

# LMX3161

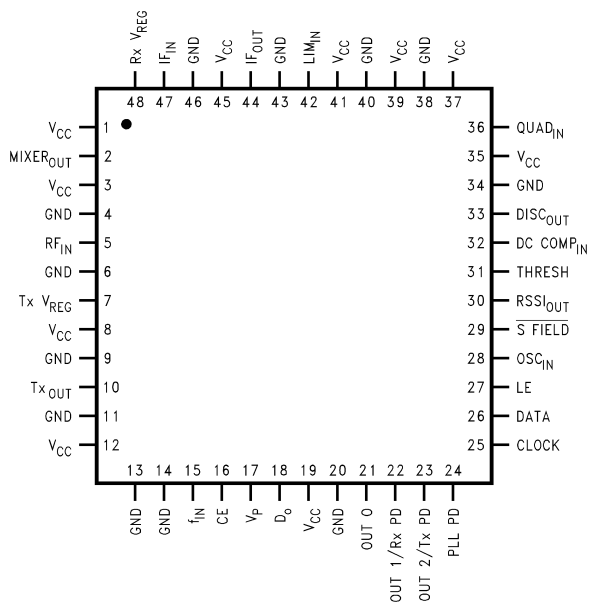
*LMX3161 Single Chip Radio Transceiver*



Literature Number: SNOS871



## LMX3161 Pin Diagram



# LMX3161 Pin Diagram (Continued)

| Pin No. | Pin Name              | I/O | Description                                                                                                                                                                                                                                                                                                                                 |
|---------|-----------------------|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1       | V <sub>CC</sub>       | —   | Power supply for CMOS section of PLL and ESD bussing.                                                                                                                                                                                                                                                                                       |
| 2       | MIXER <sub>OUT</sub>  | O   | IF output from the mixer.                                                                                                                                                                                                                                                                                                                   |
| 3       | V <sub>CC</sub>       | —   | Power supply for mixer section.                                                                                                                                                                                                                                                                                                             |
| 4       | GND                   | —   | Ground.                                                                                                                                                                                                                                                                                                                                     |
| 5       | RF <sub>IN</sub>      | I   | RF input to the mixer.                                                                                                                                                                                                                                                                                                                      |
| 6       | GND                   | —   | Ground.                                                                                                                                                                                                                                                                                                                                     |
| 7       | Tx V <sub>REG</sub>   | —   | Regulated power supply for external PA gain stage.                                                                                                                                                                                                                                                                                          |
| 8       | V <sub>CC</sub>       | —   | Power supply for analog sections of PLL and doubler.                                                                                                                                                                                                                                                                                        |
| 9       | GND                   | —   | Ground.                                                                                                                                                                                                                                                                                                                                     |
| 10      | TX <sub>OUT</sub>     | O   | Frequency doubler output.                                                                                                                                                                                                                                                                                                                   |
| 11      | GND                   | —   | Ground.                                                                                                                                                                                                                                                                                                                                     |
| 12      | V <sub>CC</sub>       | —   | Power supply for analog sections of PLL and doubler.                                                                                                                                                                                                                                                                                        |
| 13      | GND                   | —   | Ground.                                                                                                                                                                                                                                                                                                                                     |
| 14      | GND                   | —   | Ground.                                                                                                                                                                                                                                                                                                                                     |
| 15      | f <sub>IN</sub>       | I   | RF Input to PLL and frequency doubler.                                                                                                                                                                                                                                                                                                      |
| 16      | CE                    | I   | Chip Enable. Pulling LOW powers down entire chip. Taking CE HIGH powers up the appropriate functional blocks depending on the state of bits F6, F7, F11, and F12 programmed in F-latch. It is necessary to initialize the internal registers once, after the power up reset. The registers' contents are kept even in power-down condition. |
| 17      | V <sub>P</sub>        | —   | Power supply for charge pump.                                                                                                                                                                                                                                                                                                               |
| 18      | D <sub>O</sub>        | O   | Charge pump output. For connection to a loop filter for driving the input of an external VCO.                                                                                                                                                                                                                                               |
| 19      | V <sub>CC</sub>       | —   | Power supply for CMOS section of PLL and ESD bussing.                                                                                                                                                                                                                                                                                       |
| 20      | GND                   | —   | Ground.                                                                                                                                                                                                                                                                                                                                     |
| 21      | OUT 0                 | O   | Programmable CMOS output. Refer to Function Register Programming Description section for details.                                                                                                                                                                                                                                           |
| 22      | Rx PD/OUT 1           | I/O | Receiver power down control input or programmable CMOS output. Refer to Function Register Programming Description section for details.                                                                                                                                                                                                      |
| 23      | Tx PD/OUT 2           | I/O | Transmitter power down control input or programmable CMOS output. Refer to Function Register Programming Description section for details.                                                                                                                                                                                                   |
| 24      | PLL PD                | I   | PLL power down control input. LOW for PLL normal operations, and HIGH for PLL power saving.                                                                                                                                                                                                                                                 |
| 25      | CLOCK                 | I   | MICROWIRE™ clock input. High impedance CMOS input with Schmitt Trigger.                                                                                                                                                                                                                                                                     |
| 26      | DATA                  | I   | MICROWIRE data input. High impedance CMOS input with Schmitt Trigger.                                                                                                                                                                                                                                                                       |
| 27      | LE                    | I   | MICROWIRE load enable input. High impedance CMOS input with Schmitt Trigger.                                                                                                                                                                                                                                                                |
| 28      | OSC <sub>IN</sub>     | I   | Oscillator input. High impedance CMOS input with feedback.                                                                                                                                                                                                                                                                                  |
| 29      | S FIELD               | I   | DC compensation circuit enable. While LOW, the DC compensation circuit is enabled and the threshold is updated through the DC compensation loop. While HIGH, the switch is opened, and the comparator threshold is held by the external capacitor.                                                                                          |
| 30      | RSSI <sub>OUT</sub>   | O   | Received signal strength indicator (RSSI) output.                                                                                                                                                                                                                                                                                           |
| 31      | THRESH                | O   | Threshold level to external comparator.                                                                                                                                                                                                                                                                                                     |
| 32      | DC COMP <sub>IN</sub> | I   | Input to DC compensation circuit.                                                                                                                                                                                                                                                                                                           |
| 33      | DISC <sub>OUT</sub>   | O   | Demodulated output of discriminator.                                                                                                                                                                                                                                                                                                        |
| 34      | GND                   | —   | Ground.                                                                                                                                                                                                                                                                                                                                     |
| 35      | V <sub>CC</sub>       | —   | Power supply for the discriminator circuit.                                                                                                                                                                                                                                                                                                 |
| 36      | QUAD <sub>IN</sub>    | I   | Quadrature input for tank circuit.                                                                                                                                                                                                                                                                                                          |
| 37      | V <sub>CC</sub>       | —   | Power supply for limiter output stage.                                                                                                                                                                                                                                                                                                      |
| 38      | GND                   | —   | Ground.                                                                                                                                                                                                                                                                                                                                     |
| 39      | V <sub>CC</sub>       | —   | Power supply for limiter gain stages.                                                                                                                                                                                                                                                                                                       |
| 40      | GND                   | —   | Ground.                                                                                                                                                                                                                                                                                                                                     |
| 41      | V <sub>CC</sub>       | —   | Power supply for IF amplifier gain stages.                                                                                                                                                                                                                                                                                                  |

