

## 用于 2.4-GHz USB 应用的片上系统

### 特性

- 射频 (RF) 部分
  - 单片 **2.4GHz RF** 收发器和微控制器 (MCU)
  - 数据速率和调制格式:
    - **2Mbps** 高斯频移键控 (GFSK), **320kHz** 偏差
    - **2Mbps GFSK**, **500kHz** 偏差
    - **1Mbps GFSK**, **160kHz** 偏差
    - **1Mbps GFSK** **250kHz** 偏差
    - **500kbps** 最小频移键控 (MSK)
    - **250kbps GFSK**, **160kHz** 偏差
    - **250kbps MSK**
  - 出色的链路预算, 无需外部前端即可实现长距离通信
  - 高达 **4dBm** 的可编程输出功率
  - 出色的接收器灵敏度 (**2Mbps** 时为 **-88dBm**)
  - 适用于符合世界范围内的射频标准的系统: **ETSI EN 300 328** 和 **EN 300 440 2** 类 (欧洲), **FCC CFR47 15** 部分 (美国), 和 **ARIB STD-T66** (日本)
  - 精确的接收到的信号强度指示器 (RSSI) 功能
- 布局
  - 极少的外部组件
  - 提供参考设计
  - **32** 引脚 **5mm x 5mm** 四方扁平无引线 (QFN) (8 个通用 I/O 引脚) 封装
- 低功率
  - 激活模式 **RX**: **22.5mA**
  - 激活模式 **TX (0dBm)**: **27mA**
  - 功率模式 **1 (4μs 唤醒)**: **1mA**
  - 宽泛的电源电压范围
    - **3.3V** 低压降 (LDO) 输出
    - 电源范围: **2V-3.6V**
    - **USB 5V** 稳压器: **4V-5.5V**
- 微控制器
  - 具有代码预取功能的高性能和低功率 **8051** 微控制器内核
  - **32KB** 闪存程序内存
  - **2KB SRAM**
  - 支持硬件调试
  - 扩展基带自动化, 包括自动确认和地址解码
- 外设
  - 全速 **USB 2.0**
    - **6** 个端点 (端点 **0** 和 **5** 个输入/输出端点)
    - 用于 **D+** 的内部上拉
    - **5V** 至 **3.3V** 稳压器
  - 强大的两通道 **DMA**
  - 通用定时器 (1 个 **16** 位, 2 个 **8** 位)
  - 无线电定时器, **40** 位
  - 红外 (IR) 生成电路
  - 几个振荡器:
    - **32MHz** 晶体振荡器
    - **16MHz RC** 振荡器
    - **32MHz RCOSC**
  - 具有捕捉功能的 **32kHz** 睡眠定时器
  - 高级加密标准 (AES) 安全协处理器
  - 通用异步收发器 (UART) / 串行外设接口 (SPI) 串行接口
  - **8** 个通用 I/O 引脚 (6 x **4mA** 和 2 x **20mA** 驱动强度)
  - 安全装置定时器
  - 真随机数生成器

### 应用范围

- 私有的 **2.4 GHz** 系统
- 人机接口器件 (USB 软件保护器)
- 消费类电子产品



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



这些装置包含有限的内置 ESD 保护。

存储或装卸时，应将导线一起截短或将装置放置于导电泡棉中，以防止 MOS 门极遭受静电损伤。

## 说明

CC2544 是一款经优化的针对数据速率高达 2Mbps 且使用低物料清单成本制造的 USB 应用的片上系统 (SoC) 解决方案。CC2544 将处于领先地位的 RF 收发器的出色性能与一个单周期 8051 兼容 CPU，32KB 系统内可编程闪存存储器，高达 2KB RAM，和很多其它功能强大的特性组合在一起。

CC2544 与 CC2541/CC2543/CC2545 兼容。它采用带有 SPI/UART/USB 接口的 5mm x 5mm QFN32 封装。供货时，CC2544 带有由德州仪器 (TI) 提供的完整参考设计。

此器件针对无线消费类产品和人机接口器件 (HID) 应用。CC2544 是 USB 软件加密应用的理想选择。

方框图请见 [Figure 7](#)。

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                  | TEST CONDITIONS  | MIN  | MAX  | UNIT |
|----------------------------|--|------|------|------|
| Supply voltage VBUS        |  | −0.3 | 5.5  | V    |
| Supply voltage VDD         | All supply pins must have the same voltage                               | −0.3 | ≤3.9 | V    |
| Voltage on any digital pin |  | −0.3 | ≤3.9 | V    |
| Input RF level             |  |      | 10   | dBm  |
| Storage temperature range  |  | −40  | 125  | °C   |
| ESD <sup>(2)</sup>         | All pins, according to human-body model, JEDEC STD 22, method A114 (HBM) |      | 2    | kV   |
|                            | According to charged-device model, JEDEC STD 22, method C101 (CDM)       |      | 750  | 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 *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) **CAUTION:** ESD sensitive device. Precautions should be used when handling the device in order to prevent permanent damage.

## RECOMMENDED OPERATING CONDITIONS

| PARAMETER   | TEST CONDITIONS                        | MIN | MAX  | UNIT |
|---|--|-----|------|------|
| Operating ambient temperature range, T <sub>A</sub> |  | −40 | 85   | °C   |
| Operating supply voltage VBUS                       | Optional to use this regulator         | 4   | 5.45 | V    |
| Operating supply voltage VDD                        | All supply pins must have same voltage | 2   | 3.6  | V    |

## ELECTRICAL CHARACTERISTICS

Measured on Texas Instruments CC2544EM reference design with  $T_A = 25^\circ\text{C}$  and  $V_{DD} = 3.3\text{ V}$ ,  $V_{BUS}$  tied to 5 V, unless otherwise noted.

| PARAMETER  | TEST CONDITIONS  | MIN | TYP  | MAX | UNIT          |
|--|--|-----|------|-----|---------------|
| <b>2 Mbps, GFSK, 320-kHz Deviation, 0.1% BER</b>   |  |     |      |     |               |
| $I_{core}$ – Core current consumption  | RX mode, no peripherals active, low MCU activity   |     | 22.5 |     | mA            |
|  | TX mode, 0-dBm output power, no peripherals active, low MCU activity   |     | 27   |     | mA            |
|  | TX mode, 4-dBm output power, no peripherals active, low MCU activity   |     | 30   |     | mA            |
|  | Active mode, 16-MHz RCOSC, Low MCU activity  |     | 4    |     | mA            |
|  | Active mode, 32-MHz clock frequency, low MCU activity  |     | 7    |     | mA            |
|  | Power mode 0, CPU clock halted, all peripherals on, no clock division, 32-MHz crystal selected   |     | 6    |     | mA            |
|  | Power mode 0, CPU clock halted, all peripherals on, clock division at max. (Limits max. speed in peripherals except radio), 32-MHz crystal selected                |     | 3.5  |     | mA            |
|  | Power mode 1. Digital regulator on; 16-MHz RCOSC and 32-MHz crystal oscillator off; 32.753-kHz RCOSC, POR, BOD, and sleep timer active; RAM and register retention |     | 1    |     | mA            |
| $I_{peri}$ – Peripheral current consumption (Adds to core current $I_{core}$ for each peripheral unit activated) | Timer 1 (16-bit). Timer running, 32-MHz XOSC used  |     | 90   |     | $\mu\text{A}$ |
|  | Radio timer(40 bit). Timer running, 32-MHz XOSC used   |     | 90   |     | $\mu\text{A}$ |
|  | Timer 3 (8-bit). Timer running, 32-MHz XOSC used   |     | 60   |     | $\mu\text{A}$ |
|  | Timer 4 (8-bit). Timer running, 32-MHz XOSC used   |     | 70   |     | $\mu\text{A}$ |
|  | Sleep timer. Including 32.753-kHz RCOSC  |     | 0.6  |     | $\mu\text{A}$ |

## GENERAL CHARACTERISTICS

Measured on Texas Instruments CC2544EM reference design with  $T_A = 25^\circ\text{C}$  and  $V_{DD} = 3.3\text{ V}$ ,  $V_{BUS}$  tied to 5 V, unless otherwise noted.

| PARAMETER                         | TEST CONDITIONS  | MIN  | TYP | MAX  | UNIT          |
|-----------------------------------|--|------|-----|------|---------------|
| <b>WAKE-UP AND TIMING</b>         |  |      |     |      |               |
| Power mode 1 → Active             | Digital regulator on, 16-MHz RCOSC and 32-MHz crystal oscillator off. Start-up of 16-MHz RCOSC.  |      | 4   |      | $\mu\text{s}$ |
| Active → TX or RX                 | Crystal ESR = 16 $\Omega$ . Initially running on 16-MHz RCOSC, with 32-MHz XOSC OFF.   |      | 410 |      | $\mu\text{s}$ |
|                                   | With 32-MHz XOSC initially on.   |      | 160 |      | $\mu\text{s}$ |
| RX/TX turnaround                  |  |      | 130 |      | $\mu\text{s}$ |
| <b>RADIO PART</b>                 |  |      |     |      |               |
| RF frequency range                | Programmable in 1-MHz steps  | 2380 |     | 2495 | MHz           |
| Data rates and modulation formats | 2 Mbps, GFSK 320-kHz deviation<br>2-Mbps, GFSK 500 kHz deviation<br>1-Mbps, GFSK 160 kHz deviation<br>1-Mbps, GFSK 250 kHz deviation<br>500 kbps, MSK<br>250 kbps, GFSK 160 kHz deviation<br>250 kbps, MSK |      |     |      |               |

## RF RECEIVE SECTION

Measured on Texas Instruments CC2544EM reference design with  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ ,  $V_{BUS}$  tied to  $5\text{ V}$ , and  $f_C = 2440\text{ MHz}$ , unless otherwise noted.

