Agilent
Understanding the Agilent 34405A DMM Operation
Application Note

Agilent Technologies

Introduction

Digital multimeter (DMM) is a basic device in the electrical world and its functions are usually not fully utilized. Therefore by understanding the DMM, it will help you to get better measurements and more accurate results.

This application note explains the architecture of the Agilent 34405A digital multimeter and helps you better understand the 34405A DMM and thus work more effectively.

The 34405A DMM's architecture

The block diagram in Figure 1 shows the architecture of the Agilent 34405A digital multimeter. The architecture of the 34405A DMM is divided into two segments, the measurement system and the input/output (I/O) and processor.

The measurement system contains several components, including multiplexers, buffers, amplifiers, RMS to DC converter, and Sigma-Delta analog-to-digital converter (A/D converter). This system handles measurement, function switching, range setting, resolution setting, sampling rate, settling time, and noise reduction.

The I/O and processor segment consists of the main process unit (MPU), display and keyboard, and USB connectivity. This part generally handles the command and data processing and transferring.

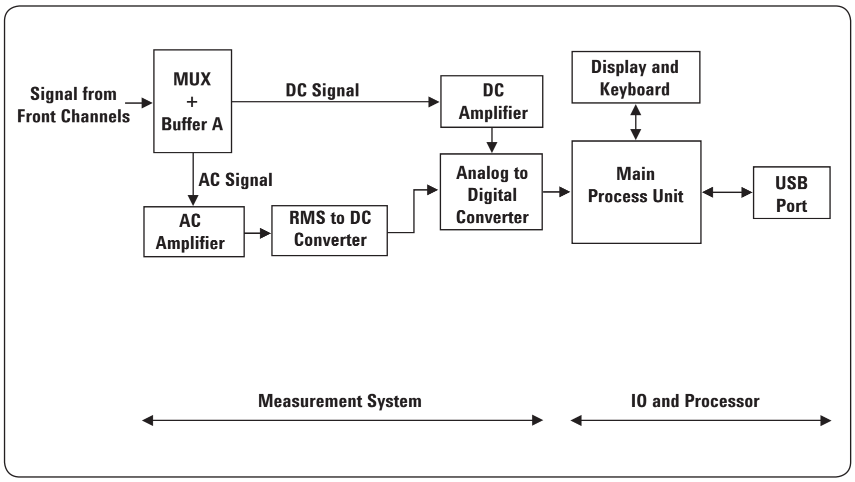

Figure 1. The 34405A DMM's architecture

Measurement system

Multiplexers and buffers

During signal measurement with a 34405A DMM, the signals will first route to the front channel via some multiplexers and buffers. The multiplexers and buffers do function setting (switching) and ranging. In function setting for DCV or ACV of the 34405A DMM, the "HI" channel will be the default channel, and "12A" or "I" will be the default channel for DCI or ACI signals. Users select the right range, or the 34405A will select the right range through some relays switching and solid-state switching for the first stage of ranging.

After passing through the multiplexers and buffers, DC and AC signals goes to different routes. The DC signal directly route to the DC amplifier for the rest of the ranging setting before reaching the A/D converter. The AC signal goes through the AC amplifier and the RMS-to-DC converter before reaching the A/D converter.

AC and DC amplifier

The main function of the DC and AC amplifier is to receive signals that have completed the first stage of ranging from multiplexers and buffers and to perform the second stage of ranging (amplifier gain), which is normally 1, 10, and 100 times.

The AC measurement signal passes AC-to-DC converter before reaching the A/D converter, and the DC signal will directly go to the A/D converter.

AC-to-DC converter (RMS-to-DC)

There are several types of AC-to-DC (RMS-to-DC) converters on the market:

- Thermal
- Peak and averaging
- Analog
- Digital sampling

The analog AC-to-DC converter has been used in the 34405A DMM. It uses a chain of analog circuits to compute the square, the mean, and the square root of the mean to deliver true RMS for nearly all signal types. The main function of the AC-to-DC converter is to change the input AC voltage to a DC voltage.

After the AC-to-DC converter, the AC signal will turn to a DC signal and subsequently channel the A/D converter.

A/D converter

The analog-to-digital converter is one of the important parts of the DMM. It does not only changes DC voltage to digital information but also defines the capabilities of the DMM such as resolution (digits), sampling rate, and noise reduction.

A Sigma-Delta A/D converter has been used for the 34405A DMM. The Sigma-Delta A/D converter oversamples the desired signal by a large factor and filter the desired signal band. It is also affordable, low-powered, linear, and capable of self-calibration.

Resolution

The resolution is the numeric ratio of the maximum displayed value to the minimum displayed value on a selected range. Resolution is often expressed in percentage, parts-per-million (ppm), counts, or bits. The 34405A DMM is a 5 ½-digit DMM with 20% over-range capability. It can display a measurement with up to 120,000 counts of resolution. This corresponds to about 0.025% (250 ppm) of full scale, or 17 bits including the sign bit.

