TI Designs
Heat Cost Allocator With wM-Bus at 868 MHz

TI Designs

Heat cost allocators (HCAs) are mandatory for billing of heat energy consumption in millions of houses and apartments in many EU countries. A wireless MCU with an integrated sensor controller reads out periodically two matched precision analog temperature sensors. This reference design can be powered by 3.6-V or 3.0-V batteries and is compliant to the EN834 heat cost allocator standard using the "two-sensor measurement method". The wireless MCU offers support for wM-Bus (EN13757-4) S, T, and C modes at 868 MHz for meter devices. A capacitive touch PCB area is integrated and implements LCD on/off functionality for saving power.

Design Resources

TIDA-00838	Design Folder
CC1310	Product Folder
LMT70A	Product Folder
MSP430FR4133	Product Folder
TIDA-00646	Tools Folder

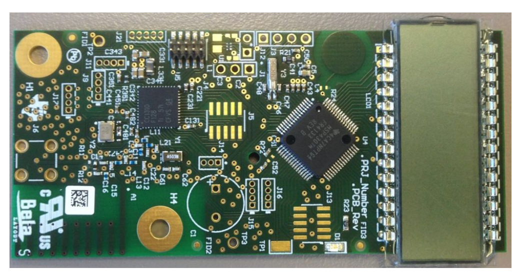
TI E2E™ Community — ASK Our E2E Experts

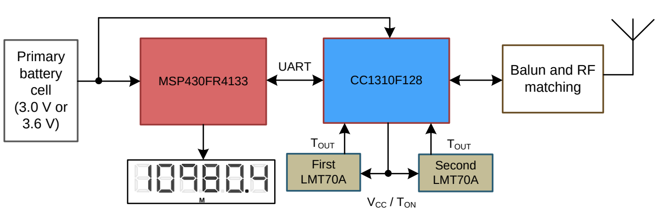
Design Features

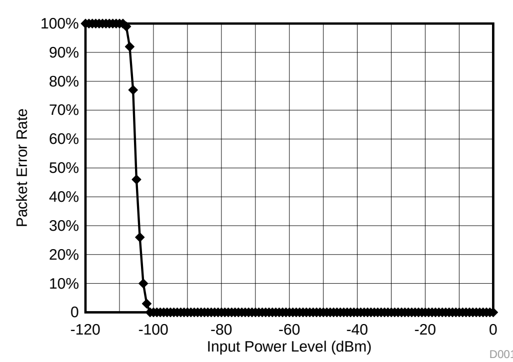
- CC1310 SimpleLink™ Wireless MCU With Sensor Controller Peripheral for Highly Accurate Temperature Sensing Across Environment Conditions: Better Than 0.5 Degrees from 20°C to 85°C
- Example CC1310 Source Code for wM-Bus at 868 MHz Transmit for S, T, and C Modes (Meter Device) With TI RTOS
- PCB With HCA Form Factor Using a 96-Segment LCD (4-MUX) and Capacitive Touch Area for LCD On/Off
- Ultralow Power FRAM Host MCU With Integrated LCD Controller and RTC
- Only 3.16 uA When MSP430FR4133 in LPM3 and LCD BTL002 Off; 20.5 mA at 12.5-dBm Current (at 3.6-V Supply) While Transmitting

Featured Applications

- HCAs Compliant to EN834 With wM-Bus RF Protocol at 868 MHz and up to 15-dBm Transmit Output Power
- Water and Heat Meters With wM-Bus at 868 MHz Subsystem and Segment LCD Functionality
- Internet of Things (IoT) or Wearable Applications With Precise Temperature Sensing and Sub-1GHz RF Link







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1 Key System Specifications

The CC1310 Wireless MCU operates from 1.8 to 3.8 V (3.9 V is the absolute maximum value allowed).

The LMT70A (the matched CMOS temperature sensors with 0.1°C (max) at 30°C) operates from 2.0 to 5.5 V; a minimum of 2.1 V is required for temperatures down to 0°C while 2.0 V is sufficient for 20°C.

The MSP430FR4133 (FRAM MCU) operates from 1.8 to 3.6 V; the absolute maximum rating is 4.1 V.

As HCAs start registering at temperatures of 20°C or above, the common supply voltage for the TIDA-00838 is from 2.0 to 3.8 V.

The common operating ambient temperature for both the CC1310 and MSP430FR4133 is T_A = –40°C to 85°C while LMT70A has a wider operating range of −55°C to 150°C.

2 System Description

Many EU countries are using HCAs for heat billing in houses and apartments, making HCAs a high-volume and cost-sensitive application.

The TIDA-00838 proposes a solution for wM-Bus at 868-MHz enabled HCAs, meeting EN834 requirements:

- Two LMT70A temperature sensors, matched in production to 0.1°C (max) at 30°C
- FRAM-based ultralow power MSP430FR4133 as the host MCU for controlling the segment LCD, supporting the capacitive touch button area and real-time clock (RTC) calendar functions and running the HCA application
- Wireless SoC for wM-Bus at 868 MHz ETSI Category 2 receiver-compliant RF subsystem

The MSP430 uses its on-chip LCD controller and charge pump to power a segment LCD and display the temperature values measured by the CC1310. The latter is directly connected to two LMT70A sensors, which are periodically enabled for temperature measurement; otherwise, the sensors are powered down. The control of the sensors is done by a firmware running inside the sensor controller peripheral of the CC1310 as described in detail in the TIDA-00646 design guide [7].

2.1 *LMT70A: Matched Precision CMOS Temperature Sensor With Analog Output*

The LMT70A is an ultra-small, high-precision, low-power CMOS analog temperature sensor with an output enable pin. Applications for the LMT70A include virtually any type of temperature sensing where cost effectiveness, high precision, and low power are required, such as IoT sensor nodes, medical thermometers, high-precision instrumentation, and battery-powered devices. The LMT70A is also a great replacement for RTD and precision NTC and PTC thermistors.

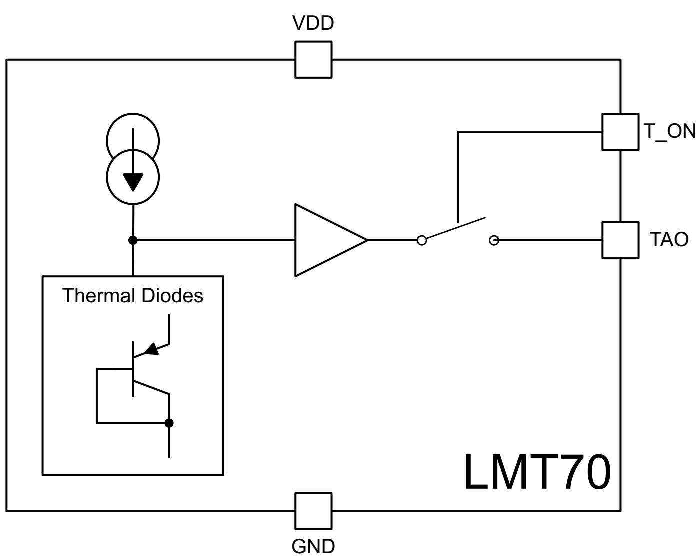


Figure 1. Block Diagram of LMT70A

The matching of two LMT70A up to 0.1°C is a an unique feature, saving significant calibration effort and time during manufacturing, thus lowering the total cost of the HCA product.

2.2 CC1310: Wireless MCU for Sub-1GHz RF Systems

The CC1310 Wireless MCU has an ARM® Cortex®-M3 core for application development while the temperature sensing with the two LMT70A sensors is controlled by the sensor controller engine of the CC1310 (see Figure 2).

