LMX2604 Triple-band VCO for GSM900/DCS1800/PCS1900

Check for Samples: LMX2604

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**

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.

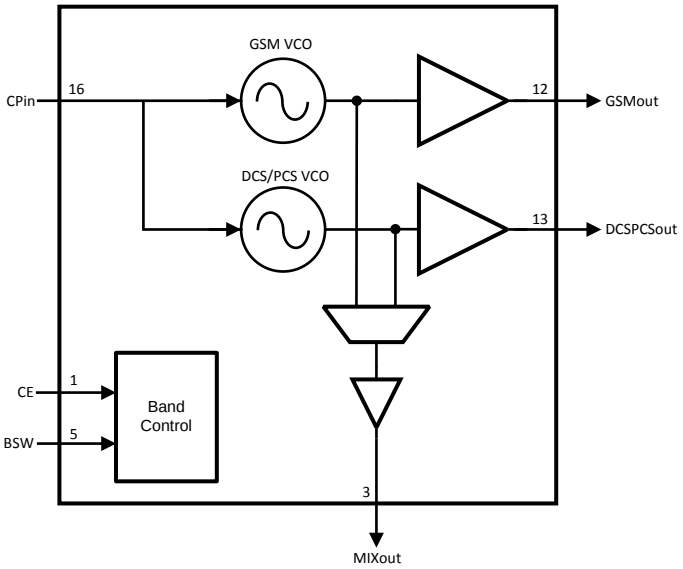
The resonant circuits of the VCOs are fully integrated in the chip to ease the application of the IC. The high quality factor of the embedded tank circuit achieves very low phase noise characteristics at the VCO output. The only required external components are a couple of supply bypass capacitors and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

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

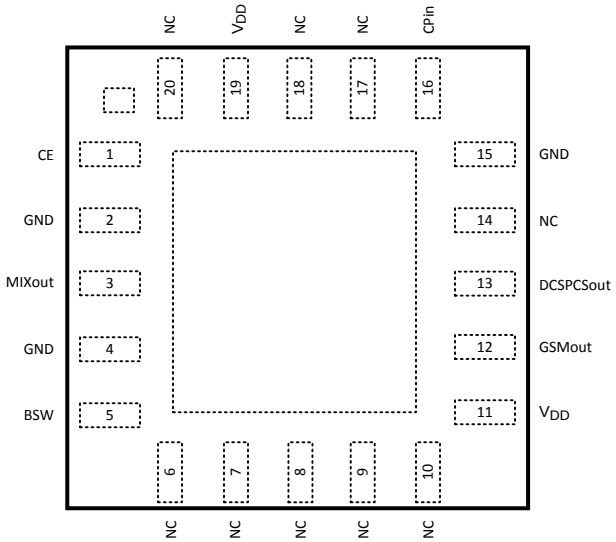
The LMX2604 IC is provided in a 20-pin 4x4 LLP (Leadless Leadframe package).

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Functional Block Diagram



20-Pin 4x4 LLP (TM) Package



Pin Functions

Pin Number	Name	I/O	Description
1	CE	I	Chip enable input pin. High=enable, Low=disable
2,4,15	GND (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

(1) The exposed die attach pad is grounded.

Absolute Maximum Ratings (1) (2) (3)

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 (4)	I_{IN}	10	mA
Storage Temperature Range	T_{STG}	-65 to 150	°C

(1) “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.
(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-free workstations.
(3) 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
(4) 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

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 (1)	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 (2)		-152		
		at 20 MHz offset (2)		-167		
L(f)	Phase Noise (DCS Band)	at 100 kHz offset		-112		dBc/Hz
		at 400 kHz offset		-130	-124	
		at 3 MHz offset (2)		-146		
		at 20 MHz offset (2)		-163		
L(f)	Phase Noise (PCS Band)	at 100 kHz offset		-110		dBc/Hz
		at 400 kHz offset		-129	-124	
		at 3 MHz offset (2)		-145		
		at 20 MHz offset (2)		-162		
	Second Harmonic Suppression	All Bands at RF output port.		-20	-15	dBc

(1) Tuning Sensitivty is measured after coarse lock. Minimum and maximum limits are supported by characterization.
(2) Supported by characterization

DC Electrical Characteristics

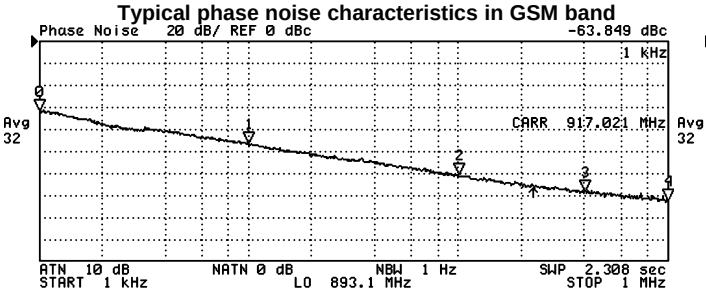
(V_{DD}=2.8V, T_A=25°C; unless otherwise noted)

