19-0806; Rev 1; 11/08

EVALUATION KIT AVAILABLE

# 2.3GHz to 2.7GHz Wireless Broadband RF Transceiver



## General Description

The MAX2837 direct-conversion zero-IF RF transceiver is designed specifically for 2.3GHz to 2.7GHz wireless broadband systems. The MAX2837 completely integrates all circuitry required to implement the RF transceiver function, providing RF-to-baseband receive path; and baseband-to-RF transmit path, VCO, frequency synthesizer, crystal oscillator, and baseband/control interface. The device includes a fast-settling sigma-delta RF synthesizer with smaller than 20Hz frequency steps and a crystal oscillator, which allows the use of a low-cost crystal in place of a TCXO. The transceiver IC also integrates circuits for on-chip DC offset cancellation, I/Q error, and carrier-leakage detection circuits. Only an RF bandpass filter (BPF), crystal, RF switch, PA, and a small number of passive components are needed to form a complete wireless broadband RF radio solution.

The MAX2837 completely eliminates the need for an external SAW filter by implementing on-chip monolithic filters for both the receiver and transmitter. The baseband filters along with the Rx and Tx signal paths are optimized to meet stringent noise figure and linearity specifications. The device supports up to 2048 FFT OFDM and implements programmable channel filters for 1.75MHz to 28MHz RF channel bandwidths. The transceiver requires only 2µs Tx-Rx switching time, which includes frequency transient settling. The IC is available in a small, 48-pin thin QFN package measuring only 6mm x 6mm x 0.8mm.

## Applications

802.16-2004 Fixed WiMAX

Korea Wibro and 802.16e Mobile WiMAX

Dual Mode™ WiMAX/802.11b/g Wi-Fi

Proprietary Wireless Broadband Systems

4G/LTE Systems

*Dual Mode is a trademark of Maxim Integrated Products, Inc.*

*SPI is a trademark of Motorola, Inc.*

## Features

- **2.3GHz to 2.7GHz Wideband Operation**
- **Complete RF Transceiver, PA Driver, and Crystal Oscillator**
  - **0dBm Linear OFDM Transmit Power**
  - **-70dBr Tx Spectral Emission Mask**
  - **2.3dB Rx Noise Figure**
  - **Tx/Rx I/Q Error and LO Leakage Detection**
  - **Monolithic Low-Noise VCO with -39dBc Integrated Phase Noise**
  - **Programmable Tx I/Q Lowpass Anti-Aliasing Filter**
  - **Sigma-Delta Fractional-N PLL with 20Hz Step Size**
  - **45dB Tx Gain-Control Range**
  - **94dB Receive Gain-Control Range**
  - **60dB Analog RSSI Instantaneous Dynamic Range**
  - **4-Wire SPI™ Digital Interface**
  - **I/Q Analog Baseband Interface**
  - **Digitally Tuned Crystal Oscillator**
  - **On-Chip Digital Temperature Sensor Read-Out**
- **+2.7V to +3.6V Transceiver Supply**
- **Low-Power Shutdown Current**
- **Small 48-Pin Thin QFN Package (6mm x 6mm x 0.8mm)**

## Ordering Information

| PART | TEMP RANGE | PIN-PACKAGE |
|---|---|---|
| MAX2837ETM+TD | -40°C to +85°C | 48 TQFN-EP* |

**EP = Exposed paddle.*

*+Denotes a lead-free package.*

***Pin Configuration appears at end of data sheet.***



**For information on other Maxim products, visit Maxim's website at www.maxim-ic.com.**

# 2.3GHz to 2.7GHz Wireless Broadband RF Transceiver

## ABSOLUTE MAXIMUM RATINGS

$V_{CCLNA}$, $V_{CCTXMX}$, $V_{CCTXPAD}$, $V_{CCDIG}$, $V_{CCCP}$, $V_{CCXTAL}$, $V_{CCVCO}$, $V_{CCRXVGA}$, $V_{CCRXFL}$ and $V_{CCRXMX}$ to GND.....-0.3V to +3.9V

B1–B7, TXRF_, $\overline{CS}$, SCLK, DIN, DOUT, TXBBI_, TXBBQ_, RXHP, RXBBI_, RXBBQ_, RSSI, ENABLE, BYPASS, CPOUT_, CLOCKOUT, XTAL1, XTAL2, RXRF_,RXENABLE, TXENABLE to GND.....-0.3V to (Operating $V_{CC}$ + 0.3V)

RXBBI_, RXBBQ_, RSSI, BYPASS, CPOUT_, DOUT, CLOCKOUT, PABIAS Short-Circuit Duration.....10s

RF Input Power .....+10dBm

Continuous Power Dissipation ($T_A$ = +70°C)
48-Pin Thin QFN (derates 37mW/°C above +70°C).....2.96W

Operating Temperature Range .....-40°C to +85°C

Junction Temperature.....+150°C

Storage Temperature Range .....-65°C to +160°C

Lead Temperature (soldering, 10s) .....+260°C

**CAUTION!** ESD SENSITIVE DEVICE

*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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

## DC ELECTRICAL CHARACTERISTICS

(MAX2837 evaluation kit: $V_{CC_}$ = 2.7V to 3.6V, Rx set to the maximum gain; $\overline{CS}$ = high, RXHP = SCLK = DIN = low, RSSI and clock output buffer are off, no signal at RF inputs, all RF inputs and outputs terminated into 50Ω, receiver baseband outputs are open; 90$mV_{RMS}$ differential I and Q signals applied to I, Q baseband inputs of transmitter in transmit mode, $f_{REF}$ = 40MHz, registers set to recommended settings and corresponding test mode, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are at $V_{CC}$ = 2.8V, $f_{LO}$ = 2.5GHz, and $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| Supply Voltage | $V_{CC_}$ | 2.7 | | 3.6 | V |
| Supply Current | Shutdown mode, $T_A$ = +25°C | | 10 | | µA |
| | Standby mode | | 35 | 45 | mA |
| | Rx mode | | 91 | 110 | |
| | Tx mode, $T_A$ = +25°C | | 145 | 170 | |
| | Rx calibration mode | | 135 | 160 | |
| | Tx calibration mode | | 110 | 135 | |
| Rx I/Q Output Common-Mode Voltage | D9:D8 = 00 in A4:A0 = 00100 | 0.85 | 1.0 | 1.20 | V |
| | D9:D8 = 01 in A4:A0 = 00100 | | 1.1 | | |
| | D9:D8 = 10 in A4:A0 = 00100 | | 1.2 | | |
| | D9:D8 = 11 in A4:A0 = 00100 | | 1.35 | | |
| Tx Baseband Input Common-Mode Voltage Operating Range | DC-coupled | 0.5 | | 1.2 | V |
| Tx Baseband Input Bias Current | Source current | | 10 | 20 | µA |
| **LOGIC INPUTS: ENABLE, TXENABLE, RXENABLE, SCLK, DIN, $\overline{CS}$, B7:B1, RXHP** | | | | | |
| Digital Input-Voltage High, $V_{IH}$ | | $V_{CC}$ - 0.4 | | | V |
| Digital Input-Voltage Low, $V_{IL}$ | | | | 0.4 | V |
| Digital Input-Current High, $I_{IH}$ | | -1 | | +1 | µA |
| Digital Input-Current Low, $I_{IL}$ | | -1 | | +1 | µA |

## DC ELECTRICAL CHARACTERISTICS (continued)

(MAX2837 evaluation kit: $V_{CC_}$ = 2.7V to 3.6V, Rx set to the maximum gain; $\overline{CS}$ = high, RXHP = SCLK = DIN = low, RSSI and clock output buffer are off, no signal at RF inputs, all RF inputs and outputs terminated into 50Ω, receiver baseband outputs are open; 90$mV_{RMS}$ differential I and Q signals applied to I, Q baseband inputs of transmitter in transmit mode, $f_{REF}$ = 40MHz, registers set to recommended settings and corresponding test mode, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are at $V_{CC}$ = 2.8V, $f_{LO}$ = 2.5GHz, and $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| **LOGIC OUTPUTS: DOUT** | | | | | |
| Digital Output-Voltage High, $V_{OH}$ | Sourcing 100µA | $V_{CC}$ - 0.4 | | | V |
| Digital Output-Voltage Low, $V_{OL}$ | Sinking 100µA | | | 0.4 | V |

