

# LMX3162

## Single Chip Radio Transceiver

### General Description

The LMX3162 Single Chip Radio Transceiver is a monolithic, integrated radio transceiver optimized for use in ISM 2.45 GHz wireless systems. It is fabricated using National's ABiC V BiCMOS process ( $f_T = 18$  GHz).

The LMX3162 contains phase locked loop (PLL), transmit and receive functions. The 1.3 GHz PLL is shared between transmit and receive sections. The transmitter includes a frequency doubler, and a high frequency buffer. The receiver consists of a 2.5 GHz low noise mixer, an intermediate frequency (IF) amplifier, a high gain limiting amplifier, a frequency discriminator, a received signal strength indicator (RSSI), and an analog DC compensation loop. The PLL, doubler, and buffers can be used to implement open loop modulation along with an external VCO and loop filter. The circuit features on-chip voltage regulation to allow supply voltages ranging from 3.0V to 5.5V. Two additional voltage regulators provide a stable supply source to external discrete stages in the Tx and Rx chains.

The IF amplifier, high gain limiting amplifier, and discriminator are optimized for 110 MHz operation, with a total IF gain of 85 dB. The single conversion receiver architecture provides a low cost, high performance solution for communications systems. The RSSI output may be used for channel quality monitoring.

The Single Chip Radio Transceiver is available in a 48-pin 7mm X 7mm X 1.4mm PQFP surface mount plastic package.

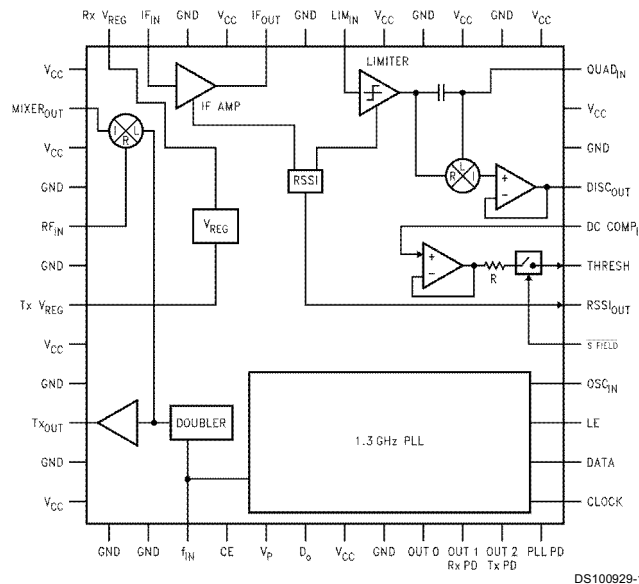
### Features

- Single chip solution for ISM 2.45 GHz RF transceiver
- System RF sensitivity to  $-93$  dBm; RSSI sensitivity to  $-100$  dBm
- Two regulated voltage outputs for discrete amplifiers
- High gain (85 dB) intermediate frequency strip
- Allows unregulated 3.0V–5.5V supply voltage
- Power down mode for increased current savings
- System noise figure 6.5 dB (typ)

### Applications

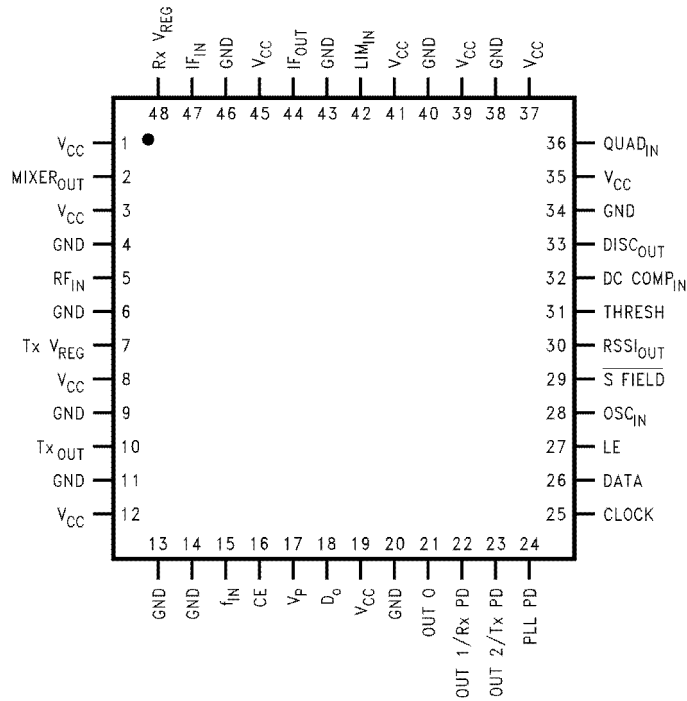
- ISM 2.45 GHz frequency band wireless systems
- Personal wireless communications (PCS/PCN)
- Wireless local area networks (WLANs)
- Other wireless communications systems

### Block Diagram



MICROWIRE™ is a trademark of National Semiconductor Corporation.  
TRI-STATE® is a registered trademark of National Semiconductor Corporation.

