SMART METERING: NOT ONE-SIZE-FITS-ALL

DESIGNING HIGHLY CONFIGURABLE AND COST EFFECTIVE NEXT GENERATION SMART METERING SOLUTIONS

By Steve McClure

Over the past few years, utility companies throughout the world have been increasingly focusing on the deployment of smart metering technologies. Although there are many important benefits in terms of operational and capital expense, service improvement and better operational control, the deployment of smart metering definitely is not a 'one-size-fits-all' undertaking. However, by standardising on highly integrated and flexibly configurable system-on-chip (SoC) metering solutions, manufacturers can bring down their research and development costs and improve their ability to serve the entire range of market requirements, as well as future-proof their meter architectures to meet continually evolving requirements.

For example, in North America Automatic Meter Reading (AMR) regulations have a significant impact on how smart meters need to operate with regard to frequency of reads and transmission, as well as the amount of data that must be retained locally at any given point in time. Because communication is not always reliable, some AMR regulations require utilities to store two or more transmissions to meet billing requirements, which in turn drives up the amount of local on-chip memory for smart meter ICs. As a result, the regulatory pressures of specific jurisdictions can have a direct impact on the design of smart metering solutions, all the way down to the chip level.

Another major driver of smart metering functionality is improving local anti-tampering capabilities, especially in developing environments such as India, China and South America, where electricity theft accounts for a large percentage of overall power usage. The ability of solid state electronic meters to detect many of the most widely used tampering methods can provide significantly improved control and cost recovery for utility companies. Here again, the high level anti-tampering objectives are both driving the adoption of solid state metering and dictating required feature sets at the chip level.

Finally, the promise of improving service to customers represents an important goal of smart metering, especially over the longer term. By enabling customers to better manage their own energy usage through incentive-based programmes, such as direct load control, interruptible rate agreements, demand bidding/buyback, etc., smart metering can help utilities manage overall energy consumption patterns and cope with peak demand challenges. In addition, with the right capabilities built into the chip-level solutions, smart metering deployments can effectively lay the groundwork for expanded customer service functions, such as wireless integration with thermostats to automatically adjust usage during peak demand periods.

For meter manufacturers serving worldwide utility markets, the above combination of driving forces presents both huge opportunities and significant challenges. While smart metering is not necessarily the right fit for all situations today, because of the long time for capitalising utility equipment investments, most companies are at least considering the implications of future smart metering applications when making today's deployment decisions. Therefore, meter manufacturers need to be able to span a range of demands for both low cost metering solutions and high-end smart meter alternatives.

One way that many meter designers are addressing this dilemma is by standardising on integrated SoC solutions, which can adapt across the whole spectrum of functionality requirements. These SoCs deliver low cost by eliminating the need for designing with discrete components, while also providing rich feature sets for smart metering and future upgrade paths with minimum additional hardware and operational costs.

EVOLUTION OF SOLID STATE METERING

According to industry research firm, IMS Research, "2007 will mark a critical inflection point in the global electricity meter market. For the first time in the industry's history, more static (electronic) meters will ship around the globe than mechanical meters." IMS Research estimates that of the 111 million electricity meters shipped worldwide in 2007, 57% will be based on electronic technology. One of the key reasons cited for the trend toward solid state metering is the evolution of electric utilities from predominantly government-managed entities to private for-profit business enterprises, which has placed more emphasis on cost containment, efficiency of operations and customer service.

The earliest solid state meter architectures combined multiple ICs to implement the required functionality. Typically, a microcontroller performed the system management and display tasks and multiple A/D converters combined with