## AC ELECTRICAL CHARACTERISTICS—Rx MODE

(MAX2837 evaluation kit: $V_{CC_}$ = 2.8V, $f_{RF}$ = 2.502GHz, $f_{LO}$ = 2.5GHz; receiver baseband I/Q outputs at 90$mV_{RMS}$ (-21dBV), $f_{REF}$ = 40MHz, ENABLE = RXENABLE = $\overline{CS}$ = high, TXENABLE = SCLK = DIN = low, with power matching for the differential RF pins using the typical applications and registers set to default settings and corresponding test mode, $T_A$ = +25°C, unless otherwise noted. Lowpass filter is set to 10MHz RF channel BW. Unmodulated single-tone RF input signal is used, unless otherwise indicated.) (Note 1)

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **RECEIVER SECTION: LNA RF INPUT TO BASEBAND I/Q OUTPUTS** | | | | | | |
| RF Input Frequency Range | | | 2.3 | | 2.7 | GHz |
| Peak-to-Peak Gain Variation over RF Input Frequency Range | Tested at band edges and band center | | | 0.8 | | dB |
| RF Input Return Loss | All LNA gain settings | | | 13 | | dB |
| Total Voltage Gain | $T_A$ = -40°C to +85°C | Maximum gain, B7:B1 = 0000000 | 90 | 99 | | dB |
| | | Minimum gain, B7:B1 = 1111111 | | 5 | 13 | |
| RF Gain Steps | From max RF gain to max RF gain - 8dB | | | 8 | | dB |
| | From max RF gain to max RF gain - 16dB | | | 16 | | |
| | From max RF gain to max RF gain - 32dB | | | 32 | | |
| Gain Change Settling Time | Any RF or baseband gain change; gain settling to within ±1dB of steady state; RXHP = 1 | | | 0.2 | | µs |
| | Any RF or baseband gain change; gain settling to within ±0.1dB of steady state; RXHP = 1 | | | 2 | | |
| Baseband Gain Range | From maximum baseband gain (B5:B1 = 00000) to minimum baseband gain (B5:B1 = 11111), $T_A$ = -40°C to +85°C | | 58 | 62 | 66 | dB |
| Baseband Gain Minimum Step Size | | | | 2 | | dB |
| DSB Noise Figure | Voltage gain ≥ 65dB with max RF gain (B7:B6 = 00) | | | 2.3 | | dB |
| | Voltage gain = 50dB with max RF gain - 8dB (B7:B6 = 01) | | | 5.5 | | |
| | Voltage gain = 45dB with max RF gain - 16dB (B7:B6 = 10) | | | 17 | | |
| | Voltage gain = 15dB with max RF gain - 32dB (B7:B6 = 11) | | | 27 | | |

# 2.3GHz to 2.7GHz Wireless Broadband RF Transceiver

## AC ELECTRICAL CHARACTERISTICS—Rx MODE (continued)

MAX2837 evaluation kit: $V_{CC_}$ = 2.8V, $f_{RF}$ = 2.502GHz, $f_{LO}$ = 2.5GHz; receiver baseband I/Q outputs at 90m$V_{RMS}$ (-21dBV), $f_{REF}$ = 40MHz, ENABLE = RXENABLE = $\overline{CS}$ = high, TXENABLE = SCLK = DIN = low, with power matching for the differential RF pins using the typical applications and registers set to default settings and corresponding test mode, $T_A$ = +25°C, unless otherwise noted. Lowpass filter is set to 10MHz RF channel BW. Unmodulated single-tone RF input signal is used, unless otherwise indicated.) (Note 1)

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| In-Band Input P-1dB | Max RF gain (B7:B6 = 00) | | | -37 | | dBm |
| | Max RF gain - 8dB (B7:B6 = 01) | | | -29 | | |
| | Max RF gain - 16dB (B7:B6 = 10) | | | -21 | | |
| | Max RF gain - 32dB (B7:B6 = 11) | | | -4 | | |
| Maximum Output Signal Level | Over passband frequency range; at any gain setting; 1dB compression point | | | 2.5 | | $V_{P-P}$ |
| Out-of-Band Input IP3 (Note 2) | Max RF gain (B7:B6 = 00), AGC set for -65dBm wanted signal | | | -11 | | dBm |
| | Max RF gain - 8dB (B7:B6 = 01), AGC set for -55dBm wanted signal | | | -8 | | |
| | Max RF gain - 16dB (B7:B6 = 10), AGC set for -40dBm wanted signal | | | -6 | | |
| | Max RF gain - 32dB (B7:B6 = 11), AGC set for -30dBm wanted signal | | | +16 | | |
| I/Q Phase Error | 50kHz baseband output; 1σ variation | | | 0.15 | | Degrees |
| I/Q Gain Imbalance | 50kHz baseband output; 1σ variation | | | 0.1 | | dB |
| Rx I/Q Output Load Impedance (R ll C) | Minimum differential resistance | | | 10 | | kΩ |
| | Maximum differential capacitance | | | 5 | | pF |
| I/Q Output DC Droop | After switching RXHP to 0; average over 1µs after any gain change, or 2µs after receive enabled with 100Hz interval AC-coupling, 1σ variation | | | ±1 | | mV/ms |
| I/Q Static DC Offset | No RF input signal; measure at 3µs after receive enable; RXHP = 1 for 0 to 2µs and set to 0 after 2µs, 1σ variation | | | ±1 | | mV |
| Loopback Gain (for Receiver I/Q Calibration) | Transmitter I/Q input to receiver I/Q output; transmitter B6:B1 = 000011, receiver B5:B1 = 10100 programmed through SPI | | -4.5 | 0 | +4.5 | dB |
| **RECEIVER BASEBAND FILTERS** | | | | | | |
| Baseband Filter Rejection | At 15MHz | | | 57 | | dB |
| | At 20MHz | | | 75 | | |
| | At > 40MHz | | | 90 | | |
| Baseband Highpass Filter Corner Frequency | RXHP = 1 (used before AGC completion) | | | 650 | | kHz |
| | RXHP = 0 (used after AGC completion) address A4:A0 = 01110 | D5:D4 = 00 | | 0.1 | | |
| | | D5:D4 = 01 | | 1 | | |
| | | D5:D4 = 10 | | 30 | | |
| | | D5:D4 = 11 | | 100 | | |

## AC ELECTRICAL CHARACTERISTICS—Rx MODE (continued)

MAX2837 evaluation kit: $V_{CC_}$ = 2.8V, $f_{RF}$ = 2.502GHz, $f_{LO}$ = 2.5GHz; receiver baseband I/Q outputs at 90m$V_{RMS}$ (-21dBV), $f_{REF}$ = 40MHz, ENABLE = RXENABLE = $\overline{CS}$ = high, TXENABLE = SCLK = DIN = low, with power matching for the differential RF pins using the typical applications and registers set to default settings and corresponding test mode, $T_A$ = +25°C, unless otherwise noted. Lowpass filter is set to 10MHz RF channel BW. Unmodulated single-tone RF input signal is used, unless otherwise indicated.) (Note 1)