| PARAMETER  | TEST CONDITIONS  | MIN  | TYP | MAX | UNIT |
|--|--|------|-----|-----|------|
| <b>2 Mbps, GFSK, 320-kHz Deviation, 0.1% BER</b> |  |      |     |     |      |
| Receiver sensitivity                             |  |      | -84 |     | dBm  |
| Saturation <sup>(1)</sup>                        |  |      | 0   |     | dBm  |
| Co-channel rejection                             | Wanted signal at -67 dBm   |      | -15 |     | dB   |
| In-band blocking rejection                       | $\pm 2$ -MHz offset, wanted signal -67 dBm   |      | -5  |     | dB   |
|  | $\pm 4$ -MHz offset, wanted signal -67 dBm   |      | 30  |     |      |
|  | $\pm 6$ -MHz offset, wanted signal -67 dBm   |      | 40  |     |      |
|  | >12-MHz offset, wanted signal -67 dBm  |      | 42  |     |      |
| Out-of-band blocking rejection                   | 1-MHz resolution. Wanted signal -67 dBm, $f < 2\text{ GHz}$<br>Two exception frequencies with poorer performance   |      | -35 |     | dBm  |
|  | 1-MHz resolution. Wanted signal -67 dBm, $2\text{ GHz} < f < 3\text{ GHz}$<br>Two exception frequencies with poorer performance  |      | -36 |     |      |
|  | 1-MHz resolution. Wanted signal -67 dBm, $f > 3\text{ GHz}$<br>Two exception frequencies with poorer performance   |      | -12 |     |      |
| Intermodulation                                  | Wanted signal -64 dBm, 1 <sup>st</sup> interferer is CW, 2 <sup>nd</sup> interferer is GFSK-modulated signal. Offsets of interferers are:<br>6 and 12 MHz<br>8 and 16 MHz<br>10 and 20 MHz |      | -43 |     | dBm  |
| Frequency error tolerance <sup>(2)</sup>         | Including both initial tolerance and drift. Limit set to minimum sensitivity of -70dBm, 250K byte payload  | -300 |     | 300 | kHz  |
| Symbol rate error tolerance <sup>(3)</sup>       | Limit set to minimum sensitivity of -70 dBm, 250K byte payload   | -120 |     | 120 | ppm  |
| <b>2 Mbps, GFSK, 500-kHz Deviation, 0.1% BER</b> |  |      |     |     |      |
| Receiver sensitivity                             |  |      | -88 |     | dBm  |
| Saturation <sup>(1)</sup>                        |  |      | 3   |     | dBm  |
| Co-channel rejection                             | Wanted signal at -67 dBm   |      | -9  |     | dB   |
| In-band blocking rejection                       | $\pm 2$ -MHz offset, wanted signal -67 dBm   |      | -3  |     | dB   |
|  | $\pm 4$ -MHz offset, wanted signal -67 dBm   |      | 33  |     |      |
|  | $\pm 6$ -MHz offset, wanted signal -67 dBm   |      | 49  |     |      |
|  | >12-MHz offset, wanted signal -67 dBm  |      | 40  |     |      |
| Frequency error tolerance <sup>(2)</sup>         | Including both initial tolerance and drift. Sensitivity better than -70 dBm. 250-byte payload  | -300 |     | 300 | kHz  |
| Symbol-rate error tolerance <sup>(3)</sup>       | Sensitivity better than -70 dBm. 250-byte payload  | -120 |     | 120 | ppm  |
| <b>1 Mbps, GFSK, 250-kHz Deviation, 0.1% BER</b> |  |      |     |     |      |
| Receiver sensitivity                             |  |      | -91 |     | dBm  |
| Saturation <sup>(1)</sup>                        |  |      | 5   |     | dBm  |
| Co-channel rejection                             | Wanted signal at -67 dBm   |      | -6  |     | dB   |
| In-band blocking rejection                       | $\pm 2$ -MHz offset, wanted signal -67 dBm   |      | 28  |     | dB   |
|  | $\pm 4$ -MHz offset, wanted signal -67 dBm   |      | 31  |     |      |
|  | $\pm 6$ -MHz offset, wanted signal -67 dBm   |      | 40  |     |      |
|  | >12-MHz offset, wanted signal -67 dBm  |      | 49  |     |      |
| Frequency error tolerance <sup>(2)</sup>         | Including both initial tolerance and drift. Sensitivity better than -70 dBm. 250-byte payload  | -250 |     | 250 | kHz  |
| Symbol-rate error tolerance <sup>(3)</sup>       | Sensitivity better than -70 dBm. 250-byte payload  | -80  |     | 80  | ppm  |

(1) AGC enabled

(2) Difference between center frequency of the received RF signal and local oscillator frequency

(3) Difference between incoming symbol rate and the internally generated symbol rate

## RF RECEIVE SECTION (continued)

Measured on Texas Instruments CC2544EM reference design with  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ ,  $V_{BUS}$  tied to 5 V, and  $f_C = 2440\text{ MHz}$ , unless otherwise noted.

| PARAMETER  | TEST CONDITIONS   | MIN  | TYP | MAX | UNIT |
|--|---|------|-----|-----|------|
| <b>1 Mbps, GFSK, 160-kHz Deviation, 0.1% BER</b> |   |      |     |     |      |
| Receiver sensitivity                             |   |      | -87 |     | dBm  |
| Saturation <sup>(1)</sup>                        |   |      | 5   |     | dBm  |
| Co-channel rejection                             | Wanted signal at -67 dBm  |      | -9  |     | dB   |
| In-band blocking rejection                       | $\pm 2\text{-MHz}$ offset, wanted signal -67 dBm  |      | 26  |     | dB   |
|  | $\pm 4\text{-MHz}$ offset, wanted signal -67 dBm  |      | 30  |     |      |
|  | $\pm 6\text{-MHz}$ offset, wanted signal -67 dBm  |      | 40  |     |      |
|  | $>12\text{-MHz}$ offset, wanted signal -67 dBm  |      | 46  |     |      |
| Frequency error tolerance <sup>(2)</sup>         | Including both initial tolerance and drift. Sensitivity better than -70 dBm. 250-byte payload | -250 |     | 250 | kHz  |
| Symbol-rate error tolerance <sup>(3)</sup>       | Sensitivity better than -70 dBm. 250-byte payload   | -80  |     | 80  | ppm  |
| <b>500 kbps, MSK, 0.1% BER</b>                   |   |      |     |     |      |
| Receiver sensitivity                             |   |      | -96 |     | dBm  |
| Saturation <sup>(4)</sup>                        |   |      | 5   |     | dBm  |
| Co-channel rejection                             | Wanted signal at -67 dBm  |      | -5  |     | dB   |
| In-band blocking rejection                       | $\pm 2\text{-MHz}$ offset, wanted signal -67 dBm  |      | 31  |     | dB   |
|  | $\pm 4\text{-MHz}$ offset, wanted signal -67 dBm  |      | 31  |     |      |
|  | $\pm 6\text{-MHz}$ offset, wanted signal -67 dBm  |      | 45  |     |      |
|  | $>12\text{-MHz}$ offset, wanted signal -67 dBm  |      | 54  |     |      |
| Frequency error tolerance <sup>(5)</sup>         | Including both initial tolerance and drift. Sensitivity better than -70 dBm. 250-byte payload | -150 |     | 150 | kHz  |
| Symbol-rate error tolerance <sup>(6)</sup>       | Sensitivity better than -70 dBm. 250-byte payload   | -60  |     | 60  | ppm  |

(4) AGC enabled

(5) Difference between center frequency of the received RF signal and local oscillator frequency

(6) Difference between incoming symbol rate and the internally generated symbol rate

## RF RECEIVE SECTION (continued)

Measured on Texas Instruments CC2544EM reference design with  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ ,  $V_{BUS}$  tied to 5 V, and  $f_C = 2440\text{ MHz}$ , unless otherwise noted.

| PARAMETER  | TEST CONDITIONS   | MIN  | TYP | MAX | UNIT |
|--|---|------|-----|-----|------|
| <b>250 kbps, GFSK, 160-kHz Deviation, 0.1% BER</b> |   |      |     |     |      |
| Receiver sensitivity                               |   |      | -95 |     | dBm  |
| Saturation <sup>(7)</sup>                          |   |      | 5   |     | dBm  |
| Co-channel rejection                               | Wanted signal at -67 dBm  |      | -9  |     | dB   |
| In-band blocking rejection                         | $\pm 2\text{-MHz}$ offset, wanted signal -67 dBm  |      | 31  |     | dB   |
|  | $\pm 4\text{-MHz}$ offset, wanted signal -67 dBm  |      | 31  |     |      |
|  | $\pm 6\text{-MHz}$ offset, wanted signal -67 dBm  |      | 55  |     |      |
|  | $>12\text{-MHz}$ offset, wanted signal -67 dBm  |      | 53  |     |      |
| Frequency error tolerance <sup>(8)</sup>           | Including both initial tolerance and drift. Sensitivity better than -70 dBm. 250-byte payload | -150 |     | 150 | kHz  |
| Symbol-rate error tolerance <sup>(9)</sup>         | Sensitivity better than -70 dBm. 250-byte payload   | -60  |     | 60  | ppm  |
| <b>250 kbps, MSK, 0.1% BER</b>                     |   |      |     |     |      |
| Receiver sensitivity                               |   |      | -95 |     | dBm  |
| Saturation <sup>(7)</sup>                          |   |      | 5   |     | dBm  |
| Co-channel rejection                               | Wanted signal at -67 dBm  |      | -5  |     | dB   |
| In-band blocking rejection                         | $\pm 2\text{-MHz}$ offset, wanted signal -67 dBm  |      | 31  |     | dB   |
|  | $\pm 4\text{-MHz}$ offset, wanted signal -67 dBm  |      | 31  |     |      |
|  | $\pm 6\text{-MHz}$ offset, wanted signal -67 dBm  |      | 45  |     |      |
|  | $>12\text{-MHz}$ offset, wanted signal -67 dBm  |      | 54  |     |      |
| Frequency error tolerance <sup>(8)</sup>           | Including both initial tolerance and drift. Sensitivity better than -70 dBm. 250-byte payload | -150 |     | 150 | kHz  |
| Symbol-rate error tolerance <sup>(9)</sup>         | Sensitivity better than -70 dBm. 250-byte payload   | -60  |     | 60  | ppm  |
| <b>ALL RATES/FORMATS</b>                           |   |      |     |     |      |
| Spurious emission in RX. Conducted measurement     | $f < 1\text{ GHz}$  |      | -67 |     | dBm  |
| Spurious emission in RX. Conducted measurement     | $f > 1\text{ GHz}$  |      | -57 |     | dBm  |

(7) AGC enabled

(8) Difference between center frequency of the received RF signal and local oscillator frequency

(9) Difference between incoming symbol rate and the internally generated symbol rate

## RF TRANSMIT SECTION

Measured on Texas Instruments CC2544EM reference design with  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ ,  $V_{BUS}$  tied to 5 V, and  $f_C = 2440\text{ MHz}$ , unless otherwise noted.

| PARAMETER                                       | TEST CONDITIONS   | MIN | TYP        | MAX | UNIT     |
|---|---|-----|------------|-----|----------|
| Output power, maximum setting                   | Delivered to a single-ended 50- $\Omega$ load through a balun using maximum recommended output power setting. |     | 4          |     | dBm      |
| Output power, minimum setting                   | Delivered to a single-ended 50- $\Omega$ load through a balun using minimum recommended output power setting. |     | -20        |     | dBm      |
| Programmable output power range                 | Delivered to a single-ended 50- $\Omega$ load through a balun.  |     | 24         |     | dB       |
| Spurious emission in TX. Conducted measurement. | $f < 1\text{ GHz}$  |     | -46        |     | dBm      |
| Spurious emission in TX. Conducted measurement. | $f > 1\text{ GHz}$  |     | -44        |     | dBm      |
| Optimum load impedance                          | Differential impedance as seen from the RF port (RF_P and RF_N) toward the antenna                            |     | $70 + j30$ |     | $\Omega$ |

