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LMX2604

Triple-band VCO for GSM900/DCS1800/PCS1900

General Description

The LMX2604 is a fully integrated VCO (Voltage-Controlled Oscillator) IC designed for GSM900/DCS1800/PCS1900 triple-band application. The IC is ideal for use in the transmitter modulation loop by providing extremely small form factor and low phase noise. The IC has two VCOs, one for GSM and a second for DCS/PCS. The IC has two separate buffer amplifiers to drive an external high power amplifier, one for GSM900 band and the other one for DCS1800/PCS1900 bands. The IC also has a differential buffer amplifier to drive a mixer for the offset PLL.

The resonant circuits of the VCOs are fully integrated in the chip to ease the application of the IC. The high quality factor of the embedded tank circuit achieves very low phase noise characteristics at the VCO output. The only required external components are a couple of supply bypass capacitors and matching components.

A control pin for controlling the oscillation frequency is shared by the two VCOs.

The LMX2604 IC is provided in a 20-pin 4x4 LLP (Leadless Leadframe package).

Features

On-chip Triple-band RF VCOs
GSM: 880 MHz to 915 MHz
DCS: 1710 MHz to 1785 MHz
PCS: 1850 MHz to 1910 MHz
On-chip tank circuit
Low phase noise
    -167 dBc/Hz @ 20 MHz offset in GSM band
    -163 dBc/Hz @ 20 MHz offset in DCS band
    -162 dBc/Hz @ 20 MHz offset in PCS band
High output power
    +6 dBm in GSM mode
    +6 dBm in DCS and PCS mode
Low current consumption
    18 mA in GSM mode
    15 mA in DCS and PCS mode
+2.6 V to +3.0 V supply voltage
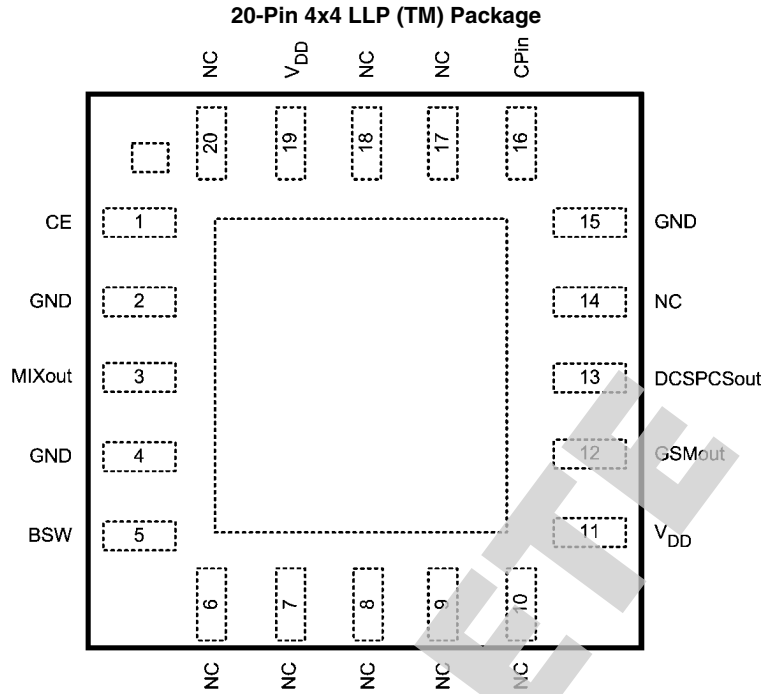0.25 µm RF CMOS process
Small 20-pin 4x4 LLP package

