

INSTRUMENTS

CC1125 Ultra-High Performance RF Narrowband Transceiver

1 Device Overview

1.1 Features

- · High-Performance, Single-Chip Transceiver
 - Adjacent Channel Selectivity: 67 dB at 6.25-kHz Offset
 - Blocking Performance: 104 dB at 10 MHz
 - Excellent Receiver Sensitivity
 - -129 dBm at 300 bps
 - –123 dBm at 1.2 kbps
 - -110 dBm at 50 kbps
 - Very Low Phase Noise: -115 dBc/Hz at 10-kHz Offset
- Suitable for Systems Targeting ETSI Category 1
- Separate 128-Byte RX and TX FIFOs
- Support for Seamless Integration With the CC1190 Device for Increased Range Giving up to 3-dB Improvement in Sensitivity and up to +27-dBm Output Power
- High Spectral Efficiency (9.6 kbps in 12.5-kHz Channel in Compliance With FCC Narrowbanding Mandate)
- Power Supply
 - Wide Supply Voltage Range (2.0 V to 3.6 V)
 - Low Current Consumption:
 - RX: 2 mA in RX Sniff Mode
 - RX: 17 mA Peak Current in Low-Power Mode
 - RX: 26 mA Peak Current in High-Performance Mode
 - TX: 47 mA at +14 dBm
 - Power Down: 0.12 μA (0.5 μA With Enhanced Wake-On-Radio (eWOR) Timer Running)

1.2 Applications

- Social Alarms
- Narrowband Ultra-Low-Power Wireless Systems
 With Channel Spacing Down to 4 kHz
- 169-, 315-, 433-, 868-, 915-, 920-, 950-MHz
 ISM/SRD Band Systems
- Wireless Metering and Wireless Smart Grid (AMR and AMI)

- Programmable Output Power up to +16 dBm With 0.4-dB Step Size
- · Automatic Output Power Ramping
- Configurable Data Rates: 0 to 200 kbps
- Supported Modulation Formats: 2-FSK, 2-GFSK, 4-FSK, 4-GFSK, MSK, OOK
- WaveMatch: Advanced Digital Signal Processing for Improved Sync Detect Performance
- RoHS-Compliant 5-mm x 5-mm No-Lead QFN 32-Pin Package (RHB)
- Regulations Suitable for Systems Targeting Compliance With
 - Europe: ETSI EN 300 220 Category 1, ETSI EN 54-25, ETSI EN 300 113, and EN 301 166
 - US: FCC CFR47 Part 15, 24, 90, 101
 - Japan: ARIB RCR STD-T30, T-67, T-108
- · Peripherals and Support Functions
 - eWOR Functionality for Automatic Low-Power Receive Polling
 - Includes Functions for Antenna Diversity Support
 - Support for Retransmissions
 - Support for Auto-Acknowledge of Received Packets
 - TCXO Support and Control, also in Power Modes
 - Automatic Clear Channel Assessment (CCA) for Listen-Before-Talk (LBT) Systems
 - Built-in Coding Gain Support for Increased Range and Robustness
 - Digital RSSI Measurement
 - Temperature Sensor
- IEEE 802.15.4g Systems
- Home and Building Automation
- Wireless Alarm and Security Systems
- Industrial Monitoring and Control
- Wireless Healthcare Applications
- Wireless Sensor Networks and Active RFID
- · Private Mobile Radios



1.3 Description

The CC1125 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, thus removing the need for costly external SAW and IF filters. The device is mainly intended for the ISM (Industrial, Scientific and Medical) and SRD (Short Range Device) frequency bands at 164–192 MHz, 274–320 MHz, 410–480 MHz, and 820–960 MHz.

The CC1125 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 CC1125 device can be controlled through an SPI interface. In a typical system, the CC1125 device will be used with a microcontroller and only a few external passive components.

Device Information⁽¹⁾

| PART NUMBER | PACKAGE | BODY SIZE |
|-------------|-----------|-------------------|
| CC1125RHB | VQFN (32) | 5.00 mm x 5.00 mm |

(1) For more information, see Section 8, Mechanical Packaging and Orderable Information

1.4 Functional Block Diagram

Figure 1-1 shows the system block diagram of the CC1125 device.

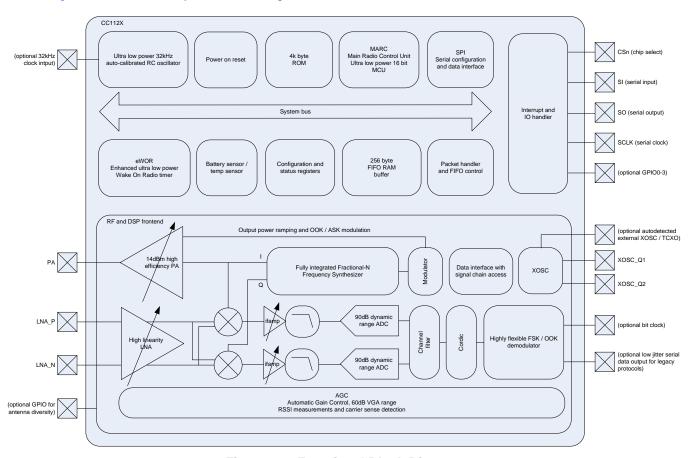


Figure 1-1. Functional Block Diagram



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2 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

This data manual revision history highlights the changes made to the SWRS120D device-specific data manual to make it an SWRS120E revision.

| Chan | ges from Revision D (June 2014) to Revision E | Pag | 36 |
|------|--|-----|----|
| • | Added Ambient to the temperature range condition and removed Tj from Temperature range | | - |



3 Terminal Configuration and Functions

3.1 Pin Diagram

Figure 3-1 shows pin names and locations for the CC1125 device.

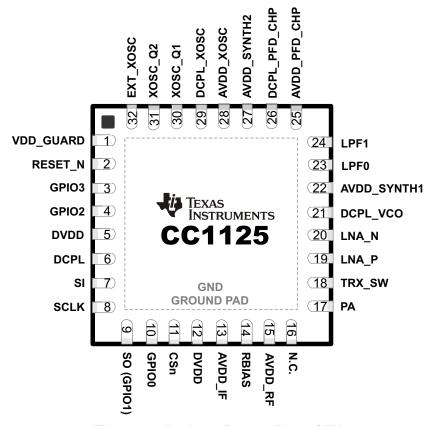


Figure 3-1. Package 5-mm × 5-mm QFN



3.2 Pin Configuration

The following table lists the pin-out configuration for the CC1125 device.

| PIN NO. | PIN NAME | TYPE / DIRECTION | DESCRIPTION |
|---------|--------------|---------------------|--|
| 1 | VDD_GUARD | Power | 2.0–3.6 V VDD |
| 2 | RESET_N | Digital input | Asynchronous, active-low digital reset |
| 3 | GPIO3 | Digital I/O | General-purpose I/O |
| 4 | GPIO2 | Digital I/O | General-purpose I/O |
| 5 | DVDD | Power | 2.0–3.6 VDD to internal digital regulator |
| 6 | DCPL | Power | Digital regulator output to external decoupling capacitor |
| 7 | SI | Digital input | Serial data in |
| 8 | SCLK | Digital input | Serial data clock |
| 9 | SO(GPIO1) | Digital I/O | Serial data out (general-purpose I/O) |
| 10 | GPIO0 | Digital I/O | General-purpose I/O |
| 11 | CSn | Digital input | Active-low chip select |
| 12 | DVDD | Power | 2.0–3.6 V VDD |
| 13 | AVDD_IF | Power | 2.0–3.6 V VDD |
| 14 | RBIAS | Analog | External high-precision resistor |
| 15 | AVDD_RF | Power | 2.0–3.6 V VDD |
| 16 | N.C. | | Not connected |
| 17 | PA | Analog | Single-ended TX output (requires DC path to VDD) |
| 18 | TRX_SW | Analog | TX and RX switch. Connected internally to GND in TX and floating (high-impedance) in RX. |
| 19 | LNA_P | Analog | Differential RX input (requires DC path to GND) |
| 20 | LNA_N | Analog | Differential RX input (requires DC path to GND) |
| 21 | DCPL_VCO | Power | Pin for external decoupling of VCO supply regulator |
| 22 | AVDD_SYNTH1 | Power | 2.0–3.6 V VDD |
| 23 | LPF0 | Analog | External loop filter components |
| 24 | LPF1 | Analog | External loop filter components |
| 25 | AVDD_PFD_CHP | Power | 2.0–3.6 V VDD |
| 26 | DCPL_PFD_CHP | Power | Pin for external decoupling of PFD and CHP regulator |
| 27 | AVDD_SYNTH2 | Power | 2.0–3.6 V VDD |
| 28 | AVDD_XOSC | Power | 2.0–3.6 V VDD |
| 29 | DCPL_XOSC | Power | Pin for external decoupling of XOSC supply regulator |
| 30 | XOSC_Q1 | Analog | Crystal oscillator pin 1 (must be grounded if a TCXO or other external clock connected to EXT_XOSC is used) |
| 31 | XOSC_Q2 | Analog | Crystal oscillator pin 2 (must be left floating if a TCXO or other external clock connected to EXT_XOSC is used) |
| 32 | EXT_XOSC | Digital input | Pin for external clock input (must be grounded if a regular crystal connected to XOSC_Q1 and XOSC_Q2 is used) |
| _ | GND | Ground pad | The ground pad must be connected to a solid ground plane. |



