Precision 300MHz to 7GHz RF Detector with Shutdown and Offset Adjustment

FEATURES

- **Temperature Compensated Internal Schottky Diode RF Detector**
- **Wide Input Frequency Range: 300MHz to 7GHz***
- **Wide Input Power Range: –32dBm to 10dBm**
- **Buffered Detector Output**
- **Precision V_{OUT} Offset Control**
- **Wide V_{CC} Range of 2.7V to 6V**
- Low Operating Current: 500µA
- Low Shutdown Current: <2µA
- Available in a Low Profile (1mm) SOT-23 Package

APPLICATIONS

- 802.11a, 802.11b, 802.11g, 802.15, 802.16
- Multimode Mobile Phone Products
- Optical Data Links
- Wireless Data Modems
- Wireless and Cable Infrastructure
- RF Power Alarm
- Envelope Detector

DESCRIPTION

The LTC®5531 is an RF power detector for RF applications operating in the 300MHz to 7GHz range. A temperature compensated Schottky diode peak detector and buffer amplifier are combined in a small ThinSOT™ package. The supply voltage range is optimized for operation from a single lithium-ion cell or 3xNiMH.

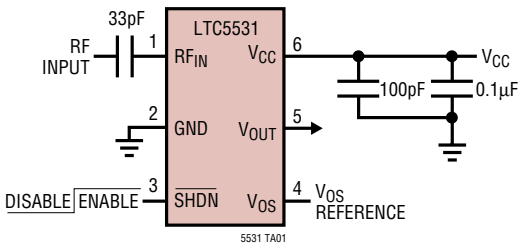
The RF input voltage is peak detected using an on-chip Schottky diode. The detected voltage is buffered and supplied to the V_{OUT} pin. A power saving shutdown mode reduces current to less than 2µA. The initial offset voltage of 120mV ±35mV can be precisely adjusted using the V_{OS} pin.

The LTC5531 operates with input power levels from –32dBm to 10dBm.

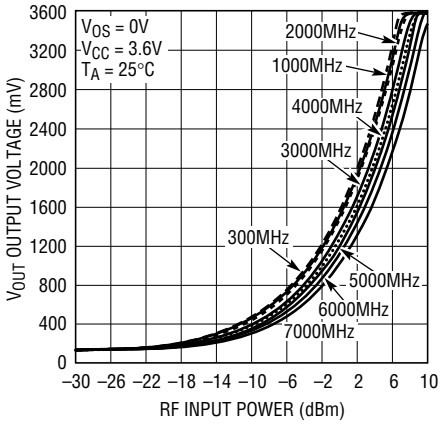
*Higher frequency operation is achievable with reduced performance. Consult factory for more information.

TYPICAL APPLICATION

300MHz to 7GHz RF Power Detector



V_{OUT} Output Voltage vs RF Input Power

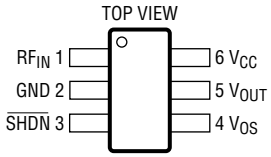


ABSOLUTE MAXIMUM RATINGS

(Note 1)

V_{CC}, V_{OUT}, $\overline{SHDN}$, V_{OS} ..... –0.3V to 6.5V
RF_{IN} Voltage ..... (V_{CC} ± 1.5V) to 7V
RF_{IN} Power (RMS) 12dBm
I_{VOUT} 5mA
Operating Temperature Range (Note 2) .. –40°C to 85°C
Maximum Junction Temperature ..... 125°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PACKAGE/ORDER INFORMATION