Applications

- Transmit VCO for GSM, DCS, and PCS
- Closed loop modulation systems

Functional Block Diagram
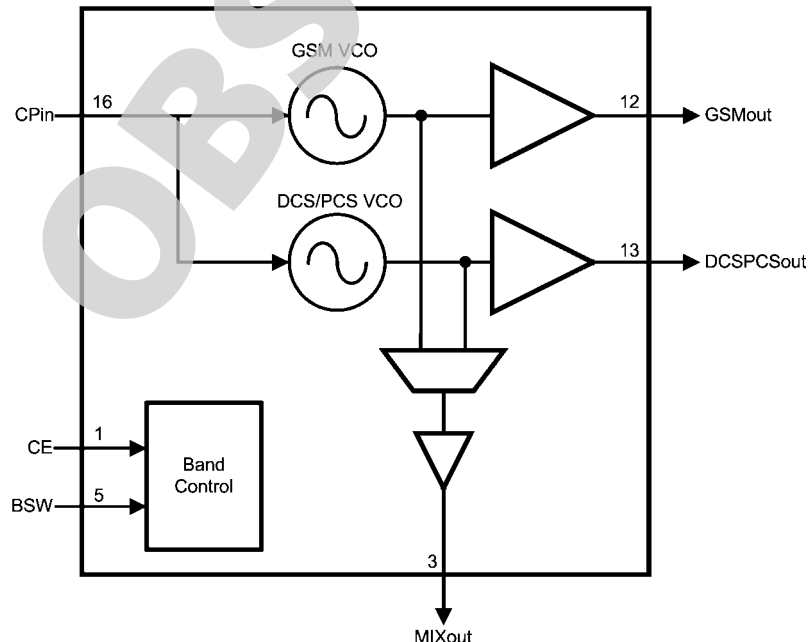
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Connection Diagram

20-Pin 4x4 LLP (TM) Package

20066102

Pin Descriptions

Pin Number	Name	I/O	Description
1	CE	I	Chip enable input pin. High=enable, Low=disable
2,4,15	GND (*Note 1*)	—	Ground pins
3	MIXout	O	Mixer output pin (RF output)
5	BSW	I	Band switch input pin. High=DCS/PCS, Low=GSM
11,19	VDD	—	Supply voltage pins
12	GSMout	O	RF output pin for VCO in GSM band
13	DCSPCSout	O	RF output pin for VCO in DCS and PCS band
16	CPin	I	Charge pump input pin
6,7,8,9,10,14,17,18,20	NC	—	No Connection, These pins must be left open

Note 1: The exposed die attach pad is grounded.

Ordering Information

Package	Part Number	Package Marking	Media Transport	NSC Drawing
20-Pin LLP	LMX2604LQ	LMX2604LQ	1000 Unit Tape and Reel	LQA20A
20-Pin LLP	LMX2604LQX	LMX2604LQ	4500 Unit Tape and Reel	LQA20A

Absolute Maximum Ratings (*Note 3*, *Note 4*, *Note 5*)

Parameter	Symbol	Ratings	Unit
Supply Voltage	V_{DD}	-0.3 to 3.6	V
Input Voltage	V_{IN}	-0.3 to V_{DD}+0.3	V
Input Current (*Note 2*)	I_{IN}	10	mA
Storage Temperature Range	T_{STG}	-65 to 150	°C

Note 2: Maximum input current is for a logic pin, not the power pins.

Recommended Operating Conditions

Parameter	Symbol	Condition	Min	Typical	Max	Unit
Ambient Temperature	T_A	V_{DD}=3V	-30	25	85	°C
Supply Voltage (to GND)	V_{DD}		2.6	2.8	3.0	V

Note 3: "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur. Operating Ratings 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. The guaranteed specifications apply only for the test conditions listed.

Note 4: 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-free workstations.

Note 5: Stresses in excess of the absolute maximum ratings can cause permanent or latent damage to the device. These are absolute stress ratings only. Functional operation of the device is only implied at these or any other conditions in excess of those given in the operation sections of the data sheet. Exposure to absolute maximum ratings for extended periods can adversely affect device reliability

AC Electrical Characteristics

(V_{DD}=2.8V, T_A=25°C; unless otherwise noted)

