19-1248; Rev 0; 7/97

EVALUATION KIT AVAILABLE

650MHz to 1050MHz Integrated Oscillator with Buffered Outputs

General Description

The MAX2620 combines a low-noise oscillator with two output buffers in a low-cost, plastic surface-mount, ultra-small µMAX package. This device integrates functions typically achieved with discrete components. The oscillator exhibits low phase noise when properly mated with an external varactor-tuned resonant tank circuit. Two buffered outputs are provided for driving mixers or prescalers. The buffers provide load isolation to the oscillator and prevent frequency pulling due to load-impedance changes. Power consumption is typically just 27mW in operating mode (V_{CC} = 3.0V), and drops to less than 0.3µW in standby mode. The MAX2620 operates from a single +2.7V to +5.25V supply.

Applications

Analog Cellular Phones

Digital Cellular Phones

900MHz Cordless Phones

900MHz ISM-Band Applications

Land Mobile Radio

Narrowband PCS (NPCS)

Features

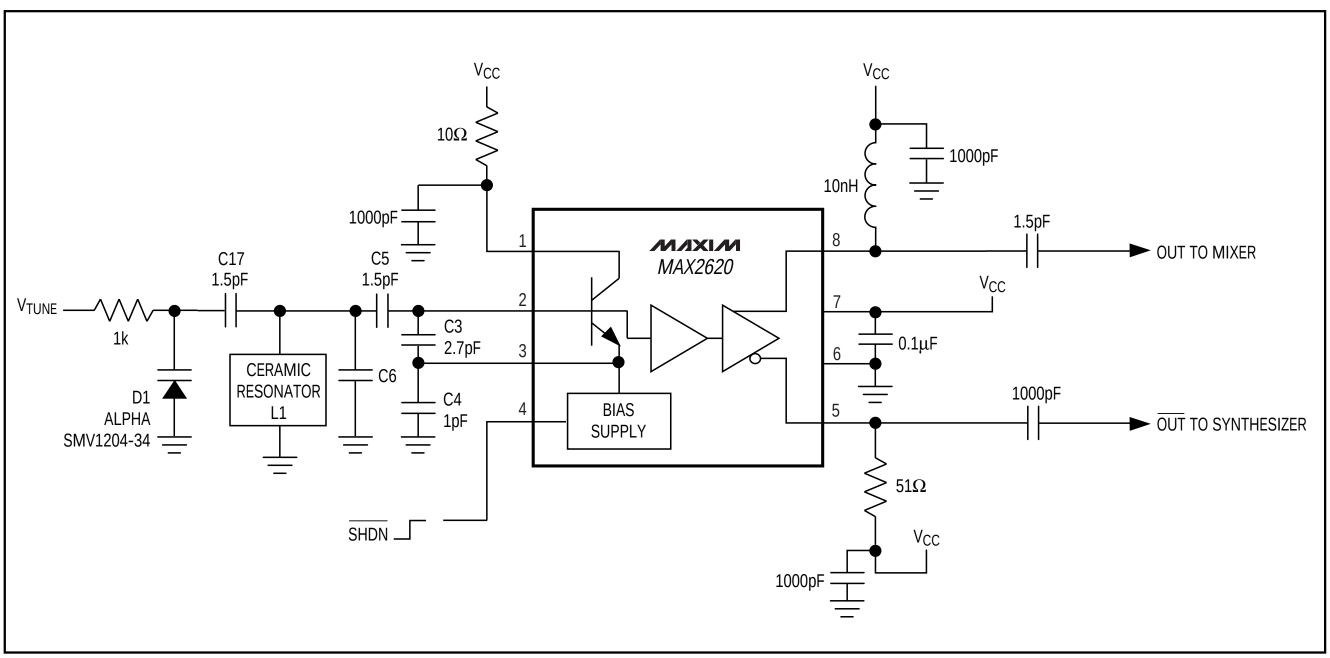
- ♦ **Low-Phase-Noise Oscillator: -110dBc/Hz (25kHz offset from carrier) Attainable**
- ♦ **Operates from Single +2.7V to +5.25V Supply**
- ♦ **Low-Cost Silicon Bipolar Design**
- ♦ **Two Output Buffers Provide Load Isolation**
- ♦ **Insensitive to Supply Variations**
- ♦ **Low, 27mW Power Consumption (V_{CC} = 3.0V)**
- ♦ **Low-Current Shutdown Mode: 0.1µA (typ)**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX2620EUA	-40°C to +85°C	8 µMAX

Pin Configuration appears at end of data sheet.

