Fischer Custom Communications, Inc.

Current Probe Calibration

Introduction

Calibration of current probes (sometimes referred to as Current Monitor Probes) is typically performed in a special calibration fixture which is often designed specifically for the Current Probe of interest in order to obtain the most accurate calibration. The calibration fixture is coaxial and when the Current Probe is installed in the fixture, the fixture-probe combination approximates a 50 Ω transmission line.

Figure 1 shows a side view of a typical calibration setup. The network analyzer drives one side of the calibration fixture and the other side of the fixture is terminated with a 50 Ω load. The network analyzer works in terms of power, but it is more convenient to think of the corresponding voltages since it is a 50 Ω system. The network analyzer will measure the ratio of the voltage appearing at the output of the Current Probe (V_P) to the voltage driving the calibration fixture (V_{in}) i.e. $\frac{V_p}{V_{in}}$. If the network analyzer is working in S parameters, this would be a S_{21} measurement. A similar calibration could be executed using a signal generator and a receiver instead of a network analyzer.

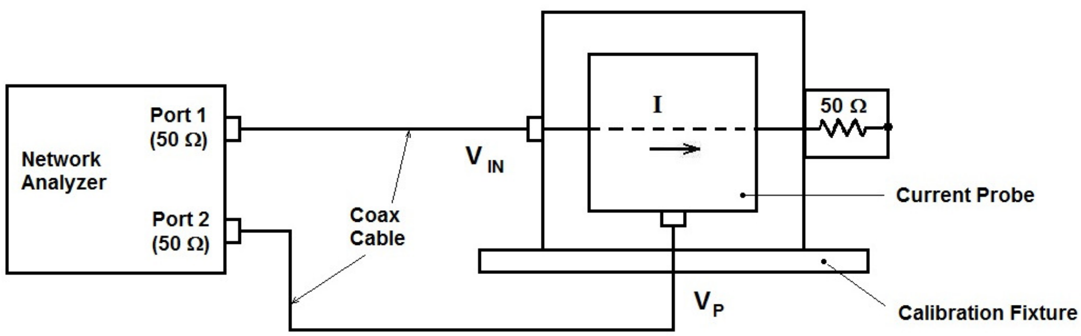

Figure 1 - Basic Setup for Calibration of a Current Probe

Transfer Impedance

The relationship between the voltage out of the Current Probe to the current flowing on the wire around which the probe is placed (the reason a Current Probe is used) is defined as the probe's Transfer Impedance - commonly denoted as Z_t.

In Figure 1, Z_t is $\frac{V_p}{I}$. To calculate current (I), Ohm's Law is used wherein $I = \frac{V_{in}}{50\ \Omega}$. So Z_t is therefore:

$$Zt = \frac{V_p}{I} = \frac{V_p}{\frac{V_{in}}{50\ \Omega}} = \frac{V_p}{V_{in}} 50\ \Omega$$

where Z_t is in units of ohms (Ω).

Z_t is often expressed in $dB\Omega$. This can be accomplished by taking $20log$ of each side of the above equation:

$$20\ log\ (Z_t)\ =\ 20\log(\frac{V_p}{I})$$

where Z_t is now in units of $dB\Omega$

$$20\ log\ (Z_t)\ =\ 20\log(V_p)\ -\ 20\log(I)$$

$$20\ log\ (Z_t)\ =\ 20\log(V_p)\ -\ 20\log(\frac{V_{in}}{50})$$

$$20\ log\ (Z_t)\ =\ 20\log(V_p)\ -\ 20\log(V_{in})\ +\ 20\log(50)$$

Finally,

$$20log\ (Z_t)\ = 20\log(V_p) - 20\log(\mathrm{V_{in}}) +\ 34\ dB$$

We see from the result above that 34 dB needs to be added to the $\frac{V_p}{V_{in}}$ measurement made by the network analyzer if V_p and V_{in} are measured in dBV. Note that I, V_p, and V_{in} could be denoted in $dB\mu A$, $dB\mu V$, and $dB\mu V$ with Z_t still in $dB\Omega$.

Example

Consider the case of a Current Probe that has a Transfer Impedance Z_t of 0 $dB\Omega$ (or 1 Ω in non-dB terms). The initial measurement from the network analyzer for $\frac{V_p}{V_{in}}$ as described above would show a ratio of $-34\ dB$. The 34 dB correction noted above would then be added to result in a Z_t of 0 $dB\Omega$.

Current Probe Usage

A common way a Current Probe is used is shown in Figure 1. It is desired to measure the current flowing on the wire or cable bundle that the probe is placed around. The voltage out of the Current Probe resulting from the current I flowing on the wire is measured on a receiver having a 50 Ω input impedance. Note this 50 Ω input impedance is necessary to match that used in the Current Probe calibration discussed above.

To convert the measured voltage out of the Current Probe (V_p in $dB\mu V$) to the current on the wire or bundle (I in $dB\mu A$), the following equation is used:

$$I\ dB\mu A\ =\ V_p\ dB\mu V\ -\ Z_t\ dB\Omega$$

In non-dB terms,

$$I\ = \frac{V_p}{Z_t}.$$

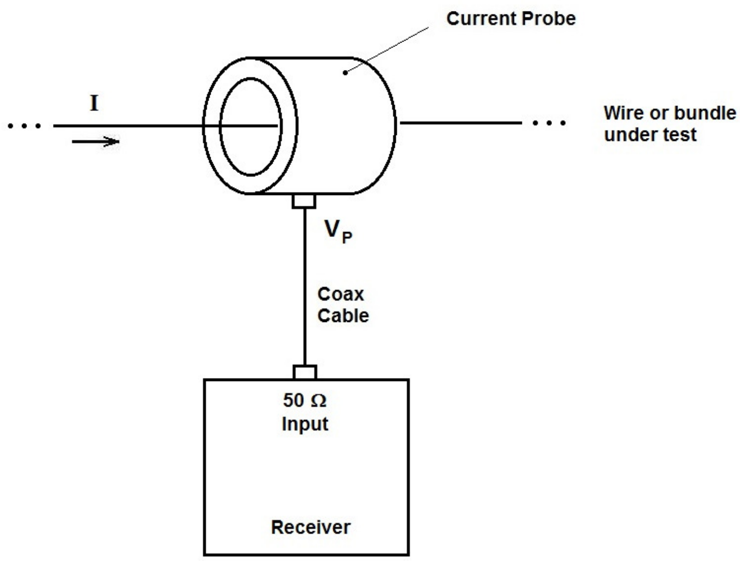

Figure 2 - Generic Test Setup for Measuring Current on a Wire Bundle