Field Applications for the U1610/20A Handheld Oscilloscopes

Application Note

Introduction

The Agilent Technologies U1610/20A handheld scope integrates test tools—scope, multimeter, and data logger—in a rugged and mobile form factor. This application note presents three field applications for the Agilent U1610/20A.

- Measuring power
- Hunting for signal irregularities
- Analyzing line current harmonics

Measuring Power

In any electrical system, the primary parameter that needs to be specified is the operating voltage. However, voltage by itself has little meaning. To understand the behavior of an electrical system you also need to accurately measure power. This knowledge is needed, for example, when working with such devices as motors, or humidity, ventilation, and air conditioning (HVAC) systems.

To understand why a scope is the ideal instrument for measuring power, let's explore these possible electrical circuits that you may encounter in the field:

- A static DC source, or a low-frequency source, connected to a resistive load
- An AC source connected to a load with non-resistive elements

Measuring a static DC source, or a low-frequency source, connected to a resistive load

Figure 1 shows an elementary electrical circuit that is comprised of a voltage source, V_S, and a load resistor, R_L. The current flows and the resulting power dissipates as heat.

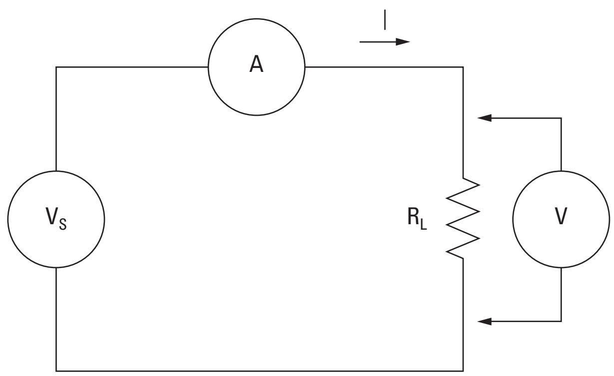

Figure 1. Static DC source connected to a resistive load

You can easily measure the power for this circuit by using a digital multimeter (DMM). Because both values of V_S and R_L are static, you can successfully measure the voltage source, V_S, and current, I, across the load, R_L. The power supplied, P, to the load can then be calculated using Equation 1.

$P = I \times V_S$ Equation 1

If the source is a low-frequency AC source, you can use the same method to measure power. Using a DMM, you measure the rms value of the voltage source, V_S, followed by the rms value of the current across the load, R_L.

Typically, a DMM can be used to measure electrical power applied to a purely resistive load at mains frequencies. In the following example, however, you will understand why a scope is a better tool to measure power.

Measuring Power

Measuring an AC source connected to a load with non-resistive elements

Figure 2 shows an electrical circuit with an AC voltage source, V_S, connected to a load that is not purely resistive. It includes inductive and capacitive elements. This results in a phase difference between the source voltage and the current that has to be taken into consideration when measuring power.

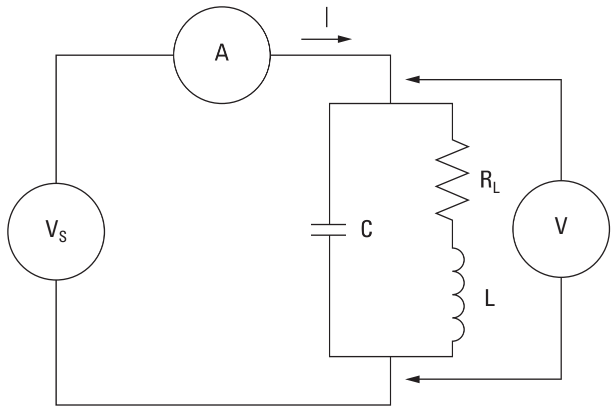

Figure 2. AC source connected to a resistive load with inductive and capacitive elements

Figure 2 shows that the phase angle is necessary to calculate power. To measure the phase angle, both voltage and current measurements have to be taken simultaneously. Because a DMM can only measure one input at a time, a scope with two or more inputs is a better measurement tool in this scenario.