## 32-MHz CRYSTAL OSCILLATOR

Measured on Texas Instruments CC2544EM reference design with  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ ,  $V_{BUS}$  tied to 5 V, unless otherwise noted.

| PARAMETER                              | TEST CONDITIONS  | MIN | TYP  | MAX | UNIT     |
|--|--|-----|------|-----|----------|
| Crystal frequency                      |  |     | 32   |     | MHz      |
| Crystal frequency accuracy requirement | 2-Mbps data rate   | –60 |      | 60  | ppm      |
| Equivalent series resistance           |  | 6   |      | 60  | $\Omega$ |
| Crystal shunt capacitance              |  | 1   |      | 7   | pF       |
| Crystal load capacitance               |  | 10  |      | 16  | pF       |
| Start-up time                          |  |     | 0.25 |     | ms       |
| Power-down guard time                  | The crystal oscillator must be in power down for a guard time before it is used again. This requirement is valid for all modes of operation. The need for power-down guard time can vary with crystal type and load. | 3   |      |     | ms       |

## 32-kHz RC OSCILLATOR

Measured on Texas Instruments CC2544EM reference design with  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ ,  $V_{BUS}$  tied to 5 V, unless otherwise noted.

| PARAMETER                                 | TEST CONDITIONS | MIN | TYP         | MAX | UNIT                |
|---|-----------------|-----|-------------|-----|---------------------|
| Calibrated frequency <sup>(1)</sup>       |                 |     | 32.753      |     | kHz                 |
| Frequency accuracy after calibration      |                 |     | $\pm 0.2\%$ |     |                     |
| Temperature coefficient <sup>(2)</sup>    |                 |     | 0.4         |     | $\%/^\circ\text{C}$ |
| Supply-voltage coefficient <sup>(3)</sup> |                 |     | 3           |     | $\%/V$              |
| Calibration time <sup>(4)</sup>           |                 |     | 2           |     | ms                  |

(1) The calibrated 32-kHz RC oscillator frequency is the 32-MHz XTAL frequency divided by 977.

(2) Frequency drift when temperature changes after calibration

(3) Frequency drift when supply voltage changes after calibration

(4) The 32-kHz RC oscillator is calibrated when a switch from the 16-MHz RC oscillator to the 32-MHz crystal oscillator is performed, while SLEEP\_CMD.OSC32K\_CALDIS is set to 0.

## 16-MHz RC OSCILLATOR

Measured on Texas Instruments CC2544EM reference design with  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ ,  $V_{BUS}$  tied to 5 V, unless otherwise noted.

| PARAMETER   | TEST CONDITIONS | MIN | TYP         | MAX | UNIT          |
|---|-----------------|-----|-------------|-----|---------------|
| Calibrated frequency                                |                 |     | 16          |     | MHz           |
| Uncalibrated frequency accuracy                     |                 |     | $\pm 18\%$  |     |               |
| Frequency accuracy after calibration <sup>(1)</sup> |                 |     | $\pm 0.6\%$ |     |               |
| Start-up time                                       |                 |     | 10          |     | $\mu\text{s}$ |
| Initial calibration time                            |                 |     | 50          |     | $\mu\text{s}$ |

(1) The calibrated 16-MHz RC oscillator frequency is the 32-MHz XTAL frequency divided by 2.

## RSSI CHARACTERISTICS

Measured on Texas Instruments CC2544 EM reference design with  $T_A = 25^\circ\text{C}$  and  $V_{DD} = 3\text{ V}$

| PARAMETER  | TEST CONDITIONS | MIN | TYP     | MAX | UNIT |
|--|-----------------|-----|---------|-----|------|
| <b>2 Mbps, GFSK, 320-kHz Deviation, 0.1% BER and 2 Mbps, GFSK, 500-kHz Deviation, 0.1% BER</b> |                 |     |         |     |      |
| RSSI range <sup>(1)</sup>  |                 |     | 60      |     | dB   |
| RSSI offset <sup>(1)</sup>   |                 |     | 97      |     | dBm  |
| Absolute uncalibrated accuracy <sup>(1)</sup>  |                 |     | $\pm 6$ |     | dB   |
| Step size (LSB value)  |                 |     | 1       |     | dB   |
| <b>All Other Rates/Formats</b>   |                 |     |         |     |      |
| RSSI range <sup>(1)</sup>  |                 |     | 60      |     | dB   |
| RSSI offset <sup>(1)</sup>   |                 |     | 101     |     | dBm  |
| Absolute uncalibrated accuracy <sup>(1)</sup>  |                 |     | $\pm 3$ |     | dB   |
| Step size (LSB value)  |                 |     | 1       |     | dB   |

(1) Assuming CC2544 EM reference design. Other RF designs give an offset from the reported value.

## FREQUENCY SYNTHESIZER CHARACTERISTICS

Measured on Texas Instruments CC2544EM reference design with  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ ,  $V_{BUS}$  tied to  $5\text{ V}$ , unless otherwise noted.

| PARAMETER                        | TEST CONDITIONS                    | MIN | TYP  | MAX | UNIT   |
|----------------------------------|------------------------------------|-----|------|-----|--------|
| Phase noise, unmodulated carrier | At $\pm 1\text{ MHz}$ from carrier |     | -112 |     | dBc/Hz |
|                                  | At $\pm 2\text{ MHz}$ from carrier |     | -119 |     |        |
|                                  | At $\pm 5\text{ MHz}$ from carrier |     | -124 |     |        |

## USB BUS 5-V to 3.3-V REGULATOR

Measured on Texas Instruments CC2544EM reference design with  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ ,  $V_{BUS}$  tied to  $5\text{ V}$ , unless otherwise noted.

| PARAMETER                      | TEST CONDITIONS | MIN | TYP  | MAX | UNIT |
|--------------------------------|-----------------|-----|------|-----|------|
| Input voltage, typical minimum |                 |     | 4    |     | V    |
| Input voltage, typical maximum |                 |     | 5.45 |     | V    |
| Current limit                  |                 |     | 100  |     | mA   |
| Start-up time                  |                 |     | 0.8  |     | ms   |
| Output voltage                 |                 |     | 3.3  |     | V    |



## DC CHARACTERISTICS

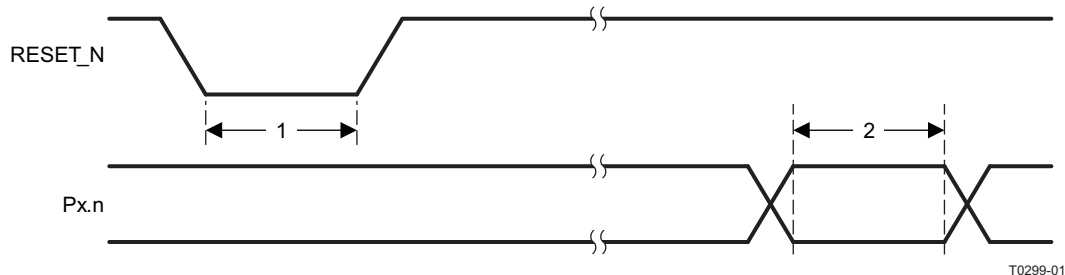
Measured on Texas Instruments CC2544EM reference design with  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ ,  $V_{BUS}$  tied to  $5\text{ V}$ , unless otherwise noted.

| PARAMETER                             | TEST CONDITIONS   | MIN | TYP | MAX | UNIT       |
|---------------------------------------|-------------------|-----|-----|-----|------------|
| Logic-0 input voltage                 |                   |     |     | 0.5 | V          |
| Logic-1 input voltage                 |                   | 2.5 |     |     | V          |
| Logic-0 input current                 |                   | –50 |     | 50  | nA         |
| Logic-1 input current                 |                   | –50 |     | 50  | nA         |
| I/O pin pullup and pulldown resistors |                   |     | 20  |     | k $\Omega$ |
| Logic-0 output voltage 4-mA pins      | Output load 4 mA  |     |     | 0.5 | V          |
| Logic-1 output voltage 4-mA pins      | Output load 4 mA  | 2.4 |     |     | V          |
| Logic-0 output voltage 20-mA pins     | Output load 20 mA |     |     | 0.5 | V          |
| Logic-1 output voltage, 20-A pins     | Output load 20 mA | 2.4 |     |     | V          |

## CONTROL INPUT AC CHARACTERISTICS

$T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ ,  $V_{DD} = 2\text{ V}$  to  $3.6\text{ V}$ .

| PARAMETER  | TEST CONDITIONS  | MIN | TYP | MAX | UNIT          |
|--|--|-----|-----|-----|---------------|
| System clock, $f_{\text{SYSCLK}}$<br>$t_{\text{SYSCLK}} = 1/f_{\text{SYSCLK}}$ | The undivided system clock is 32 MHz when crystal oscillator is used.<br>The undivided system clock is 16 MHz when calibrated 16-MHz RC oscillator is used.  | 16  |     | 32  | MHz           |
| RESET_N low duration   | See item 1, <a href="#">Figure 1</a> . This is the shortest pulse that is recognized as a complete reset pin request. Note that shorter pulses may be recognized but do not lead to complete reset of all modules within the chip. | 1   |     |     | $\mu\text{s}$ |
| Interrupt pulse duration   | See item 2, <a href="#">Figure 1</a> . This is the shortest pulse that is recognized as an interrupt request.  | 20  |     |     | ns            |



**Figure 1. Control Input AC Characteristics**

## SPI AC CHARACTERISTICS

$T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ ,  $V_{DD} = 2\text{ V}$  to  $3.6\text{ V}$

| PARAMETER   | TEST CONDITIONS      | MIN | TYP | MAX | UNIT |
|---|----------------------|-----|-----|-----|------|
| $t_1$ SCK period  | Master, RX and TX    | 250 |     |     | ns   |
|   | Slave, RX and TX     | 250 |     |     |      |
| SCK duty cycle  | Master               |     | 50% |     |      |
| $t_2$ SSN low to SCK, <a href="#">Figure 2</a> and <a href="#">Figure 3</a> | Master               | 63  |     |     | ns   |
|   | Slave                | 63  |     |     |      |
| $t_3$ SCK to SSN high   | Master               | 63  |     |     | ns   |
|   | Slave                | 63  |     |     |      |
| $t_4$ MOSI early out  | Master, load = 10 pF |     |     | 7   | ns   |
| $t_5$ MOSI late out   | Master, load = 10 pF |     |     | 10  | ns   |
| $t_6$ MISO setup  | Master               | 90  |     |     | ns   |
| $t_7$ MISO hold   | Master               | 10  |     |     | ns   |