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| RF Channel BW Supported by Baseband Filter | A4:A0 = 00010 serial bits D7:D4 = 0000 | | | 1.75 | | MHz |
| | A4:A0 = 00010 serial bits D7:D4 = 0001 | | | 2.25 | | |
| | A4:A0 = 00010 serial bits D7:D4 = 0010 | | | 3.5 | | |
| | A4:A0 = 00010 serial bits D7:D4 = 0011 | | | 5.0 | | |
| | A4:A0 = 00010 serial bits D7:D4 = 0100 | | | 5.5 | | |
| | A4:A0 = 00010 serial bits D7:D4 = 0101 | | | 6.0 | | |
| | A4:A0 = 00010 serial bits D7:D4 = 0110 | | | 7.0 | | |
| | A4:A0 = 00010 serial bits D7:D4 = 0111 | | | 8.0 | | |
| | A4:A0 = 00010 serial bits D7:D4 = 1000 | | | 9.0 | | |
| | A4:A0 = 00010 serial bits D7:D4 = 1001 | | | 10.0 | | |
| | A4:A0 = 00010 serial bits D7:D4 = 1010 | | | 12.0 | | |
| | A4:A0 = 00010 serial bits D7:D4 = 1011 | | | 14.0 | | |
| | A4:A0 = 00010 serial bits D7:D4 = 1100 | | | 15.0 | | |
| | A4:A0 = 00010 serial bits D7:D4 = 1101 | | | 20.0 | | |
| | A4:A0 = 00010 serial bits D7:D4 = 1110 | | | 24.0 | | |
| | A4:A0 = 00010 serial bits D7:D4 = 1111 | | | 28.0 | | |
| Baseband Gain Ripple | 0 to 2.3MHz for BW = 5MHz | | | 1.3 | | $dB_{P-P}$ |
| | 0 to 4.6MHz for BW = 10MHz | | | 1.3 | | |
| Baseband Group Delay Ripple | 0 to 2.3MHz for BW = 5MHz | | | 90 | | $ns_{P-P}$ |
| | 0 to 4.6MHz for BW = 10MHz | | | 50 | | |
| Baseband Filter Rejection for 5MHz RF Channel BW | At 3.3MHz | | | 7 | | dB |
| | At > 21MHz | | | 85 | | |
| Baseband Filter Rejection for 10MHz RF Channel BW | At 6.7MHz | | | 7 | | dB |
| | At > 41.6MHz | | | 85 | | |
| **RSSI** | | | | | | |
| RSSI Minimum Output Voltage | $R_{LOAD} \geq 10k\Omega$ | | | 0.4 | | V |
| RSSI Maximum Output Voltage | $R_{LOAD} \geq 10k\Omega$ | | | 2.2 | | V |
| RSSI Slope | | | | 30 | | mV/dB |
| RSSI Output Settling Time | To within 3dB of steady state | +32dB signal step | | 200 | | ns |
| | | -32dB signal step | | 800 | | |

# 2.3GHz to 2.7GHz Wireless Broadband RF Transceiver

## AC ELECTRICAL CHARACTERISTICS—Tx MODE

(MAX2837 evaluation kit: $V_{CC_}$ = 2.8V, $T_A$ = +25°C, $f_{RF}$ = 2.502GHz, $f_{LO}$ = 2.5GHz; $f_{REF}$ = 40MHz, ENABLE = TXENABLE = $\overline{CS}$ = high, and RXENABLE = SCLK = DIN = low, with power matching for the differential RF pins using the *Typical Operating Circuit*. Lowpass fitler is set to 10MHz RF channel BW, 90m$V_{RMS}$ sine and cosine signal (or 90m$V_{RMS}$ 64QAM 1024-FFT OFDMA FUSC I/Q signals wherever OFDM is mentioned) applied to baseband I/Q inputs of transmitter (differential DC-coupled).) (Note 1)

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| **TRANSMIT SECTION: Tx BASEBAND I/Q INPUTS TO RF OUTPUTS** | | | | | |
| RF Output Frequency Range | | 2.3 | | 2.7 | GHz |
| Peak-to-Peak Gain Variation over RF Band | Output optimally matched over 200MHz RF BW | | 2.5 | | dB |
| Total Voltage Gain | Max gain; at unbalanced 50Ω balun output | | 12 | | dB |
| Maximum Output Power over Frequency for Any Given 200MHz Band | OFDM signal conforming to spectral emission mask and -36dB EVM after I/Q imbalance calibration by modem (Note 3) | | 0 | | dBm |
| RF Output Return Loss | Given 200MHz band in the 2.3GHz to 2.7GHz range, for which the matching has been optimized | | 8 | | dB |
| RF Gain Control Range | | | 45 | | dB |
| Unwanted Sideband Suppression | Without calibration by modem, and excludes modem I/Q imbalance; $P_{OUT}$ = 0dBm | | 45 | | dBc |
| RF Gain-Control Binary Weights | B1 | | 1 | | dB |
| | B2 | | 2 | | |
| | B3 | | 4 | | |
| | B4 | | 8 | | |
| | B5 | | 16 | | |
| | B6 | | 16 | | |
| Carrier Leakage | Relative to 0dBm output power; without calibration by modem | | -35 | | dBc |
| Tx I/Q Input Impedance (R ll C) | Minimum differential resistance | | 100 | | kΩ |
| | Maximum differential capacitance | | 0.5 | | pF |
| Baseband Frequency Response for 5MHz RF Channel BW | 0 to 2.3MHz | | 0.2 | | dB |
| | At > 25MHz | | 80 | | |
| Baseband Frequency Response for 10MHz RF Channel BW | 0 to 4.6MHz | | 0.2 | | dB |
| | At > 17MHz | | 80 | | |
| Baseband Group Delay Ripple | 0 to 2.3MHz (BW = 5MHz) | | 20 | | ns |
| | 0 to 4.6MHz (BW = 10MHz) | | 12 | | |

## AC ELECTRICAL CHARACTERISTICS—FREQUENCY SYNTHESIS

(MAX2837 evaluation kit: $V_{CC_}$ = 2.8V, $f_{LO}$ = 2.5GHz, $f_{REF}$ = 40MHz, ENABLE = $\overline{CS}$ = high, SCLK = DIN = low, PLL loop bandwidth = 120kHz, $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| **FREQUENCY SYNTHESIZER** | | | | | |
| RF Channel Center Frequency | | 2.3 | | 2.7 | GHz |
| Channel Center Frequency Programming Minimum Step Size | | | 20 | | Hz |
| Charge-Pump Comparison Frequency | | 11 | 40 | | MHz |
| Reference Frequency Range | | 11 | 40 | 80 | MHz |
| Reference Frequency Input Levels | AC-coupled to XTAL2 pin | 800 | | | $mV_{P-P}$ |
| Reference Frequency Input Impedance (R ll C) | Resistance (XTAL2 pin) | | 10 | | kΩ |
| | Capacitance (XTAL2 pin) | | 1 | | pF |
| Programmable Reference Divider Values | | 1 | 2 | 4 | |
| Closed-Loop Integrated Phase Noise | Loop BW = 120kHz; integrate phase noise from 200Hz to 5MHz, charge-pump comparison frequency = 40MHz | | -39 | | dBc |
| Charge-Pump Output Current | On each differential side | | 1.6 | | mA |
| Close-In Spur Level | $f_{OFFSET}$ = 0 to 1.8MHz | | -40 | | dBc |
| | $f_{OFFSET}$ = 1.8MHz to 7MHz | | -70 | | |
| | $f_{OFFSET}$ > 7MHz | | -80 | | |
| Reference Spur Level | | | -85 | | dBc |
| Turnaround LO Frequency Error | Relative to steady state; measured 35µs after Tx-Rx or Rx-Tx switching instant, and 4µs after any receiver gain changes | | ±50 | | Hz |
| Temperature Range over Which VCO Maintains Lock | Relative to the ambient temperature $T_A$, as long as the VCO lock temperature range is within operating temperature range | | $T_A$ ±40 | | °C |
| Reference Output Clock Divider Values | | 1 | | 2 | |
| Output Clock Drive Level | 20MHz output, 1x drive setting | | 1.5 | | $V_{P-P}$ |
| Output Clock Minimum Load Impedance (R ll C) | Resistance | | 10 | | kΩ |
| | Capacitance | | 2 | | pF |