## LMX3162 Connection Diagram



DS100929-2

**Top View**  
**Order Number LMX3162VBH or LMX3162VBHX**  
**See NS Package Number VBH48A**

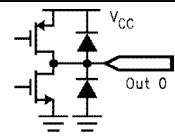
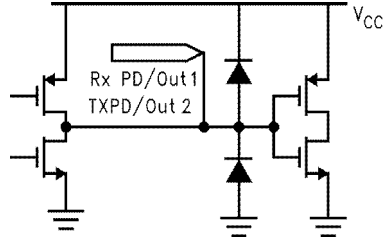
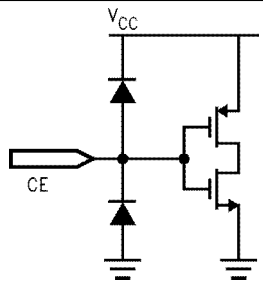
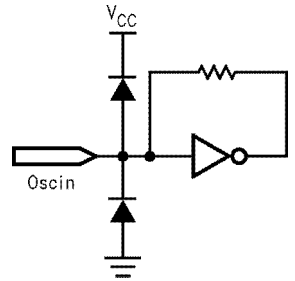
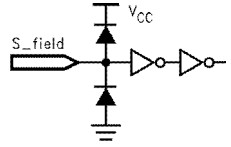
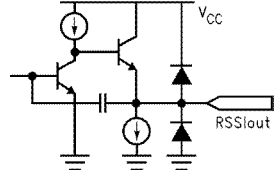
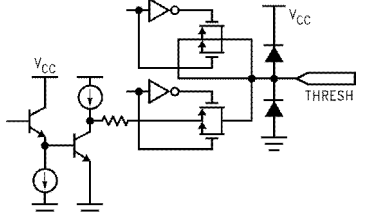
### Pin Descriptions

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.	

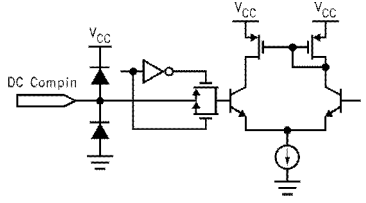
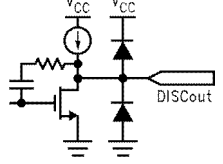
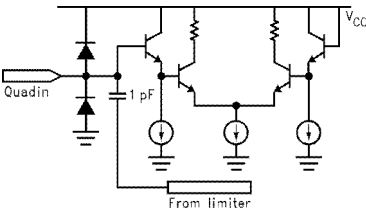
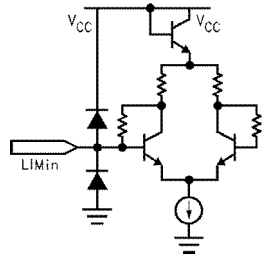
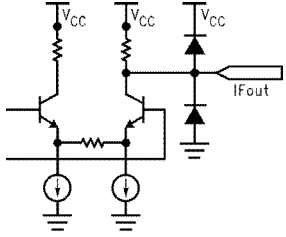
## Pin Descriptions (Continued)

Pin No.	Pin Name	I/O	Description	
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.	

## Pin Descriptions (Continued)

Pin No.	Pin Name	I/O	Description	
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 <sub>FIELD</sub>	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.	

### Pin Descriptions (Continued)

Pin No.	Pin Name	I/O	Description	
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.	
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.	

