National Semiconductor

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LMX2377U
PLLatinum™ Ultra Low Power Dual Frequency Synthesizer for RF Personal Communications 2.5 GHz/1.2 GHz

General Description

The LMX2377U device is a high performance frequency synthesizer with integrated dual modulus prescalers. The LMX2377U device is designed for use as a local oscillator for the first and second RF of a dual conversion radio transceiver.

A 16/17 or a 32/33 prescale ratio can be selected for the Main synthesizer. An 8/9 or a 16/17 prescale ratio can be selected for the Aux synthesizer. Using a proprietary digital phase lock technique, the LMX2377U device generates very stable, low noise control signals for UHF and VHF voltage controlled oscillators. Both the Main and Aux synthesizers include a two-level programmable charge pump. The Main synthesizer has dedicated Fastlock circuitry.

Serial data is transferred to the devices via a three-wire interface (Data, LE, Clock). The low voltage logic interface allows connection to 1.8V devices. Supply voltages from 2.7V to 5.5V are supported. The LMX2377U features ultra low current consumption, typically 3.5 mA at 3.0V.

The LMX2377U devices are available in 20-Pin TSSOP, 24-Pin CSP, and 20-Pin UTCSP surface mount plastic packages.

Features

- Ultra Low Current Consumption
- Upgrade and Compatible to the LMX2370
- 2.7V to 5.5V Operation
- 1.8V to 5.0V MICROWIRE Logic Interface
- Selectable Synchronous or Asynchronous Powerdown Mode:
  $I_{CC-PWDN}$ = 1 µA typical
- Selectable Dual Modulus Prescaler:
  Main: 16/17 or 32/33
  Aux: 8/9 or 16/17
- Selectable Charge Pump TRI-STATE® Mode
- Programmable Charge Pump Current Levels
  Main and Aux: 0.95 or 3.8 mA
- Selectable Fastlock™ Mode for the Main Synthesizer
- Open Drain Analog Lock Detect Output
- Available in 20-Pin TSSOP, 24-Pin CSP, and 20-Pin UTCSP

Applications

- Mobile Handsets
  (GSM, GPRS, W-CDMA, CDMA, PCS, AMPS, PDC, DCS)
- Cordless Handsets
  (DECT, DCT)
- Wireless Data
- Cable TV Tuners

Thin Shrink Small Outline Package (MTC20)

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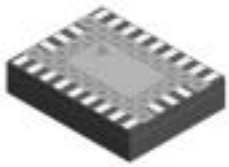
Chip Scale Package (SLB24A)



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Ultra Thin Chip Scale Package (SLE20A)

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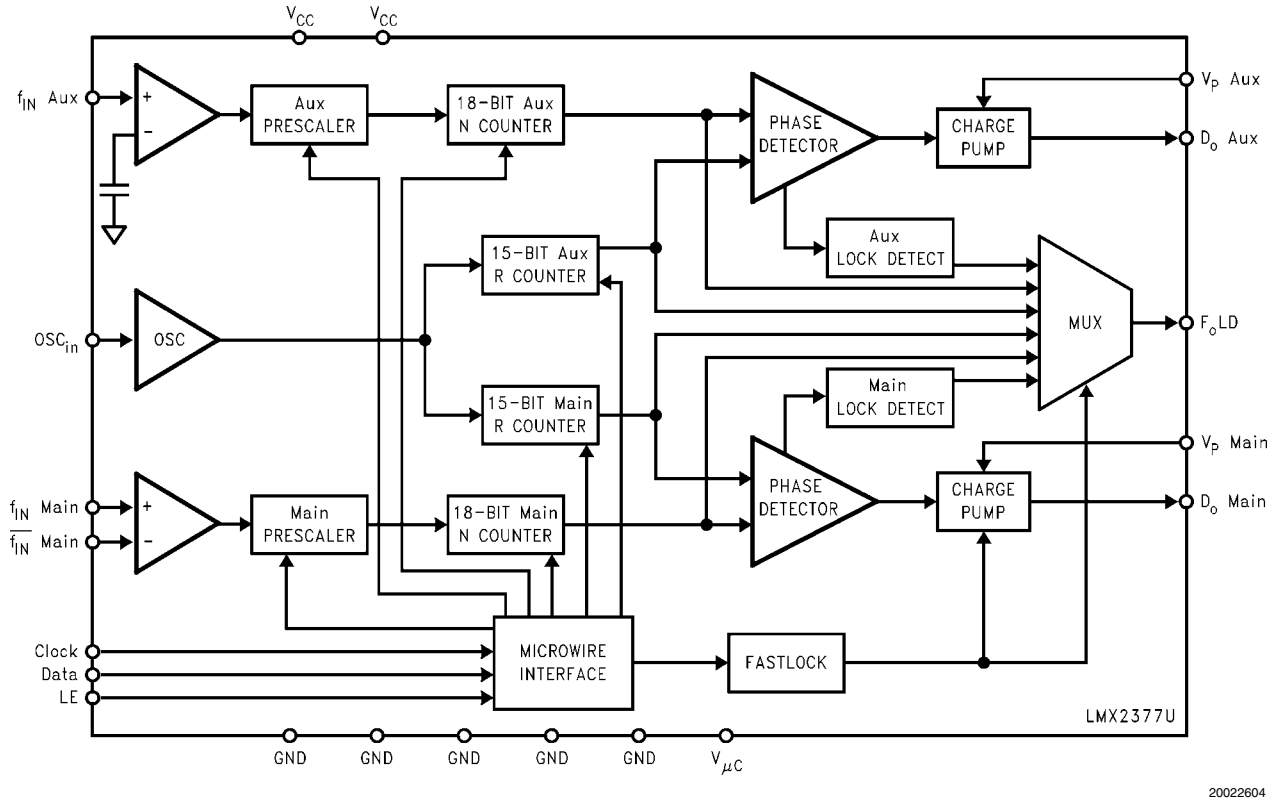
Functional Block Diagram



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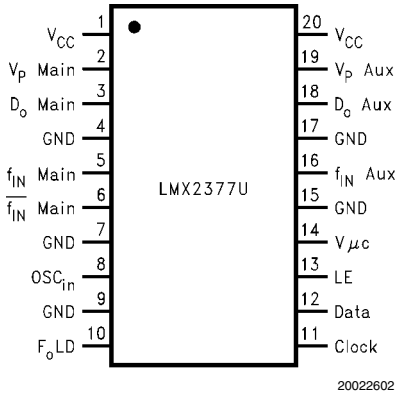
Connection Diagrams

Thin Shrink Small Outline Package (TM)
(Top View)



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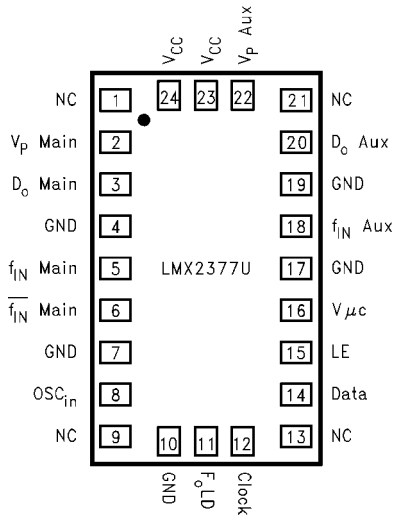
Chip Scale Package (SLB)
(Top View)



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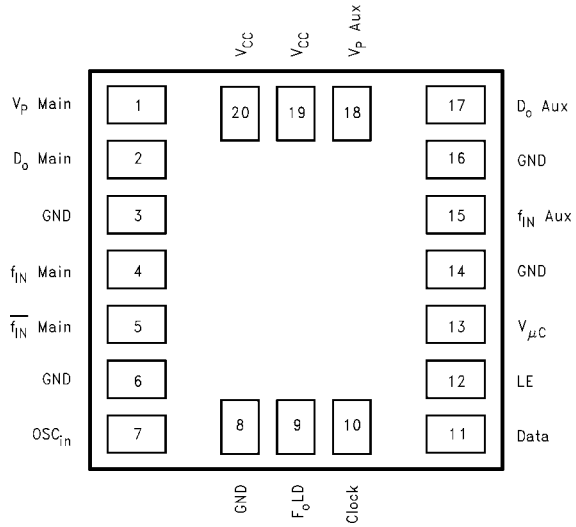
Ultra Thin Chip Scale Package (SLE)
(Top View)



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Pin Descriptions

Pin Name	Pin No. 20-Pin UTCSP	Pin No. 24-Pin CSP	Pin No. 20-Pin TSSOP	I/O	Description
V_{CC}	20	24	1	—	Power supply bias for the Main PLL analog and digital circuits. V_{CC} may range from 2.7V to 5.5V. Bypass capacitors should be placed as close as possible to this pin and be connected directly to the ground plane.
V_P Main	1	2	2	—	Main PLL charge pump power supply. Must be ≥ V_{CC}.
D_o Main	2	3	3	O	Main PLL charge pump output. The output is connected to the external loop filter, which drives the input of the VCO.
GND	3	4	4	—	Ground for the Main PLL digital circuitry.
f_{IN} Main	4	5	5	I	Main PLL prescaler input. Small signal input from the VCO.

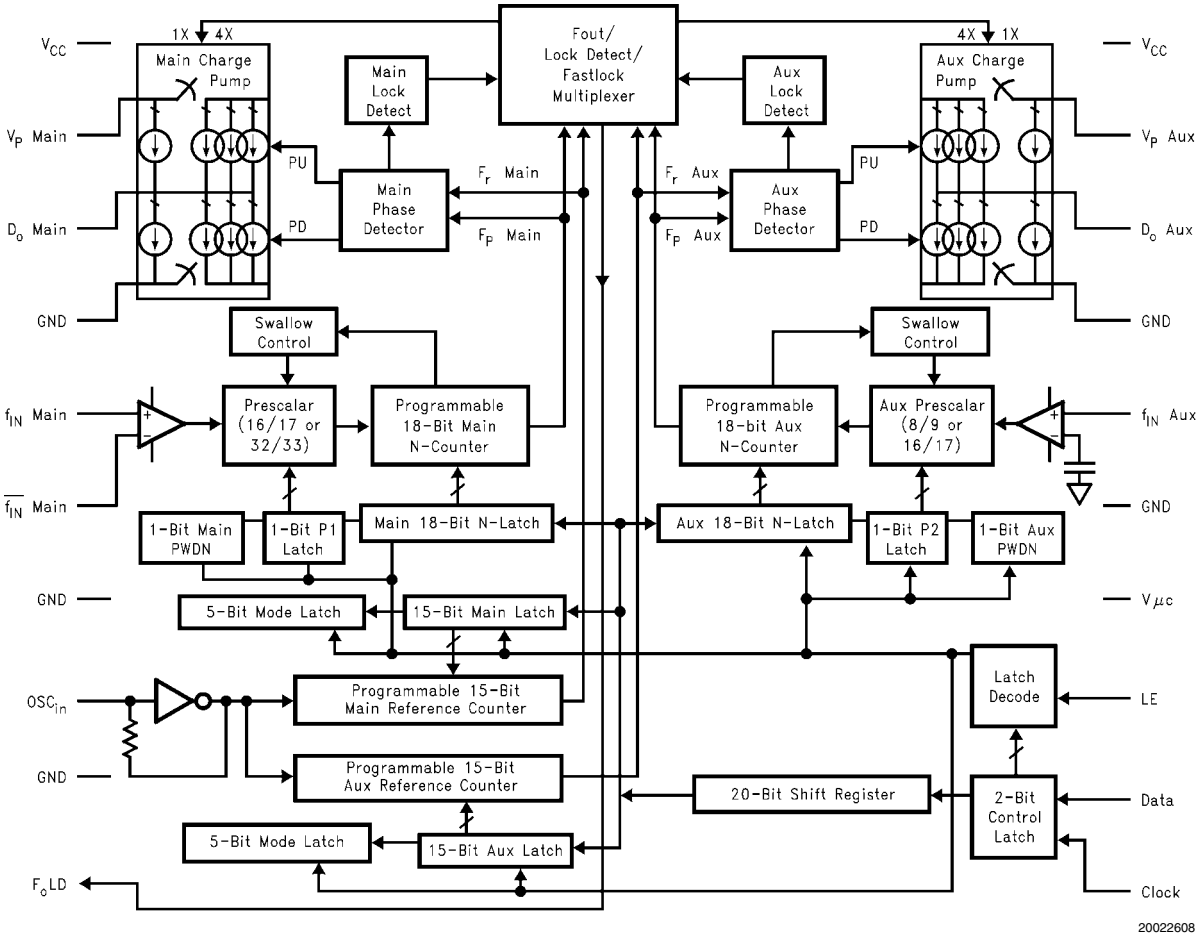
Pin Descriptions (Continued)

Pin Name	Pin No. 20-Pin UTCSP	Pin No. 24-Pin CSP	Pin No. 20-Pin TSSOP	I/O	Description
$\overline{f_{IN}}$ Main	5	6	6	I	Main prescaler complementary input. For single ended operation, this pin should be AC grounded. The LMX2377U Main PLL can be driven differentially when the bypass capacitor is omitted.
GND	6	7	7	—	Ground for the Main PLL analog circuitry.
OSC_{in}	7	8	8	I	Reference oscillator input. It has an approximate $V_{CC}/2$ input threshold and can be driven from an external CMOS or TTL logic gate.
GND	8	10	9	—	Ground for the Aux PLL digital circuitry, MICROWIRE, F_oLD, and oscillator circuits.
F_oLD	9	11	10	O	Programmable multiplexed output pin. Functions as a general purpose CMOS TRI-STATE output, Main/Aux PLL open drain analog lock detect output, N and R divider output or Fastlock output, which connects a parallel resistor to the external loop filter.
Clock	10	12	11	I	MICROWIRE Clock input. High impedance CMOS input. Data is clocked into the 22-bit shift register on the rising edge of Clock.
Data	11	14	12	I	MICROWIRE Data input. High impedance CMOS input. Binary serial data. The MSB of Data is shifted in first. The last two bits are the control bits.
LE	12	15	13	I	MICROWIRE Latch Enable input. High impedance CMOS input. When LE transitions HIGH, Data stored in the shift register is loaded into one of 4 internal control registers.
Vμc	13	16	14	—	Power supply bias for the MICROWIRE circuitry. Must be $\leq V_{CC}$. Typically connected to the same supply level as the microprocessor or baseband controller to enable programming at low voltages.
GND	14	17	15	—	Ground for the Aux PLL analog circuitry.
f_{IN} Aux	15	18	16	I	Aux PLL prescaler input. Small signal input from the VCO.
GND	16	19	17	—	Ground for the Aux PLL digital circuitry, MICROWIRE, F_oLD, and oscillator circuits.
D_o Aux	17	20	18	O	Aux PLL charge pump output. the output is connected to an external loop filter, which drives the input of the VCO.
V_P Aux	18	22	19	—	Aux PLL charge pump power supply. Must be $\geq V_{CC}$.
V_{CC}	19	23	20	—	Power supply bias for the Aux PLL analog and digital circuits, F_oLD, and oscillator circuits. V_{CC} may range from 2.7V to 5.5V. Bypass capacitors should be placed as close as possible to this pin and be connected directly to the ground plane.
NC	—	1, 9, 13, 21	—	—	No Connect

Ordering Information

Model	Temperature Range	Package Description	Packing	NS Package Number
LMX2377USLEX	−40˚C to +85˚C	Ultra Thin Chip Scale Package (UTCSP) Tape and Reel	2500 Units Per Reel	SLE20A
LMX2377USLBX	−40˚C to +85˚C	Chip Scale Package (CSP) Tape and Reel	2500 Units Per Reel	SLB24A
LMX2377UTM	−40˚C to +85˚C	Thin Shrink Small Outline Package (TSSOP)	73 Units Per Rail	MTC20
LMX2377UTMX	−40˚C to +85˚C	Thin Shrink Small Outline Package (TSSOP) Tape and Reel	2500 Units Per Reel	MTC20

Detailed Block Diagram



Notes:

1. V_{CC} supplies power to the Main and Aux prescalers, Main and Aux feedback dividers, Main and Aux reference dividers, Main and Aux phase detectors, the OSC_{in} buffer, and F_oLD circuitry.
2. Vμc supplies power to the MICROWIRE circuitry.
3. V_P Main and V_P Aux supply power to the charge pumps. They can be run separately as long as V_P Main ≥ V_{CC} and V_P Aux ≥ V_{CC}.

Absolute Maximum Ratings (Notes 1, 2, 3)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Power Supply Voltage	
V_{CC} to GND	−0.3V to +6.5V
V_P Main to GND	−0.3V to +6.5V
V_P Aux to GND	−0.3V to +6.5V
Voltage on any pin to GND (V_I)	
V_I must be < +6.5V	−0.3V to V_{CC}+0.3V
Storage Temperature Range (T_S)	−65˚C to +150˚C
Lead Temperature (solder 4 s) (T_L)	+260˚C
TSSOP θ_{JA} Thermal Impedance	114.5˚C/W
CSP θ_{JA} Thermal Impedance	112˚C/W

Recommended Operating Conditions (Note 1)

Power Supply Voltage	
V_{CC} to GND	+2.7V to +5.5V
V_P Main to GND	V_{CC} to +5.5V
V_P Aux to GND	V_{CC} to +5.5V
Operating Temperature (T_A)	−40˚C to +85˚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, refer to the Electrical Characteristics section. The guaranteed specifications apply only for the conditions listed.

