

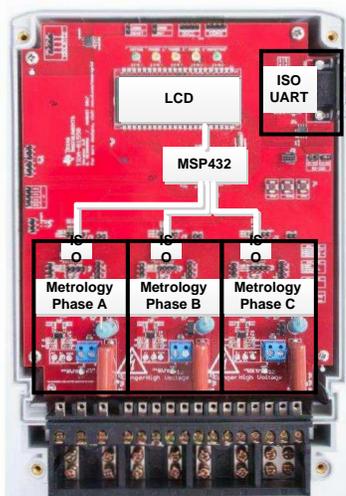
SimpleLink™ MSP432P4 – Smart Metering Host



Introduction

The world's electricity grids are undergoing a continuing evolution of the networks of transmission lines that carry power from generating plants to factories, businesses, and homes. These trends include a move from centralized constant (always-there) power generation to distributed systems, such as commercial and residential solar, whose output varies considerably.

Along with this modernization of the electric grid from traditional to "smart" grid, comes a significant increase in the complexity and capability of the devices that let us connect, monitor, and control these networks. These new or upgraded devices in the smart grid include smart meters, fault indicators, remote terminal units, and data collector gateways, among many others. This tech note highlights how the new SimpleLink™ MSP432P4111 MCUs can meet the needs of the smart grid infrastructure and smart metering hosts, in particular, to develop intelligent devices that can make the grid more secure, robust, and energy efficient.



Implementations

The core needs of an MCU in a smart metering grid host application include:

Large integrated memory. The code base of a metering host continues to increase to support more complex power analysis and to add capabilities such as multiple wireless and wired communication standards and secure, robust, and reliable over-the-air (OTA) updates. Examples of wireless standards that

can be readily supported on a MSP432P4111 as host include ZigBee over a TI-provided IEEE 802.15.4 stack for long-range, low-power Sub-1 GHz transmissions, or a *Bluetooth*® Low Energy (BLE) stack. With a large-capacity flash memory, smart meters can be future-proofed by enabling support for additional wireless protocols through over-the-air (OTA) updates.

Table 1. MSP432P4 Device Options

Part Number	Flash (KB)	SRAM (KB)
MSP432P411V	512	128
MSP432P411Y	1024	256
MSP432P4111	2048	256

Security features. While OTA updates are valuable for extending a meter's useful lifetime and enhancing its capabilities, those updates represent a special vulnerability from hackers or even from less malicious but equally damaging communication errors in changing the firmware on a large number of devices in a given network.

Table 2. Security Enablers for Over-the-Air (OTA) Updates

Security Enabler	MSP432P4 Feature
Debug security	Permanent debug lock. Factory reset with optional password protection.
Cryptography acceleration	256-bit AES hardware accelerator. True random number seed.
Software IP protection	Regional IP protection, debug lock. Secure firmware and software update. Bootloader password protection.

To maintain the integrity of the control and monitoring network in the smart grid when performing updates, several techniques are employed. First, the full firmware update should be authenticated to verify that the sender is an authorized source, and the code should be verified for integrity and completeness before execution. As code size increases, being able to fully analyze a proposed update requires a large amount of local storage to ensure that the entire code update is intact before committing the switch to the new firmware, regardless of size. [Table 1](#) lists the Flash and SRAM capacities of MCU devices in the MSP432P4 family that have sufficient memory to support even large code base updates.

Encrypted updates support. A second technique for ensuring secure robust updates is encrypted updates. The MSP432P4 devices provide **128-, 192-, or 256-bit AES hardware acceleration** and a **32-bit CRC engine** to quickly decrypt the downloaded code. Once decrypted, the firmware should be authenticated as originating from an authorized source. This is typically done with hashing algorithms such as SHA-256. [Table 2](#) summarizes the MSP432P4 security features.