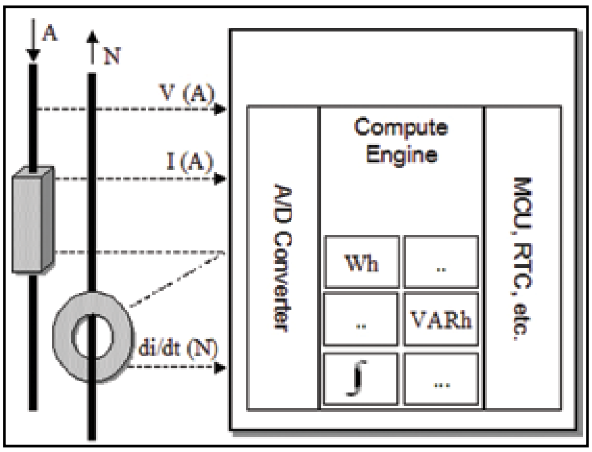

Figure 1 – The highly integrated 71M6521 metering IC with single converter technology

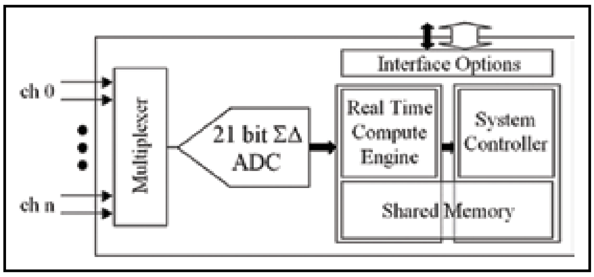

Figure 2 – Division of functionality in a mixed signal metrology subsystem

a fixed function signal processor handled the metrology functions. The next phase involved development of proprietary metrology ASICs by large meter manufacturers to combine A/D conversion and digital signal processing (DSP) functions. However, this still fell short of providing the level of integration and configuration flexibility needed to support dynamically evolving market demands.

In recent years, the development of integrated SoC solutions addressed these limitations by optimising for cost, performance and flexibility, while shortening time to market and reducing component count. A key innovation in the development of integrated SoC meter ICs has been the streamlining of the metrology functions by combining a single sigma-delta A/D converter with several multiplexed inputs and a programmable real time compute engine (Figure 1). This single converter technology provides flexibility for customising the DSP unit for utility requirements with minimal upgrades to their hardware infrastructure.

The multiplexed approach is particularly well suited for applications with separate signals that are similar in nature, such as power measurement. A key requirement is the preservation of phase information between the channels, enabling the compute engine in a multiplexed system to perform 'simultaneous' measurements across different channels. In addition, the single converter architecture provides lower channel-to-channel crosstalk when compared to architectures that dedicate separate A/D converters to each channel, a key benefit in power measurement applications. Therefore, an SoC using a single converter multiplexing approach (Figure 2) provides the smart meter system designer with gain uniformity, offset uniformity, reduced channel-to-channel crosstalk, design flexibility, and an overall lower cost, high accuracy solution with wider bandwidth for measurement (2000:1).

In addition, due to the real-time computing engine firmware upgradeability, changes can easily be made to accommodate measurements utilising various current sensors such as current transformers (CT), Rogowski coils and current shunts, along with the evolving anti-tampering technology support required by utilities.

SMART METER IMPLEMENTATION SCENARIOS

AMR has the potential to be the single biggest driving factor for the adoption of new metering technologies in North America. However, the regulatory constraints and the challenges of changing over to an Advanced Metering Infrastructure (AMI) have thus far contributed to a fairly tepid penetration rate. A recent study by the Federal Energy Regulatory Commission (FERC) reported that penetration of AMI across the US is only at 5.9% (see *Metering International* 4/2006, p 54). However, the huge potential cost saving from AMR and announced programmes from some major utility companies will significantly accelerate adoption over the next few years.

Basically there are two schools of thought with regard to the implementation of AMR, depending largely on the regulatory environment for different countries and jurisdictions. One approach uses relatively high functionality metrology capabilities at the metering end point, and the other focuses on lower cost, simpler functionality. As previously mentioned, some regulatory jurisdictions such as California mandate strict requirements to avoid loss of data and assure accuracy of AMR readings for billing purposes. With reads taken at relatively short intervals (every 15 minutes), the accumulated data is then communicated at longer intervals (every 8 hours). However, the regulations compensate for potential communications failures by requiring that at least two data builds always be retained at the metering point, which means that the metrology chip must be capable of storing up to 16 hours of data. In contrast, in regulatory environments that place less stringent demands on the AMR process, such as some South American countries, utilities have more flexibility to minimise the cost of the metrology functionality at the meter (unless they determine that a positive pay-back can be achieved from using higher end functionality for anti-tampering purposes).