S6 PACKAGE
6-LEAD PLASTIC TSOT-23
T_{JMAX} = 125°C, θ_{JA} = 250°C/W

ORDER PART NUMBER
LTC5531ES6
S6 PART MARKING
LTBBQ

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

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_{CC} = 3.6V, $\overline{SHDN}$ = V_{CC} = HI, $\overline{SHDN}$ = 0V = LO, RF Input Signal is Off, V_{OS} = 0V and $\overline{SHDN}$ = HI unless otherwise noted.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{CC} Operating Voltage		●	2.7		6	V
I_{VCC} Operating Current	I_{VOUT} = 0mA	●		0.5	0.7	mA
I_{VCC} Shutdown Current	$\overline{SHDN}$ = LO	●		0.01	2	µA
V_{OUT} (No RF Input)	R_{LOAD} = 2k, V_{OS} = 0V $\overline{SHDN}$ = LO	●	85	100 to 140 1	155	mV mV
V_{OUT} Output Current	V_{OUT} = 1.75V, V_{CC} = 2.7V, ΔV_{OUT} < 10mV	●	2	4		mA
V_{OUT} Enable Time	$\overline{SHDN}$ = LO to HI, C_{LOAD} = 33pF, R_{LOAD} = 2k	●		8	20	µs
V_{OUT} Bandwidth	C_{LOAD} = 33pF, R_{LOAD} = 2k (Note 4)			2		MHz
V_{OUT} Load Capacitance	(Notes 6, 7)	●			33	pF
V_{OUT} Slew Rate	V_{RFIN} = 1V Step, C_{LOAD} = 33pF, R_{LOAD} = 2k (Note 3)			3		V/µs
V_{OUT} Noise	V_{CC} = 3V, Noise BW = 1.5MHz, 50Ω RF Input Termination			1		mV_{P-P}
V_{OS} Voltage Range		●	0		1	V
$\overline{V_{OS}}$ Input Current		●	–0.5		0.5	µA
$\overline{SHDN}$ Voltage, Chip Disabled	V_{CC} = 2.7V to 6V	●			0.35	V
$\overline{SHDN}$ Voltage, Chip Enabled	$\overline{V_{CC}}$ = 2.7V to 6V	●	1.4			V
SHDN Input Current	SHDN = 3.6V	●		22	36	µA
RF_{IN} Input Frequency Range	(Note 8)			300 to 7000		MHz
RF_{IN} Input Power Range	RF Frequency = 300MHz to 7GHz (Note 5, 6) V_{CC} = 2.7V to 6V			–32 to 10		dBm
RF_{IN} AC Input Resistance	F = 1000MHz, Pin = –25dBm			220		Ω
RF_{IN} Input Shunt Capacitance	F = 1000MHz, Pin = –25dBm			0.65		pF

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: Specifications over the –40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.

Note 3: The rise time at V_{OUT} is measured between 1.3V and 2.3V.

Note 4: Bandwidth is calculated based on the 10% to 90% rise time equation: BW = 0.35/rise time.

Note 5: RF performance is tested at 1800MHz

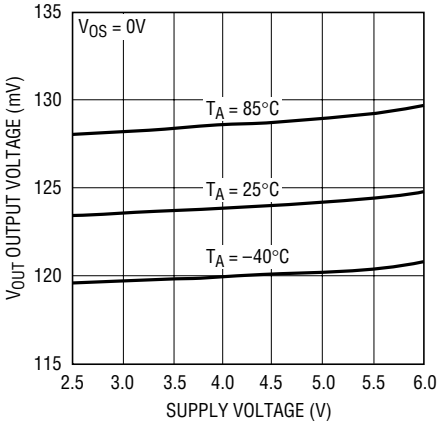
Note 6: Guaranteed by design.

Note 7: Capacitive loading greater than this value may result in circuit instability.

Note 8: Higher frequency operation is achievable with reduced performance. Consult factory for more information.

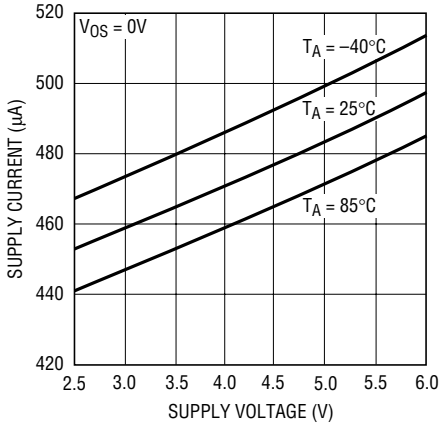
TYPICAL PERFORMANCE CHARACTERISTICS

V_{OUT} Output Voltage vs V_{CC} Supply Voltage (RF Input Signal Off)



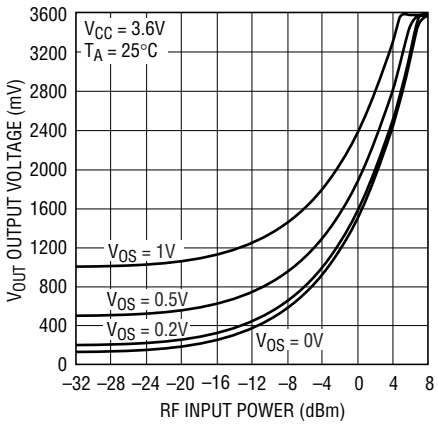
5531 G01

I_{CC} Power Supply Current vs V_{CC} Supply Voltage (RF Input Signal Off)