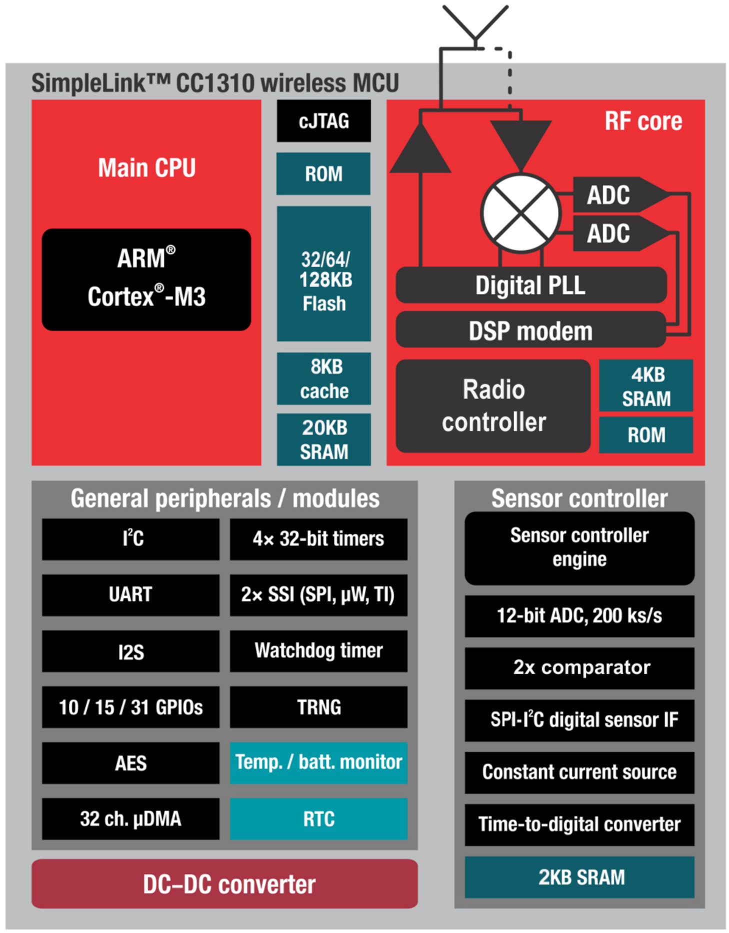


Figure 2. CC1310 Functional Block Diagram

The ARM Cortex-M3 runs with up to 48 MHz, and there is also 128KB of in-system programmable Flash, 8KB of SRAM for cache (or as general-purpose RAM), and 20-KB of ultralow leakage SRAM in the device. The sensor controller has been optimized for ultralow power and can run autonomously from the rest of the system at 24 MHz, using only 0.4 mA + 8.2 µA/MHz.

The sensor controller has a 16-bit architecture, controls the 12-bit ADC hardware block and has its dedicated 2KB of ultralow leakage SRAM for code and data. The CC1310 standby current is 0.6 µA (with RTC running and RAM and data CPU retention). Using the sensor controller to seamlessly interface to and read the LMT70A, analog output is an innovative approach that delivers outstanding low-power consumption with very good precision, suited for HCAs as per EN834. The CC1310 comes with two calibrations values at room temperature for the ADC12: one for gain and one for offset.

3 Block Diagram

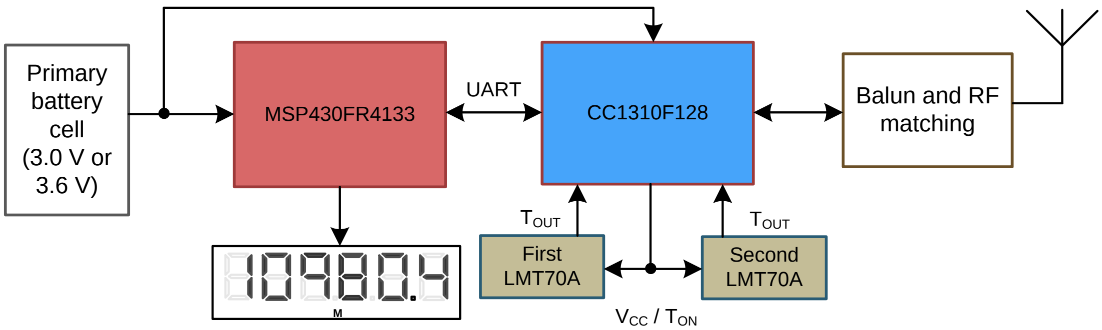


Figure 3. Block Diagram of the TIDA-00838

3.1 Highlighted Products

There are three main components in TIDA-00838 (see Figure 3): the two matched LMT70A temperature sensors, the CC1310 Wireless MCU device, and the MSP430FR4133 FRAM MCU with on-chip segment LCD controller and RTC module.

3.1.1 LMT70A: Precision Analog Temperature Sensor

The LMT70A is an ultra-small, high-precision, low-power CMOS analog temperature sensor with an output enable pin. Applications for the LMT70 include virtually any type of temperature sensing where cost effectiveness, high precision, and low-power are required, such as IoT sensor nodes, medical thermometers, high-precision instrumentation, and battery-powered devices. The LMT70 is also a great replacement for RTD, and precision NTC and PTC thermistors, with accuracy specified as:

- ±0.2°C (max) from –20°C to 90°C
- ±0.23°C (max) from 90°C to 110°C

The LMT70A is the matched version of the LMT70 and provides unparalleled temperature matching performance of 0.1°C (max) for two adjacent LMT70As picked from the same tape and reel. Dissipating less than 36 µW, the LMT70A has ultralow self-heating supporting its high precision over a wide temperature range. Due to its production precision matching, the LMT70A is an ideal solution for sub-metering applications such as HCAs.

3.1.2 CC1310: Wireless MCU for Sub-1GHz RF Systems With Sensor Controller

The CC1310 contains an ARM Cortex-M3 processor and provides 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 sensor controller contains circuitry that can be selectively enabled in standby mode. The peripherals in this domain may 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 main Cortex-M3 CPU.

One of the peripherals in the sensor controller is the SAR ADC module. The ADC is a 12-bit, 200k samples/s ADC with eight inputs and a built-in voltage reference. The ADC can be triggered by many different sources including timers, I/O pins, software, the analog comparator, and the RTC. The analog modules connect to up to eight different GPIOs. The peripherals in the sensor controller can also be controlled from the main application processor.

4 System Design Theory

The CC1310's 12-bit ADC has two references: scaled input for a scaled reference of 4.3 V or an unscaled input using a 1.44-V internal voltage reference. The 1.44-V reference was selected due to its coverage of the full range of approximately 1360 mV at –55°C down to 300 mV for 150°C (see Figure 4) of the LMT70 sensor output signal.

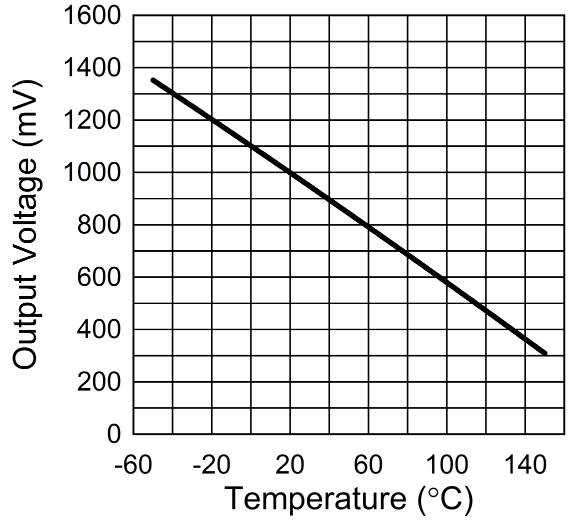
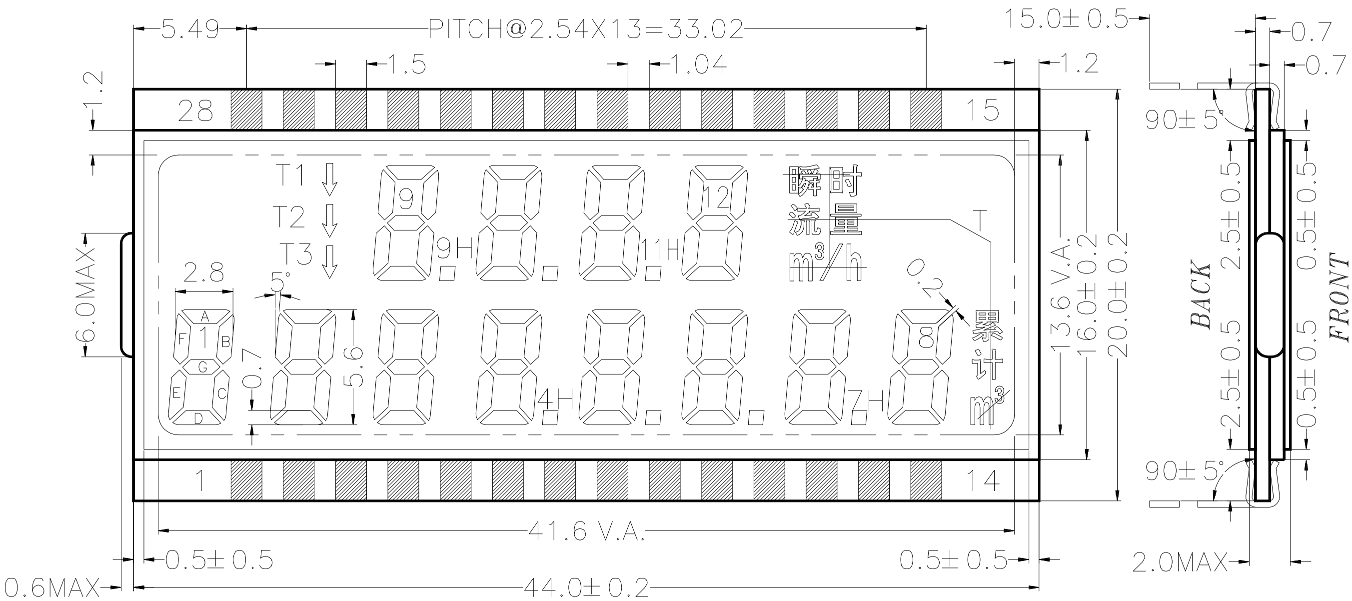