# 2.3GHz to 2.7GHz Wireless Broadband RF Transceiver

## AC ELECTRICAL CHARACTERISTICS—MISCELLANEOUS BLOCKS

(MAX2837 evaluation kit: $V_{CC_}$ = 2.8V, $f_{REF}$ = 40MHz, ENABLE = $\overline{CS}$ = high, SCLK = DIN = low, $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| **PA BIAS DAC: CURRENT MODE** | | | | | |
| Numbers of Bits | | | 6 | | Bits |
| Minimum Output Sink Current | D5:D0 = 000000 in A4:A0 = 11100 | | 0 | | µA |
| Maximum Output Sink Current | D5:D0 = 111111 in A4:A0 = 11100 | | 310 | | µA |
| Compliance Voltage Range | | 0.8 | | 2.0 | V |
| Turn-On Time | Excludes programmable delay of 0 to 7µs in steps of 0.5µs | | 200 | | ns |
| DNL | | | 1 | | LSB |
| **PA BIAS DAC: VOLTAGE MODE** | | | | | |
| Output High Level | 10mA source current | | $V_{CC}$ - 0.2 | | V |
| Output Low Level | 10mA sink current | | 0.1 | | V |
| Turn-On Time | Excludes programmable delay of 0 to 7µs in steps of 0.5µs | | 200 | | ns |
| **CRYSTAL OSCILLATOR** | | | | | |
| On-Chip Tuning Capacitance Range | Maximum capacitance, A4:A0 = 11000, D6:D0 =1111111 | | 15.5 | | pF |
| | Minimum capacitance, A4:A0 = 11000, D6:D0 =0000000 | | 0.5 | | |
| On-Chip Tuning Capacitance Step Size | | | 0.12 | | pF |
| **ON-CHIP TEMPERATURE SENSOR** | | | | | |
| Digital Output Code | Read-out at DOUT pin through SPI A4:A0 = 00111, D4:D0; $T_A$ = +25°C | | 01111 | | |
| | $T_A$ = +85°C | | 11101 | | |
| | $T_A$ = -40°C | | 00001 | | |

## AC ELECTRICAL CHARACTERISTICS—TIMING

(MAX2837 evaluation kit: $V_{CC_}$ = 2.8V, $f_{LO}$ = 2.5GHz, $f_{REF}$ = 40MHz, ENABLE = $\overline{CS}$ = high, SCLK = DIN = low, PLL loop bandwidth = 120kHz, $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **SYSTEM TIMING** | | | | | | | |
| Turnaround Time | | Measured from Tx or Rx enable rising edge; signal settling to within 0.5dB of steady state | Rx to Tx | | 2 | | µs |
| | | | Tx to Rx, RXHP = 1 | | 2 | | |
| Tx Turn-On Time (from Standby Mode) | | Measured from Tx enable rising edge; signal settling to within 0.5dB of steady state | | | 2 | | µs |

## AC ELECTRICAL CHARACTERISTICS—TIMING (continued)

(MAX2837 evaluation kit: $V_{CC_}$ = 2.8V, $f_{LO}$ = 2.5GHz, $f_{REF}$ = 40MHz, ENABLE = $\overline{CS}$ = high, SCLK = DIN = low, PLL loop bandwidth = 120kHz, $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Tx Turn-Off Time (to Standby Mode) | | From Tx enable falling edge | | 0.1 | | µs |
| Rx Turn-On Time (from Standby Mode) | | Measured from Rx enable rising edge; signal settling to within 0.5dB of steady state | | 2 | | µs |
| Rx Turn-Off Time (to Standby Mode) | | From Rx enable falling edge | | 0.1 | | µs |
| **4-WIRE SERIAL-INTERFACE TIMING (See Figure 1)** | | | | | | |
| SCLK Rising Edge to $\overline{CS}$ Falling Edge Wait Time | $t_{CSO}$ | | | 6 | | ns |
| Falling Edge of $\overline{CS}$ to Rising Edge of First SCLK Time | $t_{CSS}$ | | | 6 | | ns |
| DIN to SCLK Setup Time | $t_{DS}$ | | | 6 | | ns |
| DIN to SCLK Hold Time | $t_{DH}$ | | | 6 | | ns |
| SCLK Pulse-Width High | $t_{CH}$ | | | 6 | | ns |
| SCLK Pulse-Width Low | $t_{CL}$ | | | 6 | | ns |
| Last Rising Edge of SCLK to Rising Edge of $\overline{CS}$ or Clock to Load Enable Setup Time | $t_{CSH}$ | | | 6 | | ns |
| $\overline{CS}$ High Pulse Width | $t_{CSW}$ | | | 20 | | ns |
| Time Between Rising Edge of $\overline{CS}$ and the Next Rising Edge of SCLK | $t_{CS1}$ | | | 6 | | ns |
| Clock Frequency | $f_{CLK}$ | | | | 45 | MHz |
| Rise Time | $t_R$ | | | $f_{CLK}$ / 10 | | ns |
| Fall Time | $t_F$ | | | $f_{CLK}$ / 10 | | ns |
| SCLK Falling Edge to Valid DOUT | $t_D$ | | | 12.5 | | ns |

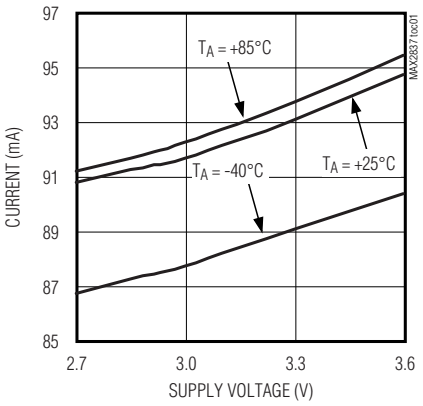
**Note 1:** Min and max limits guaranteed by test above $T_A$ = +25°C and guaranteed by design and characterization at $T_A$ = -40°C. The power-on register settings are not production tested. Recommended register setting must be loaded after $V_{CC}$ is supplied.
**Note 2:** Two tones at +25MHz and +39MHz offset with -35dBm/tone. Measure IM3 at 1MHz.
**Note 3:** Gain adjusted over max gain and max gain - 3dB. Optimally matched over given 200MHz band.

# 2.3GHz to 2.7GHz Wireless Broadband RF Transceiver

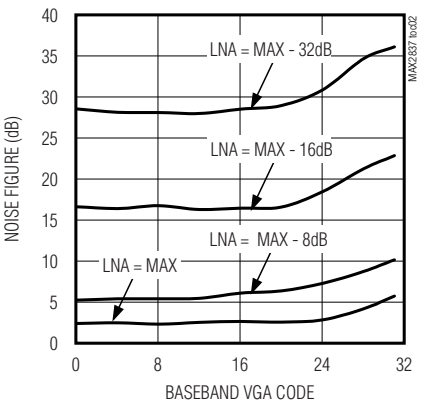
## Typical Operating Characteristics

(MAX2837 evaluation kit: $V_{CC_}$ = 2.8V, $f_{LO}$ = 2.5GHz, 10MHz channel 16E UL/DL WiMax signal, $f_{REF}$ = 40MHz, ENABLE = $\overline{CS}$ = high, RXHP = SCLK = DIN = low, $T_A$ = +25°C, unless otherwise noted.)

