

Open Source Meter Inc	3/19/2011	www.OpensourceMeter.com
	Phone: 770-365-6520	

Current Transformers

Magnelab Current Transformers (CT) operate on the basic principal of the ratio between the primary winding (N_1) and current (I_1) to the secondary winding (N_2) and current (I_2):

$$N_1 I_1 = N_2 I_2$$

In a current transformer, the primary winding is generally a single conductor with a current passing through it. This conductor is passed once through the center of the transformer and therefore $N_1 = 1$. We can then simplify the formula:

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

To understand this better, we need to look at the theoretical function of a transformer. AC voltage applied to the primary winding of an ideal transformer induces a magnetic field of flux in the core. The magnetic flux then induces a voltage in the secondary winding proportional to the turns ratio between the primary and secondary.

$$V_s = (N_s/N_p) * V_p$$

The current in the secondary winding is inversely affected.

$$V_p I_p = V_s I_s$$

Figure 1 illustrates the operation of a simple power transformer:

Current Transformers Magnelab Current Transformers (CT) operate on the basic principal of the ratio between the primary winding (N_1) and current (I_1) to the secondary winding (N_2) and current (I_2): $N_1 I_1 = N_2 I_2$ In a current transformer, the primary winding is generally a single conductor with a current passing through it. This conductor is passed once through the center of the transformer and therefore $N_1 = 1$. We can then simplify the formula: $I_1 = N_2 I_2$ or $N_2 = I_1 / I_2$ To understand this better, we need to look at the theoretical function of a transformer. AC voltage applied to the primary winding of an ideal transformer induces a magnetic field of flux in the core. The magnetic flux then induces a voltage in the secondary winding proportional to the turns ratio between the primary and secondary. $V_s = (N_s/N_p) * V_p$ The current in the secondary winding is inversely affected. $V_p I_p = V_s I_s$ Figure 1 illustrates the operation of a simple power transformer: **Figure 1: Schematic of an idealized transformer** The main considerations are the required voltage ratios. This is mathematically expressed using Faraday's law of induction: $V_{out} = N d\phi/dt$ Where, V_{out} is the resulting instantaneous voltage, N is the number of turns on the coil being induced, $d\phi$ is the amount of change in magnetic flux, and dt is the time of the change in flux.

Open Source Meter Inc	3/19/2011	www.opensourcemeter.com
	Phone: 770-365-6520	

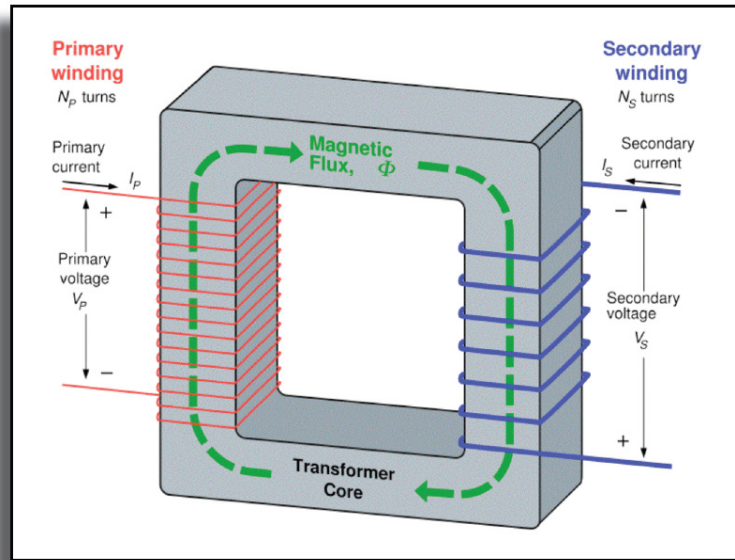


Figure 1: Schematic of an idealized transformer

The main considerations are the required voltage ratios. This is mathematically expressed using Faraday's law of induction:
 $V_{out} = N d\Phi/dt$

Where, V_{out} is the resulting instantaneous voltage, N is the number of turns on the coil being induced, $d\Phi$ is the amount of change in magnetic flux, and dt is the time of the change in flux.

Opposite of the power transformer described above, a current transformer normally looks more at the turns ratio or current ratio required. For example, to measure a 500 amp conductor using a 5 amp output, the following ratio would be used:

$$500/5 = 100$$

Assuming a 1 turn primary, a 100 turn current transformer would be required around the conductor under test in order to output 5 amps. That output would then need to be conditioned by a circuit to develop a voltage usable for measurement.