Symbol	Parameter	Remarks	Min	Typ	Max	Units
f	Frequency Range	GSM Band	880		915	MHz
		DCS Band	1710		1785	MHz
		PCS Band	1850		1910	
K_{VCO}	Tuning Sensitivity (*Note 6*)	GSM Band	10	15	20	MHz/V
		DCS Band	15	20	25	
		PCS Band	20	25	30	
Pout	Output Power	GSM Band	4	6	8	dBm
		DCS & PCS Band	4	6	8	
PMIXout	Output power of MIXout pin	GSM Band	-5.5	-3.5	-1.5	dBm
		DCS & PCS Band	-4.5	-2.5	-0.5	
L(f)	Phase Noise (GSM Band)	at 100 kHz offset		-120		dBc/Hz
		at 400 kHz offset		-136	-128	
		at 3 MHz offset (*Note 7*)		-152		
		at 20 MHz offset (*Note 7*)		-167		
L(f)	Phase Noise (DCS Band)	at 100 kHz offset		-112		dBc/Hz
		at 400 kHz offset		-130	-124	
		at 3 MHz offset (*Note 7*)		-146		
		at 20 MHz offset (*Note 7*)		-163		
L(f)	Phase Noise (PCS Band)	at 100 kHz offset		-110		dBc/Hz
		at 400 kHz offset		-129	-124	
		at 3 MHz offset (*Note 7*)		-145		
		at 20 MHz offset (*Note 7*)		-162		
	Second Harmonic Suppression	All Bands at RF output port.		-20	-15	dBc

Note 6: Tuning Sensitivty is measured after coarse lock. Minimum and maximum limits are supported by characterization.

Note 7: Supported by characterization

DC Electrical Characteristics
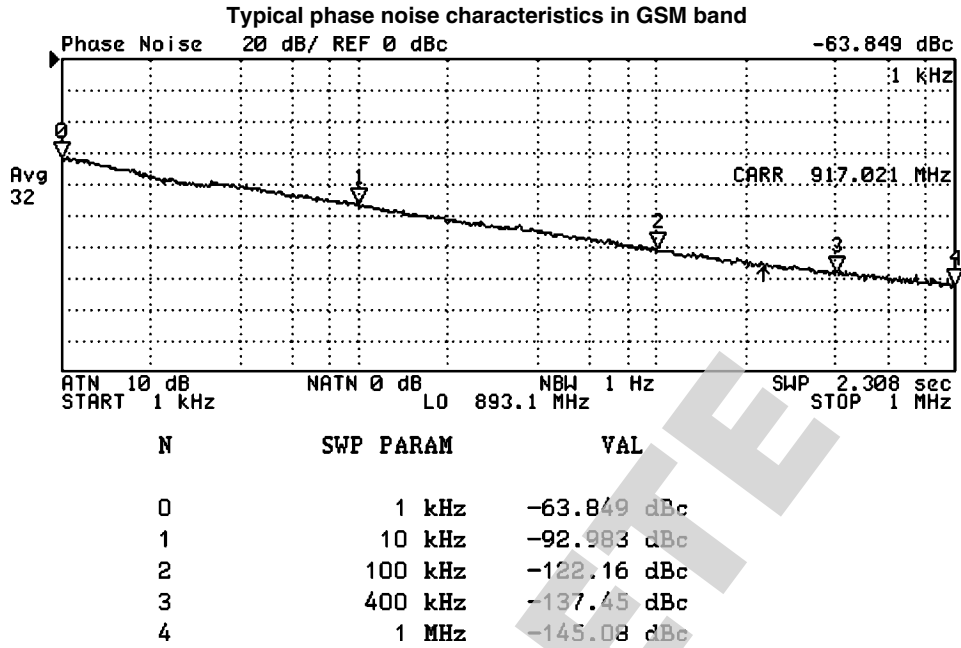
(V_{DD}=2.8V, T_A=25°C; unless otherwise noted)

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{IH}	Logical Input High Voltage		$0.8V_{DD}$		V_{DD}+0.3	V
V_{IL}	Logical Input Low Voltage		-0.3		$0.2V_{DD}$	V
I_{IH}	Logical Input High Current		-2.5		2.5	µA
I_{IL}	Logical Input Low Current		-2.5		2.5	µA
	Input Capacitance			5		pF
$I_{DD,GSM}$	Supply Current (*Note 8*)			18	21	mA
$I_{DD,DCS/PCS}$	Supply Current (*Note 8*)			15	18	mA
I_{std}	Standby Current				2.5	µA