**Pin Descriptions** (Continued)

Pin No.	Pin Name	I/O	Description	
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 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					
$I_{CC, RX}$	-Open-Loop Receive Mode	PLL & TX chain powered down	—	50	65	mA
$I_{CC, TX}$	-Open-Loop Transmit Mode	PLL & RX chain powered down	—	27	40	mA
$I_{CC, PLL}$	-PLL only Mode	RX & TX chain powered down	—	6	9	mA
$I_{PD}$	-Power Down Mode		—	—	70	$\mu A$
<b>MIXER</b>		$f_{RF} = 2.45 \text{ GHz}, f_{IF} = 110 \text{ MHz}, f_{LO} = 2340 \text{ MHz} (f_{IN} = 1170 \text{ MHz})$				
$f_{RF}$	RF Frequency Range	(Note 3)	2.4	—	2.5	GHz
$f_{IF}$	IF Frequency	(Note 4)	—	110	—	MHz
$Z_{IN}$	Input Impedance, $RF_{IN}$		—	$12+j6$	—	$\Omega$
$Z_{OUT}$	Output Impedance, Mixer Out		—	$160-j65$	—	$\Omega$
NF	Noise Figure (Single Side Band)	(Notes 5, 6)	—	11.8	16	dB
G	Conversion Gain	(Note 5)	13	17	—	dB
$P_{1dB}$	Input 1dB Compression Point	(Note 5)	—	-20	—	dBm
OIP3	Output 3rd Order Intercept Point	(Note 5)	—	7.5	—	dBm
$F_{IN-RF}$	Fin to RF Isolation	$F_{IN}=1170 \text{ MHz}, RFOUT=1170 \text{ MHz}$	—	-30	—	dB
		$F_{IN}=1170 \text{ MHz}, RFOUT=2340 \text{ MHz}$	—	-20	—	dB
		$F_{IN}=1170 \text{ MHz}, RFOUT=3510 \text{ MHz}$	—	-30	—	dB
$F_{IN-IF}$	Fin to IF Isolation	$F_{IN}=1170 \text{ MHz}, IF_{OUT}=1170 \text{ MHz}$	—	-30	—	dB
		$F_{IN}=1170 \text{ MHz}, IF_{OUT}=2340 \text{ MHz}$	—	-30	—	dB
		$F_{IN}=1170 \text{ MHz}, IF_{OUT}=3510 \text{ MHz}$	—	-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		—	$35-j180$	—	$\Omega$
$Z_{OUT}$	Output Impedance		—	$210-j50$	—	$\Omega$
<b>IF LIMITER</b>		$f_{IN} = 110 \text{ MHz}$				
Sens	Limiter/Discriminator Sensitivity	$BER=10^{-3}$ (Note 16)	—	-65	—	dBm
$IF_{IN}$	IF Limiter Input Impedance		—	$100-j300$	—	$\Omega$
<b>DISCRIMINATOR</b>		$f_{IN} = 110 \text{ MHz}$				
	Disc Gain ( $mV^\circ$ of Phase Shift from Tank Circuit)	1X Mode	—	10	—	$mV/^\circ$
		3X Mode	—	33	—	$mV/^\circ$
$V_{OUT}$	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
$DISC_{OUT}$	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
<b>RSSI (Note 11)</b>		$f_{IN} = 110 \text{ MHz}$				
RSSI <sub>out</sub>	Output Voltage	$P_{IN} = -80 \text{ dBm@IF}_{IN}$ input pin	0.12	0.2	0.6	V
		$P_{IN} = -20 \text{ dBm@IF}_{IN}$ input pin	0.9	1.2	—	V
	Slope	$P_{IN} = -85 \text{ to } -25 \text{ dBm@IF}_{IN}$ input pin	10	18	25	mV/dB
RSSI	Dynamic Range	$P_{IN \text{ min}} = -90 \text{ dBm@IF}_{IN}$ input pin	—	60	—	dB
<b>DC COMPENSATION CIRCUIT</b>						
$V_{OS}$	Input Offset Voltage		-6	—	+6	mV
$V_{IO}$	Input/Output Voltage Swing	Centered at 1.5V	—	1.0	—	$V_{PP}$
$R_{SH}$	Sample and Hold Resistor		2000	3000	3600	$\Omega$
<b>FREQUENCY SYNTHESIZER</b>						
$f_{IN}$	Input Frequency Range	(Note 9)	1100	—	1300	MHz
$P_{IN}$	Input Signal Level	$Z_{IN} = 200\Omega$ (Note 15)	—	-11.5	—	dBm
$f_{OSC}$	Oscillator Frequency Range	(Note 12)	5	—	20	MHz
$V_{OSC}$	Oscillator Sensitivity	(Note 12)	0.5	1.0	—	$V_{PP}$
$I_{Do-source}$	Charge Pump Output Current	$V_{do} = V_{P/2}$ , $I_{cpo} = \text{LOW}$ (Note 14)	—	-1.5	—	mA
$I_{Do-sink}$		$V_{do} = V_{P/2}$ , $I_{cpo} = \text{LOW}$ (Note 14)	—	1.5	—	mA
$I_{Do-source}$		$V_{do} = V_{P/2}$ , $I_{cpo} = \text{HIGH}$ (Note 14)	—	-6.0	—	mA
$I_{Do-sink}$		$V_{do} = V_{P/2}$ , $I_{CPO} = \text{HIGH}$ (Note 14)	—	6.0	—	mA
$I_{Do-Tri}$		$0.5 \leq V_{do} \leq V_p - 0.5$ $T_A = 25^\circ C$	-1.0	—	1.0	nA
<b>FREQUENCY DOUBLER (Note 17)</b>		$f_{IN} = 1225 \text{ MHz}$ , $f_{OUT} = 2.45 \text{ GHz}$				
$f_{OUT}$	Output Frequency Range	(Note 13)	2250	—	2500	MHz
$P_{OUT}$	Output Signal Level	$P_{IN} = -11.5 \text{ dBm}$ , $f_{OUT} = 2.45 \text{ GHz}$	-12	-7.5	—	dBm
	Fundamental Output Power	$P_{IN} = -11.5 \text{ dBm}$ , $f_{OUT} = 1225 \text{ MHz}$	—	-17	-10	dBm
	Harmonic Output Power	$P_{IN} = -11.5 \text{ dBm}$ , $f_{OUT} = 3.675 \text{ GHz}$	—	-30	-15.5	dBm
<b>VOLTAGE REGULATOR</b>						
$V_O$	Output Voltage	$I_{LOAD} = 5 \text{ mA}$	2.55	2.75	2.90	V
<b>DIGITAL INPUT/OUTPUT PINS</b>						
$V_{IH}$	High Level Input Voltage		2.4	—	—	V
$V_{IL}$	Low Level Input Voltage		—	—	0.8	V
$I_{IH}$	Input Current	$GND < V_{IN} < V_{CC}$	-10	—	10	$\mu A$
$V_{OH}$	High Level Output Voltage	$I_{OH} = -0.5 \text{ mA}$	2.4	—	—	V
$V_{OL}$	Low Level Output Voltage	$I_{OL} = 0.5 \text{ mA}$	—	—	0.4	V

**Note 3:** The mixer section is tested at 2.45 GHz.

**Note 4:** The IF section of this device is designed for optimum performance at 110 MHz.

**Note 5:** The matching network used on  $RF_{IN}$  for this measurement consists of a series 3.3 pF capacitance into the pin. The matching circuit used on  $MIXER_{OUT}$  consists of a series 150 nH inductance and a shunt 15 pF capacitance into the pin.

**Note 6:** Noise figure measurements are made with matching networks on  $RF_{IN}$  and  $MIXER_{OUT}$ . See (Note 5).

**Note 7:** The matching network used on pin  $IF_{IN}$  for this measurement consists of a series 330 nH inductance and a shunt 2.7 pF capacitance into the pin. The matching network used on pin  $IF_{OUT}$  consists of a series 120 nH inductance and a shunt 12 pF 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 tested at 1.225 GHz.

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

**Note 11:** It depends on loss of the inter-stage filter. These specifications are for an inter-stage 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  $V_{PP}$ .

