Design Guide: TIDA-011019

Rotary Smart Water Meter With wM-Bus and LoRa WAN Reference Design

Description

This reference design, featuring the CC1312R7 and MSPM0L2117 MCUs, is a fully functional battery powered rotary smart water meter. The instantaneous and total flow is updated on the always-on LCD display and sent out in a C-mode telegram over OMSv4.2.x wM-Bus protocol; while the rotary sensing and magnetic tampering detection are also implemented and optimized for minimal power consumption.

Resources

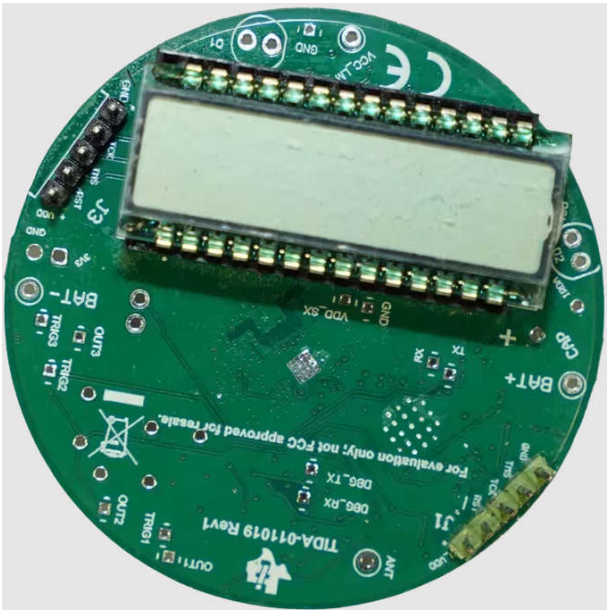
TIDA-011019	Design Folder
MSPM0L2117	Product Folder
CC1312R7	Product Folder
TPS27081A	Product Folder
TMAG5231	Product Folder

Features

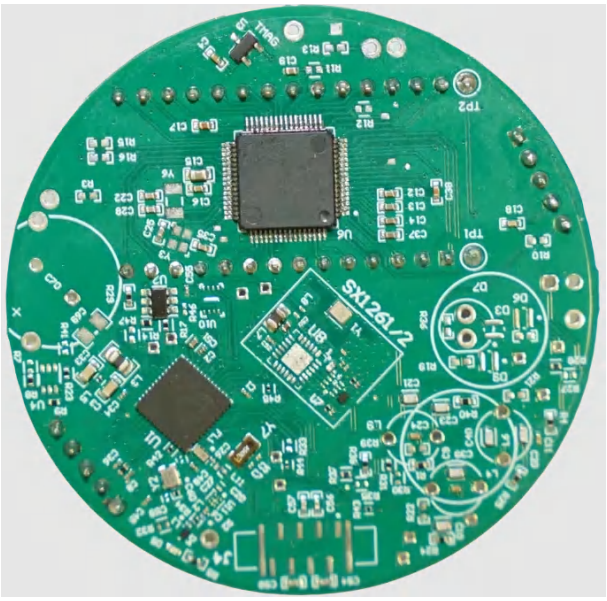
- Always-on LCD display with up to 4 × 26 or 8 × 22 segments
- 3.9µA standby current: 42 active LCD segments + 0.03µA for power switch stand-by + 0.9µA CC1312R7 with pulsed output (rotation sensing not included)
- Inductive, and optical sensing support in a four-layer, 50mm diameter circular FR4 PCB
- IrDA comms port and magnetic tamper detection
- OMS wM-Bus v4.2.x or later support with optional LoRa WAN radio (time-multiplexed)
- Population options for load switch powering an external LoRa WAN radio and an SPI flash device

Applications

- Thermal energy meter (heat meter)
- Water meter



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1 System Description

Water scarcity, aging infrastructure, and the global push for smart city development are transforming the traditional mechanical water meters into highly accurate, connected smart monitoring systems. A modern smart water meter must deliver exceptional measurement precision across a wide dynamic flow range, maintain an ultra-low power profile to provide a multi-year battery operating life, and support robust wireless communication protocols for automated meter reading (AMR) and advanced metering infrastructure (AMI).

Residential and commercial smart water meters measure the water consumption per residential unit or commercial building and are used for billing purposes. Mechanical meters still being the most popular world-wide though many regions in the world are deploying smart water meters to enable AMI.

This reference design provides a comprehensive design proposal for an advanced smart water meter using rotation detection for the flow measurement. Multiple sub-1GHz wireless protocols are supported, thus enabling several utility options for deploying dedicated and cost-optimized AMI. By combining state-of-the-art flow measurement technologies with highly efficient power management and versatile connectivity options, this design enables utility providers to detect leaks in real-time, eliminate billing inaccuracies, and optimize resource distribution.

1.1 Terminology

Water meter	A water meter is an instrument or device that measures and records the volume of water passing through a pipe or outlet
Rotary Sensing Methods	Depending on the technology behind: magnetic (or inductive or LC-sensors), optical sensors, Hall effect sensors or capacitive sensors
Sub-1G	Sub-1 Gigahertz wireless frequency band, typically the ISM frequencies around 169, 433, 868 or 915MHz, commonly used in Smart Metering
IrDA port	Infra-Red Data Association compliant interface, either uni-directional or bi-directional, typ. in 850nm to 940nm band
Tampering	An illegal act of altering, bypassing, or damaging a utility meter (flow meter) aiming at recording less usage than what is consumed
wM-Bus	European low-power RF metering standard with designs for the 169MHz, 433MHz, and 868MHz bands (EN13757-4)
LCD	Liquid crystal display with COM and SEG lines, Flow meters often utilize 3-MUX or 4-MUX displays
LoRa WAN	Low power, wide area networking (LPWAN) standard managed by the LoRa Alliance®

1.2 Key System Specifications

The CC1312R7 wireless MCU operates from 1.8V to 3.8V and MSPM0L2117 has a supply voltage range of 1.62V to 3.6V (both have 4.1V as the absolute maximum value allowed). This is a great fit for primary battery chemistries, such as LiSoCl2 with 3.6V or LiMnO2 with 3.0V.

FEATURES	DESCRIPTION
TI wireless MCU	CC1312R7, CC1314R10
LCD Frame rate	Adjustable through software (MSPM0L2117)
LCD mux ratio	4MUX, 1/3 bias
LCD segments (30 pins)	4 × 26 = 104 SEGs or 8 × 22 = 176 SEGs
Operating temperature range (°C)	-40°C to 105°C (CC1312R7) -40°C to 125°C (MSPM0L2117, TMAG5231) -40°C to 85°C (TPS27081) 4-MUX LCD unit (see datasheet)
Standby current consumption (LCD active) at 3V3	2.9µA (42 SEGs on) + 1.0µA (Pulsed Output from CC1312R7 incl. TPS27081A shutdown current)
Operating voltage	1.8V - 3.6V

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FEATURES	DESCRIPTION
Operating system (SW example)	TI-RTOS (CC1312R7 with SCE)
LCD waveform generation	MSPM0L2117
Battery (primary cell)	3.0V LiMnO2 or 3.6V LiSoCl2
RF protocol	wM-Bus OMSv 4.2.y / 5.x.y (CC1312R7) or mioty® LoRa WAN (with optional SX1262 transceiver)
Rotary detection	LC-sensing or optical sensing (on PCB) Optional extension connector for magnetic sensor (off PCB)
Pulse counting	CC1312R7 output to MSPM0L2117
UART	CC1312R7 / MSPM0L2117

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2 System Overview

This reference design introduces an electronic smart water meter intended for residential, commercial, or industrial applications. The metrology principle is based on rotary detection, with options to support inductive, optical or magnetic sensing technologies, depending on user preference. There are several key sub-systems in every smart rotary water meter, all implemented in this reference design:

- Sub-1GHz communication link in the 868MHz band, typically either OMS wM-Bus or LoRa WAN (sometimes both as time-multiplexed design) or mioty
- A segment LCD display (either always on or enabled on demand)
- Metrology function: either optical, magnetic or inductive rotation sensing
- Magnetic tamper detection
- IrDA communication link
- External NVM for data logging

The rotary meters are also referred to as volumetric smart water meters and measure water consumption using a mechanical rotating element, often a nutating disc that rotates inside the volumetric chamber. The rotary metrology sub-system senses the disc rotation, digitizes the flow measurement and transmits the data wirelessly to a smart gateway or mobile reader unit over the chosen Sub-1GHz communication protocol.

