19-0392; Rev 1; 5/96

EVALUATION KIT MANUAL FOLLOWS DATA SHEET

MAXIM

800MHz to 1000MHz Transmitter

MAX2402

General Description

The MAX2402 transmitter integrates a double-balanced mixer, buffered local oscillator (LO) port, variable gain stage, and power amplifier into a single IC. It is intended for use in the 800MHz to 1000MHz band, and is compatible with both direct-sequence and frequency-hopping spread-spectrum designs in the 902MHz to 928MHz ISM band.

In a typical application, a digital baseband signal is mixed with a local oscillator signal to yield a BPSK-modulated carrier at the antenna. Alternatively, the baseband input may be grounded and an FSK-modulated LO signal applied directly to the LO port. The LO port consists of a limiting amplifier that can accept a single-ended or differential signal with input power between -6dBm and +6dBm in the 800MHz to 1000MHz frequency range. The baseband modulation input is linear over a 2V range, and limits with larger signal levels within the supply range. The double-balanced mixer has been optimized for high carrier rejection. The variable gain stage offers typically 40dB of adjustment range. The power amplifier provides more than 20dBm output power and has a bias adjustment, which allows adjustment of efficiency and harmonic distortion.

A shutdown function reduces the current draw to less than 2µA in less than 10µs. The MAX2402 comes in a 20-pin SSOP package to minimize board area.

Applications

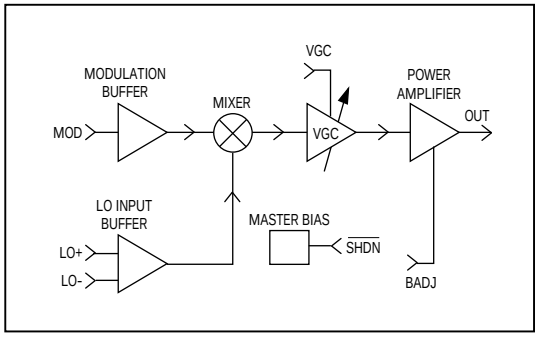
Direct-Sequence Spread-Spectrum Transmitter

Frequency-Hopping Spread-Spectrum Transmitter

FSK, GMSK, BPSK, and ASK Digital Transmitter

AM and FM Analog Transmitter

Functional Diagram



Features

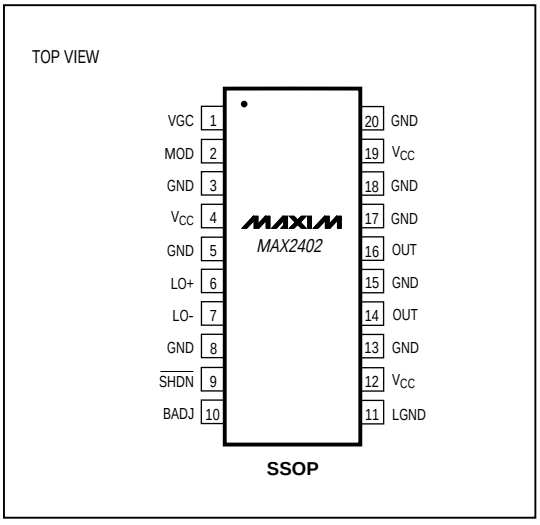
- **Low-Cost, Flexible Transmitter**
- **More than 100mW of Output Power into 50Ω**
- **Operates from 800MHz to 1000MHz**
- **Single +5V Supply**
- **20-Pin SSOP Package**
- **Uses Less than 2µA in Power-Down**
- **More than 35dB of Power Adjustment Range**
- **LO Input Power Range from -6dBm to +6dBm**
- **2V Linear Range on Modulation Input**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX2402EAP*	-40°C to +85°C	20 SSOP

** An alternate marking, MAX2402CAP, has been identically tested.*

Pin Configuration



ABSOLUTE MAXIMUM RATINGS

V_{CC} .....-0.3V to +6.5V
Continuous Power Dissipation (T_A = +70°C)
SSOP (derate 16.7mW/°C above +70°C) 1.33W
Operating Temperature Range .....-40°C to +85°C
Storage Temperature Range .....-65°C to +160°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_{CC} = 4.75V to 5.5V, BADJ = open, $\overline{SHDN}$ = V_{CC} - 0.5V, VGC = V_{CC}, MOD = open, T_A = -40°C to +85°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Current	I_{CC}	Not transmitting		105		mA
Shutdown Supply Current	I_{CCPD}	$\overline{SHDN}$ = 0.5V		0.15	2	µA
Supply Voltage Range	V_{CC}		4.75		5.50	V
VGC Input Bias Current	I_{VGC}	VGC = V_{CC}			115	µA
MOD Bias Current	I_{MOD}	MOD = V_{CC}			325	µA
		MOD = 0V	-320			
$\overline{SHDN}$ Bias Current	I_{PD}	$\overline{SHDN}$ = V_{CC}			10.5	µA
$\overline{SHDN}$ Low Threshold	$V_{\overline{SHDN}}$ Low				0.5	V
$\overline{SHDN}$ High Threshold	$V_{\overline{SHDN}}$ High		V_{CC} - 0.5			V