Software IP protection. The third technique for secure, reliable updates is software IP protection, which prevents unauthorized code from executing and/or observing sensitive code or data areas. The MSP432P411 features four IP Protected secure zones that control Read/Write/Execute privileges on select memory areas. This feature, coupled with a lockdown on debugging features and a secure bootloader, helps ensure the integrity of the meter software.

Low-power operation: While in typical use an electric meter by definition has direct access to a constant supply of current through the distribution grids, the introduction of solar, wind and other variable sources of power means some parts of the control and management infrastructure require low-power operation to be resilient in the face of power outages or outright hacks affecting power stability. Also, other utility services that are also seeing conversion to smart networks such as the gas or water flow meters are dependent on battery operation where ultra-low-power operation is critical.

Table 3. MSP432P4111 Low-Power Specifications

Mode or Feature	Specification
CPU in active mode	100 μ A/MHz
Low-power precision ADC	450 μ A at 1 Msps
Static Power Specifications	
CPU in LPM0	960 μ A
CPU in LPM3 with RTC	820 nA
CPU in LPM4	690 nA
CPU in LPM4.5	22 nA
RAM retention	30 nA per 8KB block

In an always-on application such as electricity metering or condition and fault monitoring, the MCU device parameters of interest are the active CPU, peripheral, and analog power figures, as shown in [Table 3](#). The low active power maximizes the value of the 48-MHz Arm® Cortex®-M4F performance while the low static power figures allow the device to reach even lower microamp-range power when duty cycles are low and the device can be placed into sleep modes.

Accurate sensing and measurement. The CPU active power is complemented by a low-noise **precision SAR ADC** that can perform 1-Msps conversions with 14-bit. The low-noise design supports an equivalent number of bits (ENOB) of 13.2 bits,

which allows for up to 16-bit conversions through oversampling. The speed, resolution, and power features allow for more frequent sensing and measurement from a given power budget. An additional benefit of this low-power compute capability is ability to shift intelligence further down into the smart grid network and reduce the power associated with wired or wireless communication to a central node. Multiplied by the thousands or even millions of devices present in some networks, these power savings represent substantial savings to both the network operator and the end consumer.

Integrated LCD display controller. The MSP432P4111 features an integrated LCD controller that can support up to 8-mux 320-segment or 4-mux 176-segment displays. Segment blink and animation modes lower average power by reducing the demands on the CPU for these functions. A flexible LCD multiplexing scheme allows any LCD pin to be reconfigured as a segment or a COMMON (COMx) output. This speeds board design and even allows board-level fixes in software.

Software considerations – SimpleLink SDK. In addition to the metering host device, the other smart grid applications mentioned before such as fault indicators, remote terminal units, and data collector gateways share a common requirement for a software development ecosystem that can maximize software reuse through a single unified platform. The scalable SimpleLink SDK consists of multiple software components including TI's Real-time operating system (TI-RTOS), drivers, and middleware as well as the software stacks needed to support wireless protocols like Sub-1 GHz 802.15.4, ZigBee, and BLE. The OS kernel is based on POSIX-compatible APIs, which enables support for Free-RTOS and simplifies user porting to other operating systems.

References

- [Polyphase Shunt Metrology with Isolated AFE Reference Design](#)
- [Data Collector With M-Bus And RS-485 Protocol Conversion Reference Design](#)
- [SimpleLink MSP432 Over-the-Air Wi-Fi Updates](#)
- [SimpleLink™ MSP432P4xx MCU Security](#)
- [MSP432P411x, MSP432P401x SimpleLink™ Mixed-Signal Microcontrollers](#)
- [MSP432P4xx SimpleLink™ Microcontrollers Technical Reference Manual](#)

Table 4. Device Recommendations

Part Number	Key Features
MSP432P4111I	2MB Flash, 256KB SRAM, Software IP Protection, Precision ADC, LCD
MSP432P4011I	2MB Flash, 256KB SRAM, Software IP Protection, Precision ADC

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