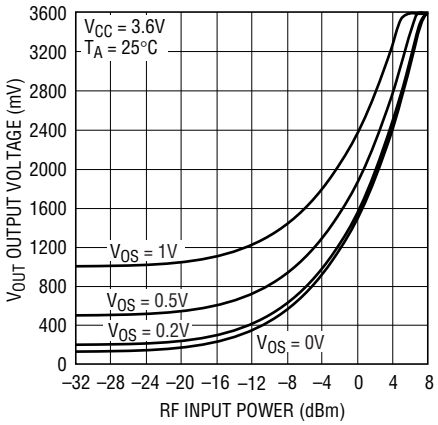
5531 G02

V_{OUT} vs RF Input Power and V_{OS}, f_{RF} = 300MHz



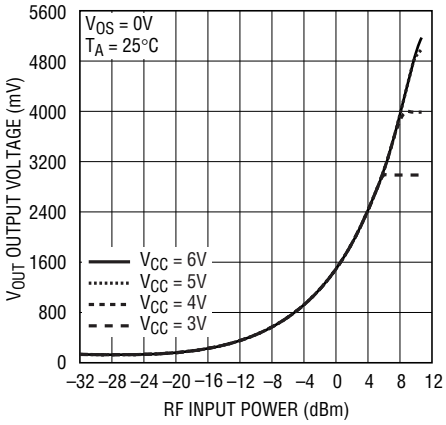
5531 G03

V_{OUT} vs RF Input Power and V_{OS}, f_{RF} = 1000MHz



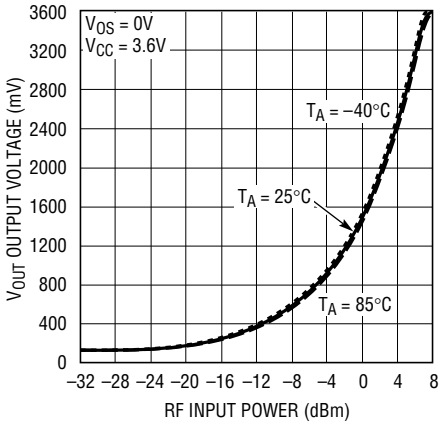
5531 G04

V_{OUT} vs RF Input Power and V_{CC} Supply Voltage, f_{RF} = 1000MHz



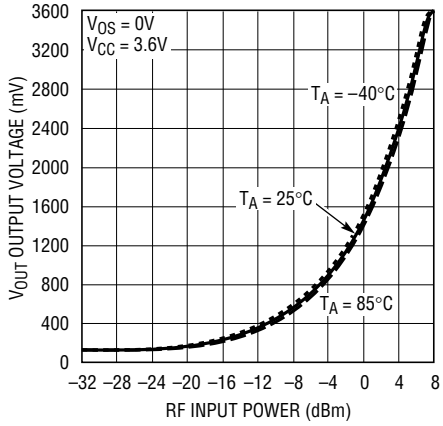
5531 G05

Typical Detector Characteristics, 300MHz



5531 G06

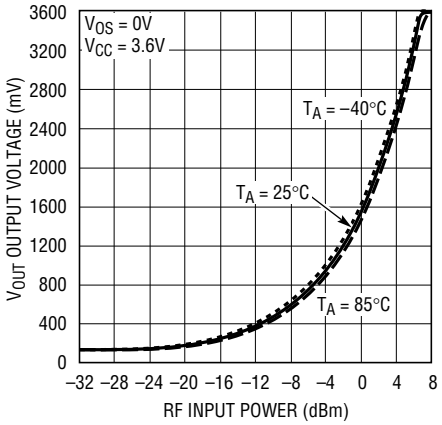
Typical Detector Characteristics, 1000MHz



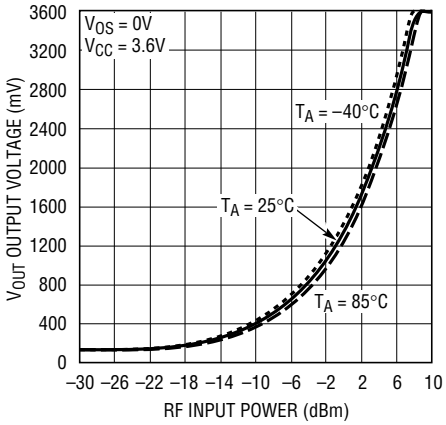
5531 G07

TYPICAL PERFORMANCE CHARACTERISTICS

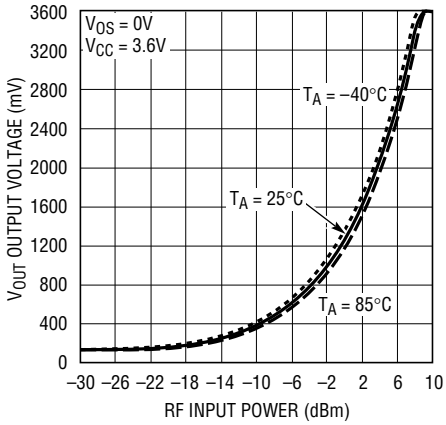
Typical Detector Characteristics, 2000MHz



