19-1764; Rev 2; 6/05

Low-Noise, High-Linearity Broadband Amplifier

MAX3524

General Description

The MAX3524 broadband amplifier is designed specifically for cable television receiver and cable modem applications. The MAX3524 is a single-ended input, differential-output low-noise amplifier (LNA) that offers 15dB of gain. It operates from a +4.75V to +5.25V single supply from 44MHz to 880MHz. The MAX3524 includes an operational amplifier that is used to control an off-chip PIN attenuator circuit at the input of the LNA. The attenuator is typically used to regulate the input signal to a value that maintains high linearity for large signals. The MAX3524 is available in a 10-pin µMAX® package with an exposed paddle (EP) and operates in the extended temperature range (-40°C to +85°C).

Features

- ♦ **Single-Ended Input, Differential Output**
- ♦ **+4.75V to +5.25V Single-Supply Operation**
- ♦ **Broadband Operation: 44MHz to 880MHz**
- ♦ **Low Noise Figure: 4.2dB**
- ♦ **High Linearity: IIP2 (42dBm), IIP3(14dBm)**
- ♦ **Voltage Gain: 15dB**
- ♦ **Independent On-Chip Op Amp**

Applications

Cable Modems

Cable Set-Top Boxes

Broadband Amplifiers

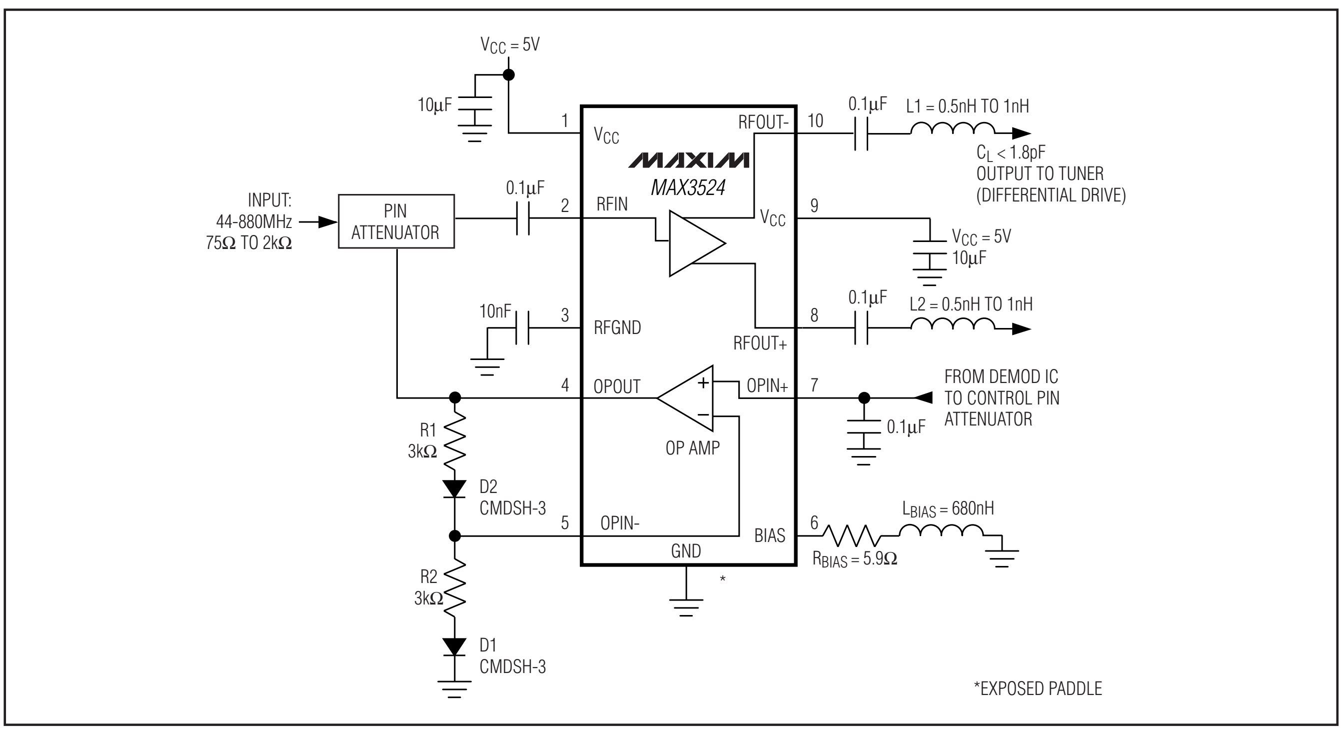
CATV Infrastructures

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX3524EVB	-40°C to +85°C	10 µMAX-EP*
MAX3524EVB+	-40°C to +85°C	10 µMAX-EP*

**EP = Exposed paddle.*
+Denotes lead-free package.

Typical Application Circuit



Pin Configuration appears at end of data sheet.

Low-Noise, High-Linearity Broadband Amplifier

ABSOLUTE MAXIMUM RATINGS

V_{CC} to GND ....-0.3V to +7.0V
RFIN ....+2.0V
P_{RFIN} 0dBm
R_{BIAS} (MINIMUM) 5Ω