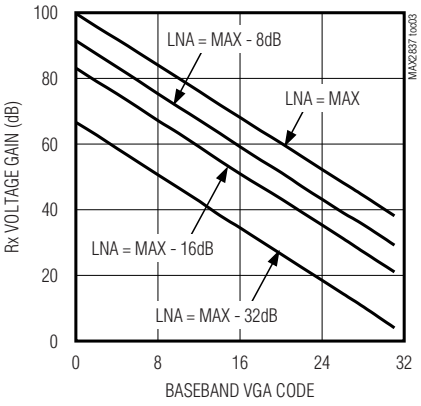
**Rx CURRENT vs. SUPPLY VOLTAGE**



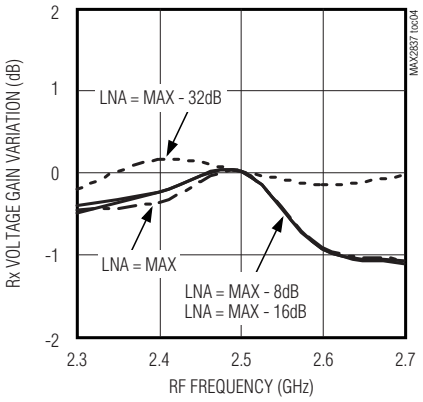

**NOISE FIGURE vs. BASEBAND VGA GAIN SETTING**



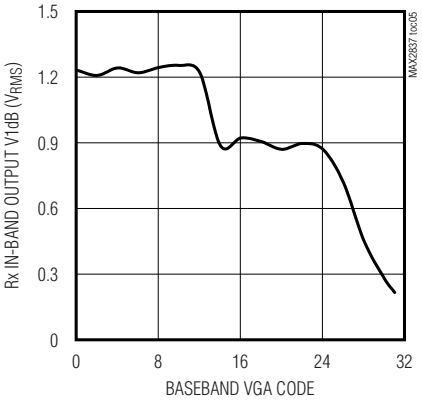

**Rx VOLTAGE GAIN vs. BASEBAND GAIN SETTING**



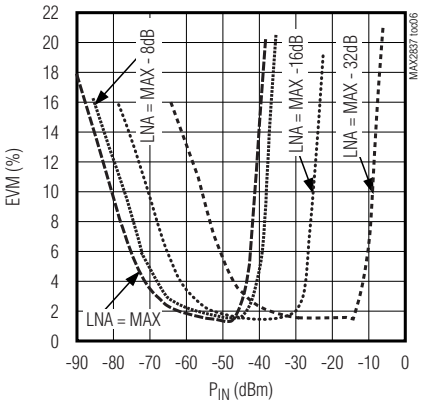

**Rx VOLTAGE GAIN VARIATION vs. RF FREQUENCY**



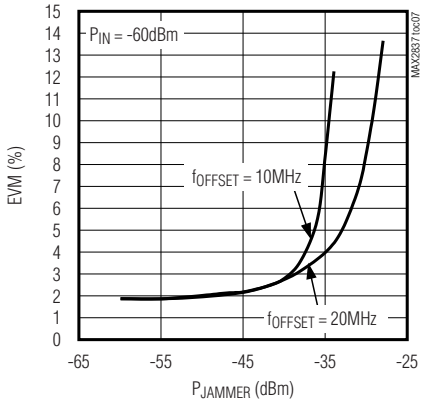

**Rx IN-BAND OUTPUT V1dB vs. BASEBAND GAIN SETTING**



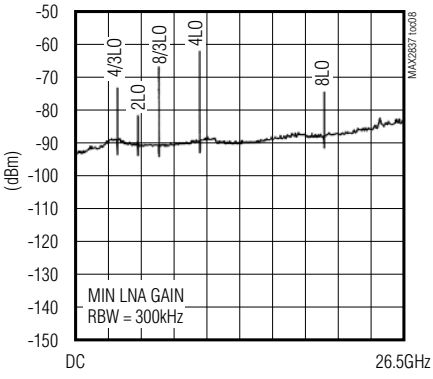

**Rx EVM vs. $P_{IN}$**




**WiMAX EVM WITH OFDM JAMMER vs. OFFSET FREQUENCY**



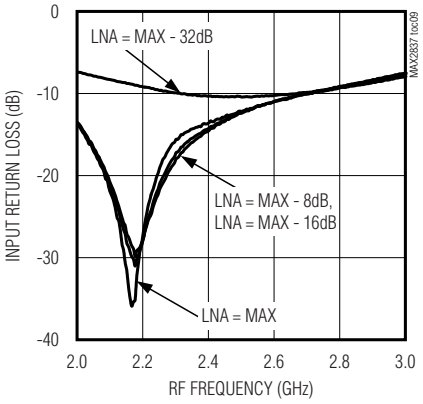

**Rx EMISSION SPECTRUM AT LNA INPUT**



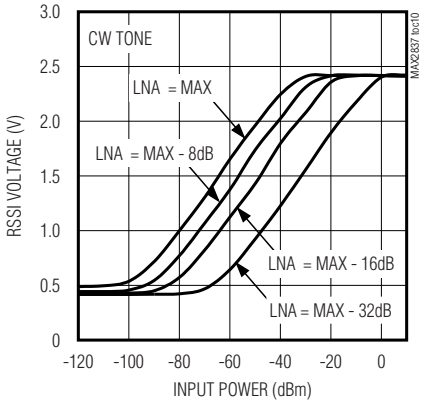
## Typical Operating Characteristics (continued)

(MAX2837 evaluation kit: $V_{CC_}$ = 2.8V, $f_{LO}$ = 2.5GHz, 10MHz channel 16E UL/DL WiMax signal, $f_{REF}$ = 40MHz, ENABLE = $\overline{CS}$ = high, RXHP = SCLK = DIN = low, $T_A$ = +25°C, unless otherwise noted.)

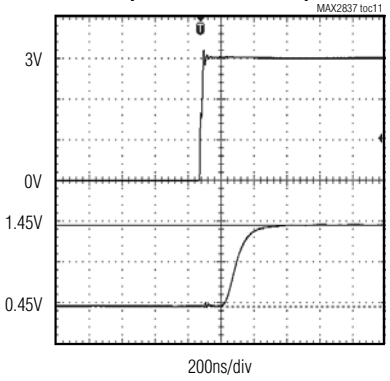
**INPUT RETURN LOSS vs. RF FREQUENCY**



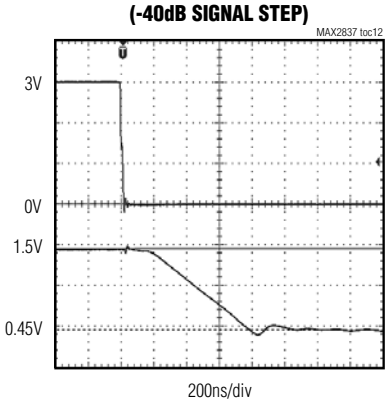

**RSSI VOLTAGE vs. INPUT POWER**



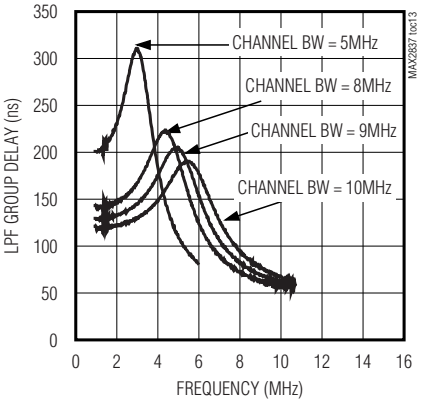

**Rx RSSI STEP RESPONSE (+40dB SIGNAL STEP)**



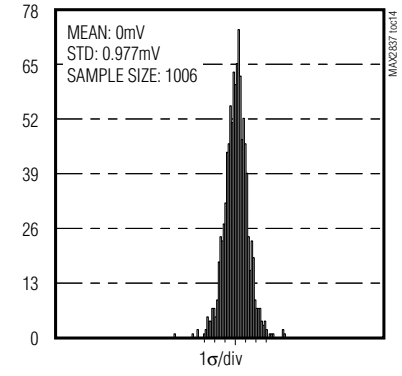

**Rx RSSI STEP RESPONSE (-40dB SIGNAL STEP)**



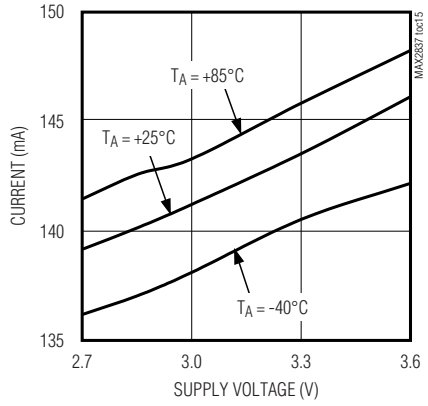

**Rx LPF GROUP DELAY vs. FREQUENCY**



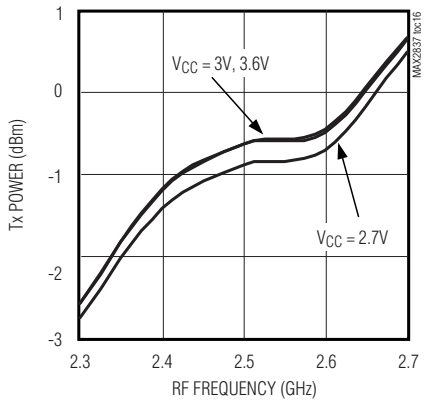

**HISTOGRAM: Rx STATIC DC OFFSET**




**Tx CURRENT vs. SUPPLY VOLTAGE**




**Tx OUTPUT POWER vs. RF FREQUENCY**

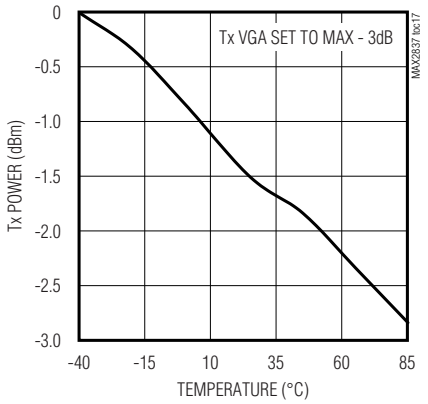


# 2.3GHz to 2.7GHz Wireless Broadband RF Transceiver

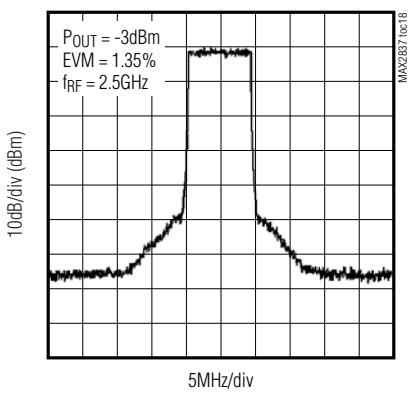
## Typical Operating Characteristics (continued)