$P = I \times V_S \times \cos\phi$ Equation 2

where $\cos\phi$ is the cosine value of the phase angle (in degrees) between the voltage and current,
I is the current, and
V_S is the source voltage.

Measuring Power

Measuring power with the U1610/20A handheld scope

With two independently isolated channels, the Agilent U1610/20A handheld scope lets you safely measure voltage and current at the same time, as well as measure and display the phase angle between them. The isolated channels let you use the U1610/20A in mixed circuits having different ground references, keeping you safe from accidental ground short circuits. It is also safety rated for measurements in CAT III 600 V environments.

The U1610/20A features four automatic measurements for power over a wide range of applied frequencies. These automatic measurements are useful when tracing and correcting electrical issues for the automobile industry, industrial power and automation technologies areas, and facility maintenance.

- Active power
- Apparent power
- Reactive power
- Power factor

Follow the procedure below to use the automatic power measurements in the U1610/20A.

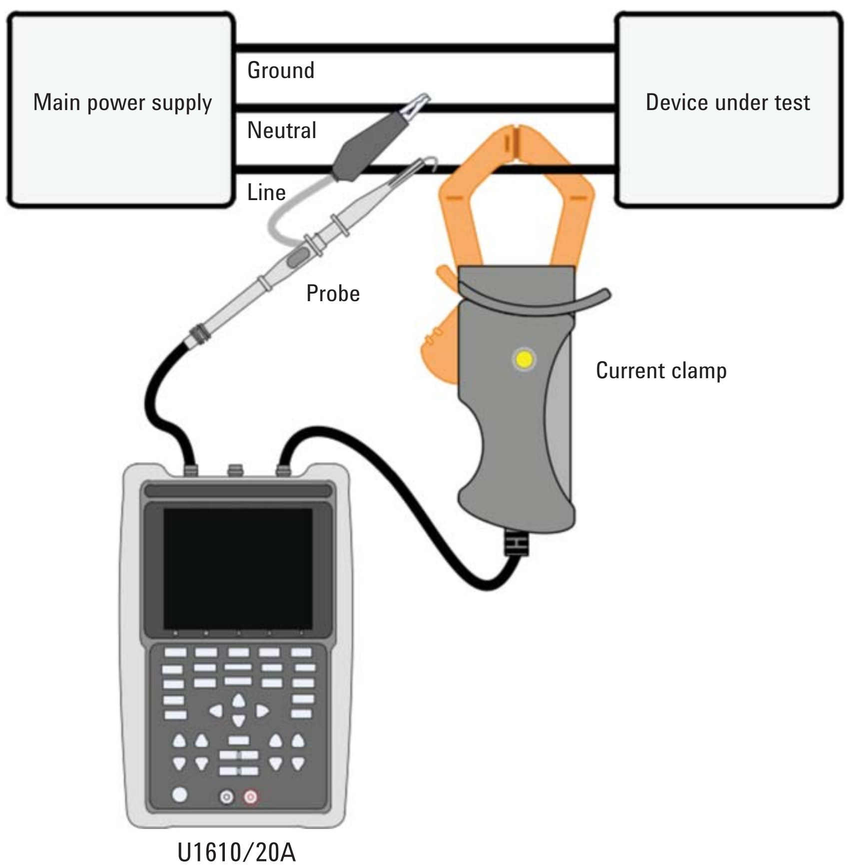

Figure 3. Setup to measure power

Measuring Power

Measuring power with the U1610/20A handheld scope *(continued)*

1. Prepare the setup as shown in Figure 3.
2. If necessary, select a probe with the appropriate attenuation factor.
3. Connect the current clamp from Channel 1 and the probe from Channel 2 close to the device under test (DUT).
4. Enable Channel 1 and Channel 2. The scope displays the waveform for both current and voltage.
5. Select an automatic power measurement: **Active Pwr**, **Apparent Pwr**, **Reactive Pwr**, and **Pwr Factor**.
6. Verify that the attenuation factor of the connected probes is set correctly.
7. Press **Measure** to make your selected power measurement.