RFOUT+, RFOUT-, OPIN-, OPIN+, OPOUT...-0.3V to (V_{CC} + 0.3V)
RFOUT+, RFOUT- Short-Circuit Duration 10s
Continuous Power Dissipation (T_A = +70°C)
10-Pin µMAX (derate 10.3mW/°C above +70°C) 825mW
Operating Temperature Range ....-40°C to +85°C
Storage Temperature Range ....-65°C to +150°C
Junction Temperature ....+150°C
Lead Temperature (soldering, 10s) ....+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.

CAUTION! ESD SENSITIVE DEVICE

DC ELECTRICAL CHARACTERISTICS

(*Typical Application Circuit*, V_{CC} = +4.75V to +5.25V, R_{BIAS} = 5.9Ω, L_{BIAS} = 680nH, T_A = -40°C to +85°C, unless otherwise indicated. Typical values measured at V_{CC} = +5.0V, T_A = +25°C.) (Notes 1, 2)

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
SUPPLY					
Supply Voltage		4.75		5.25	V
Supply Current			85	95	mA
OPERATIONAL AMPLIFIER					
Common-Mode Input Range		0.5		3.0	V
Maximum Output Voltage	I_O = 20mA	V_{CC} - 0.5			V
Minimum Output Voltage	I_O = 20mA			0.5	V

AC ELECTRICAL CHARACTERISTICS

(MAX3524 EV kit as shown in Figure 1, V_{CC} = +4.75V to +5.25V, P_{RFIN} = -20dBm, Z_S = 75Ω, R_{BIAS} = 5.9Ω, L_{BIAS} = 680nH, f_{IN} = 44MHz, Z_L = 50Ω ll 2pF, T_A = +25°C. Typical values are at V_{CC} = +5V, unless otherwise indicated.) (Notes 2, 3)

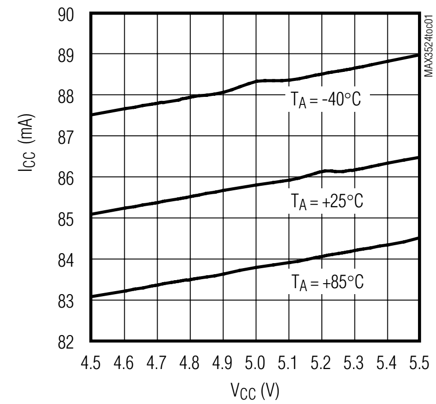
PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Frequency Range		44		880	MHz
Power Gain (Note 4)	T_A = +25°C	8.0	9.8	11	dB
	T_A = -40°C to +85°C	7.6		11.5	
Voltage Gain (Note 5)	R_L = 3kΩ		15		dB
Noise Figure (Note 3)	f_{RFIN} = 300MHz		4.2	4.9	dB
IIP3 (Notes 3, 6)		12	14		dBm
IIP2 (Notes 3, 6)		40	42		dBm
Output-to-Input Isolation	f_{RFIN} = 300MHz	40	60		dB