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

Note 3: GND = 0V

Electrical Characteristics

V_{CC} = V_P Main = V_P Aux = Vμc = 3.0V, −40˚C ≤ T_A ≤ +85˚C, unless otherwise specified

Symbol	Parameter	Conditions	Value			Units
			Min	Typ	Max	
I_{CC} PARAMETERS						
$I_{CC_{Main + Aux}}$	Power Supply Current, Main + Aux Synthesizers	Clock, Data and LE = GND OSC_{in} = GND PWDN Main Bit = 0 PWDN Aux Bit = 0		3.5	4.6	mA
$I_{CC_{Main}}$	Power Supply Current, Main Synthesizer Only	Clock, Data and LE = GND OSC_{in} = GND PWDN Main Bit = 0 PWDN Aux Bit = 1		2.3	3.0	mA
$I_{CC_{Aux}}$	Power Supply Current, Aux Synthesizer Only	Clock, Data and LE = GND OSC_{in} = GND PWDN Main Bit = 1 PWDN Aux Bit = 0		1.0	1.6	mA
$I_{CC\text{-}PWDN}$	Powerdown Current	Clock, Data and LE = GND OSC_{in} = GND PWDN Main Bit = 1 PWDN Aux Bit = 1		1.0	10.0	μA
MAIN SYNTHESIZER PARAMETERS						
f_{IN} Main	Main Operating Frequency		500		2500	MHz
N_{Main}	Main N Divider Range	Prescaler = 16/17 (Note 4)	48		131087	
		Prescaler = 32/33 (Note 4)	96		262143	
R_{Main}	Main R Divider Range		2		32767	
$F_{\phi Main}$	Main Phase Detector Frequency				10	MHz
Pf_{IN} Main	Main Input Sensitivity	2.7V ≤ V_{CC} ≤ 3.0V (Note 5)	−15		0	dBm
		3.0V < V_{CC} ≤ 5.5V (Note 5)	−10		0	dBm

Electrical Characteristics (Continued)

V_{CC} = V_P Main = V_P Aux = Vμc = 3.0V, −40˚C ≤ T_A ≤ +85˚C, unless otherwise specified

Symbol	Parameter	Conditions	Value			Units
			Min	Typ	Max	
MAIN SYNTHESIZER PARAMETERS						
ID_o Main SOURCE	Main Charge Pump Output Source Current	VD_o Main = V_P Main/2 ID_o Main Bit = 0 (Note 6)		-0.95		mA
		VD_o Main = V_P Main/2 ID_o Main Bit = 1 (Note 6)		-3.80		mA
ID_o Main SINK	Main Charge Pump Output Sink Current	VD_o Main = V_P Main/2 ID_o Main Bit = 0 (Note 6)		0.95		mA
		VD_o Main = V_P Main/2 ID_o Main Bit = 1 (Note 6)		3.80		mA
ID_o Main TRI-STATE	Main Charge Pump Output TRI-STATE Current	0.5V ≤ VD_o Main ≤ V_P Main - 0.5V (Note 6)	-2.5		2.5	nA
ID_o Main SINK Vs ID_o Main SOURCE	Main Charge Pump Output Sink Current Vs Charge Pump Output Source Current Mismatch	VD_o Main = V_P Main/2 T_A = 25˚C (Note 7)		3	10	%
ID_o Main Vs VD_o Main	Main Charge Pump Output Current Magnitude Variation Vs Charge Pump Output Voltage	0.5V ≤ VD_o Main ≤ V_P Main - 0.5V T_A = 25˚C (Note 7)		10	15	%
ID_o Main Vs T_A	Main Charge Pump Output Current Magnitude Variation Vs Temperature	VD_o Main = V_P Main/2 (Note 7)		10		%
AUX SYNTHESIZER PARAMETERS						
f_{IN} Aux	Aux Operating Frequency		45		1200	MHz
N_{Aux}	Aux N Divider Range	Prescaler = 8/9 (Note 4)	24		65559	
		Prescaler = 16/17 (Note 4)	48		131087	
R_{Aux}	Aux R Divider Range		2		32767	
$F_{\phi Aux}$	Aux Phase Detector Frequency				10	MHz
Pf_{IN} Aux	Aux Input Sensitivity	2.7V ≤ V_{CC} ≤ 5.5V (Note 5)	-10		0	dBm

Electrical Characteristics (Continued)

V_{CC} = V_P Main = V_P Aux = Vμc = 3.0V, –40˚C ≤ T_A ≤ +85˚C, unless otherwise specified

Symbol	Parameter	Conditions	Value			Units
			Min	Typ	Max	
AUX SYNTHESIZER PARAMETERS						
ID_o Aux SOURCE	Aux Charge Pump Output Source Current	VD_o Aux = V_P Aux/2 ID_o Aux Bit = 0 (Note 6)		-0.95		mA
		VD_o Aux = V_P Aux/2 ID_o Aux Bit = 1 (Note 6)		-3.80		mA
ID_o Aux SINK	Aux Charge Pump Output Sink Current	VD_o Aux = V_P Aux/2 ID_o Aux Bit = 0 (Note 6)		0.95		mA
		VD_o Aux = V_P Aux/2 ID_o Aux Bit = 1 (Note 6)		3.80		mA
ID_o Aux TRI-STATE	Aux Charge Pump Output TRI-STATE Current	0.5V ≤ VD_o Aux ≤ V_P Aux - 0.5V (Note 6)	-2.5		2.5	nA
ID_o Aux SINK Vs ID_o Aux SOURCE	Aux Charge Pump Output Sink Current Vs Charge Pump Output Source Current Mismatch	VD_o Aux = V_P Aux/2 T_A = 25˚C (Note 7)		3	10	%
ID_o Aux Vs VD_o Aux	Aux Charge Pump Output Current Magnitude Variation Vs Charge Pump OutputVoltage	0.5V ≤ VD_o Aux ≤ V_P Aux - 0.5V T_A = 25˚C (Note 7)		10	15	%
ID_o Aux Vs T_A	Aux Charge Pump Output Current Magnitude Variation Vs Temperature	VD_o Aux = V_P Aux/2 (Note 7)		10		%
OSCILLATOR PARAMETERS						
F_{OSC}	Oscillator Operating Frequency		2		40	MHz
V_{OSC}	Oscillator Sensitivity	(Note 8)	0.5		V_{CC}	V_{PP}
I_{OSC}	Oscillator Input Current	V_{OSC} = V_{CC} = 5.5V			100	μA
		V_{OSC} = 0V, V_{CC} = 5.5V	-100			μA

Electrical Characteristics (Continued)

V_{CC} = V_P Main = V_P Aux = Vμc = 3.0V, −40˚C ≤ T_A ≤ +85˚C, unless otherwise specified

Symbol	Parameter	Conditions	Value			Units
			Min	Typ	Max	
DIGITAL INTERFACE (Data, LE, Clock, F_oLD)						
V_{IH}	High-Level Input Voltage	1.72V ≤ Vμc ≤ 5.5V	0.8 Vμc			V
V_{IL}	Low-Level Input Voltage	1.72V ≤ Vμc ≤ 5.5V			0.2 Vμc	V
I_{IH}	High-Level Input Current	V_{IH} = Vμc = 5.5V	−1.0		1.0	μA
I_{IL}	Low-Level Input Current	V_{IL} = 0V, Vμc = 5.5V	−1.0		1.0	μA
V_{OH}	High-Level Output Voltage	I_{OH} = −500 μA	V_{CC} − 0.4			V
V_{OL}	Low-Level Output Voltage	I_{OL} = 500 μA			0.4	V
MICROWIRE INTERFACE						
t_{CS}	Data to Clock Set Up Time	(Note 9)	50			ns
t_{CH}	Data to Clock Hold Time	(Note 9)	20			ns
t_{CWH}	Clock Pulse Width HIGH	(Note 9)	50			ns
t_{CWL}	Clock Pulse Width LOW	(Note 9)	50			ns
t_{ES}	Clock to Load Enable Set Up Time	(Note 9)	50			ns
t_{EW}	Latch Enable Pulse Width	(Note 9)	50			ns

Electrical Characteristics (Continued)

V_{CC} = V_P Main = V_P Aux = Vμc = 3.0V, −40˚C ≤ T_A ≤ +85˚C, unless otherwise specified

Symbol	Parameter	Conditions	Value			Units
			Min	Typ	Max	
PHASE NOISE CHARACTERISTICS						
L_N(f) Main	Main Synthesizer Normalized Phase Noise Contribution (Note 10)	TCXO Reference Source ID_o Main Bit = 1		-212.0		dBc/ Hz
L(f) Main	Main Synthesizer Single Side Band Phase Noise Measured	f_{IN} Main = 2450 MHz f = 1 kHz Offset $F_{\phi Main}$ = 200 kHz Loop Bandwidth = 7.5 kHz N = 12250 F_{OSC} = 10 MHz V_{OSC} = 0.632 V_{PP} ID_o Main Bit = 1 PWDN Aux Bit = 1 T_A = 25˚C (Note 11)		-77.24		dBc/ Hz
L_N(f) Aux	Aux Synthesizer Normalized Phase Noise Contribution (Note 10)	TCXO Reference Source ID_o Aux Bit = 1		-212.0		dBc/ Hz
L(f) Aux	Aux Synthesizer Single Side Band Phase Noise Measured	f_{IN} Aux = 900 MHz f = 1 kHz Offset $F_{\phi Aux}$ = 200 kHz Loop Bandwidth = 12 kHz N = 4500 F_{OSC} = 10 MHz V_{OSC} = 0.632 V_{PP} ID_o Aux Bit = 1 PWDN Main Bit = 1 T_A = 25˚C (Note 11)		-85.94		dBc/ Hz

Note 4: Some of the values in this range are illegal divide ratios (B < A). To obtain continuous legal division, the Minimum Divide Ratio must be calculated. Use N ≥ P * (P–1), where P is the value of the prescaler selected.

Note 5: Refer to the LMX2377U f_{IN} Sensitivity Test Setup section

Note 6: Refer to the LMX2377U Charge Pump Test Setup section

Note 7: Refer to the Charge Pump Current Specification Definitions for details on how these measurements are made.

Note 8: Refer to the LMX2377U OSC_{in} Sensitivity Test Setup section

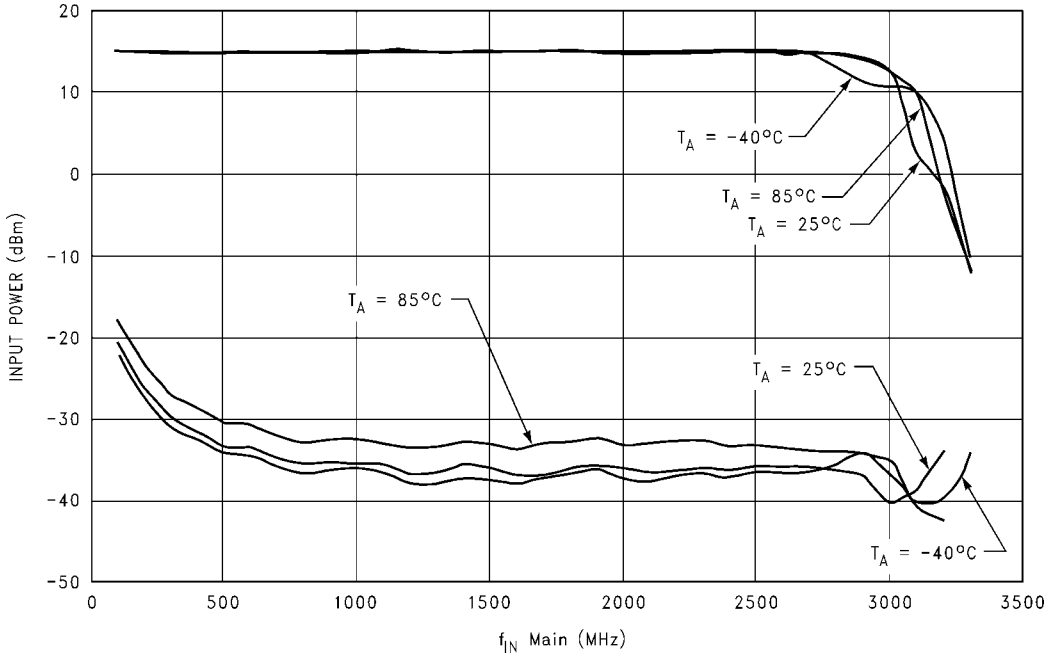
Note 9: Refer to the LMX2377U Serial Data Input Timing section

Note 10: Normalized Phase Noise Contribution is defined as : $L_N(f) = L(f) - 20 \log (N) - 10 \log (F_\phi)$, where L(f) is defined as the single side band phase noise measured at an offset frequency, f, in a 1 Hz bandwidth. The offset frequency, f, must be chosen sufficiently smaller than the PLL's loop bandwidth, yet large enough to avoid substantial phase noise contribution from the reference source. N is the value selected for the feedback divider and F_ϕ is the Main/Aux phase detector comparison frequency..

Note 11: The synthesizer phase noise is measured with the LMX2370TMEB/LMX2370SLBEB/LMX2370SLEEB Evaluation boards and the HP8566B Spectrum Analyzer.

Typical Performance Characteristics
Sensitivity

LMX2377U f_{IN} Main Input Power Vs Frequency
V_{CC} = V_P Main = Vμc = 3.0V



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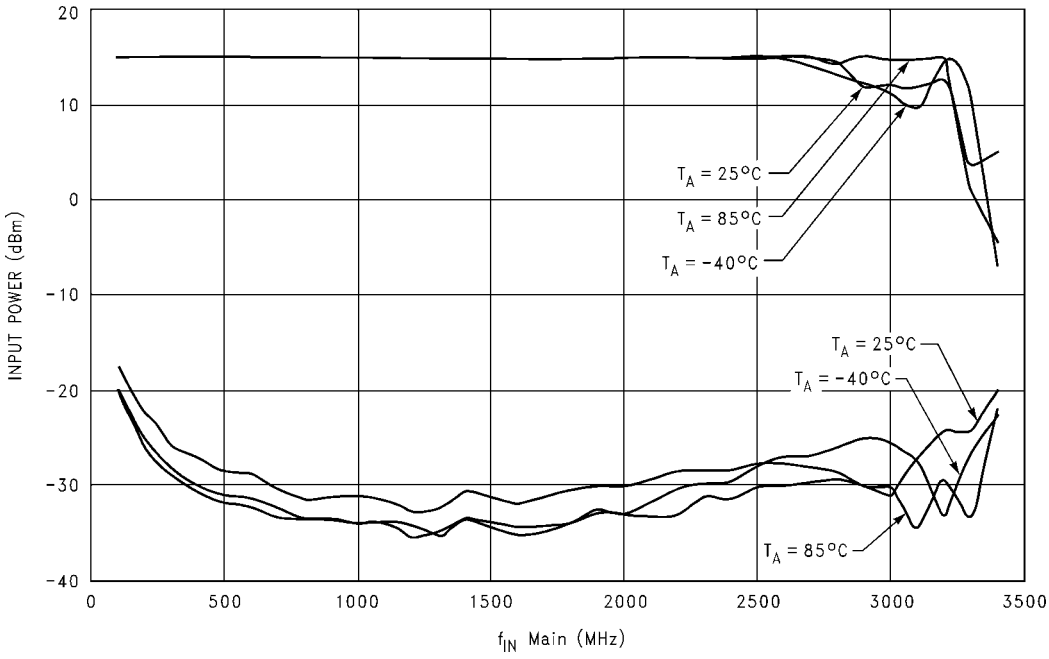
LMX2330U f_{IN} Main Input Power Vs Frequency
V_{CC} = V_P Main = Vμc = 5.5V



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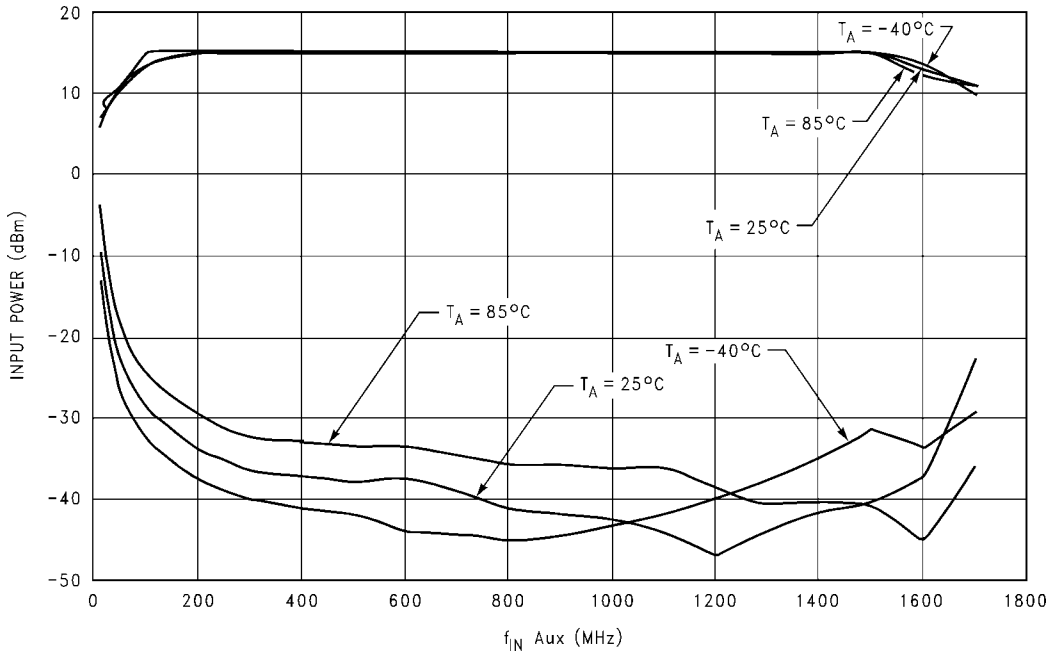
Typical Performance Characteristics
Sensitivity (Continued)

LMX2377U f_{IN} Aux Input Power Vs Frequency
V_{CC} = V_P Aux = Vμc = 3.0V



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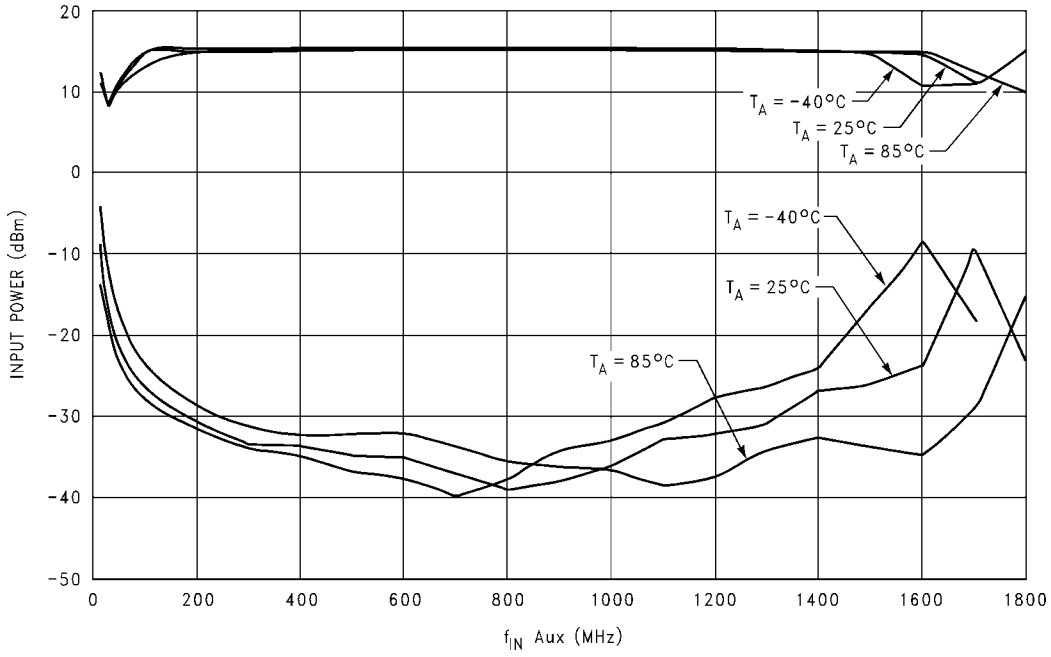
LMX2377U f_{IN} Aux Input Power Vs Frequency
V_{CC} = V_P Aux = Vμc = 5.5V



