TI Designs
Smart Grid wM-Bus RF Subsystem at 169 MHz

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Design Resources

TIDC-WMBUS-169MHz	Tool Folder Containing Design Files
CC1120	Product Folder
TPS62730	Product Folder

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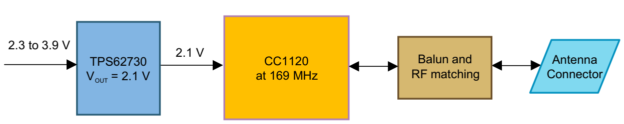
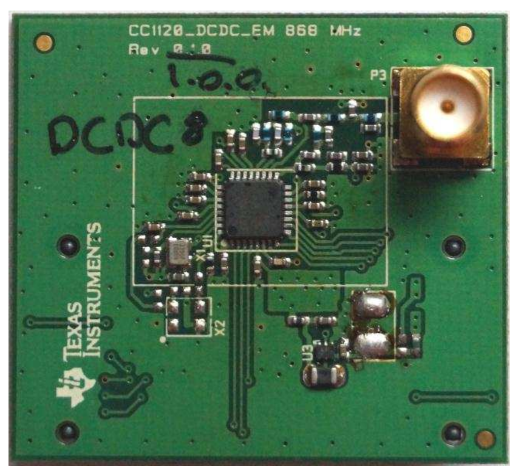
Design Features

- Low-Power 169-MHz, wM-Bus RF Device
- Market-Leading, RF-Blocking, Selectivity, and RX-Sensitivity Solution for 169 MHz
- ETSI Category 1 Receiver-Capable RF System
- No Costly SAW Filter Required
- No Costly TCXO Required
- Supports Multiple Battery Technologies (LiSoCl2, LiMnO2, and Others)

Featured Applications

- Smart Flow Meters (Gas, Water, and Heat)
- Data Collectors with 169-MHz wM-Bus
- Narrow-Band Applications for Tracking, Tracing, and Meter Reading
- Social Alarms in the 169-MHz ETSI Band





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1 Key System Specifications

CC1120 operates from 2 to 3.6 V (3.9 V is the absolute maximum value). The transmit current for 15 dBm of TX power (conducted measurement) is typically 54 mA at 3.3-V supply. The input supply voltage coming from the battery or power management system should be more than 2.1 V to provide the best RF performance of the CC1120 radio.

Supported data rates are from 0 to 200 kbps and the device supports 2-FSK, 2-GFSK, 4-FSK, 4-GFSK, MSK, and OOK modulation formats. 2-GFSK and 4-GFSK are required to comply with the wM-Bus N-modes at 169 MHz.

The BOM has been optimized for the 169-MHz band. This design uses no SAW filter and no TCXO components and is targeted at ETSI Category 1, receiver-compliant wM-Bus systems. *Adding an external SAW component is possible and a good practice in many applications.*

In addition to low-cost XTAL devices, CC1120 also supports TCXO components for applications that mandate the highest-possible frequency accuracy over temperature and lifetime, such as gas or water meters.

To achieve the lowest energy consumption with CC1120, the TPS62730 with a fixed 2.1-V output has been selected. The input voltage range for this DC-DC converter is from 1.9 to 3.9 V and a 30 nA (typical) ultra-low power bypass mode is integrated. The TPS62730 automatically enters bypass mode once the battery voltage falls below the transition threshold $V_{IT\ BYP}$.

Table 1. Energy Consumption

				MIN	TYP	MAX	UNIT
$V_{IT\ BYP}$	Automatic bypass switch transition threshold (activation/deactivation) ON/BYP = High	TPS62730 (2.1 V)	ON/falling V_{IN}	2.14	2.20	2.3	V
			OFF/rising V_{IN}	2.19	2.25	2.35	

The DC-DC converter is available in a very-small 1 × 1.5 mm^2, 6-pin QFN package. The converter achieves up to 95% DC-DC efficiency and can provide up to 100-mA output current, using up to 3-MHz switching frequency.

CC1120 uses a VQFN32 package of 5 × 5 mm with a ground pad.

The operating ambient temperature for both CC1120 and TPS62730 is T_A = –40°C to 85°C.

2 System Description

CC1120 is targeted at systems with ETSI Category 1 Compliance in 169-MHz and 433-MHz bands and offers a high spectral efficiency (9.6 kbps in 12.5-kHz channel in compliance with FCC narrow-banding mandate). CC1120 delivers market-leading blocking, selectivity, and sensitivity RF performance numbers in all supported ISM bands.

This design is focused specifically on 169-MHz wM-Bus systems, as defined for the smart gas meters rollout in Italy and France.

Using a supply voltage of up to 3.6 V delivers excellent RF results. However, the drawback is increased power loss in the internal LDOs of CC1120. To reduce these losses and extend the battery life in such an RF system, TI recommends to use the lowest-possible supply voltage.

Another consideration is that the supply voltage must be the same for both MCUs running the RF communication protocol (for example, the wM-Bus N2-mode RF stack) and the CC1120 radio. The supply voltage must be the same to avoid voltage level issues on the SPI and on the control signals between the radio and the MCU.

These considerations lead to the choice of TPS62730 with 2.1-V output for this design (TPS62733 with 2.3-V fixed output is also available).

Depending on the application’s duty cycle (for example, how many transmit and receive operations per day, how long each of these operations is, and at which transmit power level), a different power scheme will be most efficient. In wM-Bus capable gas or water meters, as used in Italy and France, the transmit operations occur just a few times per day. For these meters, the recommended solution for the highest power savings is to shut down the CC1120 device completely during the inactivity time. The power-up and initialization procedure of CC1120 takes just a few milliseconds and can be easily repeated every time the device starts from shutdown. In other cases with much higher duty cycles, using the power-down mode with register retention (a typical value is 120 nA) may be the better option.

The combination of TPS62730 plus the CC1120 radio delivers a RF solution, which is market-leading in terms of both RF performance and low-power consumption. The design has been developed to meet and exceed the requirements of all wM-Bus systems at 169 MHz, which are becoming popular in Europe for smart flow meters.

Additionally, due to the CC1120 excellent blocking and selectivity performance (see ETSI category 1 receiver requirements in ETSI EN 300 220-2), this CC1120-based solution is perfectly suited for use in social alarms and data tracking systems.

2.1 CC1120 — High-Performance RF Transceiver for Narrow-Band Systems

The CC1120 transceiver features adjacent channel selectivity of 64 dB at 12.5-kHz offset and blocking performance of 91 dB at 10-MHz offset in combination with excellent receiver sensitivity of –123 dBm at 1.2 kbps.

In transmit mode, the CC1120 transforms the data packets created in the MCU into RF signal and passes the RF signal to the antenna. In receive mode, the CC1120 receives RF signal from the antenna, detects the bit stream, and converts the bits into data bytes, which are passed to the MCU for further processing.