Note 1: Parameters are production tested at T_A = +25°C and T_A = +85°C. Limits are guaranteed by design and characterization for T_A = -40°C to +25°C.
Note 2: For optimum linearity, the DC resistance of L_{BIAS} in series with R_{BIAS} must be approximately 7.3Ω.
Note 3: Guaranteed by design and characterization.
Note 4: Gain is guaranteed over the operating frequency range, by design and characterization. Insertion loss of balun is subtracted. Production tested at 44MHz and 880MHz.
Note 5: Corresponding voltage gain at R_L = 3kΩ, calculated as in Figure 2.
Note 6: Frequencies and input power levels: 275MHz, 325MHz, and -20dBm per tone.

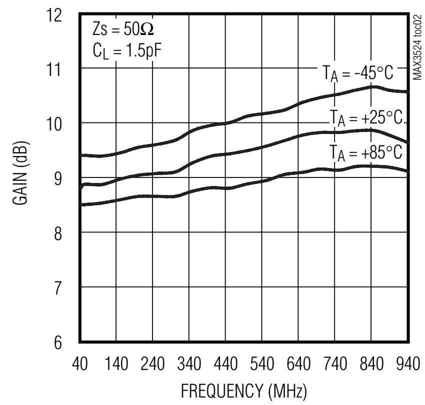
Typical Operating Characteristics

(MAX3524 EV kit as shown in Figure 1, V_{CC} = +5V, P_{RFIN} = -20dBm, Z_L = 50Ω ll 2pF, R_{BIAS} = 5.9Ω, L_{BIAS} = 680nH, insertion loss of balun subtracted, T_A = +25°C.)