Typical Operating Circuit



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ABSOLUTE MAXIMUM RATINGS

$V_{CC}1$, $V_{CC}2$ to GND ....-0.3V to +6V
TANK, $\overline{SHDN}$, $\overline{OUT}$, OUT FDBK to GND....-0.3V to (V_{CC} + 0.3V)
I_{FDBK}..±20mA
Continuous Power Dissipation (T_A = +70°C)
µMAX (derate 5.7mW/°C above +70°C) 457mW

Operating Temperature Range
MAX2620EUA ....-40°C to +85°C
Junction Temperature..+150°C
Storage Temperature Range ....-65°C to +165°C
Lead Temperature (soldering, 10sec) ....+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

DC ELECTRICAL CHARACTERISTICS

(V_{CC1}, V_{CC2} = +2.7V to +5.25V, FDBK = open, TANK = open, OUT and $\overline{OUT}$ connected to V_{CC} through 50Ω, $\overline{SHDN}$ = 2V, T_A = -40°C to +85°C, unless otherwise noted. Typical values measured at V_{CC1} = V_{CC2} = 3.0V, T_A = +25°C.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Current			9.0	12.5	mA
Shutdown Current	$\overline{SHDN}$ = 0.6V		0.1	2	µA
Shutdown Input Voltage High		2.0			V
Shutdown Input Voltage Low				0.6	V
Shutdown Bias Current High	$\overline{SHDN}$ = 2.0V		5.5	20	µA
Shutdown Bias Current Low	$\overline{SHDN}$ = 0.6V			0.5	µA

AC ELECTRICAL CHARACTERISTICS

(Per Test Circuit of Figure 1, V_{CC} = +3.0V, $\overline{SHDN}$ = V_{CC}, Z_{LOAD} = Z_{SOURCE} = 50Ω, P_{IN} = -20dBm (50Ω), f_{TEST} = 900MHz, T_A = +25°C, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Frequency Range	T_A = -40°C to +85°C (Note 1)	650		1050	MHz
Reverse Isolation	OUT or $\overline{OUT}$ to TANK; OUT, $\overline{OUT}$ driven at P = -20dBm		50		dB
Output Isolation	OUT to $\overline{OUT}$		33		dB

Note 1: Over this frequency range, the magnitude of the negative real impedance measured at TANK is greater than one-tenth the magnitude of the reactive impedances at TANK. This implies proper oscillator start-up when using an external resonator tank circuit with Q > 10.

TYPICAL OPERATING CIRCUIT PERFORMANCE—CERAMIC-RESONATOR-BASED TANK

(Per Typical Operating Circuit, V_{CC} = +3.0V, V_{TUNE} = 1.5V, $\overline{SHDN}$ = V_{CC}, load at OUT = 50Ω, load at $\overline{OUT}$ = 50Ω, L1 = coaxial ceramic resonator: Trans-Tech SR8800LPQ1357BY, C6 = 1pF, T_A = +25°C, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Tuning Range	V_{TUNE} = 0.5V to 3.0V		±13		MHz
Phase Noise	SSB @ Δf = 25kHz		-110		dBc/Hz
	SSB @ Δf = 300kHz		-132		
Output Power (single-ended)	At OUT (Note 2)	-6	-2		dBm
	At OUT, per test circuit of Figure 1. T_A = -40°C to +85° (Note 2).	-11	-8		
	At $\overline{OUT}$ (Note 2)	-16	-12.5		
Noise Power	f_O ± >10MHz		-147		dBm/Hz
Average Tuning Gain			11		MHz/V
Second-Harmonic Output			-29		dBc
Load Pull	VSWR = 1.75:1, all phases		163		kHzp-p
Supply Pushing	V_{CC} stepped from 3V to 4V		71		kHz/V

Note 2: Guaranteed by design and characterization.

