

# Wide Dynamic Range RF/IF Log Detector

## FEATURES

- Low Frequency to 1000MHz Operation
- 83dB Dynamic Range with  $\pm 1$ dB Nonlinearity at 200MHz
- Sensitivity  $-76$ dBm or Better at 200MHz
- Log-Linear Transfer Slope of 20mV/dB
- Supply Voltage Range: 2.7V to 5.25V
- Supply Current: 13.5mA at 3V
- Tiny 8-Lead (3mm  $\times$  2mm) DFN Package

## DESCRIPTION

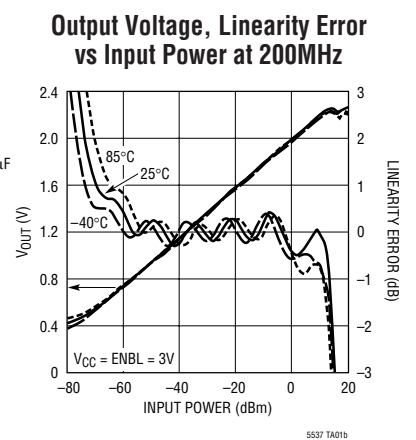
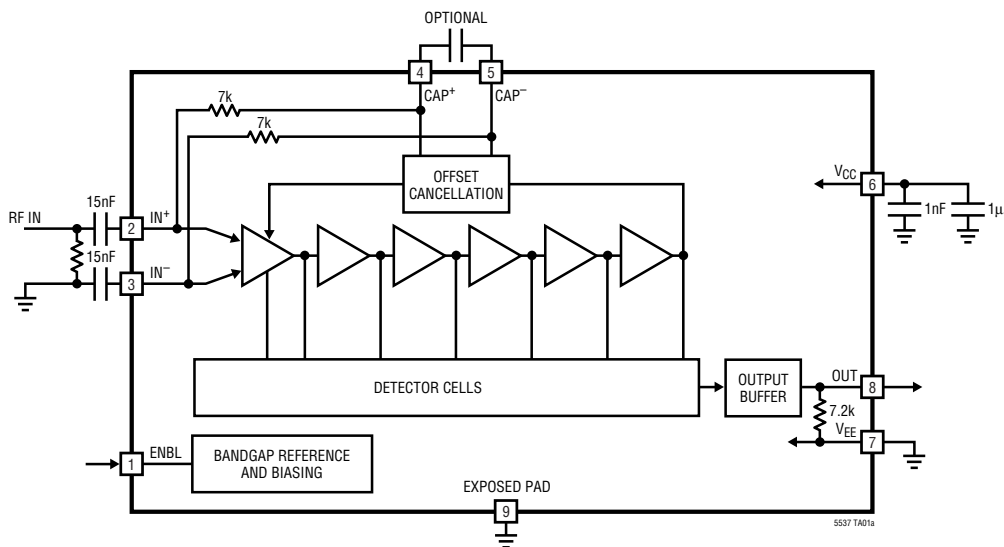
The LT<sup>®</sup>5537 is a wide dynamic range RF/IF detector, operational from below 10MHz to 1000MHz. The lower limit of the operating frequency range can be extended to near DC by the use of an external capacitor. The input dynamic range at 200MHz with  $\pm 3$ dB nonlinearity is 90dB (from  $-76$ dBm to 14dBm, single-ended 50 $\Omega$  input). The detector output voltage slope is nominally 20mV/dB, and the typical temperature coefficient is 0.01dB/ $^{\circ}$ C at 200MHz.

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## APPLICATIONS

- Linear-to-Log Signal Level Conversion
- Received Signal Strength Indication (RSSI)
- RF Power Control
- RF/IF Power Detection
- Receiver RF/IF Gain Control
- Envelope Detection
- ASK Receiver

## TYPICAL APPLICATION



## ABSOLUTE MAXIMUM RATINGS

(Note 1)

|  |                        |
|--|------------------------|
| Power Supply Voltage .....             | 5.5V                   |
| Enable Voltage .....                   | -0.2V, $V_{CC} + 0.2V$ |
| Input Power (Note 2) .....             | 22dBm                  |
| Operating Ambient Temperature Range .. | -40°C to 85°C          |
| Storage Temperature Range .....        | -65°C to 125°C         |
| Maximum Junction Temperature .....     | 125°C                  |

## PACKAGE/ORDER INFORMATION

TOP VIEW

DDB PACKAGE  
8-LEAD (3mm × 2mm) PLASTIC DFN  
 $\theta_{JA} = 76^{\circ}\text{C/W}$   
EXPOSED PAD (PIN 9) SHOULD BE SOLDERED TO PCB

| ORDER PART NUMBER | DDB PART MARKING |
|-------------------|------------------|
| LT5537EDDB        | LBJR             |

**Order Options** Tape and Reel: Add #TR  
Lead Free: Add #PBF Lead Free Tape and Reel: Add #TRPBF  
Lead Free Part Marking: <http://www.linear.com/leadfree/>

Consult LTC Marketing for parts specified with wider operating temperature ranges.

## ELECTRICAL CHARACTERISTICS $V_{CC} = 3V$ , $ENBL = 3V$ , $T_A = 25^{\circ}\text{C}$ , unless otherwise specified. (Notes 3, 4)

| PARAMETER                                | CONDITIONS  | MIN | TYP                     | MAX | UNITS             |
|--|---|-----|-------------------------|-----|-------------------|
| <b>Signal Input</b>                      |   |     |                         |     |                   |
| Input Frequency Range                    | (Note 5)  |     | 10 to 1000              |     | MHz               |
| Maximum Input Power for Monotonic Output | 50 $\Omega$ Termination<br>200MHz<br>600MHz<br>1GHz |     | 14.0<br>11.6<br>9.4     |     | dBm<br>dBm<br>dBm |
| DC Common Mode Voltage                   |   |     | $V_{CC} - 0.4$          |     | V                 |
| Small-Signal Impedance                   | Measured at 200MHz                                  |     | 1.73k $\Omega$ //1.45pF |     |                   |
| <b>f = 10MHz</b>                         |   |     |                         |     |                   |
| Linear Dynamic Range                     | $\pm 3\text{dB}$ Error<br>$\pm 1\text{dB}$ Error    |     | 88.8<br>72.5            |     | dB<br>dB          |
| Slope                                    | $R_1 = 33\text{k}$ (Note 8)                         |     | 19.6                    |     | mV/dB             |
| Intercept                                | $V_{OUT} = 0V$ , Extrapolated                       |     | -97                     |     | dBm               |
| Sensitivity                              | (Notes 3, 7)  |     | -76.7                   |     | dBm               |
| Temperature Coefficient                  | $P_{IN} = -20\text{dBm}$                            |     | -0.007                  |     | dB/°C             |
| <b>f = 50MHz</b>                         |   |     |                         |     |                   |
| Linear Dynamic Range                     | $\pm 3\text{dB}$ Error<br>$\pm 1\text{dB}$ Error    |     | 90.6<br>81.0            |     | dB<br>dB          |
| Slope                                    | $R_1 = 33\text{k}$ (Note 8)                         |     | 20                      |     | mV/dB             |
| Intercept                                | $V_{OUT} = 0V$ , Extrapolated                       |     | -96                     |     | dBm               |
| Sensitivity                              | (Notes 3, 7)  |     | -77.2                   |     | dBm               |
| Temperature Coefficient                  | $P_{IN} = -20\text{dBm}$                            |     | -0.005                  |     | dB/°C             |