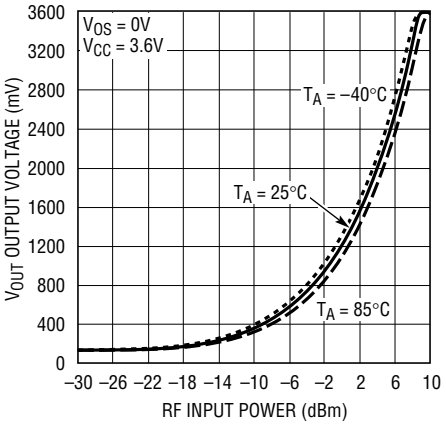
Typical Detector Characteristics, 3000MHz



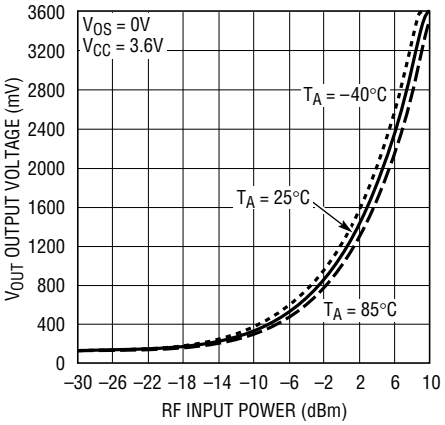
Typical Detector Characteristics, 4000MHz



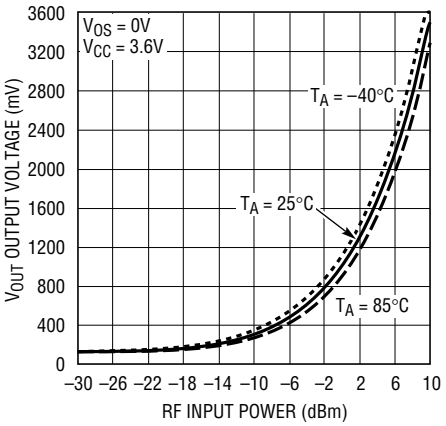
Typical Detector Characteristics, 5000MHz



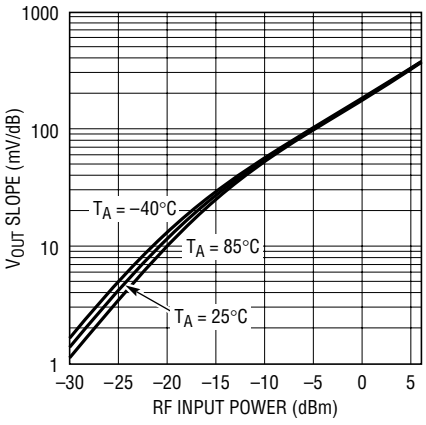
Typical Detector Characteristics, 6000MHz



Typical Detector Characteristics, 7000MHz

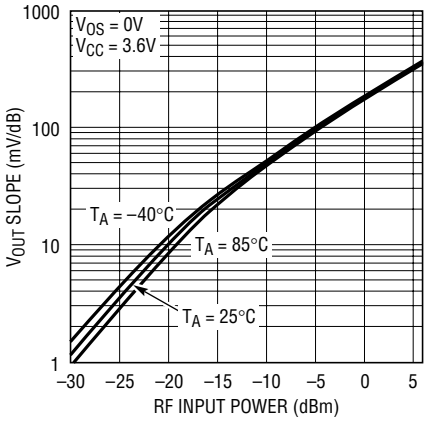


V_{OUT} Slope vs RF Input Power at 300MHz

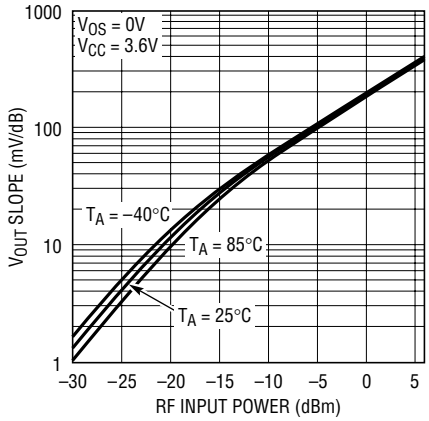


TYPICAL PERFORMANCE CHARACTERISTICS

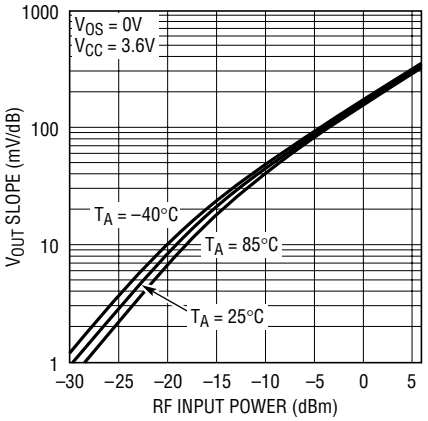
V_{OUT} Slope vs RF Input Power at 1000MHz