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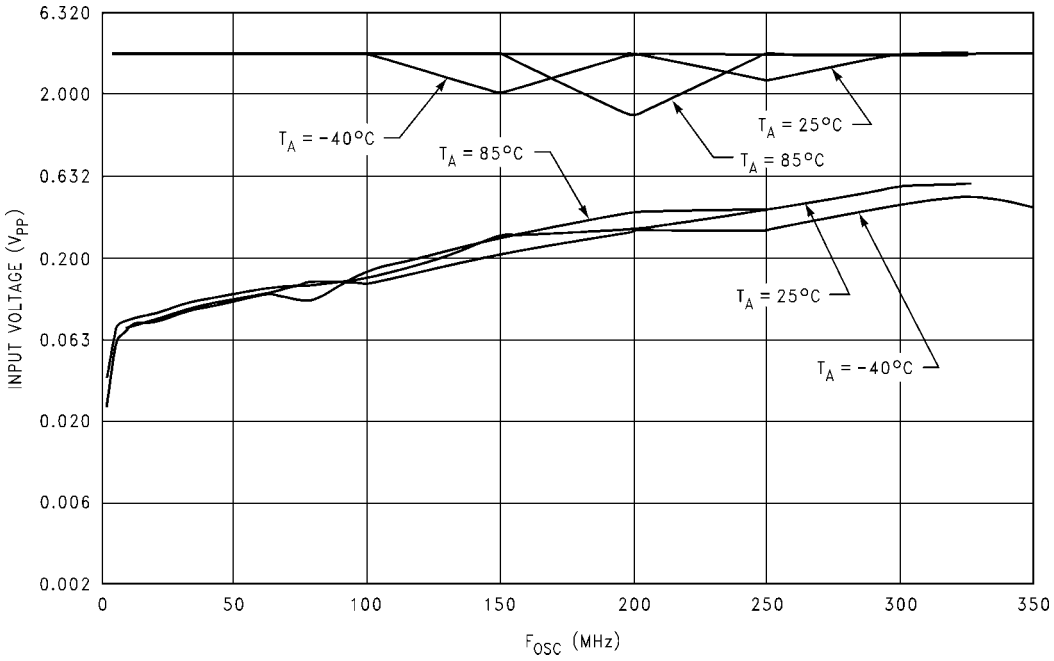
Typical Performance Characteristics
Sensitivity (Continued)

LMX2377U OSC_{in} Input Voltage Vs Frequency
V_{CC} = Vμc = 3.0V



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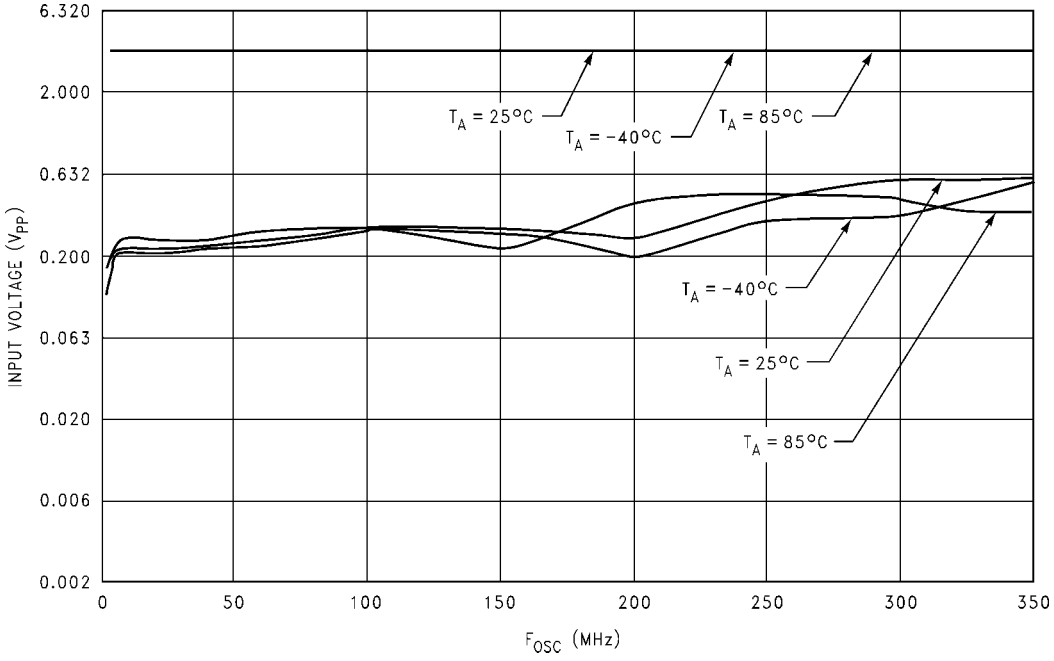
LMX2377U OSC_{in} Input Voltage Vs Frequency
V_{CC} = Vμc = 5.5V



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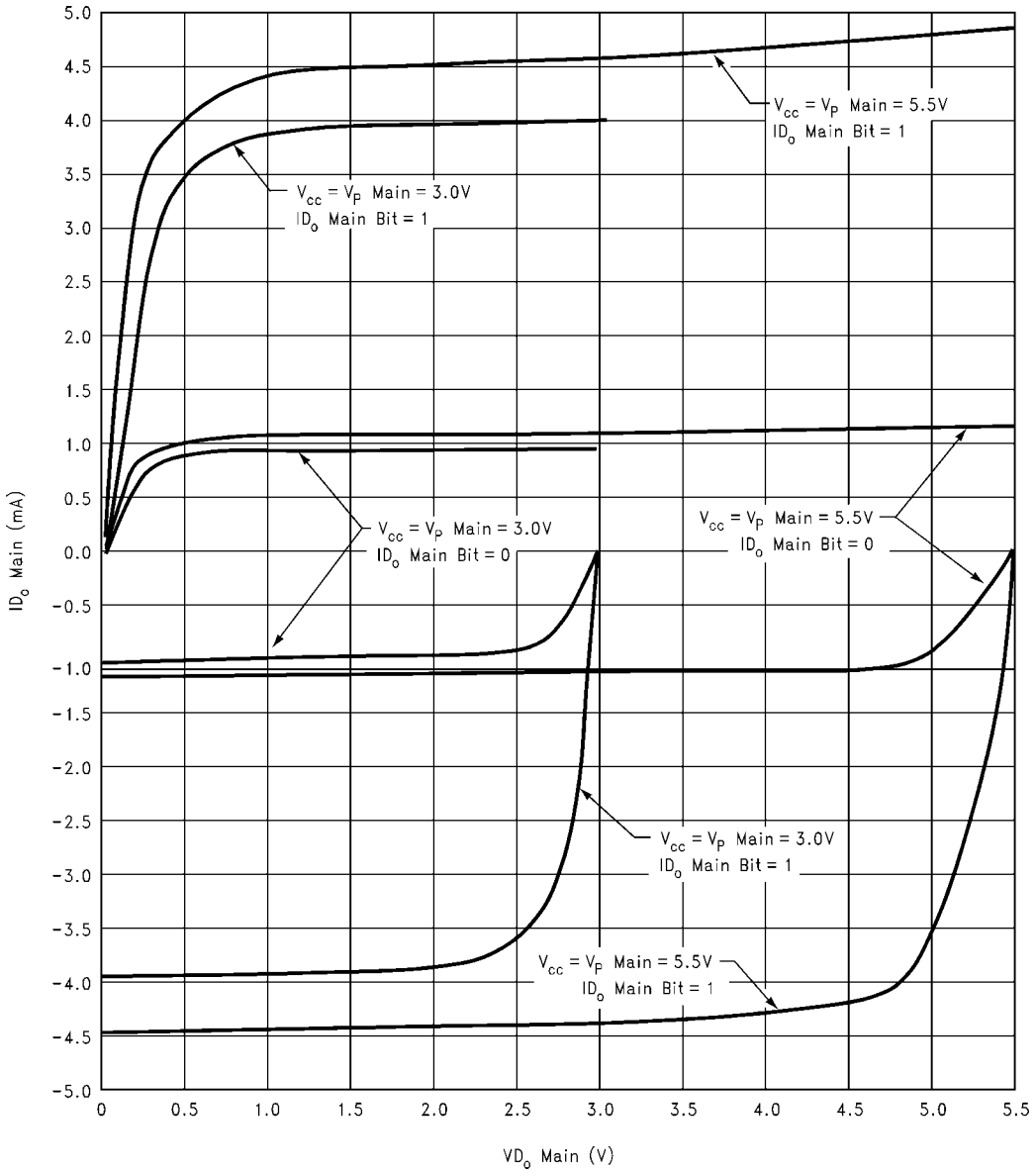
Typical Performance Characteristics
Charge Pump

LMX2377U Main Charge Pump Sweeps
$-40^{\circ}C \leq T_A \leq +85^{\circ}C$, Vμc = V_{CC}



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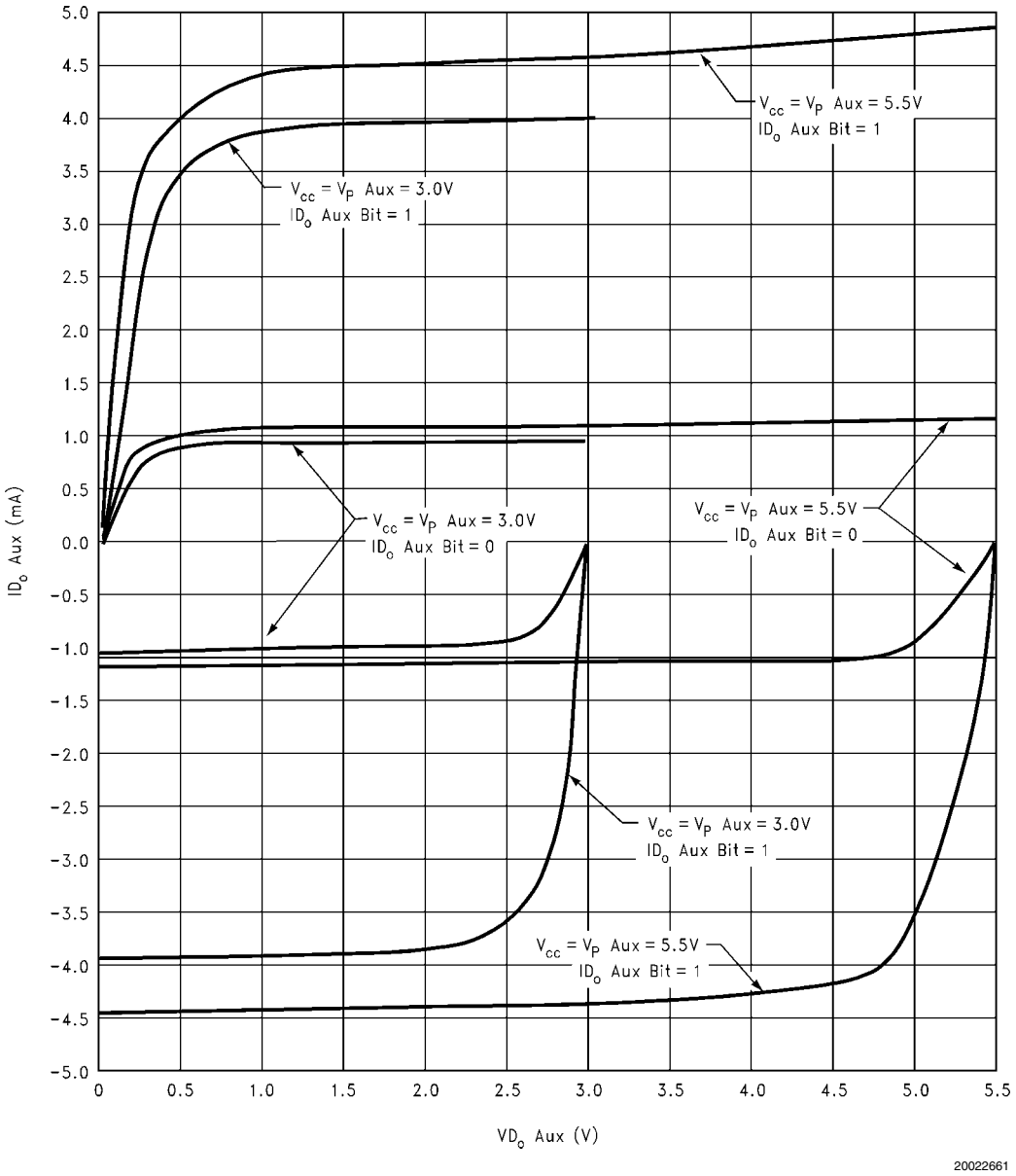
Typical Performance Characteristics
Charge Pump (Continued)

LMX2377U Aux Charge Pump Sweeps
$-40^{\circ}C \leq T_A \leq +85^{\circ}C$, Vμc = V_{CC}



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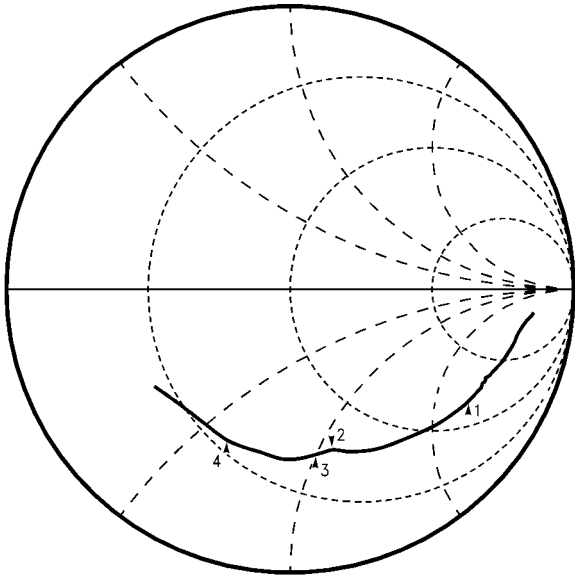
Typical Performance Characteristics
Input Impedance

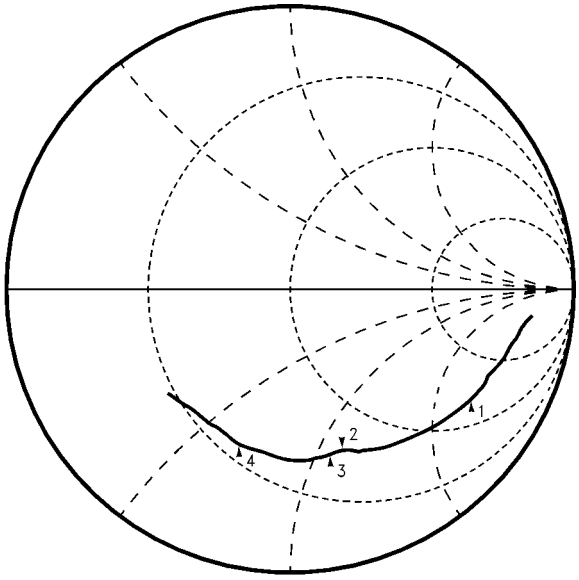
LMX2377U TSSOP
f_{IN} Main and f_{IN} Aux Input Impedance
V_{CC} = Vμc = 3.0V, T_A = +25˚C



Marker 1 = 900 MHz
Marker 2 = 1800 MHz
Marker 3 = 1900 MHz
Marker 4 = 2500 MHz

20022666

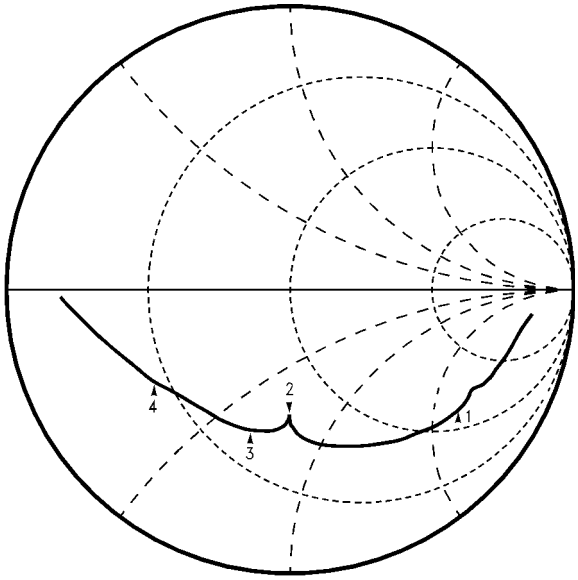
LMX2377U TSSOP
f_{IN} Main and f_{IN} Aux Input Impedance
V_{CC} = Vμc = 5.5V, T_A = +25˚C



Marker 1 = 900 MHz
Marker 2 = 1800 MHz
Marker 3 = 1900 MHz
Marker 4 = 2500 MHz

20022667

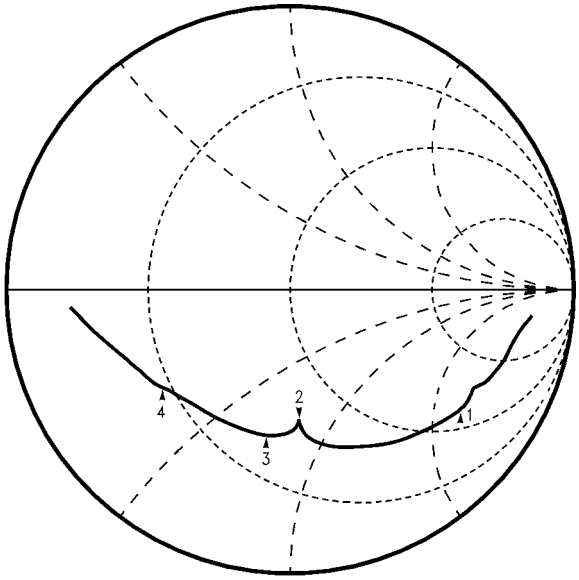
LMX2377U CSP
f_{IN} Main and f_{IN} Aux Input Impedance
V_{CC} = Vμc = 3.0V, T_A = +25˚C



Marker 1 = 900 MHz
Marker 2 = 1800 MHz
Marker 3 = 1900 MHz
Marker 4 = 2500 MHz

20022668

LMX2377U CSP
f_{IN} Main and f_{IN} Aux Input Impedance
V_{CC} = Vμc = 5.5V, T_A = +25˚C



Marker 1 = 900 MHz
Marker 2 = 1800 MHz
Marker 3 = 1900 MHz
Marker 4 = 2500 MHz

20022669

Typical Performance Characteristics
Input Impedance (Continued)