**ELECTRICAL CHARACTERISTICS**  $V_{CC} = 3V$ ,  $ENBL = 3V$ ,  $T_A = 25^\circ C$ , unless otherwise specified. (Notes 3, 4)

| PARAMETER                     | CONDITIONS                                    | MIN | TYP    | MAX | UNITS          |
|-------------------------------|---|-----|--------|-----|----------------|
| <b>f = 100MHz</b>             |   |     |        |     |                |
| Linear Dynamic Range          | $\pm 3dB$ Error                               |     | 90.5   |     | dB             |
|                               | $\pm 1dB$ Error                               |     | 82.8   |     | dB             |
| Slope                         | $R1 = 33k$ (Note 8)                           |     | 20.3   |     | mV/dB          |
| Intercept                     | $V_{OUT} = 0V$ , Extrapolated                 |     | -95    |     | dBm            |
| Sensitivity                   | (Notes 3, 7)                                  |     | -77    |     | dBm            |
| Temperature Coefficient       | $P_{IN} = -20dBm$                             |     | -0.004 |     | dB/ $^\circ C$ |
| <b>f = 200MHz</b>             |   |     |        |     |                |
| Linear Dynamic Range          | $\pm 3dB$ Error                               |     | 90.3   |     | dB             |
|                               | $\pm 1dB$ Error                               |     | 83.5   |     | dB             |
| Slope                         | $R1 = 33k$ (Note 8)                           |     | 21.2   |     | mV/dB          |
| Intercept                     | $V_{OUT} = 0V$ , Extrapolated                 |     | -94    |     | dBm            |
| Sensitivity                   | (Notes 3, 7)                                  |     | -76.4  |     | dBm            |
| Temperature Coefficient       | $P_{IN} = -20dBm$                             |     | 0.010  |     | dB/ $^\circ C$ |
| <b>f = 400MHz</b>             |   |     |        |     |                |
| Linear Dynamic Range          | $\pm 3dB$ Error                               |     | 88.2   |     | dB             |
|                               | $\pm 1dB$ Error                               |     | 70.8   |     | dB             |
| Slope                         | $R1 = 33k$ (Note 8)                           |     | 23.1   |     | mV/dB          |
| Intercept                     | $V_{OUT} = 0V$ , Extrapolated                 |     | -91    |     | dBm            |
| Sensitivity                   | (Notes 3, 7)                                  |     | -75.3  |     | dBm            |
| Temperature Coefficient       | $P_{IN} = -20dBm$                             |     | 0.019  |     | dB/ $^\circ C$ |
| <b>f = 600MHz</b>             |   |     |        |     |                |
| Linear Dynamic Range          | $\pm 3dB$ Error                               |     | 85.8   |     | dB             |
|                               | $\pm 1dB$ Error                               |     | 72.5   |     | dB             |
| Slope                         | $R1 = 33k$ (Note 8)                           |     | 25.2   |     | mV/dB          |
| Intercept                     | $V_{OUT} = 0V$ , Extrapolated                 |     | -89    |     | dBm            |
| Sensitivity                   | (Notes 3, 7)                                  |     | -74.1  |     | dBm            |
| Temperature Coefficient       | $P_{IN} = -20dBm$                             |     | 0.026  |     | dB/ $^\circ C$ |
| <b>f = 1GHz</b>               |   |     |        |     |                |
| Linear Dynamic Range          | $\pm 3dB$ Error                               |     | 63.5   |     | dB             |
|                               | $\pm 1dB$ Error                               |     | 51.7   |     | dB             |
| Slope                         | $R1 = 33k$ (Note 8)                           |     | 31.4   |     | mV/dB          |
| Intercept                     | $V_{OUT} = 0V$ , Extrapolated                 |     | -80    |     | dBm            |
| Sensitivity                   | (Notes 3, 7)                                  |     | -69.2  |     | dBm            |
| Temperature Coefficient       | $P_{IN} = -20dBm$                             |     | 0.031  |     | dB/ $^\circ C$ |
| <b>Output</b>                 |   |     |        |     |                |
| Starting Voltage              | No RF Signal Present                          |     | 0.4    |     | V              |
| Response Time                 | Input from -30dBm to 0dBm, $C_{LOAD} = 2.5pF$ |     | 110    |     | ns             |
| Baseband Modulation Bandwidth | Output Load Capacitance = 2.5pF               |     | 6      |     | MHz            |
| <b>Shutdown Mode</b>          |   |     |        |     |                |
| ENBL = High (On)              |   | 1   |        |     | V              |
| ENBL = Low (Off)              |   |     |        | 0.3 | V              |
| ENBL Input Current            | $V_{ENBL} = 3V$                               |     | 100    |     | $\mu A$        |
|                               | $V_{ENBL} = 0V$                               |     | 0      |     | $\mu A$        |
| Turn-On Time                  |   |     | 100    |     | $\mu s$        |
| Turn-Off Time                 |   |     | 100    |     | $\mu s$        |

5537a

**ELECTRICAL CHARACTERISTICS**  $V_{CC} = 3V$ ,  $ENBL = 3V$ ,  $T_A = 25^\circ C$ , unless otherwise specified. (Notes 3, 4)

| PARAMETER           | CONDITIONS    | MIN | TYP  | MAX  | UNITS   |
|---------------------|---------------|-----|------|------|---------|
| <b>Power Supply</b> |               |     |      |      |         |
| Supply Voltage      | (Note 6)      | 2.7 |      | 5.25 | V       |
| Supply Current      | $V_{CC} = 3V$ | 10  | 13.5 | 15   | mA      |
| Shutdown Current    | $ENBL = Low$  |     | 500  |      | $\mu A$ |

**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:** Maximum differential AC input voltage between  $IN^+$  and  $IN^-$  is 4V peak. Equivalent to 22dBm with  $50\Omega$  input impedance or 16dBm with  $200\Omega$  input impedance (1:4 transformer used).

**Note 3:** Tests are performed as shown in the configuration of Figure 13.

**Note 4:** Specifications over the  $-40^\circ C$  to  $85^\circ C$  temperature range are assured by design, characterization and correlation with statistical process control.

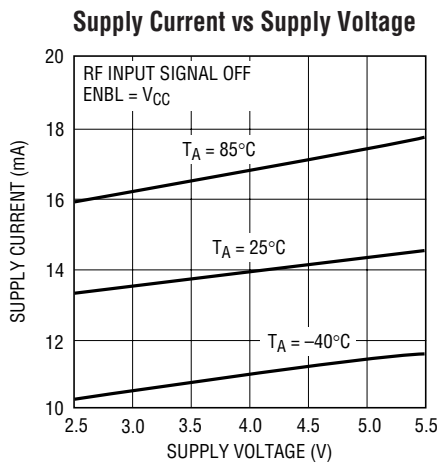
**Note 5:** Operation at lower frequency is possible as described in the “Low Frequency Operation” section in Applications Information.

**Note 6:** The maximum output voltage is limited to approximately  $V_{CC} - 0.6V$ . Either the output slope should be reduced or input power level should be limited in order to avoid saturating the output circuit when  $V_{CC} < 3V$ . See discussion in “Dynamic Range” section.

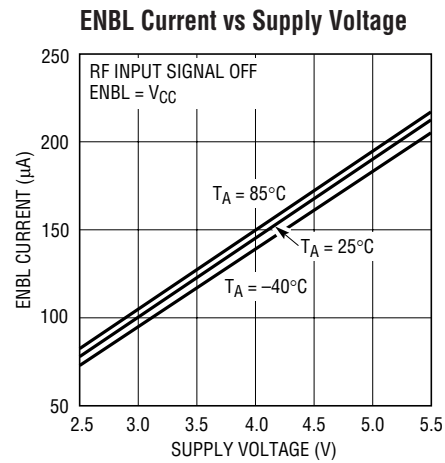
**Note 7:** Sensitivity is defined as the minimum input power required for the output voltage to be within 3dB of the ideal log-linear transfer curve. Sensitivity can be improved by as much as 10dB by using a narrowband input impedance transformation network. See discussion in “Input Matching” section.

**Note 8:** The output slope is adjustable using an external pull-down resistor (R1). See Applications Information for description of the output circuit.