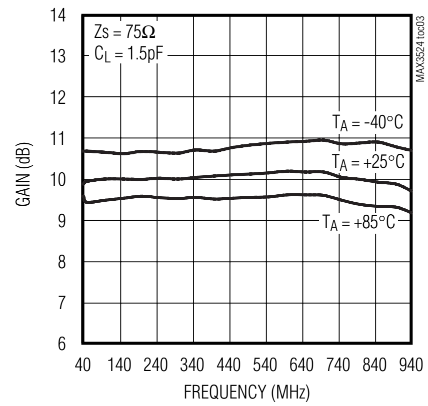
CURRENT vs. VOLTAGE



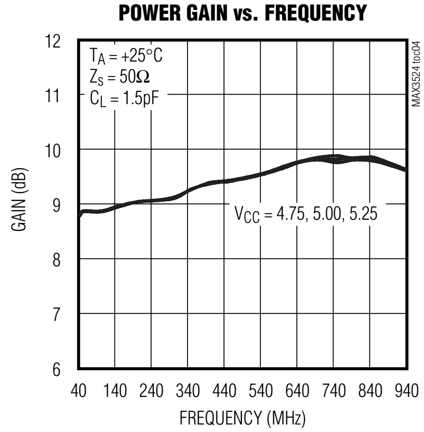
POWER GAIN vs. FREQUENCY



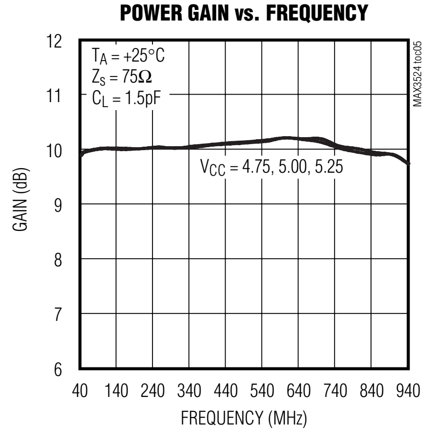
POWER GAIN vs. FREQUENCY



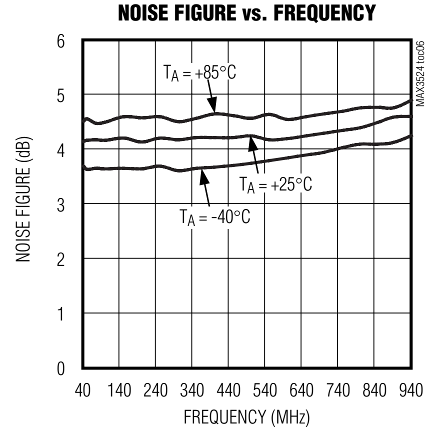
POWER GAIN vs. FREQUENCY



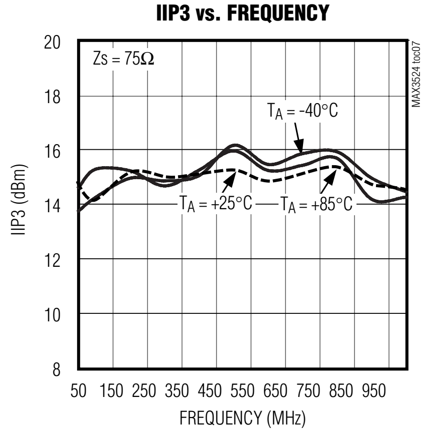
POWER GAIN vs. FREQUENCY



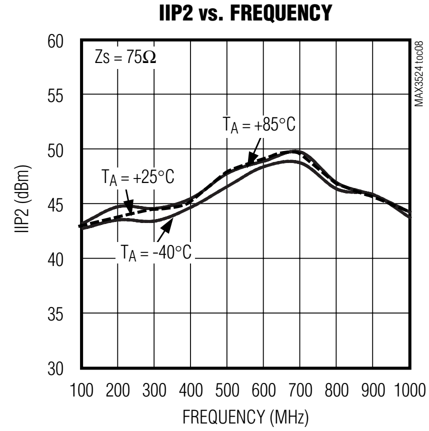
NOISE FIGURE vs. FREQUENCY



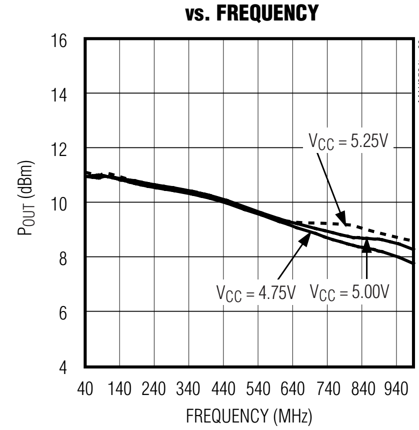
IIP3 vs. FREQUENCY



IIP2 vs. FREQUENCY



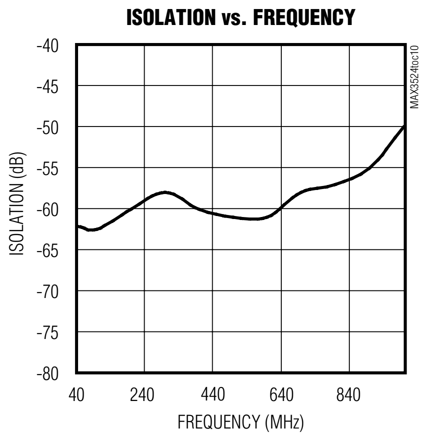
1dB COMPRESSED OUTPUT POWER vs. FREQUENCY