**LMX3161 Pin Diagram** (Continued)

| Pin No. | Pin Name            | I/O | Description                                     |
|---------|---------------------|-----|-------------------------------------------------|
| 42      | LIM <sub>IN</sub>   | I   | IF input to the limiter.                        |
| 43      | GND                 | —   | Ground.                                         |
| 44      | IF <sub>OUT</sub>   | O   | IF output from IF amplifier.                    |
| 45      | V <sub>CC</sub>     | —   | Power supply for IF amplifier output.           |
| 46      | GND                 | —   | Ground.                                         |
| 47      | IF <sub>IN</sub>    | I   | IF input to IF amplifier.                       |
| 48      | Rx V <sub>REG</sub> | —   | Regulated power supply for external LNA stages. |

**Absolute Maximum Ratings** (Notes 1, 2)

|                                               |                         |
|-----------------------------------------------|-------------------------|
| Power Supply Voltage ( $V_{CC}$ )             | -0.3V to +6.5V          |
| $V_P$                                         | -0.3V to +6.5V          |
| Voltage on Any Pin with<br>GND = 0V ( $V_I$ ) | -0.3V to $V_{CC}$ +0.3V |
| Storage Temperature Range ( $T_S$ )           | -65°C to +150°C         |
| Lead Temp. (solder, 4 sec)( $T_L$ )           | +260°C                  |

**Recommended Operating Conditions**

|                                 |                  |
|---------------------------------|------------------|
| Supply Voltage ( $V_{CC}$ )     | 3.0V to 5.5V     |
| ( $V_P$ )                       | $V_{CC}$ to 5.5V |
| Operating Temperature ( $T_A$ ) | -10°C to +70°C   |

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Recommended Operating Conditions indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics section. The guaranteed specifications apply only for the test conditions listed.

**Note 2:** This device is a high performance RF integrated circuit with an ESD rating < KeV and is ESD sensitive. Handling and assembly of this device should only be done at ESD work stations.

**Electrical Characteristics**

The following specifications are guaranteed for  $V_{CC} = 3.6V$  and  $T_A = 25^\circ C$ , unless otherwise specified.