## SPI AC CHARACTERISTICS (continued)

$T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ ,  $V_{DD} = 2\text{ V}$  to  $3.6\text{ V}$

| PARAMETER            | TEST CONDITIONS     | MIN | TYP | MAX | UNIT |
|----------------------|---------------------|-----|-----|-----|------|
| SCK duty cycle       | Slave               |     | 50% |     | ns   |
| $t_{10}$ MOSI setup  | Slave               | 35  |     |     | ns   |
| $t_{11}$ MOSI hold   | Slave               | 10  |     |     | ns   |
| $t_8$ MISO early out | Slave, load = 10 pF |     |     | 0   | ns   |
| $t_9$ MISO late out  | Slave, load = 10 pF |     |     | 95  | ns   |
| Operating frequency  | Master, TX only     |     |     | 8   | MHz  |
|                      | Master, RX and TX   |     |     | 4   |      |
|                      | Slave, RX only      |     |     | 8   |      |
|                      | Slave, RX and TX    |     |     | 4   |      |

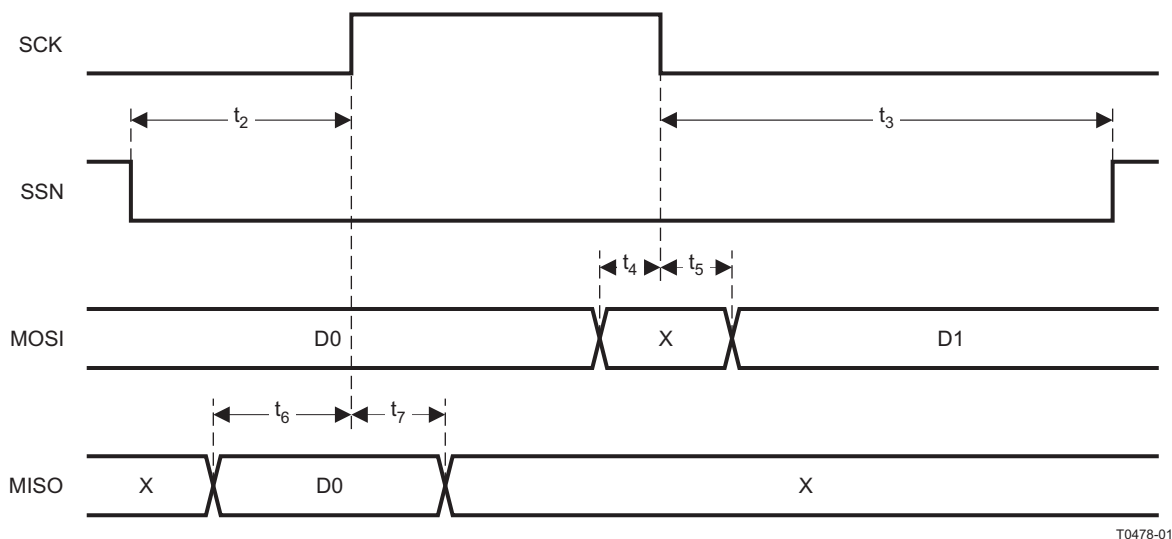


Figure 2. SPI Master AC Characteristics

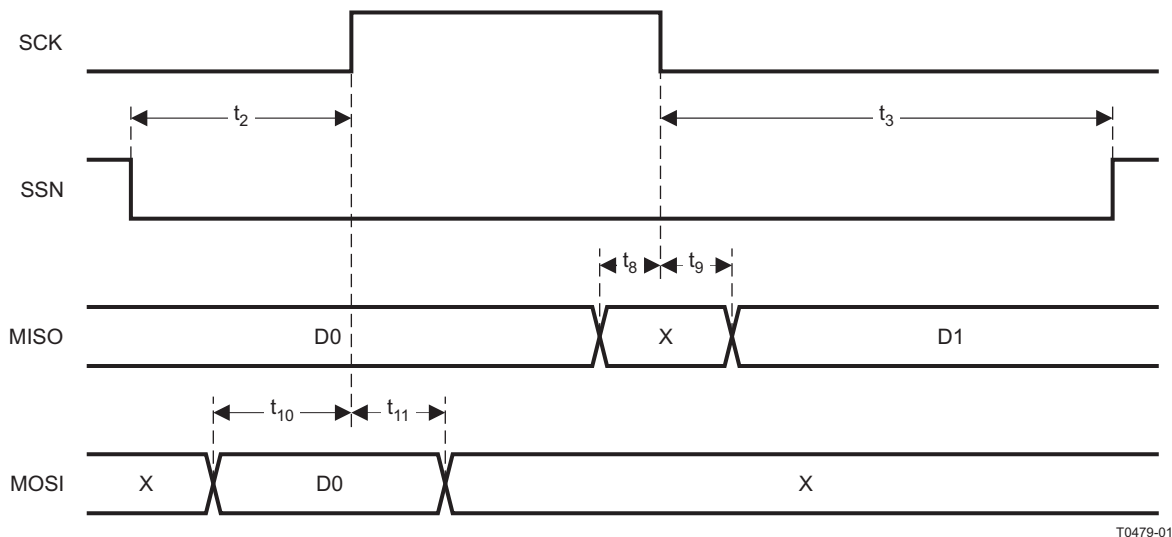
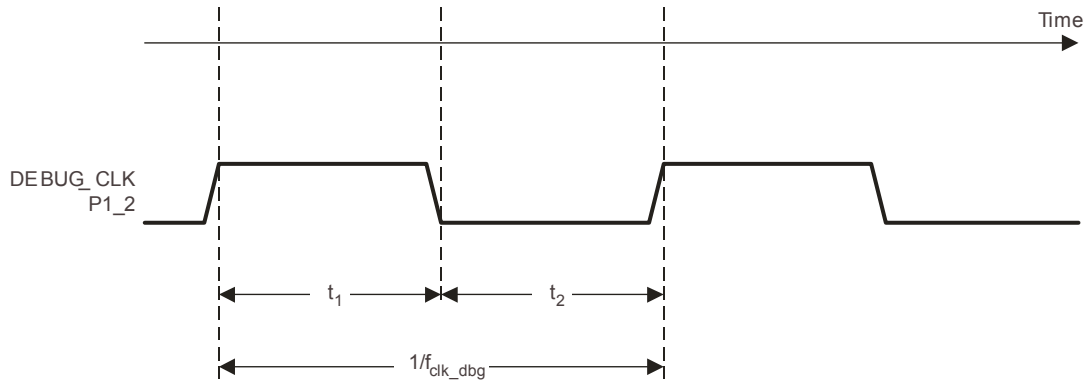


Figure 3. SPI Slave AC Characteristics

## DEBUG INTERFACE AC CHARACTERISTICS

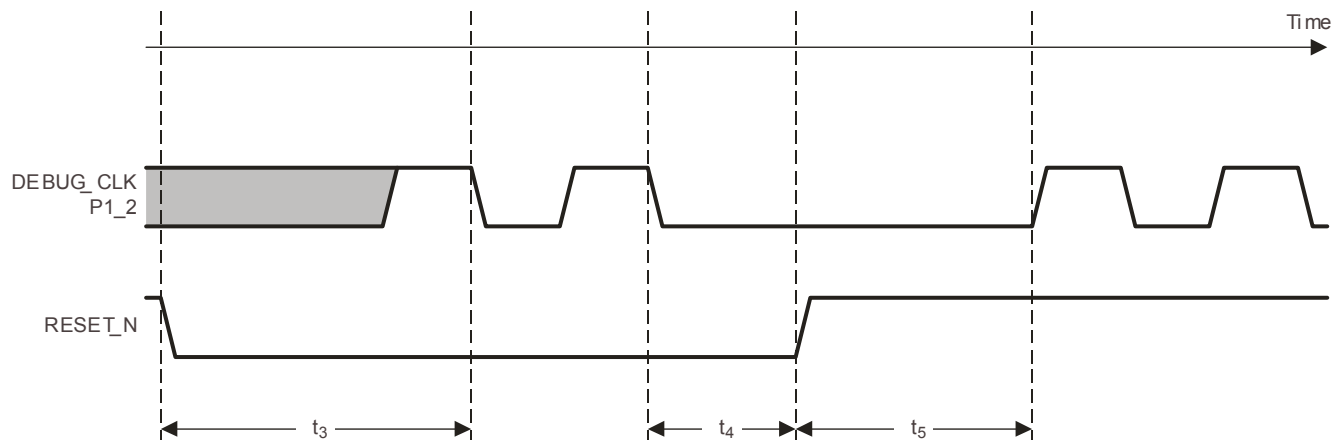
$T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ ,  $V_{DD} = 2\text{ V}$  to  $3.6\text{ V}$

| PARAMETER             | TEST CONDITIONS   | MIN | TYP | MAX | UNIT |
|-----------------------|---|-----|-----|-----|------|
| $f_{\text{clk\_dbg}}$ | Debug clock frequency (see Figure 4)                                |     |     | 12  | MHz  |
| $t_1$                 | Allowed high pulse on clock (see Figure 4)                          | 35  |     |     | ns   |
| $t_2$                 | Allowed low pulse on clock (see Figure 4)                           | 35  |     |     | ns   |
| $t_3$                 | EXT_RESET_N low to first falling edge on debug clock (see Figure 5) | 167 |     |     | ns   |
| $t_4$                 | Falling edge on clock to EXT_RESET_N high (see Figure 5)            | 83  |     |     | ns   |
| $t_5$                 | EXT_RESET_N high to first debug command (see Figure 5)              | 83  |     |     | ns   |
| $t_6$                 | Debug data setup (see Figure 6)                                     | 2   |     |     | ns   |
| $t_7$                 | Debug data hold (see Figure 6)                                      | 4   |     |     | ns   |
| $t_8$                 | Clock-to-data delay (see Figure 6)                                  |     |     | 30  | ns   |