Figure 4. LMT70 Output Transfer Function

For the relevant temperature range of 20°C to 85°C for the HCA application the expected analog voltage output of the LMT70A will be somewhere in the range of 650 mV to 1 V.

In this TI Design, the sensor controller is used for periodical read out of the room and heater sensors through the ADC12 sampling and converting the voltage measured into a temperature value. The readout period itself is software configurable and can be adapted by the user; the provided software example uses one readout every four seconds for each LMT70A sensor.

The LCD BTL002 with 96 segments and 4-MUX capability was chosen due to its small physical dimensions and low-power consumption. The MSP430FR4133's LCD_E module provides an internal charge pump with an adjustable contrast control. In addition, it supports up to 4 × 36 LCD segments in 4-MUX mode and also allows users to configure each LCD drive pin to be either SEG or COM through software settings, which simplifies the PCB layout greatly. The placement of the MSP430FR4133 and its signal connections to the LCD component on the PCB follow the TI Design TIDM-FRAM-WATERMETER and have been optimized for a two-layer design with minimum crossing of signal lines. The specification of the LCD is given in Figure 5:



PIN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
COM1	1A	1F	2A	2F	3A	3F	4A	4F	5A	5F	6A	6F	7A	7F	8A	8F	9A	9F	10A	10F	11A	11F	12A	12F	COM1	--	--	--
COM2	1B	1G	2B	2G	3B	3G	4B	4G	5B	5G	6B	6G	7B	7G	8B	8G	9B	9G	10B	10G	11B	11G	12B	12G	--	COM2	--	--
COM3	1C	1E	2C	2E	3C	3E	4C	4E	5C	5E	6C	6E	7C	7E	8C	8E	9C	9E	10C	10E	11C	11E	12C	12E	--	--	COM3	--
COM4	T1	1D	T2	2D	T3	3D	4H	4D	5H	5D	6H	6D	7H	7D	T	8D	9H	9D	10H	10D	11H	11D	--	12D	--	--	--	COM4

Figure 5. BTL002 Specification (96-Segment LCD)

The MSP430FR4133 runs the main application and the RTC due to its low cost and ultralow power features. All I/Os integrate capacitive touch I/O functionality, so a round PCB area for capacitive touch has been integrated onto TIDA-00838 PCB next to the LCD and is continuously checked for a touch event by the MSP430FR4133.

5 Getting Started: Hardware

For programming and debugging the source code on the CC1310, the J4 2×5-pin connector is used. A 10-pin flat ribbon cable interfaces J4 to a SmartRF06EB board, which includes a XDS100v3 Debugger. This XDS100v3 Debugger is used to program the CC1310.

For programming and debugging the FRAM MCU a second debugger unit, named FET430, is connected to J3 (see the yellow circle in Figure 6). The 4-pin J3 connector uses two lines for Spy-By-Wire™ and two more for VCC and GND and thus can power the full system.

To avoid power supply problems between the FET430 and the XDS100v3 Debugger, only one MCU is being programmed at a time — either the MSP430FR4133 or the CC1310.

5.1 LMT70A Connection to PCB

The TIDA-00838 PCB does not contain the LMT70A sensors because in an HCA application, one temperature sensor should measure the heater body (or heater sensor), and the second sensor should capture the room temperature (room sensor). Any HCA device is mounted firmly onto the heater body, and the heater temperature sensor should have thermal contact with the heater body. In contrast, the room temperature sensor is orientated into the opposite direction to the room or away from the heater body. The two sensors approach used in this TI Design is described in the DIN EN834 as the "two-sensor measurement method".

Therefore, the required physical placement of these two sensors makes it impractical to solder the LMT70A devices onto the PCB. Instead, this device uses two jumpers (J9 and J11) with the proper signal vias for contacting the two sensors, placed on the small PCB. The LMT70A uses a 4-pin DSBGA package, where the supply pin VCC and the output enable pin can be wired together, which saves one I/O pin for each sensor used. J9 and J11 are used to solder three insulated wires to the heater and room sensors. The later are implemented as a very small PCB, described in the Sensor Controller Studio product page [3] with board dimensions of just
2.9 × 2.16 mm. Figure 6 shows the layout of this PCB: the top-left via is GND, the next via is TAO, and the bottom-left via is for both VDD and output enable pins, wired together. The LMT70A is soldered on the back side.

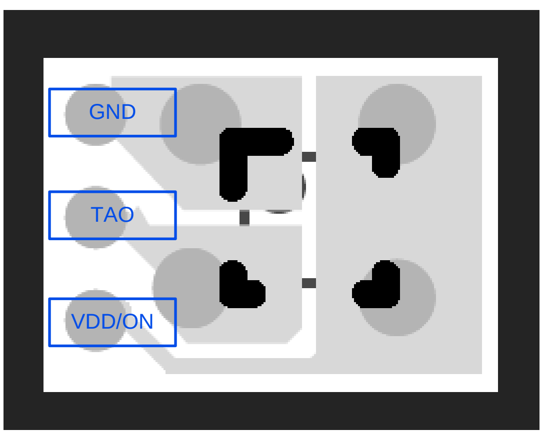


Figure 6. "Small" PCB Layout for LMT70

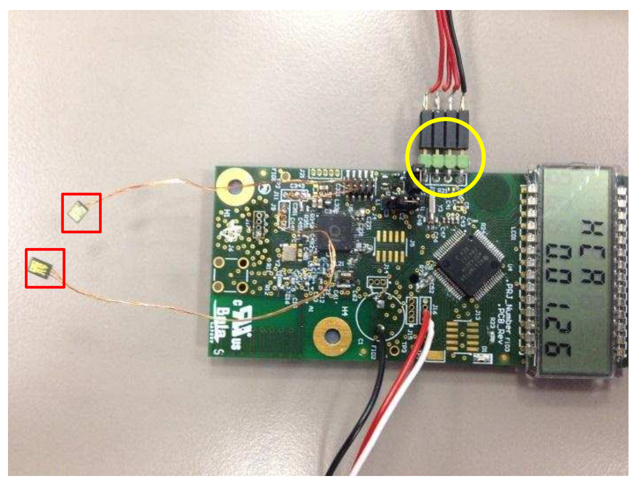


Figure 7. Two PCBs Soldered to TIDA-00838

5.2 UART Link Between CC1310 and MSP430FR4133

A simple UART connection is implemented between the CC1310 and the MSP430; the UART RX and TX signals are also present at jumper J16. These two signals can be connected to a UART-to-Virtual COM port converter, as found for example on the MSP430 FET debugger or the SmartRF06EB. Then, any terminal program can read the UART data from the CC1310 and write characters back if the user wants control over the UART function. The default UART settings used for testing are 115200 bps, 8 N 1; these UART settings can be modified using the IAR source code project as needed.

