Theft Resistant Energy Meters

By Paul Daigle, Product Manager at Analog Devices Inc, Wilmington, Massachusetts

Only profitable businesses can offer high quality at an occasional discount. Utility companies are no different. All honest consumers of electricity would like everyone else that uses electricity to also pay for their fair share of electricity so that quality of distribution can improve. With the advent of electronic energy meters, utility companies have a wide selection of approaches to combat theft on their grid. The breadth of selection depends upon the available infrastructure and investment capital available.

The most robust and technically superior solution would approach the elusive goal of a tamper-proof meter. This elegant solution would monitor every energy meter remotely and capture an energy consumption reading every 15 or 30 minutes. Usage patterns could be monitored and abnormalities detected. A decision could be made to discontinue service remotely. Potential lost revenue from consumer misuse is eliminated quickly and the likelihood of corruption is curtailed significantly.

The success of an automatic meter reading solution relies on utility companies willing to take the risk of investing in a communications network and a data management infrastructure. The return on investment of such an installation project complicated by political agendas is difficult to justify before a real life testimonial can be used as an example. Based on risk and economic environment, utility companies in developing countries are forced to adopt a low cost approach instead of a technically superior solution.

Most of the electricity in developing countries is distributed on two wire, single phase. The functional equivalent to the electromechanical meter is an electronic energy meter that measures current in the phase wire. An example of the typical connection on a standard electronic energy meter used for two wire, single phase distribution is shown in figure 1. This configuration, installed by utility companies, allows correct billing by monitoring current only in the phase wire but this is not sufficient to bill correctly under popular tampering schemes. This example uses a current transformer as the transducer on the phase current path.

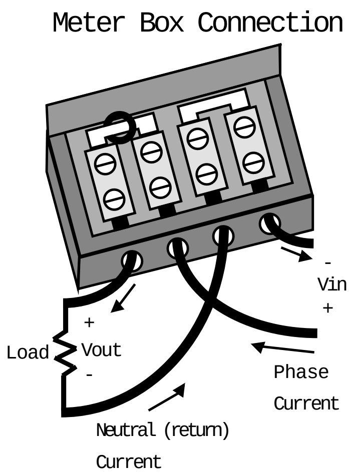

Figure 1: Proper Connection

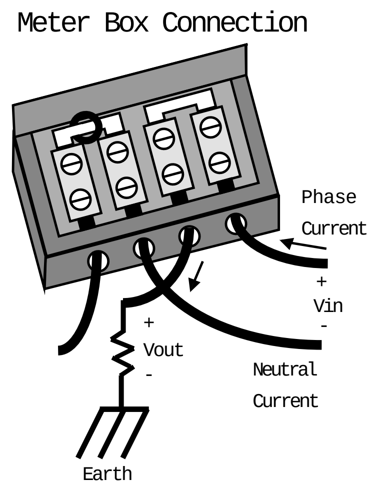

Figure 2: Improper Connection billed incorrectly

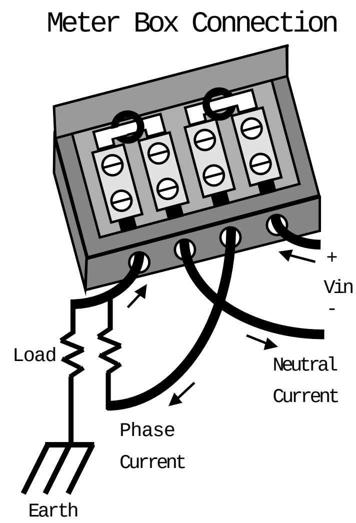

Figure 3: Improper Connection billed correctly

A popular approach to designing a tamper resistant energy meter monitors current in both the phase and return path. Monitoring both phase and neutral and calculating real average power based on the larger of the two currents eliminates most pilfering schemes that tamper with the current path through the energy meter. A mechanical meter or an electronic meter with a single current transducer is unable to detect power consumption of the load in the configuration shown in figure 2. Figure 2 illustrates blatant tampering that is easy to detect with visual inspection. Figure 3 illustrates a more subtle approach. All connections to the meter are correct but not all of the current supplied to the load is returned through the meter. A popular tactic that is difficult to detect is to reduce the size of one's bill by creating a partial earth fault. This illustration uses two current transformers that are fairly well matched to eliminate the need for calibration of the second current channel. The meter bills according to the larger of the phase or neutral currents.

These types of simple tampering schemes can cost power generation and distribution companies lots of money when implemented on high current loads. The cost for implementing a meter capable of reliably detecting differences in phase and neutral currents at very low currents is probably unwarranted. Electronic energy meter manufacturers have been designing these systems with multiple integrated circuits. The multiplexers and comparators used in these schemes increase component count and are not able to bill accurately under a fault condition. The AD7751 integrates this functionality onto a single chip to eliminate switching and threshold noise while reducing component count. A fault is indicated when the phase and neutral currents differ by more than 12.5%. Billing is continued using the larger of the two currents. The lowest cost meter still requires manual reading of a mechanical counter. The AD7751 drives the stepper motor counter directly to facilitate the lowest cost design.

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