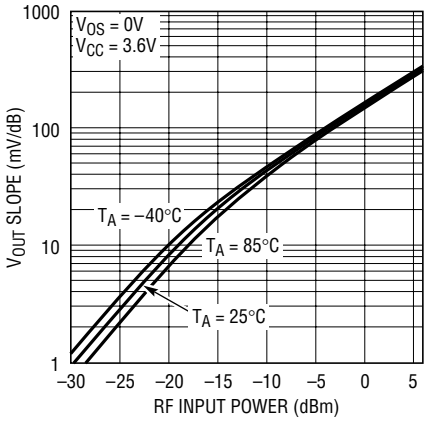
V_{OUT} Slope vs RF Input Power at 2000MHz



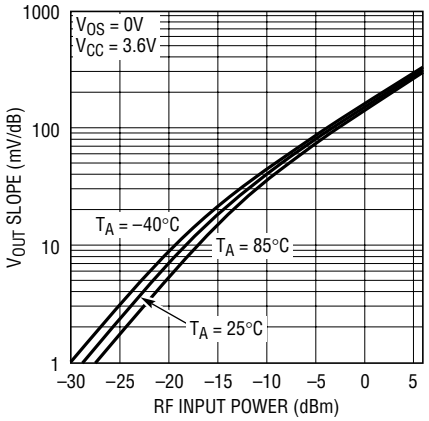
V_{OUT} Slope vs RF Input Power at 3000MHz



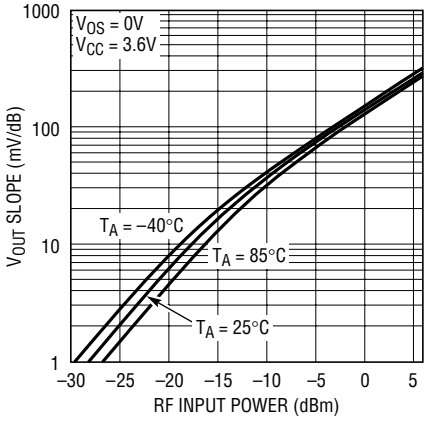
V_{OUT} Slope vs RF Input Power at 4000MHz



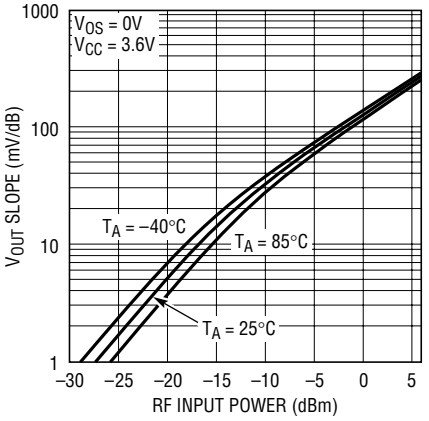
V_{OUT} Slope vs RF Input Power at 5000MHz



V_{OUT} Slope vs RF Input Power at 6000MHz



V_{OUT} Slope vs RF Input Power at 7000MHz

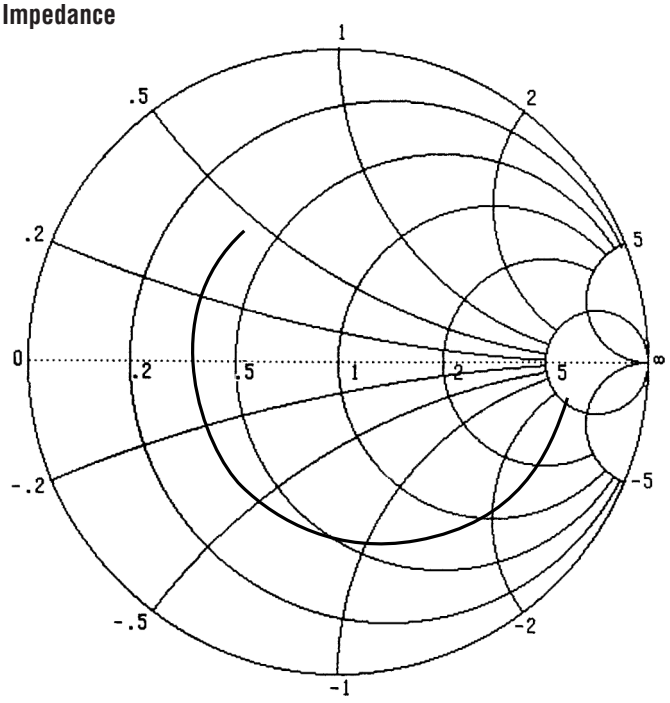


TYPICAL PERFORMANCE CHARACTERISTICS

RF_{IN} Input Impedance (Pin = 0dBm, V_{CC} = 3.6V, T_A = 25°C)

