

Digital Energy Meters by the Millions

By Paul Daigle

The advantages of highly functional three-phase meters for digital energy measurement have been demonstrated in North America's commercial and industrial markets. Many in the industry are waiting for companies that serve the residential energy markets to make the leap into single-phase digital meter implementation. These individuals believe electronic metering solutions can provide the residential energy market with accuracy, flexibility and networking benefits currently unavailable in most locations. With millions of electro-mechanical meters installed in North America, some predict that a high-volume market exists in the United States for low-cost digital residential meters to replace these analog units.

Single-phase digital meters are serving millions worldwide, so why haven't they caught on in North America?

Even though many feel the North American market is ready for the single-phase digital meter, few of these meters are actually being installed. However, millions are being installed in other parts of the world, especially in China, where they are proving to be cost-effective.



Typical PowerCom in-home unit.

Digital Meter Technology

The three-phase meters already in use by many commercial and industrial customers use electronics to interface with current transducers and digitize the voltage and current waveforms. A high-speed, high-performance microprocessor, or digital signal processor (DSP), uses digitized waveforms to calculate various information, such as power quality. The cost-sensitive residential single-phase market needs only a subset of the functionality offered by the three-phase meter. For this high-volume market, a converter that interfaces directly to the current and voltage transducers, and instantly accumulates kWh is a valuable building block for reaching innovative solutions. Semiconductor manufacturers are contributing to this goal by providing low-cost, high-performance building blocks that reduce power consumption and lower unit cost.

Single-phase Metering in the Western Hemisphere

Single-phase digital energy measurement has been widely accepted among many prepayment meter manufacturers. Prepayment meters, such as Schneider Electric's EasyWatt, Siemens' CashPower and

DIGITAL ENERGY METERS



Typical Chinese meters using latest single IC technology.

Motorola's PowerCom, use highly accurate integrated digital solutions to dispense electricity to residential consumers. In addition to prepayment strategies, digital energy measurement technology holds real promise in North America as a strategy for remote data collection. Refurbishing classical energy meters with electronic boards for data collection has proved useful in the short term, but the additional cost associated with this strategy seems unnecessary when other options are available. An alternative to such a solution could be allowing a dc power supply for the electronic retrofit to be shared by a single integrated circuit that measures watts and eliminates the components required for displaying energy. A meter without a display, although unusual in most of the Western Hemisphere, could offset the additional unit cost of a module for remote data collection.

High-Volume Deployment in China

China is currently deploying millions of single-phase digital energy meters and is proving to be one of the more progressive nations when it comes to installing high volumes of digital energy meters. The central governing body that advises the provincial, city and district utility boards is not endorsing digital energy meters yet, but it has been conducting a life-expectancy study. The digital energy meter has recently passed the seven-year mark and the study results are so promising that some utili-

ty boards have stopped purchasing electromechanical meters. In fact, it has been predicted that more than 10 million digital single-phase meters are going to be shipped to various utility boards in China this year. An understanding of the unit cost of different single-phase meters on the market helps explain

why the electromechanical meter is being replaced so quickly.

The high-end mechanical energy meter is sold for \$12-\$17, with a 15-year guarantee. The low-end mechanical meter, which typically lasts 10 years, sells for \$7 but has no guarantee of longevity. Not only are these meters calibrated every five years, but also they are randomly sampled and verified for accuracy every year. The digital energy meter costs \$9-\$12, comes with a 10-year guarantee, and its accuracy does not drift over time. If the meter fails, then it is replaced free of charge.

Reputable meter manufacturers like Hangzhou Holley-Nisko and Henan Jinque have been offering all three types of meters (high-end mechanical, low-end mechanical and digital) for years. The performance, reliability and cost of digital energy meters have prompted these manufacturers to convert their electromechanical manufacturing capacity to the simpler electronic manufacturing process.

The most popular single-phase digital meter being installed in China looks



Actual size of a single IC kWh measurement base unit.