Note 8: The current consumption in VCO and driver amplifier is all included

Note 9: For CE, BSW, and CPin pins

Typical Performance Characteristics : Phase Noise

### Typical phase noise characteristics in GSM band

```
Phase Noise    20 dB/ REF 0 dBc                          -63.849 dBc
                                                              1 kHz
0
 ▽
Avg
32                                        CARR  917.021 MHz
                    1 ▽
                                2 ▽
                                          3 ▽
                                    ↓           4 ▽

ATN  10 dB      NATN 0 dB      NBW  1 Hz      SWP  2.308 sec
START  1 kHz              LO  893.1 MHz             STOP  1 MHz
```

N	SWP PARAM	VAL
0	1 kHz	-63.849 dBc
1	10 kHz	-92.983 dBc
2	100 kHz	-122.16 dBc
3	400 kHz	-137.45 dBc
4	1 MHz	-145.08 dBc

20066161

Typical phase noise characteristics in DCS band

```
Phase Noise    20 dB/ REF 0 dBc                          -58.405 dBc
                                                              1 kHz
0
 ▽
Avg
32                                        CARR  1.788233 GHz
                    1 ▽
                                2 ▽
                                          3 ▽
                                                4 ▽

ATN  10 dB      NATN 0 dB      NBW  1 Hz      SWP  2.308 sec
START  1 kHz              LO  1.7629 GHz            STOP  1 MHz
```

N	SWP PARAM	VAL
0	1 kHz	-58.405 dBc
1	10 kHz	-88.342 dBc
2	100 kHz	-115.29 dBc
3	400 kHz	-132.2 dBc
4	1 MHz	-142.62 dBc

20066162

Typical phase noise characteristics in PCS band

N	SWP PARAM	VAL
0	1 kHz	−57.597 dBc
1	10 kHz	−84.194 dBc
2	100 kHz	−112.45 dBc
3	400 kHz	−129.21 dBc
4	1 MHz	−137.5 dBc

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Typical Performance Characteristic : GSMout Impedance

GSMout

Marker 1:
900 MHz

Start 800 MHz

Stop 1000 MHz

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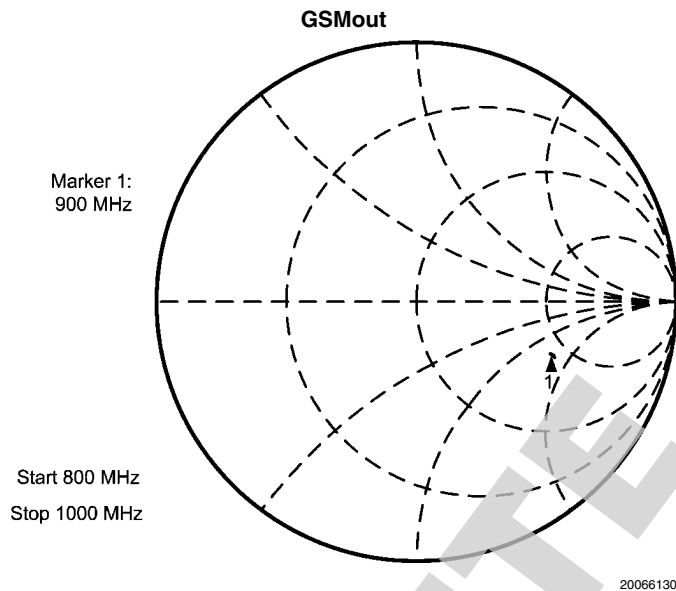
GSMout			
Frequency (MHz)	Real (Ohms)	Imaginary (Ohms)	Absolute (Ohms)
800	126	-72	146
850	126	-74	146
900	126	-75	146
950	126	-77	147
1000	125	-80	149

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Typical Performance Characteristic : MIXout Impedance, GSM

