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# Complete 450MHz Quadrature Transmitter

## General Description

The MAX2370 integrated quadrature transmitter is designed for 450MHz applications. The device takes a differential I/Q baseband input and converts it up to intermediate frequency (IF) through a quadrature modulator and IF variable-gain amplifier (VGA). The signal is then routed to an external IF filter and upconverted to RF through an image-reject mixer and RF VGA. The signal is further amplified with an on-chip power amplifier (PA) driver. An IF synthesizer, an RF synthesizer, a local oscillator buffer, and an SPI™/QSPI™/MICROWIRE™-compatible, 3-wire programmable bus complete the basic functional blocks of this IC.

The MAX2370 is available in a 48-pin TQFN package with exposed paddle and is specified for the extended temperature range (-40°C to +85°C).

## Applications

450MHz CDMA/WCDMA Phones  
OFDM, cdma2000®, WCDMA, NMT  
Wireless Data Links

SPI and QSPI are trademarks of Motorola, Inc.  
MICROWIRE is a trademark of National Semiconductor Corp.  
cdma2000 is a registered trademark of Telecommunications Industry Association.

## Features

- ◆ 450MHz Operating Frequency
- ◆ +8dBm Output Power
  - 64dBc Typical ACPR at ±885kHz Offset
  - 66dBc Typical ACPR at ±1.125MHz Offset
- ◆ 100dB Power-Control Range
- ◆ Dual Synthesizer for RF and IF Local Oscillators
- ◆ SPI/QSPI/MICROWIRE-Compatible 3-Wire Interface Bus
- ◆ Single-Sideband Upconverter
- ◆ Directly Drives External Power Amplifier

MAX2370

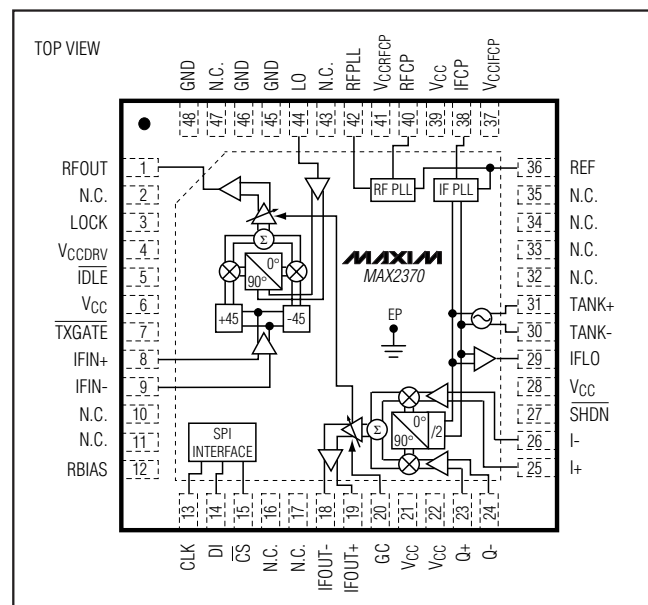
## Ordering Information

| PART        | TEMP RANGE     | PIN-PACKAGE                    | PKG CODE |
|-------------|----------------|--------------------------------|----------|
| MAX2370ETM  | -40°C to +85°C | 48 Thin QFN-EP*<br>(7mm x 7mm) | T4877-3  |
| MAX2370ETM+ | -40°C to +85°C | 48 Thin QFN-EP*<br>(7mm x 7mm) | T4877+3  |

\*EP = Exposed paddle.

+Denotes lead-free package.

## Pin Configuration/ Functional Diagram

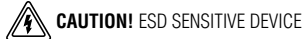


# Complete 450MHz Quadrature Transmitter

## ABSOLUTE MAXIMUM RATINGS

|  |                                   |
|--|-----------------------------------|
| V <sub>CC</sub> , RFOUT, V <sub>CCIFCP</sub> , V <sub>CCRFCP</sub> ,<br>V <sub>CCDRV</sub> to GND                  | -0.3V to +3.6V                    |
| DI, SCLK, CS, GC, SHDN, TXGATE, IDLE,<br>LOCK to GND   | -0.3V to (V <sub>CC</sub> + 0.3V) |
| AC Input Pins (IFIN <sub>-</sub> , Q <sub>-</sub> , I <sub>-</sub> , TANK <sub>-</sub> , REF,<br>RFPLL, LO) to GND | 1V Peak                           |
| Digital Input Current (SHDN, TXGATE, IDLE,<br>SCLK, DI, CS)  | ±10mA                             |

|   |                 |
|---|-----------------|
| Continuous Power Dissipation (T <sub>A</sub> = +70°C)<br>48-Pin Thin QFN (derate 38.5mW/°C above +70°C) | 3077mW          |
| Operating Temperature Range   | -40°C to +85°C  |
| Junction Temperature  | +150°C          |
| Storage Temperature Range   | -65°C to +150°C |
| Lead Temperature (soldering, 10s)   | +300°C          |



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

(V<sub>CC</sub> = +2.7V to +3.3V, SHDN = IDLE = TXGATE = high, V<sub>GC</sub> = 2.5V, R<sub>BIAS</sub> = 10kΩ, registers set according to Table 1, f<sub>REF</sub> = 19.2MHz, no AC signals applied, T<sub>A</sub> = -40°C to +85°C. Typical values are at V<sub>CC</sub> = +3.0V, T<sub>A</sub> = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER                             | CONDITIONS                         | MIN                    | TYP | MAX                   | UNITS |
|---------------------------------------|------------------------------------|------------------------|-----|-----------------------|-------|
| Supply Voltage Range                  | V <sub>CC</sub>                    | 2.7                    |     | 3.3                   | V     |
| Operating Supply Current              | V <sub>GC</sub> = 0.6V             |                        | 53  | 79                    | mA    |
|                                       | V <sub>GC</sub> = 1.95V            |                        | 57  | 87                    |       |
|                                       | PRFOUT = +5.5dBm, IFG[2:0] = 011   |                        | 118 |                       |       |
|                                       | PRFOUT = +8dBm, IFG[2:0] = 011     |                        | 134 |                       |       |
|                                       | Addition for IFLO buffer           |                        | 3.4 | 7.7                   |       |
|                                       | IDLE = low                         |                        | 6   | 10                    |       |
|                                       | TXGATE = low                       |                        | 5   | 7                     |       |
| Sleep-Mode Supply Current             | SHDN = 0V                          |                        | 0.5 | 20                    | μA    |
| Logic-High Voltage                    |                                    | 0.7 x V <sub>CC</sub>  |     |                       | V     |
| Logic-Low Voltage                     |                                    |                        |     | 0.3 x V <sub>CC</sub> | V     |
| Logic Input Current                   |                                    | -5                     |     | +5                    | μA    |
| GC Input Current                      | V <sub>GC</sub> = 0.5V to 2.5V     |                        | 3.3 | 5                     | μA    |
| GC Input Current During Shutdown      | SHDN = low, V <sub>GC</sub> = 2.5V |                        | 7   | 11                    | μA    |
| Lock Indicator High Voltage (Locked)  | 47kΩ pullup load                   | V <sub>CC</sub> - 0.4V |     |                       | V     |
| Lock Indicator Low Voltage (Unlocked) | 47kΩ pullup load                   |                        |     | 0.5                   | V     |

# Complete 450MHz Quadrature Transmitter

MAX2370

## AC ELECTRICAL CHARACTERISTICS

(MAX2370 EV kit,  $V_{CC} = +2.7V$  to  $+3.3V$ ,  $\overline{SHDN} = \overline{IDLE} = \overline{TXGATE} = \text{high}$ ,  $V_{GC} = 2.5V$ ,  $R_{BIAS} = 10k\Omega$ ,  $50\Omega$  system,  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ . Typical values are at  $V_{CC} = \overline{SHDN} = \overline{IDLE} = \overline{TXGATE} = \text{CS} = 3.0V$ ,  $f_{REF} = 19.2\text{MHz}$ , LO input power =  $-15\text{dBm}$ ,  $f_{LO} = 575\text{MHz}$ ,  $f_{RFOUT} = 455\text{MHz}$ ,  $f_{IF} = 120\text{MHz}$ , registers set according to Table 1, input voltage at I and Q =  $130\text{mV}_{RMS}$  differential, cascade specifications assume  $400\Omega$  IF filter with  $5\text{dB}$  insertion loss,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.) (Note 1)

