

# 50MHz to 3GHz RF Power Detector with 60dB Dynamic Range

## FEATURES

- **RF Frequency Range: 50MHz to 3GHz**
- **Linear Dynamic Range: 60dB**
- **Exceptional Accuracy over Temperature and Power Supply**
- **Fast Transient Response:**  
**38ns Full-Scale Settling Time**
- Single 2.7V to 5.25V Supply
- Low Supply Current: 7mA
- Shutdown Current: 0.1 $\mu$ A
- Tiny 6-Lead SC70 Package

## APPLICATIONS

- RF RSSI and ACC
- RF Power Control
- CATV Power Detection
- Optical Receiver Gain Control

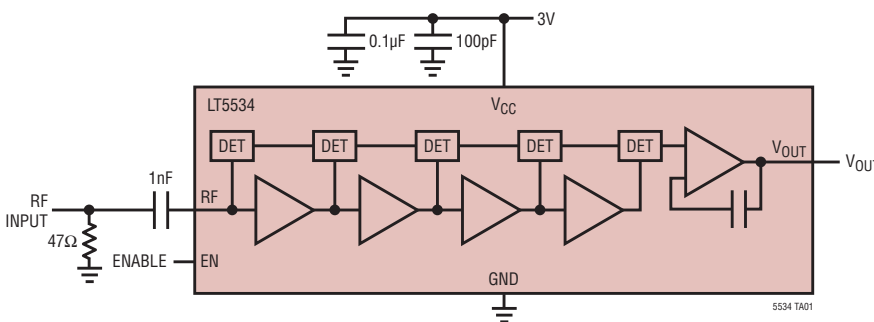
## DESCRIPTION

The LT<sup>®</sup>5534 is a 50MHz to 3GHz monolithic RF power detector capable of measuring RF signals over a 60dB dynamic range. The RF signal in a decibel scale is precisely converted into DC voltage on a linear scale. The 60dB input dynamic range is achieved using cascaded RF detectors and RF limiters. Their outputs are summed to generate an accurate log-linear DC voltage proportional to the input RF signal in dB. The output is buffered with a low output impedance driver. The LT5534 delivers superior temperature stability (typical output variation within  $\pm 1$ dB over the full temperature range). The output responds in less than 40ns to a large RF input signal.

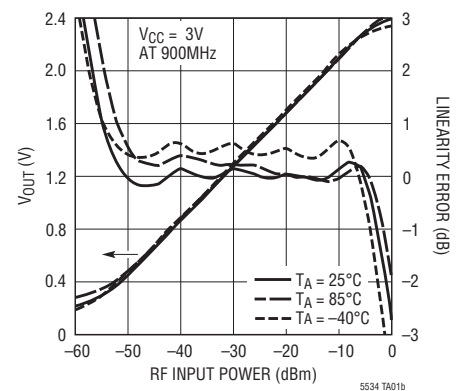
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## TYPICAL APPLICATION

50MHz to 3GHz RF Power Detector



Output Voltage vs RF Input Power

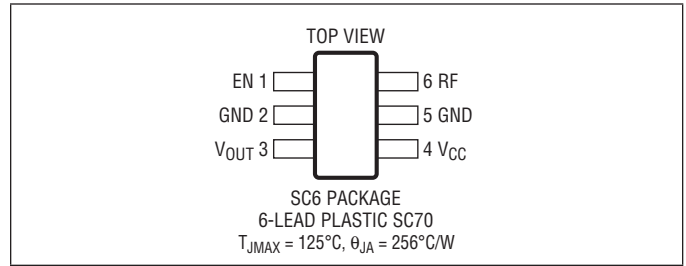


## ABSOLUTE MAXIMUM RATINGS

(Note 1)

Power Supply Voltage .....	5.5V
Enable Voltage .....	0V, $V_{CC}$
RF Voltage (+10dBm Equivalent) .....	$\pm 1V$
Operating Ambient Temperature Range ...	-40°C to 85°C
Storage Temperature Range.....	-65°C to 125°C
Lead Temperature (Soldering, 10 sec) .....	300°C

## PIN CONFIGURATION



## ORDER INFORMATION

LEAD FREE FINISH	TAPE AND REEL	PART MARKING*	PACKAGE DESCRIPTION	TEMPERATURE RANGE
LT5534ESC6#PBF	LT5534ESC6#TRPBF	LBGD	6-Lead Plastic SC70	-40°C to 85°C

Consult LTC Marketing for parts specified with wider operating temperature ranges.  
Consult LTC Marketing for information on non-standard lead based finish parts.

