Selection Guide to Clamp-On Current Probes

Selecting The Correct Clamp-On Current Probe

Answering the following questions will help you to select the appropriate probe for your applications.

1. Determine if you are measuring AC or DC (DC current probes are categorized as AC/DC because they measure both).

2. What is the maximum current you will measure, and what is the minimum current you will measure? Check that the accuracy at low levels is appropriate, or select a low current measurement probe. Most probes perform with greater accuracy at the upper end of their range. Several probes are designed to measure very low DC or AC.

3. What size conductor will you clamp onto? This parameter determines the probe jaw size needed.

4. What type of probe output do you need or can you work with (mA, mV, AC, DC, etc.)? Check the maximum receiver impedance to ensure that the probe will perform to specifications.

Other factors you may want to consider:

What is the working voltage of the conductor to be measured? AEMC probes must not be used above 600V (see specifications)?

What type of output termination do you need: lead with BNC, lead with 4mm safety banana plugs or jacks to accept 4mm leads?

Will the probe be used for harmonics or power measurements? Look at the frequency specifications and phase shift specifications.

Lastly, if you cannot find information you need or would like assistance, call our application engineers at (800) 343-1391 or fax us at (508) 698-2118, or email techsupport@aemc.com.

Introduction

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 without interrupting the circuit under test. The probe outputs a 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 AEMC 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.
the coil B2 and clamps onto a conductor where the current I1 is flowing. B1 is simply the conductor where the user is measuring the current with the number of turns N1 equal to one. The current probe clamped around the conductor provides an output proportional to the number of turns in its coil B2, such that:

$$I_2 \text{ (probe output)} = \frac{N_1}{N_2} \times I_1$$

where $N_1 = 1$ or $\text{Probe output} = \frac{I_1}{N_2}$

(Number of turns in the probe coil)

It is often difficult to measure I1 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). If N2 equals 1000, then the clamp has a ratio of N1/N2 or 1/1000, which is expressed as 1000:1. Another way to express this ratio is to say that the probe output is 1mA/A - the probe output is 1mA (I2) for 1A (or 1A @ 1000A) flowing in the jaw window.

There are numerous other ratios possible: 500:5, 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 (Model SR604) with an output of 1mA/A. This ratio means that any current flowing through the probe jaws will result in a current flowing at the output that is 1000 times smaller:

<table>
<thead>
<tr>
<th>Conductor</th>
<th>Probe Output (1000 times less or 1mA/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000A</td>
<td>1000mA (1A)</td>
</tr>
<tr>
<td>750A</td>
<td>750mA</td>
</tr>
<tr>
<td>250A</td>
<td>250mA</td>
</tr>
<tr>
<td>10A</td>
<td>10mA</td>
</tr>
</tbody>
</table>

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., 150mA read on the 200mA DMM range represents 150mA 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).

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.

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

When the Hall device drive current (Id) is held constant, the magnetic field (B) is directly proportional to the current in a conductor. Thus, the Hall output voltage (Vh) 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 basic construction of a probe jaw assembly is shown in Figure 7, (Note: one or two Hall generators are used depending on the type of current probe).

The many AEMC 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.

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.

Example (Figure 8):

AC: Probe Model: MD303
Ratio: 1000:1
Output: 1mA AC/AAC.
DMM: Set to mAAC range
DMM Reading: 125mA AC
Current in Conductor: 125mA x 1000 = 125AAC

DC: Probe Model: MR521
1mVdc/AAC (Hall sensor)
DMM: Set to mVdc range
DMM Reading: 160mVdc
Current in Conductor: 160ADC

AC: Probe Model: MR411
Output: 1mV/AAC (Hall sensor)
DMM: Set to mVAC range
DMM Reading: 120mVAC
Current in Conductor: 120AAC

DC: Micro Probe Model K100
Output: 1mVmA
DMM: Set to mVDC range
DMM Reading: 7.4mA DC
Current in Conductor: 7.4mA DC
Low Current, Process Loops, Leakage and Differential Measurements

Numerous probes are offered for low current measurements. For example, the Models K100 and K110 have a 50mADC sensitivity and the Model K110 may be used on 4 to 20mA process loops. The selection guide has a special section on low current probes.

Examples (Figure 9):

- **4 to 20mA loop**: Probe Model K110
  - Output: 10mV/mA
  - DMM: Set to mVDC range
  - DMM reading: 135mVDC
  - Loop Current: 13.5mA (135/10)

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 (Figure 10). The value of the current is the ratio of the reading to the number of turns.

**Probe Model**: SR604
- **Ratio**: 1000:1
- **DMM**: Set to mAAC range
- **Turns in Probe Jaw**: 10
- **DMM Reading**: 60mAAC
- **Current in Conductor**: 60mA x 1000/10 = 6000mA = 6A

When the probe is clamped around two conductors with different polarities, the resulting reading will be the difference between the two currents. If the currents are the same, the reading will be zero (Figure 11).

When a reading other than zero is obtained, the reading is the amount of leakage current on the load. To measure low currents or leakage, you need a clamp-on probe which will measure low values, such as the Model 2610 (see page 58). Leakage current on grounds also may be measured directly with the Model MN291 (Figure 12).
Contact Us

United States & Canada:

Chauvin Arnoux®, Inc.
d.b.a. AEMC® Instruments
200 Foxborough Blvd.
Foxborough, MA 02035 USA
(508) 698-2115 • Fax (508) 698-2118
www.aemc.com

Customer Support - for placing an order, obtaining price & delivery:
customerservice@aemc.com

Sales Department – for general sales information:
sales@aemc.com

Repair and Calibration Service - for information on repair & calibration, obtaining a user manual:
repair@aemc.com

Technical and Product Application Support – for technical and application support:
technfo@aemc.com

Webmaster - for information regarding www.aemc.com:
webmaster@aemc.com

South America, Australia & New Zealand:

Chauvin Arnoux®, Inc.
d.b.a. AEMC® Instruments
15 Faraday Drive
Dover, NH 03820 USA
(978) 526-7667 • Fax (978) 526-7605
export@aemc.com

All other countries:

Chauvin Arnoux
190, rue Championnet
75876 Paris Cedex 18, France
33 1 44 85 45 28 • Fax 33 1 46 27 73 89
info@chauvin-arnoux.com