

Seisco Water Heater Analysis

Overview

A customer reported inaccurate results when measuring the energy consumed by Seisco SH-9 hot water space heater. The customer believed the WattNode was registering roughly one-half the actual consumed energy.

We performed measurements using a Fluke 43B with the 80i-110s AC/DC probe and found that the Seisco is using half-cycle current control, frequently resulting in sustained DC current bias. Specifically, we saw large bursts (20 or more AC cycles) of all positive half-cycles, effectively resulting in DC current.

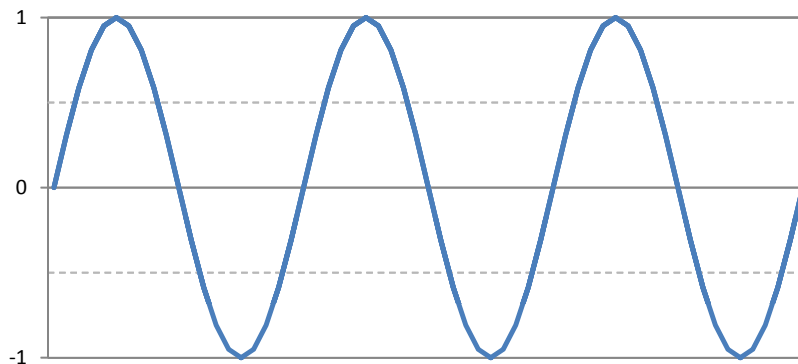
These bursts of DC current cause two problems for the WattNode current transformers (CTs). First, CTs cannot measure DC current and so fail to accurately measure the actual current, which contains a large DC component for periods of hundreds of milliseconds. Second, the DC current saturates the magnetic core of the current transformers, preventing them from accurately measuring even the AC component of the current consumed by the Seisco heater.

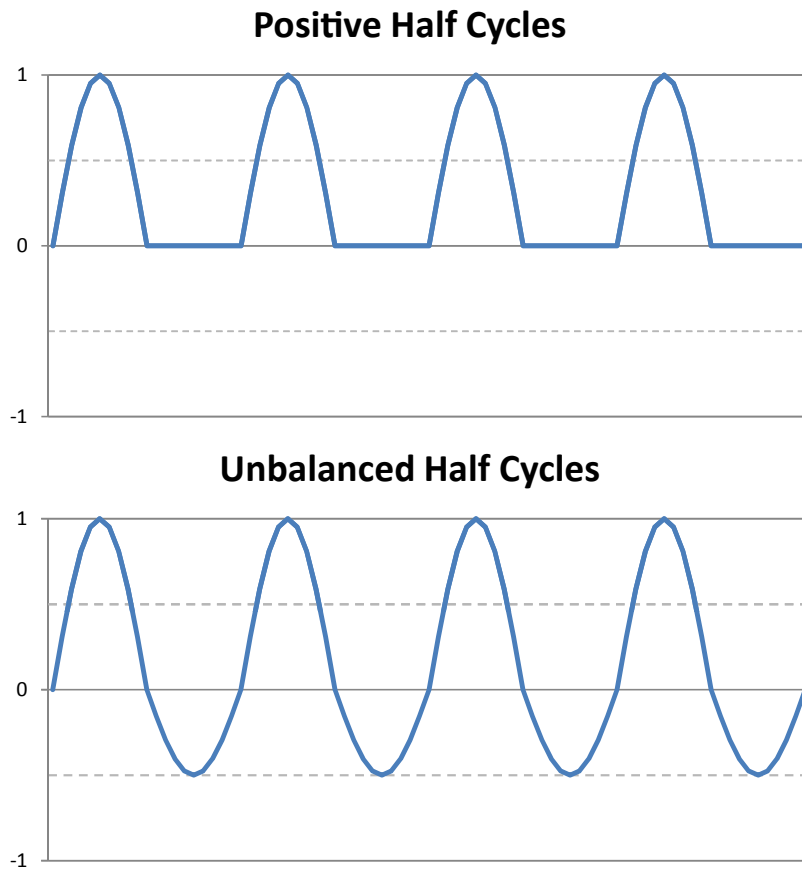
In conclusion, the combination of the WattNode with AC current transformers cannot accurately measure loads with substantial and sustained DC current, such as the Seisco SH-9. We have not tested this, but the WattNode should be capable of measuring DC current with AC/DC CTs; however, AC/DC current transformers (Hall effect) are difficult to find, very expensive, and generally require a separate power supply.

Testing

We only measured the current waveform, because once we saw significant DC current, it wasn't necessary to do measurements with the WattNode, since we knew the results would be poor. The actual waveforms showed frequent variation between different modes of operation, but essentially consisted of different combinations of the following three waveforms as well as the no current condition (not shown). The following are simulated waveforms, because our equipment was not set up to capture the actual waveforms.

Normal Cycles





We measured sustained periods of 20 cycles or more that exhibited a DC imbalance. Moreover, the “Unbalanced Half-Cycles” case only appeared with one polarity. We did see both positive and negative half cycles, but with no indication of balance. Positive half-cycles seemed far more common and there were frequently long runs of positive half cycles, then short runs of negative half-cycles, but no signs of interleaved half cycles (positive followed by negative followed by positive).

Because the overall currents were high (15-35A), the periods of imbalance represent a large effective DC current for hundreds of milliseconds, which is certainly enough to cause measurement problems for our CTs.

Future Study

We believe larger and/or higher amperage current transformers can handle more DC current without saturating, so we want to test and characterize the maximum allowable DC current for our common CT models.

We also want to simulate and test the effect of DC current on the accuracy of measured power and energy, both for brief DC currents (a few half-cycles) and for sustained DC currents (continuous half-cycles), to determine if it is possible to measure loads like the Seisco water heaters with reasonable accuracy.