IrDA communication port is widely popular and used during manufacturing, as a simple way to configure vendor parameters in each smart meter unit. The IrDA protocol is furthermore a key enabler for installation and maintenance of the smart meters, where vendors also supply dedicated reader units with IrDA interface.

Magnetic tamper detection is another required functionality, as applying strong magnet fields to the smart water meter can interfere with the metrology function of the meter.

Smart water meters in the EU are predominantly compliant with OMSv4.2.x wM-Bus or later protocol in the 868MHz band, for example in Germany. Other countries, like France, selected the so-called wM-Bus N-mode at 169MHz, to enable very long reach and thus less complex wireless Metering Infrastructure build out.

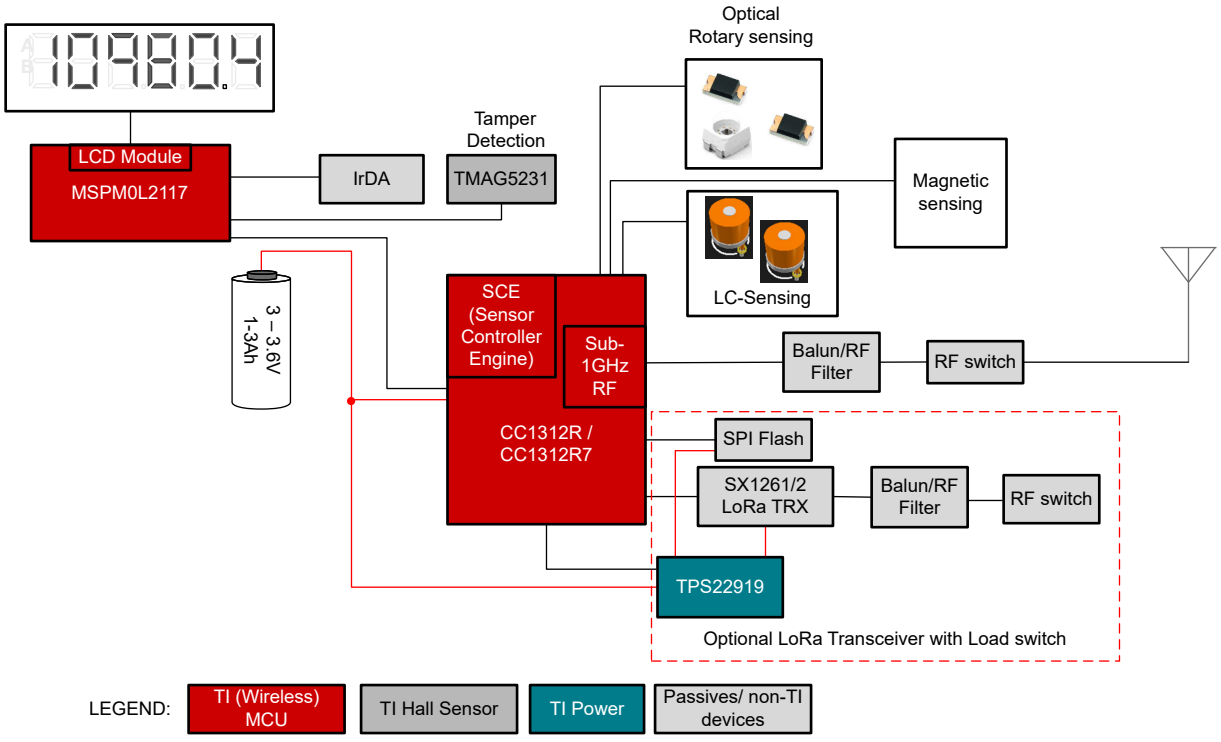


Figure 2-1. TIDA-011019 Block Diagram

TI's CC1312R/R7 and CC1314R10 Wireless MCUs can handle 169MHz, 434MHz, and 868MHz wM-Bus modes by running the wM-Bus protocol in the software defined on-chip RF sub-system.

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In proprietary long range use cases with LoRa WAN protocol, the optional external SX1262 transceiver is used, while the protocol still stack runs on TI's CC1312R/R7 or a pin-compatible CC1314R10 Wireless MCUs with 1Mbyte of FLASH and Cortex-M33 core with FPU and TZ-M support.

The dual-band Sub-1GHz and 2.4GHz devices CC1352R and CC1352P and CC1354R10 and CC1354P10 (not implemented in this reference design) can offer an additional capability of running protocols in the 2.4GHz band, for example Matter and BLE. These protocols, due to the short-range coverage, are designed for implementing vendor tools for installation and configuration, using smart phones or tablets. Another use case for 2.4GHz BLE can be displaying the consumption on a user owned device like smart phone or tablet.

2.1 Key Devices

2.1.1 CC1312R7

The CC1312R7 SimpleLink™ wireless MCU contains an Arm® Cortex®-M4F system CPU, which runs the application and the higher layers of radio protocol stacks. The system CPU is the foundation of a high-performance, low-cost platform that meets the system requirements of minimal memory implementation, and low-power consumption, while delivering outstanding computational performance and exceptional system response to interrupts.

The RF Core is a highly flexible and future proof radio module which contains an Arm Cortex-M0 processor that interfaces the analog RF and base-band circuitry, handles data to and from the system CPU side, and assembles the information bits in each packet structure. The RF core offers a high level, command-based API to the main CPU that configurations and data are passed through. The Arm Cortex-M0 processor is not programmable by customers and is interfaced through the TI-provided RF driver that is included with the SimpleLink Software Development Kit (SDK). The RF core can autonomously handle the time-critical aspects of the radio protocols, thus offloading the main CPU, which reduces power and leaves more resources for the user application. Several signals are also available to control external circuitry such as RF switches or range extenders autonomously.