4 Specifications

All measurements performed on CC1120EM_868_915 rev.1.0.1, CC1120EM_955 rev.1.2.1, CC1120EM_420_470 rev.1.0.1 or CC1120EM_169 rev.1.2 (f_{xosc} = 32 MHz), and CC1125EM_868_915 rev.1.1.0, CC1125EM_420_470 rev.1.1.0, CC1125EM_169 rev.1.1.0, CC1125EM-Cat1-868 (f_{xosc} = 40 MHz).

4.1 Absolute Maximum Ratings⁽¹⁾⁽²⁾

| PARAMETER | MIN | MAX | UNIT | CONDITION |
|--|------|---------|------|--|
| Supply voltage (VDD, AVDD_x) | -0.3 | 3.9 | V | All supply pins must have the same voltage |
| Solder reflow temperature | | 260 | °C | According to IPC/JEDEC J-STD-020 |
| Input RF level | | +10 | dBm | |
| Voltage on any digital pin | -0.3 | VDD+0.3 | V | max 3.9 |
| Voltage on analog pins (including DCPL pins) | -0.3 | 2.0 | V | |

⁽¹⁾ Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under general characteristics is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

4.2 Handling Ratings

| | | | | MIN | MAX | UNIT |
|------------------|------------------------------|---|----------------------|------|-----|------|
| T _{stg} | Storage temperature range | | | | | °C |
| | Electrostatic | Human body model (HBM), per ANSI/ESDA/JEDEC | JS001 ⁽¹⁾ | -2 | 2 | kV |
| V _{ESD} | discharge (ESD) performance: | Charged device model (CDM), per JESD22-C101 (2) | All pins | -500 | 500 | V |

⁽¹⁾ JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

4.3 Recommended Operating Conditions (General Characteristics)

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|---------------------------|-----|-----|-----|------|--|
| Voltage supply range | 2.0 | | 3.6 | V | All supply pins must have the same voltage |
| Voltage on digital inputs | 0 | | VDD | V | |
| Temperature range | -40 | | 85 | °C | Ambient |

4.4 Thermal Resistance Characteristics for RHB Package

| | | °C/W ⁽¹⁾ | AIR FLOW (m/s) ⁽²⁾ |
|-------------------|---------------------------|---------------------|-------------------------------|
| $R\theta_{JC}$ | Junction-to-case (top) | 21.1 | 0.00 |
| $R\theta_{JB}$ | Junction-to-board | 5.3 | 0.00 |
| $R\theta_{JA}$ | Junction-to-free air | 31.3 | 0.00 |
| Psi _{JT} | Junction-to-package top | 0.2 | 0.00 |
| Psi _{JB} | Junction-to-board | 5.3 | 0.00 |
| $R\theta_{JC}$ | Junction-to-case (bottom) | 0.8 | 0.00 |

⁽¹⁾ These values are based on a JEDEC-defined 2S2P system (with the exception of the Theta JC [RΘ_{JC}] value, which is based on a JEDEC-defined 1S0P system) and will change based on environment as well as application. For more information, see these EIA/JEDEC standards:

Power dissipation of 40 mW and an ambient temperature of 25°C is assumed.

(2) m/s = meters per second

⁽²⁾ All voltage values are with respect to V_{SS} , unless otherwise noted.

⁽²⁾ JEDEC document JEP157 states that 250-V HBM allows safe manufacturing with a standard ESD control process.

JESD51-2, Integrated Circuits Thermal Test Method Environmental Conditions - Natural Convection (Still Air)

[•] JESD51-3, Low Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages

JESD51-7, High Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages

JESD51-9, Test Boards for Area Array Surface Mount Package Thermal Measurements



4.5 RF Characteristics

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|----------------------|---------|------|-------|------|---|
| | 820 | | 960 | MHz | |
| | 410 | | 480 | MHz | |
| Fraguency hands | (273.3) | | (320) | MHz | See SWRA398 for more information. |
| Frequency bands | 164 | | 192 | MHz | |
| | (205) | | (240) | MHz | Contact TI for more information about the |
| | (136.7) | | (160) | MHz | use of these frequency bands. |
| | | 30 | | Hz | In 820-950 MHz band |
| Frequency resolution | | 15 | | Hz | In 410-480 MHz band |
| | | 6 | | Hz | In 164–192 MHz band |
| Data sata | 0 | | 200 | kbps | Packet mode |
| Data rate | 0 | | 100 | kbps | Transparent mode |
| Data rate step size | | 1e-4 | | bps | |

4.6 Regulatory Standards

| PERFORMANCE MODE | Frequency Band | Suitable for compliance with | Comments |
|-----------------------|----------------|--|--|
| | 820–960 MHz | ARIB T-108 ARIB T-96 ETSI EN 300 220 category 1 ETSI EN 54-25 FCC PART 101 FCC PART 24 SUBMASK D FCC PART 15.247 FCC PART 15.249 FCC PART 90 MASK G FCC PART 90 MASK J | Performance also suitable for systems targeting maximum allowed output power in the respective bands, using a range extender such as the CC1190 device |
| High-performance mode | 410–480 MHz | ARIB T-67 ARIB RCR STD-30 ETSI EN 301 166 ETSI EN 300 113 ETSI EN 300 220 category 1 FCC PART 90 MASK D FCC PART 90 MASK E FCC PART 90 MASK G | Performance also suitable for systems targeting maximum allowed output power in the respective bands, using a range extender |
| | 164–192 MHz | ETSI EN 300 220 category 1 ETSI EN 301 166 ETSI EN 300 113 FCC PART 90 MASK C FCC PART 90 MASK D FCC PART 90 MASK E | Performance also suitable for systems targeting maximum allowed output power in the respective bands, using a range extender |
| Low-power mode | 820–960 MHz | ETSI EN 300 220 category 2 FCC PART 15.247 FCC PART 15.249 | |
| | 410–480 MHz | ETSI EN 300 220 category 2 | |
| | 164–192 MHz | ETSI EN 300 220 category 2 | |



4.7 Current Consumption, Static Modes

 $T_A = 25$ °C, VDD = 3.0 V, $f_{xosc} = 32$ MHz if nothing else stated.

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|---------------------------|-----|------|-----|------|--|
| Power down with retention | | 0.12 | 1 | μA | |
| Fower down with retention | | 0.5 | | μΑ | Low-power RC oscillator running |
| XOFF mode | | 170 | | μA | Crystal oscillator / TCXO disabled |
| IDLE mode | | 1.3 | | mA | Clock running, system waiting with no radio activity |

4.8 Current Consumption, Transmit Modes

4.8.1 950-MHz Band (High-Performance Mode)

 $T_A = 25$ °C, VDD = 3.0 V, $f_{xosc} = 32$ MHz if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|--------------------------------|-----|-----|-----|------|-----------|
| TX current consumption +10 dBm | | 37 | | mA | |
| TX current consumption 0 dBm | | 26 | | mA | |

4.8.2 868-, 915-, and 920-MHz Bands (High-Performance Mode)

 $T_A = 25$ °C, VDD = 3.0 V, $f_{xosc} = 40$ MHz if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|--------------------------------|-----|-----|-----|------|-----------|
| TX current consumption +14 dBm | | 47 | | mA | |
| TX current consumption +10 dBm | | 38 | | mA | |

4.8.3 434-MHz Band (High-Performance Mode)

 $T_A = 25$ °C, VDD = 3.0 V, $f_{xosc} = 40$ MHz if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|--------------------------------|-----|-----|-----|------|-----------|
| TX current consumption +15 dBm | | 51 | | mA | |
| TX current consumption +14 dBm | | 47 | | mA | |
| TX current consumption +10 dBm | | 36 | | mA | |