AC ELECTRICAL CHARACTERISTICS

(MAX2402 evaluation kit, V_{CC} = 5.0V, BADJ = 2V, $\overline{SHDN}$ = V_{CC}, MOD = 0V, VGC = V_{CC}, R_{LOAD} = 35Ω, f_{LO} = 900MHz, LO power = -3dBm, T_A = -40°C to +85°C, unless otherwise noted.)

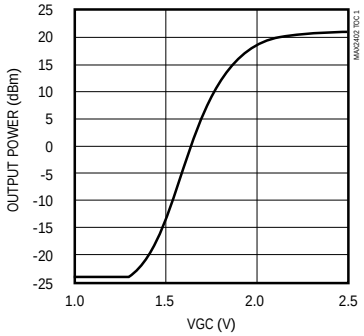
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Current	I_{CCAC}	P_{OUT} = 20dBm (including current to load)		165		mA
Maximum Output Power	P_{MAX}	(Note 1)		21		dBm
Minimum Output Power	P_{MIN}	VGC = 0V (Note 1)		-19		dBm
Power Gain from LO	P_{GAIN}			24		dB
LO Input Power Range	P_{LO}	For max power out (50Ω input term) (Note 2)	-6		6	dBm
LO Frequency Range	f_{LO}	(Note 2)	800		1000	MHz
MOD Usable Bandwidth	MODBW	(Note 2)			25	MHz
VGC Control Range	VGC	(Note 2)	1.0		2.5	V
Carrier Suppression	CS	MOD = 5Vp-p @ 100kHz		30		dBC
2nd Harmonic Suppression	HS2	(Note 1)		22		dBC
3rd Harmonic Suppression	HS3	(Note 1)		25		dBC
Output IP3 (BADJ = 1.0V)	IP3	f_{LO} = 900MHz + 901MHz		28.4		dBm

Note 1: See *Typical Operating Characteristics* graphs.
Note 2: Guaranteed by design.

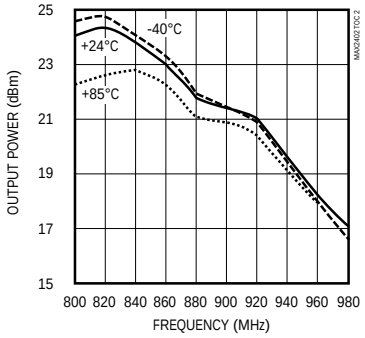
Typical Operating Characteristics

(MAX2402 evaluation kit, V_{CC} = 5.0V, BADJ = 2V, $\overline{SHDN}$ = V_{CC}, MOD = 0V, VGC = V_{CC}, R_{LOAD} = 35Ω, f_{LO} = 900MHz, LO power = -3dBm)

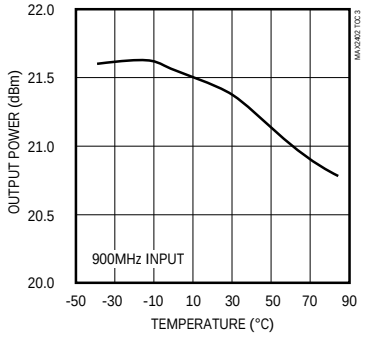
OUTPUT POWER vs. GAIN CONTROL VOLTAGE



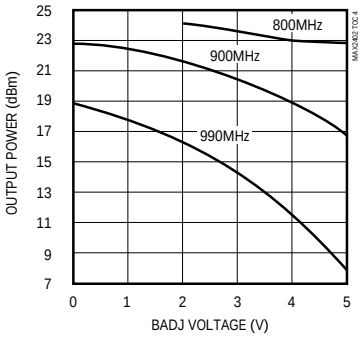
OUTPUT POWER vs. FREQUENCY vs. TEMPERATURE



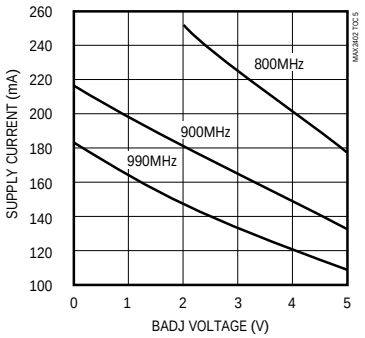
OUTPUT POWER vs. TEMPERATURE



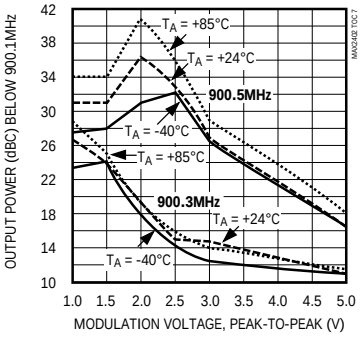
OUTPUT POWER vs. BIAS CONTROL VOLTAGE vs. FREQUENCY



