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Keys to Smart Grid Security

By Dave Buster, Director, Solutions Architecture, Elster Solutions

SMART GAS AND WATER METER TRENDS: IMPACTS ON METER DESIGNS

By Nancy Chang

The industry is in the midst of building a smarter grid. Billions of dollars worldwide are being poured into research and development, fuelling innovations for and significant growth of the smart grid. One particular example is the shift towards smarter, more advanced meters. While this trend first started off with the electricity meter market, the adoption of smart meters within the gas and water meter market is also gaining momentum.

The global smart water meter installation base continues to grow, tripling from 10.3 million units in 2011 to 29.9 million units by 2017 (Pike Research, 2012). As the global demand for this limited resource continues to increase to 45% by 2030 (World Bank, 2011) and as aging infrastructure becomes an even greater issue, governments and utility companies are under increasing pressure to better manage their water supply.

On the gas meter front, annual unit shipments will rise from 1.9 million smart gas meters in 2010 to 7.8 million by 2016. Forecasts indicate that a total of 28.4 million smart gas meters will be shipped worldwide between 2010 and 2016, and that the total installed base will reach up to 36.3 million units by the end of that period (Pike Research, 2011).

This trend is heavily driven by the European market where governments and regulations continue to drive smart gas meter rollouts. The 20% energy efficiency goal, part of the 20-20-20 initiative driven by the EU's Energy Efficiency Directive, attempts to address long term challenges around an affordable, secure and sustainable energy supply. For consumers, access to more accurate and insightful data regarding their energy consumption can help them handle their energy use and save money more effectively.

The UK currently has the largest number of gas meters in Europe with 22 million units. In response to the government's vision of deploying all smart gas meters by 2020, suppliers such as British Gas have pushed forward with smart gas meter rollouts. Italy, the second largest gas country in Europe with an installed base of 21 million units, has already kicked off large pilots for a mandatory mono gas rollout (van Dyck, 2011). Finally, in France, pilot programs have been supported by Gaz reseau Distribution France (GrDF) to analyze the possibility of a future mass deployment to its 11 million gas meter customers (Itron, 2010).

These successful pilots enable comparison among meter-reading technologies, radio frequencies, and functionalities, along with other factors such as cost of ownership, of smart metering solutions from various vendors. The results and conclusions drawn have assisted in defining requirements and technical specifications for these specific markets, leading to greater contribution to the growth of the smart meter market.

DESIGNING SMART METERS UNDER CHANGING REGULATORY ENVIRONMENTS

Regulations affect smart meter adoption rates and also specifications that determine a meter's functionality. The challenge

is that future changes in regulations can bring significant unforeseen costs to stakeholders across the entire smart grid chain.

The Department of Energy and Climate Change (DECC) in the UK, for example, is now on its second version of the Smart Metering Equipment Technical Specifications (SMETS). Under the SMETS v2, both 2.4 GHz and 868 MHz frequencies, with ZigBee® SEP v1.x as the proposed application layer for gas meters, have been recommended as viable radio frequency (RF) communication choices for Great Britain. While 2.4 GHz-based meters will continue to be developed and deployed into the market, the possibility of having to also support 868 MHz-based meters in the future adds complexity to designing future-proof smart meters.

In general, some meter manufacturers may choose to go down the path of integration, while others may choose to take a more modular approach for their gas or water meter platform. This integration versus modular dilemma is commonly seen around the metrology and communication functionalities. There are clear pros and cons for each case.

On one hand, combining the two functions onto one microcontroller can reduce up-front system cost, which can improve competitiveness in the market. RF system-on-chip (SoC) solutions, such as the CC430F6147 from Texas Instruments, can handle both metrology and communication functionalities for simpler smart meters. Designers save on board space and on device costs. However, the complexity of certifying the metrology firmware code against tampering and other potential sources of manipulation or failure, adds time and resources needed in the development process (Stefanov, 2012).

On the other hand, splitting the two functions into two separate devices brings greater security and design flexibility. Designers can approach this with a two-processor architecture (MCU plus RF SoC), a single-processor architecture (MCU plus transceiver), or another logical combination (Stefanov, 2012). Combining two processors, such as TI's ultra-low power MSP430F5438A MCU and CC2538

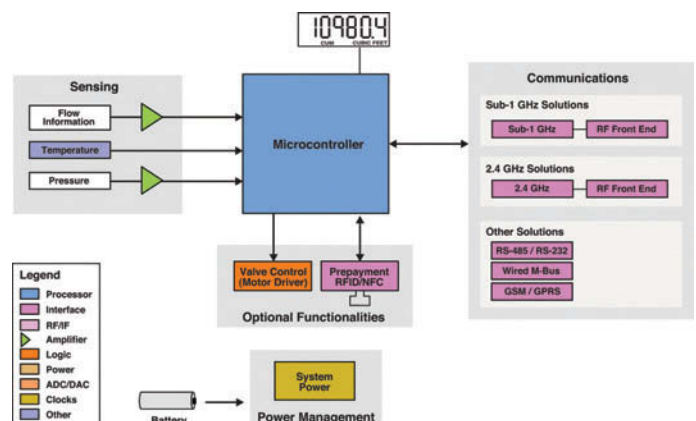


Figure 1 – Potential configurations and functionalities of a smart gas and water meter

RF SoC for the 2.4 GHz ZigBee market, creates a physical hardware separation between metrology and communication. This is more secure than running both codes from the same MCU and eliminates unnecessary time and cost for recertification of the metrology portion.