| Symbol               | Parameter                                            | Conditions                                                                                                            | Min | Typ      | Max | Unit     |
|----------------------|------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|-----|----------|-----|----------|
|                      | Current Consumption                                  |                                                                                                                       |     |          |     |          |
| $I_{DD, RX}$         | -Open-Loop Receive Mode                              | PLL & TX chain powered down                                                                                           | —   | 50       | 60  | mA       |
| $I_{DD, TX}$         | -Open-Loop Transmit Mode                             | PLL & RX chain powered down                                                                                           | —   | 27       | 37  | mA       |
| $I_{DD, PLL}$        | -Closed-Loop PLL Mode                                | RX & TX chain powered down                                                                                            | —   | 6        | 8   | mA       |
| $I_{PD}$             | -Power Down Mode                                     |                                                                                                                       | —   | —        | 70  | $\mu A$  |
| <b>MIXER</b>         |                                                      | $f_{RF} = 1.89 \text{ GHz}$ , $f_{IF} = 110 \text{ MHz}$ , $f_{LO} = 1780 \text{ MHz}$ ( $f_{IN} = 890 \text{ MHz}$ ) |     |          |     |          |
| $f_{RF}$             | RF Frequency Range                                   | (Note 3)                                                                                                              | 1.7 | —        | 2.0 | GHz      |
| $f_{IF}$             | IF Frequency                                         | (Note 4)                                                                                                              | —   | 110      | —   | MHz      |
| $Z_{IN}$             | Input Impedance, RF <sub>IN</sub>                    |                                                                                                                       | —   | 15-j5    | —   | $\Omega$ |
| $Z_{OUT}$            | Output Impedance, Mixer Out                          |                                                                                                                       | —   | 160-j70  | —   | $\Omega$ |
| NF                   | Noise Figure (Single Side Band)                      | (Notes 5, 6)                                                                                                          | —   | 10       | 14  | dB       |
| $G_C$                | Conversion Gain                                      | (Note 5)                                                                                                              | 14  | 17       | —   | dB       |
| $P_{1dB}$            | Input 1dB Compression Point                          | (Note 5)                                                                                                              | -24 | -20      | —   | dBm      |
| OIP3                 | Output 3rd Order Intercept Point                     | (Note 5)                                                                                                              | —   | 7.5      | —   | dBm      |
| $F_{IN-RF}$          | Fin to RF Isolation                                  | $f_{IN}=890 \text{ MHz}$                                                                                              | —   | -30      | —   | dB       |
|                      |                                                      | $f_{IN}=1780 \text{ MHz}$                                                                                             | —   | -10.6    | —   | dB       |
|                      |                                                      | $f_{IN}=2670 \text{ MHz}$                                                                                             | —   | -30      | —   | dB       |
| $F_{IN-IF}$          | Fin to IF Isolation                                  | $f_{IN}=890 \text{ MHz}$                                                                                              | —   | -30      | —   | dB       |
|                      |                                                      | $f_{IN}=1780 \text{ MHz}$                                                                                             | —   | -30      | —   | dB       |
|                      |                                                      | $f_{IN}=2670 \text{ MHz}$                                                                                             | —   | -30      | —   | dB       |
| RF-IF                | RF to IF Isolation                                   | $P_{IN}=0$ to -85 dB                                                                                                  | —   | -30      | —   | dB       |
| <b>IF AMPLIFIER</b>  |                                                      | $f_{IN} = 110 \text{ MHz}$                                                                                            |     |          |     |          |
| NF                   | Noise Figure                                         | (Note 7)                                                                                                              | —   | 8        | 11  | dB       |
| $A_V$                | Gain                                                 | (Note 7)                                                                                                              | 15  | 24       | —   | dB       |
| $Z_{IN}$             | Input Impedance                                      |                                                                                                                       | —   | 150-j120 | —   | $\Omega$ |
| $Z_{OUT}$            | Output Impedance                                     |                                                                                                                       | —   | 190-j20  | —   | $\Omega$ |
| <b>IF LIMITER</b>    |                                                      | $f_{IN} = 110 \text{ MHz}$                                                                                            |     |          |     |          |
| Sens                 | Limiter/Discriminator Sensitivity                    | BER= $10^{-3}$                                                                                                        | —   | -65      | —   | dBm      |
| IF <sub>IN</sub>     | IF Limiter Input Impedance                           |                                                                                                                       | —   | 100-j300 | —   | $\Omega$ |
| <b>DISCRIMINATOR</b> |                                                      | $f_{IN} = 110 \text{ MHz}$                                                                                            |     |          |     |          |
|                      | Disc Gain<br>(mV/° of Phase Shift from Tank Circuit) | 1X Mode                                                                                                               | —   | 10       | —   | mV/°     |
|                      |                                                      | 3X Mode                                                                                                               | —   | 33       | —   | mV/°     |
| $V_{OUT}$            | Discriminator Output Peak to Peak Voltage            | 1X Mode (Note 8)                                                                                                      | 80  | 160      | —   | mV       |
|                      |                                                      | 3X Mode (Note 8)                                                                                                      | 400 | 580      | —   | mV       |
| $V_{OS}$             | Disc. Output DC Voltage                              | Nominal (Note 10)                                                                                                     | 1.2 | 1.82     | —   | V        |
| DISC <sub>OUT</sub>  | Disc. Output Impedance                               |                                                                                                                       | —   | 300      | —   | $\Omega$ |

## Electrical Characteristics (Continued)

The following specifications are guaranteed for  $V_{CC} = 3.6V$  and  $T_A = 25^\circ C$ , unless otherwise specified.

| Symbol                    | Parameter                  | Conditions                                                                | Min  | Typ    | Max             | Unit            |
|---------------------------|----------------------------|---------------------------------------------------------------------------|------|--------|-----------------|-----------------|
| RSSI (Note 11)            |                            | f <sub>IN</sub> = 110 MHz                                                 |      |        |                 |                 |
| RSSI <sub>OUT</sub>       | Output Voltage             | P <sub>IN</sub> =−80 dBm@f <sub>IN</sub> input pin                        | 0.12 | 0.2    | 0.6             | V               |
|                           |                            | P <sub>IN</sub> =−20 dBm@f <sub>IN</sub> input pin                        | 0.9  | 1.2    | —               | V               |
|                           | Slope                      | P <sub>IN</sub> = −90 to −30 dBm@LIM <sub>IN</sub> input pin              | 11   | 18     | 25              | mV/d<br>B       |
| RSSI                      | Dynamic Range              | P <sub>IN</sub> min= −90 dBm@LIM <sub>IN</sub> input pin                  | —    | 60     | —               | dB              |
| DC COMPENSATION CIRCUIT   |                            |                                                                           |      |        |                 |                 |
| V <sub>OS</sub>           | Input Offset Voltage       |                                                                           | −5   | —      | +5              | mV              |
| V <sub>IO</sub>           | Input/Output Voltage Swing | Centered at 1.5V                                                          | —    | 1.0    | —               | V <sub>PP</sub> |
| R <sub>SH</sub>           | Sample and Hold Resistor   |                                                                           | 2000 | 3000   | 3600            | Ω               |
| FREQUENCY SYNTHESIZER     |                            | P <sub>IN</sub> = −14 to −9 dBm                                           |      |        |                 |                 |
| f <sub>IN</sub>           | Input Frequency Range      | (Note 9)                                                                  | 500  | —      | 1200            | MHz             |
| P <sub>IN</sub>           | Input Signal Level         | Z <sub>IN</sub> =200Ω (Note 15)                                           | —    | −11.5  | —               | dBm             |
| f <sub>OSC</sub>          | Oscillator Frequency Range | (Note 12)                                                                 | 5    | —      | 20              | MHz             |
| V <sub>OSC</sub>          | Oscillator Sensitivity     | (Note 12)                                                                 | 0.5  | 1.0    | —               | V <sub>pp</sub> |
| I <sub>Do-source</sub>    | Charge Pump Output Current | V <sub>do</sub> = V <sub>p</sub> /2, I <sub>cpo</sub> = LOW<br>(Note 14)  | —    | −1.5   | —               | mA              |
| I <sub>Do-sink</sub>      |                            | V <sub>do</sub> = V <sub>p</sub> /2, I <sub>cpo</sub> = LOW<br>(Note 14)  | —    | 1.5    | —               | mA              |
| I <sub>Do-source</sub>    |                            | V <sub>do</sub> = V <sub>p</sub> /2, I <sub>cpo</sub> = HIGH<br>(Note 14) | —    | −6.0   | —               | mA              |
| I <sub>Do-sink</sub>      |                            | V <sub>do</sub> = V <sub>p</sub> /2, I <sub>CPO</sub> = HIGH<br>(Note 14) | —    | 6.0    | —               | mA              |
| I <sub>Do-Tri</sub>       |                            | 0.5 ≤ V <sub>do</sub> ≤ V <sub>p</sub> − 0.5<br>T <sub>A</sub> = 25°C     | −1.0 | —      | 1.0             | nA              |
| FREQUENCY DOUBLER         |                            | f <sub>IN</sub> = 945 MHz, f <sub>OUT</sub> = 1.89 GHz                    |      |        |                 |                 |
| f <sub>OUT</sub>          | Output Frequency Range     | (Note 13)                                                                 | 1770 | —      | 1900            | MHz             |
| P <sub>OUT</sub>          | Output Signal Level        | P <sub>IN</sub> = −11.5 dBm, f <sub>OUT</sub> = 1.89 GHz                  | −10  | −3     | —               | dBm             |
|                           | Fundamental Output Power   | P <sub>IN</sub> = −11.5 dBm, f <sub>OUT</sub> = 945 MHz                   | —    | −22    | −13.5           | dBm             |
|                           | Harmonic Output Power      | P <sub>IN</sub> = −11.5 dBm, f <sub>OUT</sub> = 2.835 GHz                 | —    | −24    | −15             | dBm             |
| Z <sub>OUT</sub>          | Output Impedance           | TX chain powered up                                                       | —    | 25+j60 | —               | Ω               |
|                           |                            | TX chain powered down                                                     | —    | 15-j30 | —               | Ω               |
| VOLTAGE REGULATOR         |                            |                                                                           |      |        |                 |                 |
| V <sub>O</sub>            | Output Voltage             | I <sub>LOAD</sub> = 5 mA                                                  | 2.55 | 2.75   | 2.90            | V               |
| DIGITAL INPUT/OUTPUT PINS |                            |                                                                           |      |        |                 |                 |
| V <sub>IH</sub>           | High Level Input Voltage   |                                                                           | 2.4  | —      | V <sub>CC</sub> | V               |
| V <sub>IL</sub>           | Low Level Input Voltage    |                                                                           | 0.0  | —      | 0.8             | V               |
| I <sub>IH</sub>           | Input Current              | GND < V <sub>IN</sub> < V <sub>CC</sub>                                   | −10  | —      | 10              | μA              |
| V <sub>OH</sub>           | High Level Output Voltage  | I <sub>OH</sub> =−0.5 mA                                                  | 2.4  | —      | —               | V               |
| V <sub>OL</sub>           | Low Level Output Voltage   | I <sub>OL</sub> =0.5 mA                                                   | —    | —      | 0.4             | V               |