| PARAMETER  | CONDITIONS   |  | MIN        | TYP  | MAX             | UNITS         |
|--|--|--|------------|------|-----------------|---------------|
| <b>MODULATOR</b>   |  |  |            |      |                 |               |
| IF Frequency Range   | Typically meets 30dB sideband suppression over this frequency range                                    |  | 95 to 195  |      |                 | MHz           |
| I/Q Common-Mode Input Voltage                                  | (Notes 2, 3)   |  | 1.35       |      | $V_{CC} - 1.25$ | V             |
| I/Q Input Current  | $V_{CM} = 1.4V$  |  |            |      | 6               | $\mu\text{A}$ |
| Gain-Control Range   | $V_{GC} = 0.5V$ to $2.5V$  | $+25^\circ\text{C} < T_A < +85^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ | 70         | 87   |                 | dB            |
| Gain Variation Over Temperature                                | Relative to $+25^\circ\text{C}$ , $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$                     |  | -2.4, +3.4 |      |                 |               |
| Carrier Suppression  | $V_{GC} = 2.5V$  |  | 30         | 40   |                 | dB            |
| Sideband Suppression   | $V_{GC} = 2.5V$  |  | 30         | 40   |                 | dB            |
| IF Output Noise at Rx Band                                     | $V_{GC}$ set to give $-12\text{dBm}$ IF output power, noise measured at $10\text{MHz}$ offset (Note 4) |  |            | -138 | -135            | dBm/Hz        |
| IF Adjacent Channel Power Ratio IS-95 Reverse Modulation       | $V_{GC}$ set to give $-12\text{dBm}$ IF output power, IFG[2:0] = 011                                   | $f_{\text{OFFSET}} = \pm 885\text{kHz}$ in $30\text{kHz}$ BW               |            | -66  |                 | dBc           |
|  |  | $f_{\text{OFFSET}} = \pm 1.125\text{MHz}$ in $30\text{kHz}$ BW             |            | -69  |                 |               |
|  |  | $f_{\text{OFFSET}} = \pm 1.98\text{MHz}$ in $30\text{kHz}$ BW              |            | -84  |                 |               |
|  |  | $f_{\text{OFFSET}} = \pm 4\text{MHz}$ in $30\text{kHz}$ BW                 |            | -89  |                 |               |
| <b>UPCONVERTER AND PREDRIVER</b>                               |  |  |            |      |                 |               |
| RFOUT Frequency Range  | See the <i>Typical Operating Characteristics</i> for typical gain vs. frequency                        |  | 410 to 500 |      |                 | MHz           |
| LO Frequency Range   | Typically meets 30dB image suppression over this range   |  | 530 to 695 |      |                 | MHz           |
| LO and RFPLL Input Power                                       |  |  | -15        | -7   | 0               | dBm           |
| Conversion Gain  |  |  | 23         |      |                 | dB            |
| MPL Gain Change  | $MPL = 0$ , gain relative to $MPL = 1$   |  | -3.4       |      |                 | dB            |
| RF Gain-Control Range  | $V_{GC} = 0.5V$ to $2.5V$  | $+25^\circ\text{C} < T_A < +85^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ | 30         | 44   |                 | dB            |
| RF Image Suppression   | At maximum output power  |  | -20        |      |                 |               |
| Rx Band Noise Power  | $P_{RFOUT} = +8\text{dBm}$ , noise measured at $+10\text{MHz}$ offset (Note 4)                         |  |            | -130 | -128.5          | dBm/Hz        |
| <b>CASCADED MODULATOR, UPCONVERTER, AND PREDRIVER</b>          |  |  |            |      |                 |               |
| RFOUT Output Power   | Meets ACPR specifications (Note 4)   |  | 5.5        | 10   |                 | dBm           |
| Adjacent Channel Power Ratio IS-95 Reverse Modulation (Note 4) | $P_{OUT} = +8\text{dBm}$ , IFG[2:0] = 011  | $f_{\text{OFFSET}} = \pm 885\text{kHz}$ in $30\text{kHz}$ BW               |            | -64  | -57             | dBc           |
|  |  | $f_{\text{OFFSET}} = \pm 1.125\text{MHz}$ in $30\text{kHz}$ BW             |            | -66  | -61             |               |
|  |  | $f_{\text{OFFSET}} = \pm 1.98\text{MHz}$ in $30\text{kHz}$ BW              |            | -82  | -78             |               |
|  |  | $f_{\text{OFFSET}} = \pm 4\text{MHz}$ in $30\text{kHz}$ BW                 |            | -86  | -78             |               |
|  | $P_{OUT} = +5.5\text{dBm}$ , IFG[2:0] = 011  | $f_{\text{OFFSET}} = \pm 885\text{kHz}$ in $30\text{kHz}$ BW               |            | -64  | -58             |               |
|  |  | $f_{\text{OFFSET}} = \pm 1.125\text{MHz}$ in $30\text{kHz}$ BW             |            | -67  | -62             |               |
|  |  | $f_{\text{OFFSET}} = \pm 1.98\text{MHz}$ in $30\text{kHz}$ BW              |            | -81  | -78             |               |
|  |  | $f_{\text{OFFSET}} = \pm 4\text{MHz}$ in $30\text{kHz}$ BW                 |            | -86  | -85             |               |

# Complete 450MHz Quadrature Transmitter

## AC ELECTRICAL CHARACTERISTICS (continued)

(MAX2370 EV kit,  $V_{CC} = +2.7V$  to  $+3.3V$ ,  $\overline{SHDN} = \overline{IDLE} = \overline{TXGATE} = \text{high}$ ,  $V_{GC} = 2.5V$ ,  $R_{BIAS} = 10k\Omega$ ,  $50\Omega$  system,  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ . Typical values are at  $V_{CC} = \overline{SHDN} = \overline{IDLE} = \overline{TXGATE} = \overline{CS} = 3.0V$ ,  $f_{REF} = 19.2\text{MHz}$ , LO input power =  $-15\text{dBm}$ ,  $f_{LO} = 575\text{MHz}$ ,  $f_{RFOUT} = 455\text{MHz}$ ,  $f_{IF} = 120\text{MHz}$ , registers set according to Table 1, input voltage at I and Q =  $130\text{mV}_{RMS}$  differential, cascade specifications assume  $400\Omega$  IF filter with  $5\text{dB}$  insertion loss,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.) (Note 1)

| PARAMETER                                | CONDITIONS   | MIN  | TYP        | MAX                 | UNITS         |
|--|--|------|------------|---------------------|---------------|
| Output Power Variation Over Temperature  | Relative to $+25^\circ\text{C}$ , $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$ |      | 0, -2      |                     | dB            |
| <b>IF PLL</b>                            |  |      |            |                     |               |
| Reference Frequency                      |  | 5    |            | 30                  | MHz           |
| Reference Frequency Signal Level         |  | 0.1  |            | 0.6                 | $V_{P-P}$     |
| IF Main-Divide Ratio                     |  | 256  |            | 16,383              |               |
| IF Reference-Divide Ratio                |  | 2    |            | 2047                |               |
| VCO Operating Range                      |  |      | 190 to 390 |                     | MHz           |
| Charge-Pump Source/Sink Current          | ICP = 00   | 96   | 139        | 174                 | $\mu\text{A}$ |
|  | ICP = 01   | 135  | 192        | 240                 |               |
|  | ICP = 10   | 190  | 278        | 348                 |               |
|  | ICP = 11   | 267  | 390        | 488                 |               |
| TurboLock Boost Current                  | ICP = 11, ICP_MAX = 1  | 533  | 774        | 968                 | $\mu\text{A}$ |
| Charge-Pump Source/Sink Current Matching | All values of ICP, over compliance range   |      |            | 6                   | %             |
| IF Charge-Pump Compliance                |  | 0.5  |            | $V_{CCIFCP} - 0.5V$ | V             |
| <b>RF PLL</b>                            |  |      |            |                     |               |
| RF PLL Frequency Range                   | RF PLL operated at $2x$ LO frequency   |      |            | 1300                | MHz           |
| Reference Frequency                      |  | 5    |            | 30                  | MHz           |
| RF Main-Divide Ratio                     |  | 4096 |            | 262,143             |               |
| RF Reference-Divide Ratio                |  | 2    |            | 8191                |               |
| Charge-Pump Source/Sink Current          | RCP = 00   | 220  | 325        | 406                 | $\mu\text{A}$ |
|  | RCP = 01   | 441  | 650        | 813                 |               |
|  | RCP = 10   | 499  | 738        | 923                 |               |
|  | RCP = 11   | 717  | 1063       | 1329                |               |
| TurboLock Boost Current                  | (Note 5)   | 1152 | 1694       | 2118                | $\mu\text{A}$ |
| Charge-Pump Source/Sink Current Matching | All values of RCP, over compliance range   |      |            | 6                   | %             |
| RF Charge-Pump Compliance                |  | 0.5  |            | $V_{CCRFCP} - 0.5V$ | V             |
| Phase-Detector Noise Floor               | RCP = 11, RCP_TURBO1 = RCP_TURBO2 = 0, $50\text{kHz}$ comparison frequency         |      | -162       |                     | dBc/Hz        |

**Note 1:** Guaranteed by production test at  $T_A = +25^\circ\text{C}$  to  $+85^\circ\text{C}$ , design and characterization at  $T_A = -40^\circ\text{C}$ .