For more information on lead free part marking, go to: <http://www.linear.com/leadfree/>  
For more information on tape and reel specifications, go to: <http://www.linear.com/tapeandreeel/>

## ELECTRICAL CHARACTERISTICS

$V_{CC} = 3V$ ,  $EN = 3V$ ,  $T_A = 25^{\circ}C$ , source impedance = 50 $\Omega$ , unless otherwise noted. Test circuit shown in Figure 1. (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
<b>RF Input</b>					
Frequency Range			50 to 3000		MHz
Input Impedance			2		k $\Omega$
<b><math>f_{RF} = 50MHz</math></b>					
RF Input Power Range			-58 to +2		dBm
Dynamic Range (Note 3)	$\pm 3dB$ Linearity Error, $T_A = -40^{\circ}C$ to $85^{\circ}C$		60		dB
Output Slope			44		mV/dB
Output Variation vs Temperature	$P_{IN} = -48dBm$ to $-14dBm$ , $T_A = -40^{\circ}C$ to $85^{\circ}C$		0.007		dB/ $^{\circ}C$
<b><math>f_{RF} = 900MHz</math></b>					
RF Input Power Range			-60 to 0		dBm
Dynamic Range (Note 3)	$\pm 3dB$ Linearity Error, $T_A = -40^{\circ}C$ to $85^{\circ}C$		60		dB
Output Slope			41		mV/dB
Output Variation vs Temperature	$P_{IN} = -48dBm$ to $-14dBm$ , $T_A = -40^{\circ}C$ to $85^{\circ}C$		0.008		dB/ $^{\circ}C$
<b><math>f_{RF} = 1900MHz</math></b>					
RF Input Power Range			-63 to -2		dBm
Dynamic Range (Note 3)	$\pm 3dB$ Linearity Error, $T_A = -40^{\circ}C$ to $85^{\circ}C$		61		dB
Output Slope		31	36.6	43	mV/dB
Output Variation vs Temperature	$P_{IN} = -48dBm$ to $-14dBm$ , $T_A = -40^{\circ}C$ to $85^{\circ}C$		0.012		dB/ $^{\circ}C$
Output Intercept	50 $\Omega$ External Termination, $T_A = -40^{\circ}C$ to $85^{\circ}C$	-70	-64	-58	dBm
<b><math>f_{RF} = 2500MHz</math></b>					
RF Input Power Range			-63 to -3		dBm
Dynamic Range (Note 3)	$\pm 3dB$ Linearity Error, $T_A = -40^{\circ}C$ to $85^{\circ}C$		60		dB

5534fc

**ELECTRICAL CHARACTERISTICS**

$V_{CC} = 3V$ ,  $EN = 3V$ ,  $T_A = 25^\circ C$ , source impedance =  $50\Omega$ , unless otherwise noted. Test circuit shown in Figure 1. (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Slope			35		mV/dB
Output Variation vs Temperature	$P_{IN} = -48dBm$ to $-14dBm$ , $T_A = -40^\circ C$ to $85^\circ C$		0.025		dB/ $^\circ C$
<b>Output Interface</b>					
Output DC Voltage	No RF Input Signal	0	142	380	mV
Output Impedance			32		$\Omega$
Output Bandwidth			30		MHz
Full-Scale Setting Time	Input from No Signal to $-2dBm$ , to 90%		38		ns
Sinking/Sourcing			10/200		mA/ $\mu A$