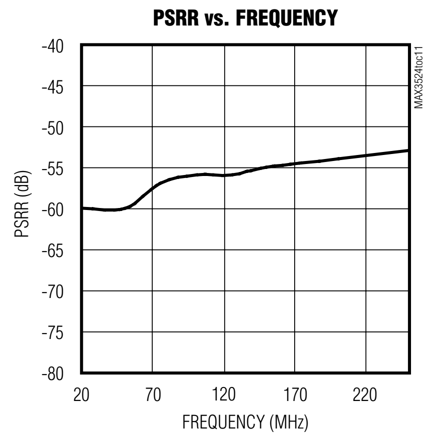


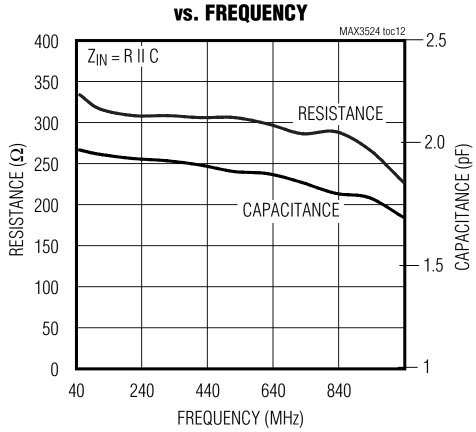
Low-Noise, High-Linearity Broadband Amplifier

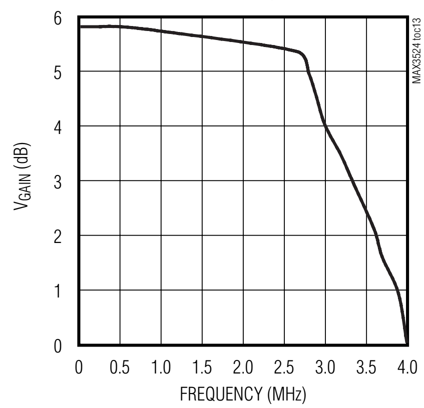
Typical Operating Characteristics (continued)

(MAX3524 EV kit as shown in Figure 1, V_{CC} = +5V, P_{RFIN} = -20dBm, Z_L = 50Ω ll 2pF, R_{BIAS} = 5.9Ω, L_{BIAS} = 680nH, insertion loss of balun subtracted, T_A = +25°C.)









Pin Description

PIN	NAME	FUNCTION
1, 9	V_{CC}	Supply Voltage Input. Connect both pins together. Bypass with a 10µF and 47pF capacitor to GND.
2	RFIN	RF Input of LNA. Requires DC blocking capacitor.
3	RFGND	Bypass to GND through 10nF capacitor.
4	OPOUT	Operational Amplifier Output
5	OPIN-	Inverting Input of Operational Amplifier
6	BIAS	LNA Bias Setting Pin. For nominal bias, connect 5.9Ω resistor in series with 680nH to GND (total DC resistance = resistance of R_{BIAS} + DC resistance of the inductor = 7.3Ω). The value of the resistor is adjusted to alter the current and therefore linearity of the LNA.
7	OPIN+	Noninverting Input of Operational Amplifier
8	RFOUT-	Inverting Output of LNA
10	RFOUT+	Noninverting Output of LNA
Slug	GND	Ground

Detailed Description

The MAX3524 is a broadband amplifier with a single-ended input and differential outputs, including an operational amplifier that can be used to control an external attenuator circuit. Figure 1 is the MAX3524 EV kit schematic.

Low-Noise Amplifier

The low-noise amplifier operates from 44MHz to 880MHz and is designed specifically for cable TV and cable modem applications. The LNA provides 15dB of insertion voltage gain (see Figure 2) when driving a 3kΩ load. At 300MHz, the noise figure is 4.2dB, IIP2 and IIP3 are 42dBm and 14dBm, respectively.

Operational Amplifier

The operational amplifier is suitable for interfacing to a PIN attenuator circuit which is typically employed at the input of the LNA. The common-mode input range is 0.5V to 3V and the output voltage swing is 0.5V to V_{CC} - 0.5V while sinking or sourcing 20mA. Input bias current and input offset voltage are 1µA and 1mV, respectively. The open-loop voltage gain is greater than 10,000. The gain bandwidth product is greater than 1MHz for a closed-loop voltage gain of one.