FREQUENCY (GHz)	RESISTANCE (Ω)	REACTANCE (Ω)
0.30	290.45	–136.22
0.50	234.41	–162.54
0.70	178.25	–170.53
0.90	137.31	–159.89
1.10	109.17	–147.57
1.30	86.30	–136.18
1.50	68.65	–121.74
1.70	57.48	–107.60
1.90	49.79	–96.72
2.10	43.56	–86.70
2.30	38.67	–77.91
2.50	34.82	–70.13
2.70	31.68	–62.86
2.90	29.13	–56.01
3.10	27.17	–49.83
3.30	25.73	–44.24
3.50	24.56	–39.74
3.70	23.18	–35.35
3.90	22.31	–30.62
4.10	20.73	–26.88
4.30	19.88	–22.31
4.50	19.40	–18.23
4.70	19.05	–14.25
4.90	19.08	–10.21
5.10	19.55	–6.30
5.30	20.85	–2.84
5.50	21.94	–1.49
5.70	20.60	–0.07
5.90	19.29	2.99
6.10	18.69	6.61
6.30	18.53	10.39
6.50	18.74	14.35
6.70	19.79	17.91
6.90	19.75	20.77
7.00	19.99	22.47

S11 Forward Reflection Impedance



0.3000GHz-7.000GHz

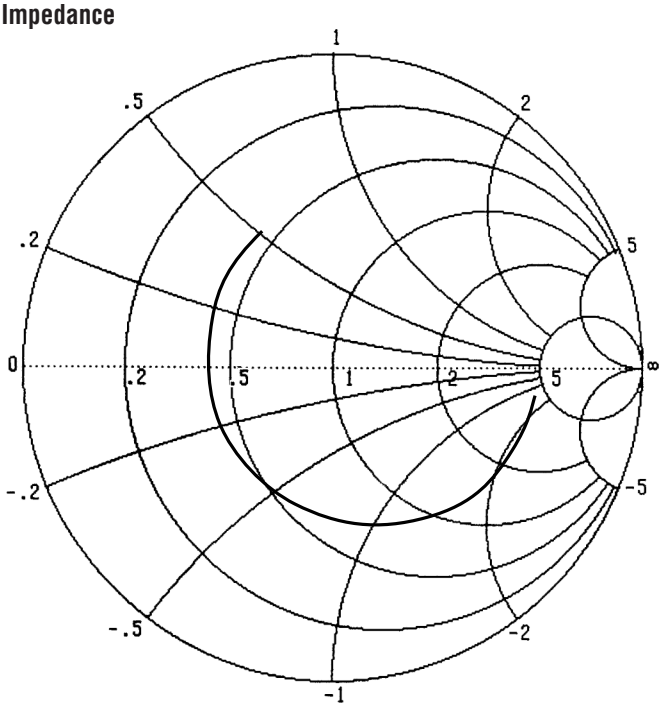
5508 TA03

TYPICAL PERFORMANCE CHARACTERISTICS

RF_{IN} Input Impedance (Pin = –25dBm, V_{CC} = 3.6V, T_A = 25°C)

FREQUENCY (GHz)	RESISTANCE (Ω)	REACTANCE (Ω)
0.30	216.45	–76.47
0.50	190.63	–98.28
0.70	161.98	–112.03
0.90	133.17	–111.53
1.10	113.08	–109.05
1.30	94.55	–107.08
1.50	75.33	–98.50
1.70	63.52	–88.19
1.90	55.19	–80.05
2.10	48.64	–72.23
2.30	43.73	–64.81
2.50	39.71	–58.31
2.70	36.47	–52.27
2.90	33.69	–46.77
3.10	31.61	–41.25
3.30	29.78	–36.61
3.50	28.27	–32.39
3.70	26.63	–28.12
3.90	26.12	–23.97
4.10	24.20	–20.75
4.30	23.28	–16.69
4.50	22.60	–12.77
4.70	22.21	–9.08
4.90	22.15	–5.24
5.10	22.61	–1.58
5.30	23.90	1.53
5.50	24.97	2.62
5.70	23.51	4.00
5.90	22.25	6.94
6.10	21.57	10.62
6.30	21.43	14.02
6.50	21.69	17.77
6.70	22.68	21.24
6.90	22.81	24.21
7.00	23.07	25.56

S11 Forward Reflection Impedance



0.3000GHz-7.000GHz

5508 TA04

PIN FUNCTIONS

RF_{IN} (Pin 1): RF Input Voltage. Referenced to V_{CC}. A coupling capacitor must be used to connect to the RF signal source. The frequency range is 300MHz to 7GHz. This pin has an internal 500Ω termination, an internal Schottky diode detector and a peak detector capacitor.