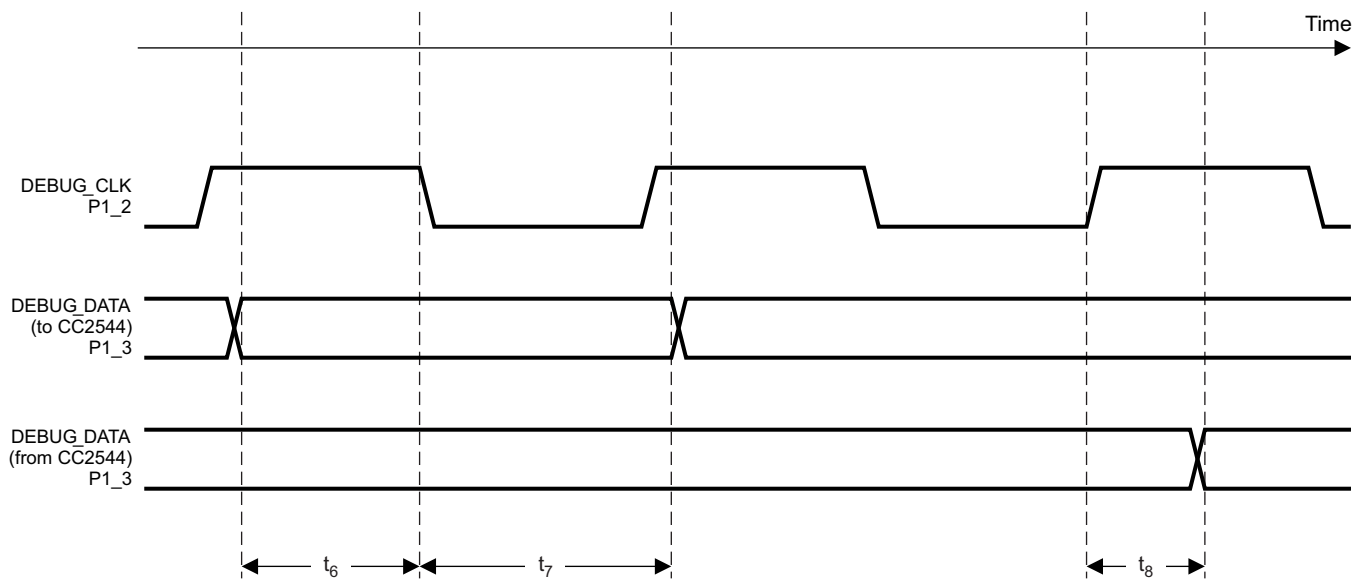
T0436-44

Figure 4. Debug Clock – Basic Timing



T0437-44

Figure 5. Debug Enable Timing



T0438-03

Figure 6. Data Setup and Hold Timing

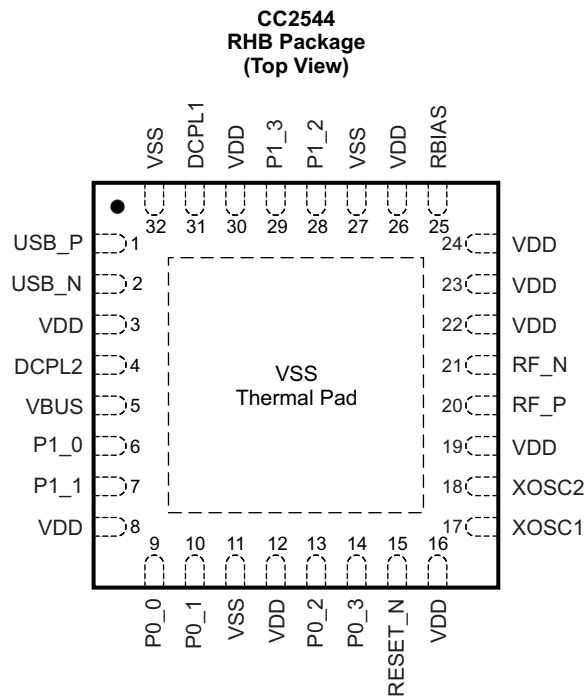
## TIMER INPUTS AC CHARACTERISTICS

 $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ ,  $V_{DD} = 2\text{ V}$  to  $3.6\text{ V}$ 

| PARAMETER                    | TEST CONDITIONS   | MIN | TYP | MAX | UNIT                |
|------------------------------|---|-----|-----|-----|---------------------|
| Input capture pulse duration | Synchronizers determine the shortest input pulse that can be recognized. The synchronizers operate at the current system clock rate (16 MHz or 32 MHz). | 1.5 |     |     | $t_{\text{SYSCLK}}$ |

## DEVICE INFORMATION

### PIN DESCRIPTIONS



P0048-19

NOTE: The exposed ground pad must be connected to a solid ground plane; this is the **main** ground connection for the chip.

**Table 1. Pin Description Table**

| NAME    | PIN                | DESCRIPTION  |
|---------|--------------------|--|
| DCPL1   | 31                 | 1.8-V reg. decouple  |
| DCPL2   | 4                  | 3.3-V reg. decouple  |
| P0_0    | 9                  | GPIO   |
| P0_1    | 10                 | GPIO   |
| P0_2    | 13                 | GPIO   |
| P0_3    | 14                 | GPIO   |
| P1_0    | 6                  | GPIO/20 mA   |
| P1_1    | 7                  | GPIO/20 mA   |
| P1_2    | 28                 | GPIO/debug clock   |
| P1_3    | 29                 | GPIO/debug data  |
| RBIAS   | 25                 | External precision bias resistor for reference current                                   |
| RESET_N | 15                 | Reset, active-low  |
| RF_N    | 21                 | Negative RF input signal to LNA during RX<br>Negative RF output signal from PA during TX |
| RF_P    | 20                 | Positive RF input signal to LNA during RX<br>Positive RF output signal from PA during TX |
| USB_P   | 1                  | USB module   |
| USB_N   | 2                  | USB module   |
| VBUS    | 5                  | 5-V power  |
| VDD     | 3                  | AVDD   |
| VDD     | 8, 12              | IOVDD  |
| VDD     | 16, 19, 22, 23, 24 | AVDD   |

**Table 1. Pin Description Table (continued)**

| NAME  | PIN        | DESCRIPTION   |
|-------|------------|---|
| VDD   | 26         | AVDD_GUARD  |
| VDD   | 30         | IOVDD   |
| VSS   | 11, 27     | Optional IOVSS  |
| VSS   | 32         | USB ground  |
| VSS   | Ground pad | Must be connected to solid ground as this is the main ground connection for the chip. |
| XOSC1 | 17         | 32-MHz crystal oscillator pin 1 or external-clock input                               |
| XOSC2 | 18         | 32-MHz crystal oscillator pin 2   |

## BLOCK DIAGRAM

A block diagram of the CC2544 is shown in Figure 7. The modules can be roughly divided into one of three categories: CPU-related modules; modules related to power, test, and clock distribution; and radio-related modules. In the following subsections, a short description of each module is given. For more details, see the CC2543/44/45 User's Guide (SWRU283).

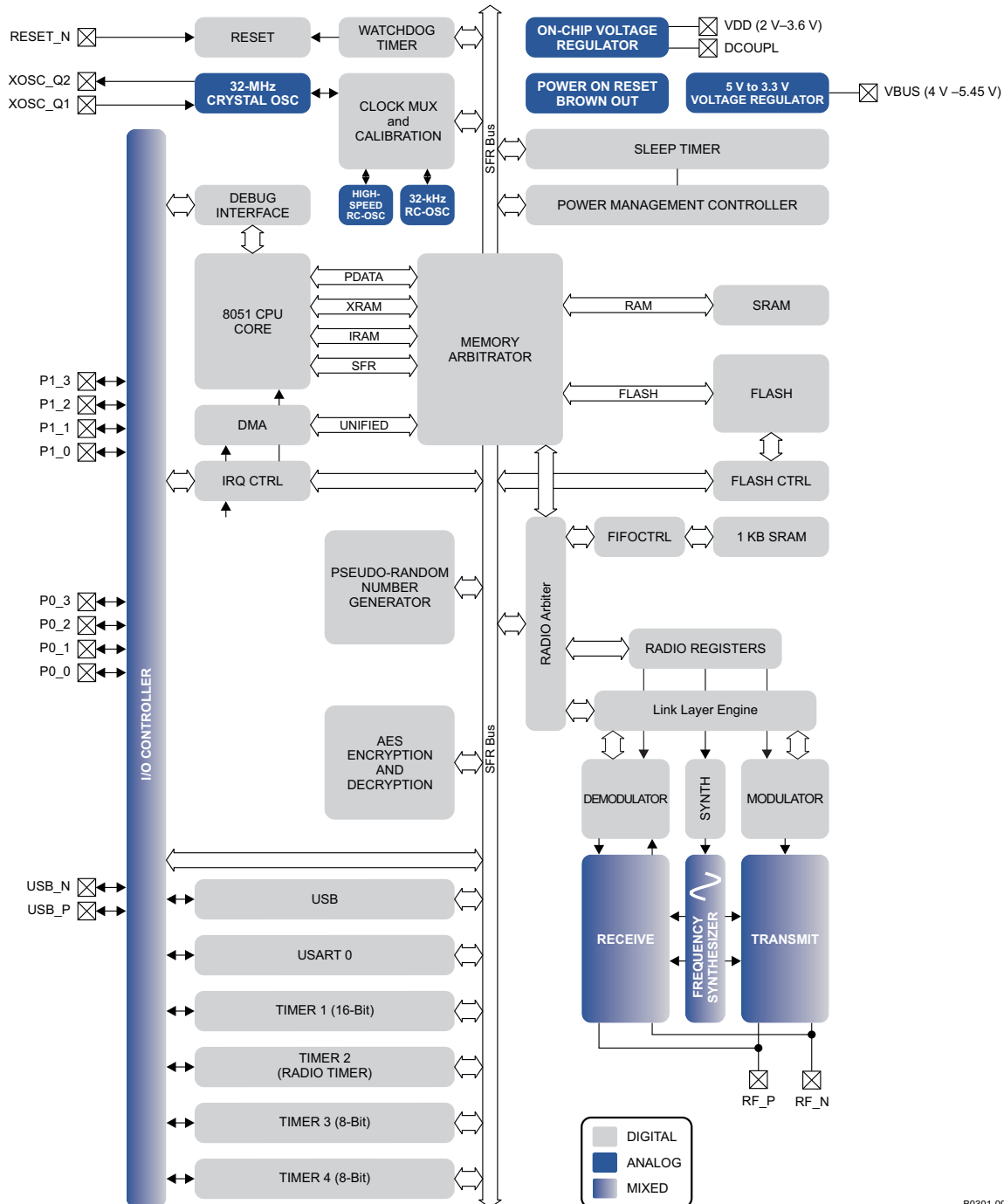


Figure 7. CC2544 Block Diagram

B0301-09

## BLOCK DESCRIPTIONS

### CPU and Memory

The **8051 CPU core** is a single-cycle 8051-compatible core. It has three different memory access busses (SFR, DATA, and CODE/XDATA), a debug interface, and an 15-input extended interrupt unit.

The **memory arbiter** is at the heart of the system, as it connects the CPU and DMA controller with the physical memories and all peripherals through the SFR bus. The memory arbiter has four memory-access points, access of which can map to one of three physical memories: an SRAM, flash memory, and XREG/SFR registers. It is responsible for performing arbitration and sequencing between simultaneous memory accesses to the same physical memory.

