Keysight Technologies
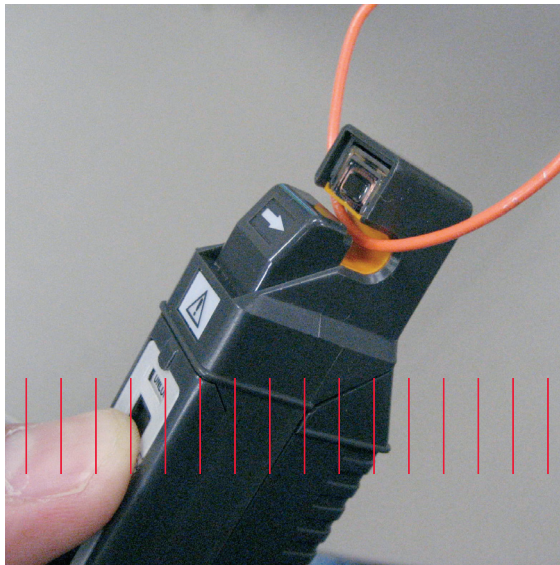# Tips for Making Low Current Measurements with an Oscilloscope and Current Probe

In recent years, engineers working on mobile phones and other battery-powered devices have demanded higher-sensitivity current measurement to help them ensure the current consumption of their devices is within acceptable limits. Measuring current is a nuisance because you have to break the circuit to put the measuring instrument in series with the circuit. Using a clamp-on current probe with an oscilloscope is an easy way to make current measurement that does not necessitate breaking the circuit. But this process gets tricky as the current levels fall into the low milliampere range or below.This article offers useful tips to help you make accurate low-level current measurements in the presence of relatively high levels of oscilloscope noise.

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Scope noise matters

As the current level decreases, the oscilloscope's inherent noise becomes a real issue. All oscilloscopes exhibit one undesirable characteristic – vertical noise. When you are measuring low-level signals, measurement system noise may degrade your actual signal measurement accuracy. Since oscilloscopes are broadband measurement instruments, the higher the bandwidth of the oscilloscope, the higher the vertical noise will be. You need to carefully evaluate the oscilloscope's noise characteristics before you make measurements. The baseline noise floor of a typical 500-MHz bandwidth oscilloscope measured at its most sensitive V/div setting is approximately 2 mV peak-to-peak. In making low-level measurements, it is important to note that the acquisition memory on the oscilloscope can affect the noise floor. Given the same bandwidth and other conditions, a deeper acquisition memory produces more noise. On the other hand, a modern AC/DC current probe such the Keysight Technologies, Inc. N2783A 100-MHz current probe iscapable of measuring 5 mA of AC or DC current with approximately 3% accuracy. The current probe is designed to output 0.1 V per one ampere current input. In other words, the oscilloscope's inherent 2-mVpp noise can be a significant source of error if you are measuring less than 20 mA of current.

So, how do you minimize the oscilloscope's inherent noise? With modern digital oscilloscopes, there are a number of possible approaches:

1) Bandwidth limit filter

Most digital oscilloscopes offer bandwidth limit filters that can improve vertical resolution by filtering out unwanted noise from input waveforms and by decreasing the noise bandwidth. Bandwidth limit filters are implemented with either hardware or software. Most bandwidth limit filters can be enabled or disabled at your discretion.

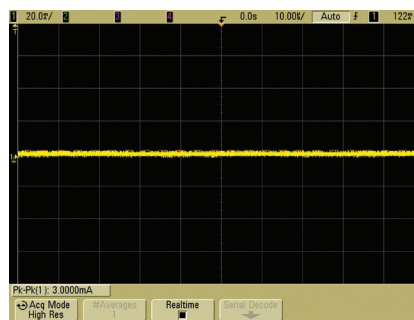## 2) High-resolution acquisition mode

Most digital oscilloscopes offer 8 bits of vertical resolution in normal acquisition mode. High-resolution mode on some oscilloscope offers much higher vertical resolution, typically up to 12 bits, which reduces vertical noise and increases vertical resolution. Typically, high-resolution mode has a large effect at slow time/div settings, where the number of on-screen data points captured is large. Since high-resolution mode acquisition averages adjacent data points from one trigger, it reduces the sample rates and bandwidth of the oscilloscope.
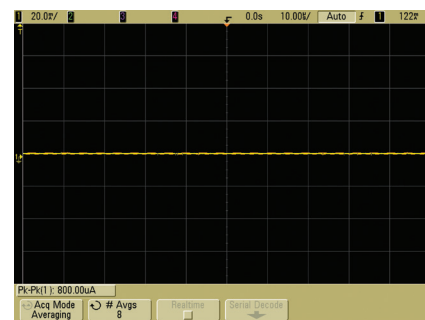
3) Averaging mode