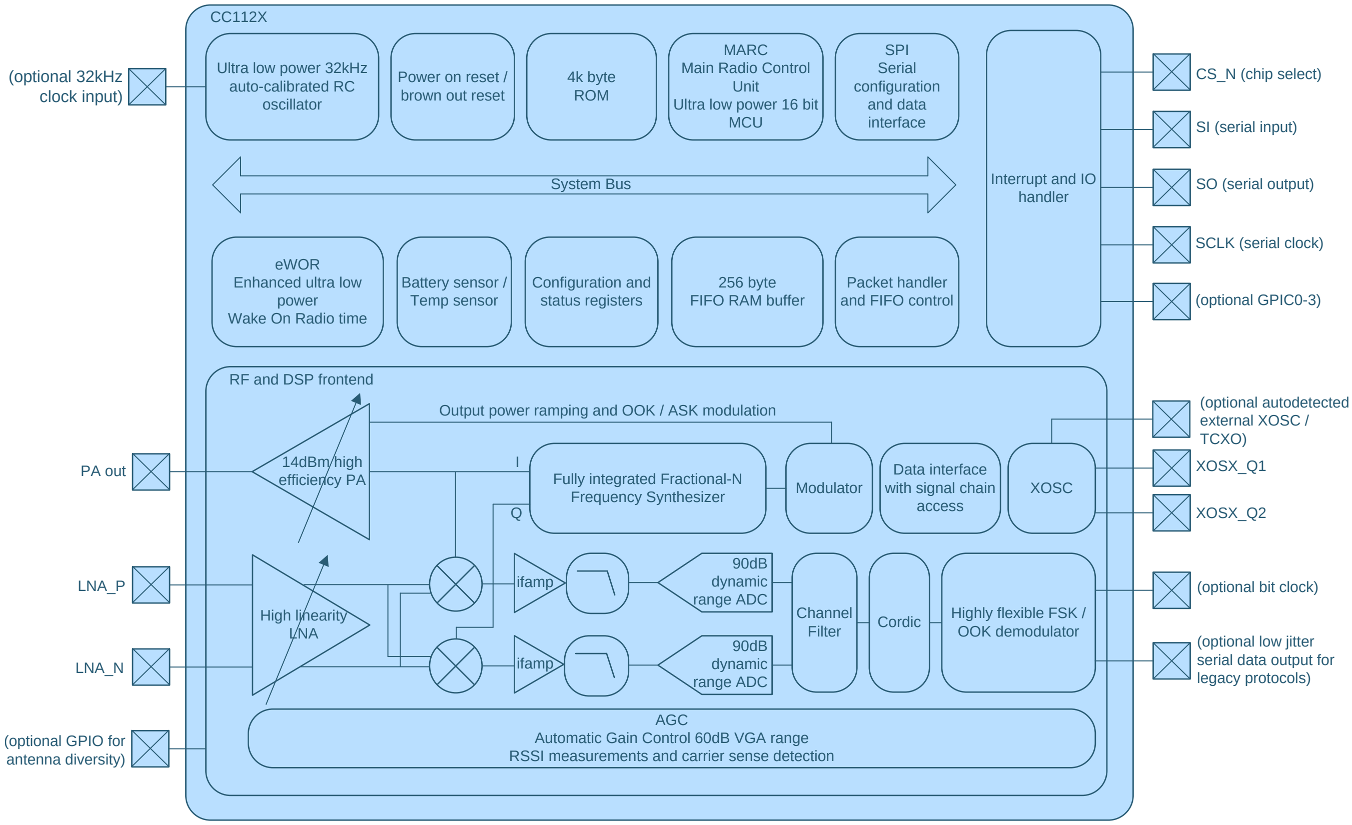

Figure 1. Functional Block Diagram of CC1120

2.2 TPS62730 — Step-Down Converter With Bypass Mode for Ultra-Low Power Wireless Applications

The TPS62730 is a high-frequency, synchronous, step-down DC-DC converter optimized for ultra-low power wireless applications, using TI’s sub 1-GHz and 2.4-GHz RF transceivers and System-on-Chip (SoC) solutions. The TPS62730 reduces the current consumption drawn from the battery during TX and RX mode, provides up to 100-mA output current, and allows the use of tiny and low-cost chip inductors and capacitors. With an input voltage range of 1.9 to 3.9 V, the device supports Li-primary battery chemistries such as Li-SOCl2, Li-SO2, Li-MnO2, and also two cell alkaline batteries.

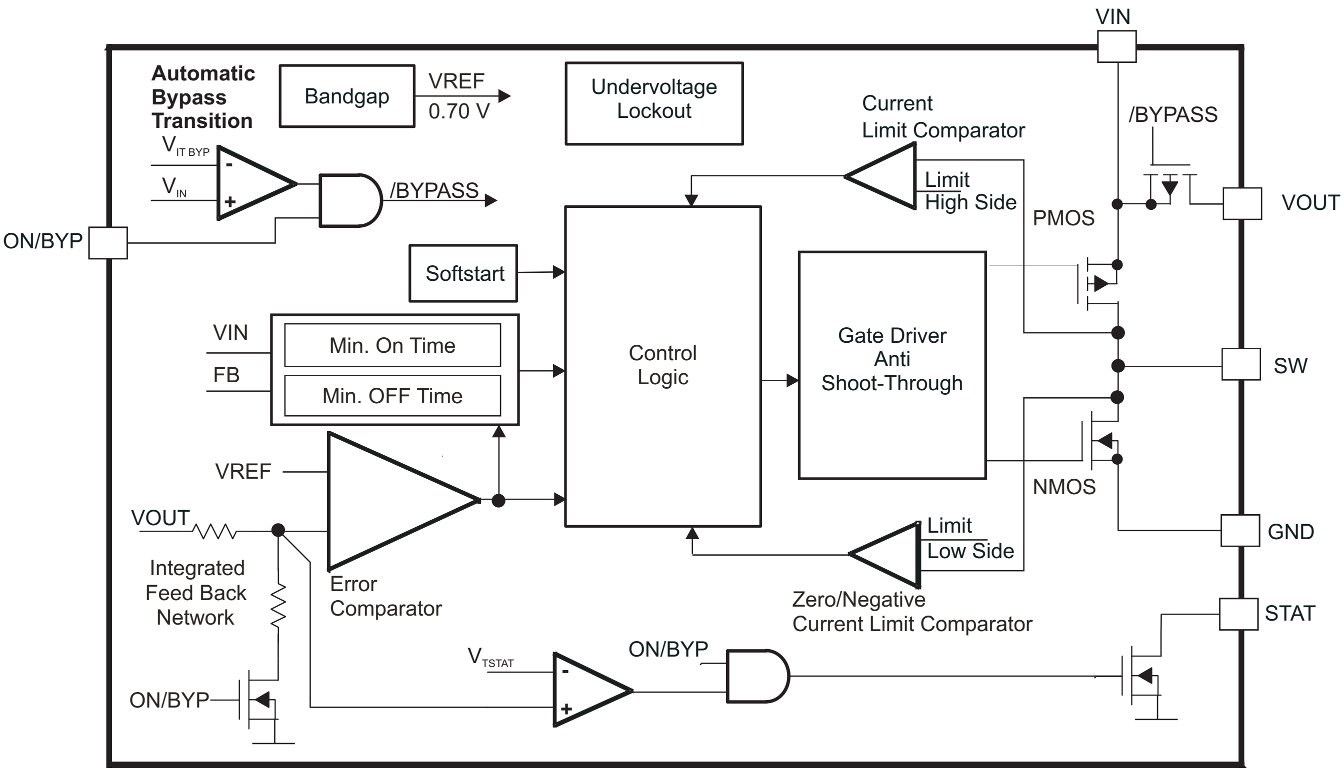

Figure 2. Block Diagram of TPS62730

3 Block Diagram

The system's block diagram is very simple – the DC-DC is between the power supply (usually a battery, or a perhaps a SuperCap device) and the CC1120 radio, downconverting the supply voltage to 2.1 V. The radio has its balun and matching network, built with discrete, 0402-sized passive components, and the antenna connector (which is the 50-Ω RF feeding point).

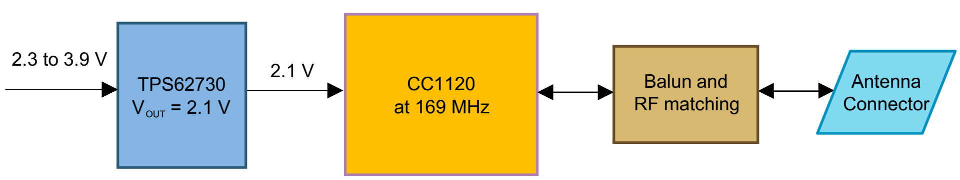

Figure 3. Block Diagram of wM-Bus RF Subsystem at 169 MHz

3.1 Highlighted Products

3.1.1 CC1120

The CC1120 device is a fully-integrated single-chip radio transceiver designed for high performance at very low-power and low-voltage operation in cost-effective wireless systems. All filters are integrated, which removes the need for costly external SAW and IF filters. The device is mainly intended for the industrial, scientific, and medical (ISM) and short-range device (SRD) frequency bands at 164 to 192 MHz, 274 to 320 MHz, 410 to 480 MHz, and 820 to 960 MHz.

The CC1120 device provides extensive hardware support for packet handling, data buffering, burst transmissions, clear channel assessment, link quality indication, and wake-on-radio. The main operating parameters of the CC1120 device can be controlled through an SPI interface. In a typical system, the CC1120 device is used together with a microcontroller, such as MSP430, and only a few external passive components.

CC1120 is suitable for RF systems targeting ETSI Category 1 compliance in 169-MHz and 433-MHz bands. Some unique and very handy features of CC1120 are as follows.