4.8.4 169-MHz Band (High Performance Mode)

 $T_A = 25$ °C, VDD = 3.0 V, $f_{xosc} = 40$ MHz if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|--------------------------------|-----|-----|-----|------|-----------|
| TX current consumption +15 dBm | | 56 | | mA | |
| TX current consumption +14 dBm | | 52 | | mA | |
| TX current consumption +10 dBm | | 40 | | mA | |

4.8.5 Low-Power Mode

 $T_A = 25$ °C, VDD = 3.0 V, $f_C = 869.5$ MHz, $f_{xosc} = 32$ MHz if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|--------------------------------|-----|-----|-----|------|-----------|
| TX current consumption +10 dBm | | 32 | | mA | |



Current Consumption, Receive Modes

4.9.1 High-Performance Mode

 $T_A = 25$ °C, VDD = 3.0 V, $f_C = 869.5$ MHz, $f_{xosc} = 32$ MHz if nothing else stated

| A 20 0, 122 old 1, 10 oddio iii ia, 1 _{x0sc} oa iii ia ii oddio old oddi oddi | | | | | | | |
|--|-----|------|-----|------|---|--|--|
| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION | | |
| RX wait for sync | | | | | Using RX sniff mode, where the receiver | | |
| 1.2 kbps, 4-byte preamble | | 2 | | mA | wakes up at regular intervals to look for an | | |
| 38.4 kbps, 4-byte preamble | | 13.4 | | mA | incoming packet | | |
| RX peak current, f _{xosc} = 40 MHz | | | | | | | |
| 433-, 868-, 915-, and 920-MHz bands | | 26 | | mA | Peak current consumption during packet reception at the sensitivity threshold | | |
| 169-MHz band | | 27 | | mA | reception at the sensitivity threshold | | |
| Average current consumption Check for data packet every 1 second using wake on radio | | 15 | | μΑ | 50 kbps, 5-byte preamble, 40-kHz RC oscillator used as sleep timer | | |

4.9.2 Low-Power Mode

 $T_A = 25$ °C, VDD = 3.0 V, $f_c = 869.5$ MHz, $f_{xosc} = 32$ MHz if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|--|-----|-----|-----|------|---|
| RX peak current low-power RX mode 1.2 kbps | | 17 | | mA | Peak current consumption during packet reception at the sensitivity level |

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4.10 Receive Parameters

All RX measurements made at the antenna connector, to a bit error rate (BER) limit of 1%.

4.10.1 General Receive Parameters (High-Performance Mode)

 $T_A = 25$ °C, VDD = 3.0 V, $f_c = 869.5$ MHz if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|---|---------------------|---------------|-------|----------------------------------|--|
| Saturation | | +10 | | dBm | |
| Digital channel filter programmable bandwidth | | | | | |
| f _{xosc} = 32 MHz | 2.8 | | 200 | kHz | |
| $f_{xosc} = 40 \text{ MHz}$ | 3.5 | | 250 | kHz | |
| IIP3, normal mode | | -14 | | dBm | At maximum gain |
| IIP3, high linearity mode | | -8 | | dBm | Using 6-dB gain reduction in front end |
| Datarate offset tolerance | | ±12 | | % | With carrier sense detection enabled and assuming 4-byte preamble |
| | | ±0.2 | | % | With carrier sense detection disabled |
| Spurious emissions | | | | | |
| 1–13 GHz (VCO leakage at 3.5 GHz) | | -56 | | dBm | Radiated emissions measured according to ETSI EN 300 220, fc = 869.5 MHz |
| 30 MHz to 1 GHz | | < -57 | | dBm | 210121V 000 220, 10 = 000.0 WH 12 |
| Optimum source impedance | | | | | |
| 868-, 915-, and 920-MHz bands | 60 + j60 / 30 + j30 | | Ω | (Differential or single-ended RX | |
| 433-MHz band | 100 + j60 / 50+ j30 | | Ω | configurations) | |
| 169-MHz band | 14 | 40 + j40 / 70 | + j20 | Ω | |



4.10.2 RX Performance in 950-MHz Band (High-Performance Mode)

 $T_A = 25$ °C, VDD = 3.0 V, $f_{xosc} = 32$ MHz if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|--|-----|------|-----|------|---|
| | | -120 | | dBm | 1.2 kbps, DEV=4 kHz CHF=10 kHz ⁽¹⁾ |
| Sensitivity Note: Sensitivity can be improved if the TX and | | -107 | | dBm | 50 kbps 2GFSK, DEV=25 kHz, CHF=100 kHz |
| RX matching networks are separated. | | -100 | | dBm | 200 kbps, DEV=83 kHz (outer symbols), CHF=200 kHz, 4GFSK ⁽²⁾ |
| | | 51 | | dB | ± 12.5 kHz (adjacent channel) |
| Blocking and Selectivity | | 52 | | dB | ± 25 kHz (alternate channel) |
| 1.2 kbps 2-FSK, 12.5-kHz channel separation, | | 73 | | dB | ± 1 MHz |
| 4-kHz deviation, 10-kHz channel filter | | 76 | | dB | ± 2 MHz |
| | | 81 | | dB | ± 10 MHz |
| | | 43 | | dB | ± 200 kHz (adjacent channel) |
| Blocking and Selectivity 50 kbps 2-GFSK, 200-kHz channel separation, | | 51 | | dB | ± 400 kHz (alternate channel) |
| 25-kHz deviation, 100-kHz channel filter | | 62 | | dB | ± 1 MHz |
| (Same modulation format as 802.15.4g Mandatory Mode) | | 65 | | dB | ± 2 MHz |
| Manaday Mode) | | 71 | | dB | ± 10 MHz |
| | | 37 | | dB | ± 200 kHz (adjacent channel) |
| Blocking and Selectivity | | 44 | | dB | ± 400 kHz (alternate channel) |
| 200 kbps 4-GFSK, 83-kHz deviation (outer | | 55 | | dB | ± 1 MHz |
| symbols), 200-kHz channel filter, zero IF | | 58 | | dB | ± 2 MHz |
| | | 64 | | dB | ± 10 MHz |

⁽¹⁾ DEV is short for deviation, CHF is short for channel filter bandwidth

⁽²⁾ BT=0.5 is used in all GFSK measurements



4.10.3 RX Performance in 868-, 915-, and 920-MHz Bands (High-Performance Mode)

 $T_A = 25$ °C, VDD = 3.0 V, $f_{xosc} = 32$ MHz if nothing else stated if nothing else stated

