

Engineer's Notebook

Selection Guide To Clamp-On Current Probes

Clamp-on current probes are designed to extend the current measuring capabilities of DMMs, power instruments, oscilloscopes, hand-held scopes, recorders or loggers and other diverse instruments. The probe is "clamped" around the current carrying conductor to perform non-contact current measurements and without interrupting the circuit under test. The probe outputs current or voltage signal directly proportional to the measured current, thereby providing current measuring and displaying capabilities to instruments with low current or voltage inputs.

When making a measurement, the current carrying conductor is not broken and remains electrically isolated from the meter input terminals. As a result, the meter's low input terminal may be either floated or grounded. It is not necessary to interrupt the power supply when using a clamp-on current probe for taking measurements, so costly down time can be eliminated.

True RMS measurements within the probe frequency response are possible by using most current probes with a true RMS Multimeter. In most cases, RMS measurements are not limited by the probes, but by the instrument to which they are connected. Best results are provided by probes offering inherent high accuracy, good frequency response and minimal phase shift.

AC CLAMP-ON CURRENT PROBES

Theory of Operation

An AC clamp-on current probe may be viewed as a variance of a simple current transformer.

$$I_2 = N_1/N_2 \times I_1 \text{ or } I_1 = N_2/N_1 \times I_2$$

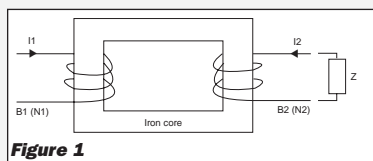


Figure 1

It is often difficult to measure directly because of currents which are too high to be fed directly into a meter or simply because breaking into the circuit is not possible. To provide a manageable output level multiple turns are set into the probe coil bobbin.

The number of turns in the clamp-on coil are generally simple multiples (e.g. 100, 500 or 1000). Another way to express this ratio is to say that the probe output is 1mA/A - the probe output is 1 mA (I₂) for 1A (or 1A @ 1000A) flowing in the jaw window.

There are numerous ratios possible: 500:5, 1000:1, 2000:2, 3000:1, 3000:5, etc. for different applications.

The most common application is the use of a current probe with a digital multimeter. Take as an example a current probe with a ratio of 1000:1 with an output of 1 mA/A. This ratio means that any current flowing through the probe jaws will result in a current flowing at the output:

Conductor	Probe Output (1000 times less or 1 mA/A)
1000A	1000 mA (1 A)
750A	750 mA
250A	250 mA
10A	10 mA

The probe output is connected to a DMM set on the AC current range to handle the probe output. Then, to determine the current in the conductor, multiply the reading of the DMM by the ratio (e.g., 150 mA read on the 200 mA DMM range represents 150 mA x 1000 = 150A in the conductor measured).

Current probes may be used with other instruments with current ranges, provided that these instruments have the required input impedance (see Figure 3).



Current probes may also have AC or DC voltage outputs to accommodate current measurements with instruments (loggers, scopes, etc.) with voltage ranges only (Figures 4 and 5). This is simply done by conditioning the current probe output inside the probe to provide voltage. In these cases, the probe mV output is proportional to the measured current (e.g., 1 mVAC/AAC).

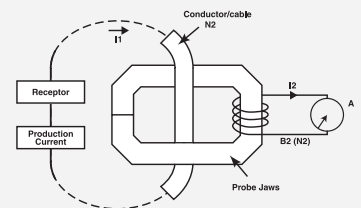


Figure 2

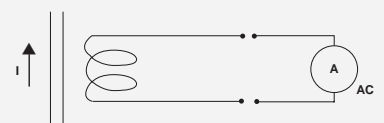


Figure 3

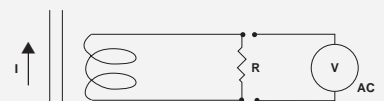


Figure 4

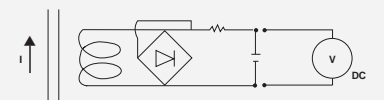


Figure 5

AC/DC CLAMP-ON CURRENT PROBES

Theory of Operation (Hall effect)

Differing from traditional AC transformers, AC/DC current sensing is often achieved by measuring the strength of a magnetic field created by a current-carrying conductor in a semiconductor chip using the Hall effect principle.