**Note 3:** The mixer section is tested at 1.89 GHz, and it is guaranteed by design to operate within 1.7 — 2.0 GHz range.

**Note 4:** The IF section of this device is designed for optimum operating performance at 110 MHz to meet the DECT specifications.

**Note 5:** The matching network used on  $RF_{IN}$  consists of a series 3.3 pF capacitance into the pin. The matching circuit used on  $MIXER_{OUT}$  consists of a series 100 nH inductance and a shunt 12 pF capacitance into the pin.

**Note 6:** Noise Figure measurements are made with 890 MHz BPF on the  $F_{IN}$  input and matching networks on  $RF_{IN}$  and  $MIXER_{OUT}$ .

**Note 7:** The matching network used on  $IF_{IN}$  consists of a series 33 nH inductance and a shunt 1.8 pF capacitance into the pin.

**Note 8:** The discriminator is with the DC level centered at 1.5V. The unloaded Q of the tank is 40.

**Note 9:** The frequency synthesizer section is guaranteed by design to operate within 500 - - 1200 MHz range.

**Note 10:** Nominal refers to zero DC offsets programmed for the discriminator.

**Note 11:** It depends on loss of inter-stage filter. These specifications are for an inter-stage filter with a loss of 8 dB.

**Note 12:** The frequency synthesizer section is guaranteed by design to operate for  $OSC_{IN}$  input frequency within 5 — 20 MHz range and minimum amplitude of 0.5  $V_{PP}$ .

## Electrical Characteristics (Continued)

**Note 13:** The doubler section is tested at 1.89 GHz, and it is guaranteed by design to operate within 1.7 — 1.9 GHz range.

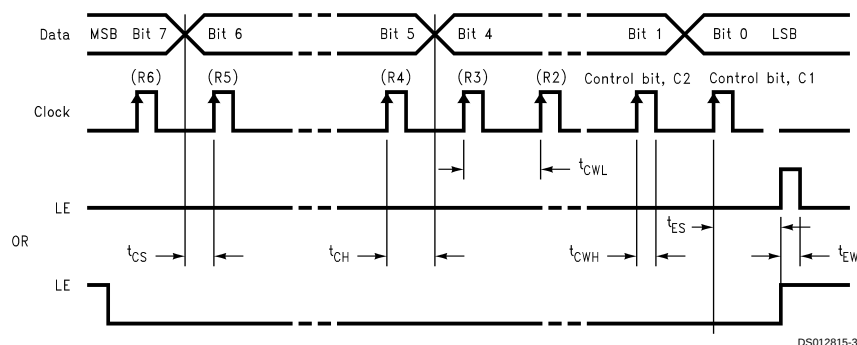
**Note 14:** See Function Register Programming Description for  $Icp_o$  description.

**Note 15:** Tested in a 50 $\Omega$  environment.

## AC Timing Characteristics

### Serial Data Input Timing

**TEST CONDITIONS:** The Serial Data Input Timing is tested using a symmetrical waveform around  $V_{CC}/2$ . The test waveform has an skew rate of 0.6 V / ns.



**Notes:** Parenthesis data indicates programmable reference divider data.

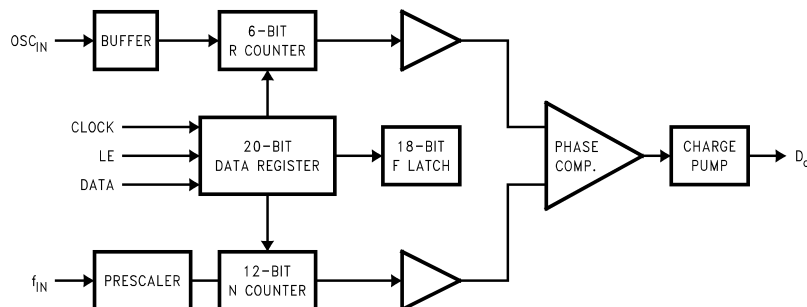
Data shifted into register on clock rising edge.