$V_{CC} = 3V$ ,  $EN = 3V$ ,  $T_A = 25^\circ C$ , unless otherwise noted. Test circuit shown in Figure 1. (Note 2)

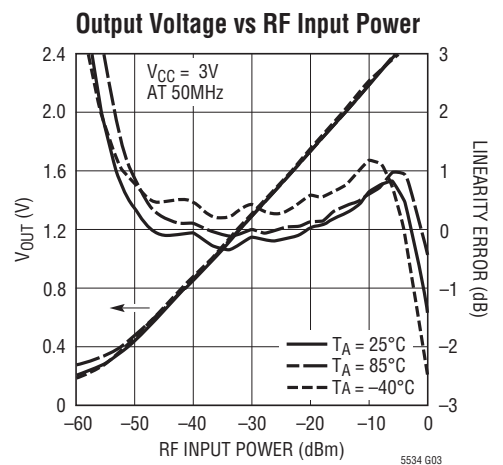
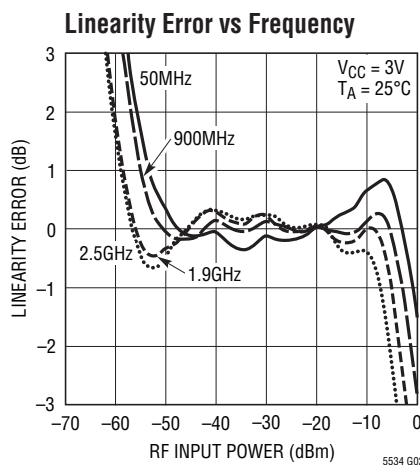
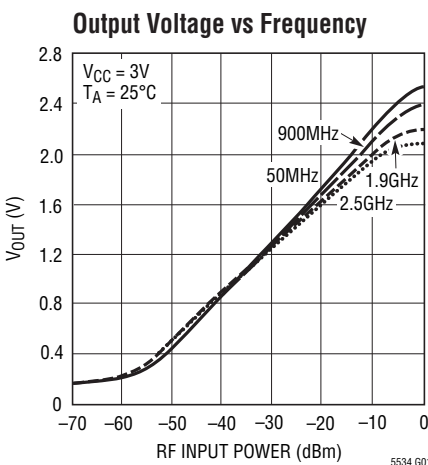
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
<b>Power Up/Down</b>					
Turn-On Time			200		ns
Turn-Off Time			800		ns
EN = High (On)		0.9			V
EN = Low (Off)				0.6	V
<b>Power Supply</b>					
Supply Voltage		2.7		5.25	V
Supply Current	EN = High	5	7	9	mA
Shutdown Current	EN = Low		0.1	10	$\mu A$