TYPICAL OPERATING CIRCUIT PERFORMANCE—INDUCTOR-BASED TANK

(Per Typical Operating Circuit, V_{CC} = +3.0V, V_{TUNE} = 1.5V, $\overline{SHDN}$ = V_{CC}, load at OUT = 50Ω, load at $\overline{OUT}$ = 50Ω, L1 = 5nH (Coilcraft A02T), C6 = 1.5pF, T_A = +25°C, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Tuning Range	V_{TUNE} = 0.5V to 3.0V		±15		MHz
Phase Noise	SSB @ Δf = 25kHz		-107		dBc/Hz
	SSB @ Δf = 300kHz		-127		
Output Power (single-ended)	At OUT (Note 2)	-6	-2		dBm
	At OUT, per test circuit of Figure 1. T_A = -40°C to +85°C (Note 2).	-11	-8		
	At $\overline{OUT}$ (Note 2)	-16	-12.5		
Noise Power	f_O ± >10MHz		-147		dBm/Hz
Average Tuning Gain			13		MHz/V
Second-Harmonic Output			-29		dBc
Load Pull	VSWR = 1.75:1, all phase angles		340		kHzp-p
Supply Pushing	V_{CC} stepped from 3V to 4V		150		kHz/V

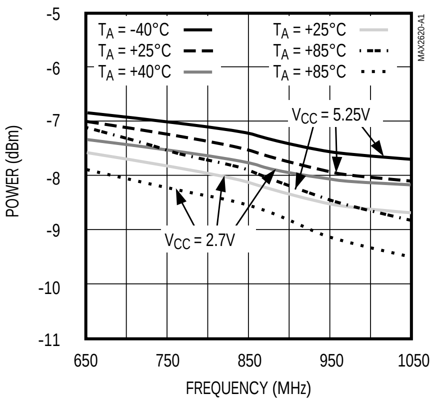
Note 2: Guaranteed by design and characterization.

650MHz to 1050MHz Integrated Oscillator with Buffered Outputs

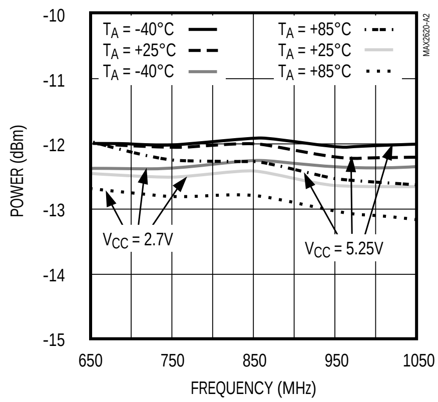
Typical Operating Characteristics

(Per test circuit of Figure 1, V_{CC} = +3.0V, $\overline{SHDN}$ = V_{CC}, Z_{LOAD} = Z_{SOURCE} = 50Ω, P_{IN} = -20dBm/50Ω, f_{TEST} = 900MHz, T_A = +25°C, unless otherwise noted.)

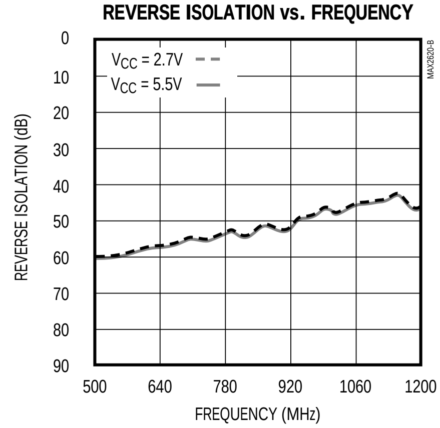
OUT OUTPUT POWER vs. FREQUENCY OVER V_{CC} AND TEMPERATURE