Data is shifted in MSB first.

| Symbol                      | Parameter                        | Conditions               | Min | Typ | Max | Unit |
|-----------------------------|----------------------------------|--------------------------|-----|-----|-----|------|
| <b>MICROWIRE™ Interface</b> |                                  |                          |     |     |     |      |
| $t_{CS}$                    | Data to Clock Set Up Time        | Refer to Test Condition. | 50  | —   | —   | ns   |
| $t_{CH}$                    | Data to Clock Hold Time          | Refer to Test Condition. | 10  | —   | —   | ns   |
| $t_{CWH}$                   | Clock Pulse Width High           | Refer to Test Condition. | 50  | —   | —   | ns   |
| $t_{CWL}$                   | Clock Pulse Width Low            | Refer to Test Condition. | 50  | —   | —   | ns   |
| $t_{ES}$                    | Clock to Load Enable Set Up Time | Refer to Test Condition. | 50  | —   | —   | ns   |
| $t_{EW}$                    | Load Enable Pulse Width          | Refer to Test Condition. | 50  | —   | —   | ns   |

## PLL Functional Description

The simplified block diagram below shows the building blocks of frequency synthesizer and all internal registers, which are 20-bit data register, 18-bit F-latch, 12-bit N-counter, and 6-bit R-counter.



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The DATA stream is clocked into the data register on the rising edge of CLOCK signal, MSB first. The last two bits are the control bits to indicate which register to be written. Upon the rising edge of the LE (Load Enable) signal, the rest of data bits is transferred to the addressed register accordingly. The decoding scheme of the two control bits is as follows:

| Control Bits |    | Register  |
|--------------|----|-----------|
| C2           | C1 |           |
| 0            | 0  | N-Counter |
| 1            | 0  | R-Counter |
| X            | 1  | F-Latch   |

**Note:** X = Don't Care Condition

## Programmable Feedback Divider (N-Counter)

The N-counter consists of the 6-bit swallow counter (A-counter) and the 6-bit programmable counter (B-counter). When the control bits are "00", data is transferred from the 20-bit shift register into two 6-bit latches. One latch sets the A-counter while the other sets the B-counter. The serial data format is shown below.

| MSB      |    |    |    |    |    | REGISTER'S BIT MAPPING   |     |     |    |    |    |    |    |    |    |    |    |   |   |    |    | LSB |  |
|----------|----|----|----|----|----|--------------------------|-----|-----|----|----|----|----|----|----|----|----|----|---|---|----|----|-----|--|
| 19       | 18 | 17 | 16 | 15 | 14 | 13                       | 12  | 11  | 10 | 9  | 8  | 7  | 6  | 5  | 4  | 3  | 2  | 1 | 0 |    |    |     |  |
| RESERVED |    |    |    |    |    | N-COUNTER's Divide Ratio |     |     |    |    |    |    |    |    |    |    |    |   |   | C2 | C1 |     |  |
| X        | X  | X  | X  | X  | X  | N12                      | N11 | N10 | N9 | N8 | N7 | N6 | N5 | N4 | N3 | N2 | N1 | 0 | 0 |    |    |     |  |

**Note:** X = Don't Care Condition

### Swallow Counter Divide Ratio (A-Counter)

| Divide Ratio, A | N6 | N5 | N4 | N3 | N2 | N1 |
|-----------------|----|----|----|----|----|----|
| 0               | 0  | 0  | 0  | 0  | 0  | 0  |
| 1               | 0  | 0  | 0  | 0  | 0  | 1  |
| *               | *  | *  | *  | *  | *  | *  |
| 63              | 1  | 1  | 1  | 1  | 1  | 1  |

**Note:** Divide ratio must be from 0 to 63, and B must be  $\geq A$ .

### Programmable Counter Divide Ratio (B-Counter)

| Divide Ratio, B | N12 | N11 | N10 | N9 | N8 | N7 |
|-----------------|-----|-----|-----|----|----|----|
| 3               | 0   | 0   | 0   | 0  | 1  | 1  |
| 4               | 0   | 0   | 0   | 1  | 0  | 0  |
| *               | *   | *   | *   | *  | *  | *  |
| 63              | 1   | 1   | 1   | 1  | 1  | 1  |

**Note:** Divide ratio must be from 3 to 63, and B must be  $\geq A$ .

## Programmable Reference Divider (R-Counter)

If the control bits are “10”, data is transferred from the 20-bit shift register into a latch, which sets the 6-bit R-counter. The serial data format is shown below.

| REGISTER'S BIT MAPPING |    |    |    |    |    |    |    |    |    |   |   | R-COUNTER's Divide Ratio |    |    |    |    |    | MSB | LSB |
|------------------------|----|----|----|----|----|----|----|----|----|---|---|--------------------------|----|----|----|----|----|-----|-----|
| 19                     | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7                        | 6  | 5  | 4  | 3  | 2  | 1   | 0   |
| RESERVED               |    |    |    |    |    |    |    |    |    |   |   | R-COUNTER's Divide Ratio |    |    |    |    |    | C2  | C1  |
| X                      | X  | X  | X  | X  | X  | X  | X  | X  | X  | X | X | R6                       | R5 | R4 | R3 | R2 | R1 | 1   | 0   |

Note: X = Don't Care Condition

## Reference Counter Divide Ratio (R-Counter)

| Divide Ratio, R | R6 | R5 | R4 | R3 | R2 | R1 |
|-----------------|----|----|----|----|----|----|
| 3               | 0  | 0  | 0  | 0  | 1  | 1  |
| 4               | 0  | 0  | 0  | 1  | 0  | 0  |
| *               | *  | *  | *  | *  | *  | *  |
| 63              | 1  | 1  | 1  | 1  | 1  | 1  |

Note: Divide ratio must be from 3 to 63.