**TYPICAL PERFORMANCE CHARACTERISTICS**



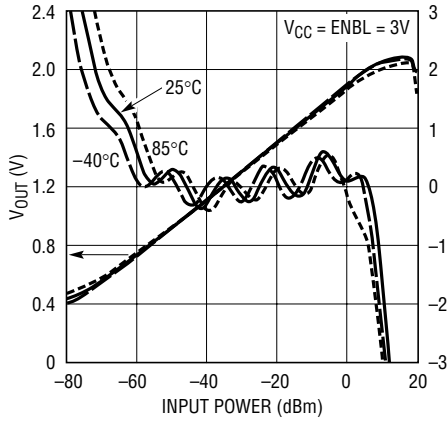
5537 G02



5537 G03

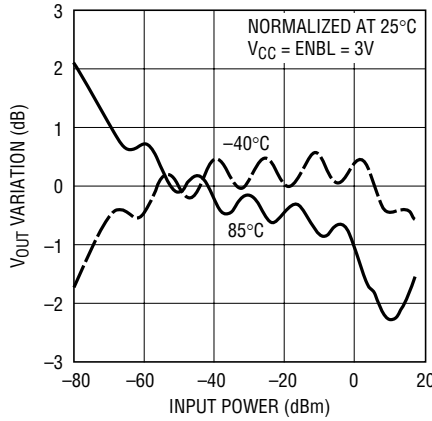
# TYPICAL PERFORMANCE CHARACTERISTICS

**Output Voltage, Linearity Error vs Input Power at 10MHz**



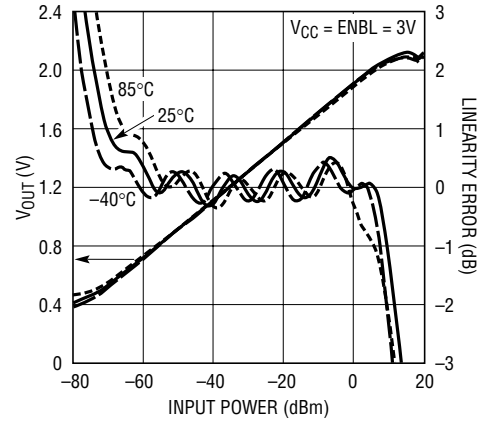
5537 G04

**V<sub>OUT</sub> Variation vs Input Power at 10MHz**



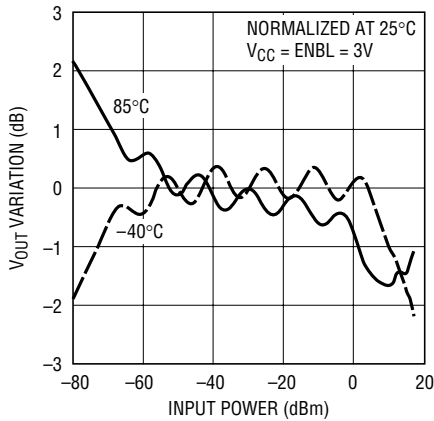
5537 G05

**Output Voltage, Linearity Error vs Input Power at 50MHz**



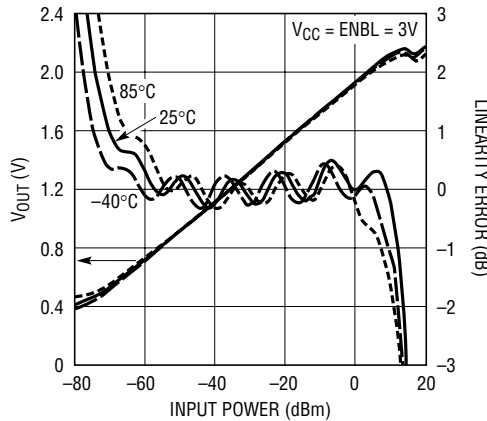
5537 G06

**V<sub>OUT</sub> Variation vs Input Power at 50MHz**



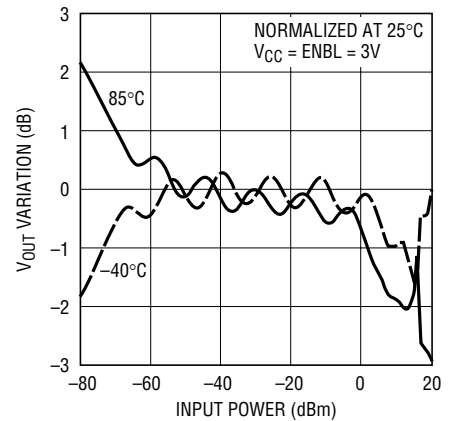
5537 G07

**Output Voltage, Linearity Error vs Input Power at 100MHz**



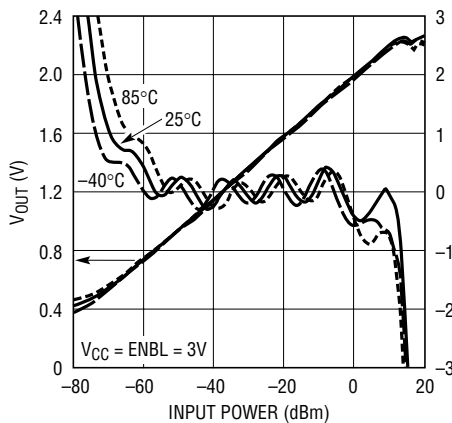
5537 G08

**V<sub>OUT</sub> Variation vs Input Power at 100MHz**



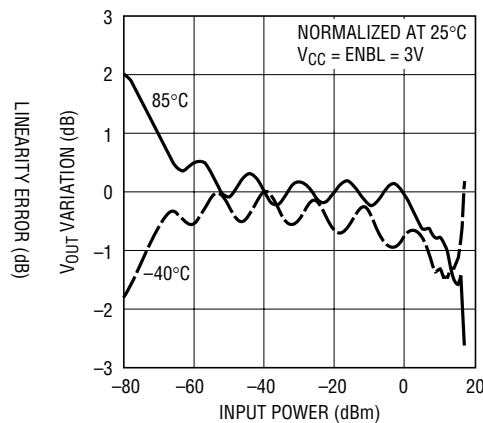
5537 G09

**Output Voltage, Linearity Error vs Input Power at 200MHz**



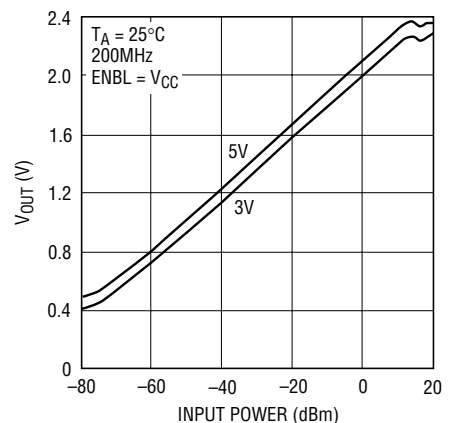
5537 G10

**V<sub>OUT</sub> Variation vs Input Power at 200MHz**



5537 G11

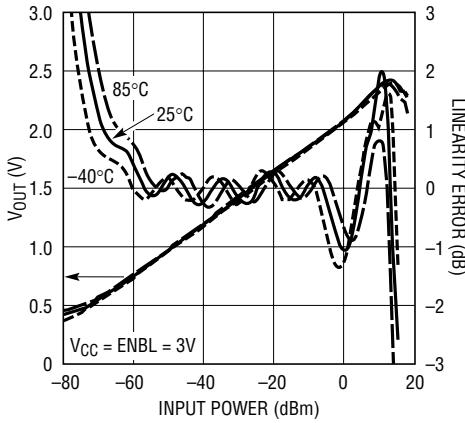
**Typical Detector Characteristics**



5537 G12

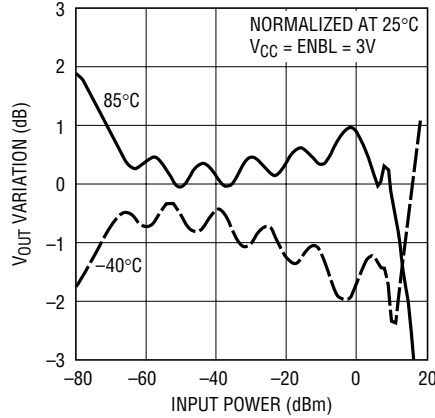
# TYPICAL PERFORMANCE CHARACTERISTICS

**Output Voltage, Linearity Error vs Input Power at 400MHz**



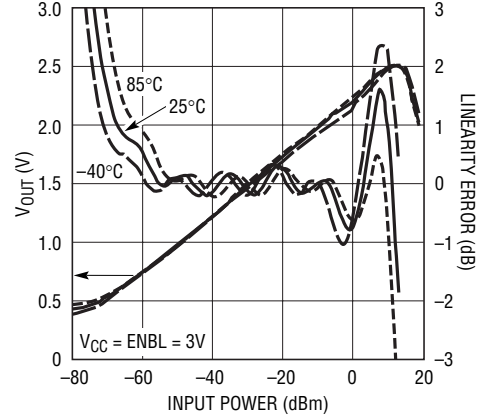
5537 G13

**V<sub>OUT</sub> Variation vs Input Power at 400MHz**



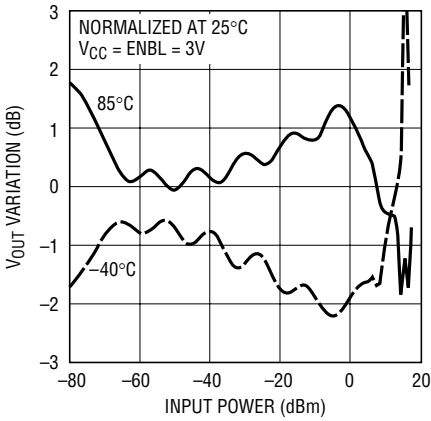
5537 G11