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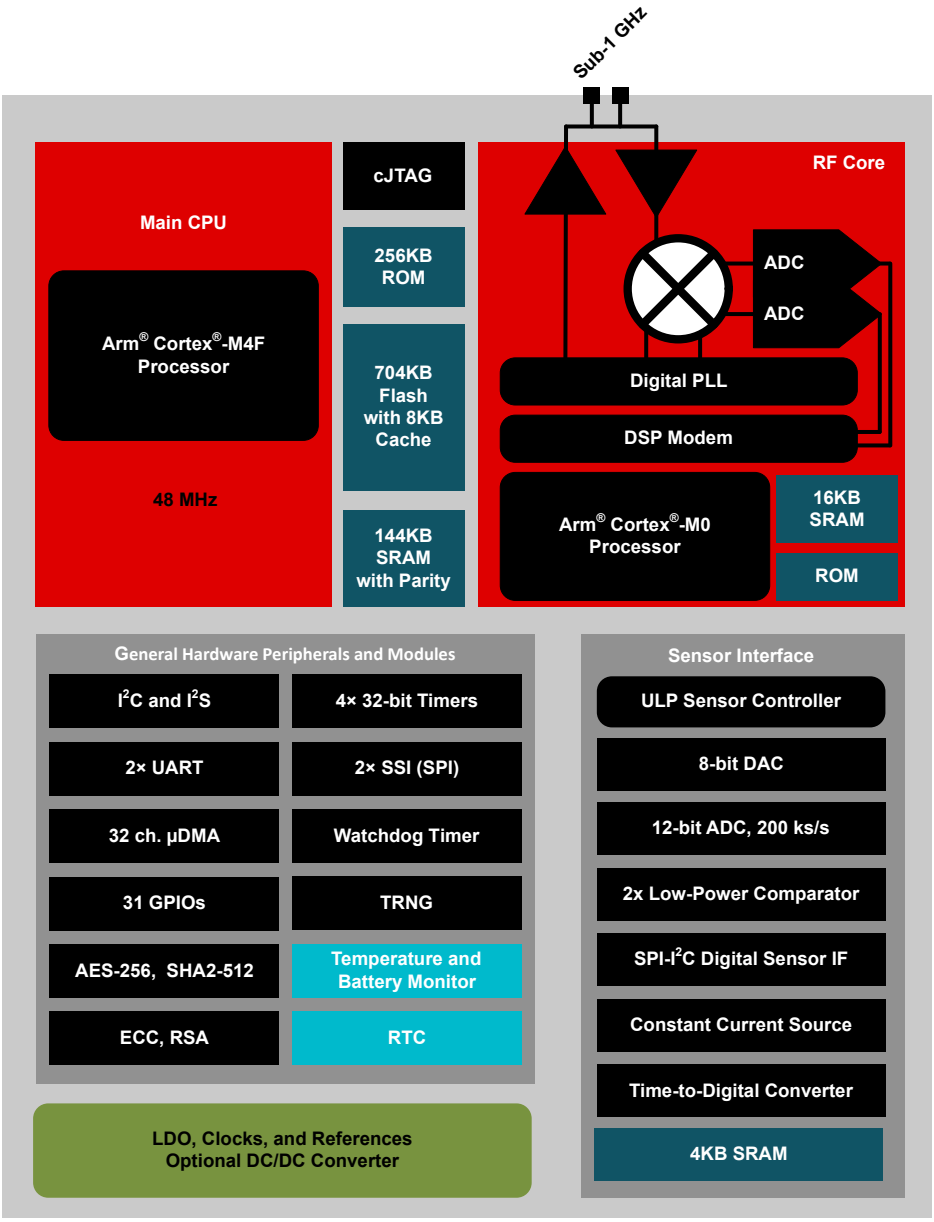


Figure 2-2. CC1312R7 Block Diagram

The sensor controller (SCE) contains circuitry that can be selectively enabled in both Standby and Active power modes. The peripherals in this domain can be controlled by the sensor controller engine, which is a proprietary power-optimized CPU. This CPU can read and monitor sensors or perform other tasks autonomously; thereby significantly reducing power consumption and offloading the system CPU. The Sensor Controller Engine is user programmable with a simple programming language that has syntax like C. This programmability allows sensor polling and other tasks to be specified as sequential algorithms rather than static configuration of complex peripheral modules, timers, DMA, register programmable state machines, or event routing. The main advantages are:

- Flexibility - data can be read and processed in unlimited manners while still providing ultra-low power
- 2MHz low-power mode enables lowest possible handling of digital sensors

Typical use cases can be (but are not limited to) the following:

- Waveform generation (TI-patented MUX SW controlled LCD implementation)
- Inductive, optical or magnetic rotation detection (flow metering)
- Very low-power pulse counting

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2.1.2 MSPM0L2117

MSPM0L2117 is an Arm 32-bit Cortex-M0+ CPU with memory protection unit, core frequency up to 32MHz and extended temperature support: –40℃ up to 125℃. The MCU has 128KB of flash memory with error correction code (ECC) and 12KB of SRAM with ECC or parity.

Ultra-low power segmented LCD controller supporting up to 4 × 48 and 8 × 44 LCD displays and a high-performance 12-bit 1.6Msps analog-to-digital converter (ADC) with configurable 1.4V or 2.5V internal shared voltage reference (VREF) are key integrated peripherals. An analog comparator (COMP) with 8-bit reference DAC is also available, and the M0+ core supports STANDBY mode with 1.6µA with SRAM and registers fully retained, the supply voltage range is 1.62V to 3.6V.

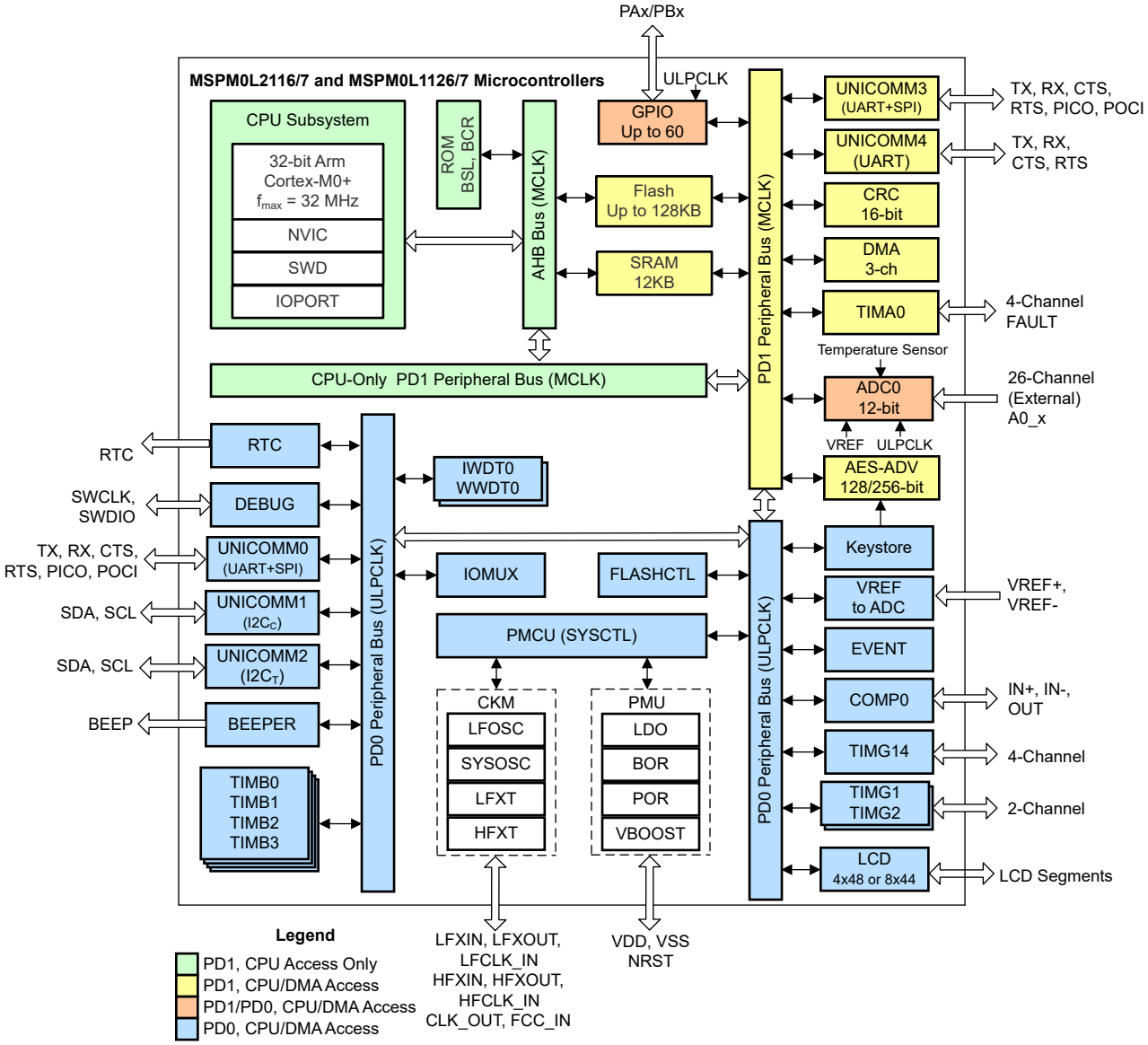


Figure 2-3. MSPM0L2116/7 and MSPM0L1126/7 Block Diagram

2.1.3 TPS27081A

The TPS27081A device is a high-side load switch that integrates a Power PFET and a Control NFET in a tiny, 6-pin, 2.9mm × 2.8mm × 0.75mm package. TPS27081A features industry-standard ESD on all pins providing better ESD compatibility with other onboard components. The TPS27081A level shifts ON/OFF logic signal to VIN levels and supports as low as 1V CPU or MCU logic to control higher voltage power supplies without requiring an external level-shifter.