## Pulse Swallow Function

$$f_{vco} = \frac{[(P \cdot B) + A] \cdot f_{osc}}{R}$$

$f_{vco}$ : Output frequency of external voltage controlled oscillator (VCO)

$B$ : Preset divide ratio of binary 6-bit programmable counter (3 to 63)

$A$ : Preset divide ratio of binary 6-bit swallow counter ( $0 \leq A \leq P$ ,  $A \leq B$ )

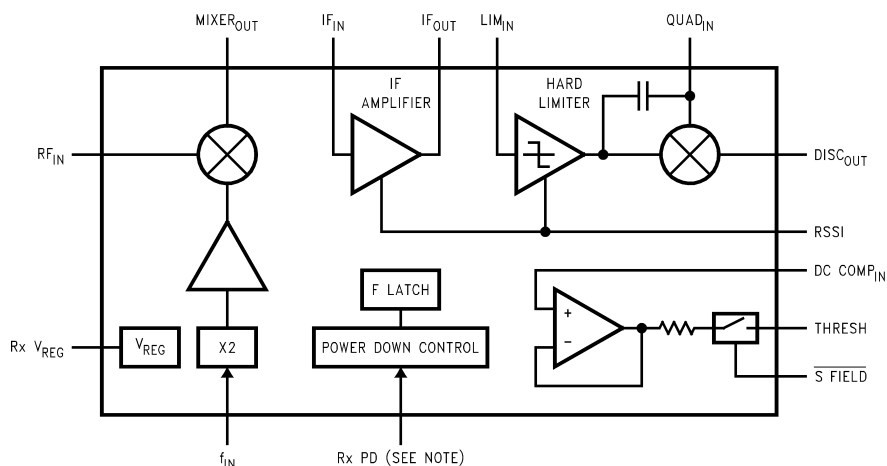
$f_{osc}$ : Output frequency of the external reference frequency oscillator

$R$ : Preset divide ratio of binary 6-bit programmable reference counter (3 to 63)

$P$ : Preset modulus of dual modulus prescaler (32 or 64)

## Receiver Functional Description

The simplified block diagram below shows the mixer, IF amplifier, limiter, and discriminator. In addition, the DC compensation circuit, doubler, and voltage regulator for an external LNA stage are shown.

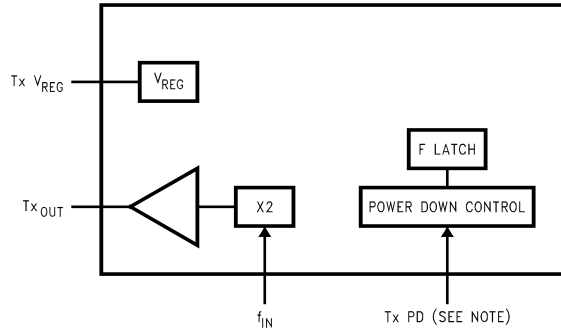


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Note: The receiver can be powered down, either by hardware through the Rx PD pin, or by software through the programming of F6 bit in F-Latch. The power down control method is determined by the settings of F11 and F12 in F-Latch. (Refer to Function Register Programming Description section for details.)

## Transmitter Functional Description

The simplified block diagram below shows the doubler and voltage regulator for an external transmit gain stage.



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**Note:** The transmitter can be powered down, either by hardware through the Tx PD pin, or by software through the programming of F7 bith in F-Latch. The power down control method is determined by the settings of F11 and F12 in F-Latch. (Refer to Function Register Programming Description section for details.)

## Function Register Programming Description (F-Latch)

If the control bits are "1X", data is transferred from the 20-bit shift register into the 18-bit F-latch. Serial data format is shown below.

| REGISTER'S BIT MAPPING |     |     |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    | MSB | LSB |
|------------------------|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|----|-----|-----|
| 19                     | 18  | 17  | 16  | 15  | 14  | 13  | 12  | 11  | 10 | 9  | 8  | 7  | 6  | 5  | 4  | 3  | 2  | 1   | 0   |
| MODE CONTROL WORD      |     |     |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    | C2  | C1  |
| F18                    | F17 | F16 | F15 | F14 | F13 | F12 | F11 | F10 | F9 | F8 | F7 | F6 | F5 | F4 | F3 | F2 | F1 | X   | 1   |

**Note:** X = Don't Care Condition

Various modes of operation can be programmed with the function register bits F1–F18, including the phase detector polarity, charge pump TRI-STATE® and CMOS outputs. In addition, software or hardware power down modes can be specified with bits F11 and F12.

| Mode Control Bit | Model Control Description                                                                                                                                                                                  | Setting to "0" to Select                 | Setting to "1" to Select                  |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|-------------------------------------------|
| F1               | <b>Prescaler modules select.</b>                                                                                                                                                                           | 32/33                                    | 64/65                                     |
| F2               | <b>Phase detector polarity.</b> It is used to reverse the polarity of the phase detector according to the VCO characteristics.                                                                             | Negative VCO Characteristics             | Positive VCO Characteristics              |
| F3               | <b>Charge pump current gain select.</b>                                                                                                                                                                    | LOW Charge Pump Current (1X $I_{cp0}$ ). | HIGH Charge Pump Current (4X $I_{cp0}$ ). |
| F4               | <b>TRI-STATE charge pump output.</b>                                                                                                                                                                       | Normal Operation                         | Force to TRI-STATE                        |
| F5               | <b>Reserved.</b> Setting to "0" always.                                                                                                                                                                    | —                                        | —                                         |
| F6               | <b>Receive chain power down control.</b> Software power down can only be activated when both F11 and F12 are set to "0".                                                                                   | Power Up RX Chain                        | Power Down RX Chain                       |
| F7               | <b>Transmit chain power down control.</b> Software power down can only be activated when both F11 and F12 are set to "0".                                                                                  | Power Up TX Chain                        | Power Down TX Chain                       |
| F8               | <b>Out 0 CMOS output.</b>                                                                                                                                                                                  | OUT 0 = LOW                              | OUT 0 = HIGH                              |
| F9               | <b>Out 1 CMOS output.</b> Functions only in software power down mode, when both F11 and F12 are set to "0".                                                                                                | OUT 1 = LOW                              | OUT 1 = HIGH                              |
| F10              | <b>Out 2 CMOS output.</b> Functions only in software power down mode, when both F11 and F12 are set to "0".                                                                                                | OUT 2 = LOW                              | OUT 2 = HIGH                              |
| F11<br>F12       | <b>Power down mode select.</b><br>Set both F11 and F12 to "0" for software power down mode.<br>Set both F11 and F12 to "1" for hardware power down mode.<br>Other combinations are reserved for test mode. | Software Power Down                      | Hardware Power Down                       |
| F13              | <b>Demodulator gain select</b>                                                                                                                                                                             | 1X Gain Mode                             | 3X Gain Mode                              |
| F14              | <b>Demodulator DC level shift +/- level shifting polarity</b>                                                                                                                                              | Set Negative Polarity                    | Set Positive Polarity                     |