**Output Voltage, Linearity Error vs Input Power at 600MHz**



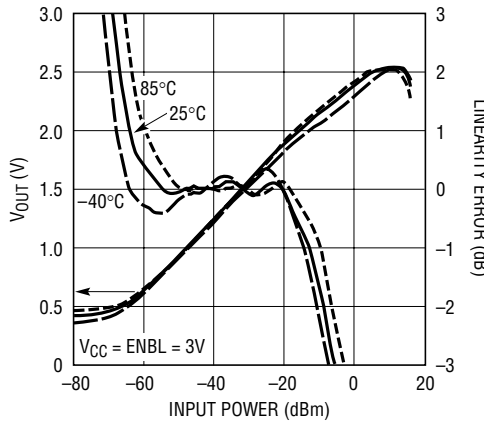
5537 G15

**V<sub>OUT</sub> Variation vs Input Power at 600MHz**



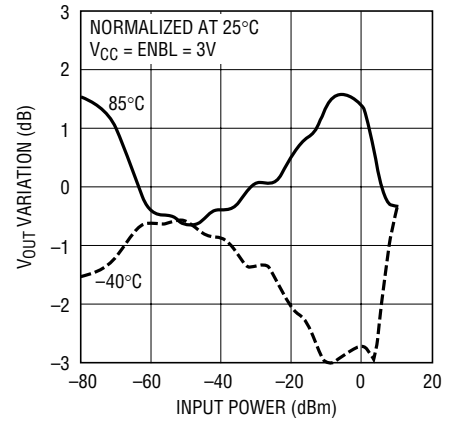
5537 G16

**Output Voltage, Linearity Error vs Input Power at 1GHz**



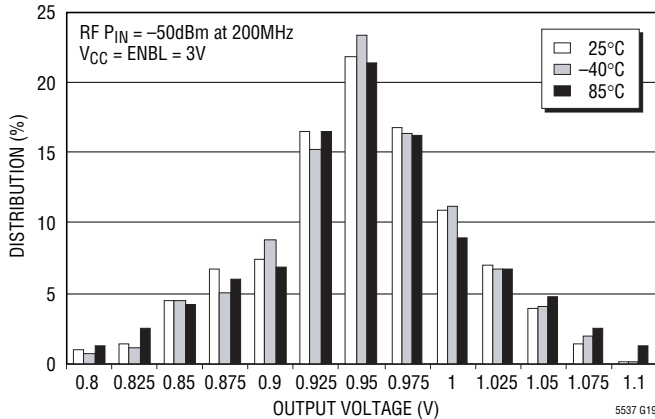
5537 G17

**V<sub>OUT</sub> Variation vs Input Power at 1GHz**



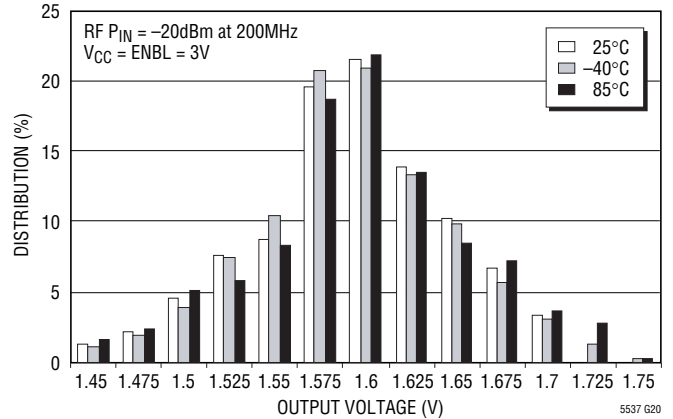
5537 G18

**Output Voltage Distribution vs Temperature at -50dBm**



5537 G19

**Output Voltage Distribution vs Temperature at -20dBm**



5537 G20

## PIN FUNCTIONS

**ENBL (Pin 1):** Enable Pin. When the input voltage is higher than 1V, the circuit is ON. When the input voltage is less than 0.3V, or this pin is not connected, the chip is disabled (OFF).

**IN<sup>+</sup>, IN<sup>-</sup> (Pins 2, 3):** Differential Signal Input Pins. These pins are internally biased to  $V_{CC} - 0.4V$ . The impedance between IN<sup>+</sup> and IN<sup>-</sup> is approximately 1.73k $\Omega$ /1.45pF at 200MHz. The input pins should be AC coupled.

**CAP<sup>+</sup>, CAP<sup>-</sup> (Pins 4, 5):** External Filter Capacitor Pins. The minimum RF input frequency can be lowered by adding an optional external capacitor between CAP<sup>+</sup> and CAP<sup>-</sup>.

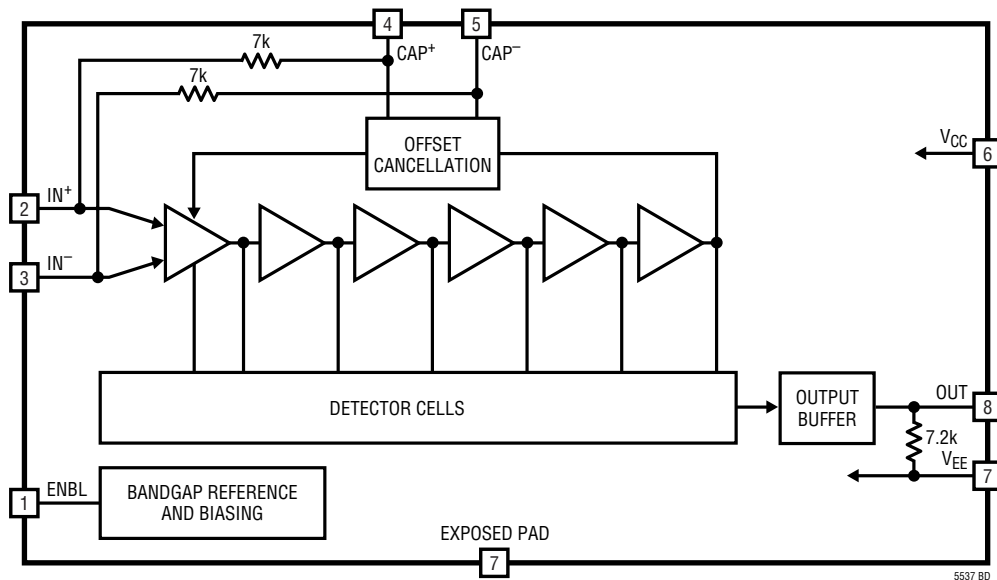
**V<sub>CC</sub> (Pin 6):** Power Supply Pin. This pin should be decoupled using 1000pF and 0.1 $\mu$ F capacitors.