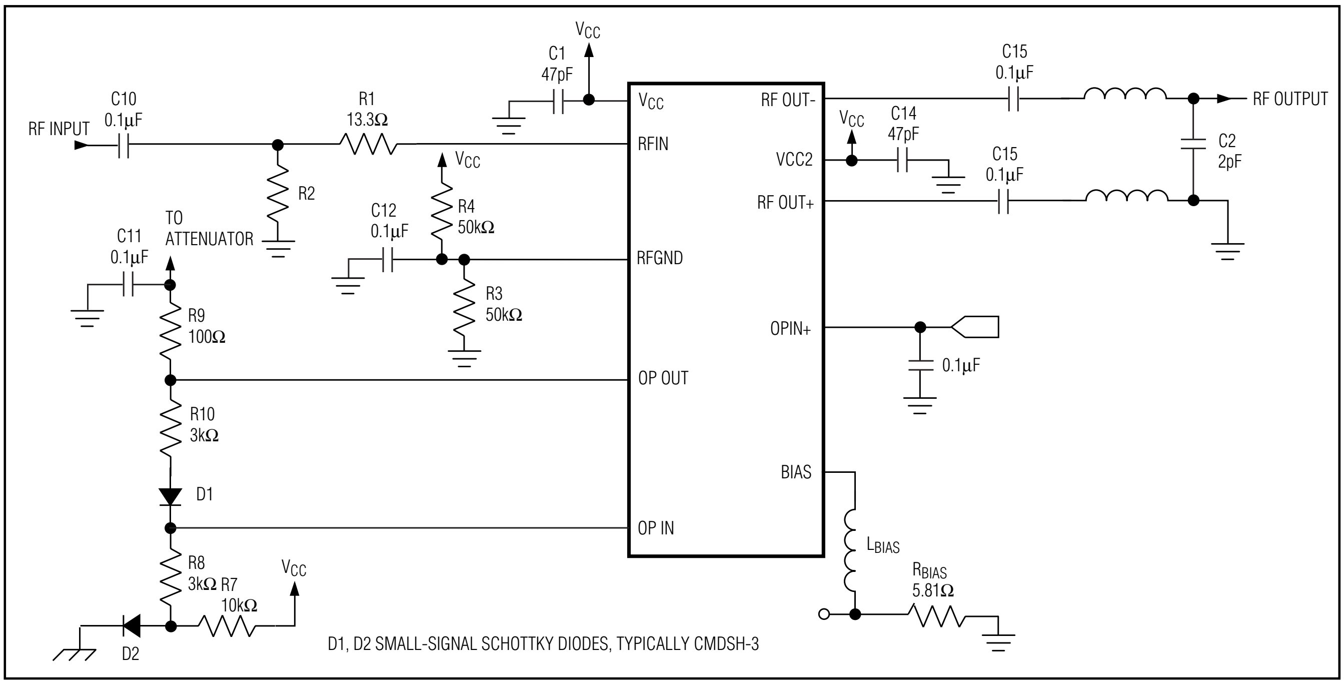


Figure 1. MAX3524 EV Kit Schematic

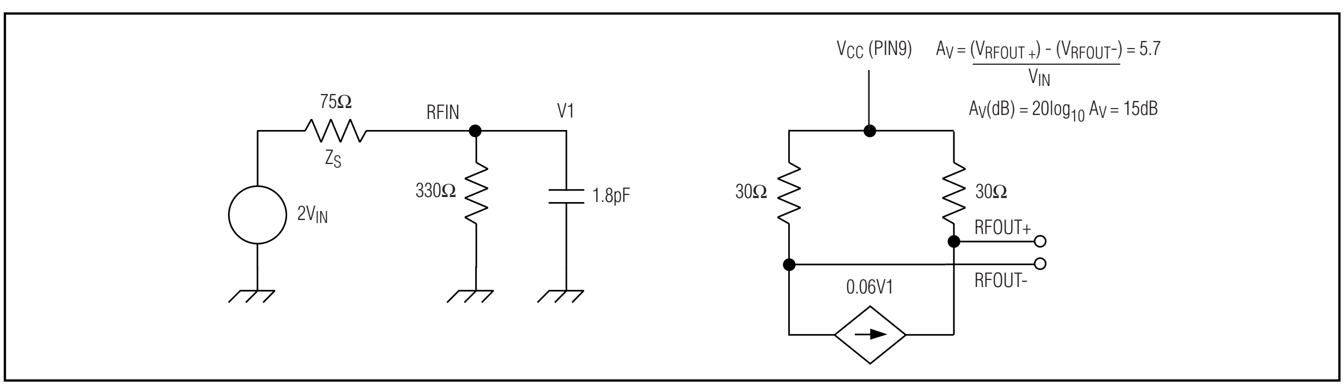


Figure 2. LNA Equivalent Circuit and Open-Circuit Voltage Gain Calculation

Table 1. Shunt-Resistor Noise-Figure Values

R_{SHUNT}(Ω)	$\lvert S11 \rvert$ (LNA) (dB)	NOISE FIGURE (dB)
450	-6	5 to 5.5
250	-8	5.5 to 6
125	-10	6 to 6.5

Applications Information

Bias Current

The resistor, R_{BIAS}, connected between BIAS and GND controls the LNA current. To make the current insensitive to temperature fluctuations, select a 1%, low temperature coefficient resistor for R_{BIAS}. The current drawn by the LNA is calculated using the following formula:

$$I_{BIAS} \approx 0.58V / (R_{BIAS} + \text{DC resistance of } L_{BIAS})$$

It is important to include the inductor resistance in the above equation as it is typically 1Ω to 2Ω. The MAX3524 EV kit uses a nominal inductor with DC resistance of 1.4Ω. Higher values of R_{BIAS} may be used to reduce supply current predominantly at the expense of linearity. Circuit board layout and source impedance may require the value of I_{BIAS} to be optimized for best linearity.

Input and Output

The LNA input is single-ended. The RF input signal is coupled to RFIN through a DC blocking capacitor. The LNA outputs drive a differential load, such as a mixer, through DC blocking capacitors. The equivalent input LNA impedance is 330Ω resistive in parallel with 1.8pf, as