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Switching a large value output capacitor CL through a fast ON/OFF logic signal can result in an excessive inrush current. To control the load inrush current, connect a resistor R2 and add an external capacitor C1. To configure TPS27081A to achieve a specific slew use external R and C components. The ultra-low leakage current in Standby is 100nA typical, here a single pullup resistor R1 is required. in standby power switch applications. In such applications connect the R2 pin of the TPS27081A to the system ground when inrush current control is not required.

2.1.4 TMAG5231

The TMAG5231 is a 2nd-generation, low-power Hall effect switch sensor, specifically designed to optimize the total system cost for compact, battery-operated consumer and industrial applications. When the applied magnetic flux density exceeds the operating point (BOP) threshold, the device outputs a low voltage. The output stays low until the flux density decreases to less than the release point (BRP), and then the device outputs a high voltage. Omni polar magnetic response allows the output to be sensitive to both north and south magnetic fields.

The TMAG5231 is able to operate at very low current consumption and achieves 2µA of current consumption when internally power cycled at a 20Hz rate. The TMAG5231 is available in the industry-standard package and pinout SOT-23, as well as X2SON. The device operates at a VCC range of 1.65V to 5.5V, as well as an extended temperature range of –40℃ to 125℃.

2.2 System Architecture

The smart rotary water meter architecture of this reference design utilizes two MCUs, where the key-subsystems are spread across these MCUs, depending on power consumption and hardware module support, where applicable. The CC1312R7 wireless MCU handles rotary detection (flow metrology) with its sensor controller engine 16-bit CPU core, and runs either wM-Bus OMS or LoRa WAN or both RF protocol stacks on its Main MCU core, communicating over SPI Interface with the optional external SX1262 radio device and the external NOR Flash memory device (often used for logging consumption data).

The MSPM0L2117 has an integrated LCD module and drives the 4-MUX LCD display with 96 segments, though the PCB supports two more pins for custom LCDs with maximum of 104 segments (in 4-MUX) or 176 segments (in 8-MUX configuration). The MSPM0L device also handles the magnetic tamper device TMAG5231 and implements the IrDA communication port, utilizing its UART module.

2.2.1 Rotary Metrology Sensing and Wireless Communication

This reference design has multiple BOM populating options, aimed at implementing LC-sensing, optical sensing, or magnetic sensing for the rotation detection inside the flow meter. The following sections briefly describe each of these options and how to configure the BOM for those.

2.2.1.1 LC-Sensing

Inductive or LC-sensing rotation detection is very popular with rotary smart flow meters and has been used in the industry since early 2000s, based on TI's MSP430FW42x devices.

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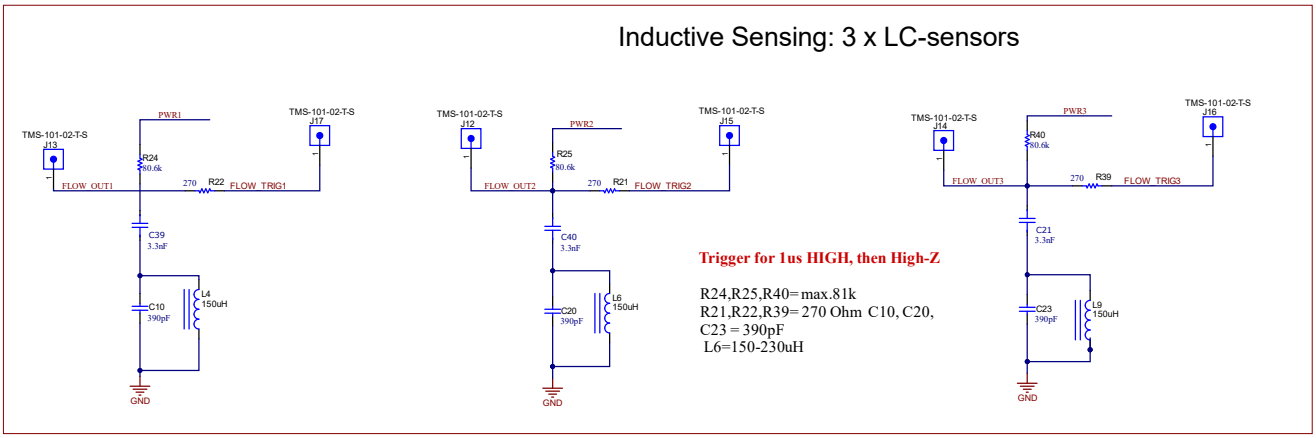


Figure 2-4. LC-Sensing Proposal for up to 3 Sensors With CC1312R7

The latter device family introduced the first dedicated hardware module for rotation detection, named scan interface.

The proposed LC-tank design is a simple though power efficient rotation detection and requires only an extra capacitor (C39, C40 and C21) and optional series resistors R21, R22 and R39. The LC-circuit is excited by a short sequence, controlling both FLOW_OUT1 and FLOW_TRIG1 pins. Basic functionality has been tested, but final optimization and test results are pending.

The latter device family introduced the first dedicated hardware module for rotation detection, named scan interface.

2.2.1.2 Optical Sensing

An example implementation of optical sensing has been documented in Low-Power Flow Meter Design Using Optical Sensors TI design, showing an optical rotary sensing sub-system that consists of two elements: an emitter (an IR LED) and a receiver (a photo diode) for the light beam generated by the emitter and reflected by a coded wheel to detect the rotation. The rotating wheel speed is directly proportional to the flow inside the meter. Typical use case represents a coding wheel, like the one used for LC-sensing, where one disc half has a more reflective surface (covered with metal plate) than the other half, so it can be distinguished which half of the disc is in front of the optical receiver. For detecting the rotation direction two optical sensors are needed, while the emitter can be a single LED, if it can be properly positioned to work with both receivers.

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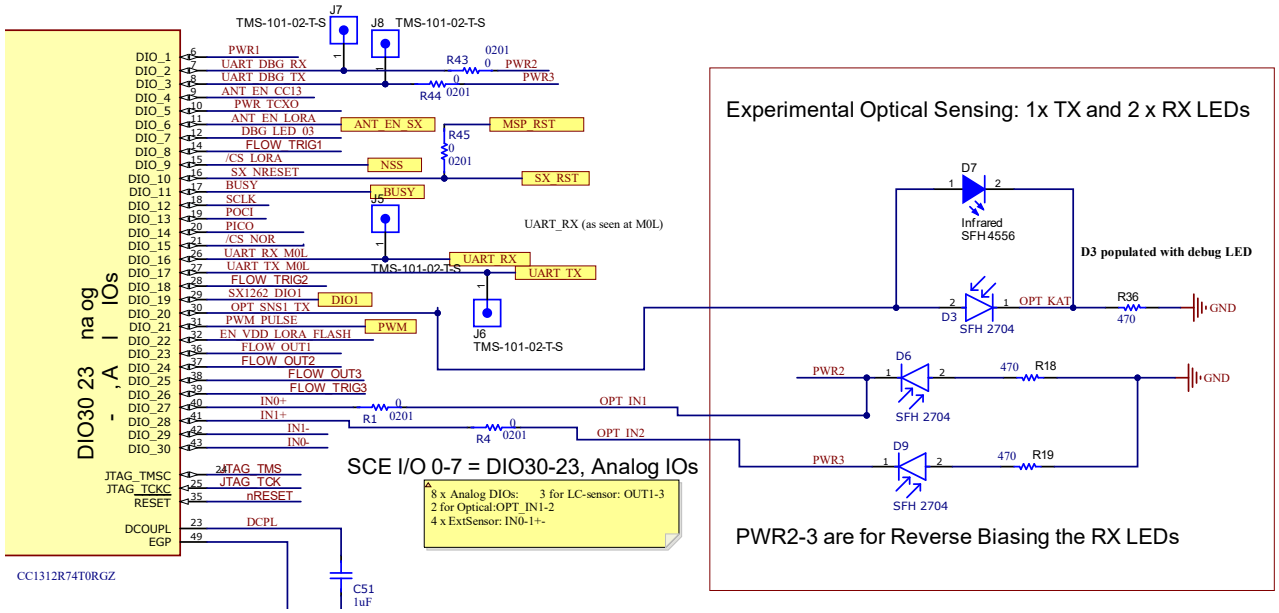