Sampling rate

Sampling rate means how fast the 34405A DMM is capable of converting the incoming analog signal to digital values. In other words, it is the reading speed of the A/D converter. The 34405A DMM is able to gather 70 readings/s for 4 ½-digit DMM and 15 readings/s for 5 ½-digit DMM in DC measurements. AC measurements with the 34405A DMM are slower than DC measurements: only 2 ½ readings/s. When configured for AC measurements, the 34405A multimeter acquires an array of 25 sequential samples that make up the AC reading data set. The final AC reading result is computed from the acquired data set as shown in the equation below:

$$\textbf{\textit{AC}}\ \mathrm{R}\textit{eading}=\sqrt{\textit{Average}[\textit{Data}\ 1{:}25]^2}$$

Oversampling and Noise reduction

With the 34405A DMM, the process of Sigma-Delta analog-to-digital conversion is to oversample the signal. The signal is always sampled at a rate much higher than Nyquist rate, and then a digital filter reduces the sampling rate, doing the noise reduction, filtering off unwanted signal noise and limiting it to the bandwidth.

What is settling time?

DMM settling time is the total time required for the amplified signals to achieve a specified DMM accuracy limit. Both DC and AC signals need to pass through the components of DMM such as multiplexers, buffers, amplifier, RMS-to-DC converter (only for AC signals), and analog-to-digital converter. Each component has its own time for doing its job. The total settling time is the settling time of all these components.

Compared to other DMMs, Agilent DMMs have the ability to insert measurement settling time automatically. Some DMMs will immediately return readings when a function has been switched without adding any settling time. In this case, the DMMs are returning an incorrect value before the stabilized point. When the signal is still ramping up, the first few readings from the DMM are not accurate.

Figure 2 below shows that when changing the function from another measurement to DC measurement with the 34405A, 0.6 seconds settling time would be automatically inserted (please refer to 34405A DMM's DC measurement function change specification). The 34405A will only return the first measurement reading after 0.6 seconds. For other DMMs, although the settling time is 0.6 seconds, the DMM starts returning measurement reading at 0.4 seconds, and the reading will only be at steady state at 0.6 seconds. The measurement readings returned before the stabilized points are not within specifications.

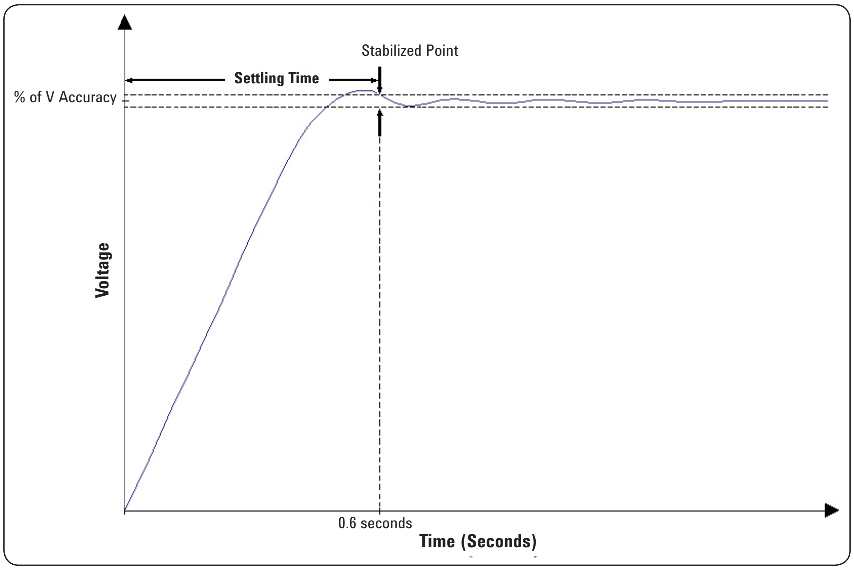

Figure 2. Settling time delay for 34405A at DC measurement

I/O and Processor

The I/O and processor part consists of the main process unit (MPU), front-panel operation display and button, and USB connectivity. This part mainly does the data and command processing. The MPU will get a command from the front panel button and from the PC through USB connectivity. The unit will do the configuration according to the command, and the MPU will get data from the A/D converter and pass it to the front panel (display) or to the PC through USB connectivity.

Reading speed via USB

There are two types of reading speed, the reading speed of the A/D converter and the reading speed of the connectivity port. Many are confused about both reading speeds. The reading rate of the A/D converter is the sampling rate of the A/D converter and how fast an A/D converter function. Reading speed through the connectivity port is always slower than the reading rate of A/D converter because the MPU will collect data from the A/D converter and pass to the connectivity port and display. Some restrictions such as bus speed and buffer will make the reading speed via USB connectivity slower. The 34405A can reach the A/D converter reading rate of 70 readings/s for 4 ½-digit DMM of DC measurement, and the reading rate through USB is 19 readings/s.

Conclusion

By understanding the 34405A DMM's capabilities and limitations, you can avoid any redundant measurement variances and uncertainty in your desired result. In addition, by knowing the product complexity and competency, you can fit the 34405A DMM in relevant application at affordable price with outperformance measurement result.

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Revised: July 17, 2008

Printed in USA, July 17, 2008
5989-9171EN

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