EUROPEAN SMART METERS DEMAND WM-BUS AT 169 MHZ

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Since its introduction in 2005 with the EN13757-4 document, the wireless MBus (wM-Bus) protocol has become the choice for many smart meter deployments in Europe due to its simple star network topology on a sub-1 GHz wireless link in the European ISM band at 868 MHz.

The mass deployment of heat cost allocators in Germany in the past 6 years has proven that a wM-Bus solution at 868 MHz delivers good range even in densely populated areas with high rise buildings that are quite common in most European countries. It also allows for battery powered meters and submeters, which can work up to 10 or 15 years on one battery.

The European Telecommunications Standards Institute (ETSI) 300 220-1 V2.4.1 (May 2012) is a regulation for sub-1 GHz communications in Europe, defining a 75 kHz narrow band at 169.400 MHz for meter reading applications, with maximum allowed ERP power of +500 mW (equals +27 dBm) and a duty cycle of less than 10%. In this 75 kHz band, a new wM-Bus N-mode has been defined, enabling long range communications in urban environments. N-mode based RF systems were adopted for the deployment of residential gas meters in both Italy and France, leading to a huge demand for 169 MHz radio solutions with the highest RF performance and optimized battery lifetime.

This article will present an example implementation for a full wM-Bus N-mode compliant system at 169 MHz and will focus on how to optimize various system parameters to achieve market-leading blocking and selectivity performance, combined with minimized battery power consumption.

HARDWARE ARCHITECTURE OF wM-BUS N-MODE SUBSYSTEM

The N-mode compliant system described here is based on a CC1120 sub-1 GHz high performance RF transceiver from Texas Instruments and an ultra-low power MSP430G2x55 microcontroller that runs the wM-Bus N-mode protocol stack, communicates with the CC1120 transceiver over the SPI interface and controls the external power amplifier (PA) thru signal lines. A UART or SPI connection to the application MCU of the smart meter enables the configuration and the data exchange with the RF subsystem. An external power amplifier is used to achieve up to +30 dBm transmit power (conducted measurement).

BEST BLOCKING AND SELECTIVITY PERFORMANCE FOR A ROBUST AND COST-OPTIMIZED SOLUTION

The wM-Bus standard defines for each N-submode that products with the highest possible receiver class (Hr) should meet ETSI Category 2 receiver blocking requirements. In practice, designers will need to target the significantly more challenging ETSI Category 1 receiver system performance to cope with the implementation requirement variations from country to country.

TI's CC1120 transceiver supports preamble lengths of only 4 bits, features an integrated 4-GFSK modulation and delivers the industry's best blocking and selectivity results for all N-modes. By applying an optimized set of register settings, called "best blocking", an ETSI Category 1 receiver system performance is achievable without needing to add a costly external surface acoustic wave (SAW) filter component.

Additionally, a unique digital filter inside the CC1120 handles the image rejection and delivers the same performance, regardless of changes in the ambient temperature or supply voltage, which leads to easier and quicker system implementation and optimization.

OVERCOMING PACKET LOSS SIGNIFICANTLY IMPROVES BATTERY LIFETIME

A robust and reliable RF link means the packet loss caused by noise or interference from other meters, which may transmit at the same time on adjacent channels, is reduced to a minimum. If a receiving unit loses a packet, it may also have to do re-transmissions because of the bi-directional nature of the wM-Bus protocol. Reducing packet loss with better sensitivity or higher robustness against interfering signals will directly improve the battery lifetime of a smart gas meter. With smart gas meters having an expected lifetime of more than 15 years, it becomes evident that every unnecessary transmission will ultimately cost energy and reduce the battery lifetime.