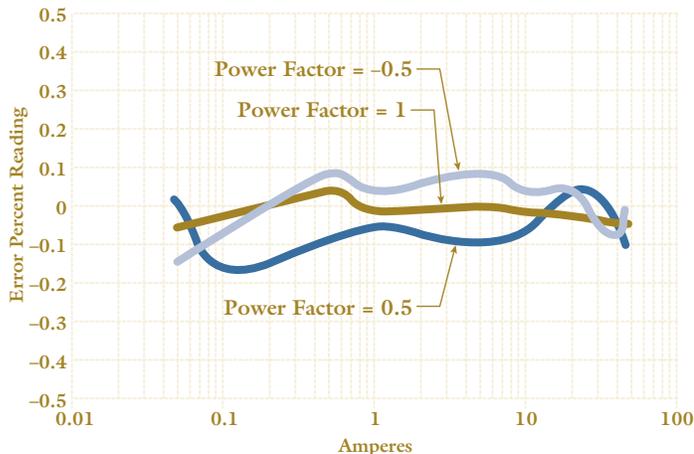
Analog vs. Digital Energy Measurement

The electromechanical meter is the most common way to measure energy using the analog method, but some electronic meters also use analog measurement. An analog solution is not synchronized to a clock or crystal, but rather continuously calculates the product of current and voltage. Electronic analog signal processing includes Hall effect multiplication and discrete analog multipliers. The analog energy meter's main disadvantage is that it doesn't provide energy consumers with data needed to make energy management decisions, nor does it give utilities the data they need to improve customer service. Analog meters lack stability and their accuracy drifts over long periods of time or if they are installed in environments that experience large temperature shifts. Inexpensive electronic solutions have been attempted with analog processing or time division multiplexing, but only digital processing meets all the requirements of a highly integrated, low-cost energy meter. The digital signal processing architecture will dictate the next-generation meter's time to market, unit cost and life expectancy.

The term digital implies a time-sampled system. An analog-to-digital converter (ADC) samples current and voltage transducers' output at a high frequency, translating real-world waveforms to binary words that digital circuitry can understand and manipulate. The ADC's resolution and speed not only influence the duplication quality of continuous time signals, which vary at a fundamental frequency, but it also affects the microprocessor bandwidth required for calculations.

Once converted to a digital signal, the voltage and current waveforms can be multiplied, filtered and integrated by digital circuits to extract just about any information. A fixed function DSP places values in registers that can be read by a low-bandwidth microprocessor. If intensive calculations such as those required for power quality monitoring are necessary, then a programmable DSP is appropriate. A fixed function DSP supported by a few resistors and capacitors makes for a small, high-performance, low-cost board (see photo at left).

Typical Chinese Meter Measurement Accuracy



like a European meter and uses a stepper motor counter to display energy consumption. Much like in North America, China’s consumers expect an energy consumption display. Admittedly the stepper motor counter has been the largest single reason for failure in the field, but it will not be replaced by more expensive options any time soon. Single-phase meters are so cost sensitive that the stepper motor counter is expected to be around for a long time, mainly because the cost of driver electronics and non-volatile memory required for other types of displays is simply too high. The stepper motor counter is believed to be more reliable than a mechanical meter because it is only exposed to low voltages from the integrated circuit’s driving pulses. Soon, the government is expected to draft minimum stepper motor counter performance requirements to reduce the proliferation of sub-standard performance.

China is in the midst of upgrading its distribution and metering. Many of the old meters have maximum currents as low as 10A. The maximum current is being increased to support all the “new” appliances in a home such as hot water heaters, washers, dryers, electric ovens and refrigerators. The Chinese digital meter

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The Chinese prefer digital meters over electromechanical for three main reasons:

1. Accuracy and stability. Digital energy meters maintain their accuracy over a larger current range than the mechanical meter. These new meters are also stable over changes in temperature, voltage

and line frequency. This is a big selling point in provinces that border Siberia. An accuracy plot of a typical Chinese meter using the latest digital technology illustrates the high performance of these low-cost meters (see figure).

- 2. Simplified and reduced cost of meter maintenance.** The digital energy meter is more accurate than the electromechanical meter and requires less maintenance. China is heavily dependent on manual labor, but utility boards are typically too poor to support it. For that reason, getting rid of periodic calibration is attractive.
- 3. Communications upgrade path.** The base of digital energy meters has two small terminals used during calibration. The outputs of these terminals are tied in a current loop of 16 meters connected in series to a hub for data collection. It is a low-cost method of consolidating meters in city apartments to a central point.

Chinese Meters in North America

Digital energy measurement technology is being used in millions of Chinese energy meters today. Some Chinese meter manufacturers are eyeing the export market. With highly accurate and stable low-cost meters, Chinese manufacturers are looking at modifying their design to suit the North American market. ■

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