**V<sub>EE</sub> (Pin 7):** Ground pin.

**OUT (Pin 8):** Output pin.

**Exposed Pad (Pin 9):** Should be connected to PCB ground.

## BLOCK DIAGRAM



## APPLICATIONS INFORMATION

The LT5537 provides a log-linear relationship between an RF/IF input voltage and its output. The input signal is amplified successively by limiting amplifier stages. A series of detector cells rectify the signals and produce an output current which is log-linearly related to the input power with a coefficient ( $I_{SLOPE}$ ) of  $3.4\mu\text{A/dB}$  at 200MHz (independent of the input termination impedance). This coefficient is almost constant below 200MHz, but rises at higher frequency. The normalized slope variation plot in Figure 1 can be used to determine the log-linear coefficient at any frequency. The slope of the output voltage curve is determined by the total load resistance at the output terminal.

$$V_{SLOPE} = I_{SLOPE} \cdot R_{LOAD}$$

The on-chip pull-down resistor is 7.2k. The total load resistance ( $R_{LOAD}$ ) can be adjusted by adding external load resistance to change the output slope. For example, to achieve a log-linear rate of 20mV/dB, a 33k resistor is connected between the output pin and ground.

$$\text{Slope} = 3.4\mu\text{A/dB} \cdot (7.2/33)\text{k}\Omega = 20.1\text{mV/dB}$$

Additionally, an off-chip capacitor may be used to reduce the output time domain voltage ripple.

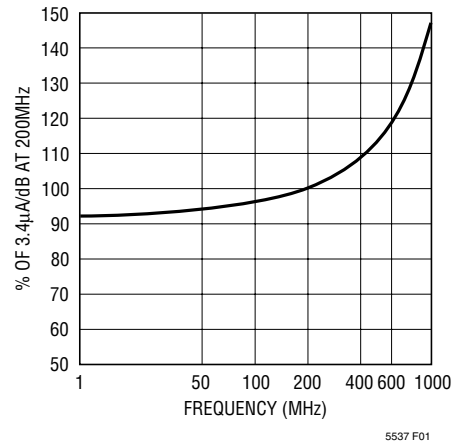


Figure 1. Slope Variation over Frequency

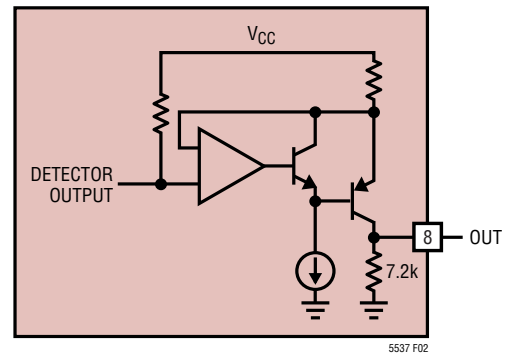


Figure 2. Simplified Output Circuit



# APPLICATIONS INFORMATION

## Dynamic Range

The LT5537 is capable of detecting and log-converting an input signal over a wide dynamic range. The range of the output voltage may be limited, however, and the monotonicity of the output versus input at high input level may be affected if the supply voltage is low and the log-linear slope is set too high. The minimum  $V_{CC}$  to support 90dB dynamic range with 20mV/dB slope is 2.8V under nominal conditions at 25°C. The data shown in the Typical Performance Characteristics plots was taken with  $V_{CC} = 3V$ . If there is difficulty encountered in achieving the desired dynamic range, then the user is advised to increase the supply voltage or else to decrease the output slope by connecting a smaller valued resistor between the output and ground.

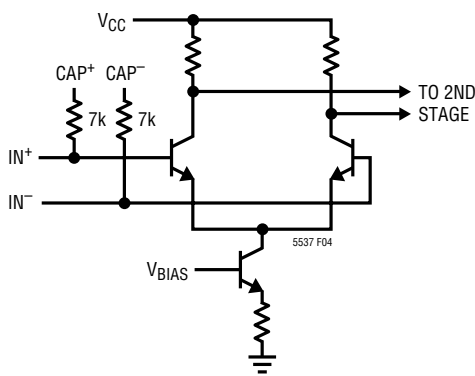


Figure 3. Simplified Input Circuit

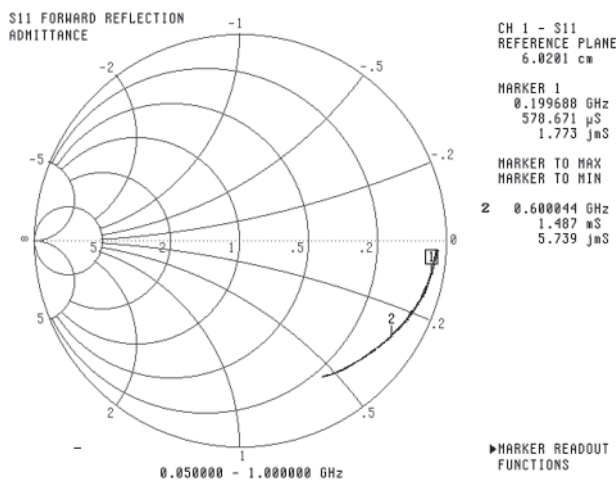


Figure 4. Input Admittance

## Input Matching

The LT5537 has a high impedance input (Figure 3). The differential input impedance is derived from S11 measurement with one of the input pins AC grounded (Figure 4). At 200MHz, the input is equivalent to 1.73k/1.45pF (Table 1).

The input dynamic range is constant in voltage terms, ranging from approximately -89dBVrms to 1dBVrms at 200MHz. The dynamic range expressed in power is dependent on the actual impedance selected in the application design.

Table 1. Parallel Equivalent RC of the LT5537 Input

| FREQUENCY | R      | C      |
|-----------|--------|--------|
| 100MHz    | 1.85kΩ | 1.51pF |
| 200MHz    | 1.73kΩ | 1.45pF |
| 400MHz    | 1.07kΩ | 1.48pF |
| 600MHz    | 673Ω   | 1.52pF |
| 800MHz    | 435Ω   | 1.65pF |
| 1000MHz   | 303Ω   | 1.78pF |

The simplest way of input matching the LT5537 is to terminate the input signal with a 50Ω resistor and AC couple it to one of the input pins while AC grounding the other input pin (Figure 13). The sensitivity (defined as the minimum input power required for the output to be within 3dB of the ideal log-linear response) is -76.4dBm at 200MHz in this case.

To achieve the best sensitivity, the input termination impedance should be increased and the input pins should be differentially driven. An example application circuit is shown in Figure 5 which uses a transformer to step up the impedance and perform the balun function. The 240Ω resistor (R2) sets the impedance at the input of the chip to 200Ω. A 1:4 transformer is used to match the 50Ω signal source impedance to the circuit input impedance. C1 and C2 are DC blocking capacitors. This application circuit has a (3dB error) sensitivity of -82.4dBm at 200MHz.

