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DMM6500 in a Keysight 34401A Application

Emulation and Migration Guide

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Introduction

Thank you for choosing a Keithley Instruments product. This document provides information about using the DMM6500 as a drop-in replacement in a Keysight 34401A test system application, and also provides a guide to migrating from a Keysight 34401A to a DMM6500 in native mode.

The DMM6500 provides greater functionality and improved accuracy over the Keysight 34401A. However, established customer test systems can be sustained after replacement without significant reconfiguration and code changes by using emulation mode.

Emulation mode is intended primarily for remote command operation. You can use the DMM6500 SCPI 34401 command set to emulate a Keysight 34401A, but you will not have access to the full range of features available in its native mode. In addition, the options that you can set from the front panel are more limited than the front-panel options on the DMM6500.

This guide describes:

- How to configure the DMM6500 for emulation mode.
- The hardware interface differences between the Keysight 34401A and the DMM6500.
- The software differences between SCPI 34401 on the DMM6500 and the standard SCPI command set available on the Keysight 34401A product.
- Application examples that provide insight into migrating from Keysight 34401A emulation to DMM6500 standard SCPI commands.

Comparison of key features

Although new functions and features are supported in native mode, the emulation mode will restrict you to legacy instrument features. The DMM6500 standard SCPI command set lets you access new measurement functions, ranges, and data analysis tools. See Updating your code to use DMM6500 SCPI commands (on page 9) for more information.

The following table is a comparison of key features between the instruments.

	DMM6500	**Keysight 34401A**
Resolution	6 ½ digits	6 ½ digits
DMM input terminals	Front and rear	Front and rear
Plug-in module slots and channels	Single slot, up to 10 independent channels	N/A
Module cards supported	2000-SCAN, 2001-TCSCAN	N/A
Reading capacity	7M	512
Non-volatile memory	No	Yes
Basic DCV accuracy	25 ppm / 1 year; 30 ppm / 2 year	35 ppm / 1 year
Measurements		
DCV, ACV (ranges)	Same	
DCI (ranges)	10 µA, 100 µA, 1 mA, 10 mA, 100 mA, 1 A, 3 A, 10 A	10 mA, 100 mA, 1 A, 3 A
ACI (ranges)	100 µA, 1 mA, 10 mA, 100 mA, 1 A, 3 A, 10 A	1 A, 3 A
Temperature	Thermocouple, RTD, thermistor	N/A
Diode	10 V clamp (10 µA, 100 µA, 1 mA, and 10 mA test currents)	1 V clamp (1 mA)
Capacitance	1 nF, 10 nF, 100 nF, 1 µF, 10 µF, 100 µF	N/A
Digitizer	Up to 1 MS/s voltage or current	N/A
Resistance (lowest ranges)	1 Ω, 10 Ω, 100 Ω	100 Ω
PC interfaces	USB/LAN-LXI (standard) GPIB/RS-232/TSP-Link (optional)	GPIB/RS-232 (standard)
USB flash drive support	Yes	No
Mechanical size (for rack mounting)	2U, ½ rack	
	14.039 in. (356.6 mm) deep	13.713 in. (348.3 mm) deep
Measurement accuracy and resolution	The datasheet for each model provides specifications. See the Keithley Instruments website.	

Select the SCPI command set for emulation mode

To use the DMM6500 as a drop-in replacement in an existing Keysight 34401A application, you must use the SCPI 34401 command set. This command set includes most of the commands that are available in the Keysight 34401A product.

You can select the SCPI 34401 command set from the front panel or over the remote interface.

When you change to the SCPI 34401 command set, you must reboot the instrument. You will be prompted by the front panel to reboot, but you will not be prompted if using remote commands.

Using the front panel:

1. Press the **MENU** key.
2. Under System, select **Settings**.
3. Select the button next to Command Set.
4. Select **SCPI 34401**. You will be prompted to reboot.
5. Select **OK**.

Using SCPI or TSP remote commands:

Send the command:

```
*lang SCPI34401
```

Reboot the instrument.

