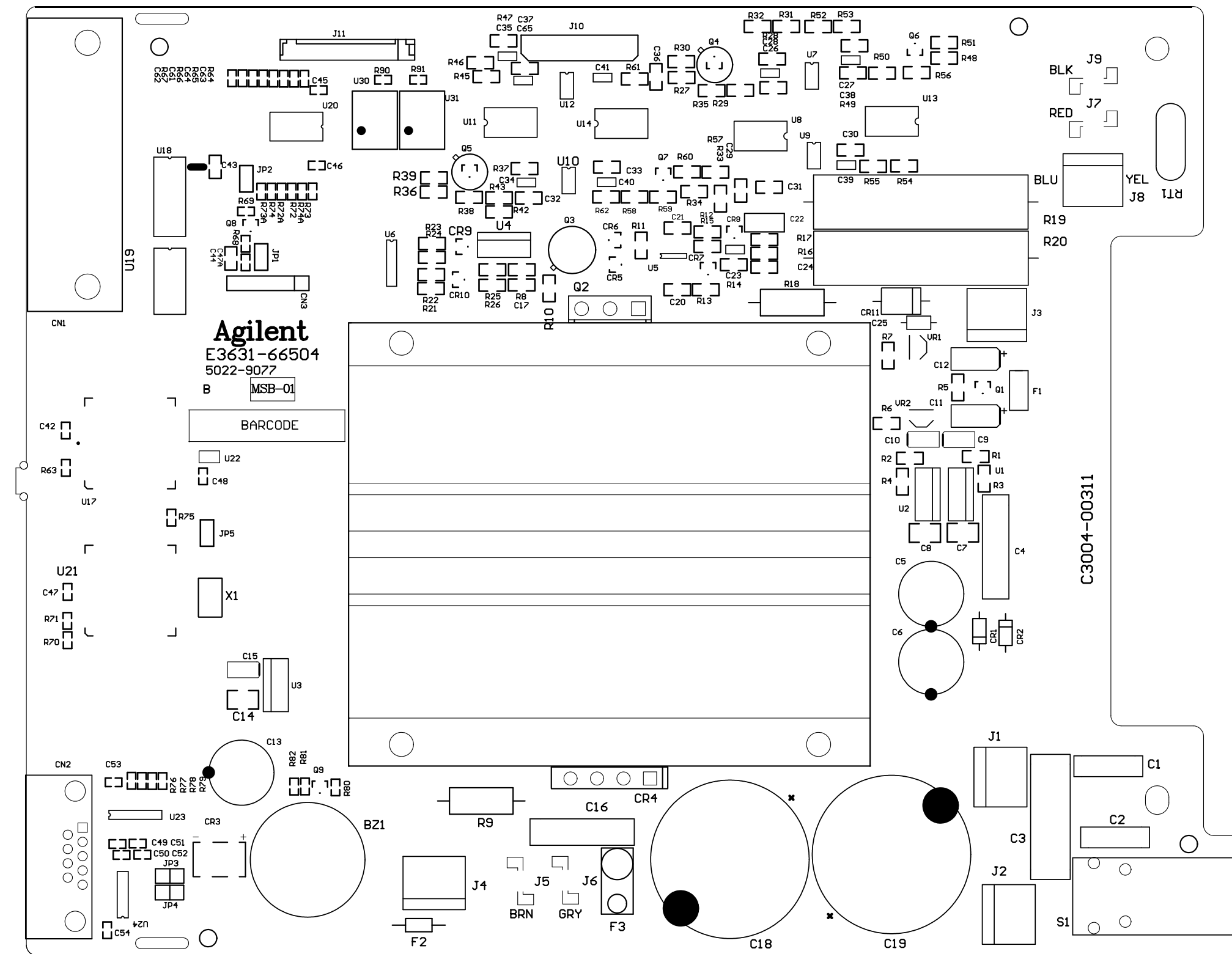


Component Locator for the Front Panel (serial MY53xx6xxx)



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Component Locator for the Main Board — Bottom (serial MY53xx6xxx)



Printing History

Edition 13, November 2014

New editions are complete revisions of the manual. Update packages, which are issued between editions, may contain additional information and replacement pages which you merge into the manual. The dates on this page change only when a new edition is published.

Certification

Keysight Technologies certifies that this product met its published specifications at the time of shipment. Keysight further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology (formerly National Bureau of Standards), to the extent allowed by that organization's calibration facility, and to the calibration facilities of other International Standards Organization members.