The **SFR bus** is drawn conceptually in [Figure 7](#) as a common bus that connects all hardware peripherals to the memory arbiter. The SFR bus in the block diagram also provides access to the radio registers in the radio register bank, even though these are indeed mapped into XDATA memory space.

The **2-KB SRAM** maps to the DATA memory space and to parts of the XDATA memory spaces.

The **32-KB flash block** provides in-circuit programmable non-volatile program memory for the device, and maps into the CODE and XDATA memory spaces.

### Peripherals

Writing to the flash block is performed through a **flash controller** that allows page-wise erasure and 4-bytewise programming. See User Guide for details on the flash controller.

A versatile two-channel **DMA controller** is available in the system, accesses memory using the XDATA memory space, and thus has access to all physical memories. Each channel (trigger, priority, transfer mode, addressing mode, source and destination pointers, and transfer count) is configured with DMA descriptors that can be located anywhere in memory. Many of the hardware peripherals (AES core, flash controller, USART, timers, etc.) can be used with the DMA controller for efficient operation by performing data transfers between a single SFR or XREG address and flash/SRAM.

The **interrupt controller** services a total of 15 interrupt sources, divided into six interrupt groups, each of which is associated with one of four interrupt priorities. Any interrupt service request is serviced also when the device is in idle mode by going back to active mode. Some interrupts can also wake up the device from sleep mode (when in sleep mode, the device is in low-power mode PM1).

The **debug interface** implements a proprietary two-wire serial interface that is used for in-circuit debugging. Through this debug interface, it is possible to perform an erasure of the entire flash memory, control which oscillators are enabled, stop and start execution of the user program, execute supplied instructions on the 8051 core, set code breakpoints, and single-step through instructions in the code. Using these techniques, it is possible to perform in-circuit debugging and external flash programming elegantly.

The **I/O controller** is responsible for all general-purpose I/O pins. The CPU can configure whether peripheral modules control certain pins or whether they are under software control, and if so, whether each pin is configured as an input or output and if a pullup or pulldown resistor in the pad is connected. Each peripheral that connects to the I/O pins can choose between several different I/O pin locations to ensure flexibility in various applications.

The **sleep timer** is an ultralow-power timer that uses an internal 32.753-kHz RC oscillator. The sleep timer runs continuously in all operating modes. Typical applications of this timer are as a real-time counter or as a wake-up timer to get out of power mode 1.

A built-in **watchdog timer** allows the CC2544 to reset itself if the firmware hangs. When enabled by software, the watchdog timer must be cleared periodically; otherwise, it resets the device when it times out.

**Timer 1** is a 16-bit timer with timer/counter/PWM functionality. It has a programmable prescaler, a 16-bit period value, and five individually programmable counter/capture channels, each with a 16-bit compare value. Each of the counter/capture channels can be used as a PWM output or to capture the timing of edges on input signals. It can also be configured in IR generation mode, where it counts timer 3 periods and the output is ANDed with the output of timer 3 to generate modulated consumer IR signals with minimal CPU interaction.



**Timer 2** is a 40-bit timer used by the Radio. It has a 16-bit counter with a configurable timer period and a 24-bit overflow counter that can be used to keep track of the number of periods that have transpired. A 40-bit capture register is also used to record the exact time at which a start-of-frame delimiter is received/transmitted or the exact time at which a packet ends. There are two 16-bit timer-compare registers and two 24-bit overflow-compare registers that can be used to give exact timing for start of RX or TX to the radio or general interrupts.

**Timer 3 and timer 4** are 8-bit timers with timer/counter/PWM functionality. They have a programmable prescaler, an 8-bit period value, and one programmable counter channel with an 8-bit compare value. Each of the counter channels can be used as PWM output.

**USART 0** is configurable as either an SPI master/slave or a UART. It provides double buffering on both RX and TX and hardware flow control and is thus well suited to high-throughput full-duplex applications. The USART has its own high-precision baud-rate generator, thus leaving the ordinary timers free for other uses. When configured as SPI slaves, the USART samples the input signal using SCK directly instead of using some oversampling scheme, and are thus well-suited for high data rates.

The **AES encryption/decryption core** allows the user to encrypt and decrypt data using the AES algorithm with 128-bit keys. The AES core also supports ECB, CBC, CFB, OFB, CTR, and CBC-MAC, as well as hardware support for CCM.

## TYPICAL CHARACTERISTICS

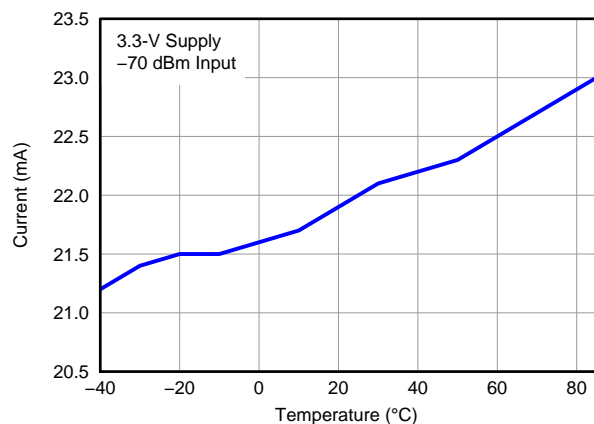
RX CURRENT  
vs  
TEMPERATURE

Figure 8.

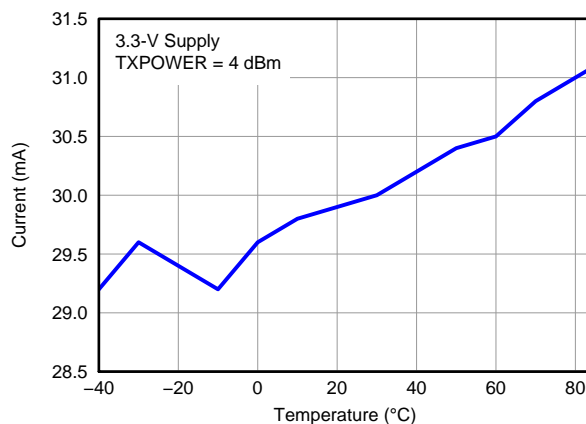
TX CURRENT  
vs  
TEMPERATURE

Figure 9.

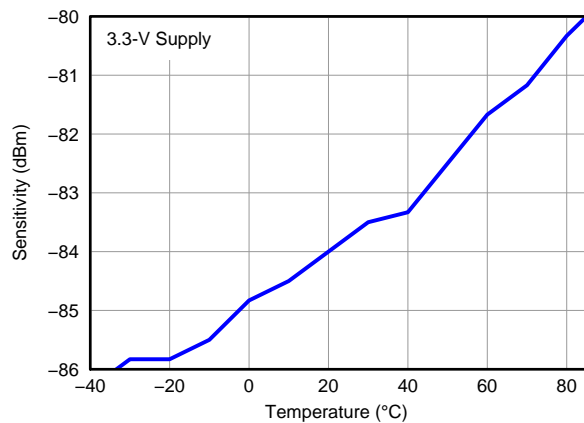
RX SENSITIVITY  
vs  
TEMPERATURE

Figure 10.

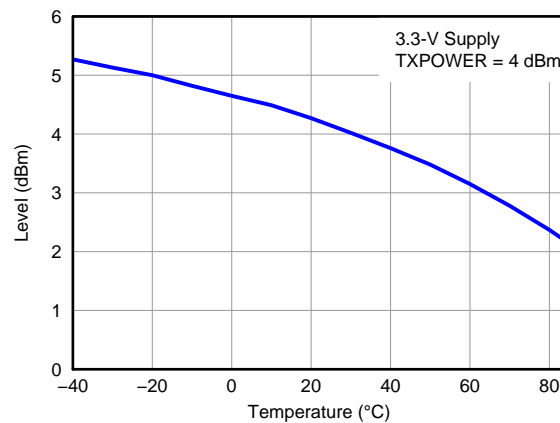
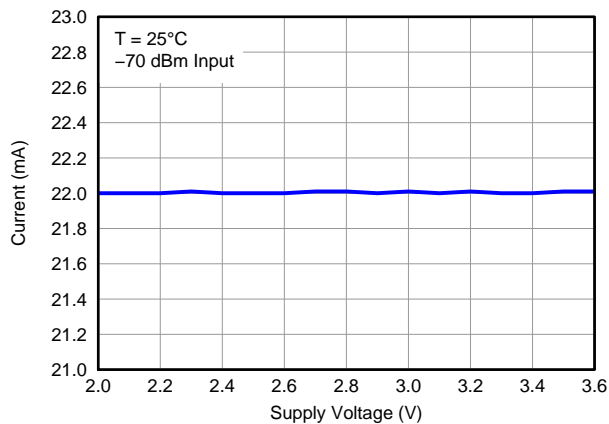
TX POWER  
vs  
TEMPERATURE

Figure 11.

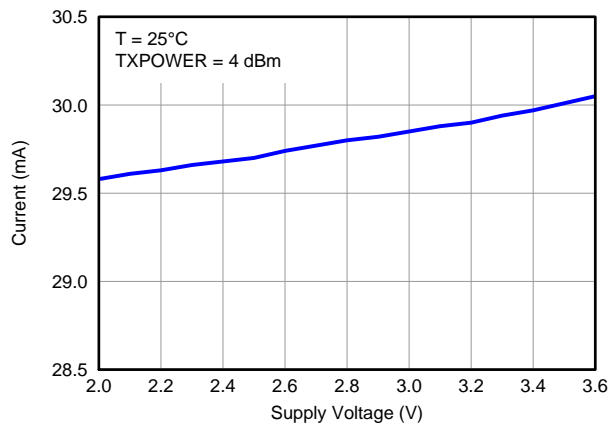
## TYPICAL CHARACTERISTICS (continued)