Identify the DMM6500 when using the SCPI 34401 command set

To ensure a level of compatibility in querying for the identification string of the instrument, when set to use the SCPI 34401 command set, the DMM6500 will return the following text string:

```
KEITHLEY INSTRUMENTS INC.,34401A,<serial_number>,<firmware_version>
```

The manufacturer will always be set to "Keithley Instruments Inc.", and is not configurable to report the manufacturer as "Keysight", "Agilent", or "Hewlett-Packard".

Front-panel operation with the SCPI 34401 command set

When the SCPI 34401 command set is selected, the options available through the front panel are limited. Emulation mode is intended primarily for remote command operation.

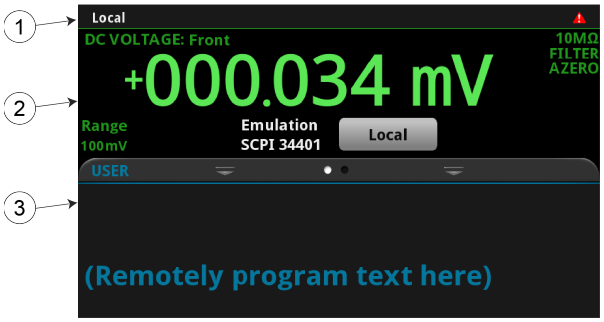
The following topics describe the options that are available when the SCPI 34401 command set is selected.

Home screen display

When the SCPI 34401 command set is selected, you can select the User, Channel, and Functions swipe screens.

The options available on the Home screen are described here.

Figure 1: Home screen when the SCPI 34401 command set is selected



#	Screen element	Description
1	**System status and event indicators**	Located at the top of the Home screen. These indicators provide information about the present state of the instrument. Some of the indicators open up a dialog box with more information or a settings menu when selected.
2	**MEASURE view area**	Green part of the Home screen; displays the value of the present measurement.
3	**Swipe screen area**	Blue part of the Home screen. It displays the User and Functions options. If the rear terminals are selected, Channel options are available.

Status and error indicators when the SCPI 34401 command set is selected

The indicators at the top of the Home screen contain information about instrument settings and states. Some of the indicators also provide access to instrument settings.

Figure 2: Status and error indicators — SCPI 34401

The communications indicator is at the left. The options you might see here include:

Indicator	Meaning
Local	Instrument is controlled from the front panel.
GPIB	Instrument is communicating through a GPIB interface.
RS-232	Instrument is communicating through an RS-232 interface.
TCPIP	Instrument is communicating through a LAN interface.
VXI-11	Instrument is communicating using VXI-11.
USBTMC	Instrument is communicating through a USB interface.
Telnet	Instrument is communicating through Telnet.

The communications indicator displays the type of communications the instrument is using. Select the indicator to display the present communications settings. Select **Change Settings** at the bottom of the dialog box to open the System Communications screen, where you can change the settings.

There is an activity indicator next to the communications indicator. When the instrument is communicating with a remote interface, the up and down arrows flash.

If a service request has been generated, `SRQ` is displayed to the right of the up and down arrows. When this indicator is on, a service request has been generated. This indicator stays on until the serial poll byte is read or all the conditions that caused SRQ are cleared.

The system event indicator is on the far right side of the instrument status indicator bar. This indicator changes based on the type of event that occurred.

Press the indicator to open a message screen with a brief description of the error, warning, or event. Press the Event Log button to see the System Events screen, which contains more detailed descriptions of the events and options for controlling the types of error events that are displayed on the front panel.