Warranty

This Keysight product is warranted against defects in materials and workmanship for a period of one year from date of shipment. Duration and conditions of warranty for this product may be superseded when the product is integrated into (becomes a part of) other Keysight products. During the warranty period, Keysight will, at its option, either repair or replace products which prove to be defective. The warranty period begins on the date of delivery or on the date of installation if installed by Keysight.

Warranty Service

For warranty service or repair, this product must be returned to a service facility designated by Keysight.

For products returned to Keysight for warranty service, the Buyer shall prepay shipping charges to Keysight and Keysight shall pay shipping charges to return the product to the Buyer. However, the Buyer

shall pay all shipping charges, duties, and taxes for products returned to Keysight from another country.

Limitation of Warranty

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by the Buyer, Buyer-supplied products or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

The design and implementation of any circuit on this product is the sole responsibility of the Buyer. Keysight does not warrant the Buyer's circuitry or malfunctions of Keysight products that result from the Buyer's circuitry. In addition, Keysight does not warrant any damage that occurs as a result of the Buyer's circuit or any defects that result from Buyer-supplied products.

To the extent allowed by local law, Keysight makes no other warranty, expressed or implied, whether written or oral with respect to this product and specifically disclaims any implied warranty or condition of merchantability, fitness for a particular purpose or satisfactory quality.

For transactions in Australia and New Zealand: The warranty terms contained in this statement, except to the extent lawfully permitted, do not exclude, restrict, or modify and are in addition to the mandatory statutory rights applicable to the sale of this product.

Exclusive Remedies

To the extent allowed by local law, the remedies provided herein are the Buyer's sole and exclusive remedies. Keysight shall not be liable for any direct, indirect, special, incidental, or consequential damages (including lost profit or data), whether based on warranty, contract, tort, or any other legal theory.

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Safety Information

Do not install substitute parts or perform any unauthorized modification to the product. Return the product to Keysight Sales and Service Office for service and repair to ensure that safety features are maintained.

Safety Symbols

Warning

Calls attention to a procedure, practice, or condition, that could possibly cause bodily injury or death.

Caution

Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.

Warning

No operator serviceable parts inside. Refer servicing to service-trained personnel.

Warning

For continued protection against fire, replace the line fuse only with a fuse of the specified type and rating.



Caution, risk of danger (refer to this manual for specific Warning or Caution information)



Direct current (DC)



Alternating current (AC)



Protective conductor terminal



Out position of a bi-stable push control



In position of a bi-stable push control



Earth (ground) terminal



Positive binding post



Negative binding post



Frame or chassis terminal

Regulatory Markings



ISM 1-A

The CE marking is a legal compliance marking of the European Community. This CE marking shows that the product complies with all the relevant European Legal Directives.



This symbol indicates the time period during which no hazardous or toxic substance elements are expected to leak or deteriorate during normal use. Forty years is the expected useful life of the product.



N10149

The C-tick mark is a registered trademark of the Spectrum Management Agency of Australia. This signifies compliance with the Australia EMC Framework regulations under the terms of the Radio Communication Act of 1992.



This symbol is a South Korean Class A EMC Declaration. This is a Class A instrument suitable for professional use and in electromagnetic environment outside of the home.

ICES/NMB-001

ICES/NMB-001 indicates that this ISM device complies with the Canadian ICES-001. Cet appareil ISM est conforme à la norme NMB-001 du Canada.



This instrument complies with the WEEE Directive (2002/96/EC) marking requirement. This affixed product label indicates that you must not discard this electrical or electronic product in domestic household waste.



The CSA mark is a registered trademark of the Canadian Standards Association.

www.keysight.com

Contact us

To obtain service, warranty, or technical assistance, contact us at the following phone or fax numbers:

United States:

(tel) 800 829 4444 (fax) 800 829 4433

Canada:

(tel) 877 894 4414 (fax) 800 746 4866

China:

(tel) 800 810 0189 (fax) 800 820 2816

Europe:

(tel) 31 20 547 2111

Japan:

(tel) 0120 (421) 345 (fax) 0120 (421) 678

Korea:

(tel) (080) 769 0800 (fax) (080) 769 0900

Latin America:

(tel) (305) 269 7500

Taiwan:

(tel) 0800 047 866 (fax) 0800 286 331

Other Asia Pacific Countries:

(tel) (65) 6375 8100 (fax) (65) 6755 0042

Or visit the Keysight World Wide Web at:

www.keysight.com/find/assist

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Edition 13, November 2014



E3631A-90011
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