**RX CURRENT  
vs  
SUPPLY VOLTAGE**



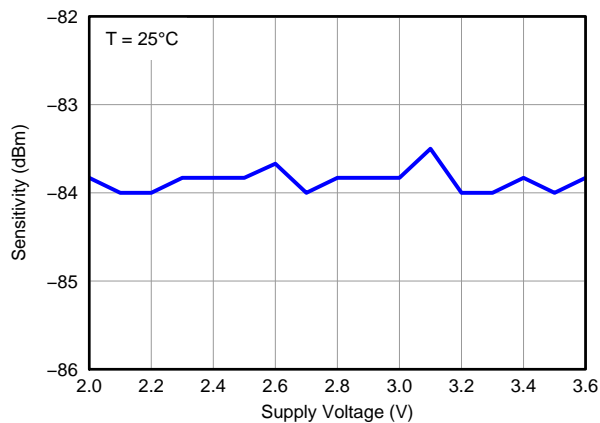
**Figure 12.**

**TX CURRENT  
vs  
SUPPLY VOLTAGE**



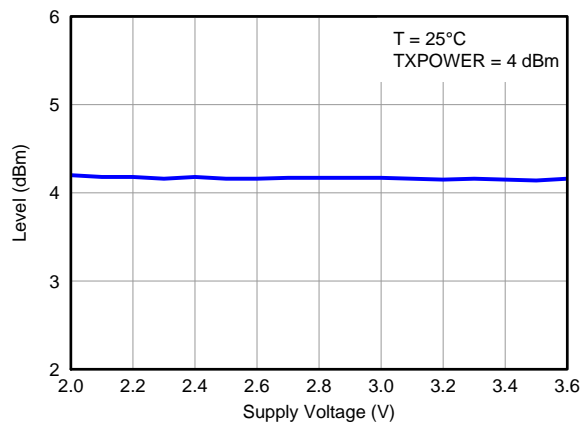
**Figure 13.**

**RX SENSITIVITY  
vs  
SUPPLY VOLTAGE**



**Figure 14.**

**TX POWER  
vs  
SUPPLY VOLTAGE**



**Figure 15.**

## TYPICAL CHARACTERISTICS (continued)

**RX SENSITIVITY  
vs  
FREQUENCY**

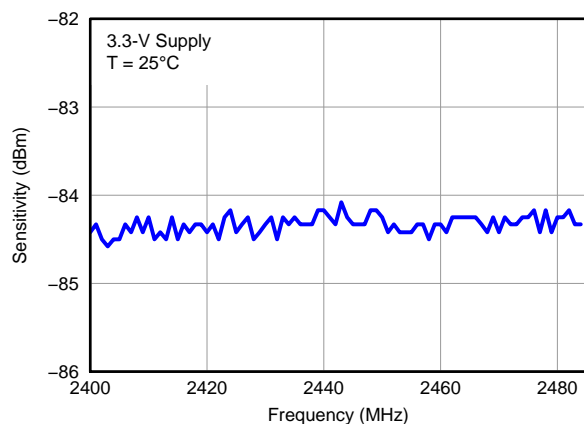


Figure 16.

**TX POWER  
vs  
FREQUENCY**

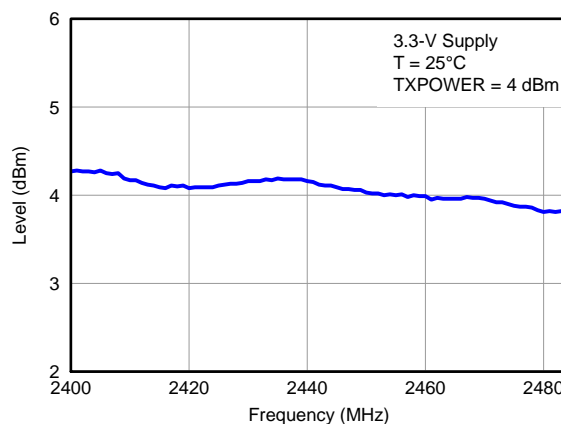


Figure 17.

**RX INTERFERER REJECTION (SELECTIVITY)  
vs  
INTERFERER FREQUENCY**

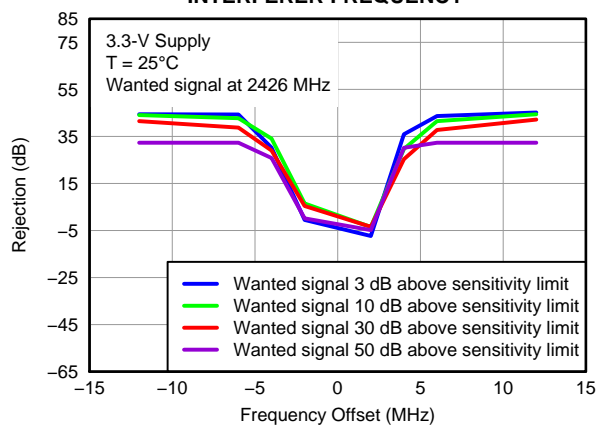
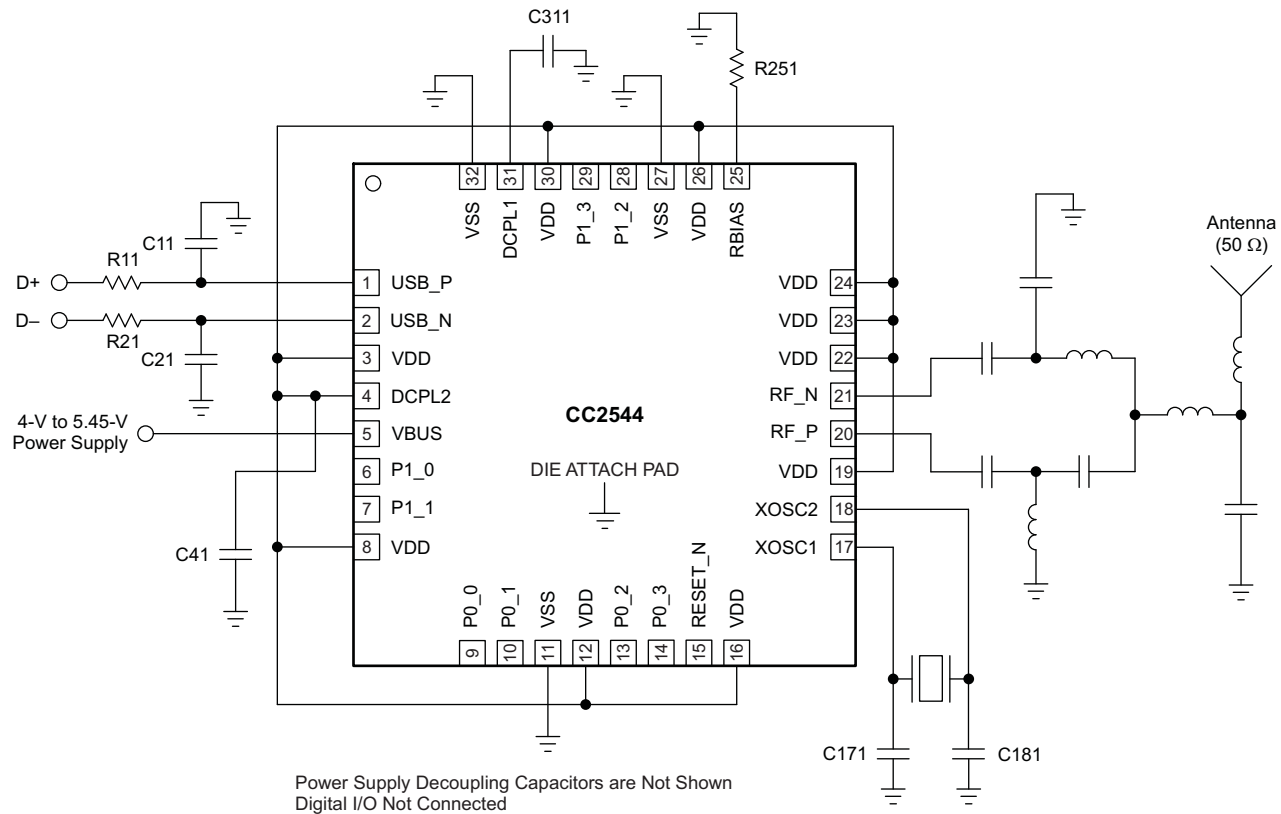


Figure 18.

## APPLICATION INFORMATION

Few external components are required for the operation of the CC2544. A typical application circuit is shown in [Figure 19](#). For suggestions of component values other than those listed in [Table 2](#), see reference design CC2544EM. The performance stated in this data sheet is only valid for the CC2544EM reference design. To obtain similar performance, the reference design should be copied as closely as possible.



### Figure 19. CC2544 Application Circuit

S0383-06

**Table 2. Overview of External Components (Excluding Balun, Crystal and Supply Decoupling Capacitors)**

| Component | Description   | Value |
|-----------|---|-------|
| C11       | USB D+ decoupling   | 47 pF |
| C21       | USB D– decoupling   | 47 pF |
| C41       | Decoupling capacitor for the internal 5V-3.3V digital voltage regulator | 1 μF  |
| C311      | Decoupling capacitor for the internal 1.8V digital voltage regulator    | 1 μF  |
| R11       | USB D+ series resistor  | 33 Ω  |
| R21       | USB D– series resistor  | 33 Ω  |
| R251      | Precision resistor ±1%, used for internal biasing                       | 56 kΩ |

## Input/Output Matching

When using an unbalanced antenna such as a monopole, a balun should be used to optimize performance. The balun can be implemented using low-cost discrete inductors and capacitors. See reference design, CC2544EM, for recommended balun.

## Crystal

An external 32-MHz crystal with two loading capacitors is used for the 32-MHz crystal oscillator. The load capacitance seen by the 32-MHz crystal is given by:

$$C_L = \frac{1}{\frac{1}{C_{171}} + \frac{1}{C_{181}}} + C_{\text{parasitic}} \quad (1)$$

A series resistor may be used to comply with ESR requirement.

## On-Chip 1.8-V Voltage Regulator Decoupling

The 1.8-V on-chip voltage regulator supplies the 1.8-V digital logic. This regulator requires a decoupling capacitor (C311) for stable operation.

## On-Chip 5-V to 3.3-V USB Voltage Regulator Decoupling

The 5-V to 3.3-V on-chip voltage regulator supplies the 1.8-V on-chip voltage regulator. This regulator requires a decoupling capacitor (C41) for stable operation.

## Power-Supply Decoupling and Filtering

Proper power-supply decoupling must be used for optimum performance. The placement and size of the decoupling capacitors and the power supply filtering are very important to achieve the best performance in an application. TI provides a compact reference design that should be followed very closely.

## REVISION HISTORY

| Changes from Original (June 2011) to Revision A      | Page |
|--|------|
| • 对产品预览数据表的改变 .....                                  | 1    |
| Changes from Revision A (March 2012) to Revision B   | Page |
| • 从：( 2Mbps 时为 -84dBm ) 改为：( 2Mbps 时为 -88dBm ) ..... | 1    |
| Changes from Revision B (April 2012) to Revision C   | Page |
| • 将器件状态从：预览改为：生产 .....                               | 1    |
| Changes from Revision C (April 2012) to Revision D   | Page |
| • 添加了说明 .....  | 2    |

## PACKAGING INFORMATION

| Orderable part number      | Status<br>(1) | Material type<br>(2) | Package   Pins  | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|----------------------------|---------------|----------------------|-----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">CC2544RHBR</a> | Active        | Production           | VQFN (RHB)   32 | 3000   LARGE T&R      | Yes         | NIPDAU   NIPDAUAG                    | Level-3-260C-168 HR               | -40 to 125   | CC2544              |
| CC2544RHBR.A               | Active        | Production           | VQFN (RHB)   32 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 125   | CC2544              |
| CC2544RHBR.B               | Active        | Production           | VQFN (RHB)   32 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 125   | CC2544              |
| <a href="#">CC2544RHBT</a> | Active        | Production           | VQFN (RHB)   32 | 250   SMALL T&R       | Yes         | NIPDAU   NIPDAUAG                    | Level-3-260C-168 HR               | -40 to 125   | CC2544              |
| CC2544RHBT.A               | Active        | Production           | VQFN (RHB)   32 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 125   | CC2544              |
| CC2544RHBT.B               | Active        | Production           | VQFN (RHB)   32 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 125   | CC2544              |

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

(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.