**Note 2:** ACPR is met over the specified  $V_{CM}$  range.

**Note 3:**  $V_{CM}$  must be supplied by the I/Q baseband source with  $\pm 8\mu\text{A}$  current capability.

**Note 4:** Guaranteed by design and characterization to  $6\sigma$ .

**Note 5:** When enabled with RCP\_TURBO1 and RCP\_TURBO2 (see Tables 3 and 4), the total charge-pump current is specified. For all values of RCP, the total turboLock current is 1.63 times the corresponding nonturbo current value.

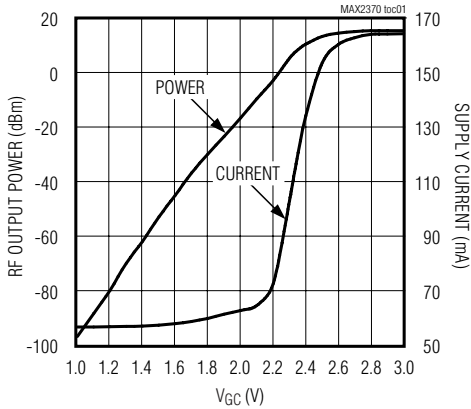
# Complete 450MHz Quadrature Transmitter

## Typical Operating Characteristics

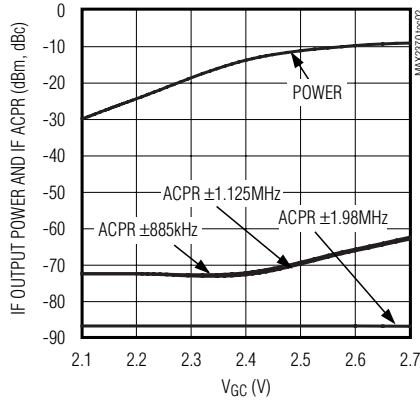
(MAX2370 EV kit,  $V_{CC\_} = \overline{\text{SHDN}} = \overline{\text{IDLE}} = \overline{\text{TXGATE}} = \overline{\text{CS}} = 3.0\text{V}$ ,  $f_{\text{REF}} = 19.2\text{MHz}$ , LO input power =  $-15\text{dBm}$ ,  $f_{\text{LO}} = 575\text{MHz}$ ,  $f_{\text{RFOUT}} = 455\text{MHz}$ ,  $f_{\text{IF}} = 120\text{MHz}$ ,  $R_{\text{BIAS}} = 10\text{k}\Omega$ ,  $V_{\text{GC}} = 2.5\text{V}$ , registers set according to Table 1, input voltage at I and Q =  $130\text{mV}_{\text{RMS}}$  differential,  $T_{\text{A}} = +25^{\circ}\text{C}$ , unless otherwise noted.)

**MAX2370**

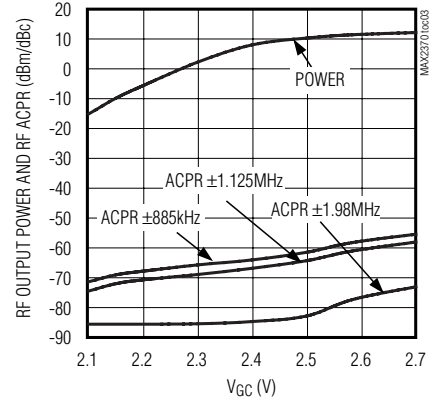
**RF OUTPUT POWER AND SUPPLY CURRENT vs. GAIN-CONTROL VOLTAGE**



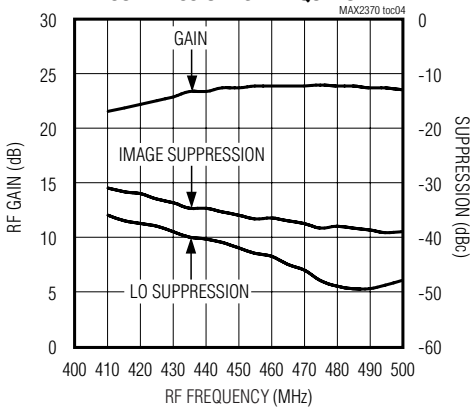
**IF OUTPUT POWER AND IF ACPR vs. GAIN-CONTROL VOLTAGE**



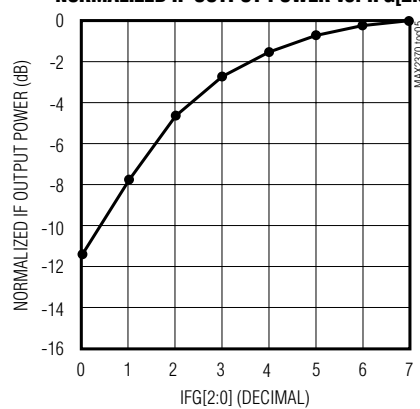
**RF OUTPUT POWER AND RF ACPR vs. GAIN-CONTROL VOLTAGE**



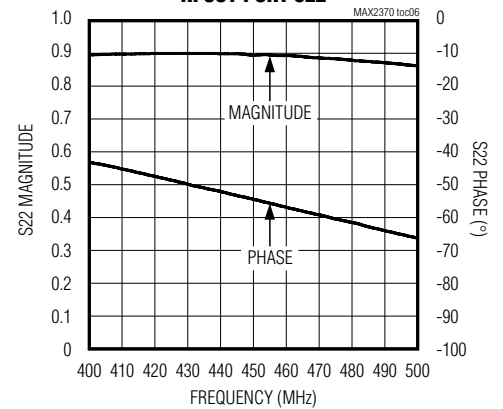
**RF GAIN, IMAGE SUPPRESSION, AND LO SUPPRESSION vs. FREQUENCY**



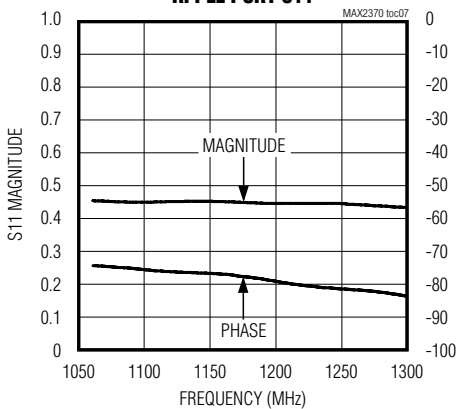
**NORMALIZED IF OUTPUT POWER vs. IFG[2:0]**



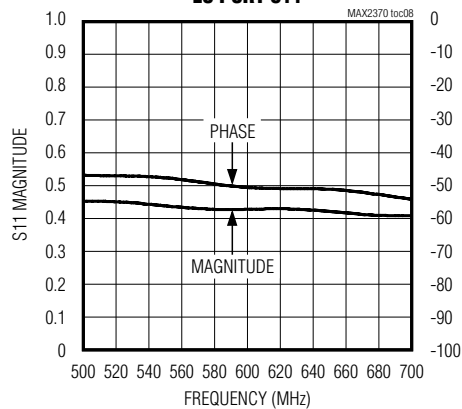
**RFOUT PORT S22**



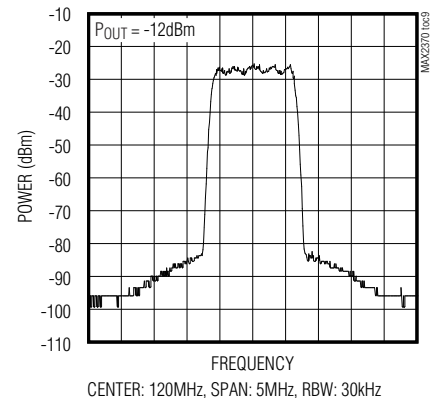
**RFPLL PORT S11**



**LO PORT S11**



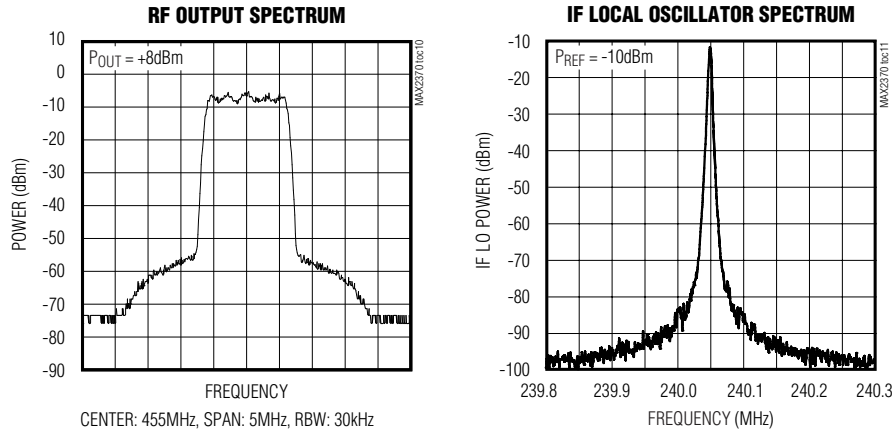
**IF OUTPUT SPECTRUM**



# Complete 450MHz Quadrature Transmitter

## Typical Operating Characteristics (continued)

(MAX2370 EV kit,  $V_{CC\_} = \overline{\text{SHDN}} = \overline{\text{IDLE}} = \overline{\text{TXGATE}} = \overline{\text{CS}} = 3.0\text{V}$ ,  $f_{\text{REF}} = 19.2\text{MHz}$ , LO input power = -15dBm,  $f_{\text{LO}} = 575\text{MHz}$ ,  $f_{\text{RFOUT}} = 455\text{MHz}$ ,  $f_{\text{IF}} = 120\text{MHz}$ ,  $R_{\text{BIAS}} = 10\text{k}\Omega$ ,  $V_{\text{GC}} = 2.5\text{V}$ , registers set according to Table 1, input voltage at I and Q = 130mV<sub>RMS</sub> differential,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.)