Magnelab current transformers are designed with the output pre-set to an ANSI standard of 0.333 volts using a calibrated internal burden resistor. This reduces the number of components required by the user to achieve a usable signal. This also enables control of other aspects of the transformer that affect the phase shift between the input signal and the output, and the linearity of the output signal to the input.

The phase relationship between the voltage and current input signal and output signal is not as simple due to coil and core properties such as hysteresis, and eddy current losses as shown in figure 2. By controlling the burden resistance of the transformer, Magnelab has minimized the affect of these losses and therefore minimized the phase shift of the output signal.

Opposite of the power transformer described above, a current transformer normally looks more at the turns ratio or current ratio required. If you want to measure a 500 amp conductor using a 5 amp output you would use the following ratio: $500/5 = 100$ Assuming a 1 turn primary, you would need a 100 turn current transformer around the conductor under test to give you a 5 amp output. That output would then need to be conditioned by a circuit to develop a voltage usable for measurement. Magnelab has designed our current transformers with the output pre-set to an ANSI standard of 0.333 volts using a calibrated internal burden resistor. This reduces the number of components required by the user to

Open Source Meter Inc	3/19/2011	www.opensourcemeter.com
	Phone: 770-365-6520	

achieve a usable signal. This also enables us to control other aspects of the transformer that affect the phase shift between the input signal and the output, and the linearity of the output signal to the input. The phase relationship between the voltage and current input signal and output signal is not as simple due to coil and core properties such as hysteresis, and eddy current losses as shown in figure 2. By controlling the burden resistance of the transformer, Magnelab has minimized the affect of these losses and therefore minimized the phase shift of the output signal. **Figure 2: Waveform relationship of transformer parametric currents and voltages** Linearity of output voltage is controlled by using precision burden resistors and reducing the losses in the secondary coil of the transformer. This characteristic, along with the phase shift, are a measure of quality and design of a current transformer when used in the energy management industry. RopeCt series transformers are current transformers that are characterized by a non-magnetic flexible core design which allows a wide range in the rated current, as well as installation in areas where space is limited. RopeCt transformers are produced in 24" length flexible cables with matched end connectors. The standard output voltage is 0.333 V. Linearity of output and position accuracy make the RopeCt series of transformers a very reliable current sensing device to be added in the Magnelab family of CT products.

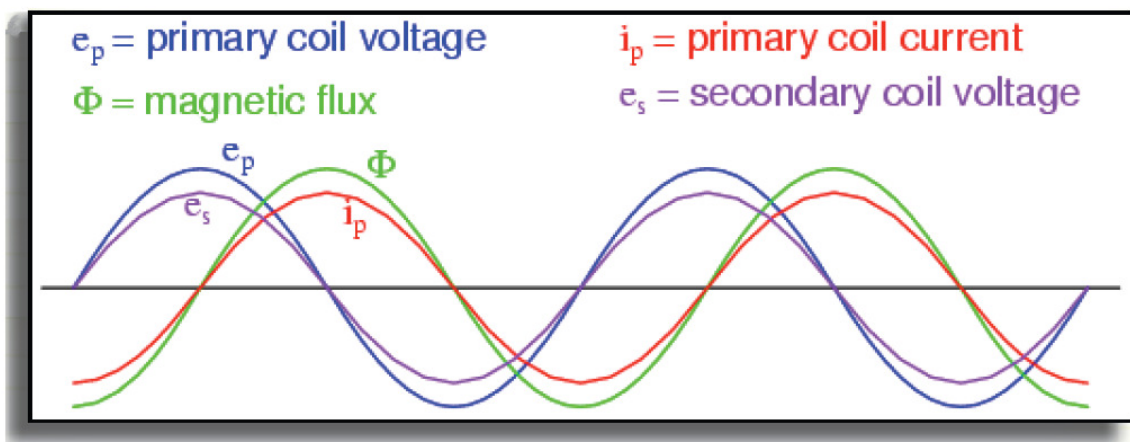


Figure 2: Waveform relationship of transformer parametric currents and voltages

Linearity of output voltage is controlled by using precision burden resistors and reducing the losses in the secondary coil of the transformer. This characteristic, along with the phase shift, are a measure of quality and design of a current transformer when used in the energy management industry.

RopeCt series transformers are current transformers that are characterized by a non-magnetic flexible core design which allows a wide range in the rated current, as well as installation in areas where space is limited. RopeCt transformers are produced in 24" length flexible cables with matched end connectors. The standard output voltage is 0.333 V. Linearity of output and position accuracy make the RopeCt series of transformers a very reliable current sensing device now added to the Magnelab family of CT products.