While the modular, more risk averse, approach tends to carry a higher price for bill-of-materials (BOM), reuse of certain portions helps realize potential cost savings for complex smart meter designs targeted for multiple markets. One example would be to use the same MCU platform based on the ultra-low power MSP430F5435A microcontroller for both sub-1 GHz and 2.4 GHz markets, or to use the same RF module based on TI's CC1120 sub-1 GHz transceiver for both gas and water meter solutions. IC suppliers typically also offer pin-compatible MCU or RF derivatives with additional memory and/or better system performance (Stefanov, 2012). Having the flexibility in options can significantly reduce resources needed for subsequent design changes. For meter manufacturers, this translates to reduced manufacturing costs and, all else being equal, greater return on investment.

A few markets have clearly defined their technical specifications for smart gas and water meters, and have moved ahead with deployments. However, other markets around the world have not yet been impacted by mandates and regulations or have been slow to adopt. Neglecting to plan for potential changes in market requirements can generate unnecessarily higher development and operational costs. Well-thought meter designs will therefore buffer future market requirements, creating sustainable and cost effective smart meters.

ENHANCING PERFORMANCE BY OPTIMIZING FOR LOW POWER AND HIGH EFFICIENCY

Traditional electronic gas and water meters require up to 20 years of battery lifetime – this has long been mastered by the metering industry. The market continues to demand support for wireless communication, remote connection and disconnection, remote firmware upgrades, end-to-end encryption and authentication, prepayment, and so on. This growing list of requirements not only compromises the ability to achieve battery lifetime standards, but also increases up-front and future costs.

The electronics that enable such a smart gas or water meter can be broken down into the following building blocks as portrayed in Figure 1 – a metrology or sensing section, a control/processing unit, a communication system, and a power management system. It goes without saying that selecting low power IC components contributes to minimizing current consumption. However, designers quickly reach a point where the power savings achieved by selecting the lowest power components is simply not enough to hit battery life goals.

Let's take Italy's smart gas meter rollout as an example. The Italian market has leaned toward 169 MHz Wireless M-Bus (EN13747-4) over 2.4 GHz ZigBee as the preferred method for wireless communication. The use of the 169 MHz band offers better range, which reduces the need for and, more importantly, the high cost of implementing repeaters (van Dyck, 2011). However, 169 MHz-based designs require a power amplifier (PA) in order to achieve desirable RF performance (Figure 2). Due to intrinsic inefficiencies, PAs consume a significant portion of the overall power budget and therein lies a major design challenge (Jacob, 2011).

In order to prolong a meter's life expectancy, designers must find the most practical way to improve RF PA efficiency and performance. The cost of adding more batteries quickly outweighs the benefits of increased capacity or voltage supplied. Using super-capacitors or lithium batteries with a hybrid layer capacitor (HLC) can assist in extending battery service life. However, these solutions alone are sometimes not sufficient.

A more design friendly and cost effective approach to enhancing the RF PA system efficiency would be to use DC/DC converters.

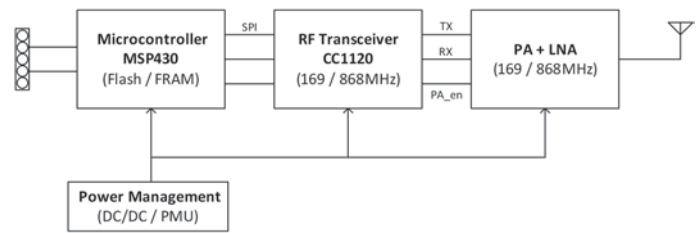


Figure 2 – Example of sub-1 GHz Wireless M-Bus solution (Stefanov, 2012)

Additionally, this approach is not only able to provide stable, higher supply voltages to the RF PA for greater output power, but it can also offer more flexibility in battery and IC selection.

Designers can boost a meter's life expectancy even further by managing other power hungry functionalities (e.g. encryption). Devices that are specifically designed for wireless and battery operated applications range from standard ICs to integrated power solutions. A linear dropout regulator or DC/DC converter is an appropriate choice to resolve isolated performance issues. For more complex metering systems, a power management IC (PMIC) provides a more compact and effective alternative to a discrete implementation. These techniques enable the industry to meet service life requirements once again, sidestepping future meter maintenance and replacement costs.

Running smart meters directly off lithium batteries has its limitations – power budgets must be increased or performance, at times, must be compromised if meter requirements are to be met. Proper selection and implementation of a power management solution can eliminate having to sacrifice one over the other. When the long term benefits that these solutions bring to the market are taken into account, the small up-front cost reveals itself as a valuable investment.

CONCLUSION

Regulations and standards continue to drive the adoption of smart gas and water meters within the industry. While migrating to smart meters adds a new layer of complexity, the return on investment, such as improved customer experience and energy efficiency, is becoming more apparent.

As the grid continues to evolve, challenges around physical infrastructure, data management infrastructure, interoperability, consumer privacy and data protection, and security also influence the scope of smart meter design. This requires careful implementation of new technologies and design methodologies for true future-proof solutions. Collaboration amongst stakeholders, now more than ever, is instrumental in building a more secure, cost effective, and resilient smart grid. ■

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