For troubleshooting activities in industrial power and automation environments, the rugged mobility of the U1610/20A gives you an integrated troubleshooting tool with a scope, multimeter, and data logger. The data logger offers unattended measurement of the total power accumulated over a period of time, and gives you more time to focus on other tasks.

Hunting for Signal Irregularities

Signal irregularities, such as current and voltage surges, mains harmonics, and electromagnetic interference (EMI), can cause breakdowns in electrical and electronic equipment.

Here are some examples of events that can trigger these signal irregularities:

- Systems starting up can cause current and voltage surges
- Switching power supplies in machines produce harmonics into the mains supply
- Electric power transmission lines, electric motors, and anywhere electrical power is toggled on and off rapidly are potential sources of EMI

Identifying the causes of signal irregularities can be challenging because the events happen at varying times. However, a scope displays voltage variations over time and is therefore an ideal instrument to capture these random events.

Locating signal irregularities using the U1610/20A handheld scope

Combining a scope, multimeter, and data logger into a compact and rugged enclosure with a bandwidth up to 200 MHz and a sampling rate of up to 2 GSa/s, the U1610/20A makes the task of hunting for signal irregularities much easier.

Signal irregularities are random events; fortunately, these signal irregularities have identifiable characteristics that allow them to be accurately locate and resolved. The U1610/20A comes with the features you need for this task:

- Trigger functions for detecting voltage spikes and missing mains cycles
- Long-term monitoring of data captured on the scope and multimeter
- Dual-window zoom

Hunting for Signal Irregularities

Locating signal irregularities using the U1610/20A handheld scope *(continued)*

Trigger functions

The U1610/20A gives you trigger types that are typically found in bench scopes: Edge, Glitch, TV, Nth Edge, Controller Area Network (CAN), and Local Interconnect Network (LIN).

For detecting voltage spikes and missing mains cycles, these trigger types are used:

- Edge trigger
- Glitch trigger

Edge trigger

The Edge trigger can be used to trigger on the rising or falling edge of a voltage pulse with the trigger level set slightly higher than the voltage level of the mains. This method can only be used for voltage surges with amplitudes that exceed the mains voltage.

Follow the procedure below to use the Edge trigger in the U1610/20A.

1. Connect the scope probes close to the DUT.
2. Select the Edge trigger to trigger on the rising edge, and set the level to 240 V.

What about voltage surges with amplitudes that do not exceed the mains voltage? To capture these events, the following section explains how the Glitch trigger is used instead.

Glitch trigger

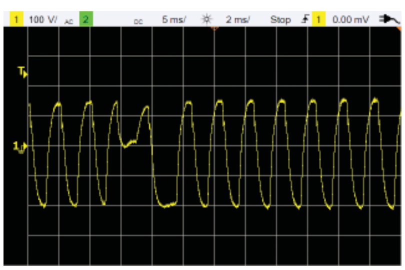

Figure 4. The scope shows a missing cycle on the mains

The Glitch trigger, available on both the U1610/20A, can be used to trigger on the positive or negative polarity of a voltage pulse, even if the voltage amplitude of the pulse remains at the mains' amplitude. For example, on the U1620A, this feature lets you set the width of the glitch from 45 ns to 10 s. This means that voltage pulses as narrow as 45 ns can be captured; also, voltage pulses as wide as 10 s can be captured, which helps to reveal missing cycles on the mains.

Follow the procedure below to use the Glitch trigger in the U1610/20A to detect missing mains cycles.

1. Connect the scope probes close to the DUT.
2. Select Glitch trigger to trigger on a positive polarity pulse with a pulse width of 10 ms.

Hunting for Signal Irregularities

Locating signal irregularities using the U1610/20A handheld scope *(continued)*

Long-term monitoring

The data logger in the U1610/20A can log either scope or multimeter data for up to eight days. The scope logger records the first two scope measurement results, while the meter logger records the multimeter data.