**Note 13:** The doubler section is tested at 2.45 GHz.

**Note 14:** See Function Register Programming Description for  $I_{cpo}$  description.



## Electrical Characteristics (Continued)

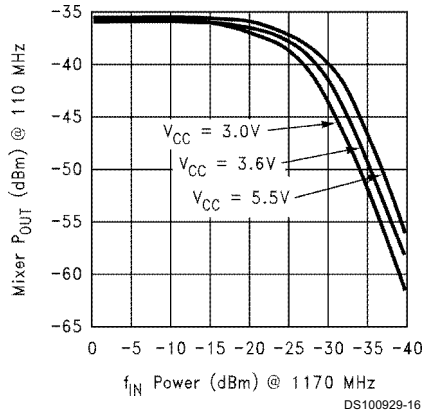
**Note 15:** Tested in a 50Ω environment.

**Note 16:** The matching network used on pin LIM<sub>IN</sub> for this measurement consists of a series 330 nH inductance and a shunt 1.8 pF into the pin.

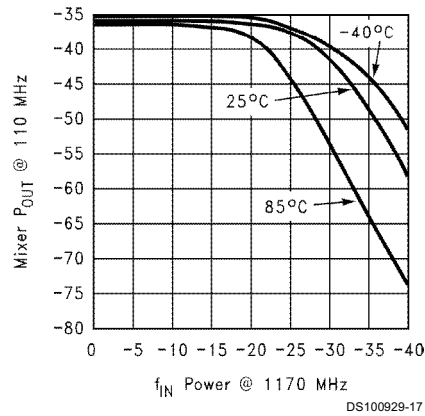
**Note 17:** The optimum load as seen by the TX OUT pin should be between 50 and 100 ohms.

## Typical Performance Characteristics

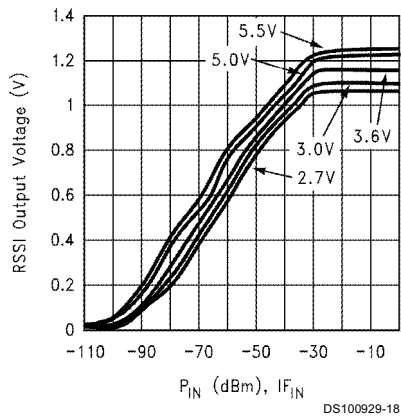
**Mixer P<sub>OUT</sub> vs  
F<sub>IN</sub> Power with RF<sub>IN</sub> =  
-51 dBm, @ 2450 MHz, 25°C**



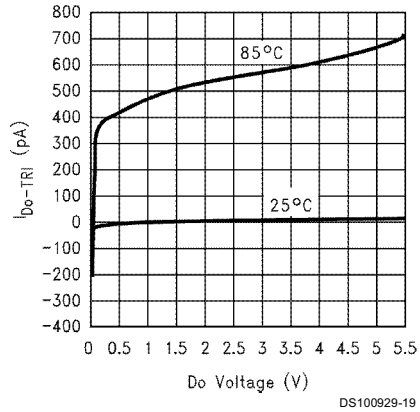
**Mixer P<sub>OUT</sub> vs  
F<sub>IN</sub> Power with RF<sub>IN</sub> =  
-51 dBm, @ 2450 MHz, V<sub>CC</sub>=3.6V**



**RSSI Output vs  
Input Power to IF<sub>IN</sub>  
with V<sub>CC</sub> as Parameter**

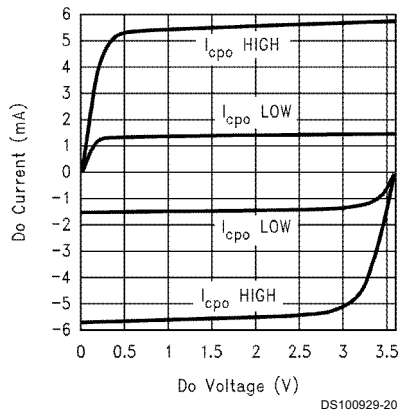


**I<sub>DO TRI-STATE™</sub> vs  
D<sub>O</sub> Voltage, V<sub>CC</sub>=5.5V**

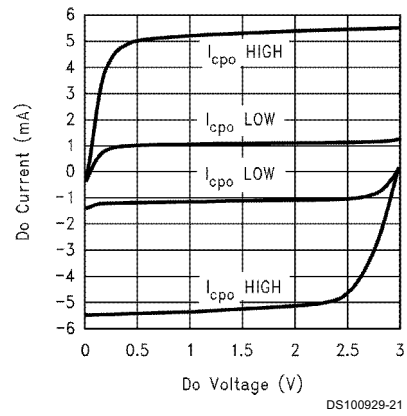


## Typical Performance Characteristics (Continued)

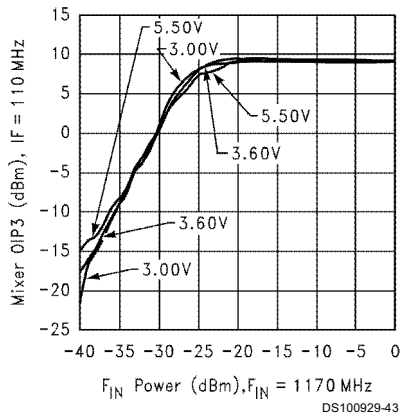
**Charge Pump Current vs D<sub>O</sub> Voltage V<sub>CC</sub>=3.6V, 25°C**



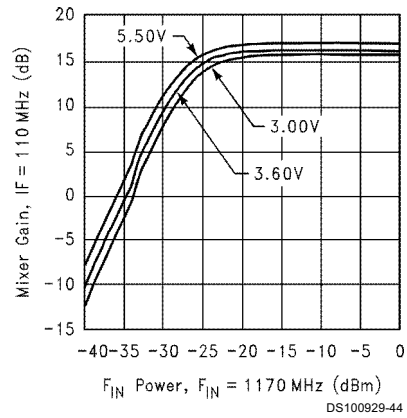
**Charge Pump Current vs D<sub>O</sub> Voltage, V<sub>CC</sub>=3.0V, 25°C**



