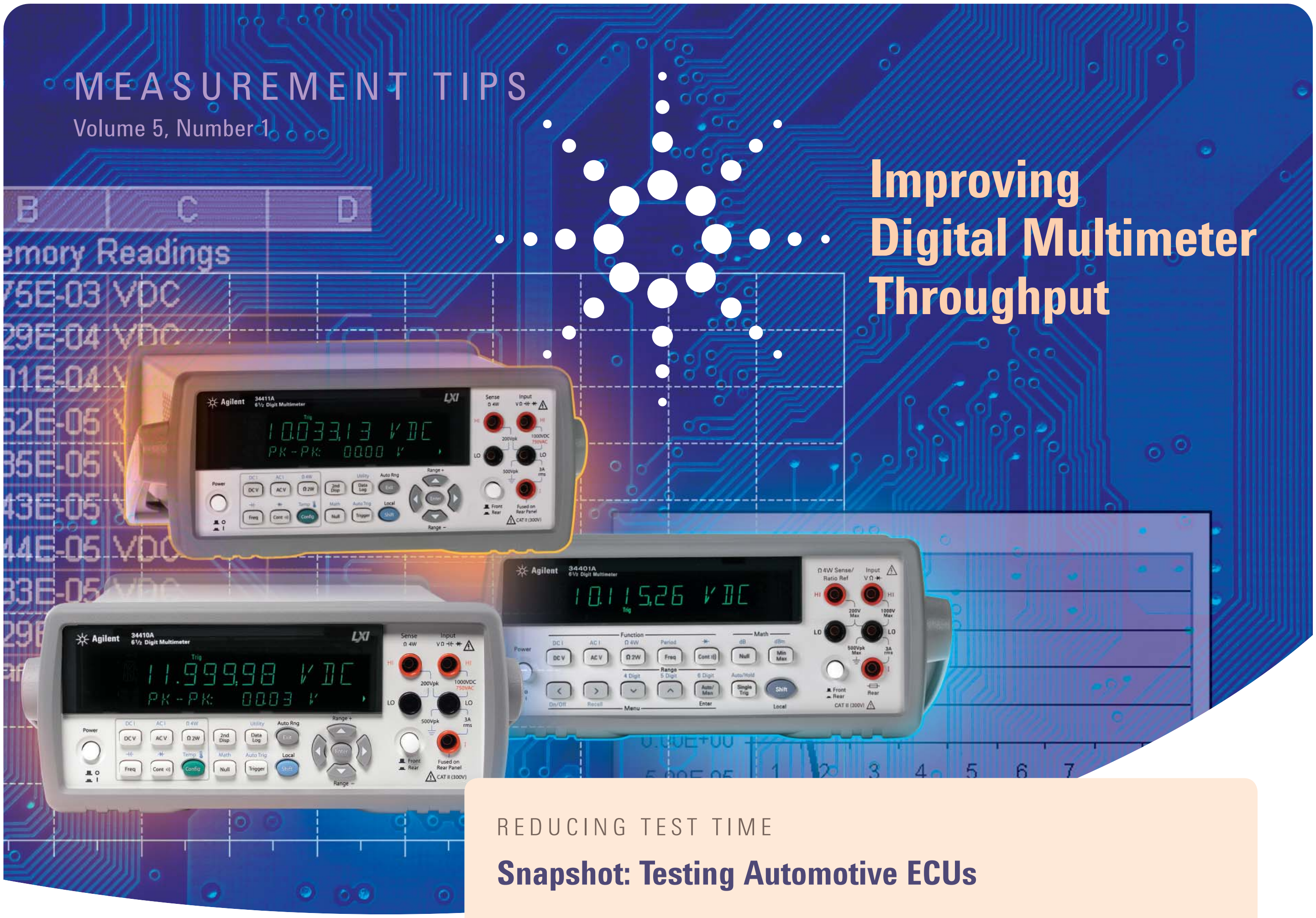
MEASUREMENT TIPS
Volume 5, Number 1

Improving Digital Multimeter Throughput

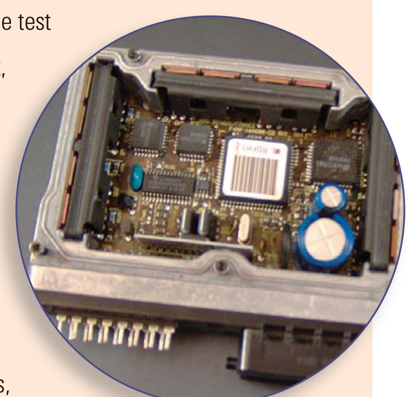


Whether your electronic test is in a manufacturing, design validation, or R&D environment, reducing your test time translates to lower cost and shortened product development schedules, both of which are clear benefits. The vast majority of electronic tests involve using a digital multimeter (DMM) at one time or another. There are a variety of ways to reduce DMM measurement times to improve overall test throughput. Of course, test time improvements sometimes require compromises in other areas, but knowing the tradeoffs involved in throughput improvements and identifying what is important in your specific test situation will help you determine which tradeoffs make the most sense.

REDUCING TEST TIME

Snapshot: Testing Automotive ECUs

A major supplier for the automobile industry was making and testing electronic control units (ECUs). During final test of the ECUs, dozens of DMM voltage and resistance measurements needed to be made. The test time per ECU was running about 43 seconds. By rearranging the tests to group all of the voltage measurements together and all of the resistance measurements together, the manufacturer was able to reduce test time per ECU by about 3 seconds. The manufacturer then evaluated the temperature of the environment that housed the test equipment and found it to be very stable. As a result, test engineers decided to do a single zeroing measurement at the start of the voltage measurements and a single zeroing measurement at the start of the resistance measurements in order to turn off auto zero. This saved an additional 6 seconds for a total savings of 9 seconds. The test time was reduced from 43 seconds to 34 seconds, a 21% reduction that increased throughput by more than 25%!



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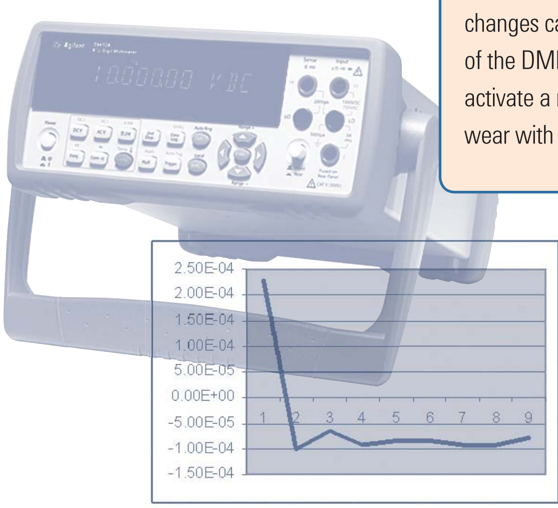
Auto zero: Accuracy versus test time