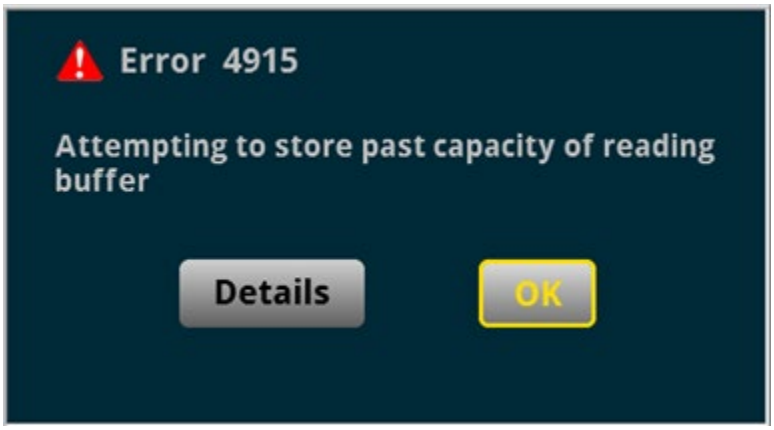
The following table describes the different event indicators and what they mean.

Icon	Description
	An empty triangle means that no new events were logged in the event log since the last time you viewed the event log.
	A blue circle means that an informational event message was logged. The message is for information only. This indicates status changes or information that may be helpful. If the Log Command option is on, it also includes commands.
	A yellow triangle means that a warning event message was logged. This message indicates that a change occurred that could affect operation.
	A red triangle means that an error event message was logged. This may indicate that a command was sent incorrectly.

Event messages

During operation and programming, front-panel messages may be displayed. Messages are information, warning, or error notifications.

Figure 3: Example front-panel error message



Menus when the SCPI 34401 command set is selected

When the SCPI 34401 command set is selected, the only menu available from the front panel is the System Settings menu.

System Settings menu when the SCPI 34401 command set is selected

The System Settings menu is available when the SCPI 34401 command set is selected. The options are the same as the options when the other command sets are selected, except that the TSP-Link options in the Communication menu are not available.

Figure 4: Main menu when the SCPI 34401 command set is selected

Keysight 34401A to DMM6500 hardware interface differences

The following topics detail the differences between the hardware connections used for the Keysight 34401A and the interfaces provided for the DMM6500.

Remote interfaces

The Keysight 34401A was supplied with both GPIB and RS-232 as standard interfaces. The DMM6500 is supplied with USB and Ethernet as standard interfaces. The instrument also supports GPIB and RS-232 with optional communication accessory modules.

The following communication accessory modules are available for the DMM6500. These modules are designed for user installation, and do not require the DMM6500 to be shipped to Keithley Instruments for service or adjustment.

- KTTI-GPIB – Communication and Digital I/O Accessory
- KTTI-RS232 – Communication and Digital I/O Accessory

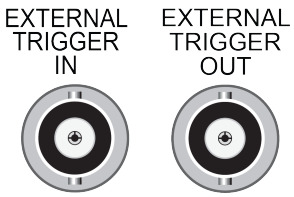
For more information about the communication accessory cards (such as configuration through the front panel and over the remote interface), visit tek.com/keithley (http://www.tek.com/keithley).

Trigger Link and external trigger and voltmeter support

The Keysight 34401A provides two BNC connectors on the rear panel for sending and receiving trigger pulses. The voltmeter complete output and external trigger input signals are supported by the VM COMP and EXT TRIG connectors,

The DMM6500 also supports the external trigger input and voltmeter complete signals. See the next figure.

Figure 5: DMM6500 external trigger connections



When using the SCPI 34401 command set, the DMM6500 trigger signal for voltmeter complete output is sent to the EXTERNAL TRIGGER OUT connector. External trigger input signals are received through the EXTERNAL TRIGGER IN connector.

Keysight 34401A to DMM6500 software differences

You can use existing code from a Keysight 34401A application with a DMM6500. Apart from the exceptions noted in this section, Keysight 34401A emulation for the DMM6500 supports all SCPI commands that are supported by the 34401A.

Details about these differences and other commands that operate differently are described in the following sections.

If a command is not listed in this section, you can use the command in the same way that you did for the Keysight 34401A. See the original Keysight 34401A documentation for details.

SCPI 34401 overview and general exceptions

When you apply the SCPI 34401 command and set, the DMM6500 operation matches Keysight 34401A operation. Commands run as described and have the same defaults as listed in the original Keysight 34401A User Manual. However, the following exceptions may affect your test system performance:

- Commands run faster than on the Keysight 34401A.
- Measurements are acquired at the same speed or faster than on a Keysight 34401A.
- Error numbers generated in emulation mode (using the SCPI 34401 command set) may not match the original product.

