Replacing the Agilent 34401A in Your Test System with the New Agilent 34410A and 34411A High-Performance Digital Multimeters

Application Note



Contents

Introduction	1
Overview - Comparing the DMMs	2
The 34401A Compatibility Mode	3
34410A/34411A Operating Differences	5
Electrical and Mechanical Compatibility	9
Conclusion	10

Introduction

The Agilent 34410A and 34411A represent the latest generation of 6½-digit multimeters from Agilent Technologies. These new DMMs build upon the phenomenal success of the industry-standard Agilent 34401A and have significantly enhanced functionality for bench and system users. Expanded ranges and accuracy, significantly faster measurement and system speeds along with added functions such as capacitance, temperature, and peak detection capability provide the ability to measure more complex signals.

This application note explains how to migrate from the Agilent 34401A to the new Agilent 34410A and 34411A digital multimeters. We will answer questions such as: "Will these new DMMs drop into my application and run? Is there some compatibility switch? What functionality is the same? What is different? How are these two new DMMs superior in performance to the 34401A?" Topics will include feature comparisons, 34401A emulation mode, measurement speed comparisons, programming/ interfacing differences, and electrical/mechanical differences. For a closer look at how to get the most performance out of the new Agilent DMMs, please refer to Application Note 5989-4039EN, Agilent 34410A/ 34411A 6½-Digit High-Performance Multimeters.

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Overview - Comparing the DMMs
The easiest way to understand the differences between the Agilent 34401A and the 34410A/34411A is to perform a side-by-side comparison. Since the 34411A capabilities are a superset of the 34410A capabilities, the additional 34411A capabilities are called out separately in the table below. The table is organized to present key features and to call out differences in bold:

Table 1 DMM Comparison

	Key 34401A features		Key 34410A features	
DC functions and ranges	DC voltage	100 mV to 1000 V	DC voltage	100 mV to 1000 V
	DC accuracy	35 ppm	DC accuracy	**30 ppm**
	DC current	10 mA to 3 A	DC current	**100 uA** to 3 A
	2 W/4 W resistance	100 Ω to 100 MΩ	2 W/4 W resistance	100 Ω to **1 G**Ω
	Continuity	1000 Ω 1 mA	Continuity	1000 Ω 1 mA
	Diode test	1 V 1 mA	Diode test	1 V 1 mA
	DC:DC ratio	**100 mV to 1000 V**	Not supported	
			Capacitance	**1 nF to 10 uF**
			Temperature	**2/4-wire RTD and thermistor**
			Real-time peak measurements	
			Offset compensated ohms	
AC functions and ranges	True RMS AC voltage	100 mV to 750 V 3 Hz to 300 kHz	True RMS AC voltage	100 mV to 750 V 3 Hz to 300 kHz
	True RMS AC current	1 A to 3 A 3 Hz to 5 kHz	True RMS AC current	**100 uA** to 3 A 3 Hz to **10 kHz**
	Frequency and period	100 mV to 750 V 3 Hz to 300 kHz	Frequency and period	100 mV to 750 V 3 Hz to 300 kHz
DC system throughput	6.5 digits	6 readings/s	6.5 digits	**1,000 readings/s**
	5.5 digits		5.5 digits	**10,000 readings/s**
	4.5 digits	1,000 readings/s	4.5 digits (34411A)	**50,000 readings/s**
AC system throughput	6.5 Digits	50 readings/s	6.5 digits	**500 readings/s**
Triggering and reading storage	External trigger latency	<1 ms	External trigger latency	**<1 µs**
	External trigger jitter	<500 µs	External trigger jitter	**<1 µs**
	Count + delay pacing		Count + delay pacing	
			Precision sample timer	
			Analog level trigger (34411A)	
			Pre-post triggering (34411A)	
	Volatile reading storage	512	Volatile reading storage **(34411A)**	**50,000 1,000,000**
			Non-volatile reading storage	**50,000**
I/O and connectivity	GPIB, **RS232**		GPIB, **LAN, USB 2.0**	
	ASCII formatted readings		ASCII or **binary formatted readings**	
			Built-in Web server Data logging to non-volatile memory	
	LabVIEW, IVI drivers, and IntuiLink DMM		LabVIEW™, IVI drivers, and IntuiLink DMM	
	Primary measurement front panel display		**Dual display and support for simultaneous measurements on second display**	

There is a common theme you can pick out of this table – the Agilent 34410A / 34411A 6½-digit multimeters have significant improvements over the Agilent 34401A in the following areas:

- Faster measurement speeds
- Faster system throughput
- Additional functions and ranges
- Expanded reading storage and triggering
- Simultaneous measurements with dual display
- Standard computer I/O interfaces and Web server

The new DMMs offer an easy to use front panel with context-sensitive setup, non-volatile data logging, and high visibility of the dual display. These system-ready instruments are fast and easy to program.