- WaveMatch: Advanced digital signal processing for improved sync detect performance.
- RX Sniff mode – Autonomously checking for preamble and reducing current consumption.
- ImageExtinct – Compensation algorithm that digitally compensates for I/Q by removing the image component, and therefore removing any issues at the system image frequency.
- Feedback to PLL – A capability to *increase the RX filter BW* without increasing the noise bandwidth, and therefore improving receive sensitivity.

3.1.2 TPS62730

The TPS62730 combines a synchronous buck converter for high-efficiency voltage conversion and an integrated ultra-low power bypass switch to support low-power modes of modern microcontrollers and RF ICs. The synchronous buck converter includes TI's DCS-Control™, an advanced regulation topology, that combines the advantages of hysteretic and voltage mode control architectures. While a comparator stage provides excellent load transient response, an additional voltage feedback loop also ensures high DC accuracy. The DCS-Control enables switch frequencies up to 3 MHz, excellent transient and AC load regulation, and operation with small and cost-competitive external components.

4 System Design Theory

Several considerations were taken into account when defining this RF subsystem as follows:

- Obtaining best RF performance (RX sensitivity and blocking parameters)
- Lowest system cost
- Highest power efficiency

4.1 Power Efficiency

TPS62730 is a RF-friendly DC-DC device, which means that RF performance of the CC1120 is not degraded to the switching frequency of TPS62730. The TPS62730 2.1-V version has been selected as this voltage level delivers the lowest current consumption and enables CC1120 to deliver excellent RF performance numbers.

In addition, 2.1 V is now a common voltage level for modern MCUs, such as MSP430. These MCUs are used to control RF devices and run communication protocol stacks. Further test data for TPS62730 in combination with the CC112x radio family is found in DN040.

4.2 RF Performance at 169 MHz (ETSI Category 1 Receiver Capable)

CC1120 easily achieves and exceeds ETSI Category 2 receiver category compliance just using the register settings, optimized for best RX sensitivity, found in the Smart RF7 Studio tool, where the receiver bandwidth is set to 10 kHz (register CHAN BW = 0x14). This performance is sufficient to meet the wM-Bus Nabcdefg modes' requirements, set in the EN13757-4:2013 document.

However, the most stringent requirements are for an ETSI Category 1 receiver. These requirements can be met by CC1120 by using just a few optimized register settings. Using the *best sensitivity* settings with 10-kHz bandwidth from SRF7 Studio results in blocking performance at ±2-MHz offset from the carrier frequency of 84.3 dB, which is slightly below the ETSI limit of 85.1 dB.

By applying an optimized set of CC1120 register settings, called *best blocking*, the ±2-MHz blocking is improved to 86.2 dB (or 1.1 dB better than the limit).

NOTE: These excellent blocking numbers are achieved without a costly external SAW filter component.

The trade-off for getting ETSI Category 1 receiver compliance and improved blocking numbers is that the RX sensitivity is reduced from –120 dB to –116 dB.

It has been confirmed in field measurements that the channel noise at 169 MHz in some European areas can be significantly higher, close to –110 or even –100 dB. In such cases, having two optimized register sets, which differ by only a few registers values, a CC1120-based 169-MHz RF system can dynamically adapt to the changing RF channel conditions in the field. This dynamic adaption is enabled by a periodic measurement of the channel noise level and switching between the *best sensitivity* or *best blocking* settings, based on the RSSI levels measured over time.

4.3 System Cost

In high-volume rollouts of 169-MHz RF systems in Europe, the total system cost (and also the BOM cost) is of the utmost importance. Achieving the ETSI Category 1 receiver performance is already quite challenging. However, achieving the performance without external TCXO and without an external SAW filter is even better. CC1120-based designs are also leading not only in RF performance, but also in terms of system cost, as TCXO and SAW filters are not needed. In addition, no external LNA device is required to meet the RX sensitivity requirements at 169 MHz for France.

5 Getting Started Hardware

The test hardware comprises two PCBs: the TRXEB platform from the CC1120DK and the CC1120 plus TPS62730 evaluation board. Two existing TPS62730 plus CC1120EM at 868-MHz boards have been modified (BOM component changes only) to support 169 MHz. All reported results were *measured conducted*, which means using a RF cable connection between the R&S® RF signal generator and the DUT (the RF boards).

5.1 Setting Up the Hardware System

To enable the DC-DC, the ON/BYP pin of TPS62730 must be connected to the supply. The control signal is available on P7, pin 7 of the TRXEB board.

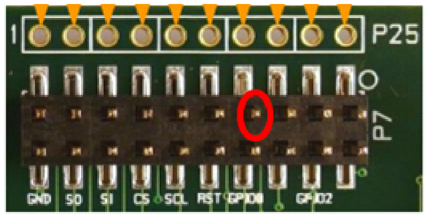

Figure 4. P7 Port of TRXEB, Red Circle Shows Pin 7

Connect P7.7 to *Power Source* pins as shown in Figure 5. Connect jumpers as shown (enables external power supply instead of USB or battery power source). Connect the control signal from P7.7 to one of the pins in the top row and connect the external supply to one of the other pins in top row.

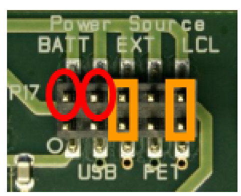

Figure 5. Power Selection Jumpers of TRXEB

External power is delivered to the TPS62730 plus CC1120 board (DUT) through a power supply unit, set at 3.6 V. A multimeter is connected to the RF core pins on the TRXEB and the multimeter measures the total current into the CC1120 device.

The SRF7 Studio uses special XML files, which deliver the optimized RF settings for the CC1120 high-performance radio.

SmartRF TrxEB has three current measurement jumpers, MCU_PWR, IO_PWR, and RF_PWR, as shown in Figure 6. By removing the *RF* jumper, an ampere meter can be easily connected to the board to measure the CC1120 current consumption.

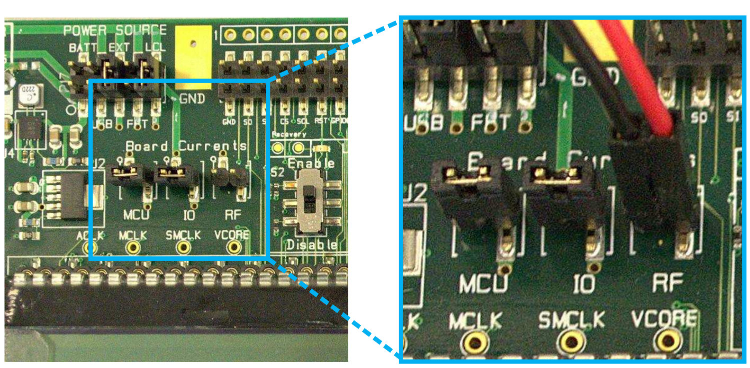

Figure 6. Jumpers for Measuring Currents on TRXEB
RF Jumper is Used in This Document

5.2 Testing Conditions

All measurements were done at room temperature, *f* = 169.000 MHz, Vin = 3.6 V to TPS62730 (from external power bench supply). V_{OUT} from TPS62730 = V_{CC} of CC1120 = 2.1-V supply voltage.

Two signal generators from R&S were used. The first signal generator was used to create the reference RF signal for RX sensitivity testing. The second signal generator was only used during blocking performance measurements, by generating an interfering signal. A special packet configuration file for the signal generators was created, including a CRC16 field at the end. Therefore, the same known transmit packet is sent out multiple times. The CRC16 field is automatically checked by the CC1120 CRC block engine and an error is indicated if at least 1 bit in the received packet is wrong.

Getting Started Firmware

No specific firmware is required for the following RF performance tests, as TI's SmartRF7 Studio software SmartRF Studio 7, running on a Windows® PC, is controlling the CC1120 radio. The embedded TRXEB firmware is used by setting the DIP switch to *USB mode Smart RF* and the TRXEB board is connected through a USB cable to the PC. SmartRF7 Studio GUI reports correct and missing or wrong packets and calculates and displays the packet error rate (PER) automatically.

5.3 SmartRF7 Studio Files

Two configuration files for SmartRF7 for are provided, which set the CC1120 registers as needed.

5.4 Test Frame

Test frame format:

Preamble ***SYNC*** ***Packet data***

55 55 ***F6 72*** 1D 55 55 55 55 55 55 55 55 55 55 55 55 55 55 55 55 55 55 55 55 55 55 55 55
55 55 55 55 **5A 82**

Binary format (transmitted by the SMU):

0101010101010101111101100111001000011101010101010101010101010101
0101010101010101010101010101010101010101010101010101010101010101
0101010101010101010101010101010101010101010101010101010101010101
0101010101010101010101010101010101010101010101010101010101010101
01010101010110101000001000000000000000000000

For this test frame, two SmartRF7 studio files are provided. The first studio file is provided for the 2.4-kbps data rate. The second studio file is provided for the 4.8-kbps data rate.