6 Getting Started: Firmware

A full version of the IAR ARM Embedded workbench version 7.40.3, together with the TI RTOS installation "tirtos_simplelink_2_14_02_22", is required to compile and debug the TIDA-00838 firmware. In addition, Sensor Controller Studio (SCS) 1.1.0.38192 — a TI-provided tool chain — is needed to generate the binary code for the sensor controller; it can be downloaded from the TIDM-FRAM-WATERMETER product page. The firmware code projects for SCS and IAR are provided as a single source code deliverable (TIDA-00838_firmware.zip).

There is one IAR project provided, which includes a SCS sub-project, found in the install path /TIDA-00838_RTOS/wmbus/. The first one is an ultralow power version, where just the LMT70A reading takes place every few seconds (this read out period is software configurable).

Multiple MSP430FR4133 source code examples are available at ti.com; the 1-pin capacitive touch code project has been adapted and integrated to enable the capacitive touch PCB area next to the BTL002 LCD.

6.1 SCS Code Project

To ease developing the program code running on the sensor controller, TI provides a complete tool chain for writing software for the controller, SCS, which is a fully integrated tool consisting of an IDE, compiler, assembler, and linker.

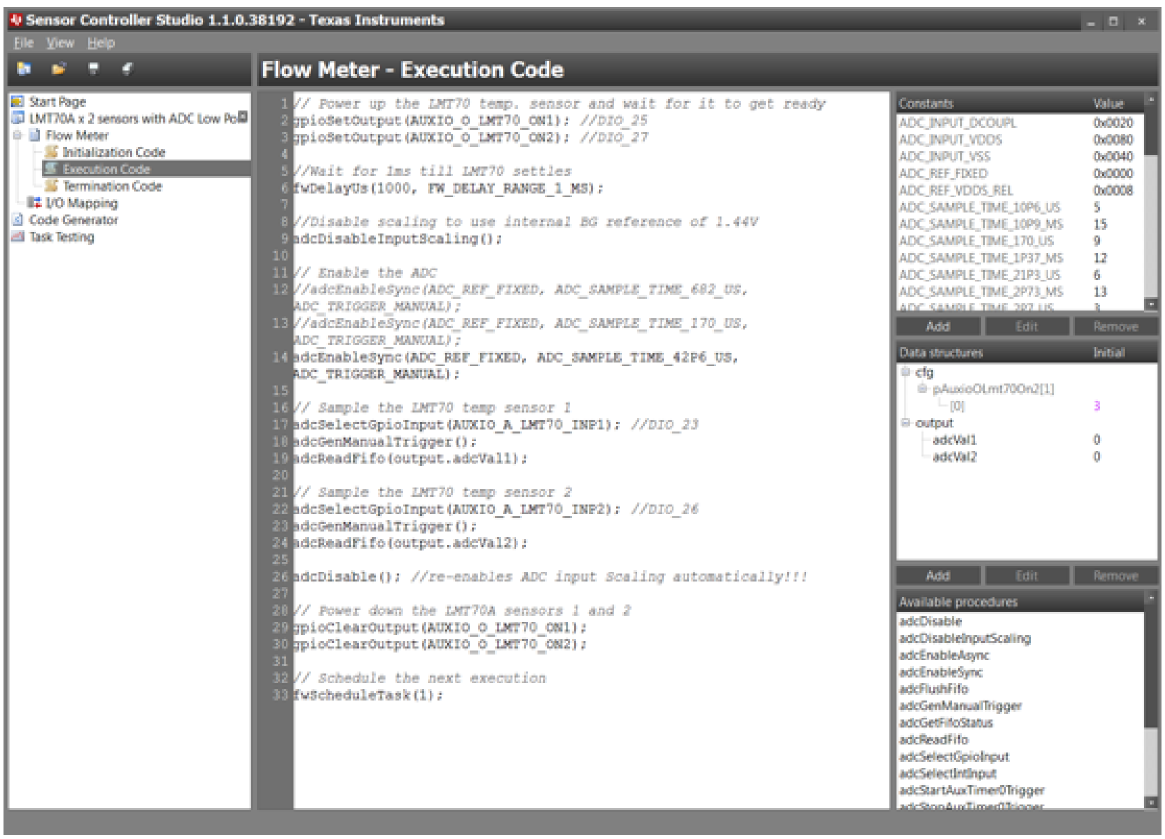


Figure 8. Sensor Controller Project for CC1310 and LMT70A Read Out of Each Sensor

This tool chain can be used to write C-like code for the controller and has a power and event management framework included behind the scenes, which handles most of the complexity regarding the sensor controller, events and power management, and the complexity that arises in a multi-CPU system such as the CC1310.

6.2 IAR EW for ARM Code Project

The code, generated by the SCS project, is a list of files that are part of a bigger IAR project. The IAR main() code example adds the TI RTOS framework and combines the code for the Cortex M3 core (such as UART functionality) with the SCS code into a single firmware image. The files generated by the SCS are shown in Figure 9 (blue circle).

The source code for the CC1310 is based upon the EasyLinkTX example, provided within the TI RTOS code examples. Several modifications have been added, the main two being:

- wM-Bus physical layer example code for S-, T-, and C-mode transmit operation, and
- Register settings changes for 32.768 kbps with Manchester coding (S mode) at 868.3 MHz and T- and C-mode settings for 100 kcps, respectively with "3-of-6" or NRZ-coding at 868.95 MHz.

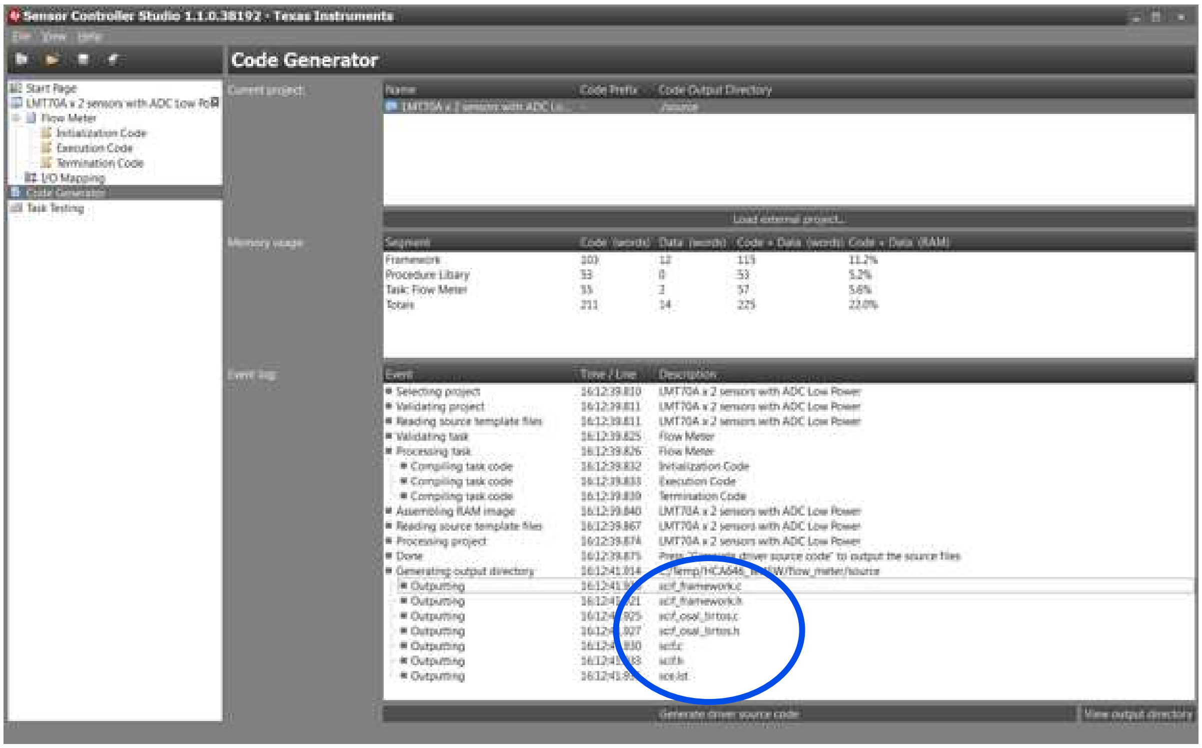


Figure 9. Sensor Controller Output Files Included in IAR Project

6.3 IAR EW for MSP430 Code Project

The MSP430FR4133 executes several functions: running the RTC supplied by an external 32.768-kHz XTAL, controlling the 4-MUX LCD, and reading the temperature values provided by the CC1310 over the UART.