MIXout, GSM

Marker 1:
900 MHz

Start 800 MHz

Stop 1000 MHz

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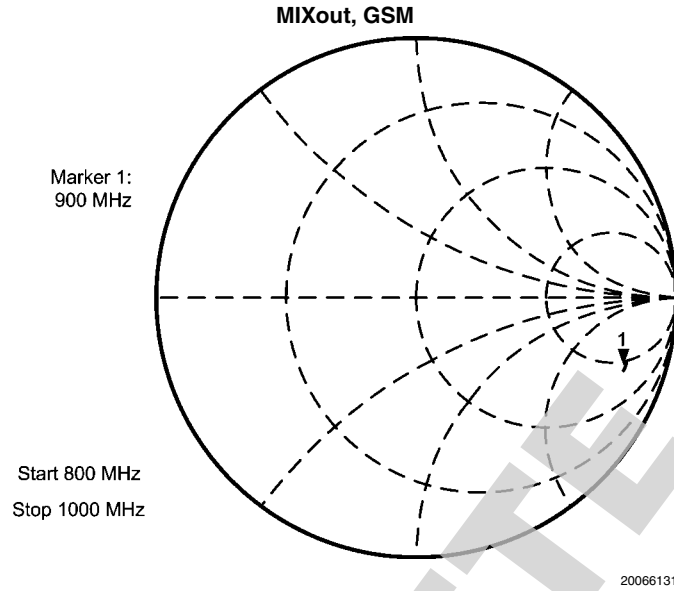
MIXout, GSM			
Frequency (MHz)	Real (Ohms)	Imaginary (Ohms)	Absolute (Ohms)
800	141	-256	292
850	133	-249	282
900	126	-243	274
950	120	-237	266
1000	115	-232	259

Typical Performance Characteristic : DCSPCSout Impedance

DCSPCSout

Marker 1:
1750 MHz

Marker 2:
1880 MHz

Start 1600 MHz

Stop 2000 MHz

20066132
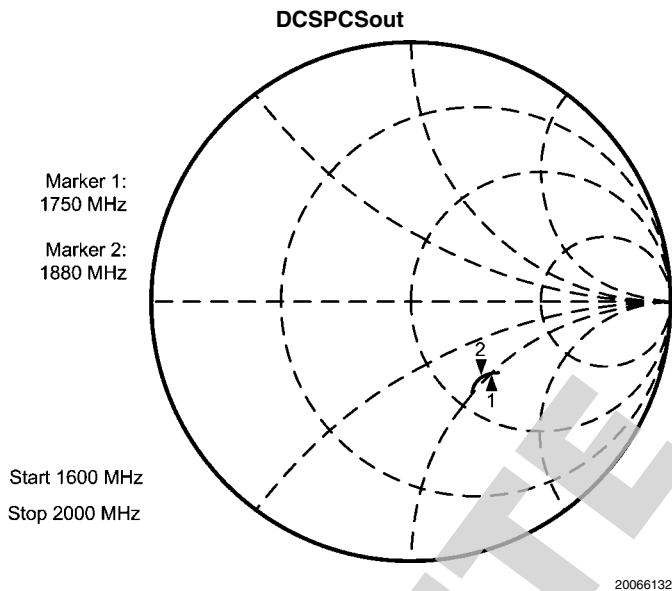
DCSPCSout			
Frequency (MHz)	**Real (Ohms)**	**Imaginary (Ohms)**	**Absolute (Ohms)**
1600	80	-54	96
1650	78	-53	94
1700	77	-51	93
1750	76	-50	91
1800	73	-49	88
1850	71	-48	85
1900	68	-48	83
1950	64	-48	80
2000	57	-51	77

Typical Performance Characteristic : MIXout Impedance, DCS/PCS

MIXout, DCS/PCS

Marker 1:
1750 MHz

Marker 2:
1880 MHz

Start 1600 MHz

Stop 2000 MHz

20066133
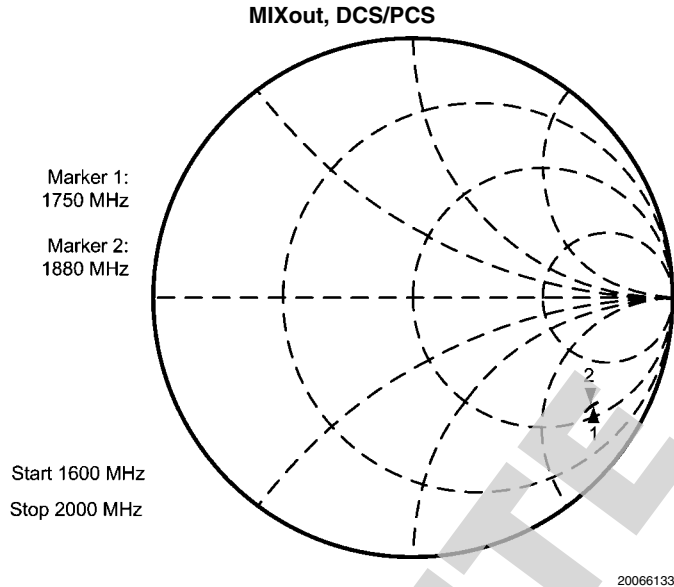
MIXout, DCSPCS			
Frequency (MHz)	**Real (Ohms)**	**Imaginary (Ohms)**	**Absolute (Ohms)**
1600	66	-164	177
1650	65	-162	175
1700	64	-160	172
1750	66	-157	171
1800	64	-157	169
1850	63	-153	166
1900	62	-150	162
1950	61	-146	159
2000	59	-143	155