**Note 1:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

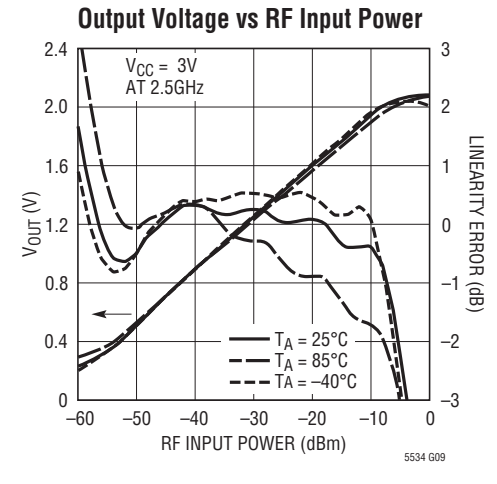
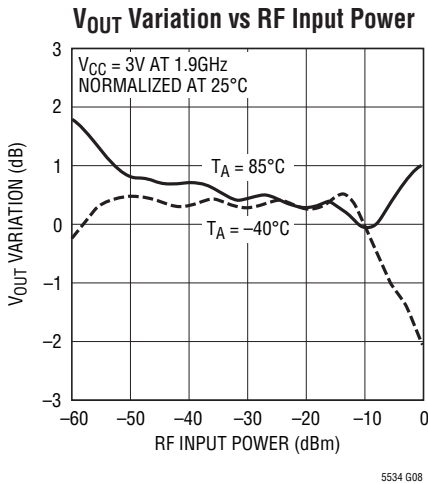
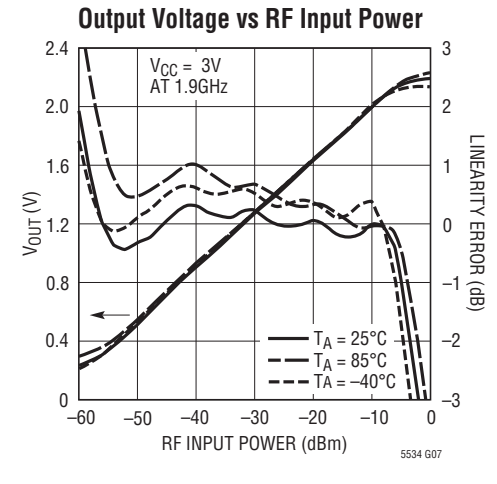
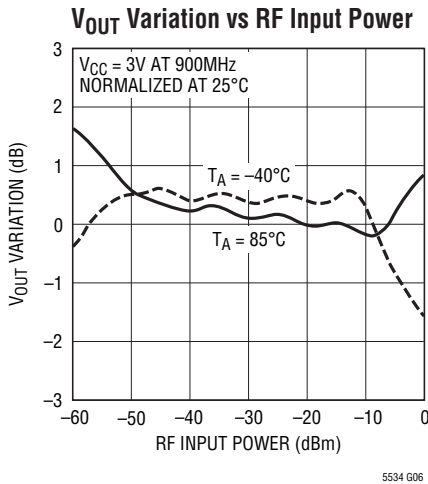
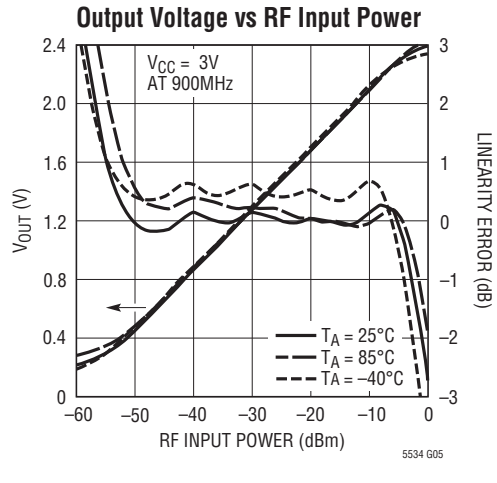
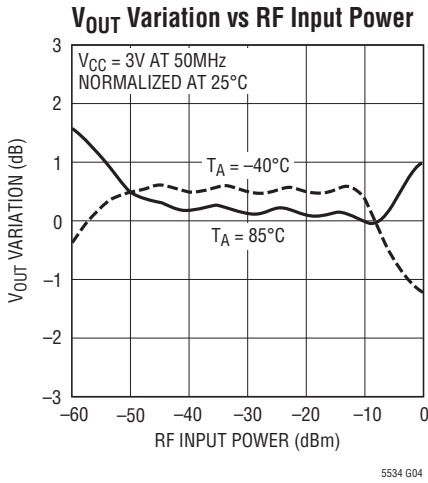
**Note 2:** Specifications over the  $-40^\circ C$  to  $85^\circ C$  temperature range are assured by design, characterization and correlation with statistical process control.

**Note 3:** The linearity error is calculated by the difference between the incremental slope of the output and the average output slope from  $-48dBm$  to  $-14dBm$ . The dynamic range is defined as the range over which the linearity error is within  $\pm 3dB$ .