Auto zero is a DMM feature that helps you improve accuracy. When you use the auto zero feature, the DMM makes an additional zeroing measurement with each measurement you make, thereby eliminating the offsets of the amplifier and integration stages inside the DMM. However, turning this feature off cuts the measurement time in half. These offsets are initially calibrated out, but the offsets can drift slightly with a change in temperature. Therefore, if your measurements are taken in an environment with a stable temperature, or if there are several measurements taken in a short period of time (temperature changes occur over longer periods of time), the improvements in throughput by turning auto zero off will far outweigh any slight compromise in accuracy. For example, with auto zero off in a stable environment, the Agilent 34410A/11A multimeter typically adds only an additional 0.0002% of range + 2 µV to the DC voltage 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 sure of the circumstances leading to an advantage from this change.



Reduce the number of changes

Changing functions or measurement ranges also requires extra time in most DMMs. Try to group your measurements to minimize function changes and range changes. For example, if you make some voltage measurements and some resistance measurements, try to do all of the voltage measurements together and all the resistance measurements together instead of changing back and forth from one function to the other. Also, try to group your low-voltage measurements together and your high-voltage measurements together 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 will reduce your measurement times considerably.

MEASUREMENT TIP

Minimizing range changes improves throughput not only because it eliminates the time it takes for the DMM to change ranges, but also because it 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 can also lengthen the life of the DMM, since some range changes activate a mechanical relay that can wear with a large number of activations.