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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## 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) | K0 (μm) | P1 (mm) | CL (mm) | CW (mm) |
|--------------|--------------|--------------|------|------|-------------------|----------------------|--------|--------|---------|---------|---------|---------|
| CC2544RHBR   | RHB          | VQFN         | 32   | 3000 | 14 x 35           | 150                  | 315    | 135.9  | 7620    | 8.8     | 7.9     | 8.15    |
| CC2544RHBR.A | RHB          | VQFN         | 32   | 3000 | 14 x 35           | 150                  | 315    | 135.9  | 7620    | 8.8     | 7.9     | 8.15    |
| CC2544RHBR.B | RHB          | VQFN         | 32   | 3000 | 14 x 35           | 150                  | 315    | 135.9  | 7620    | 8.8     | 7.9     | 8.15    |
| CC2544RHBT   | RHB          | VQFN         | 32   | 250  | 14 x 35           | 150                  | 315    | 135.9  | 7620    | 8.8     | 7.9     | 8.15    |
| CC2544RHBT.A | RHB          | VQFN         | 32   | 250  | 14 x 35           | 150                  | 315    | 135.9  | 7620    | 8.8     | 7.9     | 8.15    |
| CC2544RHBT.B | RHB          | VQFN         | 32   | 250  | 14 x 35           | 150                  | 315    | 135.9  | 7620    | 8.8     | 7.9     | 8.15    |

## GENERIC PACKAGE VIEW

**RHB 32**

**VQFN - 1 mm max height**

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.

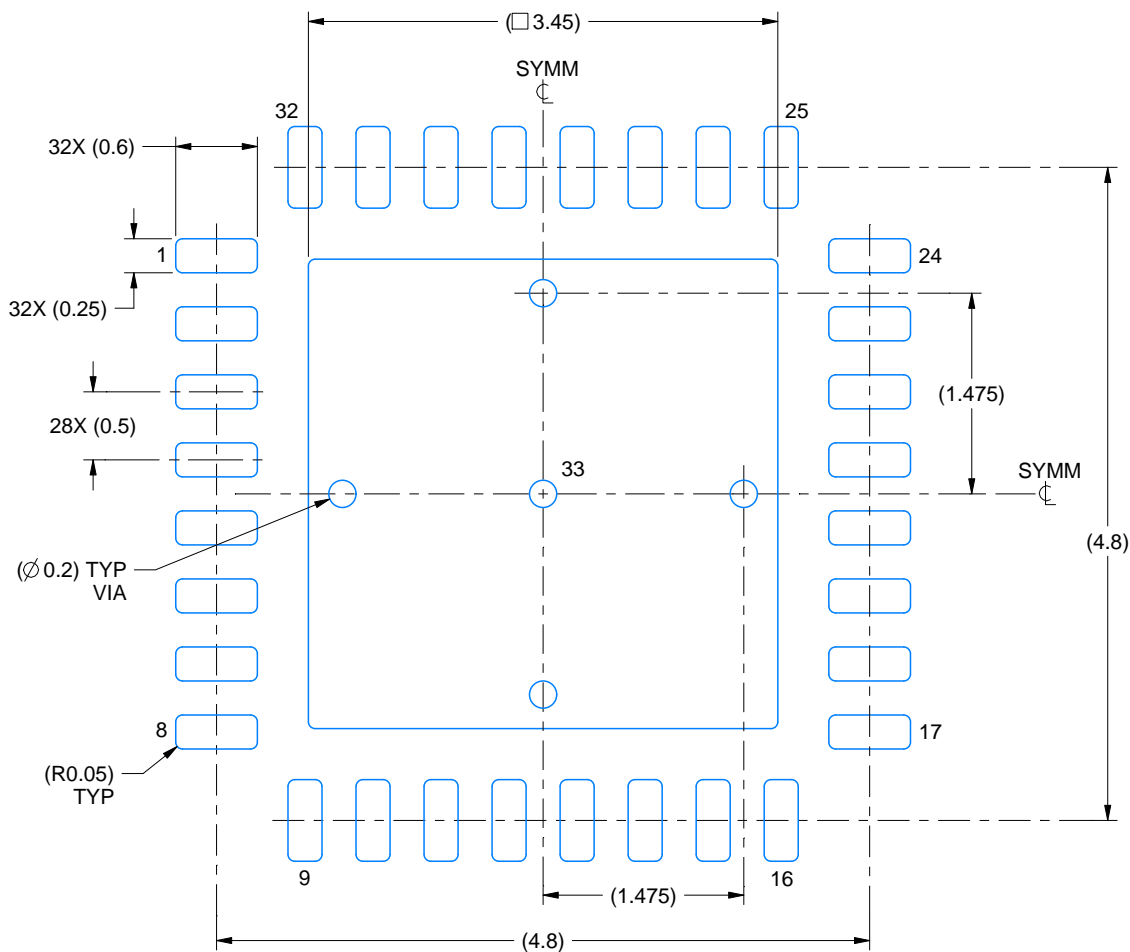
4224745/A

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.

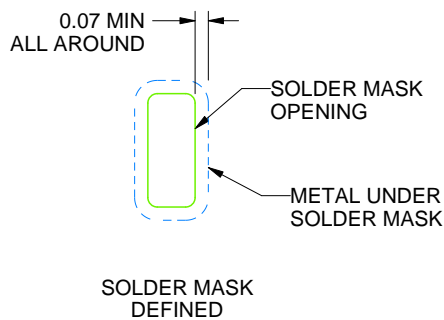
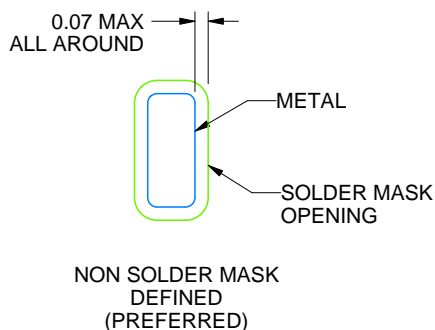
**RHB0032E**

### VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE  
SCALE:18X



## SOLDER MASK DETAILS

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NOTES: (continued)

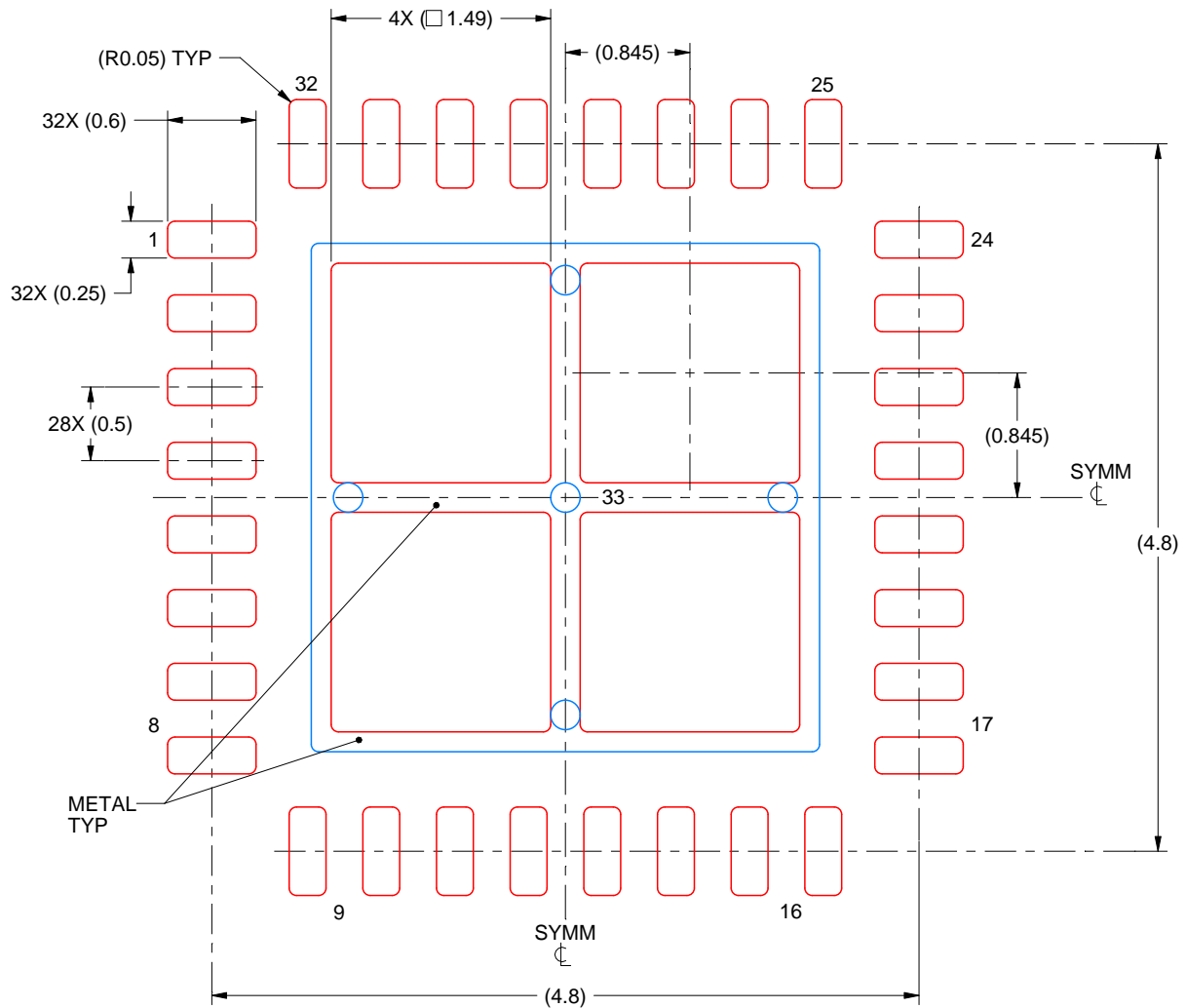
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented,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

# EXAMPLE STENCIL DESIGN

RHB0032E

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



**SOLDER PASTE EXAMPLE**  
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 33:  
75% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
SCALE:20X

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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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