



7 Steps to Improve Your DMM Measurement Throughput

Overview

Whether your electronic test is in manufacturing, design validation, or research and development, reducing your test time translates to a reduction in development time and manufacturing costs.

The vast majority of electronic tests involve using a digital multimeter (DMM). There are a variety of methods to reduce DMM measurement times to improve your overall test throughput. Of course, test time improvements sometimes require compromises in other areas. Knowing the trade-offs in throughput improvements and identifying what is important to your specific test situation will help you make choices that fit your specific requirement.

Benefits in increasing your DMM measurement throughput:

- Increase manufacturing output and optimize shippable revenue
- Require less test equipment and hence less test footprint and capital cost
- Speed up product development time especially during product characterization and validation stages
- Optimize test equipment usage and efficiency

Step 1. Accuracy versus test time with auto-zero

Auto-zero is a DMM feature that helps you improve accuracy. With the auto-zero feature, the DMM makes an additional zeroing measurement with each measurement to eliminate the offsets of the amplifier and integration stages inside the DMM. Turning this feature off reduces the measurement time in half. These offsets are initially calibrated out, but the offsets can drift slightly with a change in temperature. Measurements captured in an environment with a stable temperature, or if there are several measurements taken in a short time period (temperature changes occur over longer periods of time), the improvements in throughput by turning auto-zero off outweighs any slight compromise in accuracy.

For example, with auto-zero off in a stable environment, using a Keysight Truevolt series DMM as a reference, the DMM typically adds only an additional 0.0002% of range + $\mu 5$ V to the DC voltage — or + 5 m Ω to the resistance accuracy specification. Note that with auto zero off, any range, function, or integration time setting change can cause a single auto-zero cycle to be performed on the first reading using the new setting. Consequently, turning auto-zero off and constantly changing settings defeats the time-savings advantage. Check your DMM auto-zero operation to be you get the most advantage from changing the behavior of this feature.



Figure 1. Test engineer installing DMM in a manufacturing test system

Step 2. Reduce the number of changes during testing

Minimizing range changes improves throughput because it eliminates the time it takes for the DMM to change ranges. The process also eliminates the need for an additional auto-zero measurement that would be performed because of the different offsets encountered using different attenuation and amplifier stages in a newly set range. Minimizing range changes lengthens the life of the DMM since some range changes activate a mechanical relay that can wear with a large number of activations.

Changing functions or measurement ranges also require extra run time in most DMMs — group your measurements to minimize function and range changes by:

- Performing all voltage and resistance measurements at one time instead of reverting from one function to the other
- Grouping your low voltage and high voltage measurements to minimize range changing

Voltage ranges above 10 V use a mechanical attenuator that takes time to switch in and out. Grouping your measurements by function and range reduce your measurement time.

Step 3. Auto-range variations

The time necessary for auto-range to settle will sometimes contribute to longer test times. The time to auto-range varies with the DMM's design. DMMs using flash analog to digital converters and parallel gain amplifiers can actually reduce test times, since the time to change ranges is zero. In these cases, it is faster to auto-range than to send manual ranging commands from a computer.

Manual ranging of integrating DMMs is still the fastest way to take a measurement. Manual ranging allows you to keep the DMM on a fixed range, which eliminates unwanted zero measurements and prevents the mechanical attenuator from needlessly actuating. The input/output (I/O) speed and range command parse time for the Keysight's Truevolt series DMM is significantly faster than the auto-range algorithm.

Step 4. Integration time versus noise

Integration time is another parameter which you can directly control, but there is a clear trade-off. DMMs integrate their measurements over the set period of time, known as the integration time. A significant benefit to choosing a longer integration time is that it eliminates unwanted noise from contributing to your measurement; especially AC mainline voltage noise.

However, longer integration times increase your measurement times. For example, if the integration time is set to an integral number of power line cycles (NPLCs) such as 1, 2, 10, or 100, the power line noise contribution is minimized due to averaging over a longer period. The minimization is a direct result of the increase in the normal mode rejection (NMR). With an NPLC setting of 10 in a 60 Hz environment, the integration time is 166 ms (200 ms for a 50 Hz line). The larger the integral NPLC value, the larger the NMR (for example, 60 Hz rejection); but the longer the measurement time.

Shorter integration times can yield a lower resolution. Changing the integration time triggers another zero measurement if the auto-zero is set to on; try to group integration time measurements to save time. Performing lower voltage measurements on thermocouples usually require better noise rejection than higher voltage measurements on batteries or power supplies. Choose the right integration time to get the level of precision you need for the measurement you are conducting, jamming to shield an asset.

Step 5. AC settings and settling time

When making AC measurements, select the appropriate AC filter setting to match the signal you are measuring. Select the bandwidth setting to include the lowest frequency you expect to encounter. For example, the Keysight Truevolt DMM and 3458A multimeters have three AC filter settings, as shown in Table 1.

The AC Voltage (ACV) and AC Current (ACI) settling times are longer when the settings are for measuring low frequencies and are shorter for higher frequency measurements; see Table 1.

| AC filter | Input frequency | Settling time ACV per reading (seconds) | Settling time ACI per reading (seconds) |
|------------------|------------------------|--|--|
| Slow | 3 Hz to 300 kHz | 2.5 | 1.66 |
| Medium (default) | 20 Hz to 300 kHz | 0.625 | 0.25 |
| Fast | 200 Hz to 300 kHz | 0.025 | 0.025 |

Step 6. Turning on/off display function

Since the same processor is necessary to control the display, perform measurements, and control I/O, turning off the display will free up noticeable processing time. Whether or not turning off the display makes a difference is dependent upon the DMM's processing capability.

Step 7. Optimizing trigger delay

Whenever a signal is applied to the input of a DMM, there is a specific amount of time that must pass before the signal completely settles to make a valid measurement. This is especially true when the applicable signals route through a switching system. For example, a voltage to be measured needs to charge up any capacitance in the switching path when the signal first connects to the DMM input.

There is a trigger delay setting that is dependent on function, range, integration time, and the AC filter setting. The trigger delay is the period that must pass between the time a measurement is triggered, and when the actual measurement is made. You can optimize your measurement time by matching your trigger delay setting to correspond to the type of signal you are measuring.

When you measure a voltage that has a high source impedance, the signal takes longer to charge any capacitance on the input of the DMM when the signal first connects to the DMM. Low impedance voltages require less settling time, so the trigger delay can be set to a lower time. Default DMM delay times work for simple applications, not large switching systems or high source impedances.

Summary

DMMs are virtually in all electronic test systems; it is essential to create a DMM measurement process that saves you test time to increase the throughput. Choosing appropriate settings for auto-zero, auto-range, integration times, including reducing function and range changes, are just some of the opportunities available to improve throughput. Reducing test times translates into lower costs and faster time-to-market; both important goals in today's fast-paced and competitive marketplace.

For more information, visit <https://www.keysight.com/us/en/products/digital-multimeters-dmm.html>.