Auto range variations

Auto range time can sometimes contribute to longer test times, but not always. The time to auto range varies with the DMM design. DMMs using flash A/D converters and parallel gain amplifiers can actually reduce test times by using auto ranging, since the time to change ranges is zero. In these cases, the time to issue a range change command from a host computer and parse the command in the instrument will be slower. Manual ranging of integrating DMMs is still the fastest way to take a measurement. Manual ranging also allows you to keep the DMM on a fixed range, which eliminates unwanted zero measurements and prevents the mechanical attenuator from needlessly actuating. Note that the I/O speed and range command parse time for the Agilent 34410/11A multimeter is significantly faster than the auto range algorithm.

Integration time versus noise

Integration time is another parameter over which you have direct control, but there is a clear tradeoff. DMMs integrate their measurements over a set period of time: the integration time. The biggest benefit to choosing a longer integration time is it eliminates unwanted noise from contributing to your measurement, especially AC mains line voltage noise. However, longer integration times obviously 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 will be minimized due to averaging over a longer period of time and due to increasing 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.

AC filter	Input frequency	Settling time ACV	Settling time ACI
Slow	3 Hz – 300 kHz	2.5 sec/reading	1.66 sec/reading
Medium (default)	20 Hz – 300 kHz	0.625 sec/reading	0.25 sec/reading
Fast	200 Hz – 300 kHz	0.025 sec/reading	0.025 sec/reading

Table 1. Settling times for AC filter selections using the Agilent 34410A multimeter

Note that shorter integration times can yield lower resolution. And changing the integration time will trigger another zero measurement if auto zero is turned on, so try to group integration time measurements together if possible. Note that lower-voltage measurements such as those performed on thermocouples usually need better noise rejection than higher-voltage measurements performed on batteries or power supplies.

AC settings and settling time

When making AC measurements, be sure to 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 Agilent 34410A/11A multimeter has three AC filter settings, as shown in Table 1, above. The settling time is longest when the setting is for measuring low frequencies and is shortest for higher frequency measurements.

Display: on or off?

Since the same processor is often used to control the display, perform measurements, and control I/O, turning off the display can free up enough processing time to be noticeable. Whether or not turning off the display makes a difference is dependent upon the DMM's processing capability. Note that the 34410A/11A DMMs have no noticeable speed change when the display is on or off, but some older Agilent models do show an effect.

Optimizing trigger delay

Whenever a signal is applied to the input of a DMM, there is a certain amount of time that must pass before the signal completely settles in order to make a valid measurement. This is especially true when the applied signals are routed through a switching system, as is very common. For example, a voltage to be measured will have to charge up any capacitance in the switching path when the signal is first connected to the DMM input. Therefore, there is a trigger delay setting that is dependent on function, range, and integration time and/or AC filter setting. The trigger delay is a time that must pass between the time a measurement has been requested (or triggered) and 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 trying to measure. For example, when you measure a voltage that has high source impedance, the signal will take longer to charge any capacitance on the input of the DMM when the signal is first connected to the DMM. Low impedance voltages will require less settling time, so the trigger delay can be set to a lower time. Note that default DMM delay times are set for simple applications, not large switching systems or high source impedances, so be sure to make adjustments as needed.

Summary

DMMs are used in virtually all electronic test systems; therefore, making conscious choices about how to make DMM measurements can save large amounts of test time, thereby increasing throughput. Choosing appropriate settings for auto zero, auto range, and integration times as well as reducing function and range changes are just some of the opportunities you have to improve throughput. And reducing test times will translate directly into lower costs and faster time-to-market, both important goals in today's fast-paced, competitive marketplace.

TIP SUMMARY CHECKLIST

For maximum throughput:

- If appropriate, turn auto zero off
- Minimize function and range changes
  - Group similar measurement functions together (DCV, DC ohms, ACV, etc.)
  - Use fixed ranges instead of auto range, if appropriate
  - Shorten integration time with consideration for noise rejection, resolution, and accuracy
- Select appropriate AC filter
- Turn off the display
- Shorten the trigger delay with consideration for the type of measurement being made

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