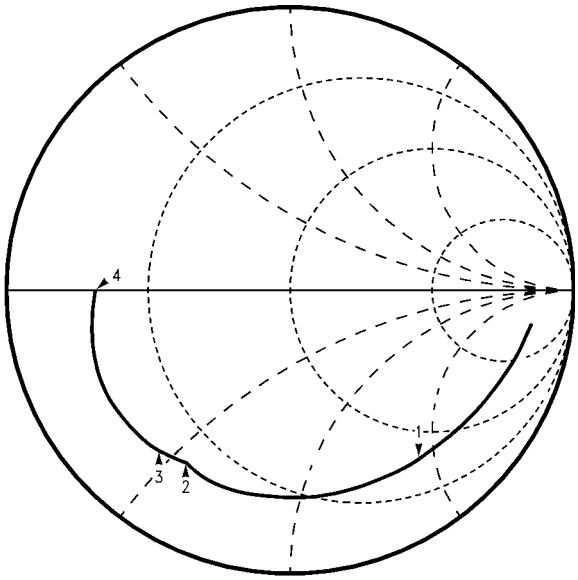
LMX2377U TSSOP and LMX2377U CSP f_{IN} Main and f_{IN} Aux Input Impedance Table

	LMX2377U TSSOP (Zf_{IN} Main and Zf_{IN} Aux)										LMX2377U CSP (Zf_{IN} Main and Zf_{IN} Aux)									
	$V_{CC} = V_P$ Main = V_P Aux = $V_{\mu C}$ = 3.0V (T_A = 25°C)					$V_{CC} = V_P$ Main = V_P Aux = $V_{\mu C}$ = 5.5V (T_A = 25°C)					$V_{CC} = V_P$ Main = V_P Aux = $V_{\mu C}$ = 3.0V (T_A = 25°C)					$V_{CC} = V_P$ Main = V_P Aux = $V_{\mu C}$ = 5.5V (T_A = 25°C)				
f_{IN} (MHz)	|Γ|	∠Γ	Re Zf_{IN} (Ω)	Im Zf_{IN} (Ω)	|Zf_{IN}| (Ω)	|Γ|	∠Γ	Re Zf_{IN} (Ω)	Im Zf_{IN} (Ω)	|Zf_{IN}| (Ω)	|Γ|	∠Γ	Re Zf_{IN} (Ω)	Im Zf_{IN} (Ω)	|Zf_{IN}| (Ω)	|Γ|	∠Γ	Re Zf_{IN} (Ω)	Im Zf_{IN} (Ω)	|Zf_{IN}| (Ω)
100	0.862	-6.23	439.774	-319.866	543.798	0.862	-6.07	448.230	-318.841	550.064	0.864	-6.44	431.004	-330.013	542.838	0.864	-6.30	438.240	-327.814	547.281
200	0.834	-9.30	307.614	-272.274	410.803	0.834	-9.00	316.479	-271.581	417.031	0.836	-9.88	291.252	-277.923	402.577	0.836	-9.57	300.190	-277.552	408.838
300	0.820	-12.11	237.700	-249.291	344.452	0.821	-11.66	247.264	-251.098	352.406	0.821	-13.24	215.318	-248.361	328.702	0.821	-12.76	224.624	-249.637	335.819
400	0.808	-15.25	185.048	-227.171	293.001	0.808	-14.61	194.668	-229.054	300.601	0.808	-16.88	163.190	-219.893	273.832	0.808	-16.24	171.345	-222.518	280.844
500	0.796	-18.51	147.785	-203.923	251.843	0.796	-17.66	156.935	-207.313	260.014	0.793	-20.90	126.193	-191.939	229.707	0.794	-20.00	133.885	-196.200	237.528
600	0.781	-21.81	122.091	-181.461	218.710	0.782	-20.70	130.906	-185.850	227.325	0.775	-24.82	102.966	-168.026	197.060	0.777	-23.70	109.531	-172.887	204.663
700	0.765	-24.72	106.107	-163.758	195.129	0.767	-23.45	113.780	-168.514	203.329	0.749	-28.29	90.820	-146.582	172.437	0.752	-27.02	96.279	-151.333	179.363
800	0.760	-28.35	87.984	-150.524	174.352	0.762	-26.97	94.255	-155.481	181.819	0.742	-31.22	79.737	-136.782	158.327	0.746	-29.85	84.470	-141.473	164.772
900	**0.747**	**-32.60**	**73.777**	**-134.500**	**153.406**	**0.750**	**-30.95**	**79.270**	**-139.668**	**160.596**	**0.739**	**-36.04**	**64.577**	**-123.951**	**139.764**	**0.742**	**-34.37**	**69.006**	**-128.610**	**145.954**
1000	0.732	-36.68	64.122	-120.908	136.859	0.735	-34.73	69.215	-126.104	143.851	0.719	-41.44	55.019	-108.415	121.577	0.723	-39.46	58.684	-113.123	127.439
1100	0.717	-41.25	55.780	-108.398	121.908	0.720	-39.12	60.041	-113.215	128.151	0.694	-47.27	48.056	-94.403	105.931	0.698	-45.08	51.159	-98.547	111.035
1200	0.698	-46.24	49.180	-96.605	108.403	0.702	-43.84	52.848	-101.254	114.216	0.669	-53.59	42.269	-82.401	92.610	0.674	-51.01	45.061	-86.388	97.434
1300	0.678	-51.43	43.982	-86.291	96.853	0.683	-48.77	47.173	-90.676	102.212	0.641	-60.42	37.856	-71.653	81.039	0.647	-57.50	40.230	-75.400	85.461
1400	0.663	-56.68	39.397	-77.901	87.296	0.667	-53.71	42.317	-82.070	92.337	0.610	-68.33	34.108	-61.481	70.308	0.613	-64.90	36.477	-64.872	74.424
1500	0.649	-62.08	35.566	-70.500	78.963	0.653	-58.74	38.281	-74.569	83.821	0.577	-77.01	31.049	-52.388	60.898	0.581	-73.18	33.064	-55.554	64.649
1600	0.630	-67.58	32.912	-63.544	71.562	0.634	-63.96	35.335	-67.423	76.121	0.539	-84.86	29.732	-44.952	53.895	0.543	-80.36	31.654	-48.119	57.597
1700	0.608	-72.22	31.565	-57.996	66.030	0.614	-68.51	33.590	-61.632	70.191	0.477	-27.97	100.359	-58.171	115.999	0.487	-84.99	33.106	-42.105	53.562
1800	**0.596**	**-75.66**	**30.440**	**-54.462**	**62.392**	**0.601**	**-71.81**	**32.358**	**-57.943**	**66.366**	**0.455**	**89.90**	**32.829**	**-37.624**	**49.933**	**0.468**	**-85.87**	**33.886**	**-40.554**	**52.847**
1900	**0.598**	**-80.06**	**27.915**	**-51.164**	**58.284**	**0.602**	**-76.22**	**29.678**	**-54.335**	**61.912**	**0.493**	**87.34**	**29.357**	**-38.214**	**48.189**	**0.500**	**-88.90**	**29.576**	**-39.369**	**49.241**
2000	0.607	-85.31	24.914	-47.651	53.771	0.607	-81.32	26.675	-50.603	57.203	0.520	79.89	25.120	-35.225	43.264	0.521	84.05	26.396	-37.576	45.921
2100	0.612	89.24	22.502	-43.994	49.414	0.611	-86.42	21.612	42.064	47.292	0.529	70.97	22.177	-30.771	37.930	0.525	75.52	23.556	-33.043	40.580
2200	0.605	84.09	21.289	-40.358	45.629	0.602	88.61	22.901	-43.251	48.940	0.531	61.99	20.155	-26.331	33.159	0.524	66.93	21.544	-28.596	35.802
2300	0.594	78.44	20.367	-36.566	41.855	0.589	83.13	21.961	-39.298	45.018	0.533	52.71	18.533	-21.975	28.747	0.525	57.61	19.706	-24.119	31.146
2400	0.590	72.27	19.111	-32.907	38.064	0.584	77.11	20.598	-35.536	41.074	0.550	43.18	16.578	-17.883	24.385	0.537	47.69	17.671	-19.749	26.501
2500	**0.586**	**67.24**	**18.297**	**-30.064**	**35.194**	**0.576**	**72.09**	**19.792**	**-32.516**	**38.066**	**0.583**	**34.44**	**14.340**	**-14.328**	**20.272**	**0.566**	**38.69**	**15.416**	**-16.055**	**22.257**

20022670

Typical Performance Characteristics
Input Impedance (Continued)

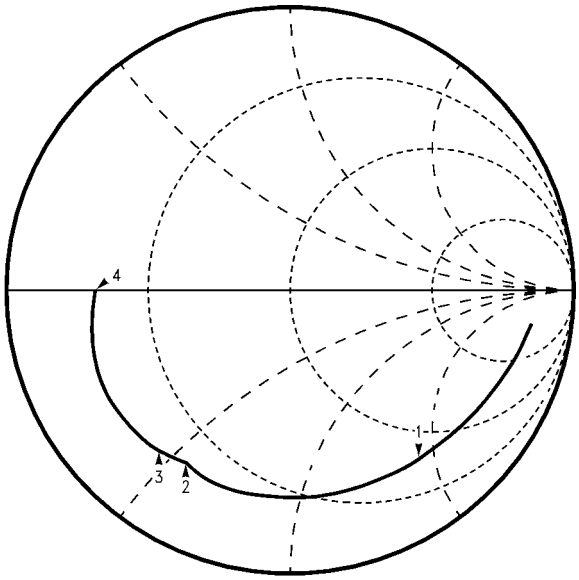
LMX2377U UTCSP
f_{IN} Main and f_{IN} Aux Input Impedance
V_{CC} = Vμc = 3.0V, T_A = +25˚C



Marker 1 = 900 MHz
Marker 2 = 1800 MHz
Marker 3 = 1900 MHz
Marker 4 = 2500 MHz

20022697

LMX2377U UTCSP
f_{IN} Main and f_{IN} Aux Input Impedance
V_{CC} = Vμc = 5.5V, T_A = +25˚C



Marker 1 = 900 MHz
Marker 2 = 1800 MHz
Marker 3 = 1900 MHz
Marker 4 = 2500 MHz

20022697

Typical Performance Characteristics

Input Impedance (Continued)

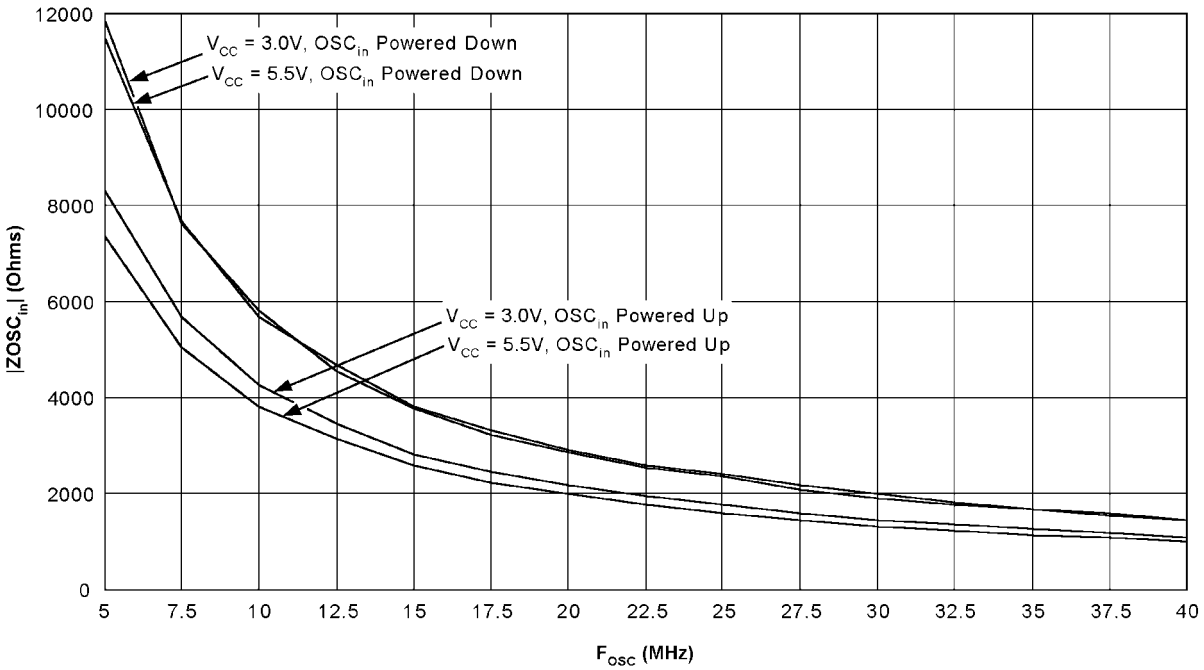
LMX2377U UTCSP f_{IN} Main and f_{IN} Aux Input Impedance Table

	LMX2377U UTCSP Zf_{IN} Main and Zf_{IN} Aux									
	V_{DD} = V_P Main = V_P Aux = $V_{\mu D}$ = 3.0V (T_A = 25°C)					V_{CC} = V_P Main = V_P Aux = $V_{\mu D}$ = 5.5V (T_A = 25°C)				
f_{IN} (MHz)	|Γ|	∠Γ	Re Zf_{IN} (Ω)	Im Zf_{IN} (Ω)	|Zf_{IN}| (Ω)	|Γ|	∠Γ	Re Zf_{IN} (Ω)	Im Zf_{IN} (Ω)	|Zf_{IN}| (Ω)
100	0.86	-8.57	335.53	-330.26	470.80	0.86	-8.61	333.98	-330.26	469.70
200	0.83	-13.59	206.36	-258.74	330.96	0.83	-13.55	207.11	-258.92	331.57
300	0.81	-18.53	143.19	-214.36	257.79	0.81	-18.45	144.06	-214.76	258.59
400	0.80	-23.67	103.09	-183.95	210.86	0.80	-23.63	103.36	-184.12	211.15
500	0.79	-29.24	76.58	-157.24	174.89	0.79	-29.07	77.30	-157.87	175.78
600	0.77	-34.87	61.79	-133.64	147.24	0.77	-34.64	62.46	-134.31	148.12
700	0.76	-40.52	50.03	-116.97	127.23	0.76	-40.33	50.42	-117.43	127.80
800	0.76	-46.45	39.82	-103.86	111.24	0.76	-46.18	40.22	-104.42	111.89
900	**0.75**	**-53.27**	**32.87**	**-90.33**	**96.13**	**0.75**	**-52.89**	**33.27**	**-90.97**	**96.86**
1000	0.74	-60.04	27.98	-79.30	84.09	0.74	-59.70	28.24	-79.77	84.63
1100	0.73	-66.62	24.49	-70.27	74.42	0.73	-66.10	24.81	-70.90	75.11
1200	0.73	-74.07	20.63	-62.00	65.34	0.73	-73.57	20.85	-62.52	65.91
1300	0.73	-81.87	17.67	-54.66	57.45	0.73	-81.15	17.85	-55.13	57.95
1400	0.73	-89.59	15.34	-47.95	50.34	0.73	-88.94	15.51	-48.47	50.89
1500	0.73	-97.85	13.48	-41.75	43.87	0.73	-97.12	13.63	-42.27	44.41
1600	0.73	-106.72	11.96	-35.80	37.74	0.73	-105.87	12.09	-36.34	38.30
1700	0.72	-115.82	11.22	-30.21	32.22	0.72	-114.76	11.35	-30.82	32.84
1800	**0.70**	**-123.41**	**11.28**	**-25.85**	**28.20**	**0.70**	**-122.28**	**11.40**	**-26.45**	**28.80**
1900	**0.72**	**-130.68**	**9.80**	**-22.22**	**24.29**	**0.72**	**-129.92**	**9.86**	**-22.61**	**24.66**
2000	0.74	-140.55	8.41	-17.48	19.39	0.74	-139.88	8.44	-17.80	19.70
2100	0.74	-150.74	7.97	-12.74	15.03	0.74	-150.01	7.99	-13.07	15.32
2200	0.73	-160.86	8.02	-8.22	11.48	0.73	-160.03	8.04	-8.58	11.76
2300	0.71	-170.43	8.54	-4.06	9.46	0.71	-169.62	8.55	-4.41	9.62
2400	0.69	-179.08	9.17	-0.39	9.18	0.69	-178.32	9.17	-0.71	9.20
2500	**0.67**	**172.38**	**9.92**	**3.20**	**10.43**	**0.67**	**173.11**	**9.91**	**2.89**	**10.33**

20022698

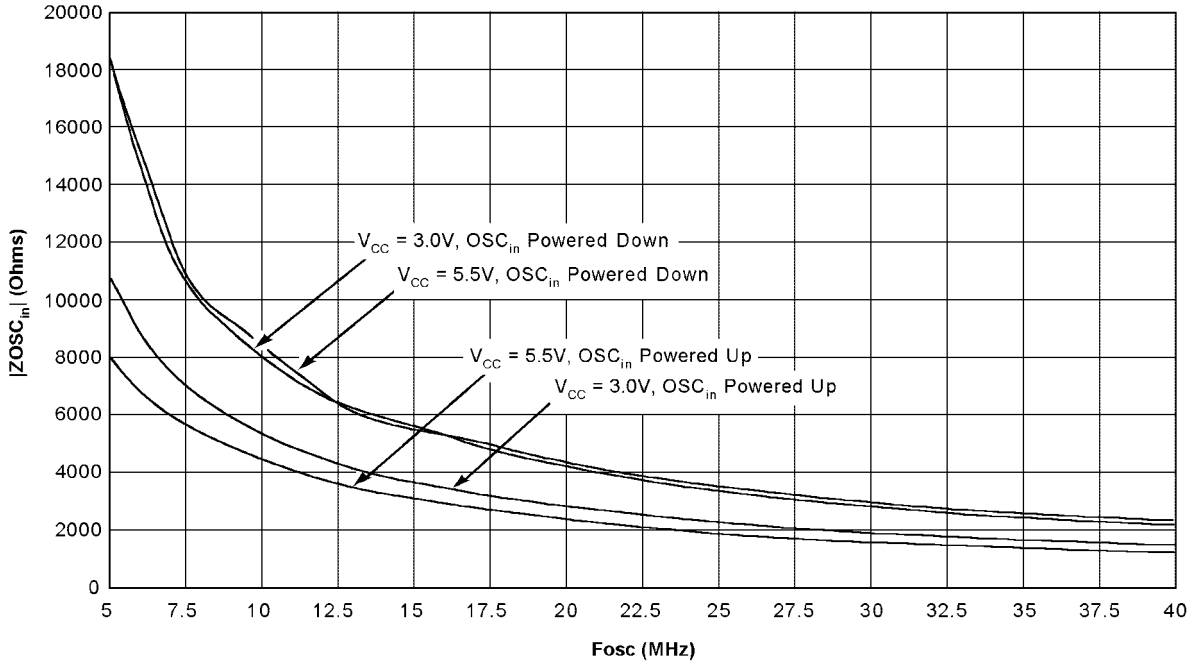
Typical Performance Characteristics
Input Impedance (Continued)