34401A Compatibility Mode

The Agilent 34410A and 34411A multimeters provide an enhanced SCPI command set that is backward-compatible with the Agilent 34401A multimeter. There is also a compatibility mode for the 34401A that will be discussed shortly.

Because of the added features and enhanced performance of the Agilent 34410A/11A, there are some issues that may prevent your 34401A program from running identically on the 34410A/11A in its normal SCPI mode. These include different range selections, resolution selections, command execution speed, overlapping command execution, and other differences to be discussed later in this document.

Even if your existing Agilent 34401A were suddenly able to run 10 times faster than before, you would likely have to make changes to your test programs. This occurs naturally when programmers are putting together test programs, and they are empirically determining how to make their tests functional.

For example, suppose you have the following sequence of commands in your test program:

- Set up the DMM for a particular measurement
- Close channel on the switch unit
- Initiate measurement on DMM

With a DMM that executes its commands 10 times faster than before, the measurement may actually begin before the switch is closed or before the input has settled to a stable level. Here are several ways to address this issue:

- Add delays after closing the channel
- Set up of the DMM after closing the channel (acts like a delay)
- Use a channel query on the last channel closed to make sure it is closed: “ROUTE: CLOSE?” command
- Set up the DMM to trigger on a channel closed signal from the switch unit

As you can see, timing issues alone can cause you to re-write your test program. Some of the above suggestions have their own complications. For example, setting up the DMM after closing the channel still may not provide enough delay if the DMM can execute the commands faster than the switch closure.

The best way to ensure that you can run your existing 34401A program on the 34410A/11A, is to use the *34401A compatibility mode*. In this mode, the SCPI syntax follows the 34401A, as described in the *Agilent 34401A User's Guide*, rather than the native 34410A or 34411A SCPI syntax. The compatibility mode can be selected using the following command:

SYSTem:LANGuage "34401A"

NOTE: The Agilent 34401A Compatibility Mode is a programmatic operation only. Due to enhancements in functionality between the 34401A and the new 34410A/11A, the front panel will remain "locked," and you only can regain control of the front panel by choosing to terminate the compatibility mode from the front panel. Web server operation is similar in that you will be limited to observe mode only, so you only can view current DMM configurations and look at reading memory. You only can terminate compatibility mode from the front panel or programmatically from one of the I/O interfaces using:

SYSTem:LANGuage "34410A"

When the 34401A *compatibility mode* has been selected, SCPI commands will run syntactically the same as the SCPI commands described in the *Agilent 34401A User's Guide*. In fact, the instrument even returns the identification string for a 34401A when you execute "*IDN?." So, in most cases, you would only be concerned with how fast the 34410A/11A DMMs execute commands and measurements compared to the 34401A. However, there are some other differences that are noted below:

1. The 34410A/11A-specific commands can be issued while in the 34401A compatibility mode. For example, "VOLT:NPLC? MIN" would return "0.02" in 34401A compatibility mode, and would return "0.006" when issued in 34410A mode. Sending "VOLT:NPLC 0.006" while in 34401A compatibility mode is an error. However, sending "VOLT:APER100e-6" will work when you are in 34401A compatibility mode. This gives you a clever way to increase the sample rate of your "34401A" without changing anything else in your test program.
2. Several commands have been added specifically for backward compatibility. These commands have been replaced with per-function commands but are mapped to their prior functionality when you are using the compatibility mode. Refer to the next section, 34410A/11A Operating Differences, for more information.

   CALCulate:NULL:OFFSet

   INPut:IMPedance:AUTO

   [SENSe:]DETector:BANDwidth

   [SENSe:]ZERO:AUTO

3. The 34410A/11A hardware does not implement the DC:DC ratio feature. Therefore, the following commands are not implemented:

   CONFigure:VOLTage:DC:RATio

   MEASure:VOLTage:DC:RATio?