Although there is also a longer term potential for cost savings by combining the AMR functions directly into the metrology SoC, this is unlikely to be practical in the near term, due primarily to fragmentation of AMR communications methodologies. Communication links may be based on modems (either fixed line or cellular wireless) or power line communications (PLC), with the Bill of Materials cost ranging from $3 for PLC up to more than $20 for cellular modems.

Over and above any specific AMR considerations, some utilities are moving more rapidly to higher end metrology smart metering functionality as part of a broader strategy to improve overall energy usage, business management and customer service. For example, deploying higher end metrology chips that allow for field programmability (via firmware), is a strategy that allows utilities to bring down both operational and capital investment costs over the longer term as well as giving them much greater flexibility to adjust policies in response to changing energy usage patterns. For example, the specific times of day set for peak-rate pricing policies may need to be adjusted as significant numbers of users shift their energy consumption or in response to seasonal fluctuations. Remote upgrades via firmware allow utilities to quickly tailor their rate incentives for customers to help smooth out peak demands, while tracking with dynamic changes in peak usage patterns.

For overall business management, smart metering gives electric utilities real-time visibility over usage patterns in the final segment of their transmission infrastructures, from the transformer to the customer. Not only does this add to the visibility that they already have throughout the electrical distribution grid and from the substations to the transformers, it also allow utilities to empower their customers with information to better manage their own usage. For instance, PG&E in California is rapidly rolling out smart metering and plans to offer customers enhanced options such as monitoring their hour-by-hour usage on the internet and adjusting their usage to take advantage of incentive rates. In addition, there are plans for enabling wireless integration of smart meters to customers' thermostats to enable automatic, pre-agreed minor adjustments in temperature settings during peak periods in exchange for an overall rate reduction.

Smart metering also opens up the possibilities for implementing sub metering strategies within larger buildings. By using a single smart meter with multi-drop communication links to individual customers (via wire, wireless or PLC) a utility can eliminate the need for individual meters for every customer, while still providing a high degree of visibility for every customer's energy usage.

Anti-tampering is another key driver for smart metering, especially in developing countries where electricity theft is a major cost concern for utilities. For example, it has been estimated that as much as 40% of the power usage in Brazil is stolen. Typical tampering techniques vary from intrusive means such as breaking the meter housing and jamming the mechanism, to more subtle methods like applying magnets to the outside of the meter to saturate magnetic components, or altering the characteristics of the load by adding capacitance, half-wave rectified loads or instantaneous high currents.

Deployment of more sophisticated solid state metrology enables advanced anti-tampering measurements such as the reflected load (VAR-hours), neutral current, DC currents invoked by rectified loads and detection of ambient magnetic fields. Substation meters may also be used to detect discrepancies between the total billed and the total generated power and report them via the AMR network. In order to prosecute and recover the costs of stolen energy, detailed information such as the exact times and amounts of energy theft are critical pieces of evidence that can be captured via smart metering technology.