(MAX2837 evaluation kit: $V_{CC_}$ = 2.8V, $f_{LO}$ = 2.5GHz, 10MHz channel 16E UL/DL WiMax signal, $f_{REF}$ = 40MHz, ENABLE = $\overline{CS}$ = high, RXHP = SCLK = DIN = low, $T_A$ = +25°C, unless otherwise noted.)

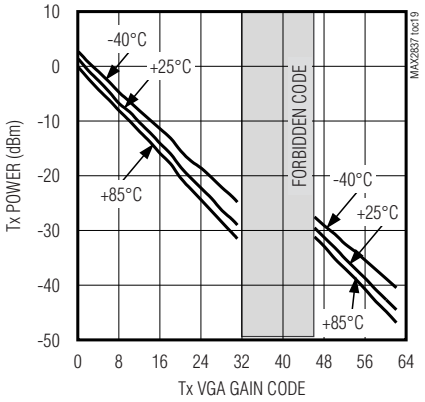
**Tx OUTPUT POWER vs. TEMPERATURE**



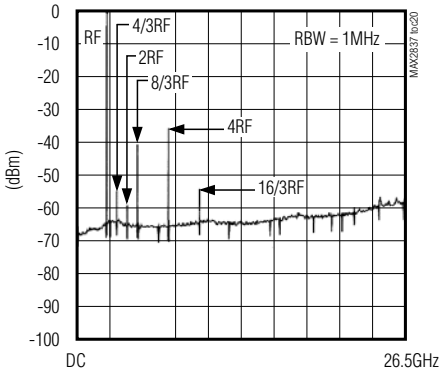

**Tx OUTPUT SPECTRUM**



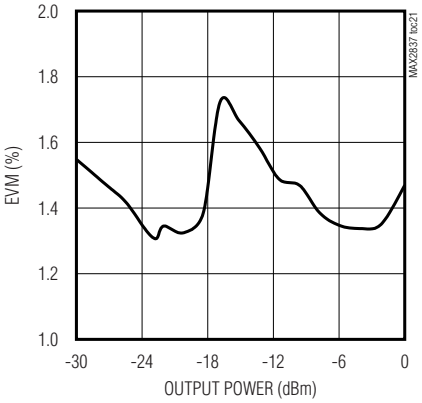

**Tx POUT vs. GAIN SETTING**



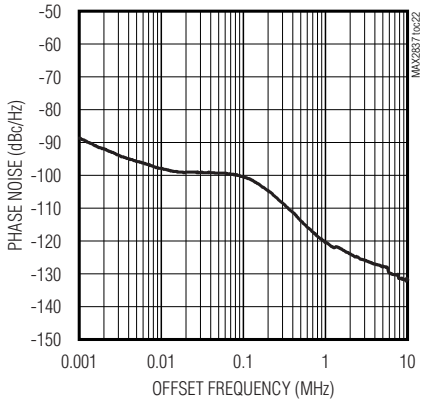

**Tx TRANSMIT SPECTRUM FROM DC TO 26.5GHz**



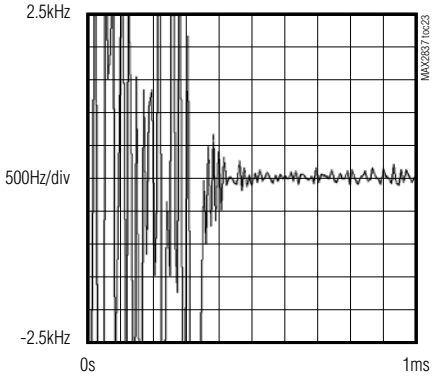

**EVM vs. Tx OUTPUT POWER**



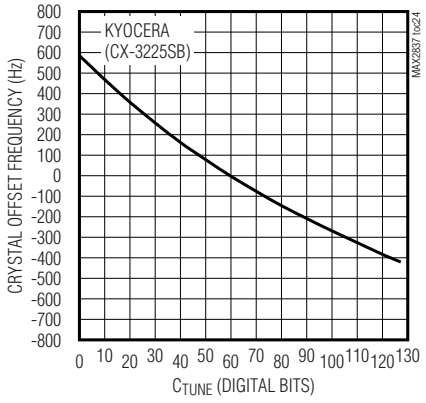

**PHASE NOISE vs. OFFSET FREQUENCY**




**PLL SETTLING TIME FROM SHUTDOWN**

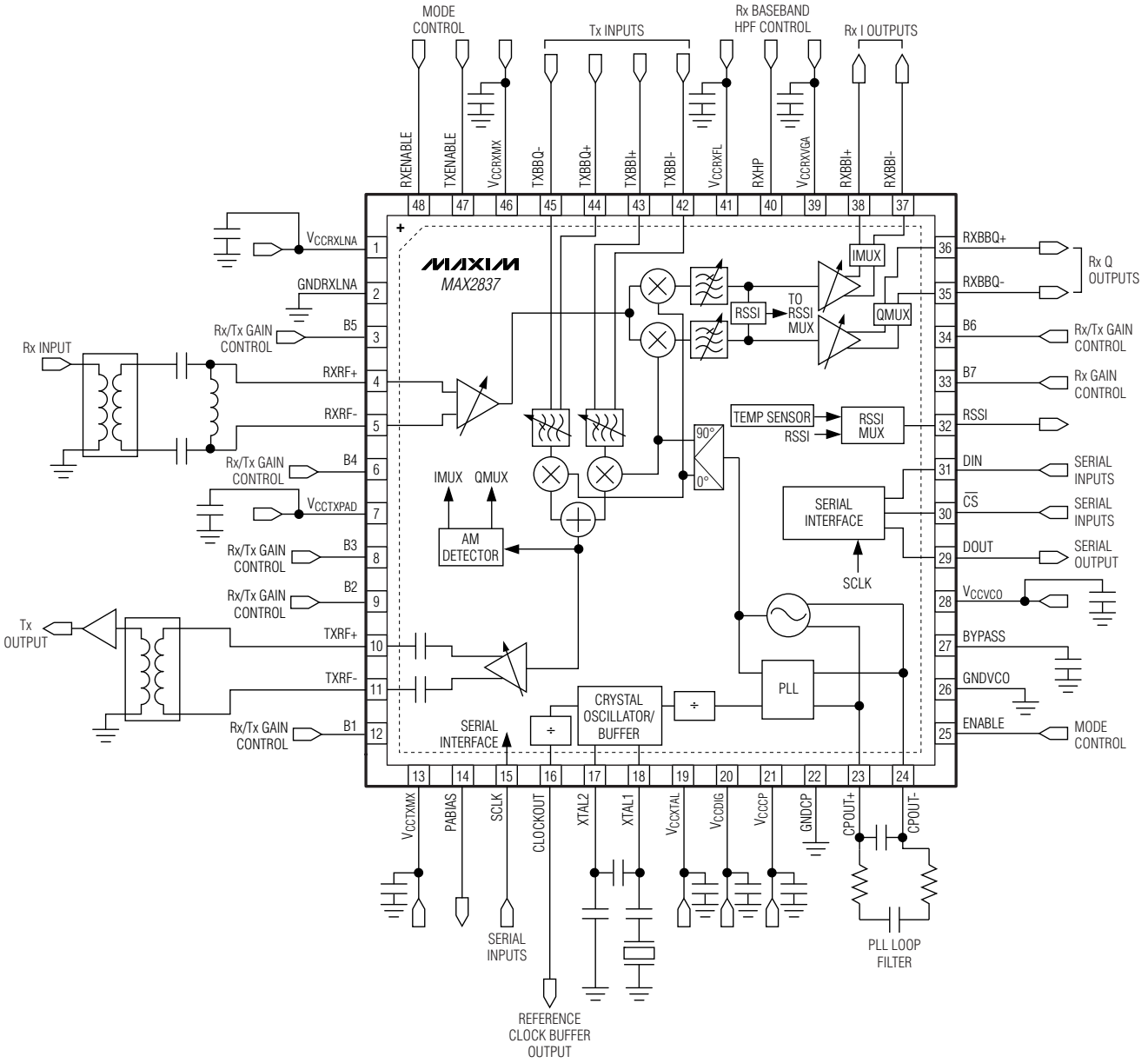



**CRYSTAL OFFSET FREQUENCY vs. $C_{TUNE}$ BITS**



# 2.3GHz to 2.7GHz Wireless Broadband RF Transceiver

## Block Diagram/Typical Operating Circuit



# 2.3GHz to 2.7GHz Wireless Broadband RF Transceiver

## Pin Description

| PIN | NAME | FUNCTION |
|---|---|---|
| 1 | $V_{CCRXLNA}$ | LNA Supply Voltage. Bypass with a capacitor as close as possible to the pin. |
| 2 | GNDRXLNA | LNA Ground |
| 3 | B5 | Receiver and Transmitter Gain-Control Logic Input Bit 5 |
| 4 | RXRF+ | LNA Differential Inputs. Inputs are internally DC-coupled. An external shunt inductor and series capacitors match the inputs to 100Ω differential. |
| 5 | RXRF- | |
| 6 | B4 | Receiver and Transmitter Gain-Control Logic Input Bit 4 |
| 7 | $V_{CCTXPAD}$ | Supply Voltage for Power-Amplifier Driver. Bypass with a capacitor as close as possible to the pin. |
| 8 | B3 | Receiver and Transmitter Gain-Control Logic Input Bit 3 |
| 9 | B2 | Receiver and Transmitter Gain-Control Logic Input Bit 2 |
| 10 | TXRF+ | Power-Amplifier Driver Differential Output. PA driver output is internally matched to a 100Ω differential. The pins have internal DC-blocking capacitors. |
| 11 | TXRF- | |
| 12 | B1 | Receiver and Transmitter Gain-Control Logic Input Bit 1 |
| 13 | $V_{CCTXMX}$ | Transmitter Upconverter Supply Voltage. Bypass with a capacitor as close as possible to the pin. |
| 14 | PABIAS | Transmit PA Bias DAC Output |
| 15 | SCLK | Serial-Clock Logic Input of 4-Wire Serial Interface (See Figure 1) |
| 16 | CLOCKOUT | Reference Clock Buffer Output |
| 17 | XTAL2 | Crystal or Reference Clock Input. AC-couple a crystal or a reference clock to this analog input. |
| 18 | XTAL1 | Connection for Crystal-Oscillator Off-Chip Capacitors. When using an external reference clock input, leave XTAL1 unconnected. |
| 19 | $V_{CCXTAL}$ | Crystal-Oscillator Supply Voltage. Bypass with a capacitor as close as possible to the pin. |
| 20 | $V_{CCDIG}$ | Digital Circuit Supply Voltage. Bypass with a capacitor as close as possible to the pin. |
| 21 | $V_{CCCP}$ | PLL Charge-Pump Supply Voltage. Bypass with a capacitor as close as possible to the pin. |
| 22 | GNDCP | Charge-Pump Circuit Ground |
| 23 | CPOUT+ | Differential Charge-Pump Output. Connect the frequency synthesizer's loop filter between CPOUT+ and CPOUT-. (See the *Typical Operating Circuit*.) |
| 24 | CPOUT- | |
| 25 | ENABLE | Operation Mode Logic Input. See Table 1 for operating modes. |
| 26 | GNDVCO | VCO Ground |