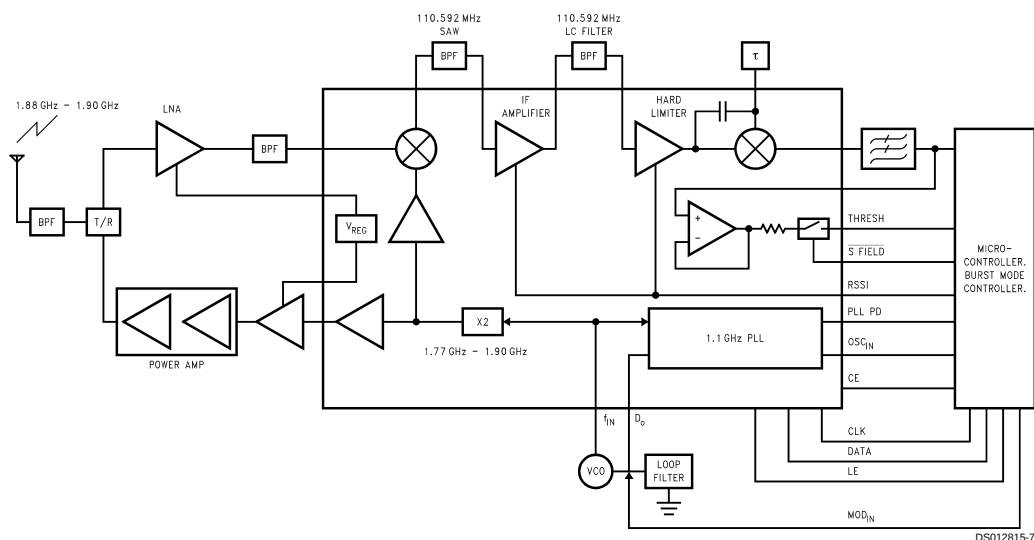
### Function Register Programming Description (F-Latch) (Continued)

| Mode Control Bit | Model Control Description            | Setting to "0" to Select | Setting to "1" to Select     |
|------------------|--------------------------------------|--------------------------|------------------------------|
| F15              | Demodulator DC level shift of 1.000V | No Shift                 | Shift the DC Level by 1.000V |
| F16              | Demodulator DC level shift of 0.500V | No Shift                 | Shift the DC Level by 0.500V |
| F17              | Demodulator DC level shift of 0.250V | No Shift                 | Shift the DC Level by 0.250V |
| F18              | Demodulator DC level shift of 0.125V | No Shift                 | Shift the DC Level by 0.125V |

### Power Down Mode/Control Table

| Software Power Down Mode (F11=F12=0) |                      |                      | Hardwire Power Down Mode (F11=F12=1) |                      |                      |
|--------------------------------------|----------------------|----------------------|--------------------------------------|----------------------|----------------------|
| Pin/Bit                              | Setting to "0" means | Setting to "1" means | Pin/Bit                              | Setting to "0" means | Setting to "1" means |
| F6                                   | Receiver ON          | Receiver OFF         | Rx PD                                | Receiver OFF         | Receiver ON          |
| F7                                   | Transmitter ON       | Transmitter OFF      | Tx PD                                | Transmitter OFF      | Transmitter ON       |
| PLL PD                               | PLL ON               | PLL OFF              | PLL PD                               | PLL ON               | PLL OFF              |
| CE                                   | LMX3161 OFF          | LMX3161 ON           | CE                                   | LMX3161 OFF          | LMX3161 ON           |

## Typical Application



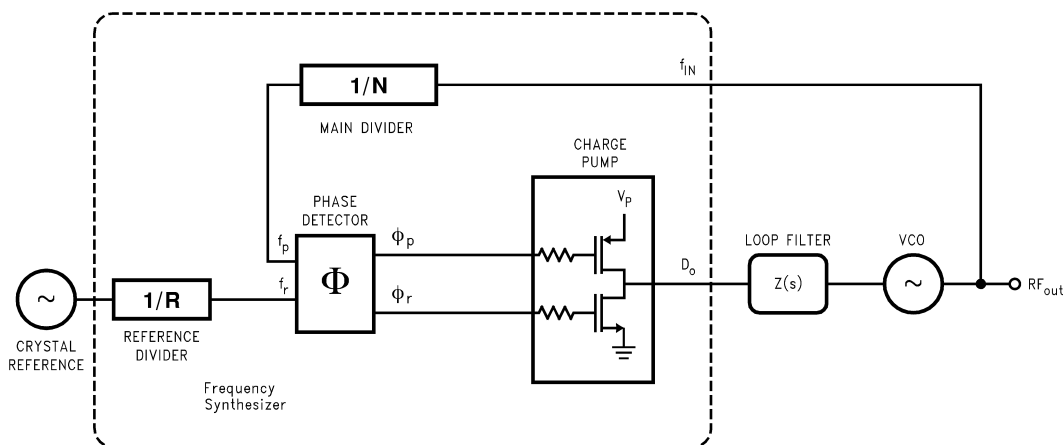
## DECT System Calculation for 3.6V Operation