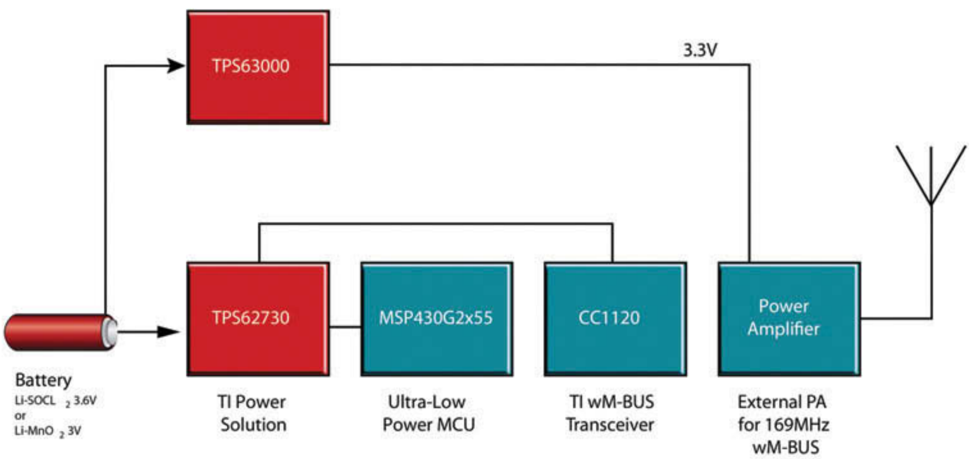

Figure 1 – Block diagram of a complete wM-Bus N-mode RF system including high efficiency battery management solution

The lower the blocking performance and/or lower sensitivity and selectivity of a RF device, the higher the packet loss and the average power consumption.

Packet loss is difficult to predict, as the RF channel behaviour in the field is generally unknown and will vary over time. One can run field trials in different geographic locations to gather statistical information about *received signal strength indicator* (RSSI) values over time on the used RF channels. In many areas, that field data shows the background noise in or close to the 169 MHz band is above the sensitivity limits

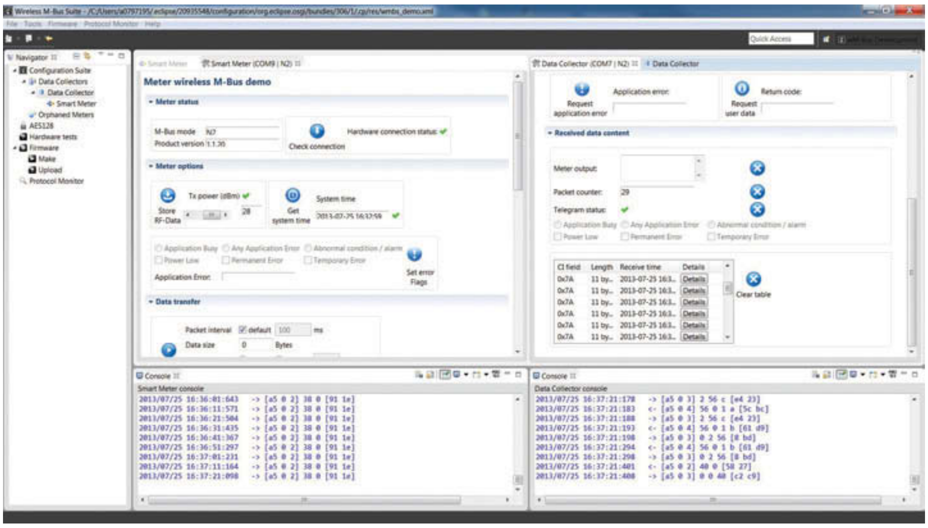

Figure 2 – TI's wM-Bus PC suite enables fast time-to-market development and supports smart meter and data collector functions

for the 2.4 and 4.8 kbps data rates. In such cases using the "best blocking" settings is the recommended solution.

Developers now have the option of implementing a flexible algorithm and deciding when to use the "best blocking" and the "best sensitivity" settings. The flexibility of dynamic switching between "best sensitivity" and "best blocking" performance can significantly reduce the packet loss of the N-mode subsystem. A CC1120-based N-mode solution supports this flexibility thanks to two optimized register sets accessible via software, that can switch between those during runtime.