shown in Figure 2. The approximate equivalent differential output impedance of the LNA is 60Ω. To achieve S11 less than -6dB, an insertion loss of greater than 1dB must exist between the cable input and MAX3524. This loss typically comes from a diplexer and PIN attenuator in a cable modem application. A shunt resistor may be added at the input of the LNA to improve the return loss (S11). Typically the return loss of the system is 2dB better, as explained above. The S11 and noise-figure values for different shunt resistors are given in Table 1.

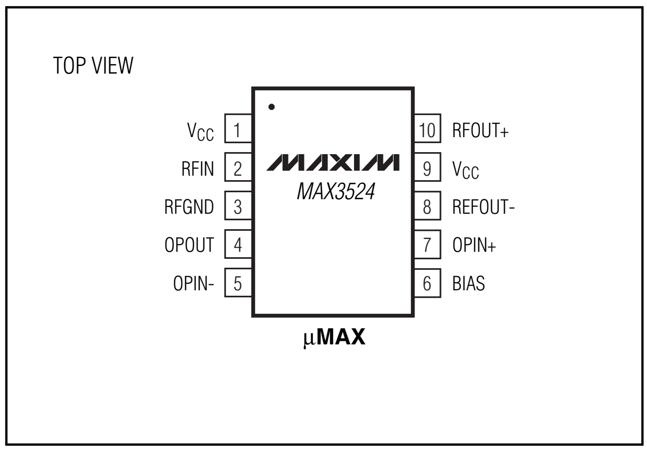
RF Input Power Control Using the Operational Amplifier

In a cable system, the power level at the LNA input is typically restricted to a maximum value to maintain linearity. This is accomplished by connecting a variable attenuator at the input of the LNA and varying the attenuation with the operational amplifier output. The operational amplifier receives a DC control input that is proportional to LNA output power. See *Typical Application Circuit*.

Layout Issues

A properly designed PC board is essential to any RF/microwave circuit. Use short interconnect and controlled impedance lines on all high-frequency inputs and outputs. Use low inductance connections to ground on all GND nodes and place decoupling capacitors close to all V_{CC} connections. The EP is the ground for the MAX3524 and must be soldered to ground for proper operation.