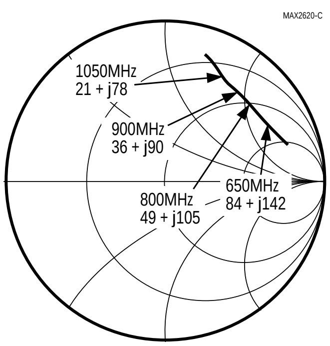
$\overline{OUT}$ OUTPUT POWER vs. FREQUENCY OVER V_{CC} AND TEMPERATURE



REVERSE ISOLATION vs. FREQUENCY



TYPICAL 1/S_{11} vs. FREQUENCY MEASURED AT TEST PORT



SUPPLY CURRENT vs. TEMPERATURE

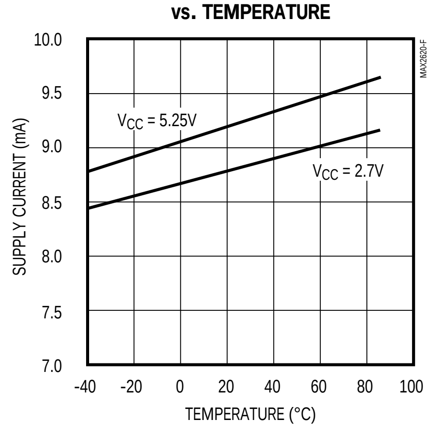
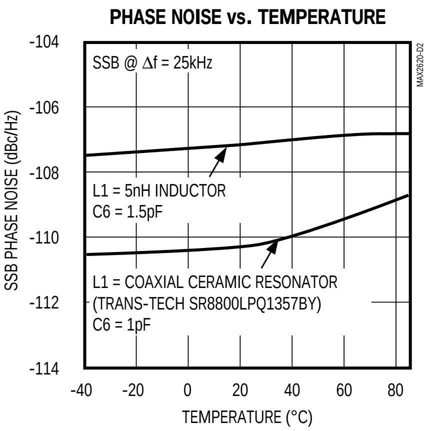


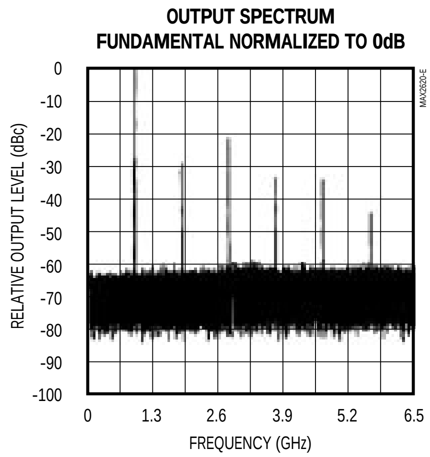
Table 1. Recommended Load Impedance at OUT or $\overline{OUT}$ for Optimum Power Transfer

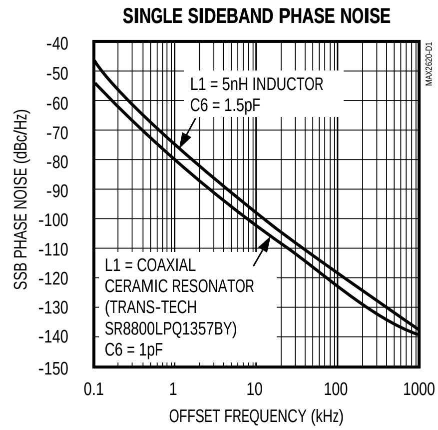
FREQUENCY (MHZ)	Real Component (R in Ω)	Imaginary Component (X in Ω)
650	17.5	62.3
750	17.2	50.6
850	10.9	33.1
950	7.3	26.3
1050	6.5	22.7

Typical Operating Characteristics (continued)

(Per *Typical Operating Circuit*, V_{CC} = +3.0V, V_{TUNE} = 1.5V, $\overline{SHDN}$ = V_{CC}, load at OUT = 50Ω, load at $\overline{OUT}$ = 50Ω, L1 = coaxial ceramic resonator: Trans-Tech SR8800LPQ1357BY, C6 = 1pF, T_A = +25°C, unless otherwise noted.)