The RTC module gets an interrupt every second, which is used to increment the seconds counter and to check the capacitive touch area for a possible touch event. The one-second interval has been selected as a compromise between the maximum capacitive touch detection time of one second and the added power consumption for running the capacitive touch algorithm. If necessary, the one-second interval setting can be modified in the source code.

7 Test Setup

Two different test setups have been used to develop and test the operation of TIDA-00838, one for the wM-Bus at 868-MHz RF functionality and one to evaluate the RF performance.

The wM-Bus functionality, or the packet data contents of the transmission, has been verified using two different hardware kits as receivers. A Radiocrafts RC1180MBUS Kit [7] with an S- and T-mode Packet Sniffer GUI (included in the *RCTools MBUS* .exe file [8]) captured and checked the wM-Bus data packets in S and T mode, transmitted by the TIDA-00838.

For testing C-mode, a CC1120EM-868 and TRXEB board from the CC1120DK with a dedicated XML configuration file was used. Note that the XML files for the SmartRF7 Studio tool for proper packet reception of S-, T-, and C-modes are provided in the TIDA-00838 firmware package named tidcbn9.zip.

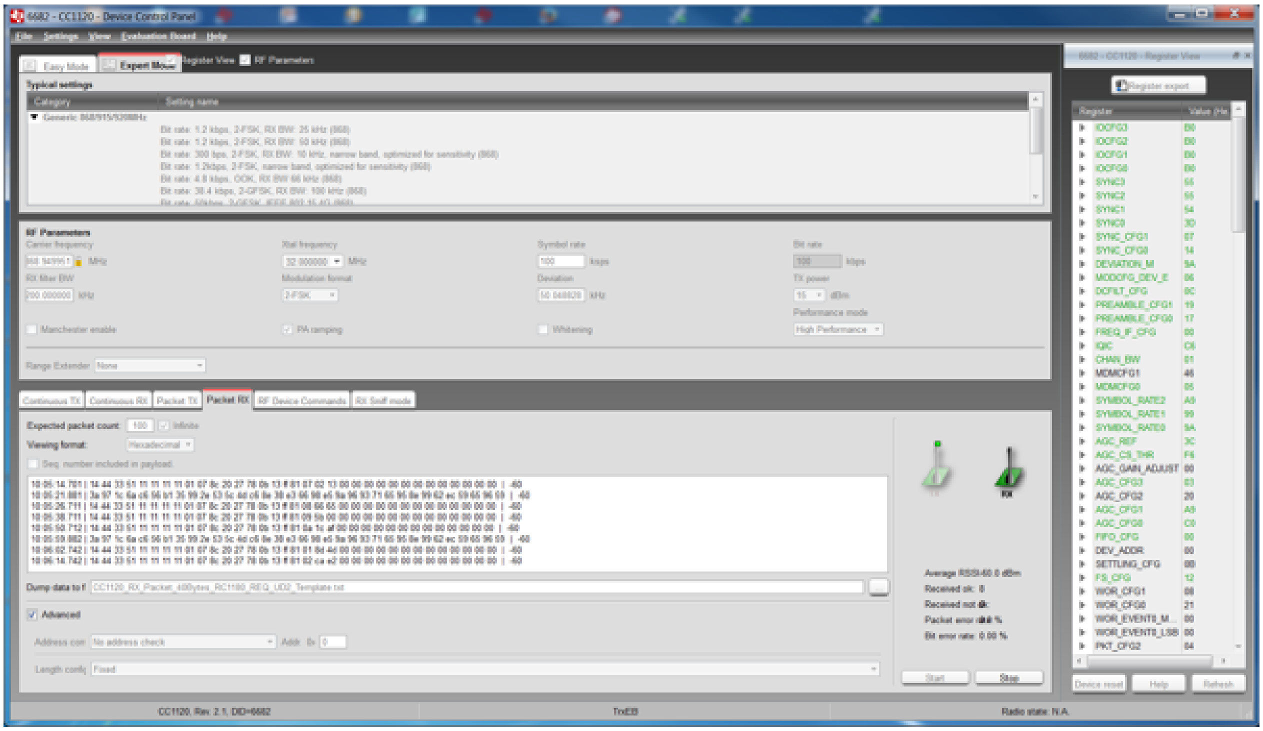


Figure 10. TRXEB + CC1120EM-868 Hardware Kit With SRF7 Studio XML File for T Mode (SYNC = 0x54 3D)

In addition, the basic MSP430 application testing was done by showing the actual RTC on the LCD segment display after a capacitive touch event has been detected. For this purpose, a finger touch to the PCB in the red circle area in Figure 11 for at least one second is required.

After successfully detecting a capacitive touch event, the main application switches on the LCD and shows the RTC for an active period of five seconds, before disabling the LCD again. This period of LCD activity is a user-configurable parameter in the MSP430 source code example.

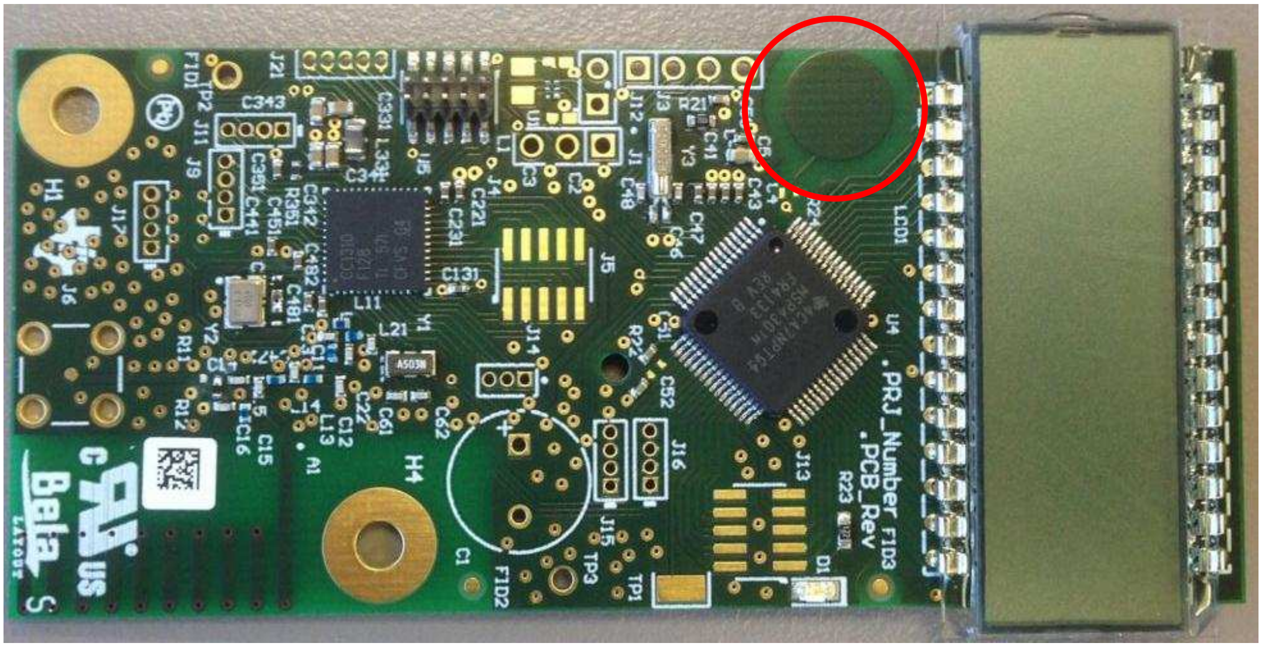


Figure 11. PCB Area for Capacitive Touch (Used to Implement LCD On/Off Functionality)

The RF performance test setup is an automated test bed environment with two RF Signal generators, a RF spectrum analyzer and software scripts to control these. In this test bed, any frequency offset between the device under test (DUT) and the RF equipment is automatically measured prior to testing and compensated for during the test itself. The results for this RF test setup are documented in Section 8.