Figure 2-5. Optical Sensing Circuit with CC1312R7

Another option for detecting the reflected beam is being proposed based on TIDA-01212 *Single Bidirectional Infrared LED Communication Port Reference Design*, where *reverse biasing* of IR LED diode for receiving the light beam is used. Again, only one transmit IRLED is used, and two reverse biased D6 and D9 IRLEDs are sampled for the receive signal, provided as 0 or 1 by the COMPA output for generating the quadrature encoded signal. One key advantage of the optical sensing is the very fast detection per IRLED compared to LC-sensing.

2.2.1.3 Magnetic Sensing

Rotary movement inside mechanical flow meters can also be measured precisely with magnetic sensors, if a flow meter impeller has a magnet attached to it and rotates with proportional rotational speed to the flow rate.

Multiple mechanical design elements dictate the performance and accuracy of the meter, the first one being the impeller size, the latter influences the minimum and maximum flow rate capable of being measured. Utilizing flow rate simulation software can help evaluate the effectiveness of the mechanical system and optimize the impeller size for the desired sensing range. More details and test results using Hall-Effect sensors are documented in *Design Considerations and Measurement Results for Mechanical Hall-Effect Flow Meters* application note.

Another important technical decision is the type of magnet and the number of S and N poles it provides, as this influences the selection of magnetic sensors and their placement in the vicinity of the magnet.

If a 2-pole magnet is used, then it can be detected with two 1D (one dimension) Hall effect latches precisely, when these are positioned 90° apart from one another. This placement is equivalent to a two-sensor LC-sensing or optical sensing methods, where a half-circle of the disc is electrically conducting or reflecting infra-red light, while the second half is non-conducting or does not reflect infra-red light.

Thus, a software implemented rotation detection state machine, as described in Section 3.3, can be reused to a large extend with some adjustments for reading the magnetic sensor inputs.

An alternative solution is to use 2D (two-dimensional) sensor which inherently delivers a quadrature output signal, which can be either analog or digital.

Magneto resistive sensors like AMR, GMR and TMR deliver a differential output signal, which can be then fed into an on-chip comparator for converting the input to a digital output. Then the state machine can do the rotation calculation and resolve the rotation in 90° steps or four counts per full magnet turn of 360°. In such case, a dual bridge AMR sensor is required, similar to the two inductors or IRLED for detection the rotation direction and speed of the impeller.

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2.2.2 LCD Display, Tamper Detection, and IrDA Communication

The LCD display is a key metrological function of any water meter and is typically implemented as always on, meaning LCD is visible to the user 24/7. To achieve this with only a few uA power consumption on average, a dedicated HW module for LCD support is required, which is provided by the MSPM0L2117 device. Reducing the average LCD power consumption even by 1uA is a significant step, as it directly impacts the battery lifetime of the water meter.

Typically, water meter LCD displays use multiple segments in 4-MUX mode, with a total number of segments ranging from 64 to 160 segments. As shown in Table 2-1 the exact power consumption depends upon the number of segments being active (or visible to the user), here the LCD refresh rate is not altered. Updating the refresh rate also has a significant impact on both contrast and power consumption, hence system designers optimize the refresh rate by reducing it to the minimum value, which delivers acceptable LCD contrast over the full voltage supply range for the water meter.

Table 2-1 shows a test application using 93 segment LCD and running on LP-MSPM0L2117 LaunchPad™, with the following configuration: MSP in STANDBY1, T1 TIMER (2sec periodic) wakeup, LCD MODE 5 with charge pump.

Table 2-1. Total Power Consumption for MSPM0L2117 and LCD Display

LCD display (see LP-MSPM0L2117) #Active segments	Power Consumption [uA]
0 (none)	2.3
42	2.9
93	5.3

Often, LCD displays have multiple views and can switch from one view to the next based on timer or user interaction, such as pressing a button. Power consumption change depending on the selected view and Table 2-1 summarizes the values, measured depending on the number of active segments. The schematic with MSPM0L2117 schematic portion uses the same LCD device and the same 64-pin MCU as on LP-MSPM0L2117, making code development with the LPAD easy.

The GDH-1638WP display (see LCD specification in Chapter 2.7 Liquid Crystal Display (LCD)) needs 30 pins total (4 COM and 26 SEG lines), and due to its dimensions MCU placement and routing under the LCD is possible.

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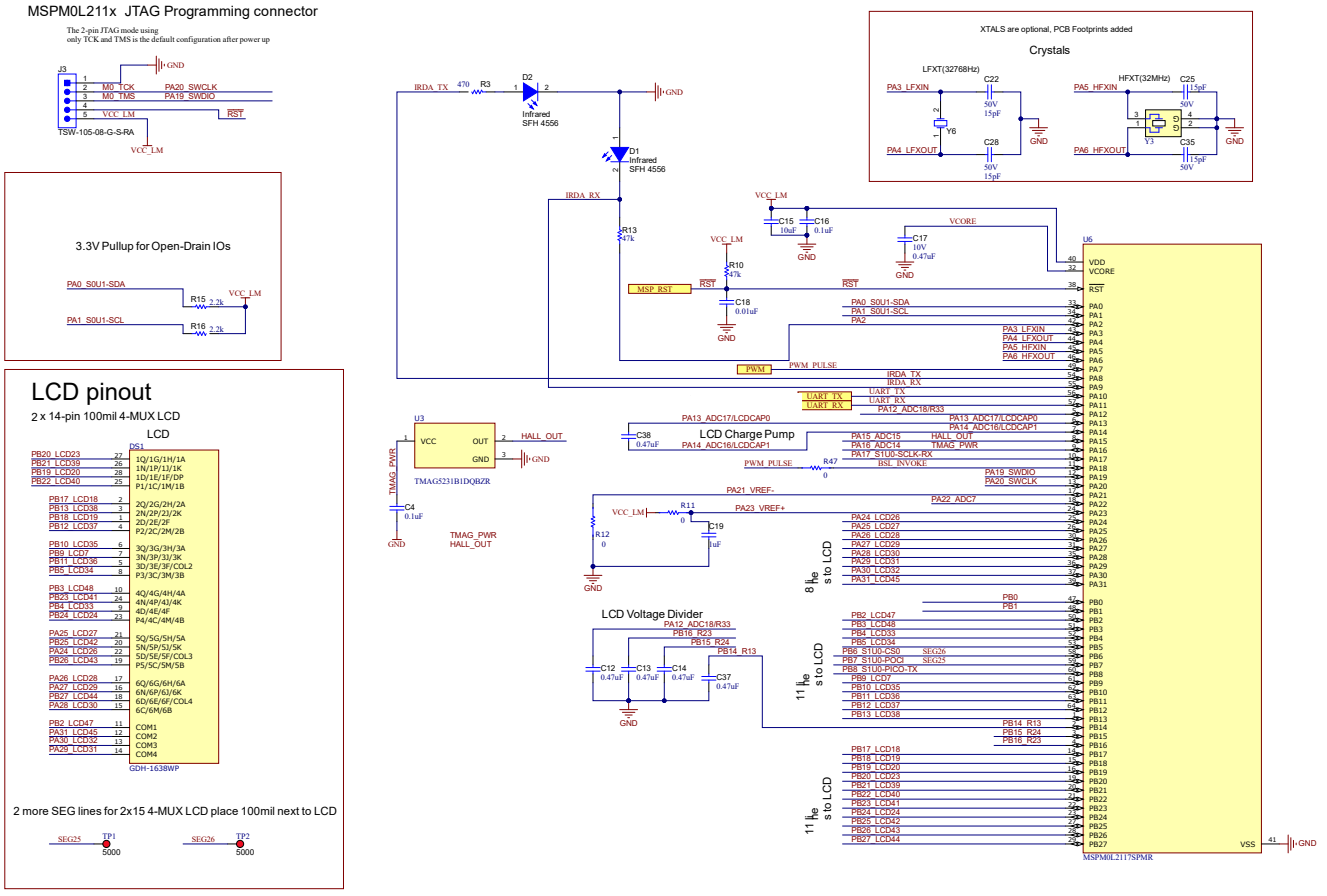


Figure 2-6. MSPM0L2117 With LCD Display, TMAG5231 and IrDA LED Port

Both SEG25 and SEG26 lines were added to support LCD displays with up to 2 × 15 pins with 2.54mm pitch on the PCB, enabling maximum of 104 segments in 4 × 26 configuration.