| $T_A = 25$ °C, VDD = 3.0 V, $f_{XOSC} =$ PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|---|-----|------|-----|------|--|
| | | -129 | | dBm | 300 bps, DEV=1 kHz CHF=3.8 kHz ⁽¹⁾ , f _{xosc} = 40 MHz |
| | | -123 | | dBm | 1.2 kbps, DEV=20 kHz CHF=50 kHz |
| Occasión de | | -114 | | dBm | 4.8 kbps OOK |
| Sensitivity | | -110 | | dBm | 38.4 kbps, DEV=20 kHz CHF=100 kHz |
| | | -110 | | dBm | 50 kbps 2GFSK, DEV=25 kHz, CHF=100 kHz |
| | | -103 | | dBm | 200 kbps, DEV=83 kHz (outer symbols), CHF=200 kHz, 4GFSK |
| | | 62 | | dB | ± 6.25 kHz (adjacent channel) |
| Blocking and Selectivity 0.3-kbps 2-FSK, 6.25-kHz channel | | 63 | | dB | ± 12.5 kHz (alternate channel) |
| separation, 1-kHz deviation, 3.8-kHz | | 83 | | dB | ± 1 MHz |
| channel filter | | 87 | | dB | ± 2 MHz |
| $f_{xosc} = 40 \text{ MHz using TCXO}$ | | 91 | | dB | ± 10 MHz |
| | | 58 | | dB | + 12.5 kHz (adjacent channel) |
| Blocking and Selectivity 1.2-kbps 2-FSK, 12.5-kHz channel | | 58 | | dB | ± 25 kHz (alternate channel) |
| separation, 4-kHz deviation, 10-kHz | | 78 | | dB | ± 1 MHz |
| channel filter | | 82 | | dB | ± 2 MHz |
| $f_{xosc} = 40 \text{ MHz using TCXO}$ | | 86 | | dB | ± 10 MHz |
| Blocking and Selectivity | | 58 | | dB | ± 25 kHz (alternate channel) |
| 1.2-kbps 2-GFSK, 25-kHz channel | | 77 | | dB | ± 1 MHz |
| separation, 4-kHz deviation, 16-kHz channel filter | | 106 | | dB | ± 2 MHz |
| f _{xosc} = 40 MHz using TCXO Using external SAW filter for compliance with ETSI category 1 | | 101 | | dB | ± 10 MHz |
| | | 42 | | dB | ± 100 kHz (adjacent channel) |
| Blocking and Selectivity | | 43 | | dB | ± 200 kHz (alternate channel) |
| 38.4-kbps 2-GFSK, 100-kHz channel separation, 20-kHz deviation, 100- | | 62 | | dB | ± 1 MHz |
| kHz channel filter | | 66 | | dB | ± 2 MHz |
| | | 74 | | dB | ± 10 MHz |
| Blocking and Selectivity | | 43 | | dB | ± 200 kHz (adjacent channel) |
| 50-kbps 2-GFSK, 200-kHz channel | | 50 | | dB | ± 400 kHz (alternate channel) |
| separation, 25-kHz deviation, 100-kHz channel filter | | 61 | | dB | ± 1 MHz |
| (Same modulation format as | | 65 | | dB | ± 2 MHz |
| 802.15.4g Mandatory Mode) | | 74 | | dB | ± 10 MHz |
| | | 36 | | dB | ± 200 kHz (adjacent channel) |
| Blocking and Selectivity | | 44 | | dB | ± 400 kHz (alternate channel) |
| 200-kbps 4-GFSK, 83-kHz deviation | | 55 | | dB | ± 1 MHz |
| (outer symbols), 200-kHz channel filter, zero IF | | 59 | | dB | ± 2 MHz |
| | | 67 | | dB | ± 10 MHz |
| Image rejection (Image compensation enabled) f _{xosc} = 40 MHz using TCXO | | 58 | | dB | 1.2 kbps, DEV=4 kHz CHF=10 kHz ⁽¹⁾ , image at -125 kHz |

⁽¹⁾ DEV is short for deviation, CHF is short for channel filter bandwidth



4.10.4 RX Performance in 434-MHz Band (High-Performance Mode)

 $T_A = 25$ °C, VDD = 3.0 V, $f_{xosc} = 32$ MHz if nothing else stated if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|---|-----|------|-----|------|--|
| | | -129 | | dBm | 300 bps, DEV=1 kHz, CHF=3.8 kHz ⁽¹⁾ f_{xosc} = 40 MHz |
| Consistivity | | -123 | | dBm | 1.2 kbps, DEV=4 kHz CHF=10 kHz ⁽¹⁾ |
| Sensitivity | | -109 | | dBm | 50-kbps 2-GFSK, DEV=25 kHz, CHF=100 kHz ⁽¹⁾ |
| | | -116 | | dBm | 1.2 kbps, DEV=20 kHz CHF=50 kHz ⁽¹⁾ |
| . | | 65 | | dB | + 6.25 kHz (adjacent channel) |
| Blocking and Selectivity 0.3-kbps 2-FSK, 6.25-kHz channel | | 66 | | dB | + 12.5 kHz (alternate channel) |
| separation, 1-kHz deviation, 3.8-kHz | | 86 | | dB | ± 1 MHz |
| channel filter $f_{xosc} = 40 \text{ MHz}$ using TCXO | | 90 | | dB | ± 2 MHz |
| TXOSC — TO THI 12 GOING TOXCO | | 95 | | dB | ± 10 MHz |
| D. 1. 10.1 4.7 | | 60 | | dB | + 12.5 kHz (adjacent channel) |
| Blocking and Selectivity 1.2-kbps 2-FSK, 12.5-kHz channel | | 61 | | dB | ± 25 kHz (alternate channel) |
| separation, 4-kHz deviation, 10-kHz | | 80 | | dB | ± 1 MHz |
| channel filter $f_{xosc} = 40 \text{ MHz}$ using TCXO | | 85 | | dB | ± 2 MHz |
| TXOSC — TO THI 12 GOING TOXCO | | 91 | | dB | ± 10 MHz |
| · | | 47 | | dB | + 100 kHz (adjacent channel) |
| Blocking and Selectivity | | 50 | | dB | ± 200 kHz (alternate channel) |
| 38.4-kbps 2-GFSK, 100-kHz channel separation, 20-kHz deviation, 100-kHz | | 67 | | dB | ± 1 MHz |
| channel filter | | 71 | | dB | ± 2 MHz |
| | | 78 | | dB | ± 10 MHz |

⁽¹⁾ DEV is short for deviation, CHF is short for channel filter bandwidth



4.10.5 RX Performance in 169-MHz Band (High-Performance Mode)

 $T_{\Delta} = 25^{\circ}\text{C}$, VDD = 3.0 V, $f_{\text{vosc}} = 32 \text{ MHz}$ if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|--|-----|------|-----|------|---|
| Sensitivity | | -129 | | dBm | 300 bps, DEV=1 kHz, CHF=3.8 kHz ⁽¹⁾ f _{xosc} = 40 MHz |
| • | | -123 | | dBm | 1.2 kbps, DEV=4 kHz CHF=10 kHz ⁽¹⁾ |
| | | 67 | | dB | ± 6.25 kHz (adjacent channel) |
| Blocking and Selectivity 0.3-kbps 2-FSK, 6.25-kHz channel | | 67 | | dB | + 12.5 kHz (alternate channel) |
| separation, 1-kHz deviation, 3.8-kHz | | 88 | | dB | ± 1 MHz |
| channel filter $f_{xosc} = 40 \text{ MHz}$ using TCXO | | 101 | | dB | −2 MHz |
| TXOSC — 40 WHIZ dailing TOXO | | 104 | | dB | ± 10 MHz |
| | | 63 | | dB | ± 12.5 kHz (adjacent channel) |
| Blocking and Selectivity 1.2-kbps 2-FSK, 12.5-kHz channel | | 65 | | dB | ± 25 kHz (alternate channel) |
| separation, 4-kHz deviation, 10-kHz | | 82 | | dB | ± 1 MHz |
| channel filter $f_{xosc} = 40 \text{ MHz}$ using TCXO | | 86 | | dB | ± 2 MHz |
| TXOSC — 40 WHIZ USING TOXO | | 93 | | dB | -10 MHz |
| Spurious Response Rejection 1.2-kbps 2-FSK, 12.5-kHz channel separation, 4-kHz deviation, 10-kHz channel filter | | 70 | | dB | |
| Image Rejection (Image compensation enabled) | | 66 | | dB | 1.2 kbps, DEV=4 kHz CHF=10 kHz ⁽¹⁾ , image at –125 kHz |

⁽¹⁾ DEV is short for deviation, CHF is short for channel filter bandwidth



4.10.6 RX Performance in Low-Power Mode

 $T_A = 25$ °C, VDD = 3.0 V, $f_C = 869.5$ MHz, $f_{xosc} = 32$ MHz if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|--|-----|------|-----|------|--|
| | | -111 | | dBm | 1.2 kbps, DEV=4 kHz CHF=10 kHz ⁽¹⁾ |
| Sensitivity | | -99 | | dBm | 38.4 kbps, DEV=50 kHz CHF=100 kHz ⁽¹⁾ |
| Constitution | | -99 | | dBm | 50-kbps 2-GFSK, DEV=25 kHz, CHF=100 kHz ⁽¹⁾ |
| | | 46 | | dB | ± 12.5 kHz (adjacent channel) |
| Blocking and Selectivity | | 46 | | dB | ± 25 kHz (alternate channel) |
| 1.2-kbps 2-FSK, 12.5-kHz channel separation, 4-kHz deviation, 10-kHz channel | | 73 | | dB | ± 1 MHz |
| filter | | 78 | | dB | ± 2 MHz |
| | | 79 | | dB | ± 10 MHz |
| | | 43 | | dB | ± 50 kHz (adjacent channel) |
| Blocking and Selectivity | | 45 | | dB | + 100 kHz (alternate channel) |
| 1.2-kbps 2-FSK, 50-kHz channel separation, | | 71 | | dB | ± 1 MHz |
| 20-kHz deviation, 50-kHz channel filter | | 74 | | dB | ± 2 MHz |
| | | 75 | | dB | ± 10 MHz |
| | | 37 | | dB | + 100 kHz (adjacent channel) |
| Blocking and Selectivity | | 43 | | dB | + 200 kHz (alternate channel) |
| 38.4-kbps 2-GFSK, 100-kHz channel separation, 20-kHz deviation, 100-kHz | | 58 | | dB | ± 1 MHz |
| channel filter | | 62 | | dB | ± 2 MHz |
| | | 64 | | dB | + 10 MHz |
| Blocking and Selectivity | | 43 | | dB | + 200 kHz (adjacent channel) |
| 50-kbps 2-GFSK, 200-kHz channel | | 52 | | dB | + 400 kHz (alternate channel) |
| separation, 25-kHz deviation, 100-kHz channel filter | | 60 | | dB | ± 1 MHz |
| (Same modulation format as 802.15.4g | | 64 | | dB | ± 2 MHz |
| Mandatory Mode) | | 65 | | dB | ± 10 MHz |
| Saturation | | +10 | | dBm | |