| 27 | BYPASS | On-Chip VCO Regulator Output Bypass. Bypass with a 1µF capacitor to GND. Do not connect other circuitry to this point. |
| 28 | $V_{CCVCO}$ | VCO Supply Voltage. Bypass with a capacitor as close as possible to the pin. |
| 29 | DOUT | Data Logic Output of 4-Wire Serial Interface (See Figure 1) |
| 30 | $\overline{CS}$ | Chip-Select Logic Input of 4-Wire Serial Interface (See Figure 1) |
| 31 | DIN | Data Logic Input of 4-Wire Serial Interface (See Figure 1) |
| 32 | RSSI | RSSI or Temperature Sensor Multiplexed Analog Output |
| 33 | B7 | Receiver Gain-Control Logic Input Bit 7 |
| 34 | B6 | Receiver and Transmitter Gain-Control Logic Input Bit 6 |
| 35 | RXBBQ- | Receiver Baseband Q-Channel Differential Outputs. In Tx calibration mode, these pins are the LO leakage and sideband detector outputs. |
| 36 | RXBBQ+ | |
| 37 | RXBBI- | Receiver Baseband I-Channel Differential Outputs. In Tx calibration mode, these pins are the LO leakage and sideband detector outputs. |
| 38 | RXBBI+ | |
| 39 | $V_{CCRXVGA}$ | Receiver VGA Supply Voltage |
| 40 | RXHP | Receiver Baseband AC-Coupling Highpass Corner Frequency Control Logic Input |
| 41 | $V_{CCRXFL}$ | Receiver Baseband Filter Supply Voltage |

## Pin Description (continued)

| PIN | NAME | FUNCTION |
|---|---|---|
| 42 | TXBBI- | Transmitter Baseband I-Channel Differential Inputs |
| 43 | TXBBI+ | |
| 44 | TXBBQ+ | Transmitter Baseband Q-Channel Differential Inputs |
| 45 | TXBBQ- | |
| 46 | $V_{CCRXMX}$ | Receiver Downconverters Supply Voltage. Bypass with a capacitor as close as possible to the pin. |
| 47 | TXENABLE | Tx Mode Control Logic Input. See Table 1 for operating modes. |
| 48 | RXENABLE | Rx Mode Control Logic Input. See Table 1 for operating modes. |
| EP | EP | Exposed Paddle. Connect to the ground plane with multiple vias for proper operation and heat dissipation. Do not share with any other pin grounds and bypass capacitors' ground. |

### Table 1. Operating Mode Table

| MODE | LOGIC PINS | | | REGISTER SETTING | | CIRCUIT BLOCK STATES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ENABLE | RXENABLE | TXENABLE | D1:D0 A4:A0 = 10000 | | Rx PATH | Tx PATH | PLL, VCO, LO GEN | CALIBRATION SECTIONS ON | CLOCK OUT |
| Clock-Out | 1 | 0 | 0 | 0 | 0 | Off | Off | Off | None | On |
| Shutdown | 0 | 0 | 0 | 0 | X | Off | Off | Off | None | Off |
| Standby | 1 | 0 | 0 | 0 | 1 | Off* | Off* | On | None | On |
| Rx | 1 | 1 | 0 | 0 | 1 | On | Off | On | None | On |
| Tx | 1 | 0 | 1 | 0 | 1 | Off | On | On | None | On |
| Rx Calibration | 1 | 1 | 0 | 1 | 1 | On (Except LNA) | Off (Except Upconverters) | On | Tx Baseband Buffer | On |
| Tx Calibration | 1 | 0 | 1 | 1 | 1 | Off | On (Except PA Driver) | On | AM Detector, Rx I/Q Buffers | On |

**Blocks of the transceiver can be selectively enabled through SPI.*

## Detailed Description

### Modes of Operation

The modes of operation for the MAX2837 are clock-out, shutdown, transmit, receive, transmitter calibration, and receiver calibration. See Table 1 for a summary of the modes of operation. The logic input pins—ENABLE (pin 25), TXENABLE (pin 47), and RXENABLE (pin 48)—control the various modes. When the parts are active, various blocks can be shut down individually through SPI.