The following items are additional general exceptions when you select the SCPI 34401 command set.

Item	Exception
Auto delay	The auto delay times are derived from hardware design and therefore may not be the same as on the Keysight 34401A. Querying the auto delay duration is not supported, and will return zero seconds.
Bandwidth	The DMM6500 will use a bandwidth of 30 Hz when the 20 Hz bandwidth is selected, and will use a bandwidth of 300 Hz when the 200 Hz bandwidth is selected.
Calibration	Not supported.
Continuity	The continuity tone is disabled when the beeper is turned off.
Display text data	When selected, this will appear on the User swipe screen of the Home screen.
Emulation of other instruments	While the Keysight 34401A can emulate other instruments, this functionality is not supported on the DMM6500 in SCPI 34401 mode.
Frequency and period aperture	The DMM6500 will accept values up to 1 s, but will use only up to 250 ms. The Keysight 34401A allows an aperture of up to 1 s.
Frequency and period threshold range	The Keysight 34401A maximum range value is 1000 V. The DMM6500 maximum is 700 V.
Front panel defaults	The DMM6500 does not support front panel defaults that differ from remote bus command defaults.
Limits	The beeper is not supported for limit testing. Limit annunciators (indicators on the front panel display) are not implemented.
MIN/MAX/DEF	Commands that accept the MIN or MAX parameter will also accept the DEF parameter.
Nonvolatile storage	Settings are not stored when you turn off the DMM6500. The instrument reverts to defaults when the instrument is turned on.
Ratio measurements	The voltage on the SENSE terminals is limited to 10 V when making VOLTage:DC:RATio measurements.

SCPI 34401 command set exceptions

The following are command set exceptions for the Keysight SCPI 34401 command set when used on the DMM6500.

Keysight 34401A command	Exceptions
`*PSC`	Not supported.
`*TST?`	Not supported. This command will return 0 (passed).
`[:SENSe[1]]:FREQuency:APERture`	If this command generates an error, the error is logged twice.
`[:SENSe[1]]:FREQuency:VOLTage:RANGe <n>`	The maximum range is 700 V. Accepts higher values, but the range will be set to 700 V. The set value is accepted and stored for later query.
`[:SENSe[1]]:PERiod:APERture`	If this command generates an error, the error is logged twice.
`[:SENSe[1]]:PERiod:VOLTage:RANGe <n>`	The maximum range is 700 V. Accepts higher values, but the range will be set to 700 V. The set value is accepted and stored for later query.
`[:SENSe[1]]:VOLTage:AC: RANGe <n>`	The maximum range is 700 V. Accepts higher values, but the range will be set to 700 V. The set value is accepted and stored for later query. The Keysight 34401A product maximum is ± 1000 V.
`DISPlay:TEXT <a>`	When enabled, text will appear on line 1 of the user swipe screen.
`:L2` `:L3`	Not supported.
`SYSTem:RWLock`	Not supported.

Updating your code to use DMM6500 SCPI commands

The DMM6500 standard SCPI command set lets you access new measurement functions, ranges, and data analysis tools. However, these new features are not available when using the SCPI 34401A command set, and you cannot run more than one command set at once.

To access these new features, you can modify your existing SCPI code to use the DMM6500 standard mode SCPI commands. The examples in this section detail the code changes you can make to the SCPI 34401A command set applications in the previous section.

You may need to make changes so that this code will run in your programming environment. In the following command tables, the SCPI commands have a light gray background. The light green shaded code represents pseudocode that will vary depending on the programming environment you use.

For more information on the functions and features available on the DMM6500, see the DMM6500 specification, available from tek.com/keithley (http://www.tek.com/keithley).