## Pin Description

| PIN                              | NAME                       | FUNCTION  |
|----------------------------------|----------------------------|---|
| 1                                | RFOUT                      | Transmitter RF Output. This open-collector output requires a pullup inductor to the supply voltage, which can be part of the output matching network.   |
| 2, 10, 11, 16, 17, 32-35, 43, 47 | N.C.                       | No Connection. Leave these pins open-circuit. Some of these pins are internally connected.  |
| 3                                | LOCK                       | Open-Drain Output Indicating LOCK Status of the IF and/or the RF PLLs. Requires an external pullup resistor. Control using configuration register bits LD_MODE[1:0].  |
| 4                                | V <sub>CCDRV</sub>         | Power Supply for the RF Driver Stage. Bypass to PC board ground with a capacitor placed as close to the pin as possible. Do not share capacitor ground vias with other ground connections.  |
| 5                                | $\overline{\text{IDLE}}$   | Digital Input. Drive to logic-high for normal operation. Logic-low on $\overline{\text{IDLE}}$ shuts down everything except the RF PLL. A small RC lowpass filter can be used to filter digital noise.  |
| 6                                | V <sub>CC</sub>            | Power Supply for the Upconverter Stage. Bypass to PC board ground with a capacitor placed as close to the pin as possible. Do not share capacitor ground vias with other ground connections.  |
| 7                                | $\overline{\text{TXGATE}}$ | Digital Input. Drive to logic-high for normal operation. Logic-low on $\overline{\text{TXGATE}}$ shuts down everything except the RF PLL, IF PLL, IF VCO. A small RC lowpass can be used to filter digital noise.   |
| 8, 9                             | IFIN+, IFIN-               | Differential IF Inputs to the RF Upconverter. IFIN+ and IFIN- are internally biased to typically V <sub>CC</sub> - 1.5V. The input impedance for this port is nominally 400Ω differential. AC-couple the output of the differential IF filter to this port. Keep the differential lines as short as possible to minimize the effects of stray pickup. |
| 12                               | RBIAS                      | Bias Resistor Connection. Internally biased to typically 1.18V. An external resistor must be connected from RBIAS to ground to set the bias current for the upconverters and PA driver stages. The nominal resistor value is 10kΩ. This value can be altered to optimize the linearity of the driver stage.   |

# Complete 450MHz Quadrature Transmitter

## Pin Description (continued)

**MAX2370**

| PIN        | NAME                     | FUNCTION   |
|------------|--------------------------|--|
| 13, 14, 15 | CLK, DI, $\overline{CS}$ | CMOS Inputs from the 3-Wire Serial Bus (SPI/QSPI/MICROWIRE Compatible). A small RC lowpass filter on each of these pins can be used to reduce noise on these lines.  |
| 18, 19     | IFOUT-, IFOUT+           | Differential IF Outputs. This port is active when IF_SEL is LOW and supports both FM and CDMA modes. IFOUT+ and IFOUT- must be inductively pulled up to V <sub>CC</sub> and differentially loaded with typically 560Ω. A 400Ω differential IF bandpass filter is connected between this port and IFIN+/- . The pullup inductors can be part of the filter structure. The differential output impedance of this port is nominally 400Ω, including the 560Ω external differential resistor. Keep the transmission lines from these pins as short as possible to minimize the unintentional pickup of spurious signals and noise. |
| 20         | GC                       | RF and IF Gain-Control Analog Input. Accepts input voltages from 0.5V (minimum gain) to 2.5V (maximum gain). When not driven, GC is internally biased to typically 1.5V. RC lowpass filter the voltage applied to this pin to remove DAC noise or PDM clock spurs.   |
| 21         | V <sub>CC</sub>          | Power Supply for the IF VGA. Bypass to PC board ground with a 0.1μF capacitor placed as close to the pin as possible. Do not share capacitor ground vias with other ground connections.  |
| 22         | V <sub>CC</sub>          | Power Supply for the I/Q Modulator. Bypass to PC board ground with a 0.1μF capacitor placed as close to the pin as possible. Do not share capacitor ground vias with other ground connections.   |
| 23, 24     | Q+, Q-                   | Differential Q-Channel Baseband Inputs to the Modulator. Q+ and Q- connect directly to the bases of a differential pair and require a typical 1.35V to (V <sub>CC</sub> - 1.5V) external common-mode bias voltage.   |
| 25, 26     | I+, I-                   | Differential I-Channel Baseband Inputs to the Modulator. I+ and I- connect directly to the bases of a differential pair and require a typical 1.35V to (V <sub>CC</sub> - 1.5V) external common-mode bias voltage.   |
| 27         | $\overline{SHDN}$        | Digital Input. Drive LOW to shut down the entire IC, drive high for normal operation. A small RC lowpass filter can be used to filter digital noise.   |
| 28         | V <sub>CC</sub>          | Power Supply for the VCO Section. Bypass to PC board ground with a 0.1μF capacitor placed as close to the pin as possible. Do not share capacitor ground vias with other ground connections.   |
| 29         | IFLO                     | IF LO Output. Provides access to the IF VCO output and can be used to drive an external PLL. It can be disabled by logic-low on the BUF_EN control bit. IFLO is internally biased to typically 1.5V.   |
| 30, 31     | TANK-, TANK+             | Differential Tank Connections for the IF VCO. TANK+ and TANK- are internally biased to approximately 1.6V and must be AC-coupled to the external tank (can be DC-coupled if tank does not sink or source current).   |
| 36         | REF                      | Reference Frequency Input. REF is internally biased to approximately 1.0V and must be AC-coupled to the reference source. This is a high-impedance port and must be externally terminated in the desired impedance.  |
| 37         | V <sub>CC</sub> IFCP     | Power Supply for the IF Charge Pump. This supply can be different from the system V <sub>CC</sub> . Bypass to PC board ground with a minimum 0.1μF capacitor placed as close to the pin as possible. Do not share capacitor ground vias with other ground connections.   |
| 38         | IFCP                     | High-Impedance IF Charge-Pump Output. Connect to the tune input of the IF VCO through the IF PLL loop filter. Keep the connection from IFCP to the tune input as short as possible to prevent spurious pickup.   |
| 39         | V <sub>CC</sub>          | Power Supply for Digital Circuitry. Bypass to PC board ground with a minimum 0.1μF capacitor placed as close to the pin as possible. Do not share capacitor ground vias with other ground connections.   |

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## Pin Description (continued)

| PIN            | NAME    | FUNCTION   |
|----------------|---------|--|
| 40             | RFCP    | High-Impedance RF Charge-Pump Output. Connect to the tune input of the RF VCO through the RF PLL loop filter. Keep the connection from RFCP to the tune input as short as possible to prevent spurious pickup.   |
| 41             | VCCRFCP | Power Supply for the RF Charge Pump. This supply can be different from the system V <sub>CC</sub> . Bypass to PC board ground with a minimum 0.1μF capacitor placed as close to the pin as possible. Do not share capacitor ground vias with other ground connections. |
| 42             | RFPLL   | RF PLL Input. This port drives the RF PLL. RFPLL is internally biased to typically V <sub>CC</sub> - 0.8V.   |
| 44             | LO      | RF LO Input. LO is internally biased to typically V <sub>CC</sub> - 0.8V.  |
| 45, 46, 48, EP | GND     | Ground Connection. Solder the exposed paddle (EP) evenly to the board's ground plane for proper operation.   |

### Detailed Description

The MAX2370 complete quadrature transmitter accepts differential I/Q baseband inputs with external common-mode bias. A modulator upconverts the baseband inputs to a 95MHz to 195MHz IF frequency. A gain-control voltage pin (GC) controls the gain of both the IF and RF VGAs simultaneously to achieve the best current consumption and linearity performance. The IF signal is brought off-chip for filtering, then fed to a single sideband upconverter followed by the RF VGA and PA driver. The RF upconverter requires an external VCO for operation. The IF PLL, RF PLL, and operating mode can be programmed by an SPI/QSPI/ MICROWIRE-compatible 3-wire interface.

The following sections describe each block in the *Functional Diagram*.

#### I/Q Modulator

Differential in-phase (I) and quadrature-phase (Q) inputs are designed to be DC-coupled and biased with the baseband output from a digital-to-analog converter (DAC). The I and Q inputs need a typical DC bias of V<sub>CC</sub> / 2 and a current-drive capability of 8μA. However, common-mode voltages in the 1.35V to (V<sub>CC</sub> - 1.25V) range are also acceptable. The I and Q input capacitances are typically 0.6pF to ground on each pin. The IF VCO output is fed into a divide-by-two quadrature generator block to derive quadrature LO components to drive the I/Q modulator. The output of the modulator is fed into the IF VGA.