8 Test Data

The TIDA-00838 was checked with RF tests specifically for S2 and C2-mode "meter" modes in receive direction. The S2-mode meter is identical to the T2-mode meter receiver side and uses 32.768-kcps 2-FSK modulation with Manchester coding for the payload data.

The C2-mode meter (receiver side) is the latest addition to the wM-Bus EN13757-4:2014-2 specification and is very similar to the IEEE802.15.4g 50-kbps mode.

8.1 C2-Mode Meter (50 kbps, 2-GFSK, 25-kHz Deviation Receive)

wM-Bus C2 mode meter (receive) system parameters:

- RF frequency: 869.525 MHz
- Modulation: 2-GFSK
- Data rate: 50 kbps
- Deviation: ±25 kHz (nominal)
- RX filter BW: 118 kHz
- Preamble: 4 bytes
- Sync: 0x54 3D 54 CD

8.1.1 RX Sensitivity

Table 1. 20-Byte Payload, 80% PER

25-kHz DEVIATION (dBm)	MINIMUM: 18.75-kHz DEVIATION (dBm)	MAXIMUM: 31.25-kHz DEVIATION (dBm)
–110.7	–110.1	–110.7

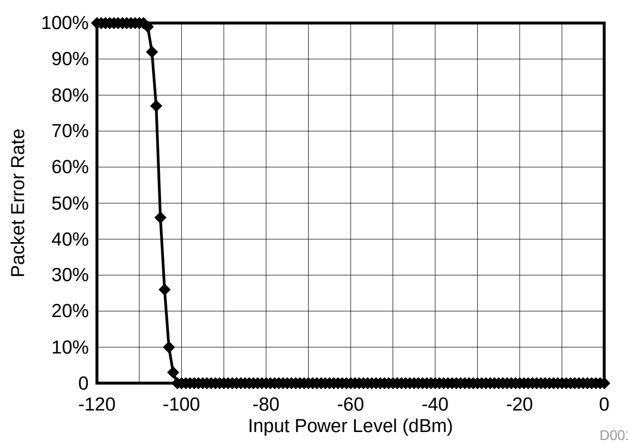


Figure 12. C2-Mode Meter RX Sensitivity for Packet Error Rate (20-Byte Payload) With Nominal Deviation

8.1.2 Selectivity or Blocking

Table 2. 20-Byte Payload, 80% PER, Nominal Deviation

OFFSET (Hz)	BLOCKING OR SELECTIVITY (dB)
–10000000	75.6
10000000	77.2
–5000000	68.8
5000000	70.2
–1000000	59.2
1000000	62.8
–200000	43.0
200000	44.8

8.1.3 PER versus Level versus Offset, 50 kbps, 25-kHz Deviation

20-byte payload, 80% PER = 1% BER

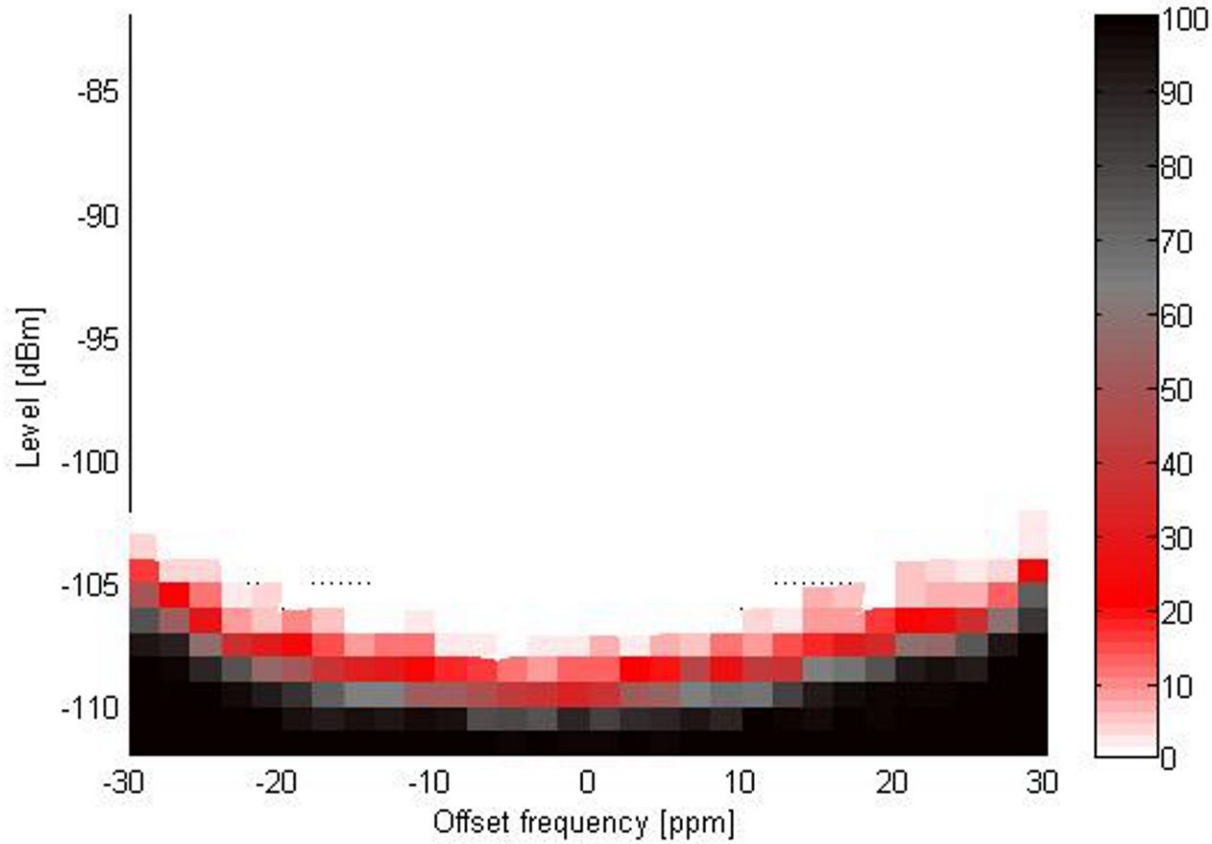


Figure 13. C2-Mode Meter RX Packet Error Rate versus Signal Level versus Frequency Offset (Nominal)