Functional Description

PRODUCT DESCRIPTION

The LMX2604 IC has two VCOs, which are configured as an LC resonant oscillator. The active components and tank elements are all integrated on the IC. The oscillator core and the tank circuit are designed to be immune to external noise such as supply and load variation. The IC is easy-to-use and occupies extremely small area in the board.

Two output amplifiers are also integrated to deliver high output power of +6 dBm in GSM/DCS/PCS applications. The amplifiers isolate the oscillator cores from the external load, and drive the external 50 ohm load. The output driver is designed to have low noise floor and to reduce pulling by load variation. An additional amplifier to drive the mixer in the transmit PLL is also provided. Only an attenuator composed of a few passive elements is necessary to meet the power level of the mixer input of the transmit PLL.

The frequency of the oscillator is controlled by the CPin pin, which is internally connected to the varactor. This control pin is connected to the loop filter of the modulation loop in the transmit path. Any additional noise on this tuning input is directly translated into FM noise, which can degrade the phase noise characteristics of the oscillator. Typically, the loop filter of the PLL provides an appropriately low impedance source at its output and thus proper additional filtering stage is often required to reduce the high frequency noise and spurious signals.

FREQUENCY SELECTION AND POWER DOWN CONTROL

The BSW pin selects the operating frequency band. The table below shows the appropriate settings with the CE pin.

CE	BSW	Output
Low	Low	X
Low	High	X
High	Low	Low Band (GSM)
High	High	High Band (DCS/PCS)

In real implementation, the component values of the tank circuit vary from the nominal value. The IC has built-in circuit to track the variation and compensate that kind of the variation during normal operation. This self-correction algorithm does not require any external control signal and elements. The figure below shows an application circuit of the LMX2604. The LMX2604 is developed for the use in a GSM handset as part of the transmitter PLL. To complete the offset PLL in the transmit path, several passive elements for the external loop filter should be also provided. The charge pump output port of the external transceiver IC is fed to the CPin pin.

The locking process of the LMX2604 is composed of two stages. First, the internal control circuitry of the LMX2604 controls the fast frequency acquisition behavior of the LMX2604. After the frequency acquisition, the whole loop enters in its normal operating mode.