Pin Description

PIN	NAME	FUNCTION
1	$V_{CC}1$	Oscillator DC Supply Voltage. Decouple $V_{CC}1$ with 1000pF capacitor to ground. Use a capacitor with low series inductance (size 0805 or smaller). Further power-supply decoupling can be achieved by adding a 10Ω resistor in series from $V_{CC}1$ to the supply. Proper power-supply decoupling is critical to the low noise and spurious performance of any oscillator.
2	TANK	Oscillator Tank Circuit Connection. Refer to the *Applications Information* section.
3	FDBK	Oscillator Feedback Circuit Connection. Connecting capacitors of the appropriate value between FDBK and TANK and between FDBK and GND tunes the oscillator's reflection gain (negative resistance) to peak at the desired oscillation frequency. Refer to the *Applications Information* section.
4	$\overline{SHDN}$	Logic-Controlled Input. A low level turns off the entire circuitry such that the IC will draw only leakage current at its supply pins. This is a high-impedance input.
5	$\overline{OUT}$	Open-Collector Output Buffer (complement). Requires external pull-up to the voltage supply. Pull-up can be resistor, choke, or inductor (which is part of a matching network). The matching-circuit approach provides the highest-power output and greatest efficiency. Refer to Table 1 and the *Applications Information* section. $\overline{OUT}$ may be used with OUT in a differential output configuration.
6	GND	Ground Connection. Provide a low-inductance connection to the circuit ground plane.
7	$V_{CC}2$	Output Buffer DC Supply Voltage. Decouple $V_{CC}2$ with a 1000pF capacitor to ground. Use a capacitor with low series inductance (size 0805 or smaller).
8	OUT	Open-Collector Output Buffer. Requires external pull-up to the voltage supply. Pull-up can be resistor, choke, or inductor (which is part of a matching network). The matching-circuit approach provides the high-est-power output and greatest efficiency. Refer to Table 1 and the *Applications Information* section. OUT may be used with $\overline{OUT}$ in a differential output configuration.

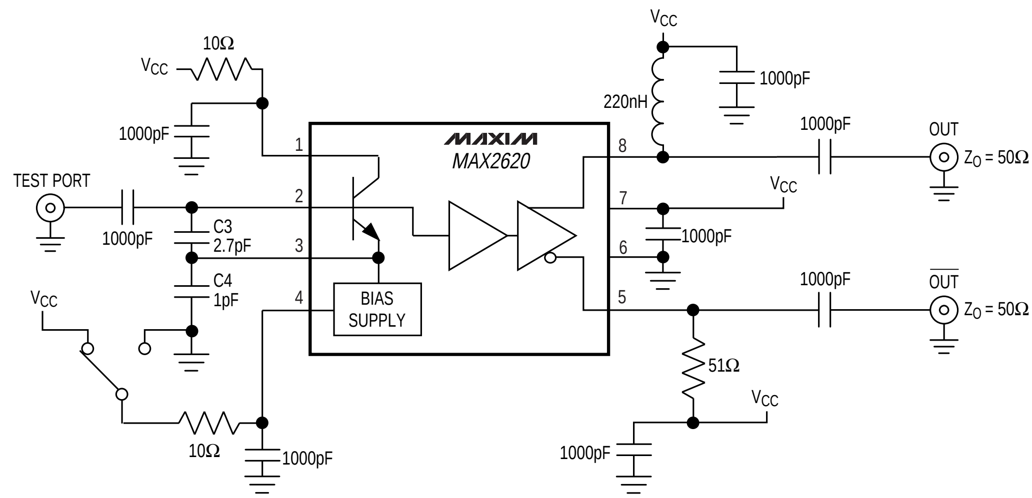


Figure 1. Test Circuit

Detailed Description

Oscillator

The oscillator is a common-collector, negative-resistance type that uses the IC's internal parasitic elements to create a negative resistance at the base-emitter port. The transistor oscillator has been optimized for low-noise operation. Base and emitter leads are provided as external connections for a feedback capacitor and resonator. A resonant circuit, tuned to the appropriate frequency and connected to the base lead, will cause oscillation. Varactor diodes may be used in the resonant circuit to create a voltage-controlled oscillator (VCO). The oscillator is internally biased to an optimal operating point, and the base and emitter leads need to be capacitively coupled due to the bias voltages present.