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 (1)			18	21	mA
$I_{DD,DCS/PCS}$	Supply Current (1)			15	18	mA
I_{std}	Standby Current				2.5	µA

(1) The current consumption in VCO and driver amplifier is all included

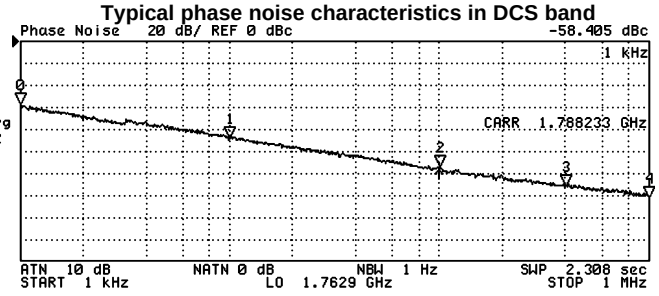
: Phase Noise

Typical phase noise characteristics in GSM band



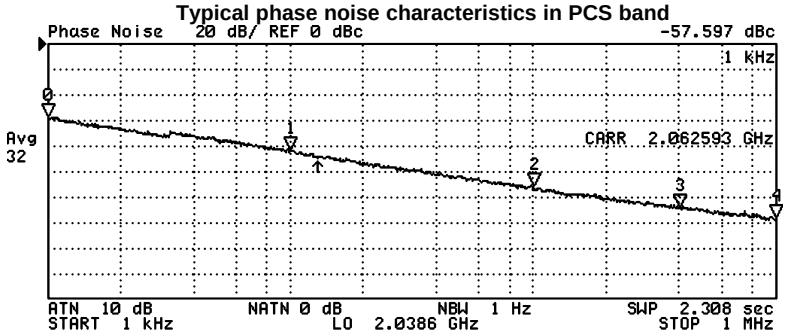
N	SWP PARAM	VAL
0	1 kHz	-63.849 dBc
1	10 kHz	-92.983 dBc
2	100 kHz	-122.16 dBc
3	400 kHz	-137.45 dBc
4	1 MHz	-145.08 dBc

Typical phase noise characteristics in DCS band



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

Typical phase noise characteristics in PCS band

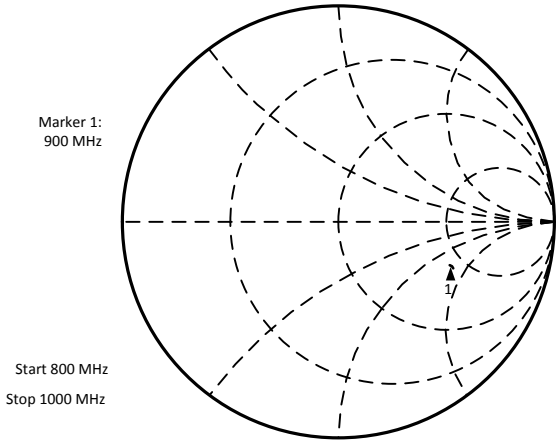


N	SWP PARAM	VAL
0	1 kHz	-57.597 dBc
1	10 kHz	-84.194 dBc
2	100 kHz	-112.45 dBc
3	400 kHz	-129.21 dBc
4	1 MHz	-137.5 dBc