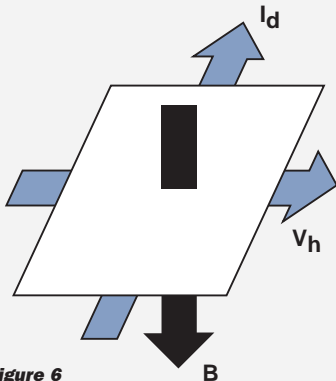


Figure 6

When a thin semiconductor (Figure 6) is placed at right angles to a magnetic field (B), and a current (I_d) is applied to it, a voltage (V_h) is developed across the semiconductor. This voltage is known as the Hall voltage, named after the US scientist Edwin Hall who first reported the phenomenon.

When the Hall device drive current (I_d) is held constant, the magnetic field (B) is directly proportional to the current in a conductor. Thus, the Hall output voltage (V_h) is representative of that current. Such an arrangement has two important benefits for universal current measurement.

First, since the Hall voltage is not dependent on a reversing magnetic field, but only on its strength, the device can be used for DC measurement. Second, when the magnetic field strength varies due to varying current flow in the conductor, response to change is instantaneous. Thus, complex AC wave forms may be detected and measured with high accuracy and low phase shift.

The many AC/DC Current Probes were developed based on the above principle, together with patented electronic circuitry incorporating signal conditioning for linear output

and a temperature compensation network. These have a wide dynamic range and frequency response with highly accurate linear output, for application in all areas of current measurement up to 1500A. Direct currents can be measured without the need of expensive, power consuming shunts, and alternating currents up to several kHz can be measured with fidelity to respond to the requirements of complex signals and RMS measurements.

The probe outputs are in mV (mV_{DC} when measuring DC, and mV_{AC} when measuring AC) and may be connected to most instruments with a voltage input, such as DMMs, loggers, oscilloscopes, hand held scopes, recorders, etc.

AC/DC probes also offer the opportunity to display or measure True RMS in AC or AC+DC.

AC OR DC CURRENT MEASUREMENT

- Connect the probe to the instrument.
- Select the function and range.
- Clamp the probe around a single conductor.
- Read the conductor's current value.

Examples:

AC: Ratio: 1000:1
Output: 1 mAAC/AAC
DMM: Set to 200 mAAC range
DMM Reading: 125 mAAC
Current in Conductor:
 $125 \text{ mA} \times 1000 = 125 \text{ AAC}$

DC: 1 mVDC/ADC (Hall sensor)
DMM: Set to 200 mVDC range
DMM Reading: 160 mVDC
Current in Conductor: 160 ADC

AC: Output: 1 mVAC/AAC (Hall sensor)
DMM: Set to 200 mVAC range
DMM Reading: 120 mVAC
Current in Conductor: 120 AAC

DC: Output: 1 mV/mA
DMM: Set to 200 mVDC range
DMM Reading: 7.4 mVDC
Current in Conductor: 7.4 mADC

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LOW CURRENT, PROCESS LOOP MEASUREMENTS

Numerous probes are offered for low current measurements.

Examples (Figure 7):

4-20 mA loop
Output: 10 mV/mA
DMM: Set to 200 mVDC range
DMM reading: 135 mVDC
Loop Current: 13.5 mADC

When the current to be measured is too low for the probe or better accuracy is required, it is possible to insert the conductor multiple times through the probe jaws. The value of the current is the ratio of the reading to the number of turns.

Ratio: 1000:1
DMM: Set to 200 mAAC range
Turns in Probe Jaw: 10
DMM Reading: 60 mAAC
Current in Conductor:
 $60 \text{ mA} \times 1000/10 = 6000 \text{ mA} = 6 \text{ A}$

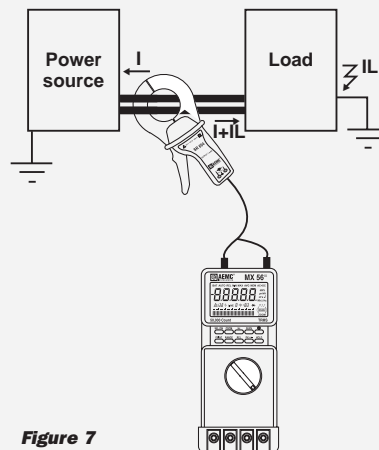


Figure 7

Information for this article contributed by AEMC® Instruments.

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