#### IF VCO

The IF VCO oscillates at twice the desired IF frequency. The oscillation frequency is determined by external tank components (see the *IF Tank Design* section). Typical spurious performance for the IF VCO is shown in the *Typical Operating Characteristics*.

#### IFLO Output Buffer

IFLO provides a buffered LO output when BUF\_EN is 1. The IFLO output frequency is equal to the IF VCO frequency, and the typical output power is -12dBm. This output is intended for applications where the receive IF is the same frequency as the transmit IF.

#### IF/RF PLL

The IF/RF PLL uses a charge-pump output to drive external loop filters. The loop filter is typically a passive second-order lead-lag filter. Outside the filter's bandwidth, phase noise is determined by the tank components. The two components that contribute most significantly to phase noise are the inductor and varactor. Use high-Q inductors and varactors to maximize equivalent parallel resistance. The IF\_TURBO\_CHARGE, RCP\_TURBO1, and RCP\_TURBO2 bits can be set to enable turbo mode. Turbo mode provides maximum charge-pump current during frequency acquisition. Turbo mode is disabled after frequency acquisition is achieved. When turbo mode is disabled, charge-pump current returns to the programmed levels as set by the ICP and RCP bits in the CONFIG register (Table 3).

#### IF VGA

The IF VGA allows the IF output level to be controlled by a voltage applied to the GC pin. The 0.5V to 2.5V voltage range on GC provides a gain-control range of > 70dB, with 2.5V providing maximum gain. The differential IF output ports are optimized for the 95MHz to 195MHz frequency range. Do not allow V<sub>GC</sub> to exceed V<sub>CC</sub> - 0.2V as this may cause oscillations at cold temperatures.

#### Single-Sideband Mixer and RF VGA

The RF transmit mixer uses a single-sideband architecture to eliminate an off-chip RF filter. The RF VGA follows the single-sideband mixer and is controlled by the same GC voltage as the IF VGA to provide optimum



# Complete 450MHz Quadrature Transmitter

current consumption and linearity performance. The power-control range of the RF VGA is typically 44dB.

## PA Driver

The MAX2370 includes a PA driver that is optimized for the 410MHz to 500MHz RF frequency range. The PA driver is an open-collector output and requires a pullup inductor to  $V_{CC}$ . The pullup inductor can act as a shunt element in a shunt-series matching network.

## Programmable Registers

The MAX2370 includes eight programmable registers consisting of four divide registers, a configuration register, an operational control register, a current control register, and a test register. Each register consists of 24 bits. The 4 least significant bits (LSBs) are the register's address. The 20 most significant bits (MSBs) are used for register data. All registers contain some "don't care" bits. These can be either a 0 or 1 and do not affect operation (Figure 1). Data is shifted in MSB first, followed by the 4-bit address. When  $\overline{CS}$  is low, the clock is active and data is shifted with the rising edge of the clock. When  $\overline{CS}$  transitions to high, the shift register is latched into the register selected by the contents of the address bits. Typical register settings for the eight registers are shown in Table 1. The dividers and control registers are programmed from the SPI/QSPI/MICROWIRE-compatible serial port.

The RFM register sets the main frequency divide ratio for the RF PLL. The RFR register sets the reference frequency divide ratio. The RF VCO frequency can be determined by the following:

$$\text{RF VCO frequency} = f_{\text{REF}} \times (\text{RFM} / \text{RFR})$$

The IFM and IFR registers are similar:

$$\text{IF VCO frequency} = f_{\text{REF}} \times (\text{IFM} / \text{IFR})$$

where  $f_{\text{REF}}$  is the external reference frequency.

The operational control register (OPCTRL) controls the state of the MAX2370. See Table 2 for a description of each bit's function.

The configuration register (CONFIG) sets the configuration for the RF and IF PLL and the baseband I/Q input levels. See Table 3 for a description of each bit's function.

The current-control register (ICCTRL) modifies the bias current to accommodate different operating modes. In the high-power mode,  $\text{MPL} = 1$  sets the bias current and conversion gain to deliver an output power of at least +5.5dBm from the PA drivers. In the low-noise mode,  $\text{MPL} = 0$  reduces output noise by 2.5dB for any given

output power at the expense of 3.4dB less maximum obtainable output power.

## Power Management

Bias control is distributed among several functional sections and can be controlled to accommodate many different power-down modes as shown in Table 8.

The serial interface remains active during shutdown. Setting bit  $\text{SHDN\_BIT} = 0$  or pin  $\text{SHDN} = \text{GND}$  powers down the device. In either case, PLL programming and register information is retained.

## Applications Information

### 3-Wire Serial Interface

Figure 3 shows the 3-wire interface timing diagram. The 3-wire bus is SPI/QSPI/MICROWIRE compatible.

### Electromagnetic Compliance Considerations

To produce a low-spur and EMC-compliant transmitter, minimize circular current-loop area to reduce H-field radiation. To minimize circular current-loop area, bypass all  $V_{CC}$  pins as close to the device as possible and use the distributed capacitance of a ground plane. To minimize voltage drops, make  $V_{CC}$  traces short and wide.

Program only the necessary bits in any register to minimize cycling of the serial interface's clock. RC filtering can also be used to slow the clock edges on the 3-wire interface, reducing high-frequency spectral content. RC filtering also provides transient protection by shunting high frequencies to ground, while the series resistance attenuates the transients for error-free operation. The same applies to the logic input pins (SHDN, TXGATE, IDLE).

Place high-frequency bypass capacitors close to the pins with a dedicated via for each capacitor to ground. The 48-pin thin QFN-EP package provides minimal ground inductance by using an exposed paddle under the part. Provide at least five low-inductance vias under the exposed paddle to ground. Use a solid ground plane wherever possible. Any cutout in the ground plane may act as a slot radiator and reduce its shield effectiveness.

Keep RF LO traces as short as possible to reduce LO radiation and susceptibility to interference.

### IF Tank Design

The IF tank is fully differential. The external tank components for 120MHz IF operation are shown in the *Typical Application Circuit*. See Maxim Application Note *IF Tank Design for the MAX2360* at [www.maxim-ic.com](http://www.maxim-ic.com) for more information on designing tanks for alternate IFs.

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Internal to the IC, the charge pump has a leakage of less than 10nA. This is equivalent to a 300M $\Omega$  shunt resistor. The charge-pump output must see an extremely high DC resistance of greater than 300M $\Omega$ . This minimizes charge-pump spurs at the comparison frequency. Make sure there is no solder flux under the varactor or loop filter and use low-leakage capacitors.

## **Layout Considerations**

The MAX2370 EV kit can be used as a starting point for layout. For best performance, take into consideration power-supply issues as well as RF, LO, and IF layout.

### **Power-Supply Layout**

To minimize coupling between different sections of the IC, the ideal power-supply layout is a star configuration, which has a large decoupling capacitor at a central V<sub>CC</sub> node. The V<sub>CC</sub> traces branch out from this node, each going to a separate V<sub>CC</sub> pin of the MAX2370. At the end of each trace is a bypass capacitor with impedance to ground less than 1 $\Omega$  at the frequency of interest. This arrangement provides local decoupling at each V<sub>CC</sub> pin. Use at least one via per bypass capacitor for a low-inductance ground connection. Also, connect the exposed paddle to the PC board GND with multiple vias to provide the lowest inductance ground connection possible.

### **Matching Network Layout**

The layout of a matching network can be very sensitive to parasitic circuit elements. To minimize parasitic inductance, keep all traces short and place components as close to the IC as possible. To minimize parasitic capacitance, a cutout in the ground plane (and any other planes) below the matching network components can be used.

Keep traces short on the high-impedance ports (e.g., IF inputs and outputs) to minimize shunt capacitance.

### **Tank Layout**

Keep the traces coming out of the tank short to reduce series inductance and shunt capacitance. Keep the inductor pads and coupling capacitor pads small to minimize stray shunt capacitance.