: MIXout Impedance, GSM

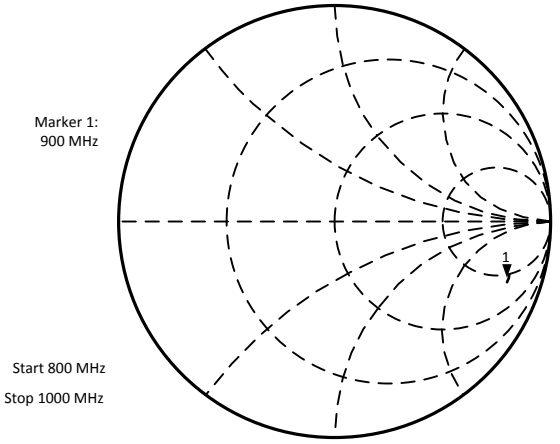
: GSMout Impedance

Figure 1. GSMout



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

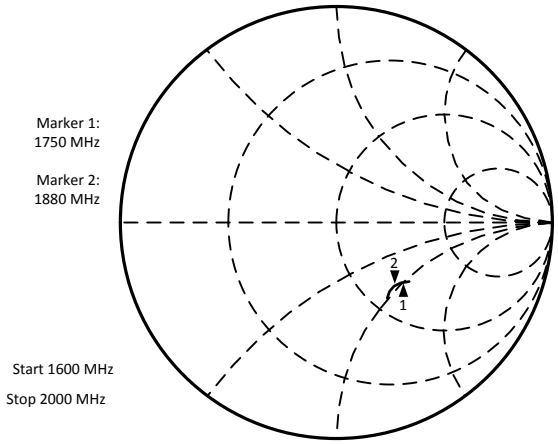
Figure 2. MIXout, GSM



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

: DCSPCSout Impedance

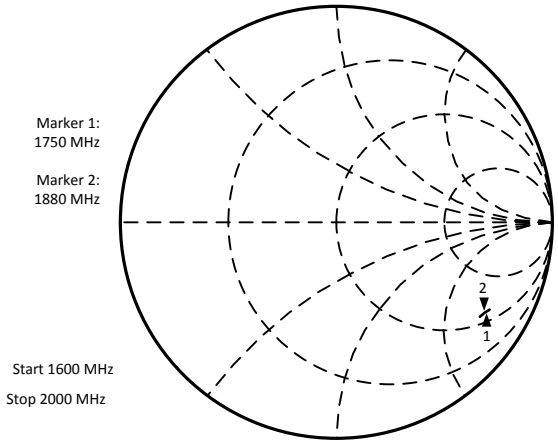
Figure 3. DCSPCSout



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

: MIXout Impedance, DCS/PCS

Figure 4. MIXout, DCS/PCS



MIXout, DCSPCS			
Frequency (MHz)	**Real (Ohms)**	**Imaginary (Ohms)**	**Absolute (Ohms)**
1600	66	-164	177
1650	65	-162	175

MIXout, DCSPCS			
Frequency (MHz)	**Real (Ohms)**	**Imaginary (Ohms)**	**Absolute (Ohms)**
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

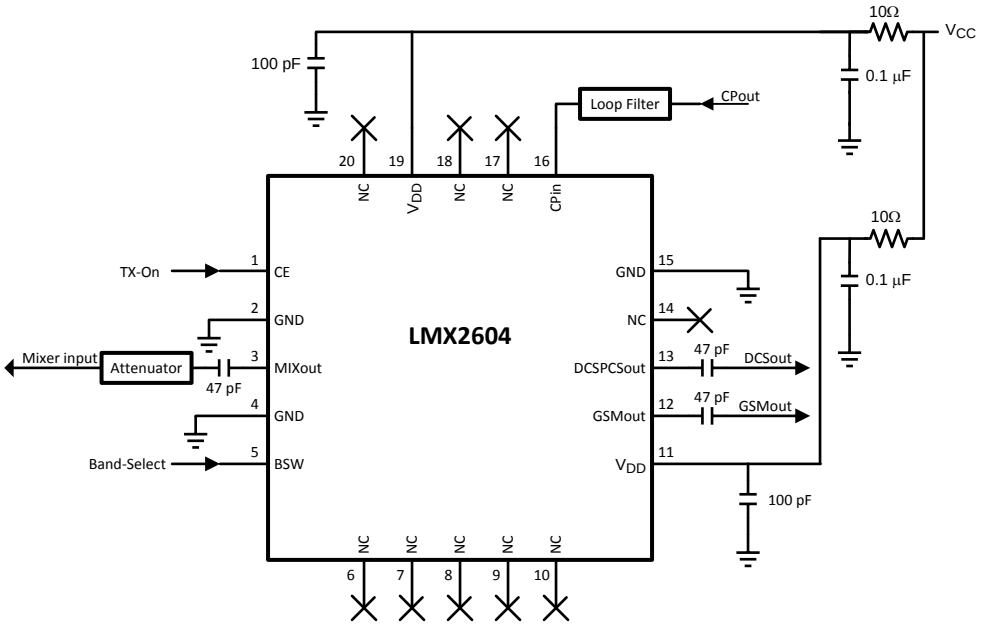
The BSW pin selects the operating frequency band. The table below shows the appropriate settings with the CE pin.

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.

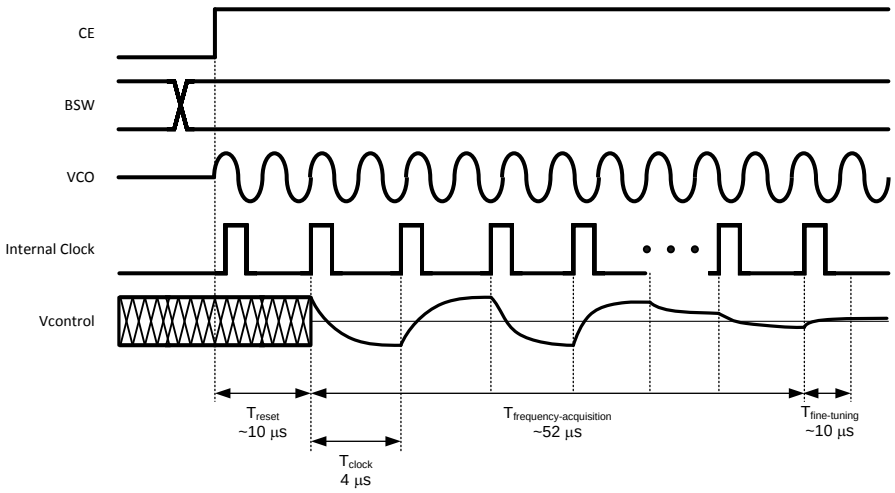
Figure 5. Application Circuit of LMX2604



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.

Figure 6. Frequency Acquisition Timing Diagram



IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265