Application Circuit of LMX2604
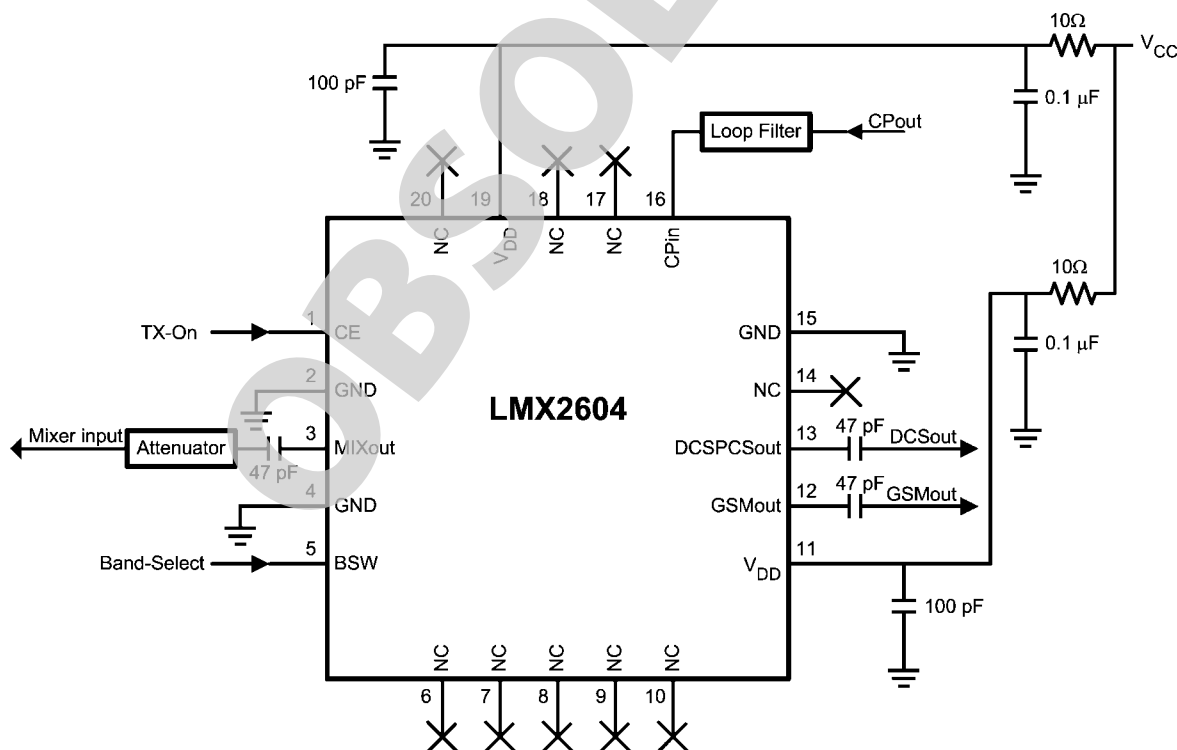
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FREQUENCY ACQUISITION

On the rising edge of CE the VCO goes through a frequency acquisition mode which coarse locks the PLL to the approximate final frequency. This portion of the lock digitally sets the frequency such that the final tuning voltage on the CPin line of the VCO is approximately Vdd/2. Benefits of this system is the maximum required charge pump voltage is reduced as large frequency ranges may be tuned with a small tuning voltage. This makes the digitally tuned VCO different from conventional analog VCOs.

Frequency Acquisition Timing Diagram
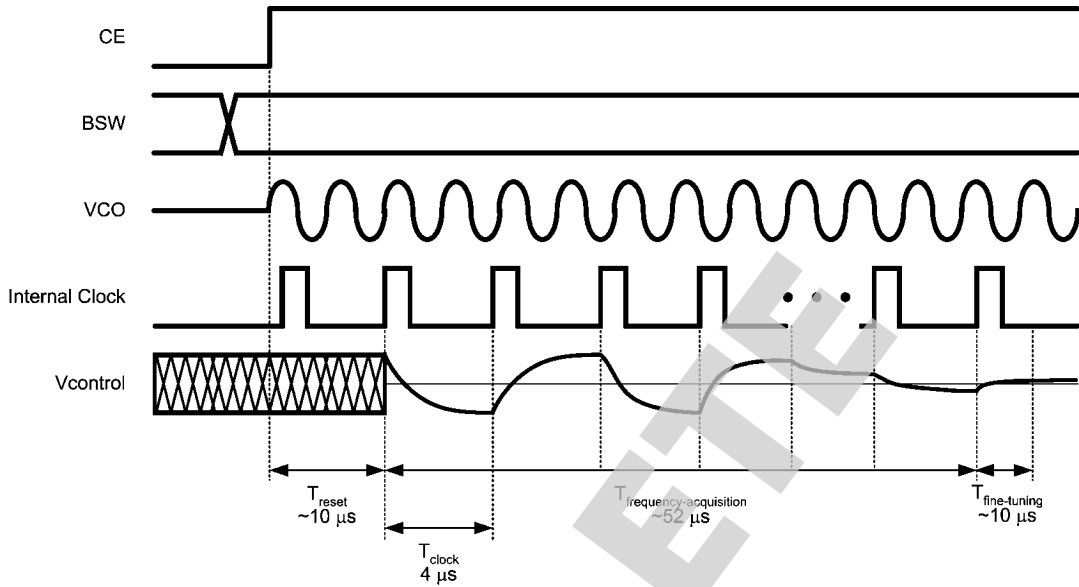
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Physical Dimensions inches (millimeters) unless otherwise noted