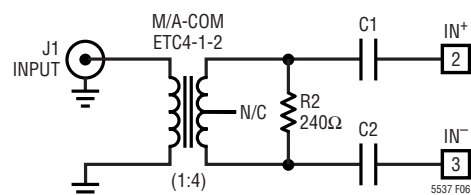


Figure 5. Differential Input Matching to 200Ω

## APPLICATIONS INFORMATION

The 1:4 input transformer can also be replaced with a narrow band discrete balun circuit using three components as shown in Figure 6. Capacitors C11, C12 and inductor L1 form a tank circuit having a transformer-like function over a narrow bandwidth. The increased power-to-voltage transformation and the narrower input passband serve to improve the sensitivity of the logarithmic detector.

The resonant balun circuit using discrete components can be custom designed for a range of different input impedance or sensitivity requirements.

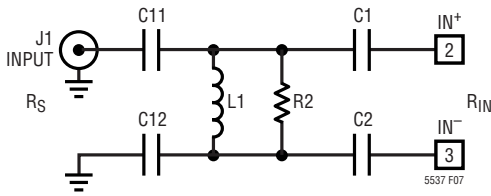


Figure 6. Input Matching Network

Table 2. Matching Network Component Values for 200MHz Center Frequency

| SENSITIVITY (dBm) | 10dB RETURN LOSS BW (MHz) | L1 (nH) | C11, C12 (pF) | R2 (Ω) | Q   | EFFECTIVE INPUT RESISTANCE (Ω) |
|-------------------|---------------------------|---------|---------------|--------|-----|--------------------------------|
| -82.4             | 55                        | 82      | 15            | 330    | 2.1 | 264                            |
| -86.1             | 18                        | 120     | 7.5           | 2k     | 3.9 | 828                            |

The examples given in Table 2 cover two different transformation ratios. The first one transforms single-ended 50Ω to differential 264Ω. The  $V_{OUT}$  vs  $P_{IN}$  transfer curves in Figure 7 indicate that the input power range for linear logarithmic detection is shifted downward by 7dB with a sensitivity improvement of 6dB compared with a simple 50Ω termination. The input return loss is 30dB at the design frequency of 200MHz. Bandwidth for better than 10dB return loss is 55MHz. The second example has a higher Q of 3.9 and a corresponding transformed impedance of 828Ω. The input power range for linear operation is shifted downward by 12dB with a sensitivity improvement of 10dB compared with a simple 50Ω termination. The input return loss is 25dB at the design frequency. Bandwidth for better than 10dB return loss is 18MHz.

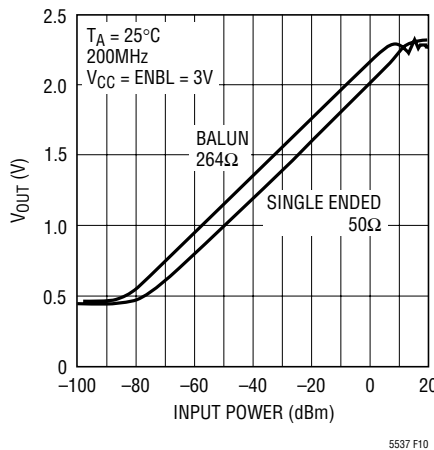


Figure 7. Measured Output with  $R_{IN} = 264\Omega$

## APPLICATIONS INFORMATION

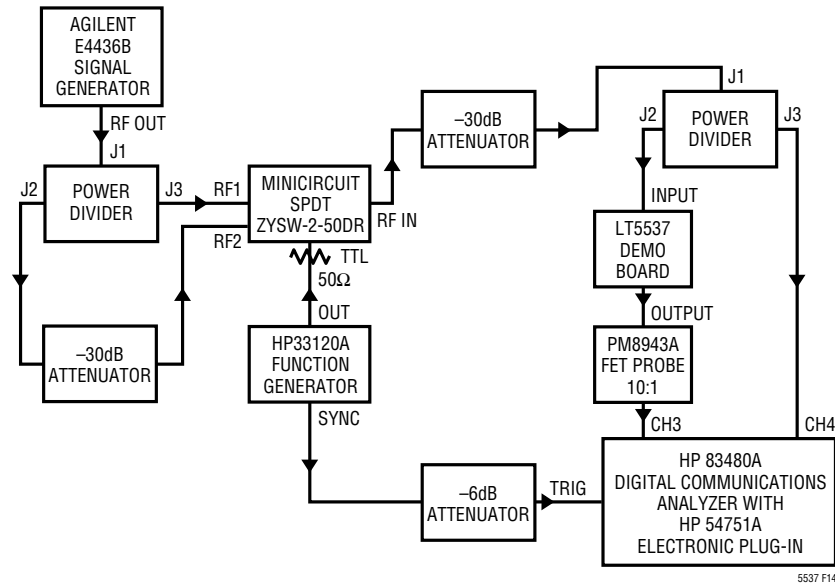


Figure 8. Timing Test Setup

### Baseband Response

The unloaded bandwidth of the LT5537 output buffer is 10MHz. With 2.5pF loading, the output bandwidth is approximately 6MHz. The baseband response of the LT5537 was characterized with a pulsed RF input using the setup shown in Figure 8. The input to the LT5537 is a 200MHz CW RF signal switched between  $-30\text{dBm}$  and  $-60\text{dBm}$  at a rate of 600kHz. The output was connected to a FET probe (Fluke PM8943A, 10:1 tip) which has a capacitive loading of 2.5pF. The 10% to 90% rise and fall times are 109ns and 115ns, respectively. The input signal and output response are shown in Figure 9.

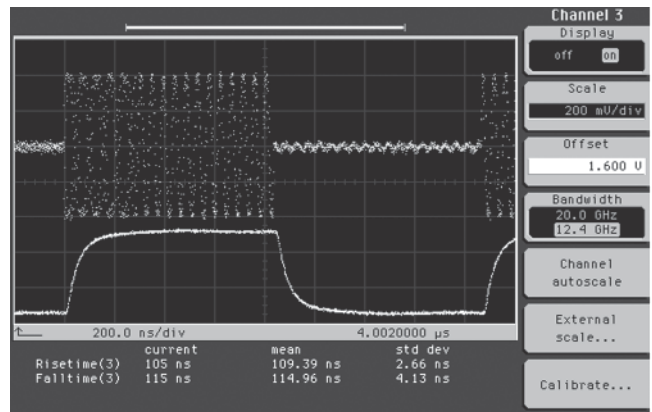


Figure 9. Response Time ( $-30\text{dBm}$  to  $-60\text{dBm}$ )

## APPLICATIONS INFORMATION

Table 3. Application Design Examples

| DESIGN NUMBER | C1, C2 | C6    | INPUT POLE    | INTERNAL POLE | DC REJECTION BW | DC LOOP PM | LOWEST OPERATING FREQUENCY | APPLICATIONS            |
|---------------|--------|-------|---------------|---------------|-----------------|------------|----------------------------|-------------------------|
| 1             | 15nF   | Open  | <b>8.5kHz</b> | 414kHz        | 1.13MHz         | 75°        | 1.13MHz                    | Minimal Component Count |
| 2             | 100pF  | 33nF  | 1.3MHz        | <b>740Hz</b>  | 160kHz          | 84°        | 1.3MHz                     | General Purpose         |
| 3             | 5pF    | 390pF | 20MHz         | <b>50kHz</b>  | 10MHz           | 60°        | 20MHz                      | HF, Fast Settling       |
| 4             | 47nF   | 2.2μF | 2.8kHz        | <b>10Hz</b>   | 2kHz            | 57°        | 2.8kHz                     | Very Low Frequency      |

Bold = dominant pole

### Low Frequency Operation

Because the limiting amplifier stages of the LT5537 are DC coupled, the high overall gain requires DC offset control. The LT5537 has internal DC offset cancellation circuitry. The voltage at the output of the limiting amplifier is low-pass filtered, inverted and fed back to the input of the limiting amplifier. The DC cancellation also reduces the gain of the amplifier at low frequency. As a result, the LT5537 has a bandpass frequency response with a lower end determined by the bandwidth of the offset cancellation feedback loop.