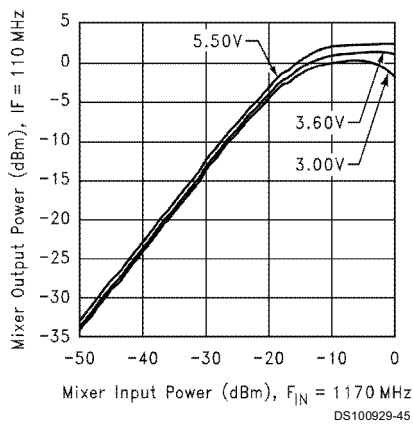
**Mixer OIP3 vs F<sub>IN</sub> Power**



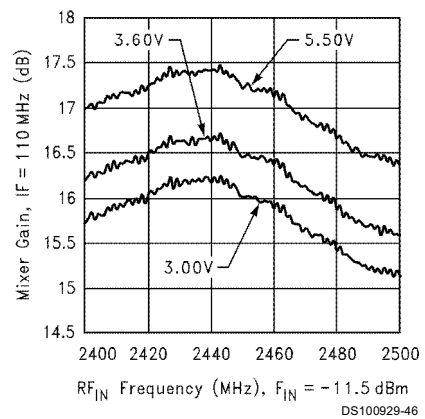
**Mixer Gain vs F<sub>IN</sub> Power**



**Mixer Output Power vs Mixer Input Power**

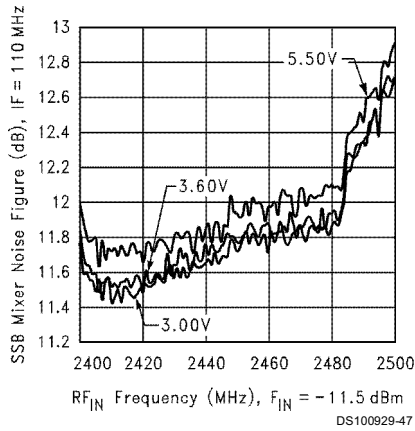


**Mixer Gain vs RF<sub>IN</sub> Frequency**

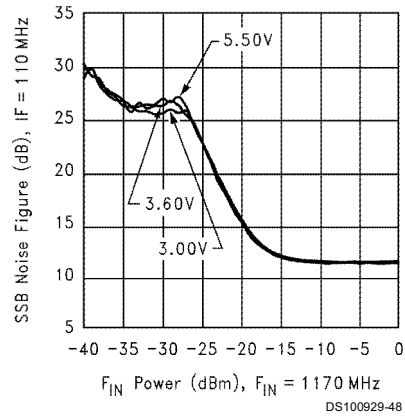


## Typical Performance Characteristics (Continued)

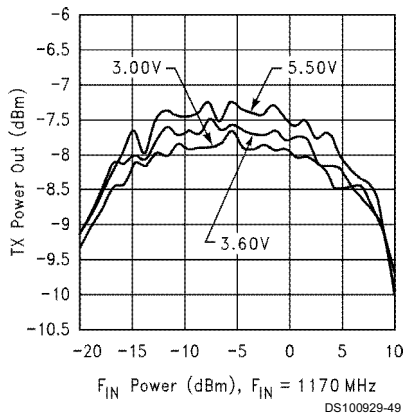
**SSB Mixer Noise Figure vs  $R_{F_{IN}}$  Frequency**



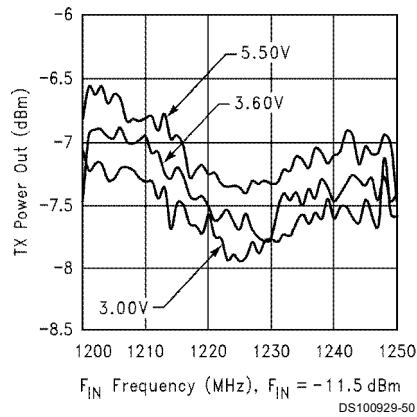
**SSB Mixer Noise Figure vs  $F_{IN}$  Power**



**TX Power Out vs  $F_{IN}$  Power**



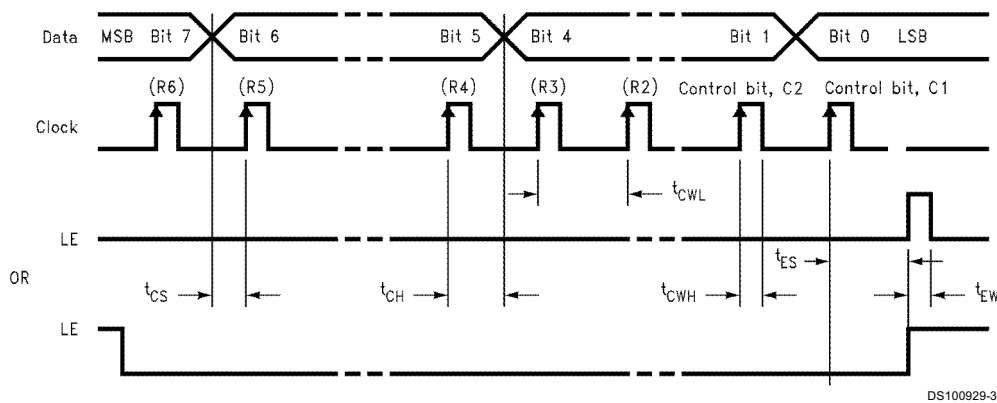
**TX Power Out vs  $F_{IN}$  Frequency**