   [SENSe:]FUNCtion "VOLTage:DC:RATio"

4. The 34410A/11A DMMs do not allow you to modify the threshold setting for continuity measurements. It is fixed at 10 ohms.
5. The 34410A/11A DMMs do not allow you to modify the sensitivity setting for the touch-hold feature. It is fixed at 0.1% of current range.
6. The 34410A/11A hardware does not provide an RS-232 serial interface.
7. Aperture resolution may be slightly different due to differences in clock sources.
8. Some error messages may be different, and there may be slight differences in rounding and resolution of programmed parameters. In addition, some queried responses may have fewer or more digits.
9. Compatibility is provided only for *SCPI commands* for the 34401A. No compatibility is provided for alternate languages such as for the Agilent 3478A or the Fluke 8840A/8842A instruments.

34410A/11A Operating Differences

Information in this section can help you understand how to take advantage of capabilities available in the new DMMs that are not offered in the 34401A. Although in many cases you can just replace a 34401A with the 34410A or 34411A without using the compatibility mode, you should be aware of operating differences. Detailed coverage of newer features is provided in Application Note 5989-4039EN, Agilent 34410A/ 34411A $6\frac{1}{2}$-Digit High-Performance Multimeters. Here is a summary of areas of difference, with each item detailed later in this section:

- Added functions and ranges
- Overlap processing and real-time measurements
- NPLC resolution and aperture decoupled
- Measurement differences and techniques
- Measurement and system performance
- Dual triggering system
- Connectivity
- Math operations

Added functions and ranges

The range comparisons are in **Table 1** of this application note. Adding lower current ranges, for example, permits a much wider dynamic range of signals. The 34410/11A DMMs have added support for capacitance and temperature measurements. Temperature includes 2.2 k, 5 k, and 10 k thermistors and 385 RTD measurements using 2-and 4-wire ohms for both RTDs and thermistors.

Overlap processing and real-time measurements

The 34401A is considered a single-tasking instrument. Though it makes very good measurements, it can perform only one operation at a time. Both the 34401A and 34410A/11A DMMs use the INIT command to ready the measurement engine to be triggered and make measurements. However, the 34410A/11A DMMs allow the following:

- Command parser is free to accept new commands
- Simultaneous measurements can be made

When sending an INIT command to the 34401A, the command must finish before any other command can be accepted. With the 34410A/11A DMMs, on-going math results, or other simultaneous measurement data can be queried.

The 34410A/11A provide real-time secondary measurements and operations:

- Statistical math: average, standard deviation, min, max, count
- Limit checking
- Real-time DC peak measurements while measuring DC
- ACV while measuring frequency
- Resistance of temperature sensors while displaying temperature

Readings or secondary measurement results can be queried from any I/O interface (GPIB, LAN, or USB) while measurements are being taken.

NPLC resolution and aperture decoupled

The 34401A does not give you access to aperture settings of the A/D integration time except through discrete choices found under NPLC: 0.02, 0.2, 1, 10, and 100. A 1 PLC setting means an aperture setting of 0.0166 s (60 Hz line frequency).

The 34410A provides an additional two NPLC settings: 0.006 and 0.06. The 34411A adds 0.001 and 0.002. But, with both DMMs, you can operate in either NPLC mode or aperture mode, and both settings can differ. You now have much more control over the actual aperture setting even though there are a finite number of NPLC settings. For example, aperature settings have a resolution of 20 µs. The last command you specify is the one the DMM obeys. You can query the DMM to see whether you are operating in NPLC or aperature mode.

Measurement differences and techniques

The 34410A/11A DMMs use a high speed A/D sampling technique combined with aperture integration time to make DC and AC measurements. Where the 34401A used a precision analog AC RMS converter, the 34410A/11A DMMs sample the AC signals and calculate the true RMS value. This high-speed A/D sampling system allows for the following:

- Real-time peak measurements during the aperture integration cycle
- Faster DC measurements at higher resolution (6.5 digits @ 1000 readings/s)
- Four to ten times faster AC measurements
- Ability to more accurately measure small AC signals below 10% full scale
- Ability to reject the effects of Crest Factor up to 10:1