One differentiated feature of MSPM0L2117 is the software configurability of each LCD pin as either COM or SEG line, which allows customers to use any segmented LCD display. If the footprint of the custom PCB is not fitting "as is", then a simple PCB adapter board can be designed. This PCB adapter can be mounted on a stand-off receptacle using the drill holes for GDH-1638WP display pins and can adjust the pinout as required.

2.2.3 Multi-Protocol Radio Sub-System

CC1312R7 has the FLASH, RAM and software defined Radio sub-system resources to run almost every well-known protocol in the Sub1GHz bands, such as OMS wM-Bus, mioty, Wi-SUN, IEEE 802.15.4, proprietary, and more.

RF designs for Sub-1GHz are quite challenging in terms of PCB stack, BOM values, and layout, hence the general recommendation is to copy-paste the reference designs provided by the RF chip vendors. Both radio devices, CC1312R7 and SX1262 have a 4-layer PCB stack, which makes the combination thereof straightforward.

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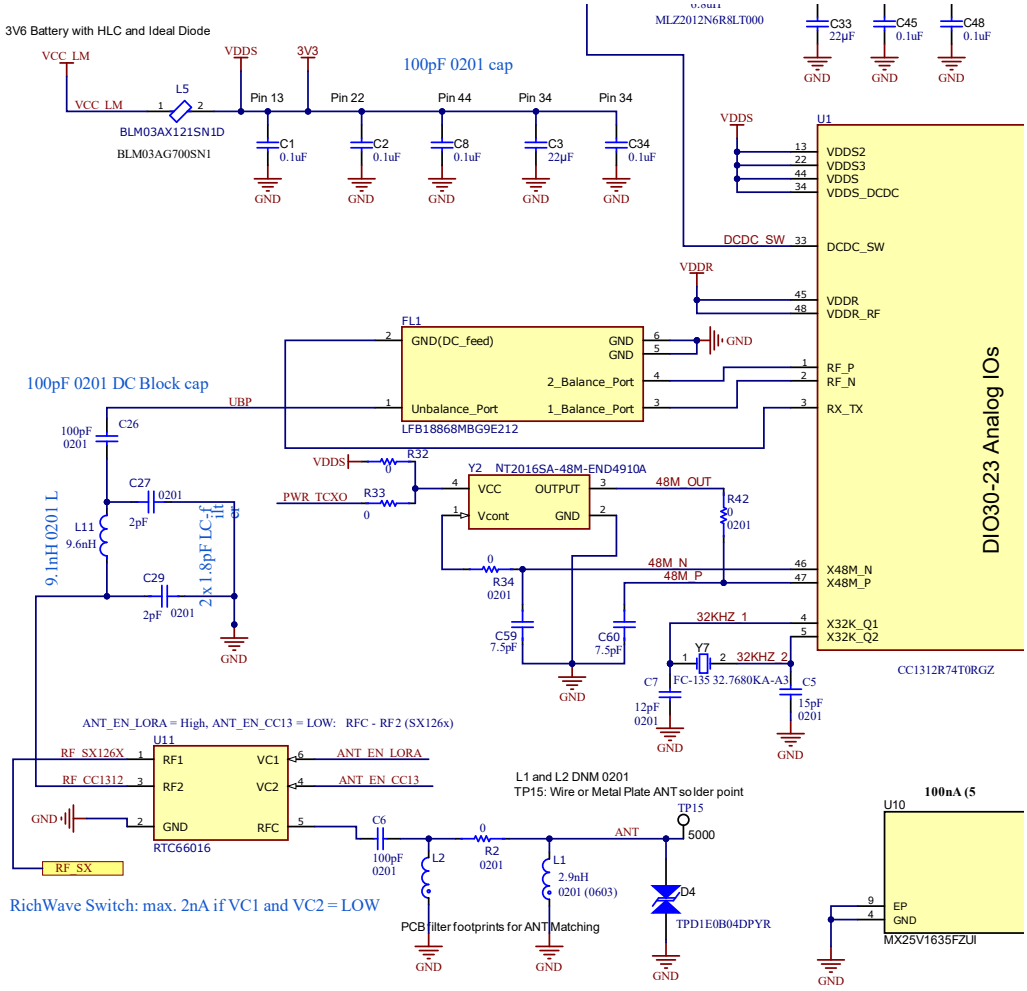


Figure 2-7. Dual Sub-1GHz Radio Sub-System

Another similarity is the utilization of integrated passive devices (IPD) for Balun and matching the impedance to the antenna port with 50Ω for each RF device. IPDs enable significant PCB area savings and reduce HW design complexity, by integrating a large number of passives.

CC1312R7 uses the dedicated LFB18868MBG9E212 from Murata™ for the 868MHz band, while SX1262 is connected to IPD 0900FM15K0039E from Johanson, the latter covering 868MHz and 915MHz bands.

As only one Sub-1GHz radio device must be active at a time, the selection is done by the CC1312R7 device using GPIO pins to control these two RF switches. The SX1262 reference design recommends the 2:1 antenna switch BGS12SN6, now replaced by the newer pin-to-pin BGS12WN6 device. TI recommends the RTC66016 2:1 antenna switch by RichWave, which selects whether the CC1312R7 or SX1262 signal gets connected to the antenna port, which is a test point for soldering an external wire or a metal plate antenna.

2.2.4 Interfaces Between M0L2117 and CC1312R7

The separation of ultra-low power metrology sensing in CC1312R7 and LCD display run by MSPM0L2117 dictates a wired communication between these two MCUs. This reference design implements two interfaces:

1. Bi-directional UART communication port
2. Pulsed Output signal from CC1312R7

The data exchange to and from CC1312R7 has been successfully tested and limits the maximum supported data rate to 3Mbps, whereas MSPM0L2117 supports up to 4Mbps.

UART

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Whenever the pulse count reaches a multiple of 5, the MSPM0L2117 sends two UART transmissions to the CC1312:

1. Wake command – causes the CC1312 to exit low power mode and reconfigure its UART RX pin (from GPIO interrupt mode to UART RX mode).
2. Data message – sent after a fixed delay (see Timers section below) to indicate that 5 pulses have been received, once the CC1312's UART RX is ready.

Upon successfully processing the message, CC1312 responds with an acknowledgment. The MSPM0L2117 UART RX pin is configured as an interrupt source; the ISR function checks whether the received message is the acknowledgment command, and if so, displays "ACK" on the LCD.

Pulsed Output

As an alternative to UART byte data transfer, a dedicated pulse output is also available; this pin can output every second (or at any per firmware configurable period) the incremental number of rotations since the last sampling, for example, 16 pulses if the disc has rotated four full turns. If there is a short back pressure with reverse disc rotation, the rotary state machine handles that and deduces it automatically from the rotation count. As a result, only real flow incremental steps are pulsed out to the MSPM0L2117, which detects the number of pulses and update the LCD displayed value accordingly.