## 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.

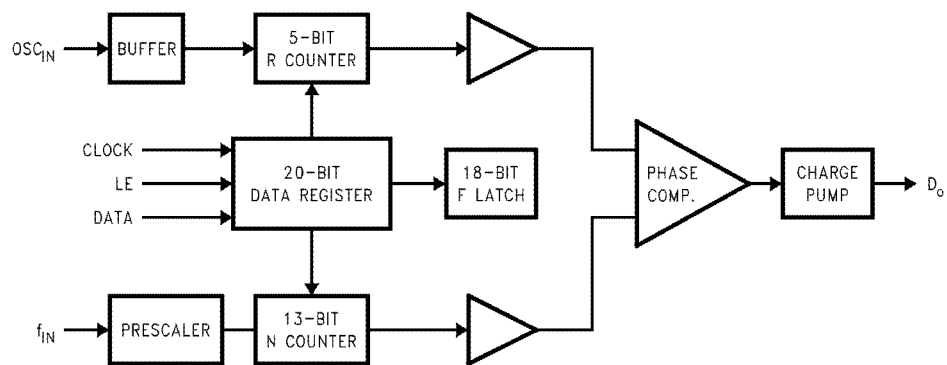


## Serial Data Input Timing (Continued)

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, 13-bit N-counter, and 5-bit R-counter.



DS100929-4

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 7-bit programmable counter (B-counter). When the control bits are "00", data is transferred from the 20-bit shift register into two latches. One latch sets the A-counter while the other sets the B-counter. The 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	C2	C1	
RESERVED				N-COUNTER's Divide Ratio															C2	C1		
X	X	X	X	X	N13	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

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

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

## Programmable Counter Divide Ratio (B-Counter)

Divide Ratio, B	N13	N12	N11	N10	N9	N8	N7
3	0	0	0	0	0	1	1
4	0	0	0	0	1	0	0
*	*	*	*	*	*	*	*
127	1	1	1	1	1	1	1

**Note:** Divide ratio must be from 3 to 127, 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 5-bit R-counter. The 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
<b>RESERVED</b>													<b>R-COUNTER's Divide Ratio</b>					<b>C2</b>	<b>C1</b>
X	X	X	X	X	X	X	X	X	X	X	X	X	R5	R4	R3	R2	R1	1	0

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

## Reference Counter Divide Ratio (R-Counter)

Divide Ratio, R	R5	R4	R3	R2	R1
3	0	0	0	1	1
4	0	0	1	0	0
*	*	*	*	*	*
31	1	1	1	1	1

**Note:** Divide ratio must be from 3 to 31.

## 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 7-bit programmable counter (3 to 127)

$A$ : 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

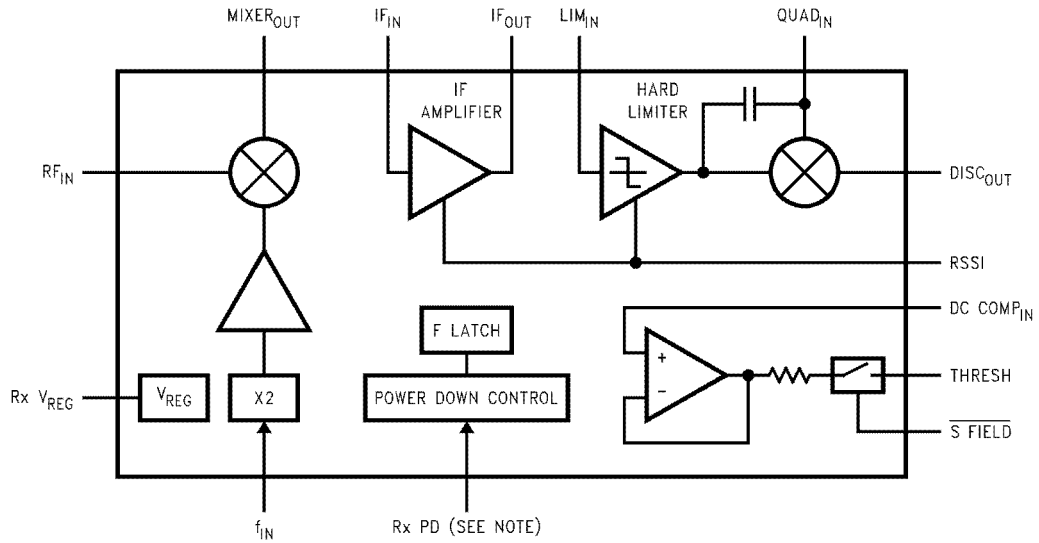
$R$ : Preset divide ratio of binary 5-bit programmable reference counter (3 to 31)

$P$ : 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.

## Receiver Functional Description (Continued)



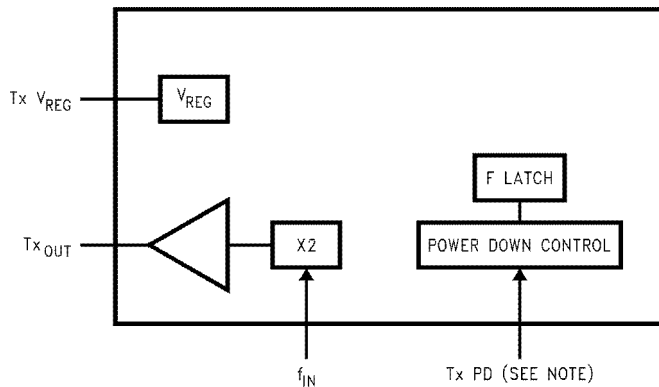
DS100929-5

**Note 18:** The receiver can be powered down, either by hardware through the Rx PD pin, or by software through the programming of F6 bit in the 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.)