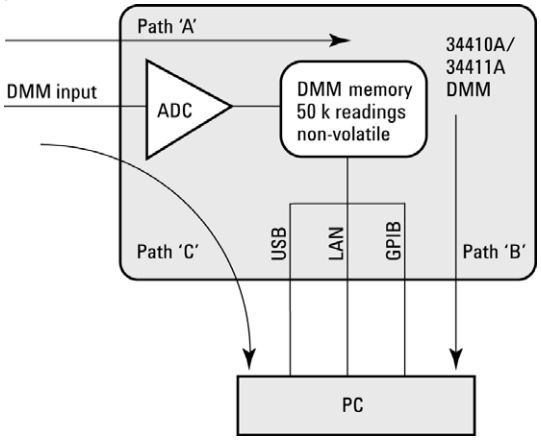


Figure 1. Measurement acquisition paths

The real-time peak measurement provides a significant benefit when you are measuring noise spikes on a DC signal. The aperture is set to the desired resolution and 4.5-digit measurements are made every 20 µs during that aperture to assess the peak level content. For example, when you are measuring the output of a power supply, you set the NPLC to 1 in order to reject ambient power line noise, but with the peak measurement function ON, you also can measure the peak-peak level of the ripple. This saves having to make a separate ACV measurement.

Measurement and system performance

The 34410A/11A DMMs have a high-speed processor combined with a new high-speed A/D technology. Measurements acquisition has several paths that are defined as follows:

1. Time to request measurements and store them in reading storage (A)
2. Time to request and read results from read storage (B)
3. Time to request a single measurement and get results (C)
4. Time to request continuous measurements and read results (C)

The 34401A was limited to 1000 readings/s via GPIB at 4.5-digits of resolution. This is due to several factors:

- Reading Storage limited to 512 readings
- Slower processor
- Higher overhead in accepting commands from I/O interface
- ASCII-only output format

The 34410A and 34411A DMMs improve on all of these categories. Here is a sampling of performance:

1. Time to request measurements and store them in reading storage (A)
   a. Command parsing time is 10 or more times faster than the 34401A
   b. Store up to 50,000 readings per second into memory (34411A)
   c. Reading storage is 50,000 readings for 34410A and 1,000,000 for the 34411A
2. Time to request and read results from read storage (B)
   a. Data can be read from readings storage in ASCII or binary
   b. ASCII rates over 4000 readings/s over LAN
   c. Binary rate over 200,000 readings/s over LAN or USB
3. Time to request a single measurement and get results (C)
   a. 3 to 10 times faster dependent upon measurement function
4. Time to request continuous measurements and read results (C)
   a. Continuous DC measurements 10,000 readings/s (34410A)
   b. Continuous DC measurements 50,000 readings/s (34411A)

Configuration, function, and range changes are 2 to 5 times faster than the 34401A. Refer to the 34410A/11A data sheet for more information.

Dual triggering system

The 34401A uses a triggering system that does not permit precise sampling of measurements. The trigger delay and the delay between samples is the same value, as illustrated in **Figure 2**. The trigger delay begins again after time required for the previous measurement. This triggering method is retained in the 34410A/11A DMMs to ensure compatibility.

With the added triggering model of the 34410A/11A DMMs, precision sampling can be achieved. The trigger delay specifies the time to wait after a trigger event has occurred. Time between readings is paced by the interval timer (sample timer). Each sample