⁽¹⁾ DEV is short for deviation, CHF is short for channel filter bandwidth

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4.11 Transmit Parameters

 $T_A = 25$ °C, VDD = 3.0 V, $f_C = 869.5$ MHz, $f_{xosc} = 32$ MHz if nothing else stated

| $I_A = 25^{\circ}C$, VDD = 3.0 V, $I_C = 869.5$ N PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|---|-----|-------------|-----|--------|---|
| | | +12 | | dBm | At 950 MHz |
| | | +14 | | dBm | At 915- and 920-MHz |
| | | +15 | | dBm | At 915- and 920-MHz with VDD = 3.6 V |
| | | +15 | | dBm | At 868 MHz |
| Max output power | | +16 | | dBm | At 868 MHz with VDD = 3.6 V |
| | | +15 | | dBm | At 433 MHz |
| | | +16 | | dBm | At 433 MHz with VDD = 3.6 V |
| | | +15 | | dBm | At 169 MHz |
| | | +16 | | dBm | At 169 MHz with VDD = 3.6 V |
| | | -11 | | dBm | Within fine step size range |
| Min output power | | -40 | | dBm | Within coarse step size range |
| Output power step size | | 0.4 | | dB | Within fine step size range |
| | | -75 | | dBc | 4-GFSK 9.6 kbps in 12.5-kHz channel, measured in 100-Hz bandwidth at 434 MHz (FCC Part 90 Mask D compliant) |
| Adjacent channel power | | -58 | | dBc | 4-GFSK 9.6 kbps in 12.5-kHz channel, measured in 8.75-kHz bandwidth (ETSI 300 220 compliant) |
| | | -61 | | dBc | 2-GFSK 2.4 kbps in 12.5-kHz channel, 1.2-kHz deviation |
| Spurious emissions (not including harmonics) | | <-60 | | dBm | |
| Harmonics | | | | | |
| Second Harm, 169 MHz | | -39 | | dBm | |
| Third Harm, 169 MHz | | -58 | | dBm | |
| Second Harm, 433 MHz | | - 56 | | dBm | Transmission at +14 dBm (or maximum allowed |
| Third Harm, 433 MHz | | - 51 | | dBm | in applicable band where this is less than +14 |
| Second Harm, 450 MHz | | -60 | | dBm | dBm) using TI reference design. Emissions measured according to ARIB T-96 in |
| Third Harm, 450 MHz | | -45 | | dBm | 950-MHz band, ETSI EN 300-220 in 169-, 433-, |
| Second Harm, 868 MHz | | -40 | | dBm | and 868-MHz bands and FCC part 15.247 in 450- and 915-MHz band. |
| Third Harm, 868 MHz | | -42 | | dBm | Fourth harmonic in 915-MHz band will require |
| Second Harm, 915 MHz | | 56 | | dBuV/m | extra filtering to meet FCC requirements if |
| Third Harm, 915 MHz | | 52 | | dBuV/m | transmitting for long intervals (>50-ms periods). |
| Fourth Harm, 915 MHz | | 60 | | dBuV/m | |
| Second Harm, 950 MHz | | -58 | | dBm | |
| Third Harm, 950 MHz | | -42 | | dBm | |
| Optimum load | | | | | |
| Impedance 868-, 915-, and 920-MHz bands | | 35 + j35 | | Ω | |
| 433-MHz band | | 55 + j25 | | Ω | |
| 169-MHz band | | 80 + j0 | | Ω | |



4.12 PLL Parameters

4.12.1 High-Performance Mode

 $T_A = 25$ °C, VDD = 3.0 V, $f_c = 869.5$ MHz, $f_{xosc} = 40$ MHz using TCXO if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|--|-----|------|-----|--------|------------------|
| | | -100 | | dBc/Hz | ± 10 kHz offset |
| Phase noise in 950-MHz band f _{xosc} = 32 MHz | | -103 | | dBc/Hz | ± 100 kHz offset |
| XOSC — GE WIIIE | | -123 | | dBc/Hz | ± 1 MHz offset |
| | | -101 | | dBc/Hz | ± 10 kHz offset |
| Phase noise in 868-, 915-, 920-MHz bands | | -102 | | dBc/Hz | ± 100 kHz offset |
| | | -124 | | dBc/Hz | ± 1 MHz offset |
| | | -107 | | dBc/Hz | ± 10 kHz offset |
| Phase noise in 433-MHz band | | -110 | | dBc/Hz | ± 100 kHz offset |
| | | -130 | | dBc/Hz | ± 1 MHz offset |
| | | -115 | | dBc/Hz | ± 10 kHz offset |
| Phase noise in 169-MHz band | | -115 | | dBc/Hz | ± 100 kHz offset |
| | | -135 | | dBc/Hz | ± 1 MHz offset |

4.12.2 Low-Power Mode

 $T_A = 25$ °C, VDD = 3.0 V, $f_C = 869.5$ MHz, $f_{xosc} = 32$ MHz if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|--|-----|------|-----|--------|------------------|
| | | -90 | | dBc/Hz | ± 10 kHz offset |
| Phase noise in 950-MHz band | | -92 | | dBc/Hz | ± 100 kHz offset |
| | | -124 | | dBc/Hz | ± 1 MHz offset |
| | | -95 | | dBc/Hz | ± 10 kHz offset |
| Phase noise in 868-, 915-, and 920-MHz bands | | -95 | | dBc/Hz | ± 100 kHz offset |
| 3335 | | -124 | | dBc/Hz | ± 1 MHz offset |
| | | -98 | | dBc/Hz | ± 10 kHz offset |
| Phase noise in 433-MHz band | | -102 | | dBc/Hz | ± 100 kHz offset |
| | | -129 | | dBc/Hz | ± 1 MHz offset |
| | | -106 | | dBc/Hz | ± 10 kHz offset |
| Phase noise in 169-MHz band | | -110 | | dBc/Hz | ± 100 kHz offset |
| | | -136 | | dBc/Hz | ± 1 MHz offset |



4.13 Wake-up and Timing

 $T_A = 25$ °C, VDD = 3.0 V, $f_C = 869.5$ MHz, $f_{xosc} = 32$ MHz if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION | | | |
|--|-----|-----|-----|-------|--|--|--|--|
| Powerdown to IDLE | | 0.4 | | ms | Depends on crystal | | | |
| IDLE to RX/TX | | 166 | | μs | Calibration disabled | | | |
| IDLE to RA/TA | | 461 | | μs | Calibration enabled | | | |
| RX/TX turnaround | | 50 | | μs | Calibrate when leaving RX/TX enabled | | | |
| RX/TX to IDLE time | | 296 | | μs | Calibrate when leaving RX/TX enabled | | | |
| RX/IX to IDLE time | | 0 | | μs | Calibrate when leaving RX/TX disabled | | | |
| Frequency synthesizer calibration | | 391 | | μs | When using SCAL strobe | | | |
| Minimum required number of preamble bytes | | 0.5 | | bytes | Required for RF front-end gain settling only. Digital demodulation does not require preamble for settling. | | | |
| Time from start RX until valid RSSI, | | 4.6 | | ms | 12.5-kHz channels | | | |
| including gain settling (function of channel bandwidth. Programmable for trade-off between speed and accuracy) | | 0.3 | | ms | 200-kHz channels | | | |

4.14 High-Speed Crystal Oscillator

 $T_A = 25$ °C, VDD = 3.0 V if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|------------------------------------|-----|-----|-----|------|---|
| Crystal frequency | 32 | | 44 | MHz | It is expected that there will be degraded sensitivity at multiples of XOSC/2 in RX, and an increase in spurious emissions when the RF channel is close to multiples of XOSC in TX. We recommend that the RF channel is kept RX_BW/2 away from XOSC/2 in RX, and that the level of spurious emissions be evaluated if the RF channel is closer than 1 MHz to multiples of XOSC in TX. |
| Load capacitance (C _L) | | 10 | | pF | |
| ESR | | <50 | | Ω | |
| Start-up time | | 0.4 | | ms | Depends on crystal |