#### Shutdown Mode

The MAX2837 features a low-power shutdown mode. Current drain is the minimum possible with the supply voltages applied. In shutdown mode, all circuit blocks are powered down, except the 4-wire serial bus and its internal programmable registers. If the supply voltage is applied, the registers are loaded and retained.

#### Standby Mode

The standby mode is used to enable the frequency synthesizer block while the rest of the device is powered down. In this mode, PLL, VCO, and LO generator are on, so that Tx or Rx modes can be quickly enabled from this mode. These and other blocks can be selectively enabled in this mode.

#### Receive (Rx) Mode

In receive mode, all Rx circuit blocks are powered on and active. Antenna signal is applied; RF is downconverted, filtered, and buffered at Rx BB I and Q outputs. The slow-charging Tx circuits are in a precharged "idle-off" state for fast Rx-to-Tx turnaround time.

#### Transmit (Tx) Mode

In transmit mode, all Tx circuit blocks are powered on. The external PA is powered on after a programmable

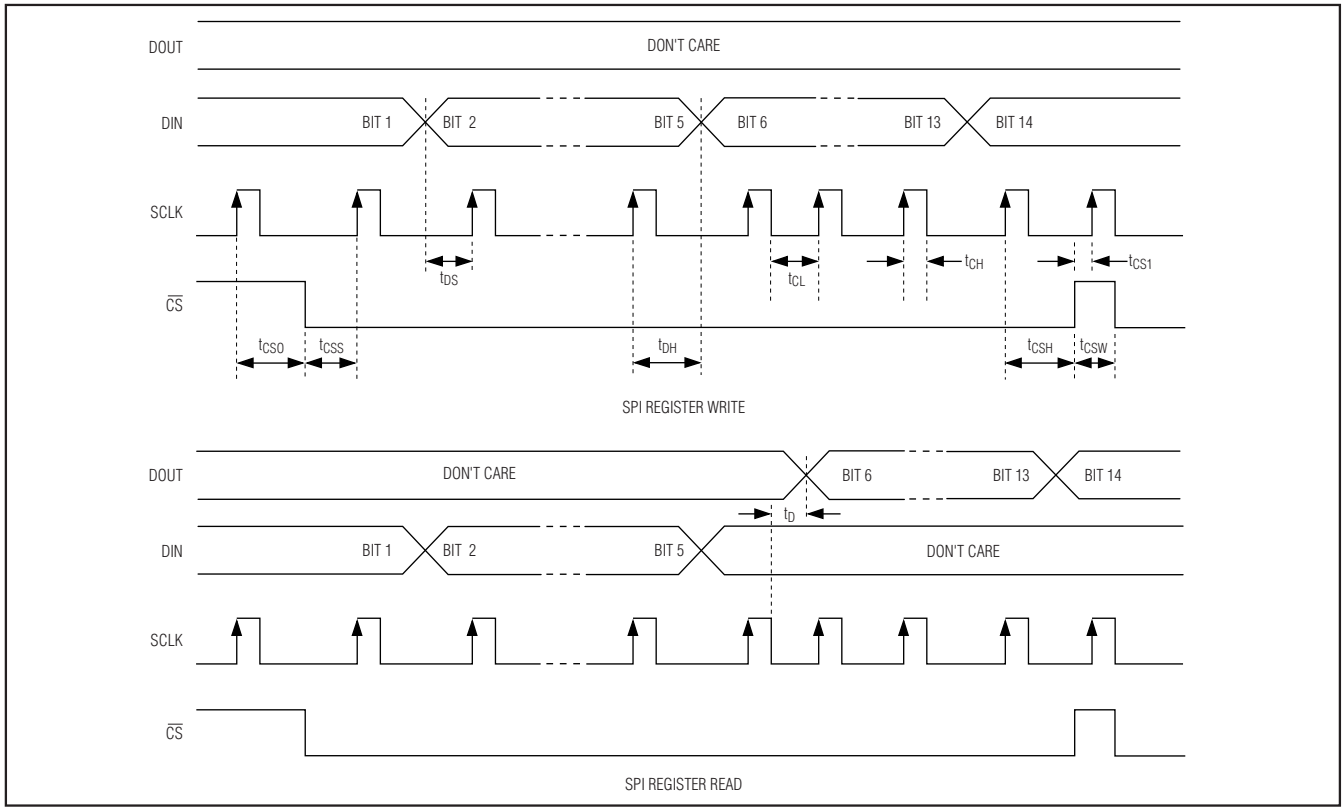



*Figure 1. 4-Wire SPI Serial-Interface Timing Diagram*

delay using the on-chip PA bias DAC. The slow-charging Rx circuits are in a precharged "idle-off" state for fast Tx-to-Rx turnaround time.

### *Clock-Out Only*

In clock-out mode, the entire transceiver is off except the divided reference clock output on the CLKOUT pin and the clock divider, which remains on.

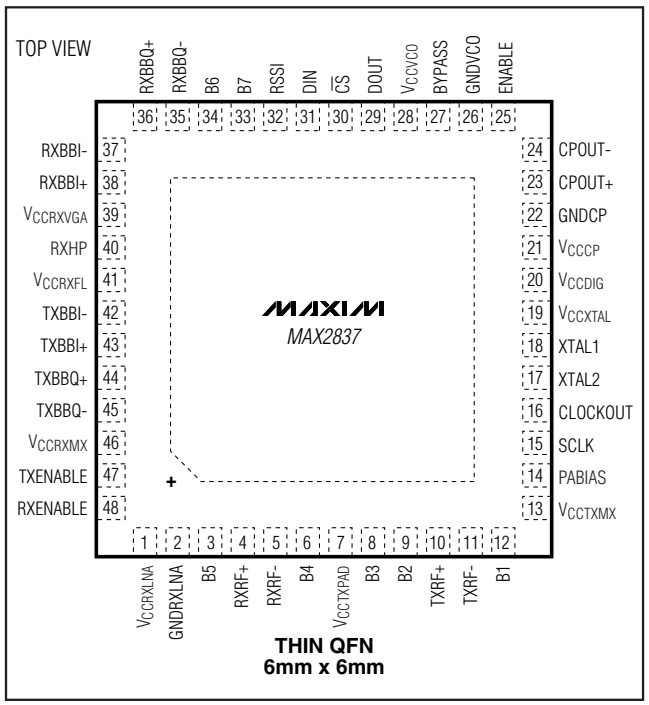
## *Programmable Registers and 4-Wire SPI Interface*

The MAX2837 includes 32 programmable 16-bit registers. The most significant bit (MSB) is the read/write selection bit. The next 5 bits are register address. The 10 least significant bits (LSBs) are register data. Register data is loaded through the 4-wire SPI/MICROWIRE™-compatible serial interface. Data at DIN is shifted in MSB first and is framed by $\overline{CS}$. When $\overline{CS}$ is low, the clock is active, and input data is shifted at the rising edge of the clock. During the read mode, register data selected by address bits is shifted out to DOUT at the falling edges of the clock. At the $\overline{CS}$ rising edge, the 10-bit data bits are latched into the register selected by address bits. See Figure 1. The register values are preserved in shutdown mode as long as the power-supply voltage is maintained. However, every time the power-supply voltage is turned on, the registers are reset to the default values. Note that default register states are not guaranteed, and the user should always reprogram all registers after power-up.

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# 2.3GHz to 2.7GHz Wireless Broadband RF Transceiver

## Pin Configuration




## Chip Information

PROCESS: SiGe BiCMOS

## Package Information

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**.

| PACKAGE TYPE | PACKAGE CODE | DOCUMENT NO. |
|---|---|---|
| 48 TQFN-EP | T4866-2 | **21-0141** |

# 2.3GHz to 2.7GHz Wireless Broadband RF Transceiver

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 0 | 5/07 | Initial release | — |
| 1 | 11/08 | Corrected SPI description in *Programmable Registers and 4-Wire SPI-Interface* section | 16 |

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