RX SNIFF MODE: MAINTAINING BEST PERFORMANCE WHILE REDUCING POWER CONSUMPTION

The CC1120 transceiver contains a special feature called RX Sniff mode. It allows the transceiver to autonomously wake-up and check for RF activity (RSSI or preamble detection) and go back to a sleep state to save power if no energy is detected. If the detected RSSI is above the programmed threshold, the transceiver will stay active and complete the reception of the incoming frame. In fact, an RX Sniff mode can be viewed as a quick duty cycling of the CC1120 receiver, enabled by its extremely fast settling time. The effect of such "pulsing" receive approach is the reduction of the average current consumption during reception, regardless of the supply voltage.

OPTIMIZING POWER CONSUMPTION AT THE SYSTEM LEVEL

Due to the low peak current (typically less than 50 to 100 mA) that batteries can provide without being damaged or degraded, a dedicated battery management solution becomes mandatory for all wM-Bus 169 MHz systems with high transmit power. Two main types of primary batteries for smart metering applications exist today – the Lithium Thionyl chloride ($Li\text{-}SOCl_2$) with 3.6 V and the Lithium Manganese Dioxide ($Li\text{-}MnO_2$) with 3.0 V nominal voltage.

The battery management solution of a smart meter should handle the following tasks:

- Provide current of several hundred mA for a period of few hundred ms (maximum current depends on the TX output power of the external PA)
- Remove the pulse load during RF transmission away from the battery
- Reduce the effective buffer capacity needed to protect the battery from high peak currents
- Allow full flexibility in the selection of battery chemistry (3 V vs. 3.6 V)
- Provide stable supply voltage at 3.3 V for the external PA
- Provide lower voltage to both MCU and transceiver (typically between 2.1 and 3.0 V).

The CC1120 transceiver has a voltage supply range of 2.0-3.6 V and uses an internal LDO to provide power to all blocks inside the device. Providing a supply voltage of 2.1 V will reduce the losses inside this internal LDO without degrading the RF performance of the device. In addition, using a high efficiency low power DC/DC device to supply the transceiver has been shown to reduce the peak battery current by up to 35%. This reduction applies for both RX and TX directions and using such a DC/DC device with more than 90% efficiency is the way to go. While choosing a suitable DC/DC looks simple, it's essential to know that the switching frequency of such device can interfere with the RF device and severely degrade its RX sensitivity. To avoid such negative impact on the RF parameters, it is mandatory to measure and prove the RF friendly behaviour of the switching component.

TI's sub-1 GHz RF high-performance line family is perfectly suited to fulfill all requirements of the wM-Bus standard (EN13757-4), including all RF requirements in the Italian and French gas meter specifications. The transceiver fully supports reception of all N-mode telegrams with 16 bits preamble (including the 4-GFSK submodes) without packet loss due to its WaveMatch™ feature. The extremely fast automatic gain control settling in only 4 bits, combined with RX Sniff mode, makes the CC1120 transceiver the best choice for N-mode compliant wM-Bus solutions.

A dedicated battery management solution for the external PA is required, which draws up to several hundred mA at 3.3 V power supply for several hundred milliseconds. The exact implementation of this PA battery management will depend on the battery type and topology used in the smart meter.

Combining the CC1120 with an RF-friendly DC/DC device like TI's TPS62730 significantly reduces the peak current drawn from the battery without penalizing the transmit spectrum or the sensitivity or blocking performance. With the addition of RX Sniff mode, which is useful when the smart gas or water meter is waiting to receive a telegram, the average battery current drawn by the radio is additionally reduced.

It is the first integrated transceiver in the industry that can achieve ETSI Category 1 compliance without an external SAW filter in wM-Bus N-mode. The ability to tweak the performance of the CC1120 for "best sensitivity" or "best blocking" with a few register changes enables a wM-Bus N-mode system, which can smartly adapt to a changing RF environment in the field. MI

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