4.15 High-Speed Clock Input (TCXO)

 $T_{\Lambda} = 25$ °C. VDD = 3.0 V if nothing else stated

| I _A = 25°C, VDD = 3.0 V II nothing else stated | | | | | | | | | | | | |
|---|-----|-----|-----|------|---|--|--|--|--|--|--|--|
| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION | | | | | | | |
| Clock frequency | 32 | | 44 | MHz | | | | | | | | |
| TCXO with CMOS output | | | | | TCXO with CMOS output directly | | | | | | | |
| High input voltage | 1.4 | | VDD | V | coupled to pin EXT_OSC | | | | | | | |
| Low input voltage | 0 | | 0.6 | V | | | | | | | | |
| Rise / Fall time | | | 2 | ns | | | | | | | | |
| Clipped sine output | | | | | TCXO clipped sine output connected | | | | | | | |
| Clock input amplitude (peak-to-peak) | 8.0 | | 1.5 | V | to pin EXT_OSC through series capacitor | | | | | | | |

4.16 32-kHz Clock Input

 $T_A = 25$ °C, VDD = 3.0 V if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|---|---------|-----|---------|------|-----------|
| Clock frequency | | 32 | | kHz | |
| 32-kHz clock input pin input high voltage | 0.8×VDD | | | V | |
| 32-kHz clock input pin input low voltage | | | 0.2×VDD | V | |



4.17 Low Speed RC Oscillator

 $T_A = 25$ °C, VDD = 3.0 V if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION |
|--------------------------------------|-----|-------|-----|------|---|
| Frequency | | 32/40 | | kHz | After calibration (calibrated against the high-speed XOSC) |
| Frequency accuracy after calibration | | ±0.1 | | % | Relative to frequency reference (for example, 32-MHz crystal or TCXO) |
| Initial calibration time | | 1.6 | | ms | |

4.18 I/O and Reset

 $T_A = 25^{\circ}C$. VDD = 3.0 V if nothing else stated

| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION | | |
|---------------------------|---------|-----|---------|----------|------------------------------|--|--|
| Logic input high voltage | 0.8×VDD | | | V | | | |
| Logic input low voltage | | | 0.2×VDD | V | | | |
| Logic output high voltage | 0.8×VDD | | | ٧ | At 4 m A sutmut load or load | | |
| Logic output low voltage | | | 0.2×VDD | V | At 4-mA output load or less | | |
| Power-on reset threshold | | 1.3 | | ٧ | Voltage on DVDD pin | | |

4.19 Temperature Sensor

 $T_{\star} = 25^{\circ}C$ VDD = 3.0 V if nothing else stated

| TA = 23 G, VDD = 3.0 V II Hottilling else stated | | | | | | | | | | |
|--|-----|------|-----|---------|--|--|--|--|--|--|
| PARAMETER | MIN | TYP | MAX | UNIT | CONDITION | | | | | |
| Temperature sensor range | -40 | | 85 | °C | | | | | | |
| Temperature coefficient | | 2.66 | | mV / °C | Change in sensor output voltage versus change in temperature | | | | | |
| Typical output voltage | | 794 | | mV | Typical sensor output voltage at $T_A = 25$ °C, VDD = 3.0 V | | | | | |
| VDD coefficient | | 1.17 | | mV / V | Change in sensor output voltage versus change in VDD | | | | | |

The CC1125 device can be configured to provide a voltage proportional to temperature on GPIO1. The temperature can be estimated by measuring this voltage (see Section 4.19, Temperature Sensor). For more information, see the temperature sensor design note (SWRA415).

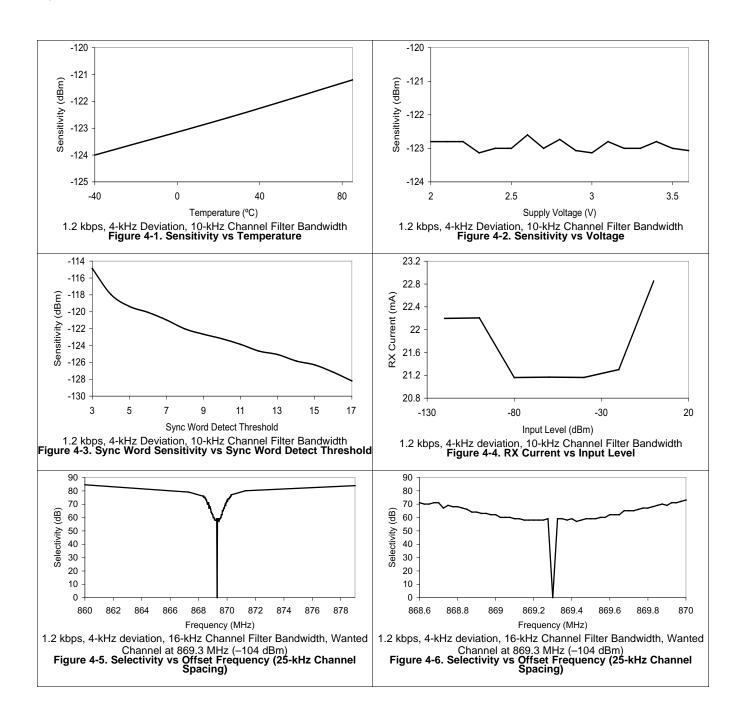


4.20 Typical Characteristics

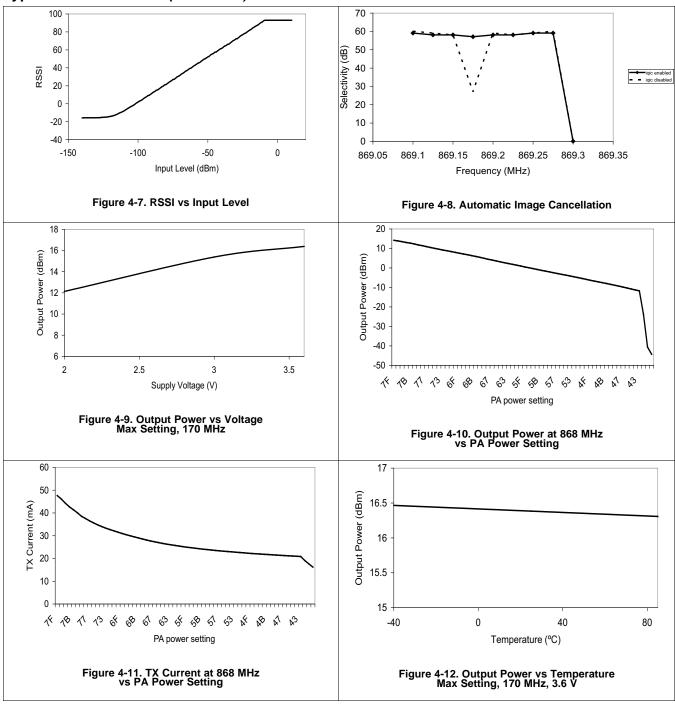
 $T_A = 25$ °C, VDD = 3.0 V, $f_c = 869.5$ MHz if nothing else stated.

All measurements performed on CC1120EM_868_915 rev.1.0.1, CC1120EM_955 rev.1.2.1, CC1120EM_420_470 rev.1.0.1 or CC1120EM_169 rev.1.2 ($f_{xosc} = 32$ MHz), and CC1125EM_868_915 rev.1.1.0, CC1125EM_420_470 rev.1.1.0, CC1125EM_169 rev.1.1.0, CC1125EM-Cat1-868 ($f_{xosc} = 40$ MHz).

Figure 4-16 was measured at the $50-\Omega$ antenna connector.