LMX2377U TSSOP OSC_{in} Input Impedance Vs Frequency
T_A = +25˚C



20022676

LMX2377U CSP OSC_{in} Input Impedance Vs Frequency
T_A = +25˚C



20022677

Typical Performance Characteristics

Input Impedance (Continued)

LMX2377U TSSOP and LMX2377U CSP OSC_{in} Input Impedance Table

	LMX2377U TSSOP $ZOSC_{in}$											
	V_{CC} = $V_{\mu C}$ = 3.0V (T_A = 25°C)						V_{CC} = $V_{\mu C}$ = 5.5V (T_A = 25°C)					
	OSC_{in} BUFFER POWERED UP			OSC_{in} BUFFER POWERED DOWN			OSC_{in} BUFFER POWERED UP			OSC_{in} BUFFER POWERED DOWN		
F_{OSC} (MHz)	Re $ZOSC_{in}$ (Ω)	Im $ZOSC_{in}$ (Ω)	$\|ZOSC_{in}\|$ (Ω)	Re $ZOSC_{in}$ (Ω)	Im $ZOSC_{in}$ (Ω)	$\|ZOSC_{in}\|$ (Ω)	Re $ZOSC_{in}$ (Ω)	Im $ZOSC_{in}$ (Ω)	$\|ZOSC_{in}\|$ (Ω)	Re $ZOSC_{in}$ (Ω)	Im $ZOSC_{in}$ (Ω)	$\|ZOSC_{in}\|$ (Ω)
5.0	2291.113	-8000.376	8321.972	985.863	-11925.209	11966.234	2832.878	-6774.525	7342.982	1248.071	-11436.600	11504.262
7.5	1202.389	-5538.197	5667.218	294.460	-7640.322	7645.994	1287.479	-4861.053	5023.579	520.098	-7675.309	7692.910
10.0	791.970	-4219.668	4292.353	266.942	-5793.060	5799.207	739.926	-3754.673	3826.886	494.656	-5659.675	5680.388
12.5	527.664	-3418.976	3459.456	197.874	-4547.094	4551.397	544.280	-3078.845	3126.584	196.239	-4665.169	4669.295
15.0	349.020	-2817.960	2838.794	161.801	-3761.566	3765.044	416.644	-2526.243	2570.238	160.236	-3799.626	3803.003
17.5	316.446	-2439.647	2460.085	141.326	-3203.351	3206.467	309.867	-2192.584	2214.372	196.406	-3305.741	3311.570
20.0	226.626	-2179.146	2191.096	63.605	-2879.931	2880.631	227.640	-1974.267	1987.347	73.816	-2917.281	2918.215
22.5	211.659	-1932.535	1944.091	98.108	-2543.330	2545.222	214.873	-1741.101	1754.310	103.131	-2608.411	2610.449
25.0	163.618	-1762.903	1770.480	89.270	-2340.221	2341.923	169.812	-1589.814	1598.857	67.246	-2388.967	2389.913
27.5	163.733	-1589.620	1598.030	68.675	-2106.253	2107.405	160.401	-1435.713	1444.646	69.923	-2161.702	2162.832
30.0	148.446	-1463.071	1470.583	81.310	-1926.869	1928.604	141.501	-1314.929	1322.520	67.843	-1984.766	1985.928
32.5	130.683	-1340.256	1346.562	46.548	-1750.824	1751.443	121.612	-1213.403	1219.482	37.610	-1812.700	1813.090
35.0	126.059	-1256.034	1261.349	38.046	-1662.230	1662.666	116.385	-1131.429	1137.399	45.646	-1689.748	1690.365
37.5	115.848	-1178.954	1184.632	37.202	-1547.816	1548.263	109.381	-1064.461	1070.066	36.346	-1591.439	1591.854
40.0	108.280	-1089.931	1095.296	36.351	-1439.460	1439.919	100.267	-985.544	990.631	39.180	-1470.482	1471.004

	LMX2377U CSP $ZOSC_{in}$											
	V_{CC} = $V_{\mu C}$ = 3.0V (T_A = 25°C)						V_{CC} = $V_{\mu C}$ = 5.5V (T_A = 25°C)					
	OSC_{in} BUFFER POWERED UP			OSC_{in} BUFFER POWERED DOWN			OSC_{in} BUFFER POWERED UP			OSC_{in} BUFFER POWERED DOWN		
F_{OSC} (MHz)	Re $ZOSC_{in}$ (Ω)	Im $ZOSC_{in}$ (Ω)	$\|ZOSC_{in}\|$ (Ω)	Re $ZOSC_{in}$ (Ω)	Im $ZOSC_{in}$ (Ω)	$\|ZOSC_{in}\|$ (Ω)	Re $ZOSC_{in}$ (Ω)	Im $ZOSC_{in}$ (Ω)	$\|ZOSC_{in}\|$ (Ω)	Re $ZOSC_{in}$ (Ω)	Im $ZOSC_{in}$ (Ω)	$\|ZOSC_{in}\|$ (Ω)
5.0	5107.668	-9526.374	10809.27	4154.104	-18073.24	18544.60	4696.960	-6544.007	8056.318	4154.104	-18073.24	18544.50
7.5	2249.061	-6544.475	6920.146	1571.331	-10205.48	10325.74	2626.329	-4998.105	5646.119	1812.311	-10602.90	10756.68
10.0	1664.886	-5170.920	5432.335	1066.661	-8350.651	8418.499	1625.723	-4209.219	4512.261	979.606	-8800.590	8854.639
12.5	1048.750	-4245.537	4373.153	727.756	-6341.105	6382.730	1182.342	-3466.962	3663.045	699.697	-6248.932	6313.367
15.0	872.629	-3558.426	3663.861	442.319	-5658.273	5675.536	856.006	-2977.931	3098.519	436.542	-5712.788	5729.443
17.5	691.377	-3158.030	3232.825	296.061	-4799.917	4809.039	697.761	-2605.886	2697.692	309.618	-4985.007	4994.613
20.0	559.597	-2791.912	2847.441	194.872	-4242.475	4246.948	554.417	-2318.961	2384.315	303.378	-4345.597	4356.174
22.5	442.147	-2512.522	2551.129	166.123	-3777.847	3782.429	485.437	-2041.170	2098.100	168.163	-3935.873	3939.464
25.0	444.524	-2261.024	2304.307	170.072	-3402.400	3406.648	424.599	-1865.270	1912.986	174.460	-3506.895	3511.232
27.5	367.245	-2060.013	2092.491	191.739	-3114.867	3120.763	379.066	-1714.793	1756.195	159.273	-3213.478	3217.422
30.0	356.692	-1893.442	1926.747	168.280	-2837.317	2843.557	357.340	-1567.979	1608.182	157.424	-2934.223	2938.443
32.5	348.916	-1776.540	1810.480	129.014	-2664.486	2667.608	332.065	-1461.571	1498.818	157.389	-2780.469	2784.920
35.0	302.932	-1648.356	1675.961	95.424	-2471.170	2473.011	299.913	-1368.120	1390.840	125.530	-2600.472	2603.500
37.5	300.020	-1549.601	1578.377	117.732	-2331.694	2334.664	284.654	-1274.370	1305.774	144.727	-2419.904	2424.228
40.0	281.334	-1454.298	1481.260	81.318	-2182.473	2183.987	273.323	-1199.918	1230.654	152.283	-2302.913	2307.942

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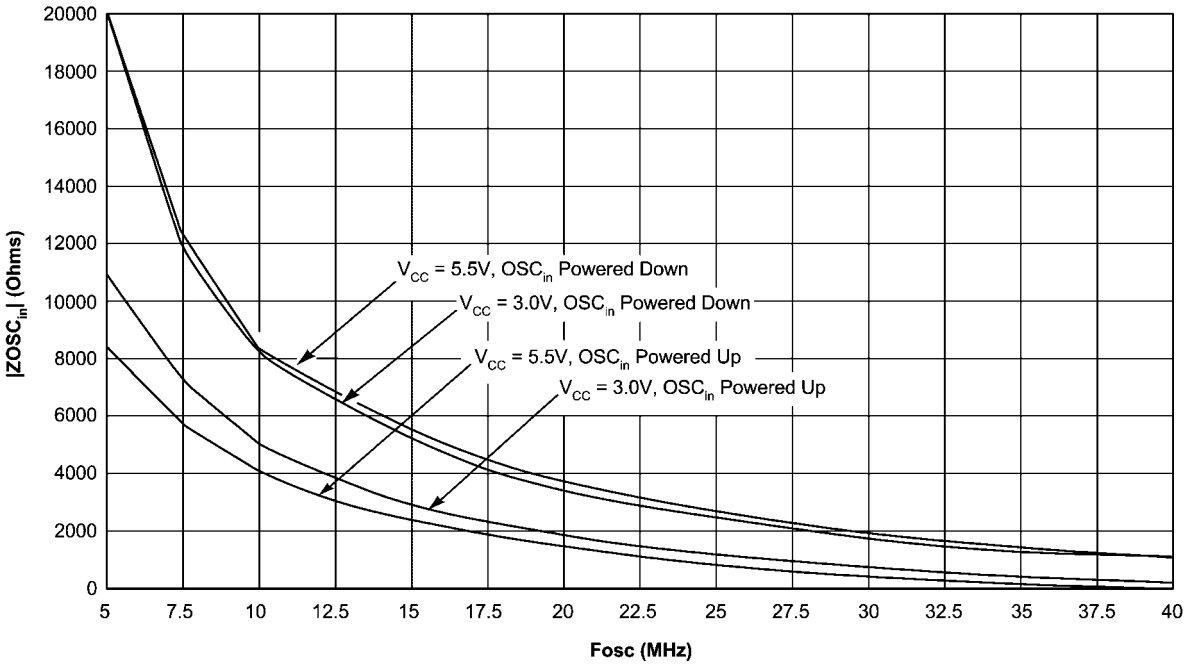
Typical Performance Characteristics
Input Impedance (Continued)

LMX2377U UTCSP OSC_{in} Input Impedance Vs Frequency
T_A = +25˚C



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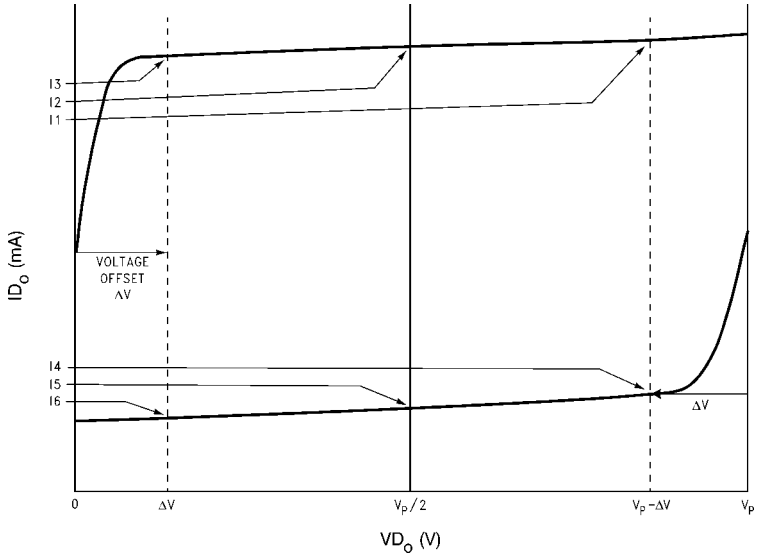
Typical Performance Characteristics
Input Impedance (Continued)

LMX2377U UTCSP OSC_{in} Input Impedance Table

	LMX2377U UTCSP $ZOSC_{in}$											
	V_{CC} = 3.0V (T_A = 25°C)						V_{CC} = 5.5V (T_A = 25°C)					
	OSC_{in} BUFFER POWERED UP			OSC_{in} BUFFER POWERED DOWN			OSC_{in} BUFFER POWERED UP			OSC_{in} BUFFER POWERED DOWN		
F_{osc} (MHz)	Re $ZOSC_{in}$ (Ω)	Im $ZOSC_{in}$ (Ω)	$\lvert ZOSC_{in} \rvert$ (Ω)	Re $ZOSC_{in}$ (Ω)	Im $ZOSC_{in}$ (Ω)	$\lvert ZOSC_{in} \rvert$ (Ω)	Re $ZOSC_{in}$ (Ω)	Im $ZOSC_{in}$ (Ω)	$\lvert ZOSC_{in} \rvert$ (Ω)	Re $ZOSC_{in}$ (Ω)	Im $ZOSC_{in}$ (Ω)	$\lvert ZOSC_{in} \rvert$ (Ω)
5.0	5918.57	-9897.80	11532.39	1822.62	-19947.73	20030.82	4982.73	-7668.32	9144.98	2478.02	-19591.11	19747.21
7.5	3097.46	-7441.43	8060.35	2238.93	-12114.22	12319.38	2742.97	-6062.16	6653.85	2483.54	-12531.99	12775.71
10.0	1695.22	-5720.83	5966.72	998.16	-9046.84	9101.74	1582.29	-4875.36	5125.70	1064.38	-9063.97	9126.25
12.5	1241.03	-4759.14	4918.29	660.39	-7338.93	7368.58	1150.39	-4034.66	4195.46	621.48	-7679.86	7704.97
15.0	820.55	-3955.33	4039.55	471.57	-6142.40	6160.48	861.48	-3448.80	3554.76	591.34	-6481.87	6508.79
17.5	646.18	-3417.20	3477.76	317.24	-5165.41	5175.14	599.49	-3009.04	3068.18	154.67	-5518.01	5520.17
20.0	520.20	-3006.22	3050.90	223.35	-4567.95	4573.41	491.78	-2647.38	2692.67	120.99	-4867.07	4868.57
22.5	459.63	-2666.05	2705.38	219.57	-4040.96	4046.92	396.64	-2342.62	2375.96	137.85	-4301.63	4303.84
25.0	391.21	-2398.19	2429.89	172.20	-3664.77	3668.81	323.46	-2108.25	2132.92	89.00	-3864.60	3865.62
27.5	348.79	-2210.66	2238.01	169.02	-3291.50	3295.84	312.14	-1920.70	1945.90	114.48	-3476.68	3478.56
30.0	285.07	-1996.71	2016.96	110.02	-3005.42	3007.43	260.59	-1763.82	1782.97	121.11	-3185.26	3187.56
32.5	267.83	-1847.30	1866.61	117.14	-2725.46	2727.97	239.41	-1612.35	1630.02	111.70	-2876.34	2878.50
35.0	252.27	-1719.32	1737.73	114.38	-2556.44	2561.00	222.16	-1503.76	1520.08	115.42	-2690.37	2692.84
37.5	224.94	-1639.80	1655.15	70.31	-2408.64	2409.67	191.46	-1422.68	1435.71	48.06	-2550.41	2550.86
40.0	208.96	-1512.91	1527.27	76.50	-2242.79	2244.09	180.75	-1329.24	1341.47	72.61	-2353.73	2354.85

200226A2

Charge Pump Current Specification Definitions



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I1 = Charge Pump Sink Current at $VD_o = V_P - \Delta V$

I2 = Charge Pump Sink Current at $VD_o = V_P/2$

I3 = Charge Pump Sink Current at $VD_o = \Delta V$

I4 = Charge Pump Source Current at $VD_o = V_P - \Delta V$

I5 = Charge Pump Source Current at $VD_o = V_P/2$

I6 = Charge Pump Source Current at $VD_o = \Delta V$

ΔV = Voltage offset from the positive and negative rails. Dependent on the VCO tuning range relative to V_{CC} and GND. Typical values are between 0.5V and 1.0V.

V_P refers to either V_P Main or V_P Aux

VD_o refers to either VD_o Main or VD_o Aux

ID_o refers to either ID_o Main or ID_o Aux

Charge Pump Output Current Magnitude Variation Vs Charge Pump Output Voltage

$$ID_o \text{ Vs } VD_o = \frac{(|I1| - |I3|)}{(|I1| + |I3|)} \times 100\%$$

$$= \frac{(|I4| - |I6|)}{(|I4| + |I6|)} \times 100\%$$

20022663

Charge Pump Output Sink Current Vs Charge Pump Output Source Current Mismatch

$$ID_o \text{ SINK Vs } ID_o \text{ SOURCE} = \frac{|I2| - |I5|}{\frac{1}{2}(|I2| + |I5|)} \times 100\%$$

20022664

Charge Pump Output Current Magnitude Variation Vs Temperature

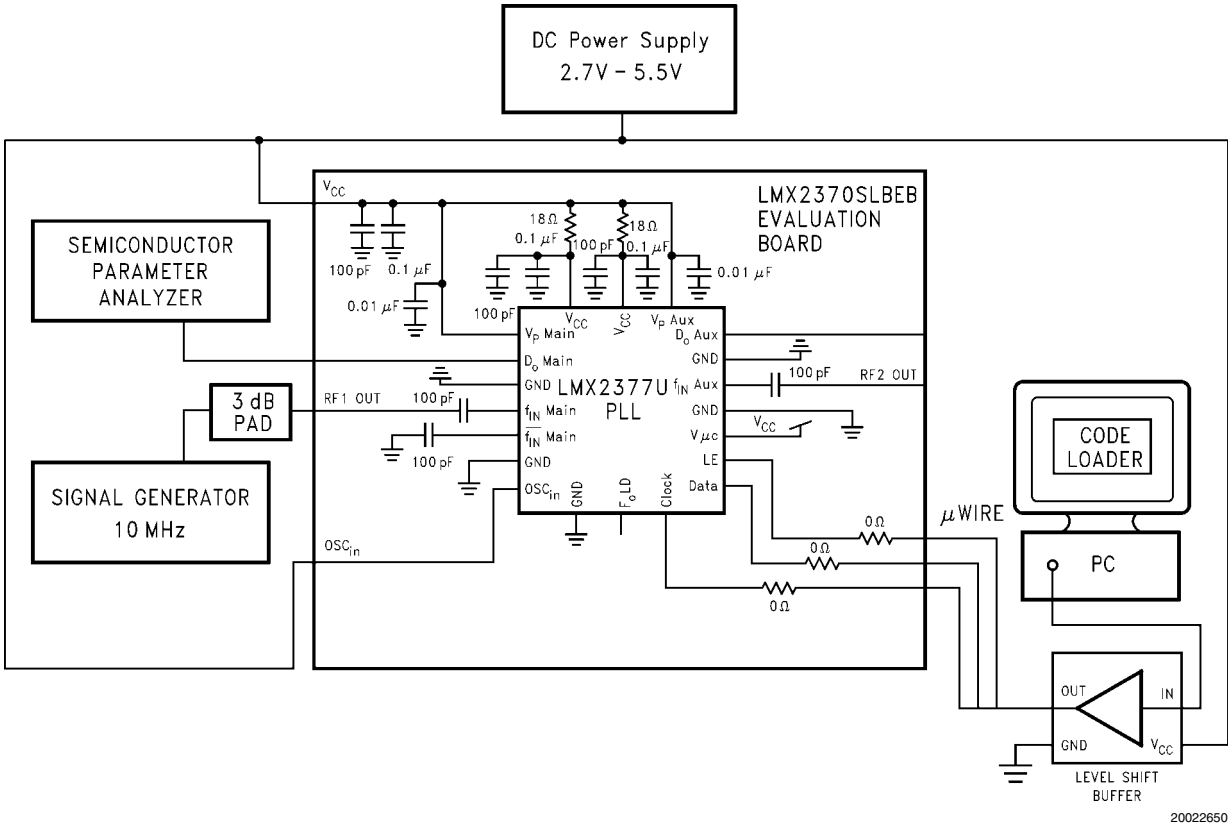
$$ID_o \text{ Vs } T_A = \frac{|I_2|\Big|_{T_A} - |I_2|\Big|_{T_A = 25°C}}{|I_2|\Big|_{T_A = 25°C}} \times 100\%$$

$$= \frac{|I_5|\Big|_{T_A} - |I_5|\Big|_{T_A = 25°C}}{|I_5|\Big|_{T_A = 25°C}} \times 100\%$$

20022665

Test Setups

LMX2377U Charge Pump Test Setup



The block diagram above illustrates the setup required to measure the LMX2377U device's Main charge pump sink current. The same setup is used for the LMX2370TMEB/ LMX2370SLEEB Evaluation Boards. The Aux charge pump measurement setup is similar to the Main charge pump measurement setup. The purpose of this test is to assess the functionality of the Main charge pump.