GND (Pin 2): Ground.

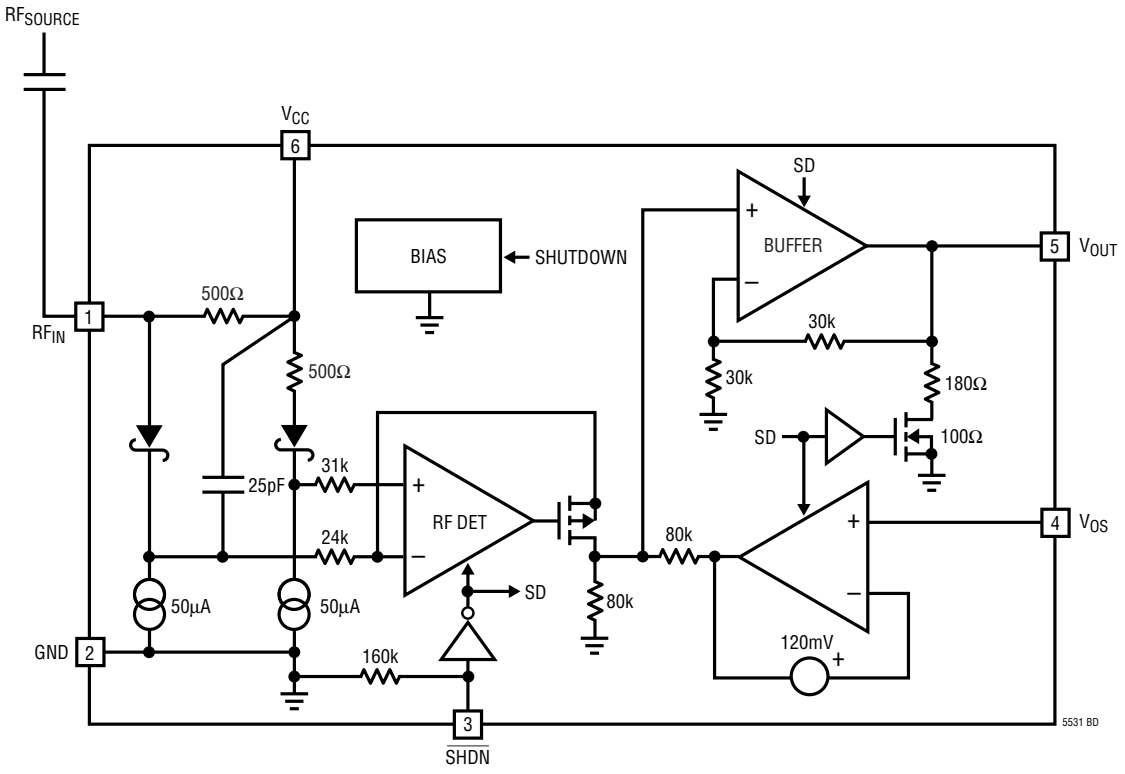
$\overline{SHDN}$ (Pin 3): Shutdown Input. A logic low on the $\overline{SHDN}$ pin places the part in shutdown mode. A logic high enables the part. $\overline{SHDN}$ has an internal 160k pulldown resistor to ensure that the part is in shutdown when no input is applied. In shutdown V_{OUT} is connected to ground via a 280Ω resistor.

V_{OS} (Pin 4): V_{OUT} Offset Voltage Adjustment. This pin adjusts the starting V_{OUT} voltage when no RF signal is present. For V_{OS} from 0V to 120mV, V_{OUT} is unaffected by V_{OS}. For V_{OS} > 120mV, V_{OUT} is the sum of V_{OS} plus the detected RF signal.

V_{OUT} (Pin 5): Detector Output.

V_{CC} (Pin 6): Power Supply Voltage, 2.7V to 6V. V_{CC} should be bypassed appropriately with ceramic capacitors.