For long-term monitoring, the data logger helps you locate causes of intermittent signal irregularities that may occur within a day or a week. An additional advantage is that the recorded data can be downloaded to a USB storage device, so you can review the information on the PC. Other than voltage surges or missing cycles on the mains, the data logger can also trace temperature fluctuations with the appropriate probe.

Follow the procedure below to use the data logger feature in the U1610/20A.

1. Connect the scope probes close to the DUT.
2. Set Channel 1 to measure the amplitude of the voltage and Channel 2 to measure the rms of the voltage.
3. Press **Logger** on the front panel.
4. Press the **Scope Logger** softkey, which logs the first two scope measurement results. In this case, the scope logger will log the amplitude and average measurements of the voltage.
5. Press **Run/Stop** to start or stop the data recording.

Dual-window zoom

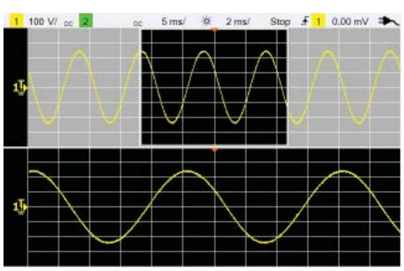

Figure 5. Dual-window zoom

With a high resolution, 5.7-inch TFT LCD color display of 640 x 480 pixels, the U1610/20A offers a dual-window zoom feature, which means you can still view the overall waveform while you zoom into a particular area of the waveform.

The clear display, viewable under different lighting conditions, gives you a better visual of the signal behavior. With the deeper memory of the U1610/20A, you can zoom closer into the waveform and see more details of the captured waveform, as well as observe the signal irregularities either captured using the triggers or recorded using the data logger.

Analyzing Line Current Harmonics

Harmonics are prevalent in modern electronics where large numbers of PCs, variable-speed drives, and other industrial equipment draw current in pulses. The following are some examples of issues caused by harmonics in the load current:

- Overheating neutral conductor
- Voltage drops due to circuit breakers tripping
- Vibrations from transformers and distribution panels
- Overheating equipment

What causes harmonics? Harmonics occur when the load current is not proportional to the instantaneous voltage. This is because the load current is not continuous; instead, it is pulsed. While this method increases energy efficiency, it causes harmonics in the load current. Examples of equipment that causes harmonics are shown below:

- Residential: personal computers, fluorescent lamps, television sets
- Industrial: inverters, arc furnaces, variable-speed drives

Harmonics are currents or voltages that occur at integer multiples of the fundamental frequency of the power line. Therefore, if the fundamental frequency of the power line is 60 Hz, then the 2nd harmonic is at 120 Hz, the 3rd harmonic is at 180 Hz, etc.

Although harmonics have a frequency component they still be measured in the line current using a scope that displays the amplitude of voltage versus time. With a scope that has the fast Fourier transform (FFT) function, you can convert a time-domain waveform into a frequency-domain waveform and therefore see the presence of harmonics.

Analyzing Line Current Harmonics

Analyzing harmonics using the U1610/20A handheld scope

The U1610/20A has a 1,024-point FFT function with the following window function: Hanning, Rectangular, Hamming, B. Harris, and Flattop.

Follow the procedure below to enable the FFT function in the U1610/20A.