(2.8)

(2.8)

(□2.2)
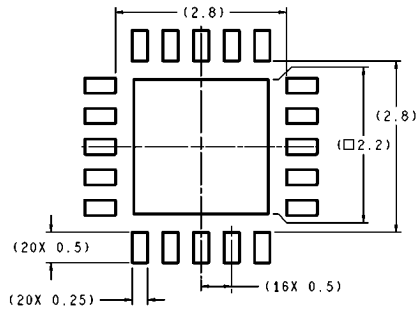
RECOMMENDED LAND PATTERN
1:1 RATIO WITH PKG SOLDER PADS

(20X 0.5)

(20X 0.25)

(16X 0.5)

PIN 1 INDEX AREA

4±0.1

B

4±0.1

A

0.8 MAX

(0.2)

C

PIN 1 ID

□2.2±0.1

(0.1)
ALL AROUND

1   5

20

6

4X 2

10

16

15   11

20X 0.25±0.05

⊕ 0.10 Ⓜ C AⓈ BⓈ

20X 0.5±0.1

16X 0.5
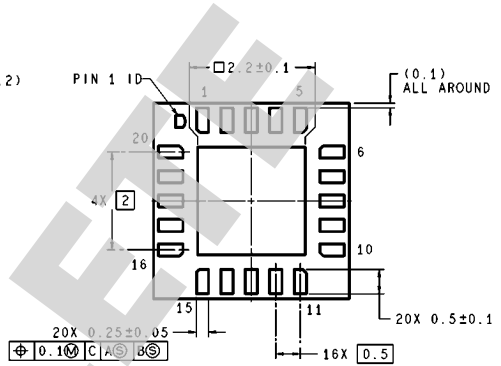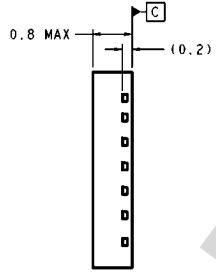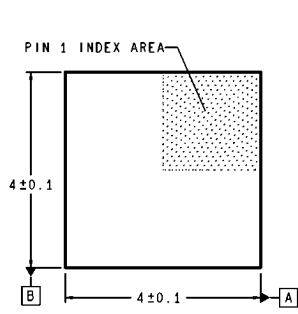
DIMENSIONS ARE IN MILLIMETERS

LQA20A (Rev A)

20-Pin LLP (Leadless Leadframe package) Package
Order Number LMX2604LQX for 4500 Unit Reel
Order Number LMX2604LQ for 1000 Unit Reel
NS Package Number LQA20
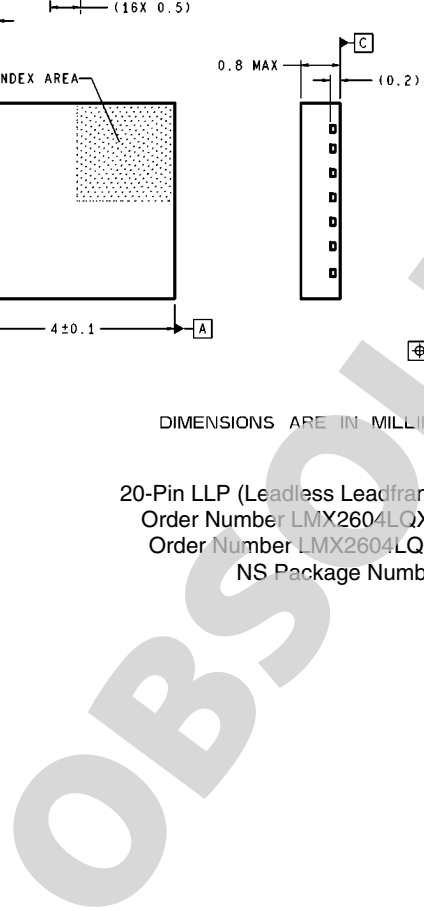
Notes

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