**TYPICAL PERFORMANCE CHARACTERISTICS** (Test circuit shown in Figure 1)

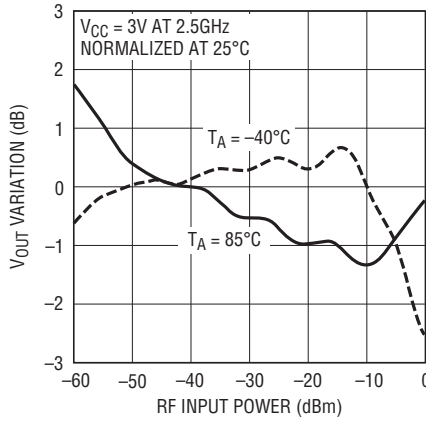


**TYPICAL PERFORMANCE CHARACTERISTICS** (Test circuit shown in Figure 1)



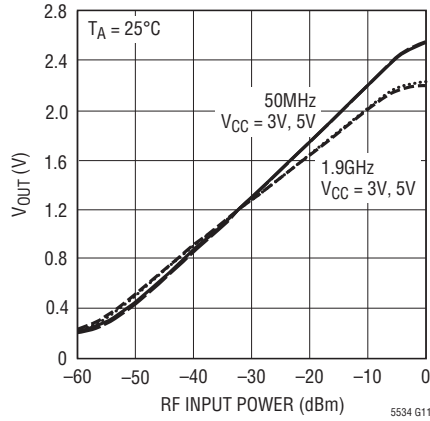
**TYPICAL PERFORMANCE CHARACTERISTICS** (Test circuit shown in Figure 1)