|                        | Filter and Switch | External LNA | Image Filter | Mixer | SAW   | IF Amplifier | Interstage Filter | Cascade Total |
|------------------------|-------------------|--------------|--------------|-------|-------|--------------|-------------------|---------------|
| NF (dB)                | 2                 | 2            | 1.5          | 10    | 11    | 8            | 8                 | 6.21          |
| Gain (dB)              | -2                | 12           | -1.5         | 15    | -11   | 25           | -8                | 29.50         |
| OIP3 (dBm)             | 100               | 7            | 100          | 5     | 100   | 50           | 100               | 10.88         |
| P <sub>OUT</sub> (dBm) | -95.0             | -83.0        | -84.5        | -69.5 | -80.5 | -55.5        | -63.5             |               |
| NF+ (dB)               |                   | 1.09         | 0.04         | 1.58  | 0.05  | 0.32         | 0.00              |               |
| OIP3+ (dBm)            | 0.00              | 0.12         | 0.00         | 15.50 | 0.00  | 0.00         |                   |               |
| Input Power (dBm)      | -93.00            |              |              |       |       |              |                   |               |
| Eb/No (dB)             |                   |              |              | 14.77 |       |              |                   |               |
| Input IP3 (dBm)        |                   |              |              |       |       |              | -18.62            |               |

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**Note:** Assumes 50 dB attenuation of interferer by the SAW filter and 8 dB attenuation by the LC filter. Cascaded totals in Input IP3 are calculated at the output of the interstage filter.

## Loop Filter Design Consideration

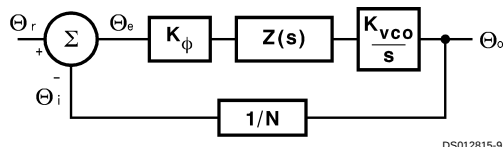


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FIGURE 1. Conventional PLL Architecture

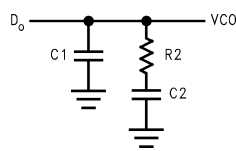
## Loop Gain Equations

A linear control system model of the phase feedback for a PLL in the locked state is shown in Figure 2. The open loop gain is the product of the phase comparator gain ( $K_\phi$ ), the VCO gain ( $K_{VCO}/s$ ), and the loop filter gain  $Z(s)$  divided by the gain of the feedback counter modulus ( $N$ ). The passive loop filter configuration used is displayed in Figure 3, while the complex impedance of the filter is given in Equation (2).



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FIGURE 2. PLL Linear Model



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FIGURE 3. Passive Loop Filter

## PASSIVE LOOP FILTER

$$\text{Open loop gain} = H(s) G(s) = \frac{\theta_i/\theta_e}{\theta_i/\theta_e} = K_\phi Z(s) K_{VCO}/Ns \quad (1)$$

$$Z(s) = \frac{s(C2 \cdot R2) + 1}{s^2(C1 \cdot C2 \cdot R2) + sC1 + sC2} \quad (2)$$

The time constants which determine the pole and zero frequencies of the filter transfer function can be defined as

$$T1 = R2 \cdot \frac{C1 \cdot C2}{C1 + C2} \quad (3)$$

and

$$T2 = R2 \cdot C2 \quad (4)$$

The 3rd order PLL Open Loop Gain can be calculated in terms of frequency,  $\omega$ , the filter time constants  $T1$  and  $T2$ , and the design constants  $K_\phi$ ,  $K_{VCO}$ , and  $N$ .

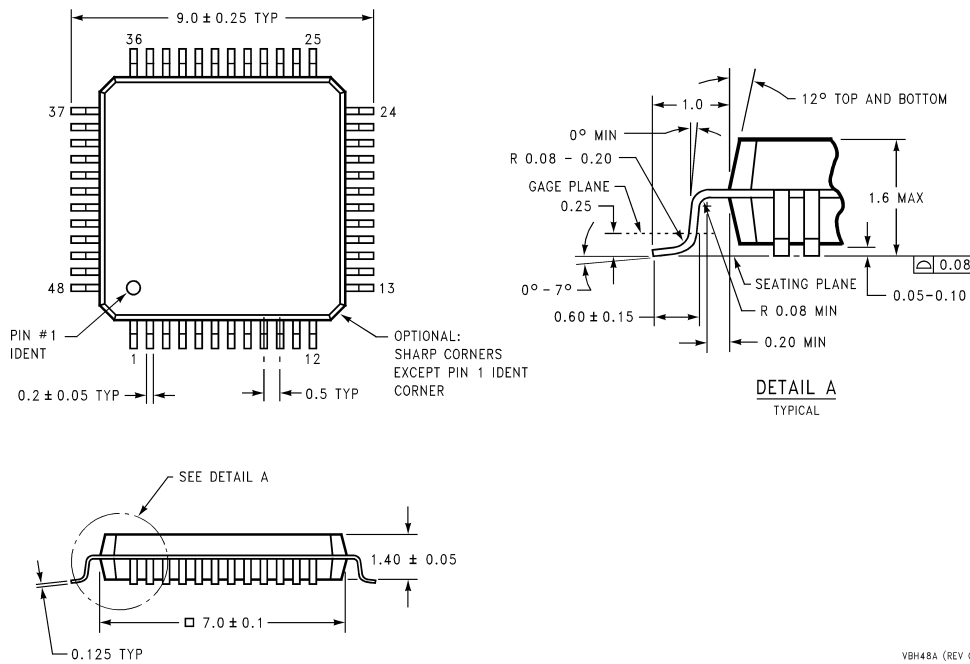
$$G(s) \cdot H(s) \Big|_{s=j\omega} = \frac{-K_\phi \cdot K_{VCO}(1 + j\omega \cdot T2)}{\omega^2 C1 \cdot N(1 + j\omega \cdot T1)} \cdot \frac{T1}{T2} \quad (5)$$

From Equations (3), (4) we can see that the phase term will be dependent on the single pole and zero such that the phase margin is determined in Equation (6).

$$\phi(\omega) = \tan^{-1}(\omega \cdot T2) - \tan^{-1}(\omega \cdot T1) + 180^\circ \quad (6)$$

## Physical Dimensions inches (millimeters) unless otherwise noted

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