Timers on MSPM0L2117

The delay between the wake command and the data message is managed by a timer rather than a blocking delay, so the MSPM0L2117 can remain in low power mode instead of idling. After sending the wake command, the device waits for a Timer value to expire and then sends the data message.

Additional timers are used for:

1. LCD 1Hz global refresh rate
2. Debounce window, for incoming GPIO pulses (from Sensor Controller and TMAG5231)

Tamper detection

The MSPM0L2117 is connected to a TMAG5231 magnetic sensor. Under normal conditions, the TMAG5231 output is HIGH; when exposed to a sufficiently strong magnetic field, its output goes LOW. The GPIO connected to the TMAG5231 is configured as a falling-edge interrupt, and its ISR function writes "TAMPER" to the LCD display for a few seconds, after which the LCD reverts back to displaying the rotation count value.

2.2.5 Additional Features

Modern smart rotary meters must meet market requirements for extended data logging and long battery lifetime, and sometimes proprietary wireless protocols like LoRA WAN and more. This reference design addresses these by adding multiple optional devices: a load switch, an external NVM memory and SX1262 radio by SEMTECH.

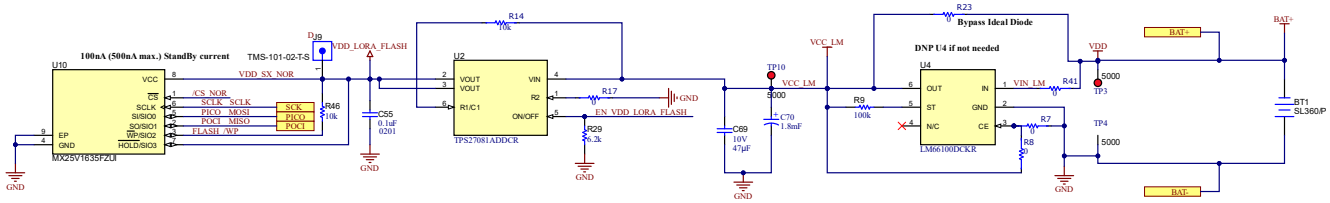


Figure 2-8. External SPI Flash Device with Load Switch TPS27081A

The load switch device supplies power to both SPI Flash memory and the SX1262 radio device; power is enabled only on demand by the ON/OFF signal on Pin 5 of TPS27081A, which is connected to a GPIO on CC1312R7.

The LM66100 ideal diode is optional and provides reverse current blocking to protect the primary battery cell, if desired, otherwise LM66100 can by left unpopulated and bypassed with the R23 = 0Ω jumper.

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The MX25V1635FZUI device is directly wired to CC1312R7 GPIOs, utilizing standard SPI bus connections and a dedicated chip select line /CS_NOR for enabling the SPI Flash only for read or write operations.

2.2.6 Future Proven Solution for EU Cyber Resilience Act (CRA)

In the EU a dedicated framework has been created (called EU CRA) to help address the following challenges:

- Fragmented regulations: multiple regulations in the EU oftentimes only partially address cybersecurity risks, creating a legislative patchwork and complexity for manufacturers and users to comply with different requirements for the same product.
- Any connected device can be vulnerable: even low-critical hardware and software products can be victim to a cyber attack, compromising the product or even the entire supply chain.
- Inconsistent security practices: manufacturers often ship products with a low level of cybersecurity, have inconsistent vulnerability handling, and provide minimal information transparency to help users choose products with adequate cybersecurity features.

What is the EU CRA?

The CRA is a mandatory EU regulation creating common cybersecurity standards for products aiming to protect consumers and businesses from the growing risks of security vulnerabilities and cyberattacks in our digitally connected world. From a conformity standpoint, the CRA requires manufacturers to:

- – Make sure products are secure-by-design
  - – Provide transparency through product risk assessment, conformity assessment, and disclosure of intended purpose and reasonably foreseeable use
  - – Disclose upfront the product cybersecurity support period
  - – Be accountable to a vulnerability handling and incident reporting process
  - – Affix a CE marking, accompanied by EU declaration of conformity

The rollout of CRA compliance started officially in December 2024 in several steps; the most recent one on September 11th 2026 introduces the reporting obligations. The final step to enforce the EU CRA is December 11th, 2027 – then the complete suite of regulations will be active.

As products become more connected, cybersecurity is no longer optional – it is nowadays a fundamental product requirement. Customers expect devices that are secure by design, resilient against cyber threats and compliant with evolving global regulations. Improving cybersecurity of modern connected devices, such as smart rotary flow meters, is a global trend and addresses multiple needs:

- *Protects critical data* – Prevents unauthorized access, data theft, and intellectual property loss.
- *Ensures product integrity* – Safeguards devices from tampering, malware, and unauthorized firmware modifications.
- *Maintains operational reliability* – Minimizes downtime and protects business continuity.
- *Builds customer trust* – Demonstrates commitment to security, privacy, and product quality.
- *Supports regulatory compliance* – Enables customers to meet standards such as the Cyber Resilience Act (CRA) in EU (European Union as well as man other non-EU cybersecurity regulations.
- *Reduces lifecycle costs* – Security by design lowers the cost of vulnerabilities, recalls, and field updates.

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3 Design and Documentation Support

3.1 Design Files

All reference design files can be found in TIDA-011019 reference design folder on TI.com.

3.1.1 Schematics

To download the schematics, see the design files at TIDA-011019 reference design folder on TI.com.

3.1.2 BOM

To download the bill of materials (BOM), see the design files at TIDA-011019 reference design folder on TI.com.

3.1.3 PCB Layout Recommendations

The TIDA-011019 is a 4-layer PCB with 1.6mm overall thickness; the four layers are required to accommodate the connections between the two MCUs and the optional external SX1262 radio and SPI flash devices.

Full PCB diameter is 50mm, which makes it suitable to fit into a standard brass water meter body, widely used in EMEA and other regions.

For CC1312R7, which handles main metrology application, rotation sensing and the Sub-1GHz wireless protocol stacks, this reference design follows the guidelines of TI's four-layer PCB reference design with Integrated Passive device (IPD). Similarly, for SX1262 radio the recommendations in AN1200.91 including the Altium PCB layout example have been integrated and combined with CC1312R7.

For MSPM0L2117 layout, the example in the LP-MSPM0L2117 Evaluation Module User's Guide has been used, together with the LCD display unit.

3.1.3.1 Layout Prints

To download the layer plots, see the design files at TIDA-011019 reference design folder on TI.com.

3.1.3.2 Gerber Files

To download the gerber files, see the design files at TIDA-011019 reference design folder on TI.com.

3.1.3.3 Assembly Drawings

To download the assembly drawings, see the design files at TIDA-011019 reference design folder on TI.com.

3.1.3.4 Altium project

To download the Altium project files, see the design files at TIDA-011019 reference design folder on TI.com.

3.2 Tools and Software

This section outlines the software architecture, modular layout, memory footprint, and communication workflow for this reference design utilizing the MSPM0L2117 host MCU and the CC1312R7 sub-1GHz wireless MCU.

There are two examples of firmware, one for each MCU device, supporting bi-directional UART communication and a dedicated pulsed output from CC312R7 to MSPM0L2117.

3.2.1 System Architecture Overview

MSPM0 main task is to control the LCD display and update the metrological value, which is measured by the CC1312R7 wireless MCU and reported using pulsed output to the MSPM0L2117 device. Using pulsed output enables power savings, as only rotation counts are reported by the CC1312R7 device and this only if such rotation happens. In addition, it manages the tamper detection TMAG5132 device and detects Interrupt signal edge, when a magnet is detected near the PCB. The CC1312R7 acts as the flow Metrology engine, which runs on the Sensor Controller Engine module, and supports the UART-based network processor interface (NPI) to the MSPM0L2117.