Pin Configuration

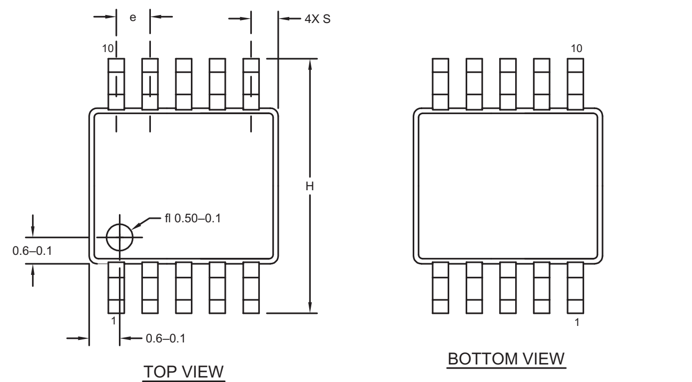


Chip Information

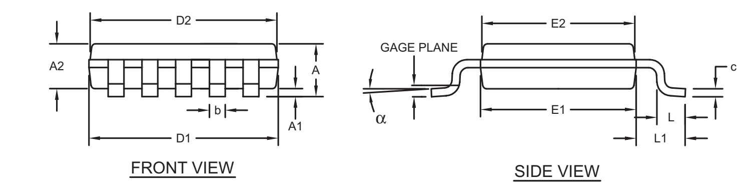
TRANSISTOR COUNT: 550

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to **www.maxim-ic.com/packages**.)



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	-	0.043	-	1.10
A1	0.002	0.006	0.05	0.15
A2	0.030	0.037	0.75	0.95
D1	0.116	0.120	2.95	3.05
D2	0.114	0.118	2.89	3.00
E1	0.116	0.120	2.95	3.05
E2	0.114	0.118	2.89	3.00
H	0.187	0.199	4.75	5.05
L	0.0157	0.0275	0.40	0.70
L1	0.037 REF		0.940 REF	
b	0.007	0.0106	0.177	0.270
e	0.0197 BSC		0.500 BSC	
c	0.0035	0.0078	0.090	0.200
S	0.0196 REF		0.498 REF	
α	0¡	6¡	0¡	6¡



NOTES:

1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. CONTROLLING DIMENSION: MILLIMETERS.
4. MEETS JEDEC MO-187C-BA.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, 10L uMAX/uSOP

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0061	I	1/1

MAX3524

Part Number Table

Notes:

1. See the MAX3524 QuickView Data Sheet for further information on this product family or download the MAX3524 full data sheet (PDF, 180kB).
2. Other options and links for purchasing parts are listed at: http://www.maxim-ic.com/sales.
3. Didn't Find What You Need? Ask our applications engineers. Expert assistance in finding parts, usually within one business day.
4. Part number suffixes: T or T&R = tape and reel; + = RoHS/lead-free; # = RoHS/lead-exempt. More: See full data sheet or Part Naming Conventions.
5. * Some packages have variations, listed on the drawing. "PkgCode/Variation" tells which variation the product uses.

Part Number	Free Sample	Buy Direct	Package: TYPE PINS SIZE DRAWING CODE/VAR *	Temp	RoHS/Lead-Free? Materials Analysis
MAX3524EUB			uMAX;10 pin;3 x 3mm Dwg: 21-0109D (PDF) Use pkgcode/variation: U10E-3*	-40C to +85C	RoHS/Lead-Free: No Materials Analysis
MAX3524EUB-T			uMAX;10 pin;3 x 3mm Dwg: 21-0109D (PDF) Use pkgcode/variation: U10E-3*	-40C to +85C	RoHS/Lead-Free: No Materials Analysis
MAX3524EUB+			uMAX;10 pin;3 x 3mm Dwg: 21-0109D (PDF) Use pkgcode/variation: U10E+3*	-40C to +85C	RoHS/Lead-Free: Yes Materials Analysis
MAX3524EUB+T			uMAX;10 pin;3 x 3mm Dwg: 21-0109D (PDF) Use pkgcode/variation: U10E+3*	-40C to +85C	RoHS/Lead-Free: Yes Materials Analysis

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