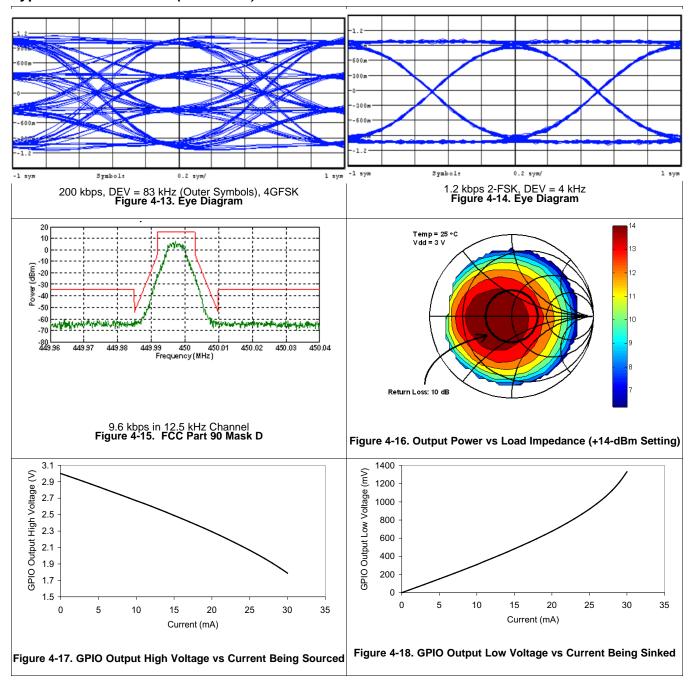


Typical Characteristics (continued)





Typical Characteristics (continued)



5 Detailed Description

5.1 Block Diagram

Figure 5-1 shows the system block diagram of the CC1125 device.

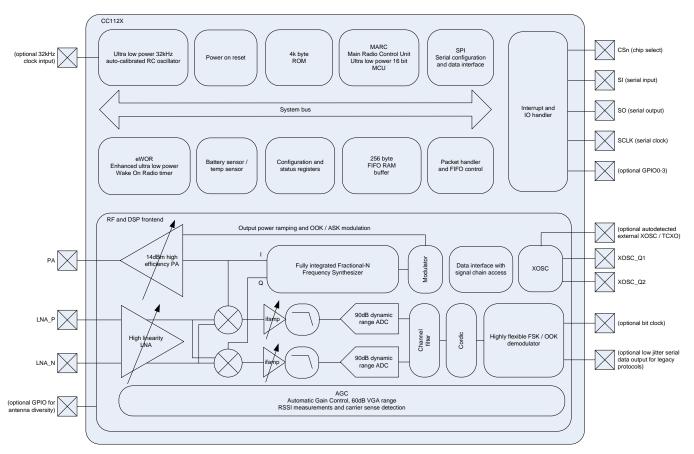


Figure 5-1. System Block Diagram

5.2 Frequency Synthesizer

At the center of the CC1125 device there is a fully integrated, fractional-N, ultra-high-performance frequency synthesizer. The frequency synthesizer is designed for excellent phase noise performance, providing very high selectivity and blocking performance. The system is designed to comply with the most stringent regulatory spectral masks at maximum transmit power.

Either a crystal can be connected to XOSC_Q1 and XOSC_Q2, or a TCXO can be connected to the EXT_XOSC input. The oscillator generates the reference frequency for the synthesizer, as well as clocks for the analog-to-digital converter (ADC) and the digital part. To reduce system cost, CC1125 device has high-accuracy frequency estimation and compensation registers to measure and compensate for crystal inaccuracies. This compensation enables the use of lower cost crystals. If a TCXO is used, the CC1125 device automatically turns on and off the TCXO when needed to support low-power modes and Wake-On-Radio operation.



5.3 Receiver

The CC1125 device features a highly flexible receiver. The received RF signal is amplified by the low-noise amplifier (LNA) and is down-converted in quadrature (I/Q) to the intermediate frequency (IF). At IF, the I/Q signals are digitized by the high dynamic-range ADCs.

An advanced automatic gain control (AGC) unit adjusts the front-end gain, and enables the CC1125 device to receive strong and weak signals, even in the presence of strong interferers. High-attenuation channels and data filtering enable reception with strong neighbor channel interferers. The I/Q signal is converted to a phase and magnitude signal to support the FSK and OOK modulation schemes.

NOTE

A unique I/Q compensation algorithm removes any problem of I/Q mismatch, thus avoiding time-consuming and costly I/Q image calibration steps.

5.4 Transmitter

The CC1125 transmitter is based on direct synthesis of the RF frequency (in-loop modulation). To use the spectrum effectively, the CC1125 device has extensive data filtering and shaping in TX mode to support high throughput data communication in narrowband channels. The modulator also controls power ramping to remove issues such as spectral splattering when driving external high-power RF amplifiers.

5.5 Radio Control and User Interface

The CC1125 digital control system is built around the main radio control (MARC), which is implemented using an internal high-performance, 16-bit ultra-low-power processor. MARC handles power modes, radio sequencing, and protocol timing.

A 4-wire SPI serial interface is used for configuration and data buffer access. The digital baseband includes support for channel configuration, packet handling, and data buffering. The host MCU can stay in power-down mode until a valid RF packet is received. This greatly reduces power consumption. When the host MCU receives a valid RF packet, it burst-reads the data. This reduces the required computing power.

The CC1125 radio control and user interface are based on the widely used CC1101 transceiver. This relationship enables an easy transition between the two platforms. The command strobes and the main radio states are the same for the two platforms.

For legacy formats, the CC1125 device also supports two serial modes.

- Synchronous serial mode: The CC1125 device performs bit synchronization and provides the MCU with a bit clock with associated data.
- Transparent mode: The CC1125 device outputs the digital baseband signal using a digital interpolation filter to eliminate jitter introduced by digital filtering and demodulation.

5.6 4.5 Enhanced Wake-On-Radio (eWOR)

eWOR, using a flexible integrated sleep timer, enables automatic receiver polling with no intervention from the MCU. When the CC1125 device enters RX mode, it listens and then returns to sleep if a valid RF packet is not received. The sleep interval and duty cycle can be configured to make a trade-off between network latency and power consumption. Incoming messages are time-stamped to simplify timer resynchronization.

The eWOR timer runs off an ultra-low-power 32-kHz RC oscillator. To improve timing accuracy, the RC oscillator can be automatically calibrated to the RF crystal in configurable intervals.



5.7 Sniff Mode

The CC1125 device supports quick start up times, and requires few preamble bits. Sniff mode uses these conditions to dramatically reduce the current consumption while the receiver is waiting for data.

Because the CC1125 device can wake up and settle much faster than the duration of most preambles, it is not required to be in RX mode continuously while waiting for a packet to arrive. Instead, the enhanced Wake-On-Radio feature can be used to put the device into sleep mode periodically. By setting an appropriate sleep time, the CC1125 device can wake up and receive the packet when it arrives with no performance loss. This sequence removes the need for accurate timing synchronization between transmitter and receiver, and lets the user trade off current consumption between the transmitter and receiver.

For more information, see the sniff mode design note (SWRA428).

5.8 Antenna Diversity

Antenna diversity can increase performance in a multipath environment. An external antenna switch is required. The CC1201 device uses one of the GPIO pins to automatically control the switch. This device also supports differential output control signals typically used in RF switches.

If antenna diversity is enabled, the GPIO alternates between high and low states until a valid RF input signal is detected. An optional acknowledge packet can be transmitted without changing the state of the GPIO.

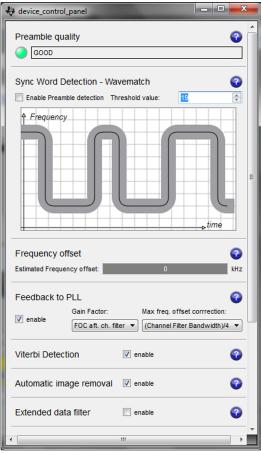
An incoming RF signal can be validated by received signal strength or by using the automatic preamble detector. Using the automatic preamble detector ensures a more robust system and avoids the need to set a defined signal strength threshold (such a threshold sets the sensitivity limit of the system).



5.9 WaveMatch

Advanced capture logic locks onto the synchronization word and does not require preamble settling bytes. Therefore, receiver settling time is reduced to the settling time of the AGC, typically 4 bits.

The WaveMatch feature also greatly reduces false sync triggering on noise, further reducing the power consumption and improving sensitivity and reliability. The same logic can also be used as a high-performance preamble detector to reliably detect a valid preamble in the channel.



See SWRC046 for more information.

Figure 5-2. Receiver Configurator in SmartRF™ Studio

6 Typical Application Circuit

NOTE

This section is intended only as an introduction.

Very few external components are required for the operation of the CC1125 device. Figure 6-1 shows a typical application circuit. The board layout will greatly influence the RF performance of the CC1125 device. Figure 6-1 does not show decoupling capacitors for power pins.