Example 1 - Single-point DC current measurement

This example performs the following operations:

- Resets the unit and clears event register bits
- Places the unit in DC current measurement mode in the fixed 1 A range with 1 µA of resolution

Keysight 34401A SCPI commands	DMM6500 SCPI commands
*RST	*RST
*CLS	*CLS
MEASURE:CURRENT:DC? 1A,0.001MA	SENS:FUNC "CURR:DC"
	SENS:CURR:DC:RANG 1
	DISP:CURR:DC:DIG 6
	SENS:CURR:DC:NPLC 1
	READ?

Example 2 - Single-point DC voltage measurement with status and error checking

This example performs the following operations:

- Resets the unit and clears the event bits
- Configures the instrument for DC voltage measurement with autoranging applied
- Sets the trigger and sample count values
- Queries the instrument for the measurement

Keysight 34401A SCPI commands	DMM6500 SCPI commands
*RST	*RST
*CLS	*CLS
CONF:VOLT:DC	SENS:FUNC "VOLT:DC"
	SENS:VOLT:DC:RANG:AUTO ON
	SENS:VOLT:DC:NPLC 1
	DISP:VOLT:DC:DIG 6
TRIG:SOUR IMM	
TRIG:DEL:AUTO ON	
TRIG:COUN 1	
SAMP:COUN 1	
READ?	READ?
SYST:ERR?	SYST:ERR?

Example 3 - Use an external trigger signal to start a series of DC voltage measurements

This example performs the following operations:

- Resets the instrument and clears the event register bits
- Configures the instrument for DC voltage measurement with a fixed range
- Configures the instrument to respond to five external trigger signals, each starting a series of ten measurements
- Auto-zeroes the instrument once prior to the start of measurements to remove any offset at the input terminals
- Initiates the trigger model
- Queries the instrument to return all 50 readings

Keysight 34401A SCPI commands	DMM6500 SCPI commands
*RST	*RST
*CLS	*CLS
CONF:VOLT:DC:10.0 V,10mV	SENS:FUNC "VOLT:DC"
	SENS:VOLT:DC:RANG 10
	SENS:VOLT:DC:NPLC 1
	DISP:VOLT:DC:DIG 6
TRIG:SOUR EXT	
TRIG:DEL:AUTO 0.0000	
TRIG:COUN 5	
SAMP:COUN 10	
ZERO:AUTO ONCE	SENS:VOLT:DC:AZER ON
	TRIG:LOAD "Empty"
	TRIG:BLOC:WAIT 1, EXT
	TRIG:BLOC:DEL:CONS 2, 0.0
	TRIG:BLOC:MDIG 3, "defbuffer1", 10
	TRIG:BLOC:BRAN:COUN 4, 5, 1
INIT	INIT
	*WAI
FETCH?	FETCH?

Example 4 - Read back calculated values

This example performs the following operations:

- Resets the instrument and clears the event register bits
- Configures the instrument for 2-wire resistance with a fixed range
- Configures the trigger and sample count values
- Auto-zeroes the instrument once prior to the start of measurements to remove any offset at the input terminals
- Initiates calculations on the buffer readings
- Queries the instrument to return all 20 readings as well as the average, minimum, and maximum values

Keysight 34401A SCPI commands	DMM6500 SCPI commands
*RST	*RST
*CLS	*CLS
CONF:RES 1000.0, 0.01	SENS:FUNC "RES"
	SENS:RES:RANG 1000.0
	SENS:RES:NPLC 1
	DISP:RES:DIG 6
TRIG:SOUR IMM	
TRIG:DEL:AUTO 0.0000	
TRIG:COUN 1	
SAMP:COUN 20	
ZERO:AUTO ONCE	SENS:RES:AZER ON
	TRAC:CLE
CALC:FUNC AVER;STAT ON	
DATA:FEED RDG_STORE, "CALC"	
	TRIG:LOAD "SimpleLoop", 20, 0
	INIT
	*WAI
READ?	TRAC:DATA?
CALC:AVER:AVER?	TRAC:STAT:AVER?
CALC:AVER:MIN?	TRAC:STAT:MIN?
CALC:AVER:MAX?	TRAC:STAT:MAX?