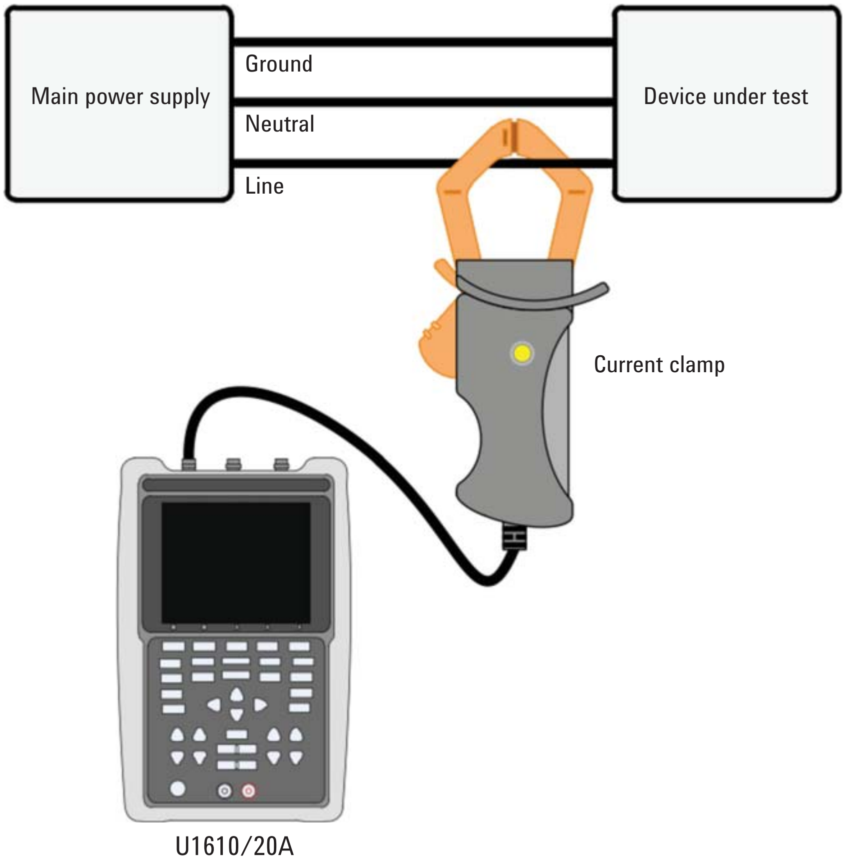

Figure 6. Setup to analyze line current harmonics

1. Prepare the setup as shown in Figure 6.
2. Connect the current clamp from Channel 1 to the DUT.
3. Enable Channel 1. The scope will show the waveform for the current.
4. Turn on the FFT function of the scope.
5. Adjust the time base setting until the scope displays the harmonics clearly.
6. Adjust the scale factor (dB/division) or offset (dB or DBV) respectively.
7. Select one of the following FFT window functions: Hanning, Rectangular, Hamming, B. Harris, or Flattop.

Summary

Presented in this application note are three applications for handheld scopes in the field.

- **Measuring power**
  By measuring power, you can understand the behavior of an electrical system. Although a DMM can be used for low-frequency linear systems, the U1610/20A is the ideal instrument for troubleshooting more complex and mixed-frequency systems. The U1610/20A has automatic measurements for active power, apparent power, reactive power, and power factor.
- **Hunting for signal irregularities**
  Current and voltage surges, mains harmonics, and electromagnetic interference (EMI) can cause equipment to fail. These events happen randomly, but the U1610/20A comes with trigger functions, long-term monitoring, and a dual-window zoom display to help you capture and analyze these events.
- **Analyzing line harmonics**
  Harmonics, which are made up of current and voltage that appear at certain frequencies, cause the neutral conductor to overheat, equipment to vibrate, power trips, and equipment to overheat. With its 1,024-point FFT and deep memory, the U1610/20A lets you see more details and perform waveform analysis in the frequency domain.

Conclusion

Modern electrical systems for industrial applications are complex networks that are tightly regulated for safety and efficiency. This tight integration makes installation and maintenance tasks for electrical systems challenging to engineers and necessitate the need for more sophisticated tools.

With 30 types of automatic measurements (for time, voltage, and power), and Math and FFT analyzer functions, the U1610/20A lets you see and understand the behavior of electrical systems on a vibrant 5.7-inch TFT LCD VGA (640×480 pixels) color display. The U1610/20A handheld scope is designed for engineers that insist on accuracy, reliability, and safety when making measurements in demanding environments.

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