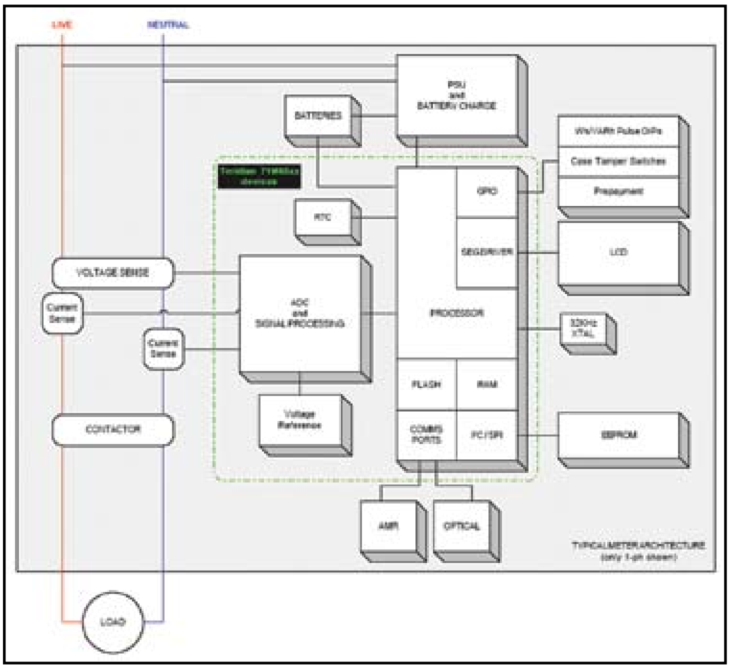

Figure 3 – Typical meter architecture

REQUIREMENTS FOR ENABLING SMART METERING

It is clear from the current state of evolving market requirements, jurisdictional regulatory differences, and varying implementation approaches, that there is no near-term opportunity for meter manufacturers to offer a "one-size-fits-all" solution. However, by standardising on highly integrated and flexibly configurable SoC metering solutions, manufacturers can bring down their R&D costs and improve their ability to serve the entire range of market requirements, as well as future-proof their meter architectures to meet continually evolving requirements.

Some of the key ingredients that make up an ideal SoC smart metering solution are:

- Flexible, multiple-port, communications options (e.g. multiple UARTs for simultaneous communications, or optical port and a UART) to support AMR links, integration with local devices such as thermostats, and potential multi-drop sub-metering topologies (RS485/Modbus/Canbus, etc.)
- Streamlined multi-read processing capabilities to reduce unit cost by multiplexing inputs through a delta-sigma A/D converter in conjunction with a programmable compute engine
- Support for a variety of sensor inputs with minimum hardware and the capability to adjust for temperature and other environmental variations for improved efficiency and accuracy
- Field firmware upgradeability to allow for both extending the useful life of the metering solutions and dynamically adjusting policies to optimise energy usage
- Polyphase monitoring and analysis capabilities to help commercial and industrial customers manage their energy efficiency, load analysis and optimise motor functions
- Built-in real-time clock functionality
- LCD interface capable of supporting multiple voltages and screen resolutions
- Various levels of internal flash memory sizes, along with external memory management capabilities to support a wide portfolio of data storage options
- Technology to support several tamper detection mechanisms and prevention of energy thefts, utilising a combination of CT, Rogowski and current sensing, and combinational current sensing mechanisms along with open current sensor detection
- Ability to work with one wire power measurement for special tamper detection conditions on line and neutral lines for single and three phase power measurements.

By leveraging the flexible feature set described above, manufacturers can effectively span the gamut of metering options from low-cost fixed function devices to high memory, reprogrammable, high accuracy premium devices (Figure 3).

As the market for smart metering functionality continues to evolve and change, this flexibility will enable both meter manufacturers and utility companies to adapt to the needs of customers and the dictates of regulatory authorities, while simultaneously optimising operational efficiency and profitability. MI

ABOUT THE AUTHOR: Steve McClure is the Vice President of Marketing for Teridian Semiconductor Corp. In this role he is responsible for product management and strategy, partnerships and licensing, marketing communications, and other business development activities for the company. He has more than 13 years in both technical and marketing leadership roles, and served previously as Executive Director of Marketing at Mindspeed and Director of Marketing at AMCC.

McClure received a Masters of Business Administration degree with honors, and both Masters of Science and Bachelors of Science degrees in Electrical Engineering from the University of Southern California.

ABOUT THE COMPANY: Teridian Semiconductor Corporation brings intelligence and integration to real-world designs. The company's best-in-class analogue and mixed-signal integrated circuits play a primary role in energy and automation, networking, and secure access applications. Teridian solutions can be found in smart card readers, VOIP gateways, set-top boxes, point-of-sale equipment, utility meters and factory floor automation across the globe, enabling customers to get to market quickly with advanced applications that are tailored to meet the specific needs of their target markets.

www.teridian.com