The equivalent circuit of the loop filter is shown in Figure 10. C1 and C2 are the external DC blocking capacitors of the differential inputs; C6 is an optional external filter capacitor which is in parallel with an on-chip filter capacitor ( $C_{INT} = 60\text{pF}$ ). For analysis purposes only, the values for C6 and the on-chip filter capacitor are doubled when a single-ended equivalent circuit is derived from a differential implementation.

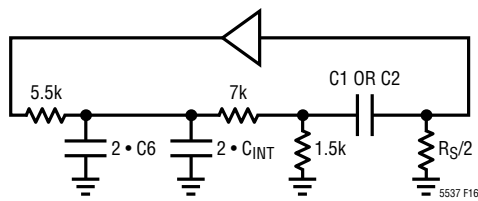


Figure 10. Offset Cancellation Loop Filter

The optional capacitance (C6) placed between CAP+ (Pin 4) and CAP- (Pin 5) together with the input DC blocking capacitors C1 and C2 are used to adjust the operating frequency range. The DC offset cancellation loop contains two poles and one zero (in the low frequency region for the purpose of this analysis). The loop filter capacitance ( $C6 + C_{INT}$ ) generates one of the two poles, the input AC coupling capacitors (C1 and C2) determine the other pole and the input termination resistance leads to the zero. (The pole associated with the input AC coupling capacitor also sets the lower corner frequency of the signal path). The presence of the two poles in the circuit enables two approaches to the design of the application circuit for a desired frequency response. But stability margin has to be ensured in order to avoid ringing in response to any input transient. Table 3 lists four low frequency loop designs suitable for different applications.

Design 1 is the simplest application circuit. The external capacitor C6 is not used. The input pole is set by the AC coupling capacitors (C1, C2) and is the dominant pole at 8.5kHz. The zero generated by the input coupling capacitor and the termination resistor is at 60 times the input pole frequency. The second pole set by the on-chip filter capacitor ( $C_{INT}$ ) should be at approximately the same frequency as that of the zero. This design has a stability phase margin (PM) of 75 degrees.

## APPLICATIONS INFORMATION

Design 2 is the application circuit (Figure 13) used for characterization in this data sheet. This is a robust general purpose design which can operate as low as 1.3MHz. Optional filter capacitor (C6 = 33nF) together with the on-chip capacitor set the dominant pole at 740Hz. The input pole associated with the AC coupling capacitors (C1, C2 = 100pF) is at 1.3MHz which is beyond the loop cut-off frequency of 160kHz. The zero is at an even higher frequency and can be safely ignored. This design has a stability phase margin of 84 degrees, resulting in a very well damped response to any input biasing transients.

Design 3 features fast settling. This design is appropriate when fast response in the presence of input biasing transients is required, and very low frequency operation is not needed.

Design 4 demonstrates the possibility of operating the LT5537 at very low frequency (<10kHz) by configuring the offset cancellation loop for very low bandwidth. The response of this circuit at 10kHz is plotted in Figure 11.

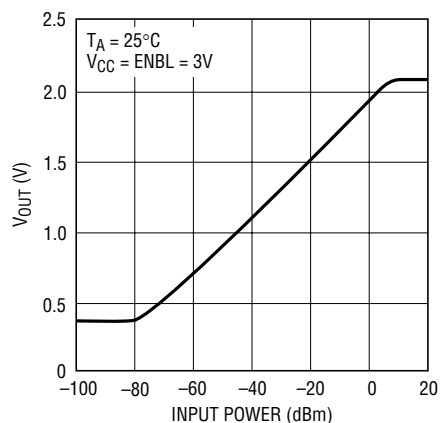


Figure 11. 10kHz Operation

### Offset Cancellation Loop and the Timing Response

The input of the LT5537 is AC coupled, and the on-chip DC biasing is automatically regulated as described above. But if the DC component of the input signal has any transient step with sufficiently short rise or fall time (for example the output of an active RF switch has a biasing shift between switching states), a transient voltage pulse is induced by the displacement current needed to charge the input AC coupling capacitor. Also, if the pulse frequency or the repetition rate is within the loop bandwidth of the offset cancellation circuit, the LT5537 will respond to the induced voltage pulse in the same way it nulls out its internal DC offset, even though the chip is DC isolated from the input signal.

If the external capacitor (C6) is used to extend the low frequency response of the LT5537, then this will also lengthen the response time of the DC offset cancellation circuit. In the presence of DC steps or glitches at the input, the transient response of the slowed offset cancellation loop will be superimposed on the faster logarithmic detector output, degrading the overall response time of the chip.

The sensitivity of the LT5537 is very high. An input biasing step with amplitude of 0.5mV can generate a output voltage response of 400mV before the input voltage transient dissipates or the offset cancellation loop nulls out the transient, whichever occurs first.

One way to prevent the input signal containing a biasing transient from degrading the timing response is to design the offset cancellation loop to have a high bandwidth, allowing faster settling. Design 3 in Table 3 is suitable for this purpose, but will not operate below 20MHz.

## APPLICATIONS INFORMATION

### Enable Pin Operation

The enable circuit of the LT5537 is shown in a simplified form in Figure 12. When the voltage at the ENBL pin is  $\geq 1V$ , the enable circuit biases the chip up for normal operation. The current drawn by the ENBL pin is dependent on the voltage on that pin. At  $V_{CC} = ENBL = 3V$ , the ENBL current is typically  $100\mu A$ . At  $V_{CC} = ENBL = 5V$ , the ENBL current increases to about  $200\mu A$ . When the voltage at the ENBL pin is  $\leq 0.3V$ , or if the pin is not connected, the chip is disabled and draws a reduced supply current of about  $500\mu A$ , with  $V_{CC} = 3V$ .