5.5 Signal Generator Settings

The SMU200A setting files were used; the files are named *169M_TestFrame37Bytes.dm_iqd* and *169M_TestFrame37_Bytes_allZeros.dm_iqd*. The first setting file is coding the standard frame with a 0x55 data payload. The second setting file is for a data payload of only 0. Using these two setting files is much more challenging for the radio demodulator to keep bit synchronization. However, C1120 has no problems receiving these frames as well.

5.6 RX Sniff Mode C-Code Example

For easy testing of RX Sniff mode performance of CC1120 and for current measurements, a source code IAR project for the TRXEB (based on MSP430F5438A) and CC1120 was developed. The application can be compiled for a transmitter unit (TRXEB plus CC1120EM-169 board). The source code is also for the receiver unit, consisting of TRXEB and the TIDC-wMBus-169MHz board. Using the buttons on the TRXEB, the engineer can choose between 2.4- and 4.8-kbps data rates, respectively using the wM-Bus Nc- and Na-mode settings (each setting has the correct preamble type and length, SYNC word, modulation, and deviation parameters).

The received packets are counted and displayed on TRXEB's LCD. The transmit unit sends either single packets or bursts of 100 packets.

6 Test Setup

The performance numbers were tested on two boards. The TPS62730 DC-DC device is enabled (not in bypass) and delivers a regulated 2.1 V to the CC1120 radio from the Vin = 3.6 V, provided by the bench power supply unit. A multimeter is connected to the RF core pins on TRXEB and shows the current drawn by the RF device.

The 3.3-V values in the test data apply when a USB cable from the PC powers the TRXEB (instead of the external power supply).

7 Test Data

7.1 TX Current

Table 2. Transmit Current for TIDC-WMBUS-169MHz for Various TX Power Levels for V_{IN} = 3.6 V and V_{IN} = 3.3 V

TX Power	V_{IN} to TPS62730 = 3.6 V (Current in mA)	V_{IN} to TPS62730 = 3.3 (Current in mA) (RF Equipment and Ampere Meter Not Calibrated)	Comment
–14.1 dBm	11.34	13.10 (–12.4 dBm)	
–8 dBm	12.10	13.73 (–8.2 dBm)	
–4.3 dBm	13	15.10 (–3 dBm)	
0 dBm	14.45	16.49	
3.7 dBm	17.31	19.20 (+3.9 dBm)	
10 dBm	25	26.87	
12.2 dBm	29.50	31.37 (+12.1 dBm)	
12.4 dBm	30.34	32.16 (+12.4 dBm)	Max TX power possible at 2.1 V
12.3 dBm	43.95 (+12.18)	44.47	Bypass
14 dBm	50.28	50.56	Bypass
15.7 dBm	58.72	58.34	Bypass
16.0 dBm	60.13	NA	Bypass

Table 3. TX Current for Different V_{IN} Levels

TX Power Level Max	V_{IN} to TPS62730 in mA V_{OUT} = 2.1 V	Current in mA
12.2 dBm	3.6 V	29.5
12.2 dBm	3.3 V	32.9
12.2 dBm	3.0 V	36.0
12.2 dBm	2.7 V	40.5
12.2 dBm	2.5 V	43.4

Comparison: TX current is 60.13 mA at + 16.0 dBm V_{IN} = 3.6 V (TPS62730 in bypass)

Summary: the CC1120 transmits current at 12.3-dBm TX power level: 30.4 mA (with DC-DC V_{IN} = 3.6 V) versus 44 mA (no DC-DC).

Assuming the system runs from a primary battery, then 30.4 / 44 = 0.691, or 31% higher efficiency during transmit operation. Therefore, the lifetime is 31% longer in transmit mode.

7.2 RX Current

The RX configuration files for SmartRF7 Studio were used with one DUT board (TIDC-WMBUS-169MHz), V_{IN} = 3.6 V from the power supply, V_{OUT} = 2.1 V.

Table 4. RX Sniff Currents at V_{IN} = 3.6 V

Data Rate	RX Sniff Mode TPS62730 = 3.6 V (Current in mA)	V_{IN} to TPS62730 = 3.6 V Normal Mode (Current in mA)	V_{IN} = 3.6 V Bypass Mode Normal RX Mode (Current in mA)	Comment
PHY-WM2400	10.5	13.20	22.45	Data packets 999/1000 OK
PHY-WM2400	8.5	13.54	23.08	No data packets
PHY-WM4800	10.0	13.35	22.76	Data packets 999/1000 OK
PHY-WM4800	10.0	13.72	23.28	No data packets

Comparison: CC1120 RX current = 23 mA at 3.6 V

Summary: The CC1120 receive current when using TPS62730 is reduced from 23 to 13.5 mA, which equals 13.5 / 23 = 0.5869 or 41% higher efficiency during receive. Therefore, the lifetime is 41% longer in receive operation.

Enabling RX sniff mode, which is working for 2.4- and 4.8-kbps wM-Bus modes at 169 MHz, can drive the average receive current consumption to approximately 10 mA if a 3.6-V external supply voltage is provided.

7.3 RX Current With Sniff Mode Enabled

RX Sniff mode, which can reduce the current consumption without sacrificing RF performance, has been tested for both PHY-WM2400 and PHY-WM4800 (used in France) and Ncd and Nabef modes (used in Italy).

RX Sniff mode uses another feature of CC1120 called *Wavematch*, which uses on-chip DSP circuitry to lock onto the incoming waveform. The on-chip advantage is much faster settling the receiver. Therefore, the result is lower current consumption. RX Sniff mode is a feature that automatically duty cycles the radio and quickly triggers on either RSSI or preamble conditions. Triggering on RSSI or carrier sense (CS) is faster and gives the lowest average power consumption (if there is no RF noise), so this method has been implemented in the software example.

Table 5. Average RX Current Consumption in RX Sniff Mode in PHY-WM2400 and PHY-WM4800

Data Rate	Preamble Bytes	Triggering On RSSI, CC1120EM-169 (No TPS62730)	Triggering On RSSI With TPS62730 CS = –116 dBm	Comments
2.4 kb/s GFSK = PHY-WM2400	2	13.8 mA	8.5 mA	Using RX Sniff code project
4.8 kb/s GFSK = PHY-WM4800	2	18.0 mA	10.0 mA	Using RX Sniff code project

Note that the values in Table 5 can be achieved only if the RF channel is *noise free* or if the noise level is below the RX sensitivity limit, which is set in the CC1120. This limit is called the CS threshold and can be adjusted as needed by the application through the AGC_CS_THRESHOLD register field found in the AGC_CS_THR register. The AGC_CS_THRESHOLD field is a 2's complement number with 1-dB resolution and is given by Equation 1.

$$\text{CS Threshold} = \text{AGC\_CS\_THR} + \text{RSSI Offset}$$

where

- RSSI Offset of CC1120 = –102 dBm (1)

7.4 RX Sensitivity

A test packet of 31 bytes payload plus 2 bytes CRC has been used. The CRC bytes were adjusted so the CC1120 hardware block checks the CRC16 sum and reports error or OK status automatically. The corresponding XML configuration file for SmartRF7 Studio is loaded and puts the RF board in RX mode. The proper IQD configuration file for the RF signal generator (CMU) is loaded and used as the TX reference packet.

Table 6. RX Sensitivity versus Frequency Offset Variation

RF Input Power Level (dBm)	Number of TX Packets	Frequency Offset	Errors in % [= Lost or Erroneous Packets]
–118	100	0	1
–119	100	0	2
–119.4	100	0	1
–119.5	100	0	4
–119.7	100	0	9
–119.5	100	–2	9
–119.3	100	–2	2
–119.3	100	–3	18
–118.5	100	–3	4
–119	100	+2	2
–119.5	100	+2	8
–119.3	100	+2	7
–119	100	+3	>20
–118.5	100	+3	31
–117.5	100	+3	21
–119	100	+2.5	22
–118	100	+2.5	10
–118	100	+2.3	3
–118.5	100	+2.3	2
–119	100	+2.3	13

Summary: DC-DC does not affect RX sensitivity performance and can be used in 169-MHz wM-Bus systems. The achieved numbers are inline with TI wM-Bus Application Note AN121, where CC1120EM-169-MHz boards without a DC-DC device were measured.