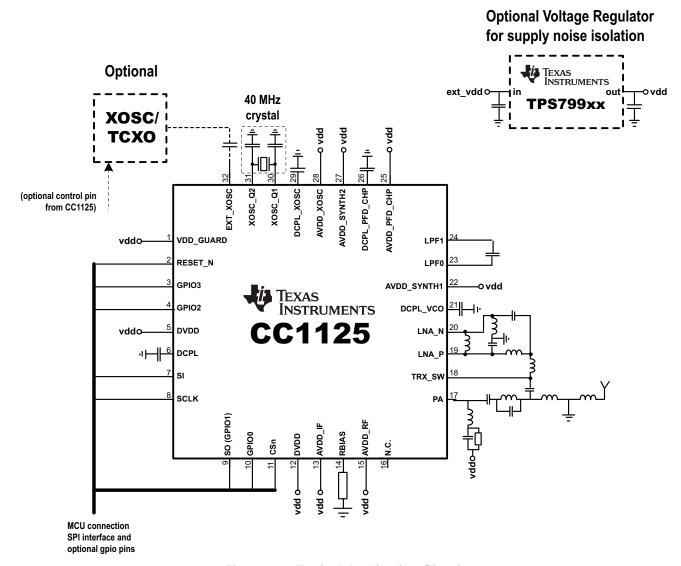


Figure 6-1. Typical Application Circuit

For more information, see the reference designs available for the CC1125 device in Section 7.2, Documentation Support.



7 Device and Documentation Support

7.1 Device Support

7.1.1 Development Support

7.1.1.1 Configuration Software

The CC1125 device can be configured using the SmartRF Studio software (<u>SWRC046</u>). The SmartRF Studio software is highly recommended for obtaining optimum register settings, and for evaluating performance and functionality.

7.1.2 Device and Development-Support Tool Nomenclature

To designate the stages in the product development cycle, TI assigns prefixes to the part numbers of all microprocessors (MPUs) and support tools. Each device has one of three prefixes: X, P, or null (no prefix) (for example, CC1125). Texas Instruments recommends two of three possible prefix designators for its support tools: TMDX and TMDS. These prefixes represent evolutionary stages of product development from engineering prototypes (TMDX) through fully qualified production devices and tools (TMDS).

Device development evolutionary flow:

X Experimental device that is not necessarily representative of the final device's electrical specifications and may not use production assembly flow.

P Prototype device that is not necessarily the final silicon die and may not necessarily meet final electrical specifications.

null Production version of the silicon die that is fully qualified.

Support tool development evolutionary flow:

TMDX Development-support product that has not yet completed Texas Instruments internal qualification testing.

TMDS Fully qualified development-support product.

X and P devices and TMDX development-support tools are shipped against the following disclaimer:

"Developmental product is intended for internal evaluation purposes."

Production devices and TMDS development-support tools have been characterized fully, and the quality and reliability of the device have been demonstrated fully. Tl's standard warranty applies.

Predictions show that prototype devices (X or P) have a greater failure rate than the standard production devices. Texas Instruments recommends that these devices not be used in any production system because their expected end-use failure rate still is undefined. Only qualified production devices are to be used.

TI device nomenclature also includes a suffix with the device family name. This suffix indicates the package type (for example, RHB), the temperature range (for example, blank is the default commercial temperature range), and the device speed range, in megahertz. provides a legend for reading the complete device name for any CC1125 device.

For orderable part numbers of CC1125 devices in the QFN package types, see the Package Option Addendum of this document, the TI website (www.ti.com), or contact your TI sales representative.



7.2 Documentation Support

The following documents supplement the CC1125 processor. Copies of these documents are available on the Internet at www.ti.com. Tip: Enter the literature number in the search box provided at www.ti.com.

| SWRR106 | CC112x IPC 868- and 915-MHz 2-layer Reference Design |
|----------------|--|
| SWRR107 | CC112x IPC 868- and 915-MHz 4-layer Reference Design |
| SWRR100 | CC1125EM 169-MHz Reference Design |
| SWRR101 | CC1125EM 420- to 470-MHz Reference Design |
| SWRR102 | CC1121EM 868- to 915-MHz Reference Design |
| SWRR097 | CC1120EM CAT1 868-MHz Reference Design |
| SWRC046 | SmartRF Studio Software |
| | |

CC112x/CC120x Sniff Mode Application Note

7.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community TI's Engineer-to-Engineer (E2E) Community. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

TI Embedded Processors Wiki Texas Instruments Embedded Processors Wiki. Established to help developers get started with Embedded Processors from Texas Instruments and to foster innovation and growth of general knowledge about the hardware and software surrounding these devices.

7.4 Trademarks

SmartRF, E2E are trademarks of Texas Instruments.

7.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

7.6 Glossary

SLYZ022 — TI Glossary.

This glossary lists and explains terms, acronyms, and definitions.

www.ti.com

8 Mechanical Packaging and Orderable Information

The following pages include mechanical packaging and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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PACKAGING INFORMATION

| Orderable part number | Status | Material type | Package Pins | Package qty Carrier | RoHS | Lead finish/ | MSL rating/ | Op temp (°C) | Part marking |
|-----------------------|--------|---------------|-----------------|-----------------------|------|-------------------|---------------------|--------------|--------------|
| | (1) | (2) | | | (3) | Ball material | Peak reflow | | (6) |
| | | | | | | (4) | (5) | | |
| CC1125RHBR | Active | Production | VQFN (RHB) 32 | 3000 LARGE T&R | Yes | NIPDAU NIPDAUAG | Level-3-260C-168 HR | -40 to 85 | CC1125 |
| CC1125RHBR.A | Active | Production | VQFN (RHB) 32 | 3000 LARGE T&R | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 85 | CC1125 |
| CC1125RHBT | Active | Production | VQFN (RHB) 32 | 250 SMALL T&R | Yes | NIPDAU NIPDAUAG | Level-3-260C-168 HR | -40 to 85 | CC1125 |
| CC1125RHBT.A | Active | Production | VQFN (RHB) 32 | 250 SMALL T&R | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 85 | CC1125 |

⁽¹⁾ Status: For more details on status, see our product life cycle.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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⁽²⁾ Material type: When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ RoHS values: Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

⁽⁴⁾ Lead finish/Ball material: Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

⁽⁵⁾ MSL rating/Peak reflow: The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ Part marking: There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.



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TRAY



Chamfer on Tray corner indicates Pin 1 orientation of packed units.

*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | Unit array matrix | Max temperature (°C) | L (mm) | W (mm) | Κ0 (μm) | P1 (mm) | CL (mm) | CW (mm) |
|--------------|-----------------|-----------------|------|------|----------------------|----------------------------|--------|-----------|------------|------------|------------|------------|
| CC1125RHBR | RHB | VQFN | 32 | 3000 | 14 x 35 | 150 | 315 | 135.9 | 7620 | 8.8 | 7.9 | 8.15 |
| CC1125RHBR | RHB | VQFN | 32 | 3000 | 14 x 35 | 150 | 315 | 135.9 | 7620 | 8.8 | 7.9 | 8.15 |
| CC1125RHBR.A | RHB | VQFN | 32 | 3000 | 14 x 35 | 150 | 315 | 135.9 | 7620 | 8.8 | 7.9 | 8.15 |
| CC1125RHBR.A | RHB | VQFN | 32 | 3000 | 14 x 35 | 150 | 315 | 135.9 | 7620 | 8.8 | 7.9 | 8.15 |
| CC1125RHBT | RHB | VQFN | 32 | 250 | 14 x 35 | 150 | 315 | 135.9 | 7620 | 8.8 | 7.9 | 8.15 |
| CC1125RHBT | RHB | VQFN | 32 | 250 | 14 x 35 | 150 | 315 | 135.9 | 7620 | 8.8 | 7.9 | 8.15 |
| CC1125RHBT.A | RHB | VQFN | 32 | 250 | 14 x 35 | 150 | 315 | 135.9 | 7620 | 8.8 | 7.9 | 8.15 |
| CC1125RHBT.A | RHB | VQFN | 32 | 250 | 14 x 35 | 150 | 315 | 135.9 | 7620 | 8.8 | 7.9 | 8.15 |

5 x 5, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD



Images above are just a representation of the package family, actual package may vary. Refer to the product data sheet for package details.

4224745/A





PLASTIC QUAD FLATPACK - NO LEAD



NOTES:

- 1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
 2. This drawing is subject to change without notice.
- 3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.



PLASTIC QUAD FLATPACK - NO LEAD



NOTES: (continued)

- 4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
- Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.



PLASTIC QUAD FLATPACK - NO LEAD



NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.



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