This setup uses an open loop configuration. A power supply is connected to V_{cc} and swept from 2.7V to 5.5V. The MICROWIRE power supply, Vμc, is tied to V_{cc}. By means of a signal generator, a 10 MHz signal is typically applied to the f_{IN} Main pin. The signal is one of two inputs to the phase detector. The 3 dB pad provides a 50 Ω match between the PLL and the signal generator. The OSC_{in} pin is tied to V_{cc}. This establishes the other input to the phase detector. Alternatively, this input can be tied directly to the ground plane. With the D_o Main pin connected to a Semiconductor Parameter Analyzer in this way, the sink, source, and TRI-STATE currents can be measured by simply toggling the **Phase Detector Polarity** and **Charge Pump State** states in Code Loader. Similarly, the LOW and HIGH currents can be measured by switching the **Charge Pump Gain's** state between **1X** and **4X** in Code Loader.

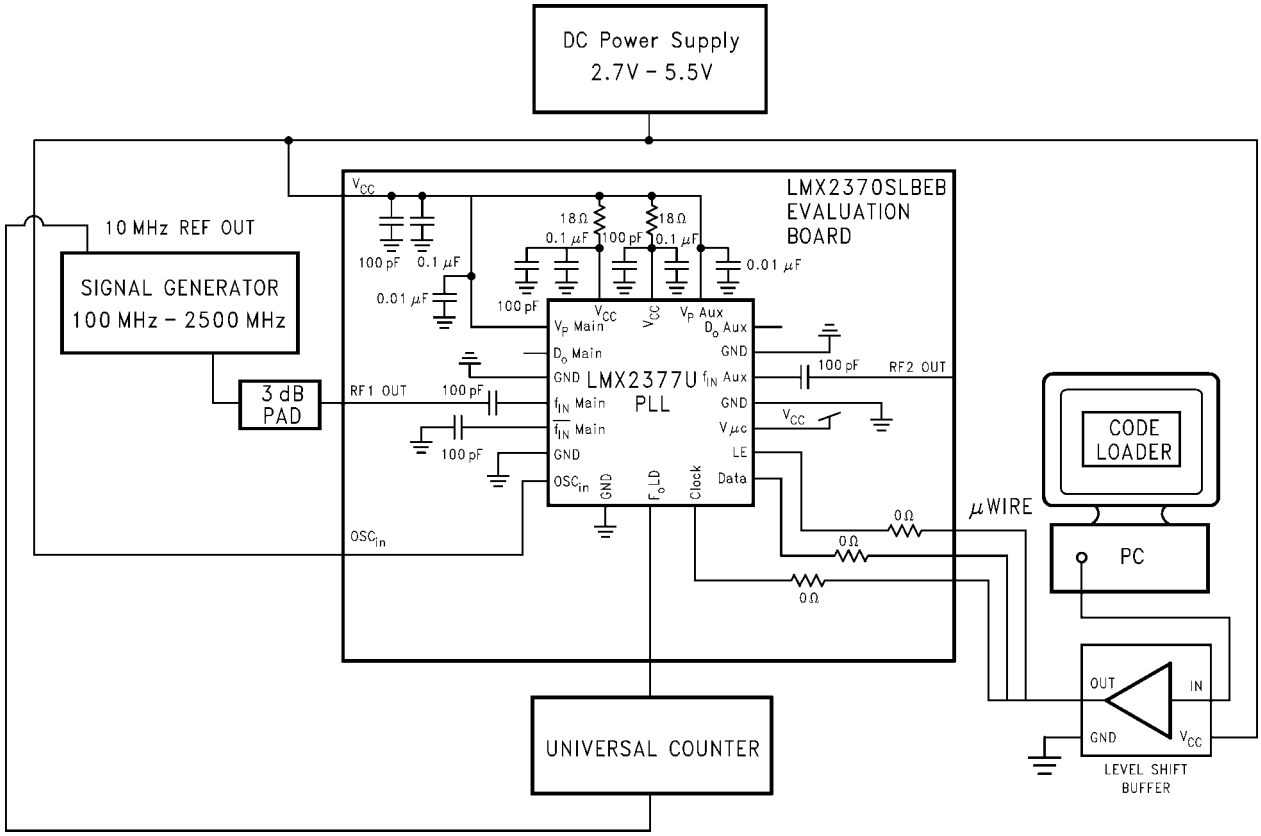
Let F_r represent the frequency of the signal applied to the OSC_{in} pin, which is simply zero in this case (DC), and let F_p represent the frequency of the signal applied to the f_{IN} Main pin. The phase detector is sensitive to the rising edges of F_r and F_p. Assuming positive VCO characteristics; the charge pump turns ON and sinks current when the first rising edge of F_p is detected. Since F_r has no rising edge, the charge pump continues to sink current indefinitely.

Toggling the **Phase Detector Polarity** state to negative VCO characteristics allows the measurement of the Main charge pump source current. Likewise, selecting **TRI-STATE** (TRI-STATE ID_o Main Bit = 1) for **Charge Pump State** in Code Loader facilitates the measurement of the TRI-STATE current.

The measurements are repeated at different temperatures, namely T_A = -40˚C, +25˚C, and +85˚C.

Test Setups (Continued)

LMX2377U f_{IN} Sensitivity Test Setup



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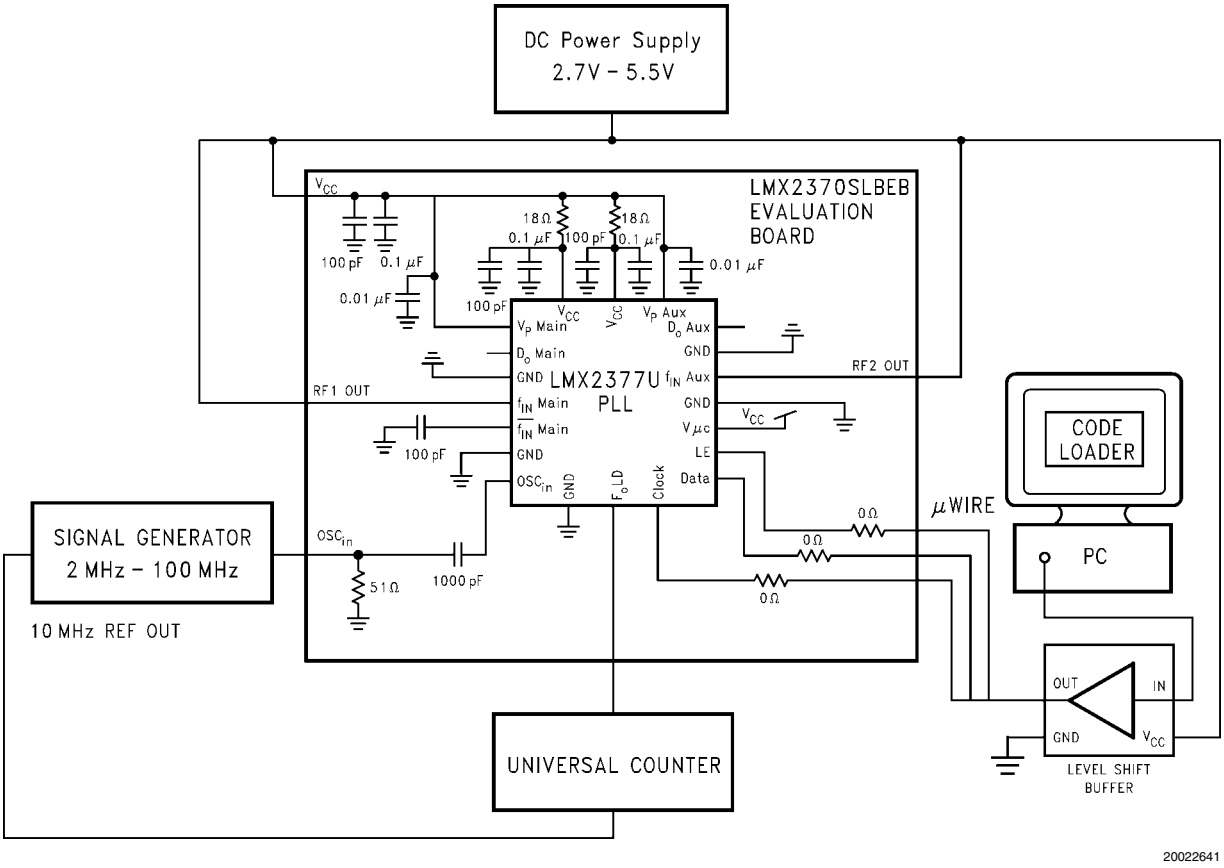
The block diagram above illustrates the setup required to measure the LMX2377U device's Main input sensitivity level. The same setup is used for the LMX2370TMEB/ LMX2370SLEEB Evaluation Boards. The Aux input sensitivity test setup is similar to the Main input sensitivity test setup. The purpose of this test is to measure the acceptable signal level to the f_{IN} Main input of the PLL chip. Outside the acceptable signal range, the feedback divider begins to divide incorrectly and miscount the frequency.

The setup uses an open loop configuration. A power supply is connected to V_{cc} and the bias voltage is swept from 2.7V to 5.5V. The MICROWIRE power supply, Vμc, is tied to V_{cc}. The Aux PLL is powered down (PWDN Aux Bit = 1). By means of a signal generator, an RF signal is applied to the f_{IN} Main pin. The 3 dB pad provides a 50 Ω match between the PLL and the signal generator. The OSC_{in} pin is tied to V_{cc}. The N value is typically set to 10000 in Code Loader, i.e. Main N_CNTRB Word = 312 and Main N_CNTRA Word = 16 for PRE Main Bit = 1. The feedback divider output is routed to the F_oLD pin by selecting the **Main PLL N Divider Output** word (F_oLD Word = 6 or 14) in Code Loader. A Universal Counter is connected to the F_oLD pin and tied to the 10 MHz reference output of the signal generator. The output of the feedback divider is thus monitored and should be equal to f_{IN} Main/ N.

The f_{IN} Main input frequency and power level are then swept with the signal generator. The measurements are repeated at different temperatures, namely T_A = -40˚C, +25˚C, and +85˚C. Sensitivity is reached when the frequency error of the divided RF input is greater than or equal to 1 Hz. The power attenuation from the cable and the 3 dB pad must be accounted for. The feedback divider will actually miscount if too much or too little power is applied to the f_{IN} Main input. Therefore, the allowed input power level will be bounded by the upper and lower sensitivity limits. In a typical application, if the power level to the f_{IN} Main input approaches the sensitivity limits, this can introduce spurs and degradation in phase noise. When the power level gets even closer to these limits, or exceeds it, then the Main PLL loses lock.

Test Setups (Continued)

LMX2377U OSC_{in} Sensitivity Test Setup



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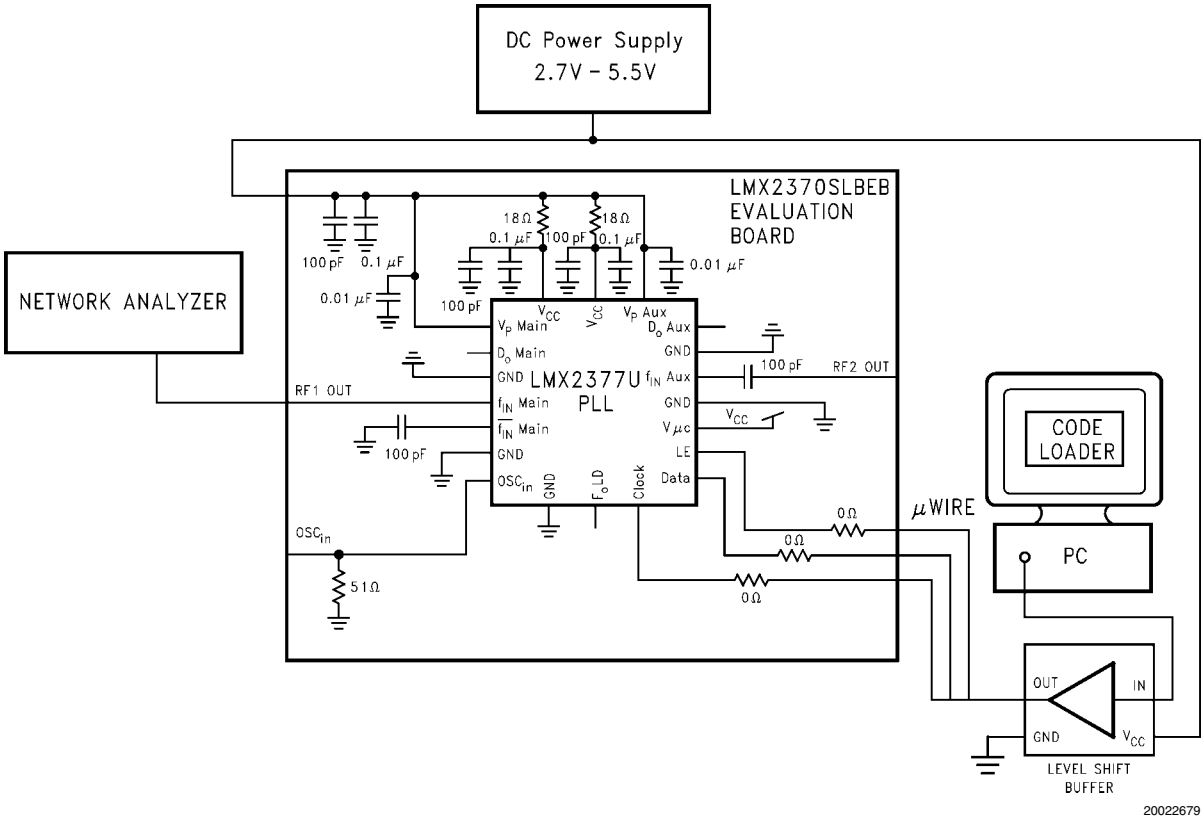
The block diagram above illustrates the setup required to measure the LMX2377U device's OSC_{in} buffer sensitivity level. The same setup is used for the LMX2370TMEB/ LMX2370SLEEB Evaluation Boards. This setup is similar to the f_{IN} sensitivity setup except that the signal generator is now connected to the OSC_{in} pin and both f_{IN} pins are tied to V_{CC}. The 51 Ω shunt resistor matches the OSC_{in} input to the signal generator. The R counter is typically set to 1000, i.e. Main R_CNTR Word = 1000 or Aux R_CNTR Word = 1000. The reference divider output is routed to the F_oLD pin by selecting the **Main PLL R Divider Output** word (F_oLD Word = 2 or 10) or the **Aux PLL R Divider Output** word (F_oLD Word = 1 or 9) in Code Loader. Similarly, a Universal Counter is connected to the F_oLD pin and is tied to the 10 MHz reference output from the signal generator. The output of the reference divider is monitored and should be equal to OSC_{in}/ Main R_CNTR or OSC_{in}/ Aux R_CNTR.

Again, V_{CC} is swept from 2.7V to 5.5V. The MICROWIRE power supply, Vμc, is tied to V_{cc}. The OSC_{in} input frequency and voltage level are then swept with the signal generator. The measurements are repeated at different temperatures, namely T_A = -40˚C, +25˚C, and +85˚C. Sensitivity is reached when the frequency error of the divided input signal is greater than or equal to 1 Hz.

Test Setups (Continued)

LMX2377U f_{IN} Impedance Test Setup



The block diagram above illustrates the setup required to measure the LMX2377U device's Main input impedance. The Aux input impedance and reference oscillator impedance setups are very much similar. The same setup is used for the LMX2370TMEB/ LMX2370SLEEB Evaluation Boards. Measuring the device's input impedance facilitates the design of appropriate matching networks to match the PLL to the VCO, or in more critical situations, to the characteristic impedance of the printed circuit board (PCB) trace, to prevent undesired transmission line effects.

Before the actual measurements are taken, the Network Analyzer needs to be calibrated, i.e. the error coefficients need to be calculated. Therefore, three standards will be used to calculate these coefficients: an **open**, **short** and a **matched load**. A 1-port calibration is implemented here.

To calculate the coefficients, the PLL chip is first removed from the PCB. The Network Analyzer port is then connected to the RF1 OUT connector of the evaluation board and the desired operating frequency is set. The typical frequency range selected for the LMX2377U device's Main synthesizer is from 100 MHz to 2500 MHz. The standards will be located down the length of the RF1 OUT transmission line. The transmission line adds electrical length and acts as an offset from the reference plane of the Network Analyzer; therefore, it must be included in the calibration. Although not shown, 0 Ω resistors are used to complete the RF1 OUT transmission line (trace).

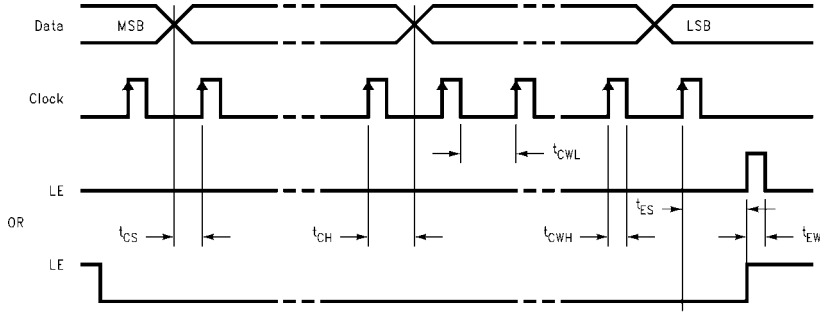
To implement an **open** standard, the end of the RF1 OUT trace is simply left open. To implement a **short** standard, a 0 Ω resistor is placed at the end of the RF1 OUT transmission line. Last of all, to implement a **matched load** standard, two 100 Ω resistors in parallel are placed at the end of the RF1 OUT transmission line. The Network Analyzer calculates the calibration coefficients based on the measured S_{11} parameters. With this all done, calibration is now complete.