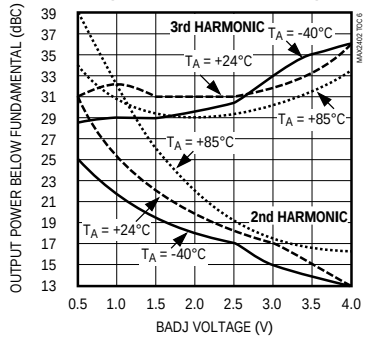
SUPPLY CURRENT vs. BIAS CONTROL VOLTAGE vs. FREQUENCY



AMPLITUDE OF 3rd & 5th HARMONICS OF MODULATED WAVEFORM
(100kHz SINEWAVE MODULATION OF 900MHz LO)



OUTPUT POWER LEVEL OF 2nd AND 3rd HARMONICS OF LO
(LO = 900MHz, -3dBm, MOD = 5V)



Pin Description

PIN	NAME	FUNCTION
1	VGC	Variable Gain Control Input. Connect to V_{CC} for maximum gain.
2	MOD	Baseband Modulation Input to mixer
3, 5, 8, 13, 15, 17, 18, 20	GND	Ground
4, 12, 19	V_{CC}	Supply Voltage, set between 4.75V and 5.5V
6	LO+	Local-Oscillator Positive Input
7	LO-	Local-Oscillator Negative Input
9	$\overline{SHDN}$	Shutdown Control Input. Low level = off, high level = on.
10	BADJ	Bias Adjustment Control for power amplifier. Connect resistor from BADJ to V+ or GND (see Table 1).
11	LGND	Connect 27nH inductor from LGND to GND to maximize output power.
14, 16	OUT	Power-Amplifier Output

Detailed Description

The MAX2402 transmitter is a versatile design that integrates several RF functions on a single IC. It has a wide variety of applications in portable and stationary wireless designs. Each of the functional blocks (shown in the *Functional Diagram*) is described in detail in the following sections.

LO Inputs

The LO inputs are internally capacitively coupled and self biasing. The LO port can be driven differentially or single ended. When terminated at the LO inputs with 50Ω, the transmitter will provide full output power for LO inputs from -6dBm to +6dBm with single-ended drive, and -12dBm to +6dBm with differential drive. Input power beyond this range may saturate the LO input buffer, while input power below this range may result in less output power. The limiter is two cascaded differential stages, which also isolates the LO input from the mixer. This will help reduce any frequency-pulling effects in an external LO due to mixer loading. The limiter output drives one port of a double-balanced Gilbert mixer.

MOD Input

The mixer's other port, the MOD input, remains linear over a 2V range from about 1.5V to 3.5V at the input. When driven with digital modulation (0V to 5V), this port will completely limit, resulting in a hard BPSK-modulated signal. Since this input is self biasing, carrier suppression can be improved by externally capacitively coupling the signal into the port (the MOD input resistance is approximately 10kΩ). This would compensate for voltage offset or duty-cycle offset at this port, thus increasing carrier suppression. This MOD self bias is designed for very low on-chip offset, resulting in excellent carrier suppression. Since this port self biases when the signal is removed from MOD, the mixer will attenuate the output power by about 40dB, resulting in further attenuation past that attained from VGC control—a useful feature for ASK modulation.

VGC Stage

The mixer output drives the VGC stage. This stage attenuates through a multiplication technique that does not distort the signal with increased attenuation. VGC control is nonattenuating when connected to the V_{CC} supply. VGC will attenuate for voltages from 2.5V to 1.0V. Most attenuation occurs between 1V and 2V. Maximum attenuation is achieved below 0.8V. Typical maximum attenuation is 40dB. At or beyond 40dB of attenuation, the signal may be slightly nonmonotonic. This means that there may be a slight upturn in the signal level at the low end of the VGC control range (typically about 1dB). Because of the stability implications, we suggest that the user not plan on attenuating past 35dB within a feedback loop.

Power Amplifier

The VGC stage passes the signal to the power amplifier. This class AB stage will produce at least 20dBm of output power for almost the complete transmit frequency range (with T_A = +25°C). See *Typical Operating Characteristics*.

BADJ Input

The BADJ input adjusts the bias of the output stage. Increasing this voltage decreases bias current in the output devices, which increases efficiency, but also increases harmonic distortion (since the stage will be pushed further toward class B operation). Decreasing BADJ's voltage increases bias current in the output devices, resulting in higher output power and less harmonic distortion. Be sure to optimize BADJ for your application.