7.5 *Blocking Performance*

A test packet of 31-byte payload plus 2-bytes CRC was used. The CRC bytes were adjusted so the CC1120 hardware block checks the CRC16 sum and reports error or OK status automatically. Again, the configuration file for SRF7 in RX mode is loaded, as well as the corresponding configuration file for the RF signal generator (CMU) and generates the TX reference packet. A second RF signal generator (CMU) is generating a carrier wave (unmodulated) interference signal at 3 dB above the sensitivity level.

Table 7. Blocking Performance for ±2 MHz and ±10 MHz

CMU1 RF Input Power (dBM)	CMU2 Blocking RF Level (dB)	Number of TX Packets	Number of RX Erroneous Packets	Blocking at Offset (MHz)
–114	75	100	0	–2
–114	80	100	0	–2
–114	82	100	0	–2
–114	85	100	2	–2
–114	87	100	21	–2
–114	86	100	9	–2
–114	85	100	0	–10
–114	87	100	0	–10
–114	89	100	1	–10
–114	90	100	6	–10
–114	85	100	1	+2
–114	86	100	6	+2

Table 7. Blocking Performance for ±2 MHz and ±10 MHz (continued)

CMU1 RF Input Power (dBM)	CMU2 Blocking RF Level (dB)	Number of TX Packets	Number of RX Erroneous Packets	Blocking at Offset (MHz)
–114	87	100	25	+2
–114	87	100	0	+10
–114	89	100	0	+10
–114	90	100	2	+10
–114	91	100	8	+10

Summary: TPS62730 does not affect blocking performance and can be used in 169-MHz wM-Bus systems with ETSI category 1 receiver compliance. The achieved blocking numbers are inline with AN121, where CC1120EM-169-MHz boards without a DCDC device were measured.

8 Design Files

8.1 Schematics

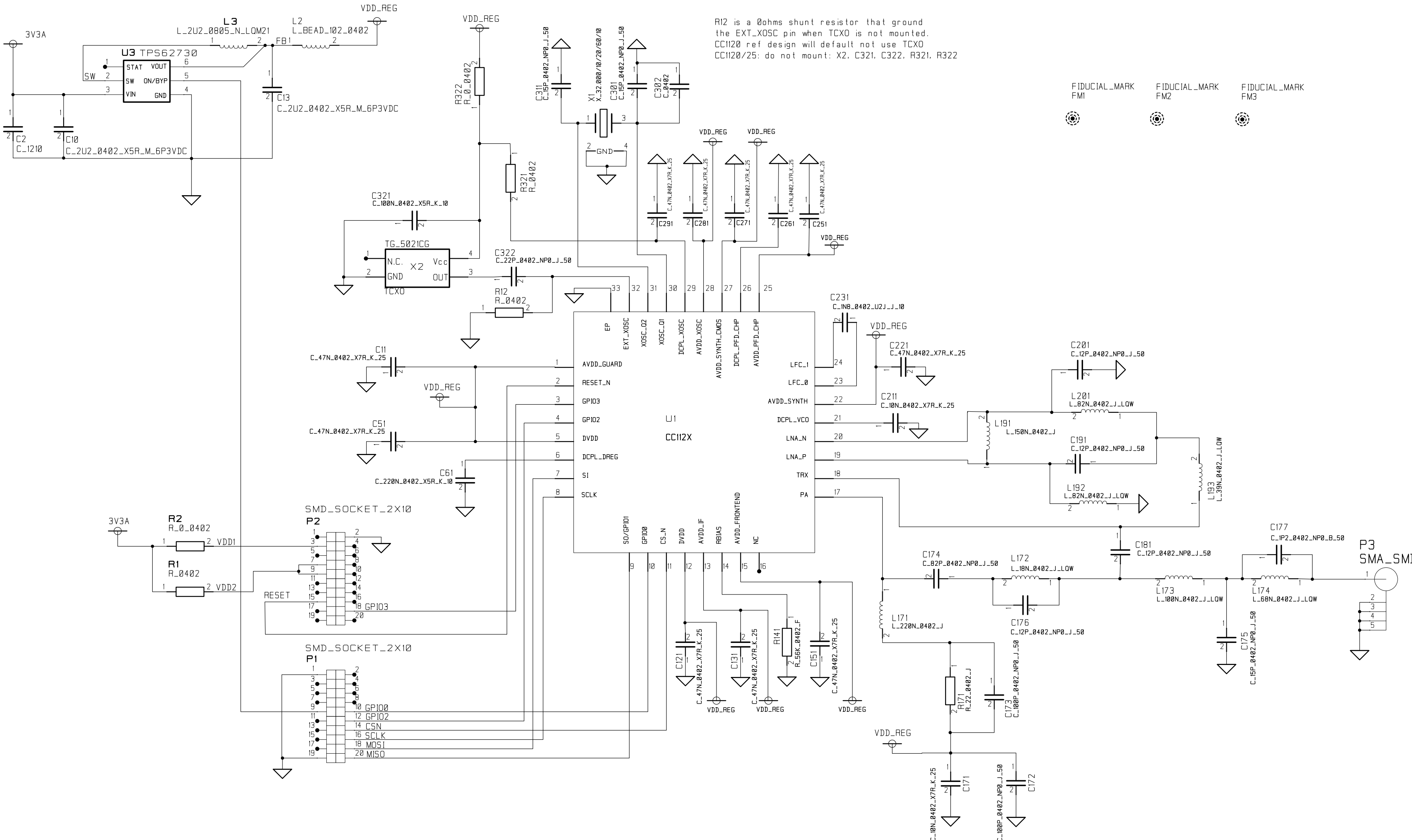

Figure 7. TIDC-WMBUS-169MHz Schematics

8.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDC-WMBUS-169MHz.

Table 8. BOM of TIDC-WMBUS-169MHz

ITEM	QTY	REFERENCE	VALUE	PART DESCRIPTION	MANUFACTURER	PARTNUMBER	ALTERNATE PART	PCB FOOTPRINT	NOTE
U1	1	CC1120	CC1120	TI Transceiver	TI	N/A	N/A	N/A	N/A
C302	1	C_0402	Capacitor, general, 0402; Do not mount						
C177	1	C_1P2_0402_NP0_B_50	Capacitor, 1p2, 0402, NP0, +/- 0.1pF 50V	Capacitor	Murata	GRM1555C1H1R2BZ01D		0402	
C321	1	C_100N_0402_X5R_K_10	Do not mount	Capacitor				0402	
C172;C173	2	C_100P_0402_NP0_J_50	Capacitor, 100p, 0402, NP0, 5% 50V	Capacitor	Murata	GRM1555C1H101JZ01D		0402	
C171;C211	2	C_10N_0402_X7R_K_25	Capacitor, 10n, 0402, X7R, 10%, 25V	Capacitor	Murata	GRM155R71E103KA01D		0402	
C2	1	C_1210	Capacitor, general, 1210	Capacitor					
C174	1	C_82P_0402_NP0_J_50	Capacitor, 82p, 0402, NP0, 5% 50V	Capacitor	Murata	GRM1555C1H820JZ01D		0402	
C301;C311;C175	3	C_15P_0402_NP0_J_50	Capacitor, 15p, 0402, NP0, 5%, 50V	Capacitor	Murata	GRM1555C1H150JA01D		0402	
C231	1	C_1N8_0402_U2J_J_10	Capacitor, 1n8, 0402, U2J, 5%, 10V	Capacitor	Murata	GRM1557U1A182JA01D		0402	
C61	1	C_220N_0402_X5R_K_10	Capacitor, 220n, 0402, X5R, 10%, 10V	Capacitor	Murata	GRM155R61A224KE19D		0402	
C322	1	C_22P_0402_NP0_J_50	Do not mount	Capacitor	Murata	GRM1555C1H220JZ01D		0402	
C201; C191; C181	3	C_12P_0402_NP0_J_50	Capacitor, 12p, 0402, NP0, 5%, 50V	Capacitor	Murata	GRM1555C1H120JA01D		0402	
C10;C13	2	C_2U2_0402_X5R_M_6P3VDC	Capacitor, 2u2, 0402, X5R, +/- 20%, 6.3V	Capacitor				0402	