The PLL chip is then placed on the PCB. A power supply is connected to V_{CC} and swept from 2.7V to 5.5V. The MICROWIRE power supply, Vμc, is tied to V_{cc}. The OSC_{in} pin is tied to the ground plane. Alternatively, the OSC_{in} pin can be tied to V_{CC}. In this setup, the complementary input ($\overline{f_{IN}}$ Main) is AC coupled to ground. With the Network Analyzer still connected to RF1 OUT, the measured f_{IN} Main impedance is displayed.

Note: The impedance of the reference oscillator is measured when the oscillator buffer is powered up (PWDN Main Bit = 0 **or** PWDN Aux Bit = 0), and when the oscillator buffer is powered down (PWDN Main Bit = 1 **and** PWDN Aux Bit = 1).

Test Setups (Continued)

LMX2377U Serial Data Input Timing



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Notes:

1. Data is clocked into the 22-bit shift register on the rising edge of Clock
2. The MSB of Data is shifted in first.

1.0 Functional Description

The basic phase-lock-loop (PLL) configuration consists of a high-stability crystal reference oscillator, a frequency synthesizer such as the National Semiconductor LMX2377U, a voltage controlled oscillator (VCO), and a passive loop filter. The frequency synthesizer includes a phase detector, current mode charge pump, programmable reference R and feedback N frequency dividers. The VCO frequency is established by dividing the crystal reference signal down via the reference divider to obtain a comparison reference frequency. This reference signal, F_r, is then presented to the input of a phase/frequency detector and compared with the feedback signal, F_p, which was obtained by dividing the VCO frequency down by way of the feedback divider. The phase/frequency detector measures the phase error between the F_r and F_p signals and outputs control signals that are directly proportional to the phase error. The charge pump then pumps charge into or out of the loop filter based on the magnitude and direction of the phase error. The loop filter converts the charge into a stable control voltage for the VCO. The phase/frequency detector's function is to adjust the voltage presented to the VCO until the feedback signal's frequency and phase match that of the reference signal. When this "Phase-Locked" condition exists, the VCO frequency will be N times that of the comparison frequency, where N is the feedback divider ratio.

1.1 REFERENCE OSCILLATOR INPUT

The reference oscillator frequency for both the Main and Aux PLLs is provided from an external reference via the OSC_{in} pin. The reference buffer circuit supports input frequencies from 2 to 40 MHz with a minimum input sensitivity of 0.5 V_{PP}. The reference buffer circuit has an approximate $V_{CC}/2$ input threshold and can be driven from an external CMOS or TTL logic gate. Typically, the OSC_{in} pin is connected to the output of a crystal oscillator.

1.2 REFERENCE DIVIDERS (R COUNTERS)

The reference dividers divide the reference input signal, OSC_{in}, by a factor of R. The output of the reference divider circuits feeds the reference input of the phase detector. This reference input to the phase detector is often referred to as the comparison frequency. The divide ratio should be chosen such that the maximum phase comparison frequency ($F_{\phi Main}$ or $F_{\phi Aux}$) of 10 MHz is not exceeded.

The Main and Aux reference dividers are each comprised of 15-bit CMOS binary counters that support a continuous integer divide ratio from 2 to 32767. The Main and Aux reference divider circuits are clocked by the output of the reference buffer circuit which is common to both.

1.3 PRESCALERS

The f_{IN} Main and $\overline{f_{IN}}$ Main input pins drive the input of a bipolar, differential-pair amplifier. The output of the bipolar, differential-pair amplifier drives a chain of ECL D-type flip-flops in a dual modulus configuration. The output of the prescaler is used to clock the subsequent feedback dividers. The Main PLL complementary inputs can be driven differentially, or the negative input can be AC coupled to ground through an external capacitor for single ended configuration. A 16/17 or a 32/33 prescale ratio can be selected for the LMX2377U Main synthesizer. On the other hand, the Aux PLL is only intended for single ended operation. An 8/9 or a 16/17 prescale ratio can be selected for the LMX2377U Aux synthesizer.

1.4 PROGRAMMABLE FEEDBACK DIVIDERS (N COUNTERS)

The programmable feedback dividers operate in concert with the prescalers to divide the input signal f_{IN} by a factor of N. The output of the programmable reference divider is provided to the feedback input of the phase detector circuit. The divide ratio should be chosen such that the maximum phase comparison frequency ($F_{\phi Main}$ or $F_{\phi Aux}$) of 10 MHz is not exceeded.

The programmable feedback divider circuit is comprised of an A counter (swallow counter) and a B counter (programmble binary counter). The Main N_CNTRA and the Aux N_CNTRA counters are both 5-bit CMOS swallow counters, programmable from 0 to 31. The Main N_CNTRB and Aux N_CNTRB counters are both 13-bit CMOS binary counters, programmable from 3 to 8191. A continuous integer divide ratio is achieved if $N \geq P * (P-1)$, where P is the value of the prescaler selected. Divide ratios less than the minimum continuous divide ratio are achievable as long as the binary programmable counter value is greater than the swallow counter value (N_CNTRB ≥ N_CNTRA). Refer to **Sections 2.5.1, 2.5.2, 2.7.1** and **2.7.2** for details on how to program the N_CNTRA and N_CNTRB counters. The following equations are useful in determining and programming a particular value of N:

$N = (P \times N\_CNTRB) + N\_CNTRA$

$f_{IN} = N \times F_{\phi}$

Definitions:

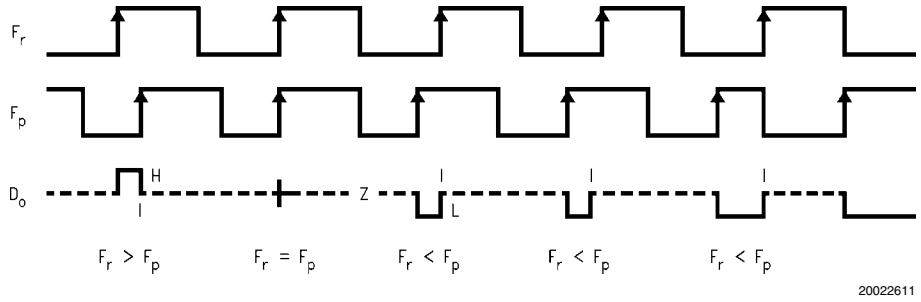
F_{ϕ}:	Main or Aux phase detector comparison frequency
f_{IN}:	Main or Aux input frequency
N_CNTRA:	Main or Aux A counter value
N_CNTRB:	Main or Aux B counter value
P:	Preset modulus of the dual modulus prescaler
	Main synthesizer: P = 16 or 32
	Aux synthesizer: P = 8 or 16

1.0 Functional Description (Continued)

1.5 PHASE/FREQUENCY DETECTORS

The Main and Aux phase/frequency detectors are driven from their respective N and R counter outputs. The maximum frequency for both the Main and Aux phase detector inputs is 10 MHz. The phase/frequency detector outputs control the respective charge pumps. The polarity of the pump-up or pump-down control signals are programmed using the **PD_POL Main** or **PD_POL Aux** control bits, depending on whether the Main or Aux VCO characteristics are positive or negative. Refer to **Sections 2.4.2** and **2.6.2** for more details. The phase/frequency detectors have a detection range of -2π to $+2\pi$. The phase/frequency detectors also receive a feedback signal from the charge pump in order to eliminate dead zone.

PHASE COMPARATOR AND INTERNAL CHARGE PUMP CHARACTERISTICS



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Notes:

1. The minimum width of the pump-up and pump-down current pulses occur at the D_o Main or D_o Aux pins when the loop is phase locked.
2. The diagram assumes positive VCO characteristics, i.e. PD_POL Main or PD_POL Aux = 1.
3. F_r is the phase detector input from the reference divider (R counter).
4. F_p is the phase detector input from the programmable feedback divder (N counter).
5. D_o refers to either the Main or Aux charge pump output.

1.6 CHARGE PUMPS

The charge pump directs charge into or out of an external loop filter. The loop filter converts the charge into a stable control voltage which is applied to the tuning input of the VCO. The charge pump steers the VCO control voltage towards V_P Main or V_P Aux during pump-up events and towards GND during pump-down events. When locked, D_o Main or D_o Aux are primarily in a TRI-STATE mode with small corrections occuring at the phase comparator rate. The charge pump output current magnitude can be selected by toggling the **ID_o Main** or **ID_o Aux** control bits.

1.7 MICROWIRE SERIAL INTERFACE

The programmable register set is accessed via the MICROWIRE serial interface. The supply for the MICROWIRE circuitry is separate from the rest of the IC to allow direct connection to 1.8V devices. The interface is comprised of three signal pins: Clock, Data and LE (Latch Enable). Serial data is clocked into the 22-bit shift register on the rising edge of Clock. The last two bits decode the internal control register address. When LE transitions HIGH, data stored in the shift register is loaded into one of four control registers depending on the state of the address bits. The MSB of Data is loaded in first. The synthesizers can be programmed even in power down mode. A complete programming description is provided in **Section 2.0 Programming Description**.

1.8 MULTI-FUNCTION OUTPUTS

The LMX2377U device's F_oLD output pin is a multi-function output that can be configured as the Main synthesizer Fast-Lock output, an open drain analog lock detect output, counter reset, or used to monitor the output of the various reference divider (R counter) or feedback divider (N counter) circuits. The F_oLD control word is used to select the desired output function. When the PLL is in powerdown mode, the F_oLD output is pulled to a LOW state. A complete programming description of the multi-function output is provided in **Section 2.8 F_oLD**.

1.8.1 Open Drain Analog Lock Detect Output

An analog lock detect status generated from the phase detector is available on the F_oLD output pin if selected. The lock detect output goes to a high impedance state when the charge pump is inactive. It goes low when the charge pump is active during a comparison cycle. When viewed with an oscilloscope, and when a pull-up resistor is used, narrow negative pulses are observed when the charge pump turns on. The lock detect output signal is an open drain configuration.

Three separate lock detect signals are routed to the multiplexer. Two of these monitor the 'lock' status of the individual synthesizers. The third detects the condition when both the Main and Aux synthesizers are in a 'locked state'. External circuitry however, is required to provide a steady DC signal to indicate when the PLL is in a locked state. Refer to **Section 2.8 F_oLD** for details on how to program the different lock detect options.

1.0 Functional Description (Continued)

1.8.2 Open Drain FastLock Output

The LMX233xU Fastlock feature allows faster loop response time during lock aquisition. The loop response time (lock time) can be approximately halved if the loop bandwidth is doubled. In order to achieve this, the same gain/ phase relationship at twice the loop bandwidth must be maintained. This can be achieved by increasing the charge pump current from 0.95 mA (ID_o Main Bit = 0) in the steady state mode, to 3.8 mA (ID_o Main Bit = 1) in Fastlock. When the F_oLD output is configured as a FastLock output, an open drain device is enabled. The open drain device switches in a parallel resistor R2' to ground, of equal value to resistor R2 of the external loop filter. The loop bandwidth is effectively doubled and stability is maintained. Once locked to the correct frequency, the PLL will return to a steady state condition. Refer to **Section 2.8 F_oLD** for details on how to configure the F_oLD output to an open drain Fastlock output.

1.8.3 Counter Reset

Three separate counter reset functions are provided. When the F_oLD is programmed to **Reset Aux PLL Counters**, both the Aux feedback divider and the Aux reference divider are held at their load point. When the **Reset Main PLL Counters** is programmed, both the Main feedback divider and the Main reference divider are held at their load point. When the **Reset All Counters** mode is enabled, all feedback dividers and reference dividers are held at their load point. When the device is programmed to normal operation, both the feedback divider and reference divider are enabled and resume counting in 'close' alignment to each other. Refer to **Section 2.8 F_oLD** for more details.

1.8.4 Reference Divider and Feedback Divider Output

The outputs of the various N and R divders can be monitored by selecting the appropriate F_oLD word. This is essential when performing OSC_{in} or f_{IN} sensitivity measurements. Refer to the **Test Setups** section for more details. Refer to **Section 2.8 F_oLD** for details on how to route the appropriate divder output to the F_oLD pin.

1.9 POWER CONTROL

Each synthesizer in the LMX2377U device is individually power controlled by device powerdown bits. The powerdown word is comprised of the **PWDN Main** (**PWDN Aux**) bit, in conjuction with the **TRI-STATE ID_o Main** (**TRI-STATE ID_o Aux**) bit. The powerdown control word is used to set the operating mode of the device. Refer to **Sections 2.4.4, 2.5.4, 2.6.4**, and **2.7.4** for details on how to program the Main or Aux powerdown bits.

When either the Main synthesizer or the Aux synthesizer enters the powerdown mode, the respective prescaler, phase detector, and charge pump circuit are disabled. The D_o Main (D_o Aux), f_{IN} Main (f_{IN} Aux), and $\overline{f_{IN}}$ Main pins are all forced to a high impedance state. The reference divider and feedback divider circuits are held at the load point during powerdown. The oscillator buffer is disabled when both the Main and Aux synthesizers are powered down. The OSC_{in} pin is forced to a HIGH state through an approximate 100 kΩ resistance when this condition exists. When either synthesizer is activated, the respective prescaler, phase detector, charge pump circuit, and the oscillator buffer are all powered up. The feedback divider, and the reference divider are held at load point. This allows the reference oscillator, feedback divider, reference divider and prescaler circuitry to reach proper bias levels. After a finite delay, the feedback and reference dividers are enabled and they resume counting in 'close' alignment (the maximum error is one prescaler cycle). The MICROWIRE control register remains active and capable of loading and latching data while in the powerdown mode.

Synchronous Powerdown Mode

In this mode, the powerdown function is gated by the charge pump. When the device is configured for synchronous powerdown, the device will enter the powerdown mode upon completion of the next charge pump pulse event.

Asynchronous Powerdown Mode

In this mode, the powerdown function is NOT gated by the completion of a charge pump pulse event. When the device is configured for asynchronous powerdown, the part will go into powerdown mode immediately.

TRI-STATE ID_o	PWDN	Operating Mode
0	0	PLL Active, Normal Operation
1	0	PLL Active, Charge Pump Output in High Impedance State
0	1	Synchronous Powerdown
1	1	Asynchronous Powerdown

Notes:

1. TRI-STATE ID_o refers to either the TRI-STATE ID_o Main or TRI-STATE ID_o Aux bit .
2. PWDN refers to either the PWDN Main or PWDN Aux bit.

2.0 Programming Description

2.1 MICROWIRE INTERFACE

The 22-bit shift register is loaded via the MICROWIRE interface. The shift register consists of a 20-bit Data[19:0] Field and a 2-bit Address[1:0] Field as shown below. The Address Field is used to decode the internal control register address. When LE transitions HIGH, data stored in the shift register is loaded into one of 4 control registers depending on the state of the address bits. The MSB of Data is loaded in first. The Data field assignments are shown in **Section 2.3 CONTROL REGISTER CONTENT MAP**.

MSB		LSB
Data[19:0]		Address[1:0]
21	2 1	0

2.2 CONTROL REGISTER LOCATION

The address bits Address[1:0] decode the internal register address. The table below shows how the address bits are mapped into the target control register.

Address[1:0] Field		**Target Register**
0	0	Aux R
0	1	Aux N
1	0	Main R
1	1	Main N

2.3 CONTROL REGISTER CONTENT MAP

The control register content map describes how the bits within each control register are allocated to specific control functions.

2.0 Programming Description (Continued)

Control Register Content Map

Reg.	Most Significant Bit									SHIFT REGISTER BIT LOCATION										Least Significant Bit	
	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Data Field																				*Address Field*	
Aux R	F_oLD0	F_oLD2	TRI-STATE ID_o Aux	ID_o Aux	PD_ POL Aux	Aux R_CNTR[14:0]															0	0
Aux N	PWDN Aux	PRE Aux	Aux N_CNTRB[12:0]													Aux N_CNTRA[4:0]					0	1
Main R	F_oLD1	F_oLD3	TRI-STATE ID_o Main	ID_o Main	PD_ POL Main	Main R_CNTR[14:0]															1	0
Main N	PWDN Main	PRE Main	Main N_CNTRB[12:0]													Main N_CNTRA[4:0]					1	1

2.0 Programming Description (Continued)

2.4 AUXILIARY R REGISTER

The Aux R register contains the Aux R_CNTR, PD_POL Aux, ID_o Aux, and TRI-STATE ID_o Aux control words, in addition to two bits that compose the F_oLD control word. The detailed description and programming information for each control word is discussed in the following sections.

Reg.	Most Significant Bit					SHIFT REGISTER BIT LOCATION														Least Significant Bit	
	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Data Field																				*Address Field*	
Aux R	F_oLD0	F_oLD2	TRI-STATE ID_o Aux	ID_o Aux	PD_POL Aux	Aux R_CNTR[14:0]															0	0

2.4.1 Aux R_CNTR[14:0] AUXILIARY SYNTHESIZER PROGRAMMABLE REFERENCE DIVIDER (R COUNTER) Aux R[2:16]

The Aux reference divider (Aux R_CNTR) can be programmed to support divide ratios from 2 to 32767. Divide ratios less than 2 are prohibited.

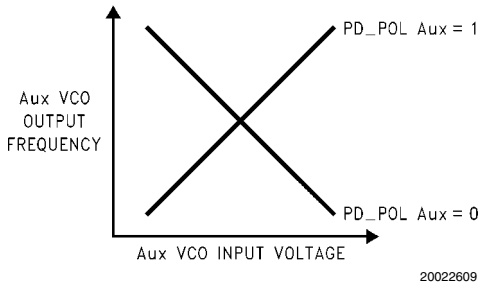
Divide Ratio	Aux R_CNTR[14:0]														
	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
32767	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

2.4.2 PD_POL Aux AUXILIARY SYNTHESIZER PHASE DETECTOR POLARITY Aux R[17]

The PD_POL Aux bit is used to control the Aux synthesizer's phase detector polarity based on the VCO tuning characteristics.

Control Bit	Register Location	Description	Function	
			0	1
PD_POL Aux	Aux R[17]	Aux Phase Detector Polarity	Aux VCO Negative Tuning Characteristics	Aux VCO Positive Tuning Characteristics

Aux VCO Characteristics



2.4.3 ID_o Aux AUXILIARY SYNTHESIZER CHARGE PUMP CURRENT GAIN Aux R[18]

The ID_o Aux bit controls the Aux synthesizer's charge pump gain. Two current levels are available.