Output Buffers

The output buffers (OUT and $\overline{\text{OUT}}$) are an open-collector, differential-pair configuration and provide load isolation to the oscillator. The outputs can be used differentially to drive an integrated circuit mixer. Alternatively, isolation is provided between the buffer outputs when one output drives a mixer (either upconversion or downconversion) and the other output drives a prescaler. The isolation in this configuration prevents prescaler noise from corrupting the oscillator signal's spectral purity.

A logic-controlled $\overline{\text{SHDN}}$ pin turns off all bias to the IC when pulled low.

Applications Information

Tank Circuit Design

At the frequency of interest, the MAX2620 portion of Figure 2 shows the one-port circuit model for the TANK pin (test port in Figure 1).

For the circuit to oscillate at a desired frequency, the resonant tank circuit connected to TANK must present an impedance that is a complement to the network. This resonant tank circuit must have a positive real component that is one-third to one-half the magnitude of the negative real part of the oscillator device, as well as a reactive component that is opposite in sign to the reactive component of the oscillator device.

Keeping the resonant tank circuit's real component between one-third and one-half the magnitude of the negative real component ensures that oscillations will start. After start-up, the oscillator's negative resistance decreases, primarily due to gain compression, and reaches equilibrium with the real component (the circuit losses) in the resonant tank circuit. Making the resonant tank circuit reactance tunable (e.g., through use of a varactor diode) allows for tuneability of the oscillation frequency, as long as the oscillator exhibits negative resistance over the desired tuning range.

The MAX2620 provides an optimized negative-resistance device. The one-port characteristics of the device are given as a plot of 1/S11 in the *Typical Operating Characteristics*. 1/S11 is used because it maps inside the unit circle Smith chart when the device exhibits negative resistance (reflection gain).

Feedback Capacitors

To tune the negative-resistance characteristics, adjust the values of the feedback capacitors connected between TANK and FDBK (C3), and from FDBK to ground (C4). The capacitor valves to yield the desired TANK port impedance can be approximated as:

$$R_{TANK} = g_m X_{C3} X_{C4}$$

where g_m = 0.018mS, and X_{C3} and X_{C4} are the reactances of C3 and C4.

This tuning should be directly measured on a vector network analyzer performing a one-port measurement into TANK (test port in Figure 1). This measurement will establish more precisely what the tank characteristics need to be, such that the resonant tank network can be designed.

The MAX2620's oscillator is optimized for low-phase-noise operation. Achieving lowest phase-noise characteristics requires the use of high-Q (quality factor) components such as ceramic transmission-line type resonators or high-Q inductors. Also, keep C5 and C17 (see *Typical Operating Circuit*) as small a value as possible while still maintaining desired frequency and tuning range to maximize loaded Q.

There are many good references on the topic of oscillator design. An excellent reference is "The Oscillator as a Reflection Amplifier, an Intuitive Approach to Oscillator Design," by John W. Boyles, *Microwave Journal*, June 1986, pp. 83–98.

Output Matching Configuration

Both of the MAX2620's outputs (OUT and $\overline{\text{OUT}}$) are open collectors. They need to be pulled up to the supply by external components. An easy approach to this pull-up is a resistor. A 50Ω resistor value would inherently match the output to a 50Ω system. The *Typical Operating Circuit* shows $\overline{\text{OUT}}$ configured this way. Alternatively, a choke pull-up (Figure 1), yields greater output power (approximately -8dBm at 900MHz).

When maximum power is required, use an inductor as the supply pull-up, and match the inductor's output impedance to the desired system impedance. Table 1 in the *Typical Operating Characteristics* shows recommended load impedance presented to OUT and $\overline{\text{OUT}}$ for maximum power transfer. Using this data and standard matching-network synthesis techniques, a matching network can be constructed that will optimize power output into most load impedances. The value of the inductor used for pull-up should be used in the synthesis of the matching network.