**V<sub>OUT</sub> Variation vs RF Input Power**



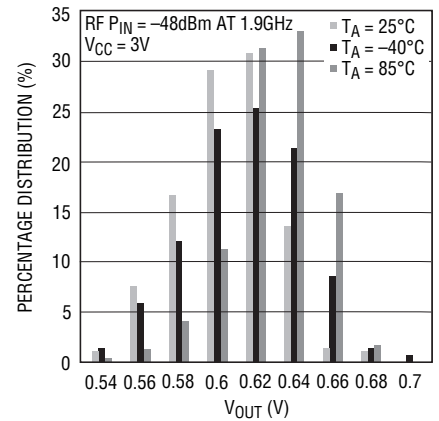
5534 G10

**Output Voltage vs RF Input Power at V<sub>CC</sub> = 3V and 5V**



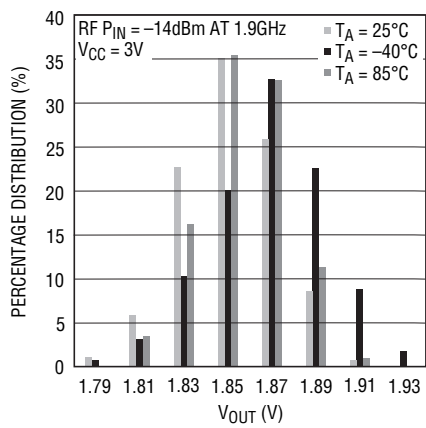
5534 G11

**Output Voltage Distribution vs Temperature**



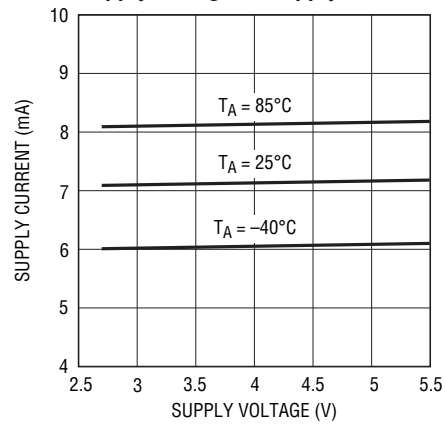
5534 G12

**Output Voltage Distribution vs Temperature**



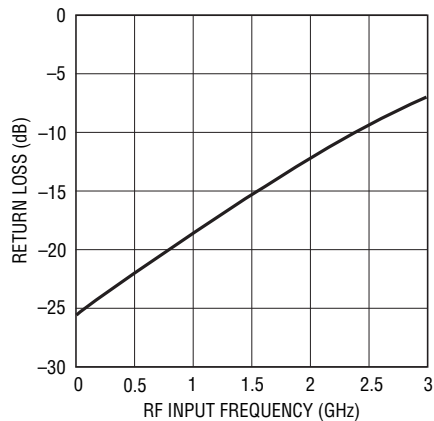
5534 G13

**Supply Voltage vs Supply Current**



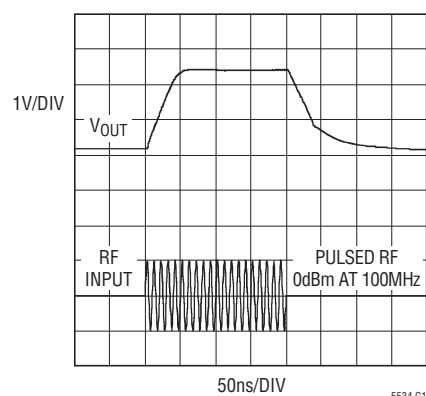
5530 G14

**RF Input Return Loss vs Frequency**



5534 G15

**Output Transient Response**



5534 G16

## PIN FUNCTIONS

**EN (Pin 1):** Enable. When the input voltage is higher than 0.9V, the circuit is completely turned on. When the input voltage is less than 0.6V, the circuit is turned off.

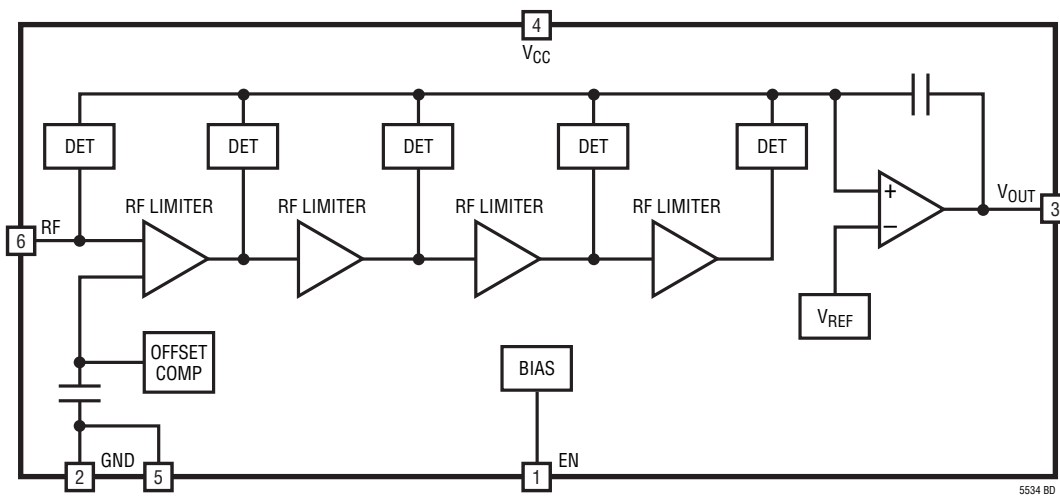
**GND (Pins 2, 5):** Ground.

**V<sub>OUT</sub> (Pin 3):** RF Detector Output.

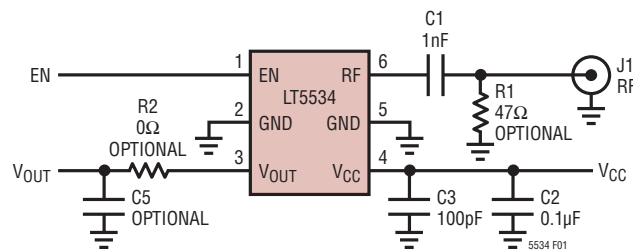
**V<sub>CC</sub> (Pin 4):** Power Supply. This pin should be decoupled using 100pF and 0.1μF capacitors.

**RF (Pin 6):** RF Input. This pin is internally biased to  $V_{CC} - 0.18V$ . A coupling capacitor must be used to connect to the RF signal source.