Control Bit	Register Location	Description	Function	
			0	1
ID_o Aux	Aux R[18]	Aux Charge Pump Current Gain	LOW 0.95 mA	HIGH 3.80 mA

2.0 Programming Description (Continued)

2.4.4 TRI-STATE ID_o Aux AUXILIARY SYNTHESIZER CHARGE PUMP TRI-STATE CURRENT Aux R[19]

The TRI-STATE ID_o Aux bit allows the charge pump to be switched between a normal operating mode and a high impedance output state. This happens asynchronously with the change in the TRI-STATE ID_o Aux bit.

Furthermore, the TRI-STATE ID_o Aux bit operates in conjuction with the PWDN Aux bit to set a synchronous or an asynchronous powerdown mode.

Control Bit	Register Location	Description	Function	
			0	1
TRI-STATE ID_o Aux	Aux R[19]	Aux Charge Pump TRI-STATE Current	Aux Charge Pump Normal Operation	Aux Charge Pump Output in High Impedance State

2.5 AUXILIARY N REGISTER

The Aux N register contains the Aux N_CNTRA, Aux N_CNTRB, PRE Aux, and PWDN Aux control words. The Aux N_CNTRA and Aux N_CNTRB control words are used to setup the programmable feedback divider. The detailed description and programming information for each control word is discussed in the following sections.

Reg.	Most Significant Bit								SHIFT REGISTER BIT LOCATION											Least Significant Bit	
	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Data Field																				*Address Field*	
Aux N	PWDN Aux	PRE Aux	Aux N_CNTRB[12:0]													Aux N_CNTRA[4:0]					0	1

2.5.1 Aux N_CNTRA[4:0] AUXILIARY SYNTHESIZER SWALLOW COUNTER (A COUNTER) Aux N[2:6]

The Aux N_CNTRA control word is used to setup the Aux synthesizer's A counter. The A counter is a 5-bit swallow counter used in the programmable feedback divider. The Aux N_CNTRA control word can be programmed to values ranging from 0 to 31.

Divide Ratio	Aux N_CNTRA[4:0]				
	4	3	2	1	0
0	0	0	0	0	0
1	0	0	0	0	1
•	•	•	•	•	•
31	1	1	1	1	1

2.5.2 Aux N_CNTRB[12:0] AUXILIARY SYNTHESIZER PROGRAMMABLE BINARY COUNTER (B COUNTER) Aux N[7:19]

The Aux N_CNTRB control word is used to setup the Aux synthesizer's B counter. The B counter is a 13-bit programmable binary counter used in the programmable feedback divider. The Aux N_CNTRB control word can be programmed to values ranging from 3 to 8191.

Divide Ratio	Aux N_CNTRB[12:0]												
	12	11	10	9	8	7	6	5	4	3	2	1	0
3	0	0	0	0	0	0	0	0	0	0	0	1	1
4	0	0	0	0	0	0	0	0	0	0	1	0	0
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
8191	1	1	1	1	1	1	1	1	1	1	1	1	1

2.0 Programming Description (Continued)

2.5.3 PRE Aux **AUXILIARY SYNTHESIZER PRESCALER SELECT** **Aux N[20]**

The Aux synthesizer utilizes a selectable dual modulus prescaler.

Control Bit	Register Location	Description	Function	
			0	1
PRE Aux	Aux N[20]	Aux Prescaler Select	8/9 Prescaler Selected	16/17 Prescaler Selected

2.5.4 PWDN Aux **AUXILIARY SYNTHESIZER POWERDOWN** **Aux N[21]**

The PWDN Aux bit is used to switch the Aux PLL between a powered up and powered down mode.

Furthermore, the PWDN Aux bit operates in conjuction with the TRI-STATE ID_o Aux bit to set a synchronous or an asynchronous powerdown mode.

Control Bit	Register Location	Description	Function	
			0	1
PWDN Aux	Aux N[21]	Aux Powerdown	Aux PLL Active	Aux PLL Powerdown

2.6 MAIN R REGISTER

The Main R register contains the Main R_CNTR, PD_POL Main, ID_o Main, and TRI-STATE ID_o Main control words, in addition to two bits that compose the F_oLD control word. The detailed description and programming information for each control word is discussed in the following sections.

Reg.	Most Significant Bit					SHIFT REGISTER BIT LOCATION														Least Significant Bit	
	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Data Field																				*Address Field*	
Main R	F_oLD1	F_oLD3	TRI-STATE ID_o Main	ID_o Main	PD_ POL Main	Main R_CNTR[14:0]															1	0

2.6.1 Main R_CNTR[14:0] MAIN SYNTHESIZER PROGRAMMABLE REFERENCE DIVIDER (R COUNTER) Main R[2:16]

The Main reference divider (Main R_CNTR) can be programmed to support divide ratios from 2 to 32767. Divide ratios less than 2 are prohibited.

Divide Ratio	Main R_CNTR[14:0]														
	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
32767	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

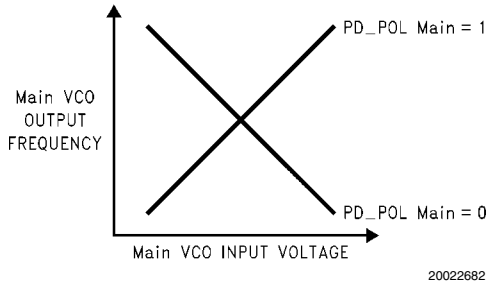
2.0 Programming Description (Continued)

2.6.2 PD_POL Main **MAIN SYNTHESIZER PHASE DETECTOR POLARITY** **Main R[17]**

The PD_POL Main bit is used to control the Main synthesizer's phase detector polarity based on the VCO tuning characteristics.

Control Bit	Register Location	Description	Function	
			0	1
PD_POL Main	Main R[17]	Main Phase Detector Polarity	Main VCO Negative Tuning Characteristics	Main VCO Positive Tuning Characteristics

Main VCO Characteristics



2.6.3 ID_o Main **MAIN SYNTHESIZER CHARGE PUMP CURRENT GAIN** **Main R[18]**

The ID_o Main bit controls the Main synthesizer's charge pump gain. Two current levels are available.

Control Bit	Register Location	Description	Function	
			0	1
ID_o Main	Main R[18]	Main Charge Pump Current Gain	LOW 0.95 mA	HIGH 3.80 mA

2.6.4 TRI-STATE ID_o Main **MAIN SYNTHESIZER CHARGE PUMP TRI-STATE CURRENT** **Main R[19]**

The TRI-STATE ID_o Main bit allows the charge pump to be switched between a normal operating mode and a high impedance output state. This happens asynchronously with the change in the TRI-STATE ID_o Main bit.

Furthermore, the TRI-STATE ID_o Main bit operates in conjuction with the PWDN Main bit to set a synchronous or an asynchronous powerdown mode.

Control Bit	Register Location	Description	Function	
			0	1
TRI-STATE ID_o Main	Main R[19]	Main Charge Pump TRI-STATE Current	Main Charge Pump Normal Operation	Main Charge Pump Output in High Impedance State

2.0 Programming Description (Continued)

2.7 MAIN N REGISTER

The Main N register contains the Main N_CNTRA, Main N_CNTRB, PRE Main, and PWDN Main control words. The Main N_CNTRA and Main N_CNTRB control words are used to setup the programmable feedback divider. The detailed description and programming information for each control word is discussed in the following sections.

Reg.	Most Significant Bit								SHIFT REGISTER BIT LOCATION											Least Significant Bit	
	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Data Field																				*Address Field*	
Main N	PWDN Main	PRE Main	Main N_CNTRB[12:0]													Main N_CNTRA[4:0]					1	1

2.7.1 Main N_CNTRA[4:0] MAIN SYNTHESIZER SWALLOW COUNTER (A COUNTER) Main N[2:6]

The Main N_CNTRA control word is used to setup the Main synthesizer's A counter. The A counter is a 5-bit swallow counter used in the programmable feedback divider. The Main N_CNTRA control word can be programmed to values ranging from 0 to 31.

Divide Ratio	Main N_CNTRA[4:0]				
	4	3	2	1	0
0	0	0	0	0	0
1	0	0	0	0	1
•	•	•	•	•	•
31	1	1	1	1	1

2.7.2 Main N_CNTRB[12:0] MAIN SYNTHESIZER PROGRAMMABLE BINARY COUNTER (B COUNTER) Main N[7:19]

The Main N_CNTRB control word is used to setup the Main synthesizer's B counter. The B counter is a 13-bit programmable binary counter used in the programmable feedback divider. The Main N_CNTRB control word can be programmed to values ranging from 3 to 8191.

Divide Ratio	Main N_CNTRB[12:0]												
	12	11	10	9	8	7	6	5	4	3	2	1	0
3	0	0	0	0	0	0	0	0	0	0	0	1	1
4	0	0	0	0	0	0	0	0	0	0	1	0	0
•	•	•	•	•	•	•	•	•	•	•	•	•	•
8191	1	1	1	1	1	1	1	1	1	1	1	1	1

2.7.3 PRE Main MAIN SYNTHESIZER PRESCALER SELECT Main N[20]

The Main synthesizer utilizes a selectable dual modulus prescaler.

Control Bit	Register Location	Description	Function	
			0	1
PRE Main	Main N[20]	Main Prescaler Select	16/17 Prescaler Selected	32/33 Prescaler Selected

2.7.4 PWDN Main MAIN SYNTHESIZER POWERDOWN Main N[21]

The PWDN Main bit is used to switch the Main PLL between a powered up and powered down mode.

Furthermore, the PWDN Main bit operates in conjuction with the TRI-STATE ID_o Main bit to set a synchronous or an asynchronous powerdown mode.

Control Bit	Register Location	Description	Function	
			0	1
PWDN Main	Main N[21]	Main Powerdown	Main PLL Active	Main PLL Powerdown

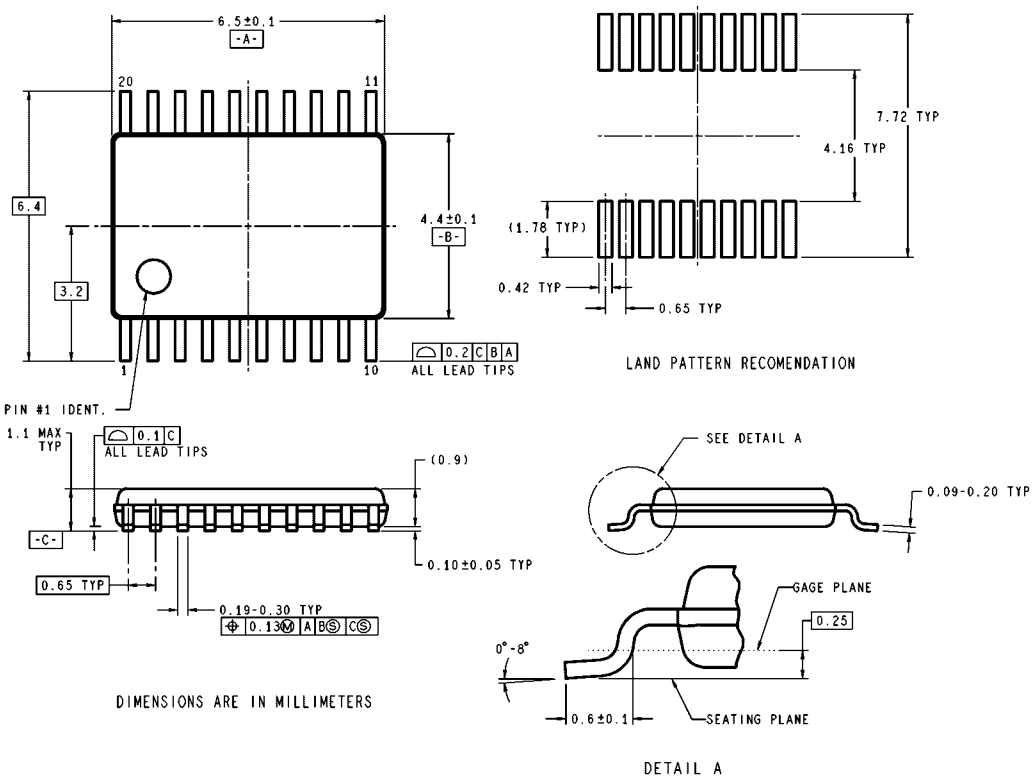
2.0 Programming Description (Continued)

2.8 F_oLD[3:0] MULTI-FUNCTION OUTPUT SELECT [Main R[20], Aux R[20], Main R [21], Aux R[21]]

The F_oLD control word is used to select which signal is routed to the F_oLD pin.

F_oLD3	F_oLD2	F_oLD1	F_oLD0	F_oLD Output State
0	0	0	0	LOW Logic State Output
0	0	0	1	Aux PLL R Divider Output, Push-Pull Output
0	0	1	0	Main PLL R Divider Output, Push-Pull Output
0	0	1	1	Open Drain Fastlock Output
0	1	0	0	Aux PLL Analog Lock Detect, Open Drain Output
0	1	0	1	Aux PLL N Divider Output, Push-Pull Output
0	1	1	0	Main PLL N Divider Output, Push-Pull Output
0	1	1	1	Reset Aux PLL Counters, LOW Logic State Output
1	0	0	0	Main PLL Analog Lock Detect, Open Drain Output
1	0	0	1	Aux PLL R Divider Output, Push-Pull Output
1	0	1	0	Main PLL R Divider Output, Push-Pull Output
1	0	1	1	Reset Main PLL Counters, LOW Logic State Output
1	1	0	0	Main and Aux Analog Lock Detect, Open Drain Output
1	1	0	1	Aux PLL N Divider Output, Push-Pull Output
1	1	1	0	Main PLL N Divider Output, Push-Pull Output
1	1	1	1	Reset All Counters, LOW Logic State Output

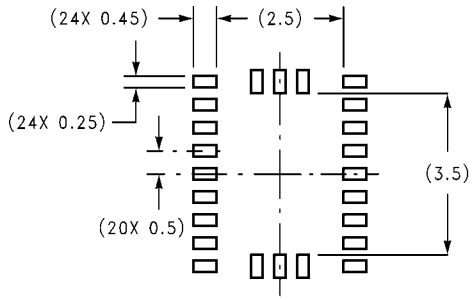
Physical Dimensions inches (millimeters) unless otherwise noted



MTC20 (Rev D)

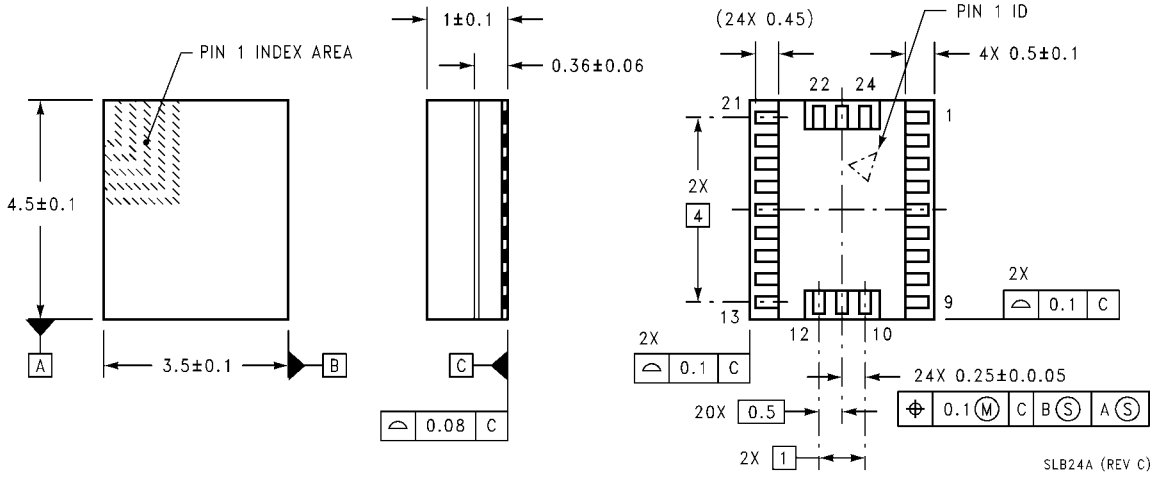
20-Pin Thin Shrink Small Outline Package (TM)
NS Package Number MTC20

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



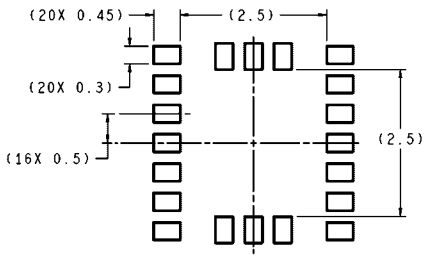
DIMENSIONS ARE IN MILLIMETERS

RECOMMENDED LAND PATTERN
1:1 RATIO WITH PACKAGE SOLDER PADS



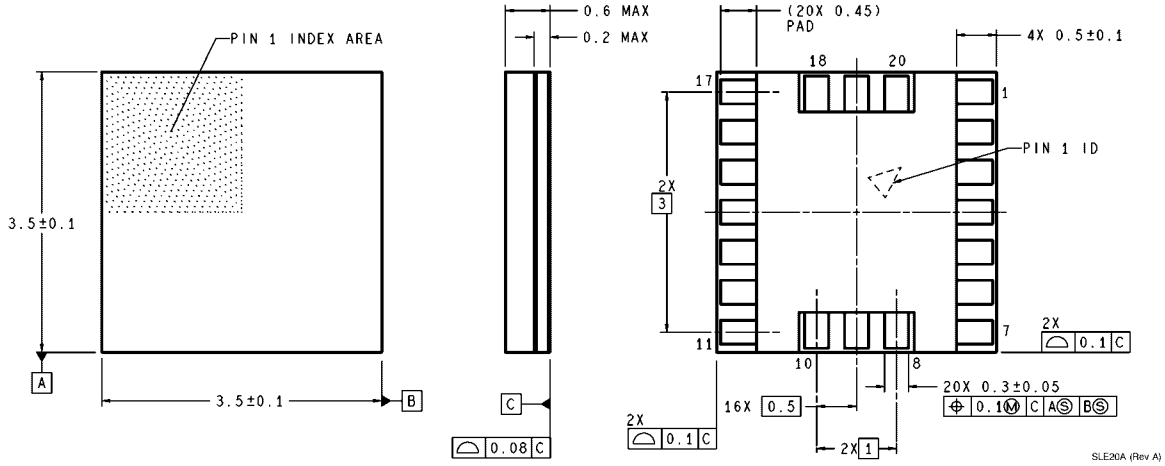
24-Pin Chip Scale Package (SLB)
NS Package Number SLB24A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



RECOMMENDED LAND PATTERN
1:1 RATIO WITH PACKAGE SOLDER PADS

DIMENSIONS ARE IN MILLIMETERS



20-Pin Ultra Thin Chip Scale Package (SLE)
NS Package Number SLE20A

LIFE SUPPORT POLICY

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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
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