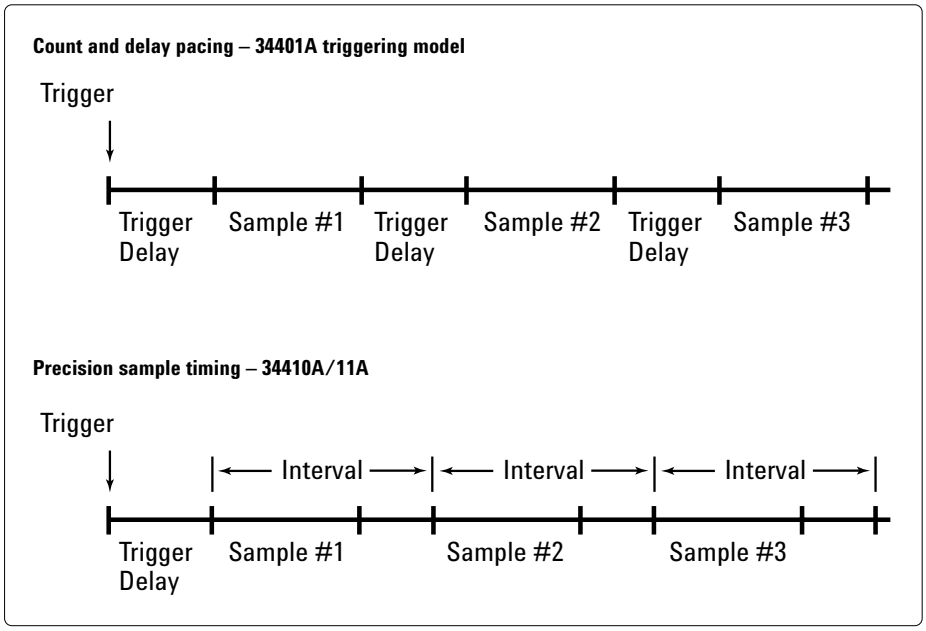


Figure 2

can vary as long as none of the samples exceed the interval shown in **Figure 2**. Typically, the highest speed setting for the particular function is set, so the sample time is relatively constant. However, this model can also be used for autorange ON and auto zero ON, where multiple readings are taken—as long as the worst-case sample time is accounted for in the interval setting.

Sample timing allows you to capture mechanical-electrical waveforms, and the combination of up 50,000 readings/s (34411A) and the input bandwidth of the DC front end circuits allow 6X over-sampling of frequency content up to 8 kHz.

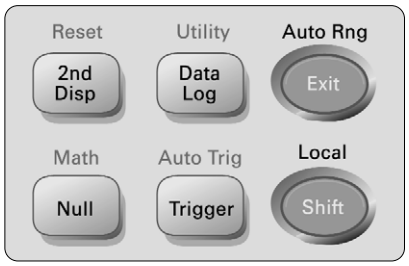


Figure 3.

Connectivity
The 34401A provided GPIB and RS-232 interfaces. The 34410A/11A DMMs provide GPIB, USB, and LAN. The addition of LAN provides new capabilities:

- LAN VXI-11 protocol (emulation of GPIB on LAN)
- LAN sockets (fastest way to communicate)
- Web server allows remote access to the DMM
  - o Monitor measurement results in a test system
  - o Full control of all functionality of instrument
  - o Up to 3 Web browsers can be connected at once
  - o You can cut and paste readings into your applications
  - o No software or driver installation is required on your PC to connect to the built-in Web server. If you can access the Internet, you can connect to this instrument.

USB 2.0 provides a fast interface to your personal computer (PC) and makes data logging quite simple and powerful. You can use the 34410/11A DMMs as standalone instruments; use the Data Logging button on the front panel to set up measurements without using a PC. When measurements are made, they are stored in non-volatile storage. You can bring the DMM back to your PC later; hook it up to the USB port and retrieve readings.

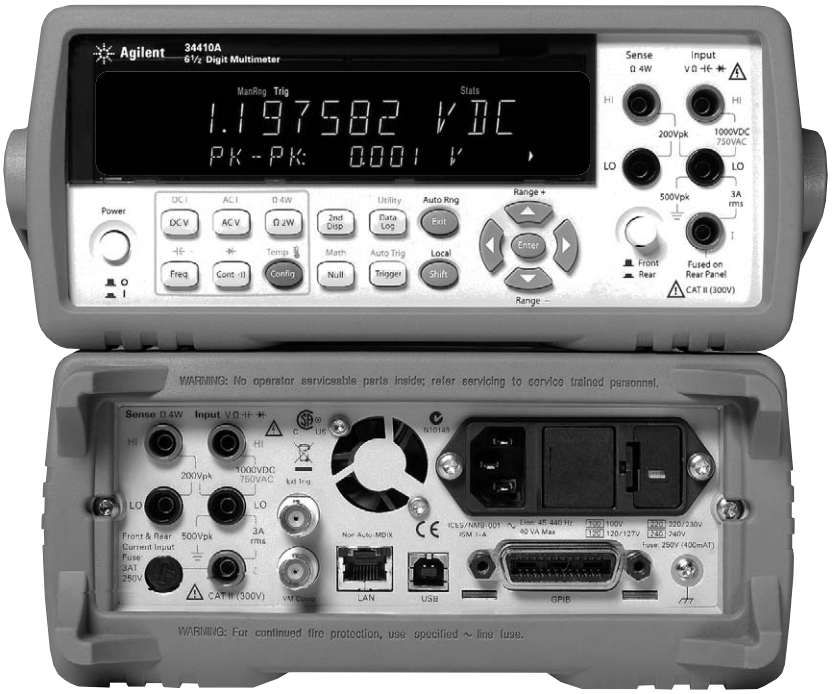
Math operations
The 34401A specifies auto zero and null operations outside the path of each function. If auto zero is ON, it is ON for all functions. If math null is turned ON, it is used for whichever function is currently active. You have to re-null each time you change between functions. As indicated in the compatibility mode section, the 34401A commands for these functions and for input impedance are retained for backwards compatibility.