## BLOCK DIAGRAM



## TEST CIRCUIT



REF DES	VALUE	SIZE	PART NUMBER
C1	1nF	0402	AVX 04025C102JAT2A
C2	0.1μF	0603	TAIYO YUDEN TMK107BJ104KA
C3	100pF	0603	AVX 06035C101KAT2A
C5		0603	OPTIONAL
R1	47Ω	0402	OPTIONAL
R2	0Ω	0603	OPTIONAL

Figure 1. Evaluation Circuit Schematic

## TEST CIRCUIT

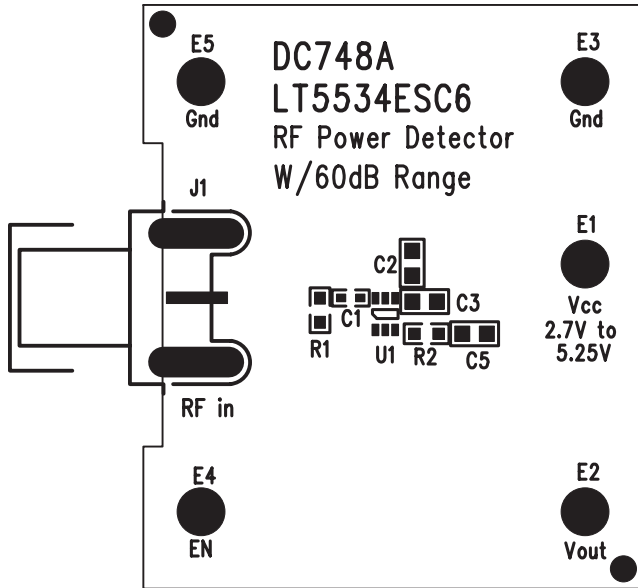


Figure 2. Component Side Silkscreen of Evaluation Board

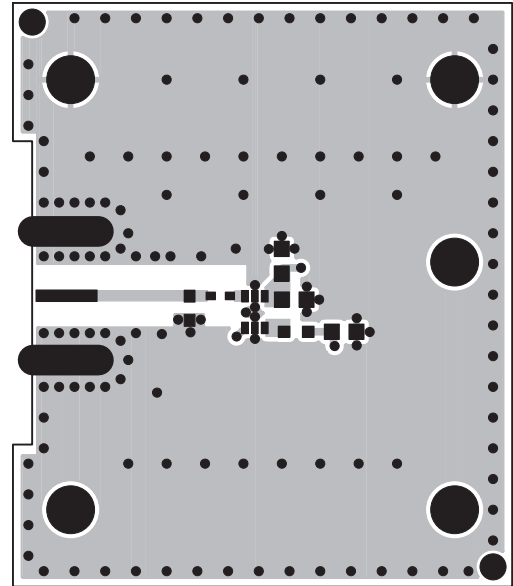


Figure 3. Component Side Layout of Evaluation Board

## APPLICATIONS INFORMATION

The LT5534 is a logarithmic-based detector, capable of measuring an RF signal over the frequency range from 50MHz to 3GHz. The 60dB linear dynamic range is achieved with very stable output over the full temperature range from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ . The absolute variation over temperature is typically within  $\pm 1\text{dB}$  over a 47dB dynamic range at 1.9GHz.

### RF Input Port

The RF port is internally biased at  $V_{CC}-0.18\text{V}$ . The pin should be DC blocked when connected to ground or other matching components. A  $47\Omega$  resistor (R1) connected to ground will provide better than 10dB input return loss up to 2.5GHz. An additional 2nH inductance in series with R1 will provide improved input matching up to 3GHz. The impedance vs frequency of the RF input is detailed in Table 1.