## **Chip Information**

PROCESS: BiCMOS

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|                          | 24-BIT REGISTER             |     |     |     |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    | ADDRESS        |    |    |    |
|--------------------------|-----------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|----|----|----------------|----|----|----|
|                          | DATA 20 BITS                |     |     |     |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    | ADDRESS 4 BITS |    |    |    |
|                          | B19                         | B18 | B17 | B16 | B15 | B14 | B13 | B12 | B11 | B10 | B9 | B8 | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | A3             | A2 | A1 | A0 |
| RFM-DIVIDE REGISTER      | RFM-DIVIDE RATIO (18)       |     |     |     |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    | ADDRESS        |    |    |    |
|                          | X                           | X   |     |     |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    | 0              | 0  | 0  | 0  |
| RFR-DIVIDE REGISTER      | RFR-DIVIDE RATIO (13)       |     |     |     |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    | ADDRESS        |    |    |    |
|                          | X                           | X   | X   | X   | X   | X   | X   |     |     |     |    |    |    |    |    |    |    |    |    |    | 0              | 0  | 0  | 1  |
| IFM-DIVIDE REGISTER      | IFM-DIVIDE RATIO (14)       |     |     |     |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    | ADDRESS        |    |    |    |
|                          | X                           | X   | X   | X   | X   | X   | X   |     |     |     |    |    |    |    |    |    |    |    |    |    | 0              | 0  | 1  | 0  |
| IFR-DIVIDE REGISTER      | IFR-DIVIDE RATIO (11)       |     |     |     |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    | ADDRESS        |    |    |    |
|                          | X                           | X   | X   | X   | X   | X   | X   | X   | X   |     |    |    |    |    |    |    |    |    |    |    | 0              | 0  | 1  | 1  |
| CONTROL REGISTER         | OPERATION CONTROL BITS (16) |     |     |     |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    | ADDRESS        |    |    |    |
|                          | X                           | X   | X   | X   |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    | 0              | 1  | 0  | 0  |
| CONFIGURATION REGISTER   | CONFIGURATION BITS (16)     |     |     |     |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    | ADDRESS        |    |    |    |
|                          | X                           | X   | X   | X   |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    | 0              | 1  | 0  | 1  |
| CURRENT-CONTROL REGISTER | CURRENT CONTROL BITS (16)   |     |     |     |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    | ADDRESS        |    |    |    |
|                          | X                           | X   | X   | X   |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    | 0              | 1  | 1  | 0  |
| TEST REGISTER            | TEST BITS (9)               |     |     |     |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    | ADDRESS        |    |    |    |
|                          | X                           | X   | X   | X   | X   | X   | X   | X   | X   | X   |    |    |    |    |    |    |    |    |    |    | 0              | 1  | 1  | 1  |

X = DONT CARE

Figure 1. Register Configuration

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Table 1. Register Settings for Typical Operation

| REGISTER NAME | TYPICAL SETTINGS     | REGISTER ADDRESS  | FUNCTION  |
|---------------|----------------------|-------------------|---|
| RFM[17:0]     | 23000 <sub>DEC</sub> | 0000 <sub>b</sub> | RF M-Divider Count  |
| RFR[12:0]     | 384 <sub>DEC</sub>   | 0001 <sub>b</sub> | RF R-Divider Count  |
| IFM[13:0]     | 4800 <sub>DEC</sub>  | 0010 <sub>b</sub> | IF M-Divider Count  |
| IFR[10:0]     | 384 <sub>DEC</sub>   | 0011 <sub>b</sub> | IF R-Divider Count  |
| OPCTRL[15:0]  | 090F <sub>hex</sub>  | 0100 <sub>b</sub> | Operational Control Settings  |
| CONFIG[15:0]  | D03F <sub>hex</sub>  | 0101 <sub>b</sub> | Configuration and Setup Control   |
| ICCCTRL[15:0] | 0C38 <sub>hex</sub>  | 0110 <sub>b</sub> | Current Multiplication Factor, Throttle-Back Control, Modulator Bypass, Compensation for Gain Variation Over Temperature, Maximum Power-Level Setting |
| TEST[8:0]     | 100 <sub>hex</sub>   | 0111 <sub>b</sub> | Test Mode Control   |

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**Table 2. Operation Control Register (OPCTRL, Address: 0100<sub>b</sub>)**

| BIT NAME                   | BIT LOCATION (0 = LSB) | TYPICAL SETTINGS | FUNCTION  |
|----------------------------|------------------------|------------------|---|
| RESERVED                   | 15                     | 0                | Reserved. Set to 0 for normal operation.  |
| RCP_TURBO1                 | 14                     | 0                | Works with RCP_TURBO2 (in the configuration register) to set the turbo charge-pump mode (see Table 7).  |
| ICP_MAX                    | 13                     | 0                | 0 = Normal operation.<br>1 = Sets IF charge-pump current to turbo level and keeps it there even after lock is established. This mode provides the highest charge-pump current, but effectively no turbo mode since current is already at maximum. |
| RESERVED                   | 12, 11                 | 01               | Reserved. Set to 01 for normal operation.   |
| RESERVED                   | 10, 9                  | 00               | Reserved. Set to 00 for normal operation.   |
| IFG                        | 8, 7, 6                | 100              | 3-bit gain balancing control. Increases IF gain by approximately 2dB per LSB. Provides a means for adjusting balance between RF and IF gain for optimized linearity.  |
| RESERVED                   | 5                      | 0                | Reserved. Set to 0 for normal operation.  |
| BUF_EN                     | 4                      | 0                | LO buffer enable.<br>0 = LO buffer off.<br>1 = LO buffer on.  |
| MOD_TYPE                   | 3                      | 1                | Selects type of modulation.<br>0 = Selects direct VCO modulation (IF VCO is directly modulated and the I/Q modulator is bypassed).<br>1 = Selects quadrature modulation.  |
| $\overline{\text{STBY}}$   | 2                      | 1                | Standby control.<br>0 = Shuts down everything except the registers and serial interface.<br>1 = Normal operation.   |
| $\overline{\text{TXSTBY}}$ | 1                      | 1                | Transmitter standby control.<br>0 = Shuts down the modulator and upconverter leaving PLLs locked and registers active. This bit's functionality is equivalent to that of the $\overline{\text{TX\_GATE}}$ pin.<br>1 = Normal operation.           |
| SHDN_BIT                   | 0                      | 1                | Shutdown control.<br>0 = Shuts down everything except the serial interface.<br>1 = Normal operation.  |

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**Table 3. Configuration Register (CONFIG, Address: 0101<sub>b</sub>)**

| BIT NAME        | BIT LOCATION (0 = LSB) | TYPICAL SETTINGS | FUNCTION  |
|-----------------|------------------------|------------------|---|
| IF_PLL_SHDN     | 15                     | 1                | IF PLL shutdown control.<br>0 = Shuts down IF PLL. This mode is used with an external IF PLL.<br>1 = Normal operation.  |
| RF_PLL_SHDN     | 14                     | 1                | RF PLL shutdown control.<br>0 = Shuts down RF PLL. This mode is used with an external RF PLL.<br>1 = Normal operation.  |
| RESERVED        | 13                     | 0                | Reserved. Set to 0 for normal operation.  |
| IQ_LEVEL        | 12                     | 1                | Selects the nominal I/Q input levels.<br>0 = Selects 300mV <sub>p-p</sub> input mode.<br>1 = Selects 600mV <sub>p-p</sub> input mode.   |
| RESERVED        | 11, 10                 | 00               | Reserved. Set to 00 for normal operation.   |
| ICP             | 9, 8                   | 00               | Sets the IF charge-pump current.<br>00 = 139μA.<br>01 = 192μA.<br>10 = 278μA.<br>11 = 390μA.  |
| RCP             | 7, 6                   | 00               | Sets the RF charge-pump current.<br>00 = 325μA.<br>01 = 650μA.<br>10 = 738μA.<br>11 = 1063μA.   |
| RESERVED        | 5, 4                   | 11               | Reserved. Set to 11 for normal operation.   |
| IF_TURBO_CHARGE | 3                      | 1                | IF turbo-charge control.<br>0 = Disables extra charge-pump current during acquisition.<br>1 = Activates turbo-charge feature providing extra current during acquisition.                      |
| RCP_TURBO2      | 2                      | 1                | Works with RCP_TURBO1 (in the operation control register) to set the turbo charge-pump mode (see Table 7).  |
| LD_MODE         | 1, 0                   | 11               | Determines output mode for LOCK pin as defined below:<br>00 = Test mode.<br>01 = IF PLL lock detector.<br>10 = RF PLL lock detector.<br>11 = Logical AND of IF PLL and RF PLL lock detectors. |

**Table 4. Current-Control Register (I<sub>CC</sub>CTRL, Address: 0110<sub>b</sub>)**

| BIT NAME      | BIT LOCATION (0 = LSB) | TYPICAL SETTINGS | FUNCTION   |
|---------------|------------------------|------------------|--|
| RESERVED      | 15, 14, 13, 12         | 0000             | Reserved. Set to 0000 for normal operation.  |
| MPL           | 11                     | 1                | Sets the maximum RF output power level.<br>0 = Sets to low-noise mode.<br>1 = Sets to normal power mode. |
| RESERVED      | 10, 9, 8, 7            | 1000             | Reserved. Set to 1000 for normal operation.  |
| THROTTLE_BACK | 6, 5, 4                | 011              | Controls the throttleback rate (see Table 6).  |
| I_MULT        | 3, 2, 1, 0             | 1000             | Sets the current scale factor for the PA driver (see Table 5).   |