BADJ can be left open or adjusted with a single pull-up or pull-down resistor to V_{CC} or GND, respectively. The value of this resistor determines the amount of adjustment applied. A single resistor results in no current flow at BADJ during power-down (whereas a resistor divider always has current flowing through the resistors). Table 1 shows the approximate bias adjust voltage at the pin for different resistor values. At lower LO frequencies, where the transmitter gain and output power is the highest, setting BADJ to a low voltage (maximum bias current) causes excessive current in the output and can cause unstable behavior in the IC. At lower LO frequencies (around 800MHz), more than 22dBm of power is easily obtained with BADJ set for 3V or more. If higher bias current and less distortion is desired in the 800MHz range, using a lower inductor value on LGND (pin 11) (see the *Typical Application Circuit*) might make the desired bias level stable. At higher frequencies (near 1000MHz), a lower bias level voltage results in more power (see the Output Power vs. Bias Control Voltage vs. Frequency graph in the *Typical Operating Characteristics*).

Table 1. Bias-Adjust Voltage for Various Resistor Values

Resistor Value (Ω)	BADJ with Resistor Connected to GND (V)*	BADJ with Resistor Connected to V_{CC} (V)
10k	0.36	4.54
20k	0.63	4.27
30k	0.84	4.05
40k	1.00	3.89
50k	1.13	3.75
100k	1.54	3.34
200k	1.89	3.00
300k	2.05	2.85
400k	2.13	2.75
500k	2.20	2.68
1M	2.31	2.57

* Typical variation of BADJ over temperature and process is less than 5%.

Power Amplifier Output

The power amplifier has an open-collector output that can drive into a load of 30Ω to 50Ω; however, maximum power transfer is obtained at about 35Ω. 27nH to ground is recommended on LGND (pin 11), as shown in the *Typical Application Circuit*. This inductor is used as a current source on the base of the output stage to pull stored charge out of the base.

$\overline{SHDN}$ Input

The $\overline{SHDN}$ input completely shuts down the current from the supply and all signal pins when switched below 0.5V. During normal operation, $\overline{SHDN}$ should remain above V_{CC} - 0.5V.

The shutdown control shuts down the total current to below 150nA (typ). Power-up occurs within 10µs.

Applications Information

The MAX2402 transmitter operates within the 800MHz to 1000MHz frequency range. Figure 1 shows a typical application circuit. Additional applications information can be obtained from the MAX2402 evaluation kit manual.

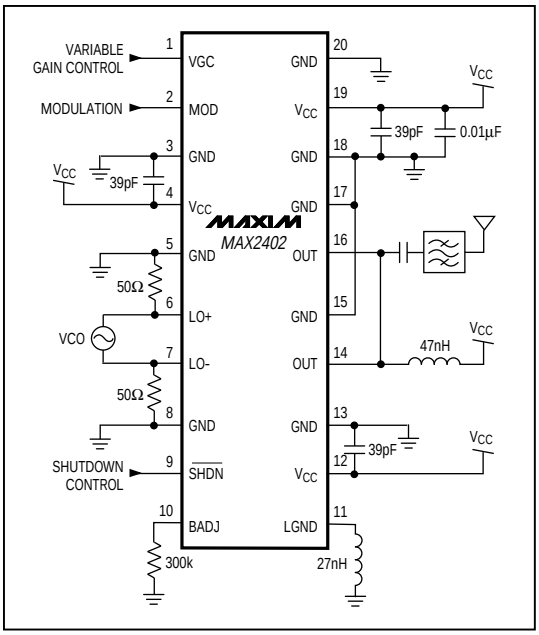
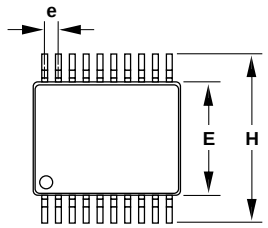
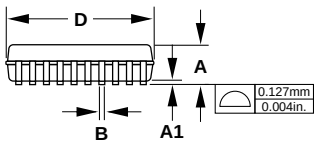
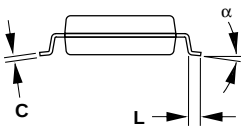


Figure 1. Typical Application Circuit

Package Information







DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.068	0.078	1.73	1.99
A1	0.002	0.008	0.05	0.21
B	0.010	0.015	0.25	0.38
C	0.005	0.009	0.13	0.22
D	0.278	0.289	7.07	7.33
E	0.205	0.212	5.20	5.38
e	0.0256 BSC		0.65 BSC	
H	0.301	0.311	7.65	7.90
L	0.022	0.037	0.55	0.95
α	0°	8°	0°	8°

21-0003A

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