The approximate linear RF input power range of the LT5534 is from  $-62\text{dBm}$  to  $-2\text{dBm}$  with a  $50\Omega$  source impedance. However, this range can be adjusted either upward or

Table 1. RF Input Impedance

FREQUENCY (MHz)	INPUT IMPEDANCE ( $\Omega$ )	S11	
		MAG	ANGLE (DEG)
50	1429-j429	0.938	-1.1
100	947-j710	0.934	-2.9
200	509-j609	0.922	-5.6
400	250-j440	0.908	-9.9
600	149-j344	0.900	-14.1
800	96.8-j278	0.896	-18.3
1000	67.6-j229	0.893	-22.7
1200	49.7-j193	0.889	-27.3
1400	38.4-j165	0.883	-32.3
1600	30.8-j143	0.879	-37.3
1800	25.4-j125	0.873	-42.6
2000	21.4-j109	0.866	-48.0
2200	18.5-j96.2	0.862	-53.6
2400	16.6-j85.0	0.848	-59.6
2600	15.2-j75.7	0.834	-65.6
2800	13.7-j67.5	0.826	-71.8
3000	12.1-j60.1	0.822	-78.2

## APPLICATIONS INFORMATION

downward to tailor for a particular application need. By simply inserting an attenuator in front of the RF input, the power range is shifted higher by the amount of the attenuation. Moreover, due to the high RF input impedance of the LT5534, the detecting range can be moved downward for better detection sensitivity by using a narrow band L-C matching network. By this means, the sensitivity of the detector can be extended to as low as  $-75\text{dBm}$ . By changing the value of resistor R1, the sensitivity of the detector can be fine-tuned within the range from  $-75\text{dBm}$  to  $-62\text{dBm}$ . Though the range is adjustable, the overall linear dynamic range remains the same.

### Output Interface

The output interface of the LT5534 is shown in Figure 4. The output currents from the RF detectors are summed and converted into an output voltage,  $V_{\text{OUT}}$ . The maximum charging current available to the output load is about  $200\mu\text{A}$ . The internal compensation capacitor  $C_C$  is used to guarantee stable operation for a large capacitive output load. The slew rate is  $133\text{V}/\mu\text{s}$ , and the small-signal output bandwidth is approximately  $30\text{MHz}$  when the output is resistively terminated or open. The fastest output transient response is achieved when a large signal is applied to the RF input port. See the Output Transient Response plot in the Typical Performance Characteristics section.

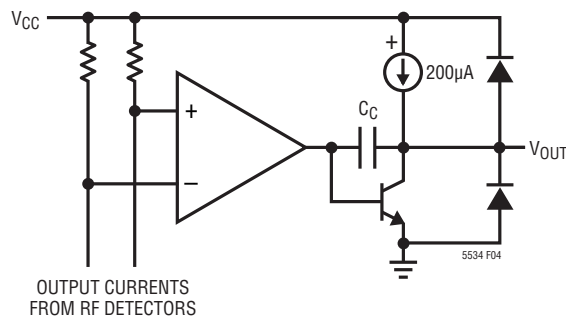
When the output is terminated with a load capacitance  $C_L$ , the slew rate is then limited to  $200\mu\text{A}/(C_L + 1.5\text{pF})$ . For example, the slew rate is reduced to  $17.4\text{V}/\mu\text{s}$  when  $C_L = 10\text{pF}$ . A capacitive load may result in output voltage overshoot, which can be minimized with a series compensation resistor R2, as shown in Figure 1. The suggested resistor values for various capacitive loads are listed in Table 2.

**Table 2. Resistor Value for Capacitive Output**

C5 (pF)	R2 (kΩ)
1.5	5
5	4
10	2.5
20	2

The optional RC network at the output (R2 and C5 on the demo board) can also provide further output filtering, if needed. The output bandwidth is primarily dictated by the RC constant of this lowpass filter when its corner frequency is less than  $30\text{MHz}$ .

When a large signal (e.g.,  $-2\text{dBm}$ ) is present at the RF input port, the output voltage swing can be as high as  $2.4\text{V}$ . To assure proper operation of the chip, the minimum resistive load at the output termination should be greater than  $18\text{k}\Omega$ .



**Figure 4. Simplified Circuit Schematic of the Output Interface**



**REVISION HISTORY** (Revision history begins at Rev B)

REV	DATE	DESCRIPTION	PAGE NUMBER
B	8/10	Revised Output DC Voltage minimum and maximum values in Electrical Characteristics section	3
		Updated package drawing in Package Description section	10
C	12/10	Corrected part numbers in Order Information	2