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**Table 5. Typical Current Scale Factors Set By I\_MULT Bits**

| BIT NAME | BITS           | NOMINAL CURRENT SCALE FACTOR |
|----------|----------------|------------------------------|
| I_MULT   | 0011           | 0.69                         |
|          | 0100           | 0.75                         |
|          | 0101           | 0.81                         |
|          | 0110           | 0.88                         |
|          | 0111           | 0.94                         |
|          | 1000 (default) | 1.00                         |
|          | 1001           | 1.13                         |
|          | 1010           | 1.25                         |
|          | 1011           | 1.38                         |
|          | 1100           | 1.50                         |

**Table 6. Typical Throttleback Rate Set By THROTTLE\_BACK Bits**

| BIT NAME      | BITS | NOMINAL RATE (dBmA/dB) |
|---------------|------|------------------------|
| THROTTLE_BACK | 000  | 1.3                    |
|               | 001  | 1.2                    |
|               | 010  | 1.1                    |
|               | 011  | 1.0                    |
|               | 100  | 0.9                    |
|               | 101  | 0.8                    |
|               | 110  | 0.7                    |
|               | 111  | 0.6                    |

**Table 7. RF Turbo Charge-Pump Current Setting**

| RCP_TURBO1 | RCP_TURBO2 | FUNCTION  |
|------------|------------|---|
| 0          | 0          | No turbo current. Charge-pump current is set by RCP bits.   |
| 0          | 1          | Turbo current turns on every time RF PLL is reprogrammed. Turbo current is automatically turned off after RF PLL is locked. |
| 1          | 0          | Turbo current is always on.   |
| 1          | 1          | Turbo current is turned on every time RF PLL is out of lock.  |

**Table 8. Power-Down Modes**

| POWER-DOWN MODE                | COMMENTS                                 | UPCONVERTER | MODULATOR | RF PLL | IF VCO | IF PLL |
|--------------------------------|--|-------------|-----------|--------|--------|--------|
| $\overline{\text{SHDN}}$ Pin   | Ultra-low shutdown current               | OFF         | OFF       | OFF    | OFF    | OFF    |
| $\overline{\text{IDLE}}$ Pin   | Rx only mode                             | OFF         | OFF       | —      | OFF    | OFF    |
| $\overline{\text{TXGATE}}$ Pin | For punctured Tx mode                    | OFF         | OFF       | —      | —      | —      |
| RF_PLL_SHDN Bit                | For external RF PLL use                  | —           | —         | OFF    | —      | —      |
| IF_PLL_SHDN Bit                | For external IF PLL use                  | —           | —         | —      | —      | OFF    |
| TXSTBY Bit                     | Tx is OFF, but IF and RF LOs stay locked | OFF         | OFF       | —      | —      | —      |

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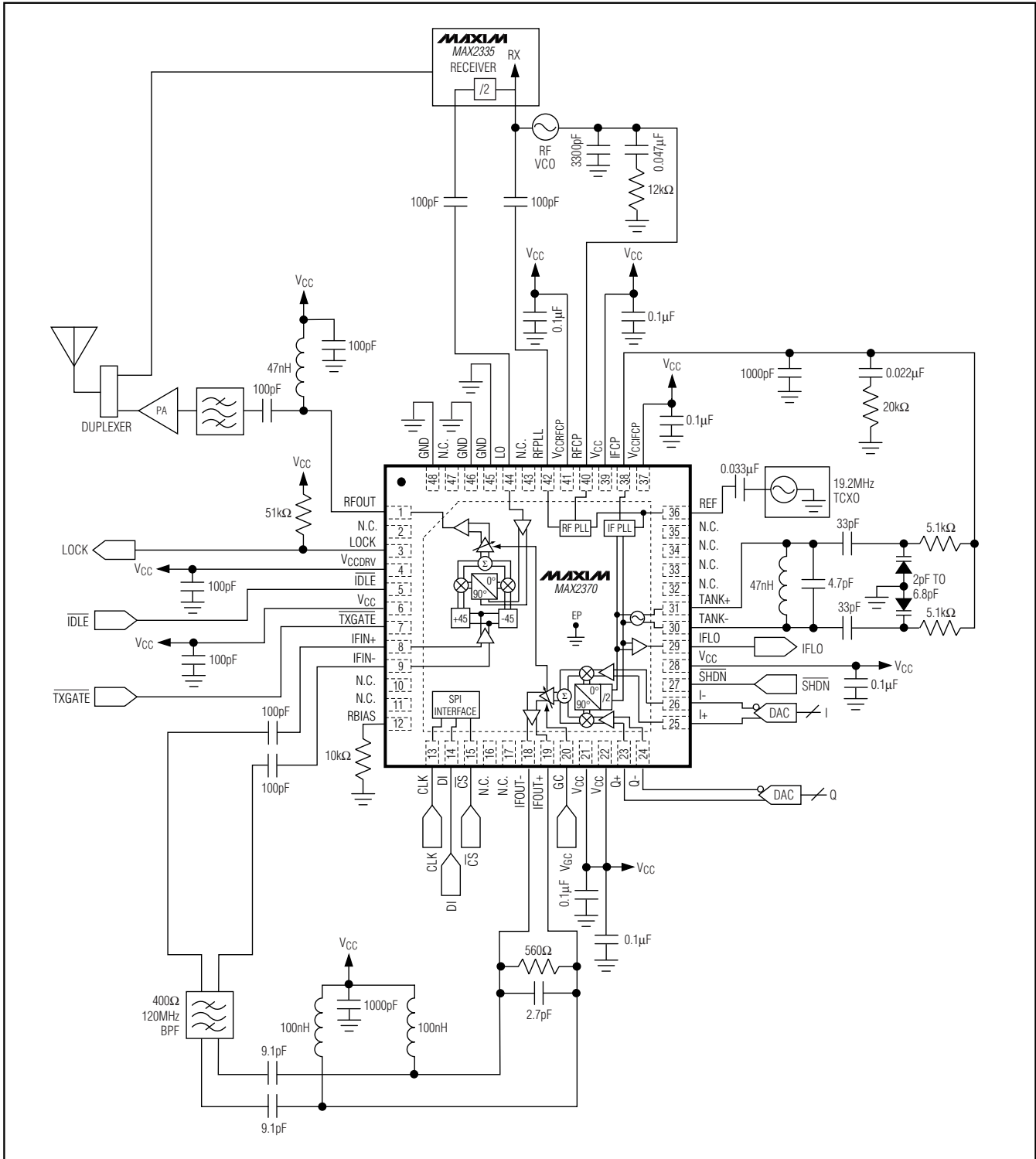


Figure 2. MAX2370 Typical Application Circuit



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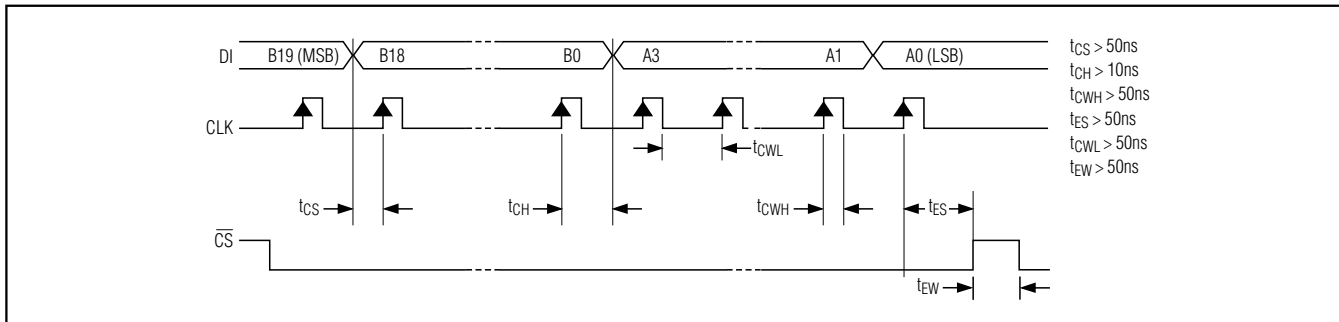
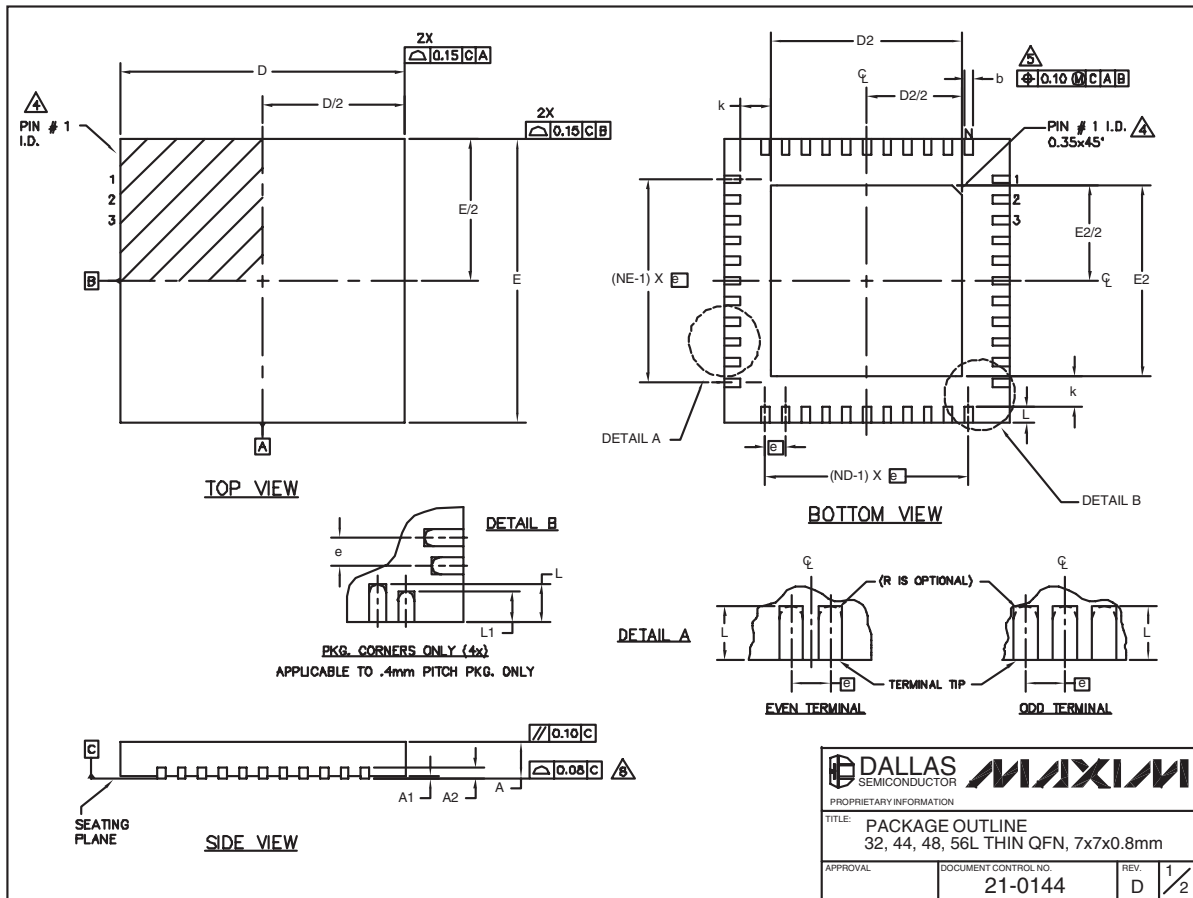