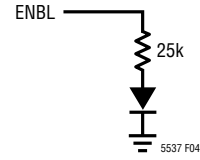


Figure 12. Equivalent ENBL Input Circuit

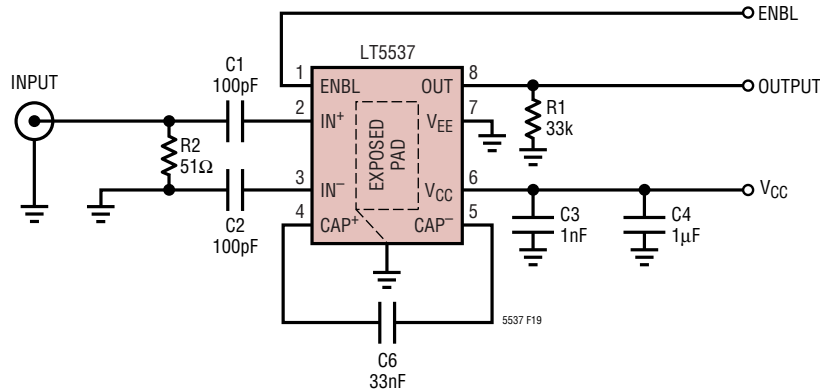


Figure 13. Application Board Schematic

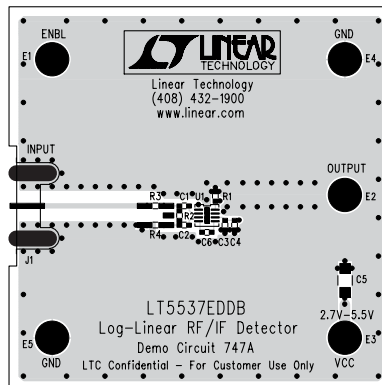
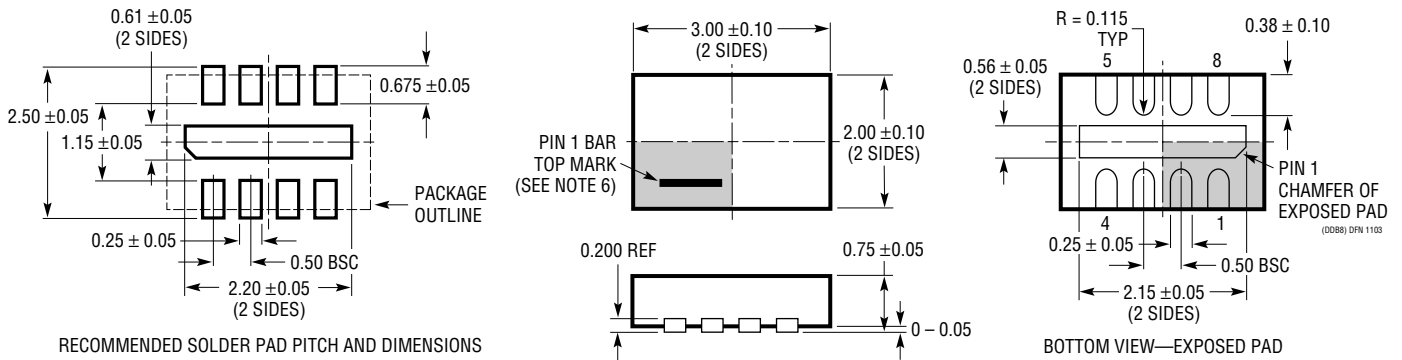


Figure 14. Layout of the Evaluation Board

# PACKAGE DESCRIPTION

## DDB Package 8-Lead Plastic DFN (3mm × 2mm) (Reference LTC DWG # 05-08-1702)



RECOMMENDED SOLDER PAD PITCH AND DIMENSIONS

**NOTE:**

1. DRAWING CONFORMS TO VERSION (WECD-1) IN JEDEC PACKAGE OUTLINE M0-229
2. DRAWING NOT TO SCALE
3. ALL DIMENSIONS ARE IN MILLIMETERS
4. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.15mm ON ANY SIDE
5. EXPOSED PAD SHALL BE SOLDER PLATED
6. SHADED AREA IS ONLY A REFERENCE FOR PIN 1 LOCATION ON THE TOP AND BOTTOM OF PACKAGE

**RELATED PARTS**

| PART NUMBER                          | DESCRIPTION   | COMMENTS   |
|--------------------------------------|---|--|
| <b>Infrastructure</b>                |   |  |
| LT5511                               | High Linearity Upconverting Mixer   | RF Output to 3GHz, 17dBm IIP3, Integrated LO Buffer  |
| LT5512                               | DC-3GHz High Signal Level Downconverting Mixer                              | DC to 3GHz, 17dBm IIP3, Integrated LO Buffer   |
| LT5514                               | Ultralow Distortion, IF Amplifier/ADC Driver with Digitally Controlled Gain | 850MHz Bandwidth, 47dBm OIP3 at 100MHz, 10.5dB to 33dB Gain Control Range  |
| LT5515                               | 1.5GHz to 2.5GHz Direct Conversion Quadrature Demodulator                   | 20dBm IIP3, Integrated LO Quadrature Generator   |
| LT5516                               | 0.8GHz to 1.5GHz Direct Conversion Quadrature Demodulator                   | 21.5dBm IIP3, Integrated LO Quadrature Generator   |
| LT5517                               | 40MHz to 900MHz Quadrature Demodulator                                      | 21dBm IIP3, Integrated LO Quadrature Generator   |
| LT5519                               | 0.7GHz to 1.4GHz High Linearity Upconverting Mixer                          | 17.1dBm IIP3 at 1GHz, Integrated RF Output Transformer with 50Ω Matching, Single-Ended LO and RF Ports Operation   |
| LT5520                               | 1.3GHz to 2.3GHz High Linearity Upconverting Mixer                          | 15.9dBm IIP3 at 1.9GHz, Integrated RF Output Transformer with 50Ω Matching, Single-Ended LO and RF Ports Operation |
| LT5521                               | 10MHz to 3700MHz High Linearity Upconverting Mixer                          | 24.2dBm IIP3 at 1.95GHz, NF = 12.5dB, 3.15V to 5.25V Supply, Single-Ended LO Port Operation                        |
| LT5522                               | 400MHz to 2.7GHz High Signal Level Downconverting Mixer                     | 4.5V to 5.25V Supply, 25dBm IIP3 at 900MHz, NF = 12.5dB, 50Ω Single-Ended RF and LO Ports                          |
| LT5524                               | Low Power, Low Distortion ADC Driver with Digitally Programmable Gain       | 450MHz Bandwidth, 40dBm OIP3, 4.5dB to 27dB Gain Control   |
| LT5525                               | High Linearity, Low Power Downconverting Mixer                              | Single-Ended 50Ω RF and LO Ports, 17.6dBm IIP3 at 1900MHz, I <sub>CC</sub> = 28mA                                  |
| LT5526                               | High Linearity, Low Power Downconverting Mixer                              | 3V to 5.3V Supply, 16.5dBm IIP3, 100kHz to 2GHz RF, NF = 11dB, I <sub>CC</sub> = 28mA, -65dBm LO-RF Leakage        |
| LT5527                               | 400MHz to 3.7GHz High Linearity, Downconverting Mixer                       | 23.5dBm IIP3, 12.5dB NF at 1.9GHz, 50Ω Single-Ended RF and LO Ports  |
| LT5528                               | 1.5GHz to 2.4GHz High Linearity Direct I/Q Modulator                        | 21.8dBm OIP3 at 2GHz, -159dBm/Hz Noise Floor, 50Ω Interface at All Ports   |
| <b>RF Power Detectors</b>            |   |  |
| LT5504                               | 800MHz to 2.7GHz RF Measuring Receiver                                      | 80dB Dynamic Range, Temperature Compensated, 2.7V to 5.25V Supply  |
| LTC®5505                             | RF Power Detectors with >40dB Dynamic Range                                 | 300MHz to 3GHz, Temperature Compensated, 2.7V to 6V Supply   |
| LTC5507                              | 100kHz to 1000MHz RF Power Detector   | 100kHz to 1GHz, Temperature Compensated, 2.7V to 6V Supply   |
| LTC5508                              | 300MHz to 7GHz RF Power Detector  | 44dB Dynamic Range, Temperature Compensated, SC70 Package  |
| LTC5509                              | 300MHz to 3GHz RF Power Detector  | 36dB Dynamic Range, Low Power Consumption, SC70 Package  |
| LTC5530                              | 300MHz to 7GHz Precision RF Power Detector                                  | Precision V <sub>OUT</sub> Offset Control, Shutdown, Adjustable Gain   |
| LTC5531                              | 300MHz to 7GHz Precision RF Power Detector                                  | Precision V <sub>OUT</sub> Offset Control, Shutdown, Adjustable Offset   |
| LTC5532                              | 300MHz to 7GHz Precision RF Power Detector                                  | Precision V <sub>OUT</sub> Offset Control, Adjustable Gain and Offset  |
| LT5534                               | 50MHz to 3GHz RF Power Detector with 60dB Dynamic Range                     | ±1dB Output Variation over Temperature, 38ns Response Time   |
| LTC5536                              | Precision 600MHz to 7GHz RF Detector with Fast Comparator Output            | 25ns Response Time, Comparator Reference Input, Latch Enable Input, -26dBm to +12dBm Input Range                   |
| <b>Low Voltage RF Building Block</b> |   |  |
| LT5546                               | 500MHz Quadrature Demodulator with VGA and 17MHz Baseband Bandwidth         | 17MHz Baseband Bandwidth, 40MHz to 500MHz IF, 1.8V to 5.25V Supply, -7dB to 56dB Linear Power Gain                 |
| <b>Wide Bandwidth ADCs</b>           |   |  |
| LTC1749                              | 12-Bit, 80Msps  | 500MHz BW S/H, 71.8dB SNR  |
| LTC1750                              | 14-Bit, 80Msps  | 500MHz BW S/H, 75.5dB SNR  |