**Note 19:** The internal capacitor of the discriminator has a value of 1 pF, and has been optimized for operation at 110 MHz.

## Transmitter Functional Description

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



DS100929-6

**Note:** The transmitter can be powered down, either by hardware through the Tx PD pin, or by software through the programming of F7 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.)

## 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	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	LSB
<b>MODE CONTROL WORD</b>																			<b>C2</b>	<b>C1</b>	
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.

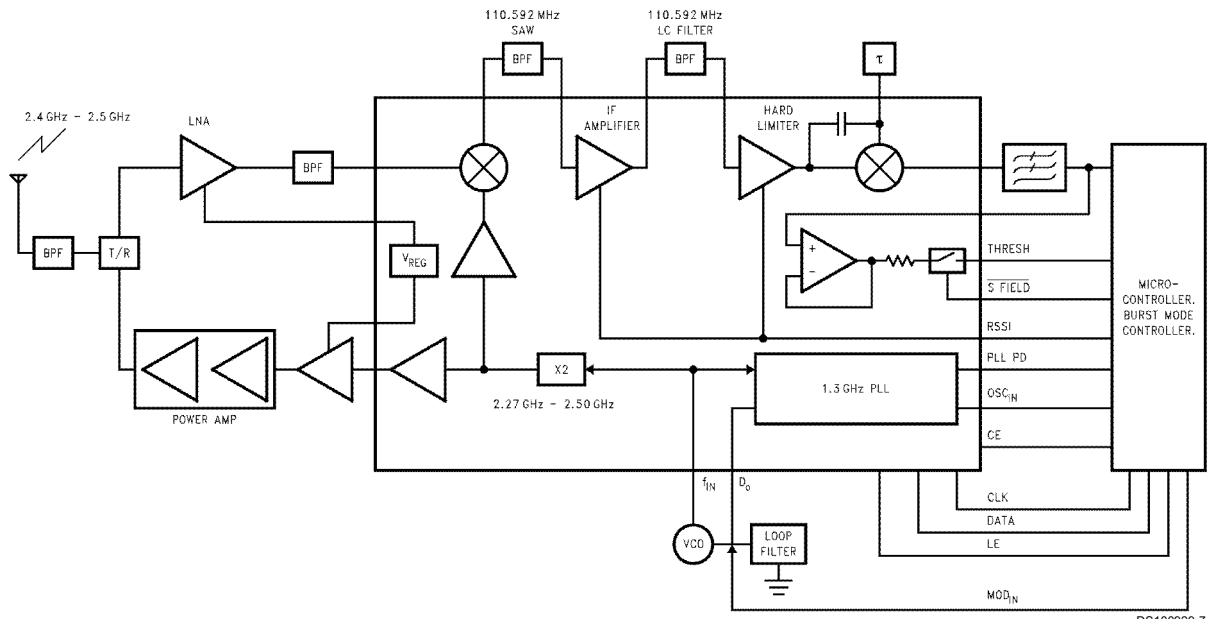
## Function Register Programming Description (F-Latch) (Continued)

Mode Control Bit	Mode 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 F12	<b>Power down mode select.</b> Set both F11 and F12 to "0" for software power down mode. Set both F11 and F12 to "1" for hardware power down mode. 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
F15	<b>Demodulator DC level shift of 1.000V</b>	No Shift	Shift the DC Level by 1.000V
F16	<b>Demodulator DC level shift of 0.500V</b>	No Shift	Shift the DC Level by 0.500V
F17	<b>Demodulator DC level shift of 0.250V</b>	No Shift	Shift the DC Level by 0.250V
F18	<b>Demodulator DC level shift of 0.125V</b>	No Shift	Shift the DC Level by 0.125V

### Power Down Mode/Control Table

Software Power Down Mode (F11=F12=0)			Hardware 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	LMX3162 OFF	LMX3162 ON	CE	LMX3162 OFF	LMX3162 ON