When the signal is periodic or DC, you can use averaging mode to reduce the oscilloscope's vertical noise. Averaging mode takes multiple acquisitions of a periodic waveform and creates a running average to reduce random noise. High-resolution mode does reduce the sample rates and bandwidth of the signal, whereas, normal averaging does not. However, averaging mode compromises the waveform update rate as it takes multiple acquisitions to average out the waveforms and draws a trace on the screen. The noise reduction effect is larger than with any of the methods above as you select a greater number of averages.
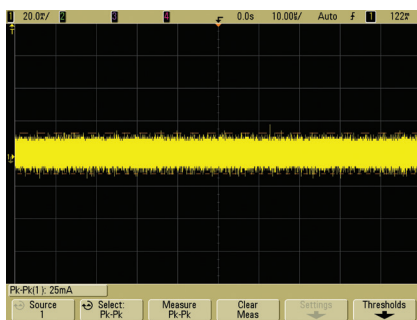
500-MHz normal mode – 25 mApp noise   High-res mode – 3 mApp noise   8x averaging mode – 800 µApp noise

Figure 1. There are a number of possible approaches to reduce scope's inherent vertical noise.

Improving current probe measurement accuracy and sensitivity

Now that you know how to lower the oscilloscope's vertical noise with one of the techniques above, let's take a look at how to improve accuracy and sensitivity of a current probe. There are a number of different types of current probes in the market. The one that offers the most convenience and performance is a clamp-on AC/DC current probe that you can clip on a current-carrying conductor to measure AC and DC current. Keysight's N2780A Series or 1147B current probe is an example.

Two useful tips for using this type of current probe:

1. Remove magnetism (demagnetize/degauss) and DC offset

To ensure accurate measurement of low-level current, you need to eliminate residual magnetism by demagnetizing the magnetic core. Just as you would remove undesired magnetic field built up within a CRT display to improve picture quality, you can degauss or demagnetize a current probe to remove any residual magnetization. If a measurement is made while the probe core is magnetized, an offset voltage proportional to the residual magnetism can occur and induce measurement error. . It is especially important to demagnetize the magnetic core whenever you connect the probe to power on/off switching or excessive input current. To perform the probe demagnetization/degauss, remove the probe from all conductors, make sure the probe is locked closed, and then press the probe DEMAG (or DEGAUSS) button.

In addition, you can correct a probe's undesired voltage offset or temperature drift using the zero adjustment control on the probe.

2. Improve the probe sensitivity

A current probe measures the magnetic field generated by the current flowing through the jaw of a probe head. Current probes generate voltage output proportional to the input current. If you are measuring DC or low-frequency AC signals of small amplitude, you can increase the measurement sensitivity on the probe by winding several turns of the conductor under test around the probe. The signal is multiplied by the number of turns around the probe. For example, if a conductor is wrapped around the probe 5 times and the oscilloscope shows a reading of 25 mA, the actual current flow is 25 mA divided by 5, or 5 mA. You can improve the sensitivity of the current probe by a factor of 5 in this case.

Conclusion

An oscilloscope and a clamp-on current probe provide an easy way to make current measurements without necessarily breaking the circuit. However, when you introduce an oscilloscope's broadband noise to the measurement, the oscilloscope's vertical noise can get in the way of making accurate low-level current measurement. By applying one or more of the measurement tips outlined in this article, you can eliminate the oscilloscope's random noise and the current probe's undesired magnetism or DC offset to significantly improve your measurement accuracy.

Figure 2. To improve current probe's accuracy remove magnetism and DC offset.

Figure 3. Improve the probe sensitivity by winding several turns of the conductor under test around the probe.

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