

Current Transformers—and Vacuum Cleaners

Q. You referred to Current Transformers in a recent RAQ. What are they and how are they used?



A. Current transformers are normal transformers used in a slightly different way. You'll find them in textbooks, but many engineers seem to have missed that bit! I use one to turn on a vacuum cleaner.

The usual concept of a transformer consists of two magnetically coupled coils—primary and secondary—with a turns ratio of 1:N. An ac signal voltage V on the primary produces a secondary signal voltage $N \times V$.

When a transformer is used as a current transformer, we pass an ac current through the primary. With a mythical "perfect transformer," the short-circuit secondary current is proportional to the input current and inversely proportional to the turns ratio.

This relationship persists if the secondary is connected to a resistance instead of a short circuit, assuming the resistance is not too large. This provides a way of measuring the ac current in the secondary—from which we can deduce the ac current in the primary—and allows us to measure ac currents with an isolated circuit.

The design of current transformers is often trivial, although care is needed for extreme cases (ac+dc measurements, high voltages, and low-loss measurements). At line and audio frequencies, a small iron-core transformer from the junk box or Radio Shack—modified by threading a new primary of one to five turns of hook-up wire around the existing windings—often suffices, assuming there is space for such a winding. Commercial current transformers often consist of a wound toroidal core, with the primary being a wire through the center of the toroid. The toroid is sometimes hinged, allowing it to be opened for primary insertion.

The secondary resistance must be sufficiently low that the core of transformer does not saturate. The lower the resistance, the lower the possible operating frequency for a given transformer. If the transformer output is applied to the inverting input of an op amp with resistive feedback, the resistance is very low, so the minimum operating frequency is also very low. It is often possible to use a miniature current transformer, specified at 10 kHz with a 200- Ω load, at just 50/60 Hz with an op amp as its load.

In addition to measuring ac current, current transformers can sense current for control purposes—one senses the current in my woodworking saw to operate the dust-collection vacuum cleaner—and they are widely used in domestic power monitors.