Table 8. BOM of TIDC-WMBUS-169MHz (continued)

ITEM	QTY	REFERENCE	VALUE	PART DESCRIPTION	MANUFACTURER	PARTNUMBER	ALTERNATE PART	PCB FOOTPRINT	NOTE
C176	1	C_12P_0402_NP0_J_50	Capacitor, 12p, 0402, NP0, 5%, 50V	Capacitor	Murata	GRM1555C1H120JA01D		0402	
C11;C51;C121;C131;C151;C221;C251;C261;C271;C281;C291;	11	C_47N_0402_X7R_K_25	Capacitor, 47n, 0402, X7R, 10%, 25V	Capacitor	Murata	GRM155R71E473KA88D		0402	
L192;L201	2	L_82N_0402_J_LQW	Inductor, 82n, 0402, ±5%, wire-wound type	Inductor	Murata	LQW15AN82NJ00		0402	
L174	1	L_68N_0402_J_LQW	Inductor, 68n, 0402, ±5%, wire-wound type	Inductor	Murata	LQW15AN68NJ00		0402	
L172	1	L_18N_0402_J_LQW	Inductor, 18n, 0402, ±5%, wire-wound type	Inductor	Murata	LQW15AN18NJ00D		0402	
L191	1	L_150N_0402_J	Inductor, 150n, 0402, ±5%	Inductor	Murata	LQG15HSR15J02		0402	
L193	1	L_39N_0402_J_LQW	Inductor, 39n, 0402, ±5%, wire-wound type	Inductor	Murata	LQW15AN39NJ00D		0402	
L173	1	L_100N_0402_J_LQW	Inductor, 100n, 0402, ±5%, wire-wound type	Inductor	Murata	LQW15ANR10J00		0402	
L3	1	L_2U2_0805_N_LQM21	Inductor, 2u2, 0805, ±30%	Inductor	Murata	LQM21PN2R2NGC		0805	
L171	1	L_220N_0402_J	Inductor, 220n, 0402, ±5%	Inductor	Murata	LQG15HSR22J02		0402	
L2	1	L_BEAD_102_0402	EMI filter bead, 0402 1k ohms Tape GHz Band Gen Use	Filter bead	Murata	BLM15HG102SN1D		0402	
R1;R321	2	R_0402	Resistor, general, 0402; Do not mount	Resistor				0402	
R12 (edited manually)	1	R_0_0402	Resistor, 0 ohm, 0402	Resistor	Koa	RK73Z1ETTP		0402	
R322	1	R_0_0402	Do not mount	Resistor				0402	
R2	1	R_0_0402	Resistor, 0 ohm, 0402	Resistor	Koa	RK73Z1ETTP		0402	

Table 8. BOM of TIDC-WMBUS-169MHz (continued)

ITEM	QTY	REFERENCE	VALUE	PART DESCRIPTION	MANUFACTURER	PARTNUMBER	ALTERNATE PART	PCB FOOTPRINT	NOTE
R171	1	R_22_0402_J	Resistor, 22 ohms, 0402, 5%	Resistor	Koa	RK73H1ETTP22 R0F (±1%)		0402	
R141	1	R_56K_0402_F	Resistor, 56k ohms, 0402, ±1%	Resistor	Koa	RK73H1ETTP56 02F		0402	
P3	1	SMA_SMD	SMA connector, straight SMD-mount	Connector	Hus-Tsan Group Taiwan	SMA-10V21-TGG			
P1-2	2	SMD_SOCKET_2X10	SMD pinrow socket, .050 spacing, 2x10	Connector	Samtec	SFM-110-02-SM-D-A-K-TR			
X2	1	TG_5021CG	Do not mount	TCXO	Epson Toyocom	TG_5021CG			
U3	1	TPS62730	Step Down Converter with Bypass Mode	TI DC-DC converter	TI	TPS62730DRY			
X1	1	X_32.000/10/20/60/10	Crystal, 32.000000MHz, FA-128, 10.0pF, +/-10ppm, (FTC: +/-20ppm at -40/85C), 60ohms	XTAL	NDK, Epson				

8.3 Layout Guidelines

Copy the layout exactly as shown in the Gerber files as it has been optimized for best RF performance; the RF subsystem is using a 4-layer PCB. Find additional information on PCB layout considerations in the TI documents AN098 and AN068.

8.4 Layer Plots

To download the layer plots, see the design files at TIDC-WMBUS-169MHz.