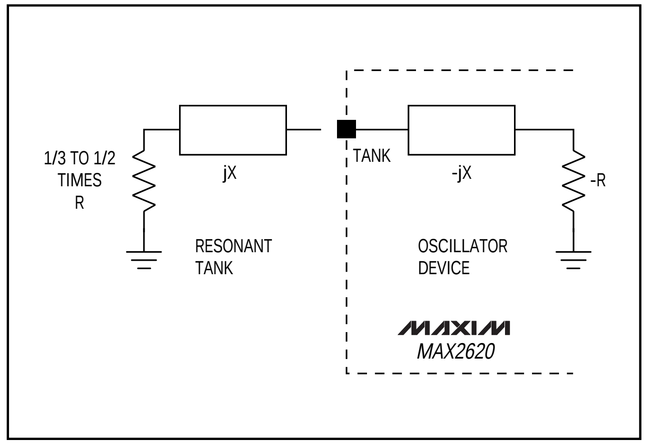
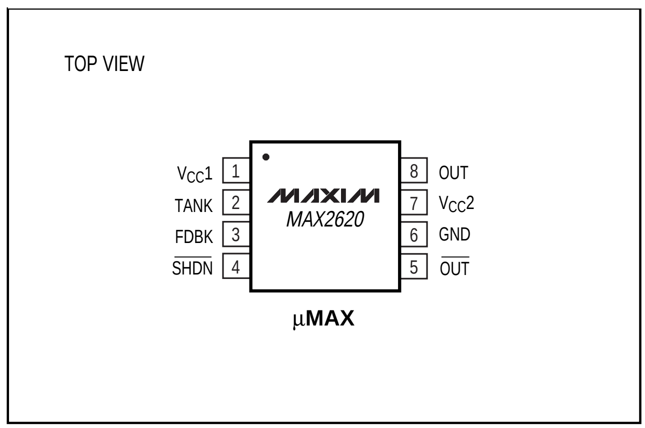


Figure 2. Oscillator Circuit Model

Pin Configuration



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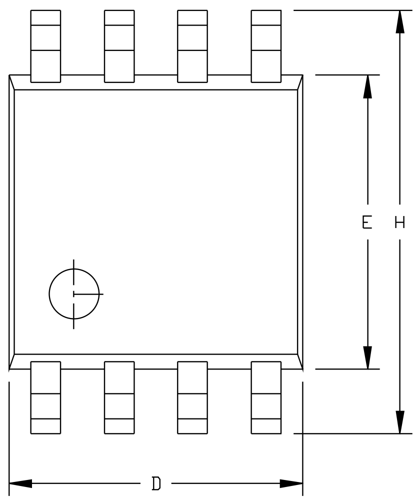
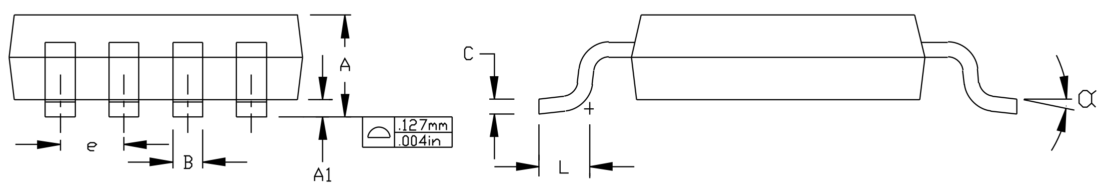
Package Information



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.036	0.044	0.91	1.11
A1	0.004	0.008	0.10	0.20
B	0.010	0.014	0.25	0.36
C	0.005	0.007	0.13	0.18
D	0.116	0.120	2.95	3.05
e	0.0256		0.65	
E	0.116	0.120	2.95	3.05
H	0.188	0.198	4.78	5.03
L	0.016	0.026	0.41	0.66
α	0°	6°	0°	6°



NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm(.006").
3. CONTROLLING DIMENSION: INCHES

MAXIM
PROPRIETARY INFORMATION
TITLE:
8LD uMAX PACKAGE OUTLINE DWG.

APPROVAL	DOCUMENT CONTROL NO.	REV	
	21-0036	D	1/1

8LUMAXD.EPS