Figure 3. 3-Wire Interface Timing Diagram

# Complete 450MHz Quadrature Transmitter

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



32, 44, 48L QFN.EPS

# Complete 450MHz Quadrature Transmitter

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

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| COMMON DIMENSIONS |           |      |      |           |      |      |           |      |      |                                     |      |      |           |      | EXPOSED PAD VARIATIONS |            |                   |      |      |      |      |      |      |                    |                    |
|-------------------|-----------|------|------|-----------|------|------|-----------|------|------|-------------------------------------|------|------|-----------|------|------------------------|------------|-------------------|------|------|------|------|------|------|--------------------|--------------------|
| PKG               | 32L 7x7   |      |      | 44L 7x7   |      |      | 48L 7x7   |      |      | CUSTOM PKG.<br>(T4877-1)<br>48L 7x7 |      |      | 56L 7x7   |      |                        | PKG. CODES | DEPOPULATED LEADS | D2   |      |      | E2   |      |      | JEDEC MO220 REV. C | DOWN BONDS ALLOWED |
|                   | MIN.      | NOM. | MAX. | MIN.      | NOM. | MAX. | MIN.      | NOM. | MAX. | MIN.                                | NOM. | MAX. | MIN.      | NOM. | MAX.                   |            |                   | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |                    |                    |
| A                 | 0.70      | 0.75 | 0.80 | 0.70      | 0.75 | 0.80 | 0.70      | 0.75 | 0.80 | 0.70                                | 0.75 | 0.80 | 0.70      | 0.75 | 0.80                   | T3277-1    | -                 | 4.55 | 4.70 | 4.85 | 4.55 | 4.70 | 4.85 | -                  | NO                 |
| A1                | 0         | 0.02 | 0.05 | 0         | 0.02 | 0.05 | 0         | 0.02 | 0.05 | 0                                   | 0.02 | 0.05 | 0         | -    | 0.05                   | T3277-2    | -                 | 4.65 | 4.70 | 4.85 | 4.65 | 4.70 | 4.85 | -                  | YES                |
| A2                | 0.20 REF. |      |      | 0.20 REF. |      |      | 0.20 REF. |      |      | 0.20 REF.                           |      |      | 0.20 REF. |      |                        | T4477-1    | -                 | 4.55 | 4.70 | 4.85 | 4.55 | 4.70 | 4.85 | WKKD-1             | NO                 |
| b                 | 0.25      | 0.30 | 0.35 | 0.25      | 0.30 | 0.35 | 0.25      | 0.30 | 0.35 | 0.25                                | 0.30 | 0.35 | 0.25      | 0.30 | 0.35                   | T4477-2    | -                 | 4.65 | 4.70 | 4.85 | 4.65 | 4.70 | 4.85 | WKKD-1             | YES                |
| D                 | 6.90      | 7.00 | 7.10 | 6.90      | 7.00 | 7.10 | 6.90      | 7.00 | 7.10 | 6.90                                | 7.00 | 7.10 | 6.90      | 7.00 | 7.10                   | T4477-3    | -                 | 4.55 | 4.70 | 4.85 | 4.55 | 4.70 | 4.85 | WKKD-1             | YES                |
| E                 | 6.90      | 7.00 | 7.10 | 6.90      | 7.00 | 7.10 | 6.90      | 7.00 | 7.10 | 6.90                                | 7.00 | 7.10 | 6.90      | 7.00 | 7.10                   | T4877-1**  | 13,24,37,48       | 4.20 | 4.30 | 4.40 | 4.20 | 4.30 | 4.40 | -                  | NO                 |
| e                 | 0.65 BSC. |      |      | 0.50 BSC. |      |      | 0.50 BSC. |      |      | 0.50 BSC.                           |      |      | 0.40 BSC. |      |                        | T4877-2    | -                 | 5.45 | 5.60 | 5.63 | 5.45 | 5.60 | 5.63 | -                  | NO                 |
| k                 | 0.25      | -    | -    | 0.25      | -    | -    | 0.25      | -    | -    | 0.25                                | -    | -    | 0.25      | 0.35 | 0.45                   | T4877-3    | -                 | 4.95 | 5.10 | 5.25 | 4.95 | 5.10 | 5.25 | -                  | YES                |
| L                 | 0.45      | 0.55 | 0.65 | 0.45      | 0.55 | 0.65 | 0.30      | 0.40 | 0.50 | 0.45                                | 0.55 | 0.65 | 0.40      | 0.50 | 0.60                   | T4877-4    | -                 | 5.45 | 5.60 | 5.63 | 5.45 | 5.60 | 5.63 | -                  | YES                |
| L1                | -         | -    | -    | -         | -    | -    | -         | -    | -    | -                                   | -    | -    | 0.30      | 0.40 | 0.50                   | T4877-5    | -                 | 2.40 | 2.80 | 2.60 | 2.40 | 2.80 | 2.60 | -                  | NO                 |
| N                 | 32        |      |      | 44        |      |      | 48        |      |      | 44                                  |      |      | 56        |      |                        | T4877-6    | -                 | 5.45 | 5.60 | 5.63 | 5.45 | 5.60 | 5.63 | -                  | NO                 |
| ND                | 8         |      |      | 11        |      |      | 12        |      |      | 10                                  |      |      | 14        |      |                        | T5677-1    | -                 | 5.20 | 5.30 | 5.40 | 5.20 | 5.30 | 5.40 | -                  | YES                |
| NE                | 8         |      |      | 11        |      |      | 12        |      |      | 12                                  |      |      | 14        |      |                        |            |                   |      |      |      |      |      |      |                    |                    |

\*\* NOTE: T4877-1 IS A CUSTOM 48L PKG. WITH 4 LEADS DEPOPULATED. TOTAL NUMBER OF LEADS ARE 44.

NOTES:

- DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
- ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
- N IS THE TOTAL NUMBER OF TERMINALS.
- THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JESD 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.
- DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.25 mm AND 0.30 mm FROM TERMINAL TIP.
- ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.
- DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.
- COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
- DRAWING CONFORMS TO JEDEC MO220 EXCEPT THE EXPOSED PAD DIMENSIONS OF T3277-1; T4877-1/-2/-3/-4/-5/-6 & T5677-1.
- WARPAGE SHALL NOT EXCEED 0.10 mm.

|  |                                 |
|--|---------------------------------|
|  |                                 |
| PROPRIETARY INFORMATION<br>TITLE: PACKAGE OUTLINE<br>32, 44, 48, 56L THIN QFN, 7x7x0.8mm |                                 |
| APPROVAL   | DOCUMENT CONTROL NO.<br>21-0144 |
| REV. D   | 2/2                             |

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