8.1.4 PER versus Level versus Offset, 50 kbps, 18.75-kHz Deviation

20-byte payload, 80% PER = 1% BER

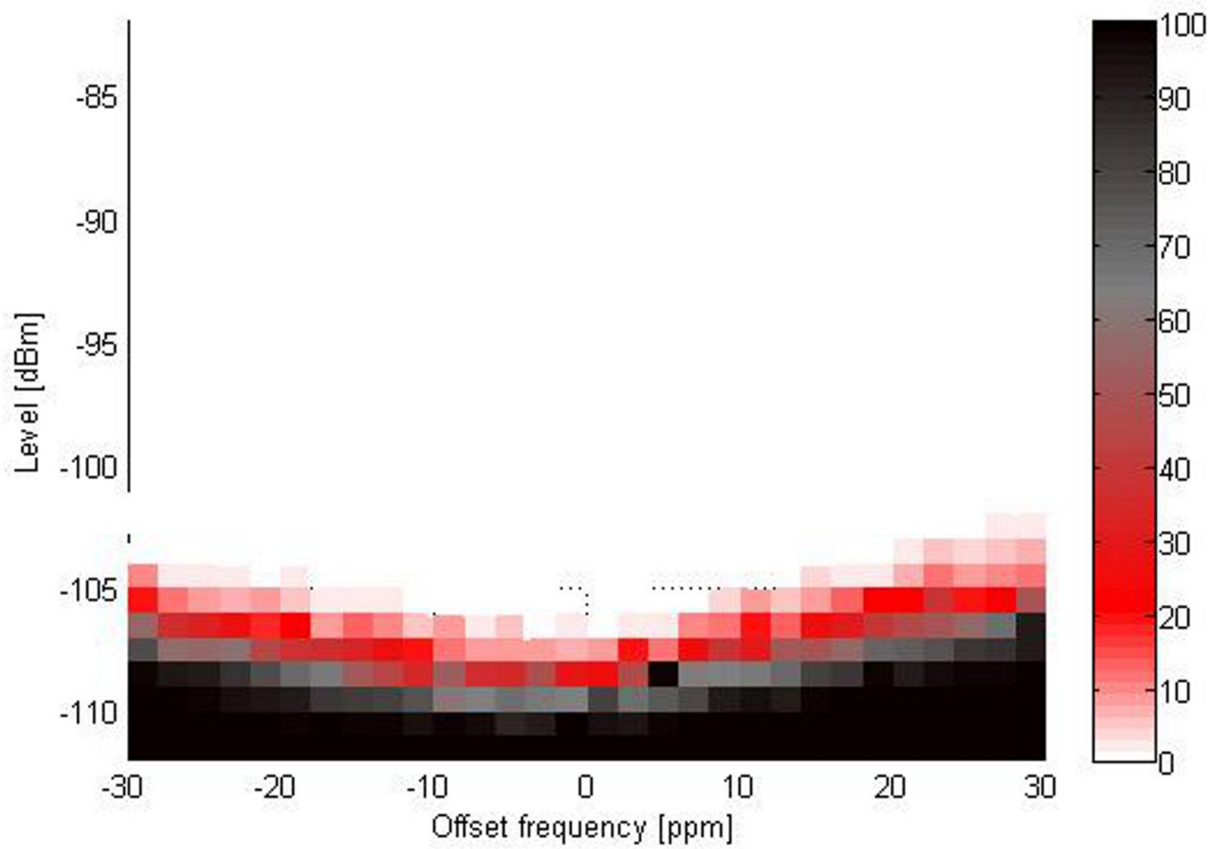


Figure 14. C2-Mode Meter RX Packet Error Rate versus Signal Level versus Frequency Offset (Minimal Deviation of 18.75 kHz)

8.1.5 PER versus Level versus Offset, 50 kbps, 31.25-kHz Deviation

20-byte payload, 80% PER = 1% BER

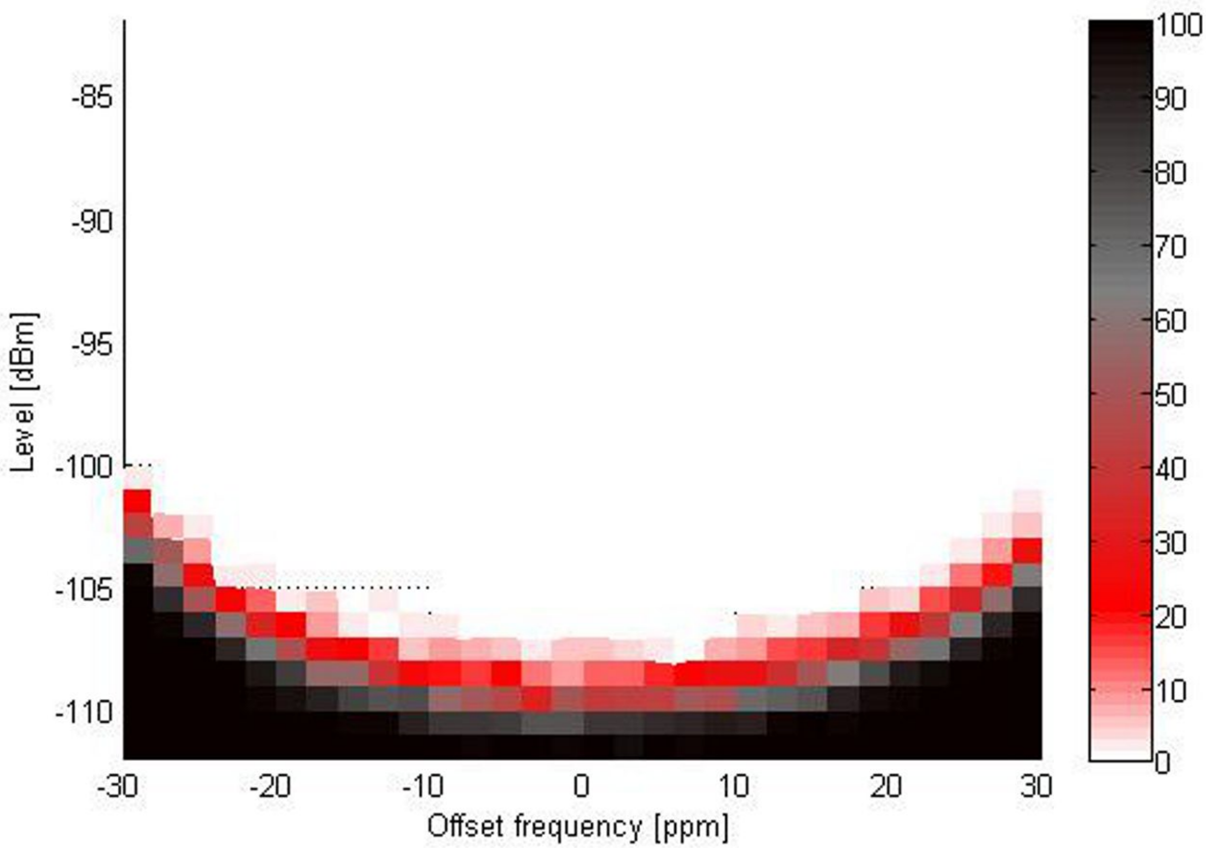


Figure 15. C2-Mode Meter RX Packet Error Rate versus Signal Level versus Frequency Offset (Maximum Deviation of 31.25 kHz)

8.2 S-Mode Meter (Receive)

wM-Bus S2 mode (meter and other) system parameters:

- RF frequency: 869.300 MHz
- Modulation: 2-FSK
- Data rate: 32.768 kcps
- Deviation: ±50 kHz (nominal)
- Preamble: 3 bytes of 0x55
- Sync: 0x54 76 96

8.2.1 S-Mode RX Sensitivity

Table 3. 20-Byte Payload, 80% PER; DR = Data Rate

NOMINAL DR, NOMINAL DEVIATION	NOMINAL DR, MIN DEVIATION	NOMINAL DR, MAX DEVIATION	MIN DR, NOMINAL DEVIATION	MAX DR, NOMINAL DEVIATION
–111.6 dBm	–111.0 dBm	–110.9 dBm	–111.1 dBm	–111.0 dBm

8.2.2 Packet Error Rate

20-byte payload

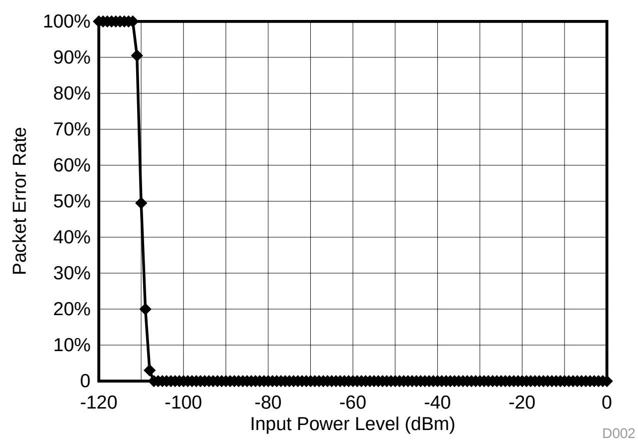


Figure 16. S2-Mode Meter RX Packet Error Rate versus Signal Level

8.3 Current Consumption

The temperature sensing for the TIDA-00838 was measured with an Agilent N6781A 2-quadrant source or measure unit for battery drain analysis.

The CC1310 is running the temperature sensing algorithm for reading two LMT70A sensors once per four seconds with a sampling time of 42 µs for the ADC12. The on-chip LCD controller is disabled unless the capacitive touch PCB area has been touched to activate the LCD.