# Typical Application



DS100929-7



## Loop Filter Design Consideration

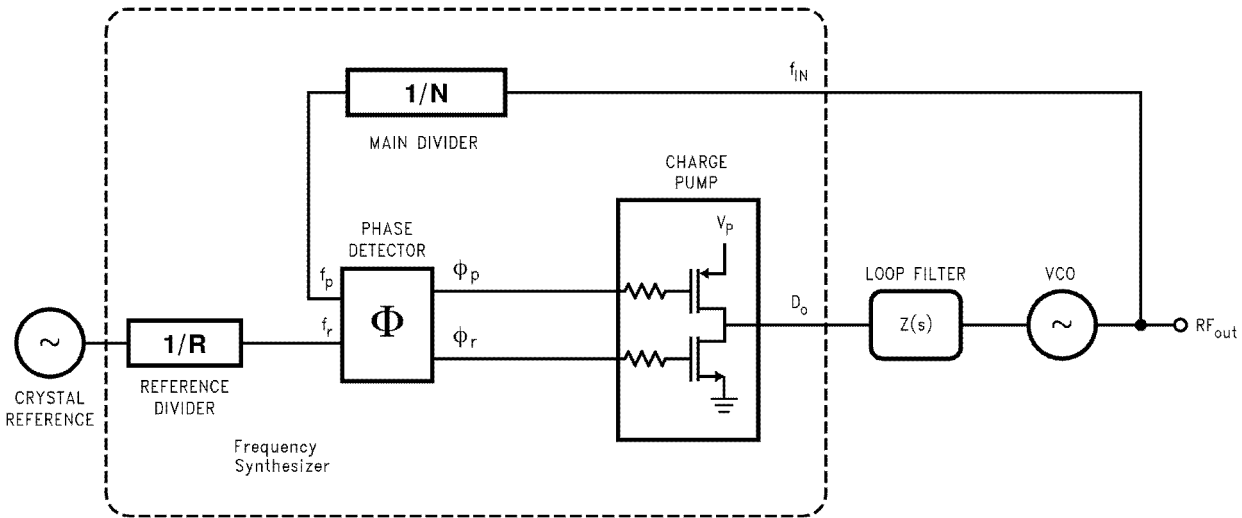


FIGURE 1. Conventional PLL Architecture

DS100929-8

## 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).

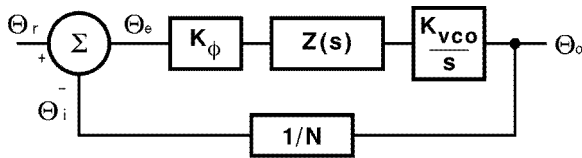


FIGURE 2. PLL Linear Model

DS100929-9

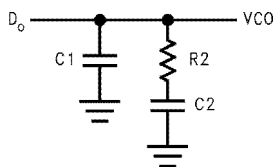


FIGURE 3. Passive Loop Filter

DS100929-10

## PASSIVE LOOP FILTER

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

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

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

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

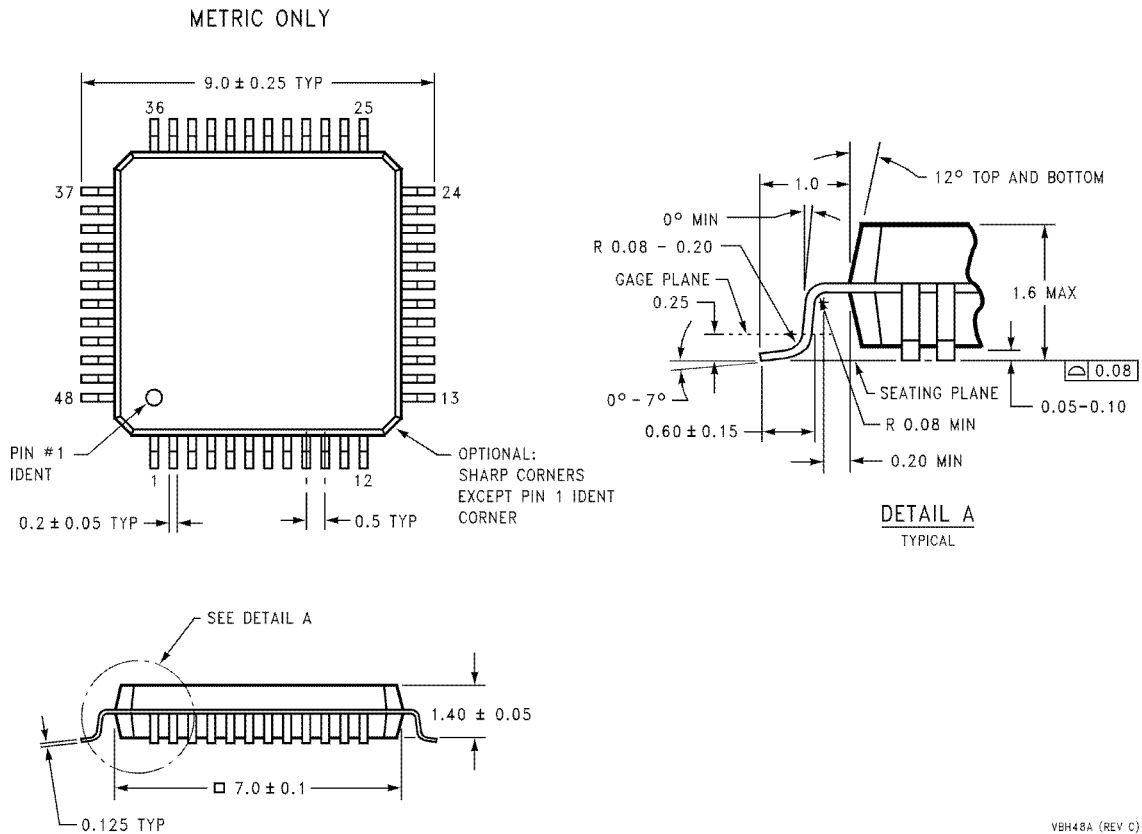
The 3rd order PLL Open Loop Gain can be calculated in terms of frequency,  $\omega$ , the filter time constants  $T1$  and  $T2$ , and the design constants  $K_{\phi}$ ,  $K_{VCO}$ , and  $N$ .

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

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



**48-Lead (7mm x 7mm) Molded Plastic Quad Flat Package, JEDEC**  
**For Tape and Reel (2500 Units per Reel)**  
**Order Number LMX3162VBH or LMX3162VBHX**  
**NS Package Number VBH48A**

**LIFE SUPPORT POLICY**

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

**National Semiconductor Corporation**  
 Americas  
 Tel: 1-800-272-9959  
 Fax: 1-800-737-7018  
 Email: support@nsc.com  
 www.national.com

**National Semiconductor Europe**  
 Fax: +49 (0) 180-530 85 86  
 Email: europe.support@nsc.com  
 Deutsch Tel: +49 (0) 69 9508 6208  
 English Tel: +44 (0) 870 24 0 2171  
 Français Tel: +33 (0) 1 41 91 8790

**National Semiconductor Asia Pacific Customer Response Group**  
 Tel: 65-2544466  
 Fax: 65-2504466  
 Email: ap.support@nsc.com

**National Semiconductor Japan Ltd.**  
 Tel: 81-3-5639-7560  
 Fax: 81-3-5639-7507