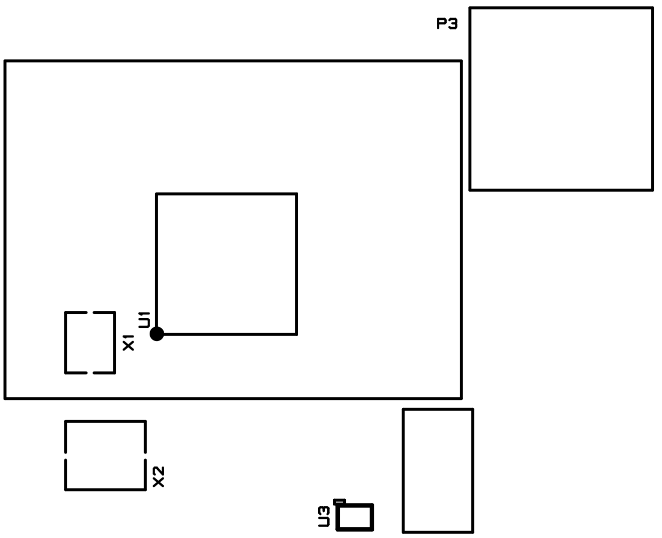

Figure 8. Top Silkscreen

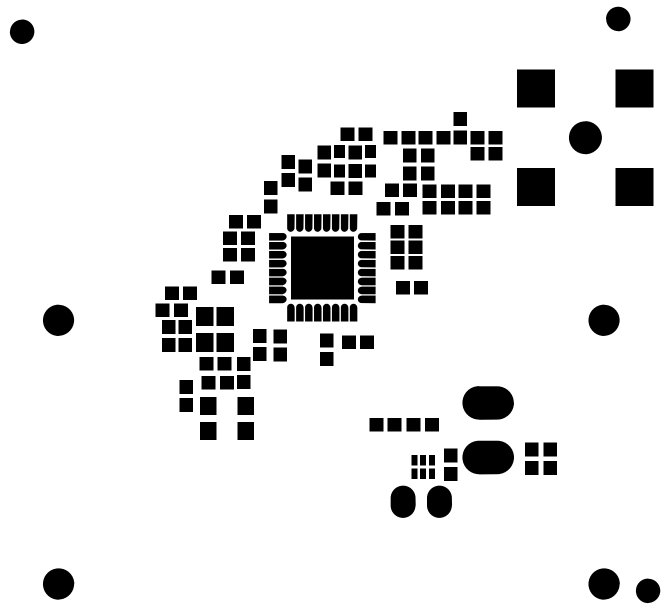

Figure 9. Top Solder Mask

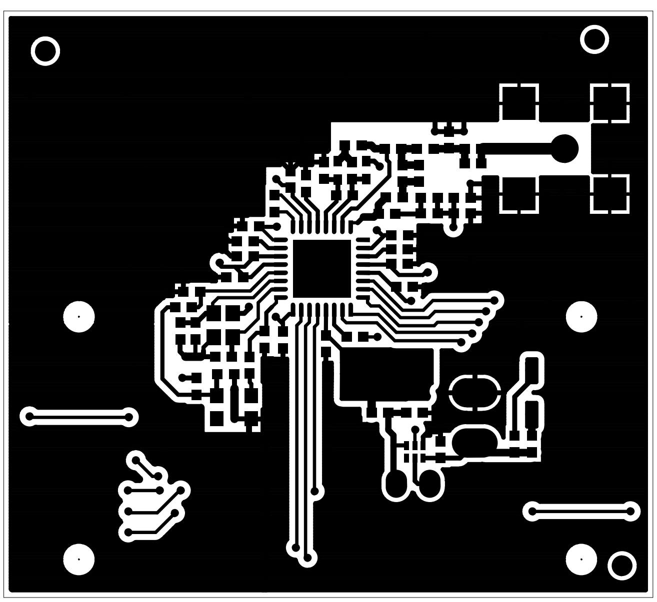

Figure 10. Top Layer

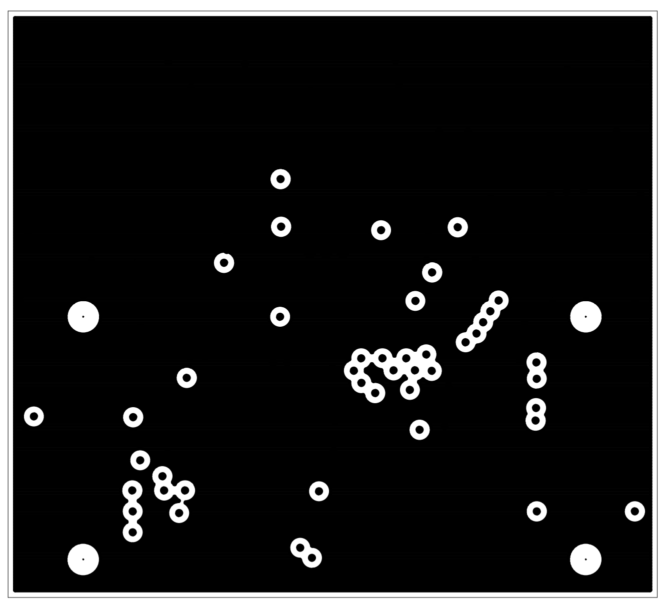

Figure 11. Ground Plane Layer 2

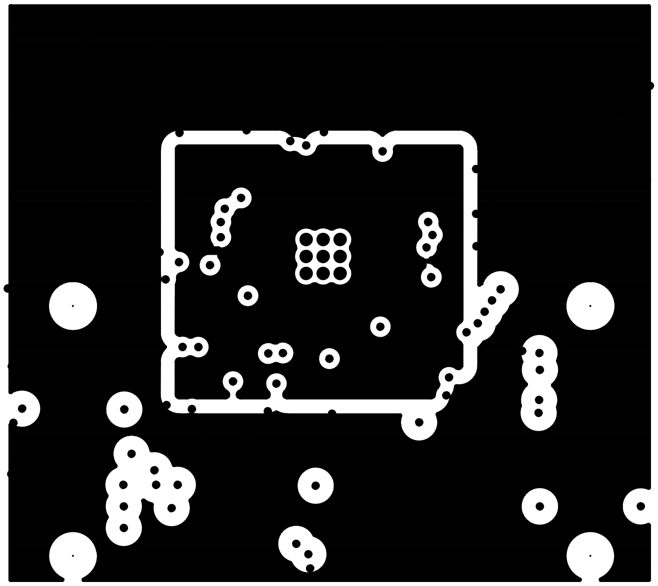

Figure 12. Power Plane Layer 3

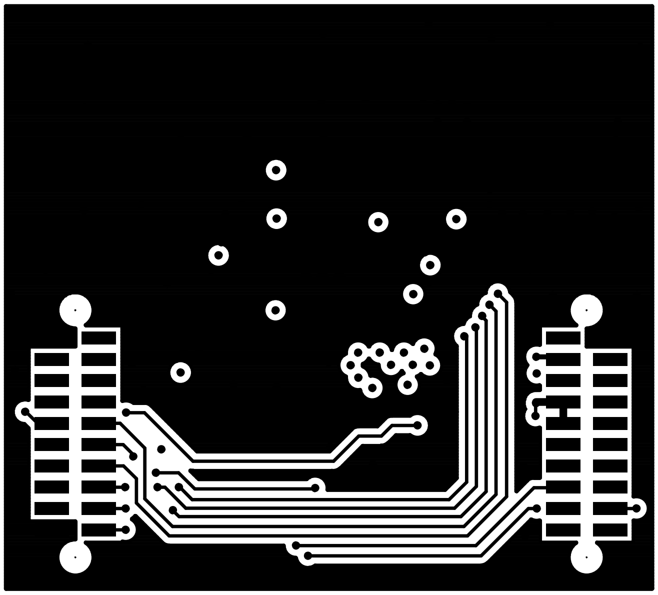

Figure 13. Bottom Layer 4

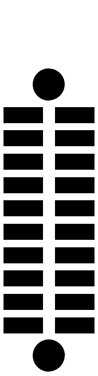

Figure 14. Bottom Solder Mask

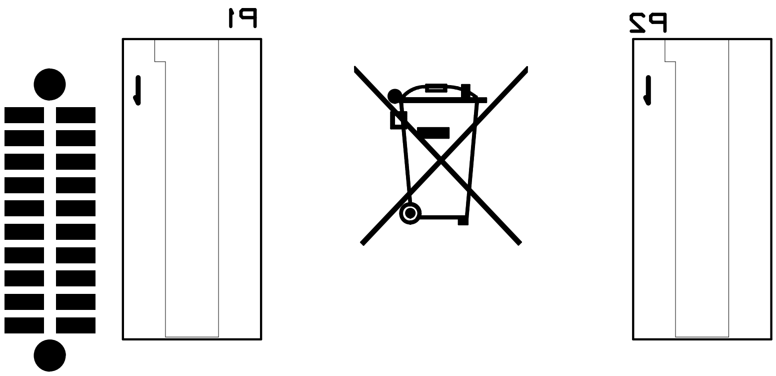

Figure 15. Bottom Silkscreen

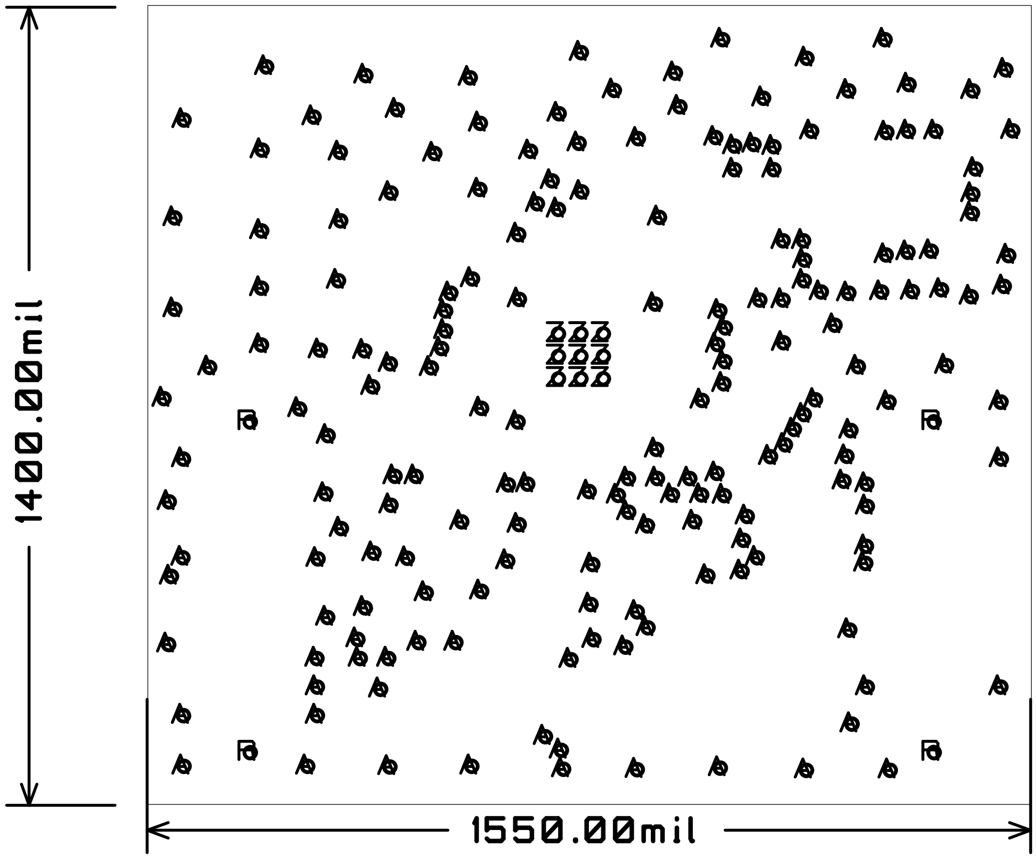

Figure 16. Mechanical Dimensions

8.5 CAD files

To download the CAD project files, see the design files at TIDC-WMBUS-169MHz.

8.6 Gerber Files

To download the Gerber files, see the design files at TIDC-WMBUS-169MHz.