- *MSPM0L2117 Software Architecture:* Details the bare-metal architecture built on TI DriverLib, UART-based communications, tamper detection and driving capability for IrDA LED.
- *CC1312R7 Software Architecture:* Covers the real-time execution environment structured on TI-RTOS7, focusing on the inductive or optical rotation detection sensing, pulsed count output and OMS wM-Bus 4.2.1 RF protocol stack or LoRaWAN stack.

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- *Data exchange:* CC312R7 and MSPM0L2117 are running UART messages with handshake and acknowledgments (for demo purpose), in addition a pulsed output from CC132R7 to MSPM0L2117 coding the rotations counted each second enables a power efficient update of metrology values to the LCD display.

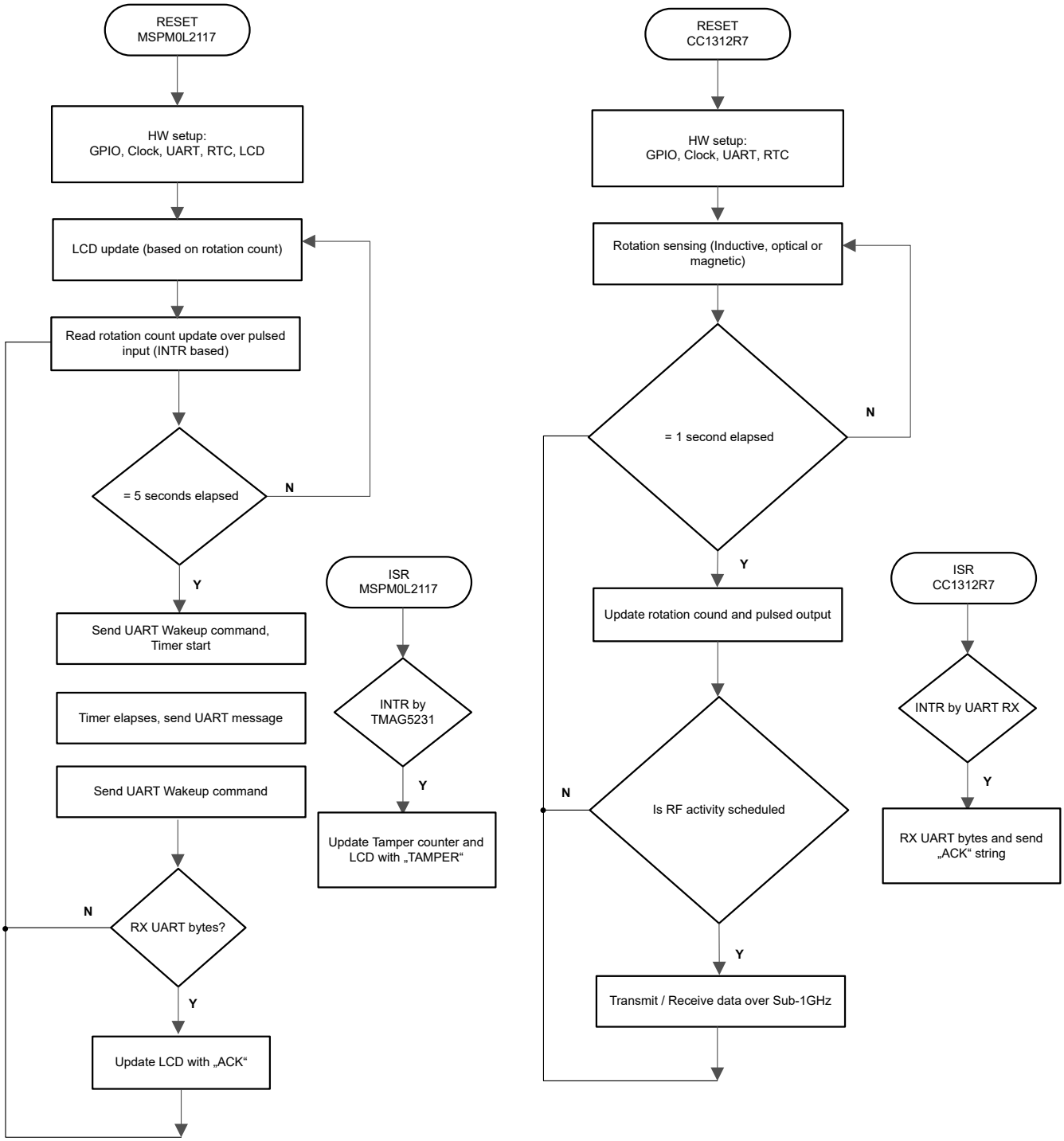


Figure 3-1. Software Flow for MSPM0L2117 and CC1312R7

The firmware architecture overview is based on distributed processing topology, where each MCU is running independently. MSPM0L2117 is a bare-metal SDK implementation, while CC1312R7 runs TI_RTOS as ultra low-power scheduler for rotation sensing and pulsed output generation.

The wM-Bus RF stack can be implemented on demand, with multiple options available, either from TI or from a third party:

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- TI WMBUS Application software & framework | TI.com
- Stackforce wM-Bus Stack for CC1312R/R7 family:
  - https://stackforce.com/produkte/oms-v4-3-3-wm-bus-for-end-devices/
  - https://stackforce.com/produkte/oms-v4-3-3-wm-bus-for-gateways/

But before doing the full stack implementation, the easiest and fastest way to test the basic RF functionality in Receive and Transmit is using TI's SmartRF™ Studio tool which supports all Sub-1GHz devices, including CC1312R and CC1312R7.

This tool requires a c-JTAG (2-wire compact JTAG) connection to CC1312R7 over header J1 and power with VDD and GND (total four wires) to XDS110 debugger, present on all CC1312R LaunchPad.

When powered over the USB Cable the PC GUI of the Tool will auto-detect the CC1312R7 Chip and its silicon revision and enable an easy configuration interface to configure the radio parameters and send or receive wM-Bus S-mode, T-mode, or C-mode modulated packets.

3.2.2 Tools

- CCStudio integrated development environment (IDE): CCSTUDIO
- Sensor Controller Studio: SENSOR-CONTROLLER-STUDIO IDE, configuration, compiler or debugger | TI.com
- MSPM0 software development kit (SDK): MSPM0 SDK
- SimpleLink low-power software development kits (SDKs): CC1312R SDK
- Version 7 SMARTRFTM-STUDIO Calculation tool | TI.com

3.3 Documentation Support

1. Texas Instruments, *MSPM0L2116/7 and MSPM0L1126/7 Mixed-Signal Microcontrollers*, datasheet
2. Texas Instruments, *CC1312R7 SimpleLink™ High-Performance Sub-1 GHz Wireless MCU*, datasheet
3. Texas Instruments, *TPS27081A 1.2-V to 8-V, 3-A PFET High-Side Load Switch With Level Shift and Adjustable Slew Rate Control*, datasheet
4. Texas Instruments, *TMAG5231 Low-Power, Hall Effect Switch*, datasheet
5. Texas Instruments, *Ultra-Low Power Water Flow Measurement for AMR Reference Design*, design guide
6. Texas Instruments, *Design Considerations and Measurement Results for Mechanical Hall-Effect Flow Meters*, application note
7. Texas Instruments, *Low-Power Flow Meter Design Using Optical Sensors*, design guide

3.4 Support Resources

- CC1312R7 LaunchPad™ development kit for SimpleLink™ multi-standard wireless MCU
- MSPM0L2117 LaunchPad™ development kit evaluation module LP-MSPM0L2117
- SX1261/62 Miniaturized Ref Design with Johanson Technology IPD (see AN1200.91)
- European Union. Nov. 20, 2025. "Regulation - 2024/2847 - EN - EUR-Lex". Accessed Sept. 24, 2026
- European Cyber Resilience Act. n.d. "Cyber Resilience Act (CRA) | Updates, Compliance". Accessed Sept. 24, 2026
- European Commission. Jul. 2026. "Commission publishes new guidance to support timely Cyber Resilience Act implementation". Accessed Sept. 24, 2026.

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4 About the Author

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