Figure 17. Average Current of 3.162 µA With MSP430FR4133 in LPM3 and LCD BTL002 Off in Between RF Transmission

The MSP430FR4133 has been programmed with the example source code that runs an RTC, sourced by an external 32.768-kHz XTAL, and gets an interrupt every second to through the RTC interrupt. After adding the second to the clock, the capacitive touch area is sensed for any changes to detect a possible touch event. If such event has been detected, the LCD is enabled for five seconds and then switched-off automatically to save battery power. The LCD active time can be easily extended or shortened, based on application requirements that will either increase or decrease the average current drawn.

Figure 18. 43.65-µA Average Current When Running RF Transmission at 12.5-dBm TX Power Every 12 Seconds; MSP430FR4133 is in LPM3; LCD BTL002 is Off

The CC1310 RF transmit power is set at 12.5 dBm for the test in Figure 18. This power level can be adjusted by exporting the proper C-code in SmartRF7 Studio tool, where the default setting of 0xa73f equals 12.5 dBm.

If a higher TX power level is desired, then the user must manually set the variable CCFG_FORCE_VDDR_HH = 1 in the file ccfg.c (located at \ti\tirtos_simplelink_2_14_03_28\products\cc13xxware_2_01_00_16101\startup_files).

Power level settings:

(a) The combination of TX power level = 0xa73f and CCFG_FORCE_VDDR_HH = 0 will deliver an RF output power level of 12.5 dBm.

(b) If CCFG_FORCE_VDDR_HH = 1 is set, then 14 dBm will be the output (conducted measurement at the SMA connector).

(c) If the user needs an even higher TX power level, such as 15 dBm, then in addition to b), the user must populate different values for the matching components, as described in the schematics page in the tool's design files [2].

To properly calculate the device lifetime, depending on the battery chemistry type and the buffer cap, it is important to know the peak current drawn during RF transmission. For the 12.5-dBm output power an average current consumption of 20.54 mA has been measured, as shown in Figure 19.

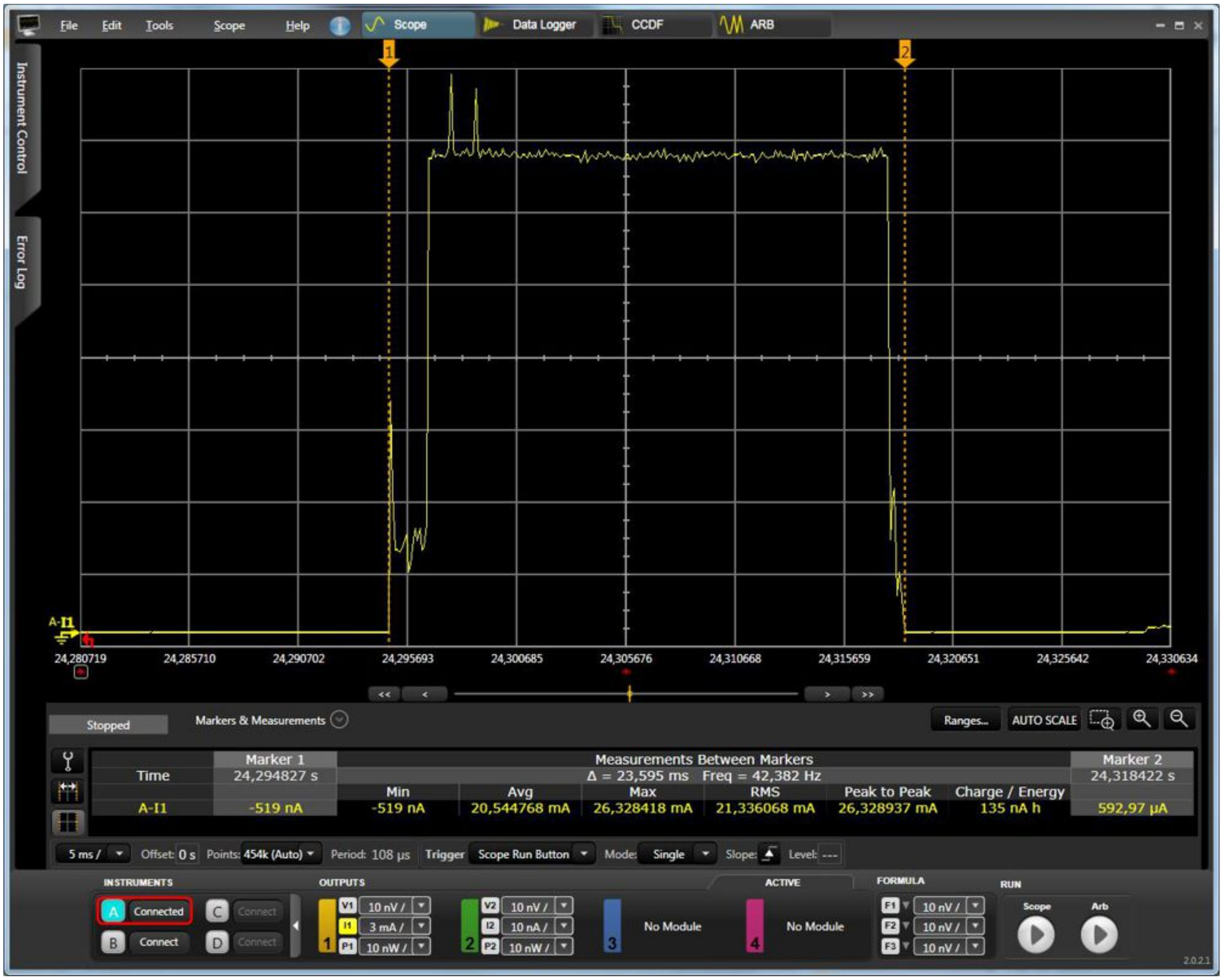


Figure 19. 20.54-mA Average Current During RF Transmission Pulse at 12.5 dBm; MSP430FR4133 is in LPM3; LCD BTL002 is Off

9 Design Files

9.1 Schematics

To download the schematics, see the design files at TIDA-00838.

9.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDA-00838.

9.3 PCB Layout Recommendations

The TIDA-00838 is a two-layer PCB with approximately 1-mm overall thickness; the two layers are for the lowest cost while the 1-mm thickness increases the mechanical stability of the PCB. The layout closely follows the CC1310 reference design in the TIDM-FRAM-WATERMETER but has been modified on the top layer copper to achieve 50-Ω strip-line impedance of the RF line to the SMA antenna connector.

9.3.1 Layout Prints

To download the layout prints, see the design files at TIDA-00838.

9.4 Altium Project

To download the Altium project files, see the design files at TIDA-00838.

9.5 Gerber Files

To download the Gerber files, see the design files at TIDA-00838.

9.6 Assembly Drawings

To download the assembly drawings, see the design files at TIDA-00838.

10 Software Files

To download the software files, see the design files at TIDA-00838.

11 References

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12 Terminology

Heat cost allocators (HCAs)—Battery –powered electronic devices, used to capture the proportionate thermal output of radiators in consumer units

Heater sensor—Temperature sensor, attached to the radiator (or heating element)

Room sensor—Temperature sensor for monitoring the room or ambient air temperature

wM-Bus— The European RF Metering standard, providing solutions for the 169-, 433-, and 868-MHz bands

ETSI Cat. 2 Receiver—Definition for a set of RF parameters in EN300 220 v2.4.1, representing the minimum requirement in wM-Bus capable RF systems at 868 MHz

13 About the Author

MILEN STEFANOV (M.Sc.E.E) is a System Engineer at TI, working in the field of Grid Infrastructure and an expert in RF communication technologies and metering applications. After graduating, he spent 5 years as a research assistant at University of Chemnitz (TUC) and 3.5 years in the semiconductor industry in high-speed optical and wired communications as a system engineer. He joined TI in 2003 to become a Wi-Fi expert and support TI's Wi-Fi products at major OEMs; since 2010, he is focusing on Metering and Sub-1GHz RF solutions for the European Grid Infrastructure market. Mr. Stefanov has published multiple articles on wM-Bus technology in Europe and presented technical papers at the Wireless Congress and Smart Home & Metering summits in Munich.

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