8.7 Assembly Drawings

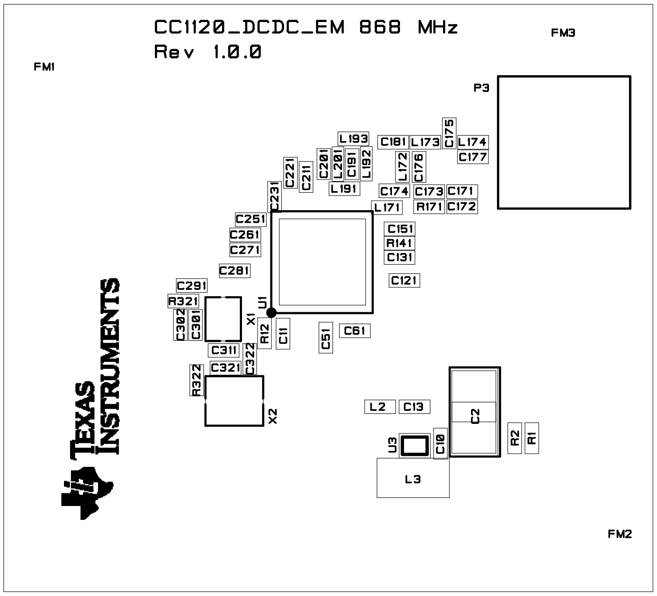

Figure 17. Assembly Top

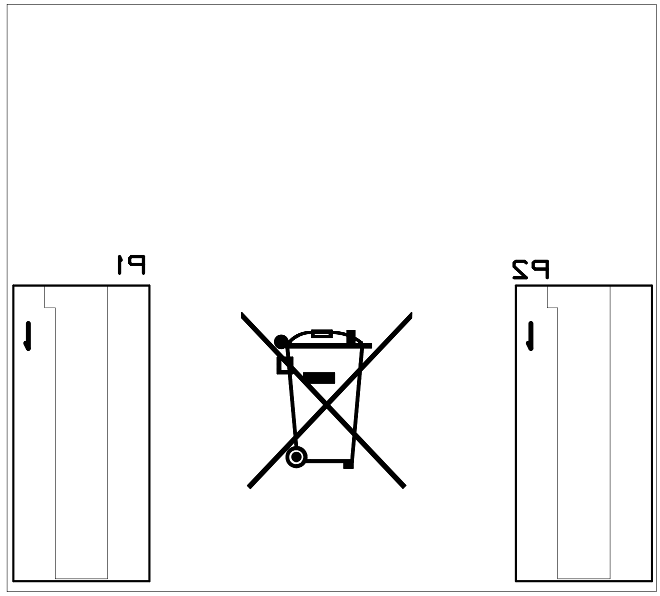

Figure 18. Assembly Bottom

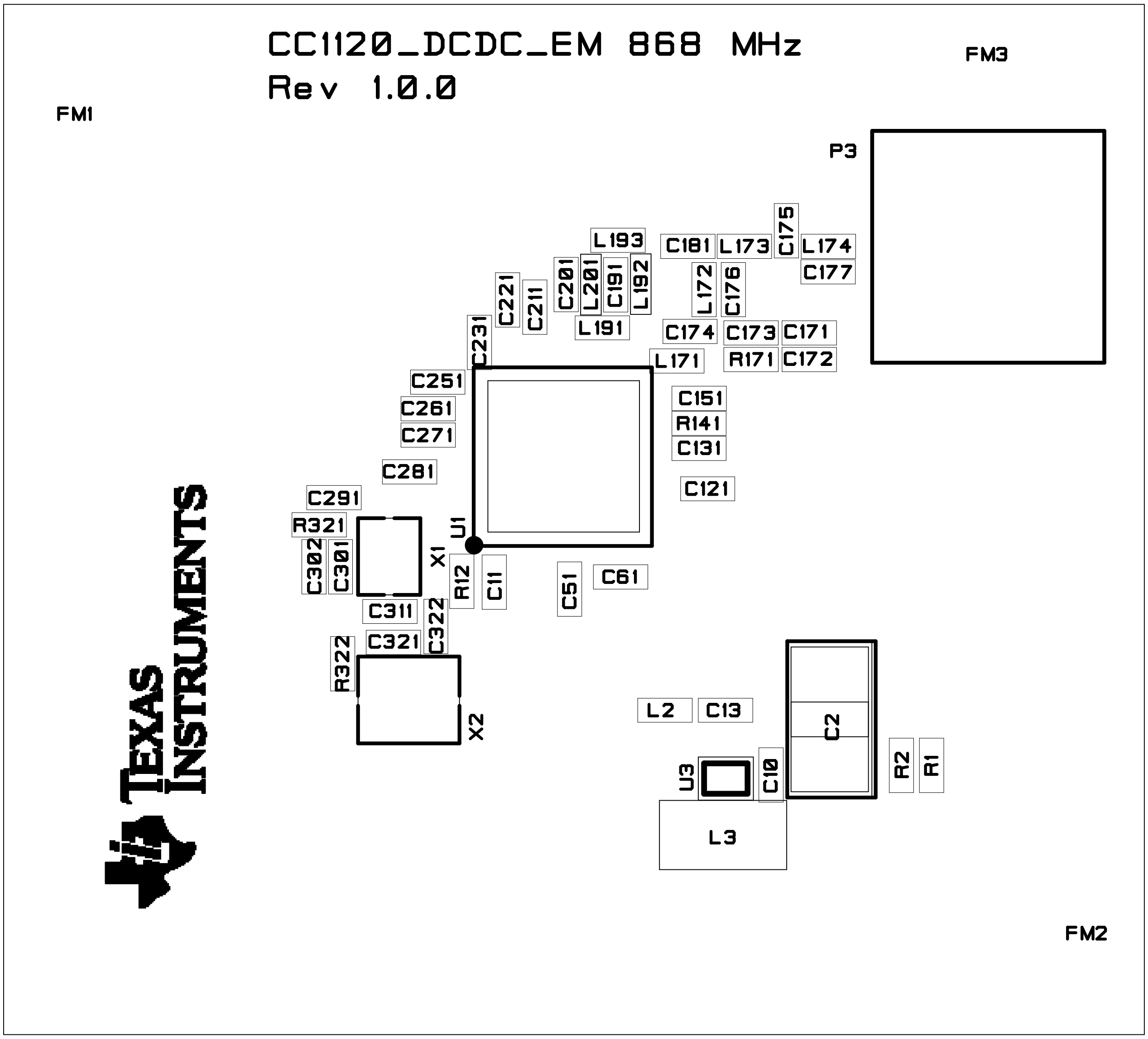

Figure 19. Assembly All Layers

8.8 Software Files

To download the software files for this reference design, see the link at TIDC-WMBUS-169MHz.

9 References

1. CC1120 data sheet, *CC1120 High-Performance RF Transceiver for Narrowband Systems*, CC1120
2. TPS62730 data sheet, *Step-Down Converter with Bypass Mode for Ultra Low Power Wireless Applications*, TPS62730
3. Application Note AN121, *Wireless M-Bus Implementation with CC112x / CC120x High Performance Transceiver Family*, AN121
4. Design Note DN040, *Reduced Battery Current Using CC112x/CC1175/CC1200 with TPS62730*, DN040
5. European Standard, *ETSI EN 300 220-2 V2.4.1 (2012-05)*, ETSI EN 300 220-2
6. Application Note AN098, *Layout Review Techniques for Low Power RF Designs*, AN098
7. Application Note AN068, *Adapting TI LPRF Reference Designs for Layer Stacking*, AN068
8. SmartRF Studio 7, SmartRF Studio 7
9. Application Report CC112x/CC120x, *CC112x/CC120x RX Sniff Mode*, CC112x/CC120x

10 Terminology

ETSI Category 1 Receiver— Definition for most stringent set of RF parameters in EN300 220 v2.4.1

N-mode— The wM-Bus mode at 169 MHz, selected for Italy and France smart gas meter rollout, with minor changes respectively

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

11 About the Author

MILEN STEFANOV is a system applications engineer at Texas Instruments, where he is responsible for Sub-1-GHz RF communications solutions for smart meters. Milen has significantly contributed to delivering TI's full wM-Bus system solution, consisting of MCU + RF chipset, a complete wM-Bus protocol stack, and a dedicated power management solution. Milen has system-level expertise on smart metering and RF communications and more than 15 years of experience working with customers. He has published several technical articles on wM-Bus-related topics in the past four years. He earned his master of science in electrical engineering (MSEE) from Technical University in Chemnitz, Germany.