The new DMMs place the auto zero, math null, and input impedance under the particular measurement function. When you press the Null button on the front panel, that Null is associated with that function. Moving to a different function and returning will retain the null operation. Likewise, auto zero can be enabled for some functions and disabled for others.

Also as mentioned earlier, math statistics functions can be queried while measurements are being taken. This is not possible on the 34401A.

Electrical and Mechanical Compatibility

Mechanically, the 34410A and 34411A are very similar to the 34401A. The front/rear terminals, power entry module, and current fuse are located in the same locations. The voltmeter complete and external trigger are oriented vertically to accommodate the added I/O interfaces and cooling fan. LAN and USB connectors replace the RS-232 connector of the 34401A. The 34410A/11A DMMs will rack mount in the same way as the 34401A, except that they are 3 inches (~76 mm) shorter. Agilent has been converting many of its newer products to this new shorter package. Instruments of the same length can have rack link kits that secure them together on the rear panel.



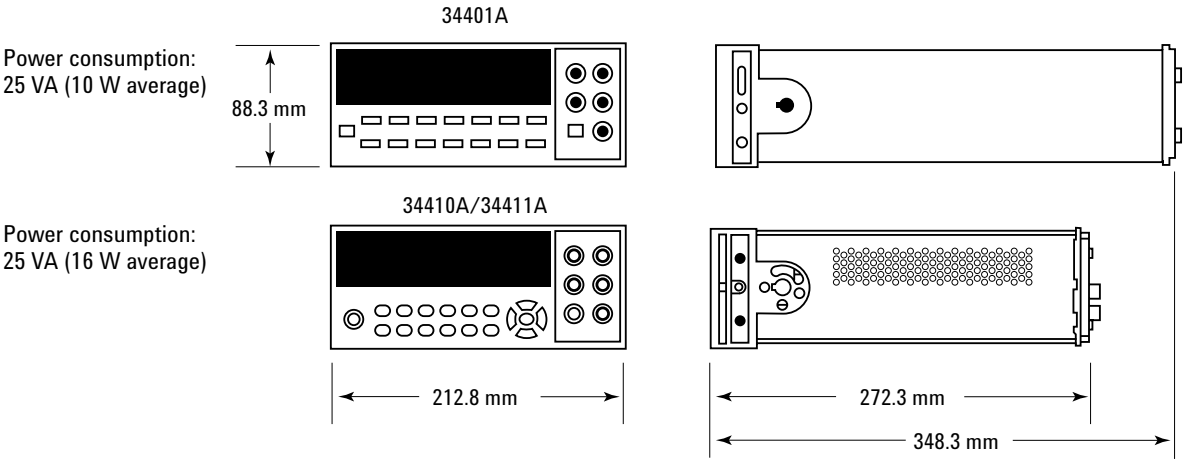


Figure 4. Power consumption and size comparison

Conclusion

You have been introduced to the key concepts in migrating Agilent 34401A applications to the new 34410A and 34411A DMMs. Let's review some key learning's from this application note:

- The Agilent 34410A/11A provide many new features and functions such as expanded ranges, capacitance, temperature, more reading storage, and much higher performance.
- The 34401A compatibility mode makes migrating to the 34410A/11A DMMs very simple.
- Added interfaces such as LAN and USB 2.0 expand system performance using standard PC I/O.
- Built-in Web server and system-ready operation make the 34410A/11A DMMs a powerful addition to your system.
- The 34410A/11A DMMs are mechanically and electrically compatible with the 34401A.

More application information can be obtained on the 34410A and 34411A DMMs from Application Note 5989-4039EN, Agilent 34410A/34411A $6\frac{1}{2}$-Digit High-Performance Multimeters.

Glossary

SCPI
Standard Commands for Programmable Instrumentation. This is an English-style language that has been used in instrumentation for many years.

Related Agilent literature

Data Sheets

Agilent 34410A/34411A $6\frac{1}{2}$ Digit Multimeters: 5989-3738EN

Application Notes

AN 1389
Digital Multimeter Measurement Errors

AN 1389-1
System Cabling Errors and DC Voltage Measurement Errors in Digital Multimeters

AN 1389-2
Resistance; DC Current; AC Current; and Frequency and Period Measurement

AN 1389-3
AC Measurement Errors in Digital Multimeters

AN 1479
Techniques for Reducing Overall Test Time When Using a DMM and Switch

AN 1392
Making Better RMS Measurements



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