BLOCK DIAGRAM



APPLICATIONS INFORMATION

Operation

The LTC5531 RF detector integrates several functions to provide RF power detection over frequencies ranging from 300MHz to 7GHz. These functions include an internal frequency compensated buffer amplifier, an RF Schottky diode peak detector and level shift amplifier to convert the RF input signal to DC and a delay circuit to avoid voltage transients at V_{OUT} when powering up. The LTC5531 has both shutdown and voltage offset adjustment capabilities.

Buffer Amplifier

The output buffer amplifier is capable of supplying typically 4mA into a load. The amplifier has a bandwidth of 2MHz and a fixed internal gain of two.

The V_{OS} input controls the DC input voltage to the buffer amplifier. V_{OS} must be connected to ground if the DC output voltage is not to be changed. The buffer is initially trimmed to approximately 120mV with V_{OS} connected to ground.

The V_{OS} pin is used to change the initial V_{OUT} starting voltage. This function enables the LTC5531 output to span the input range of a variety of analog-to-digital converters. V_{OUT} will not change until V_{OS} exceeds 120mV. The voltage at V_{OUT} for V_{OS} ≥120mV and with no RF signal present is:

$$V_{OUT} = V_{OS}$$

V_{OUT} will exactly track V_{OS} above 120mV.

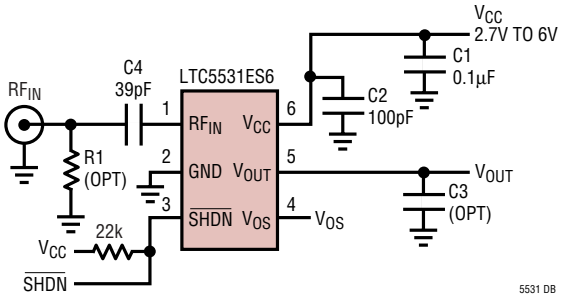
RF Detector

The internal RF Schottky diode peak detector and level shift amplifier converts the RF input signal to a low frequency signal. The detector demonstrates excellent efficiency and linearity over a wide range of input power. The Schottky diode is biased at about 55µA and drives a 25pF internal peak detector capacitor.

Shutdown

The part is in shutdown mode when $\overline{SHDN}$ is low. The supply current is reduced to < 2µA and V_{OUT} is shorted to ground via a 280Ω resistor. When $\overline{SHDN}$ is asserted high, the part is enabled after about 8µs.

Demo Board Schematic



APPLICATIONS INFORMATION

Applications

The LTC5531 can be used as a self-standing signal strength measuring receiver for a wide range of input signals from –32dBm to 10dBm for frequencies from 300MHz to 7GHz.

Operation at higher frequencies is achievable. Consult factory for more information.

The LTC5531 can be used as a demodulator for AM and ASK modulated signals with data rates up to 2MHz. Depending on specific application needs, the RSSI output can be split between two branches, providing AC-coupled data (or audio) output and DC-coupled RSSI output for signal strength measurements and AGC.

The LTC5531 can be used for RF power detection and control. Figure 1 is an example of transmitter power control, using the LTC5531 with a capacitive tap to the power amplifier. A 0.5pF capacitor (C1) followed by a 200Ω resistor (R1) forms a coupling circuit with about 20dB loss at 900MHz referenced to the LTC5531 RF input pin. In the actual product implementation, component values for the capacitive tap may be different depending on parts placement, PCB parasitics and parameters of the antenna.

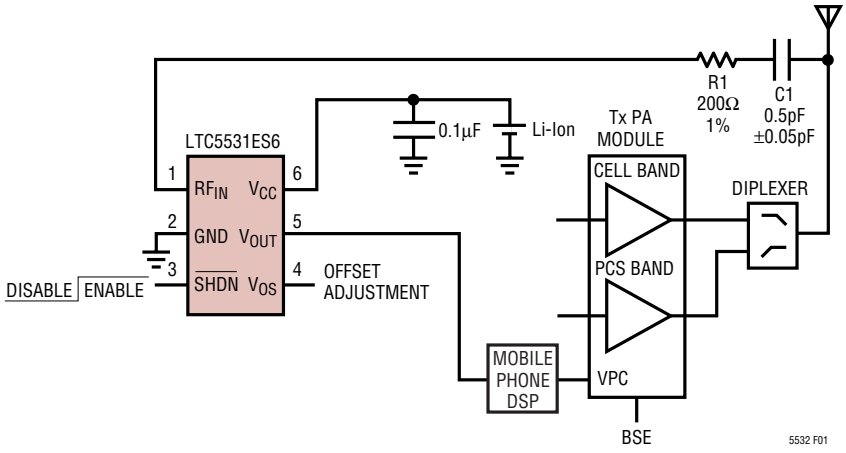
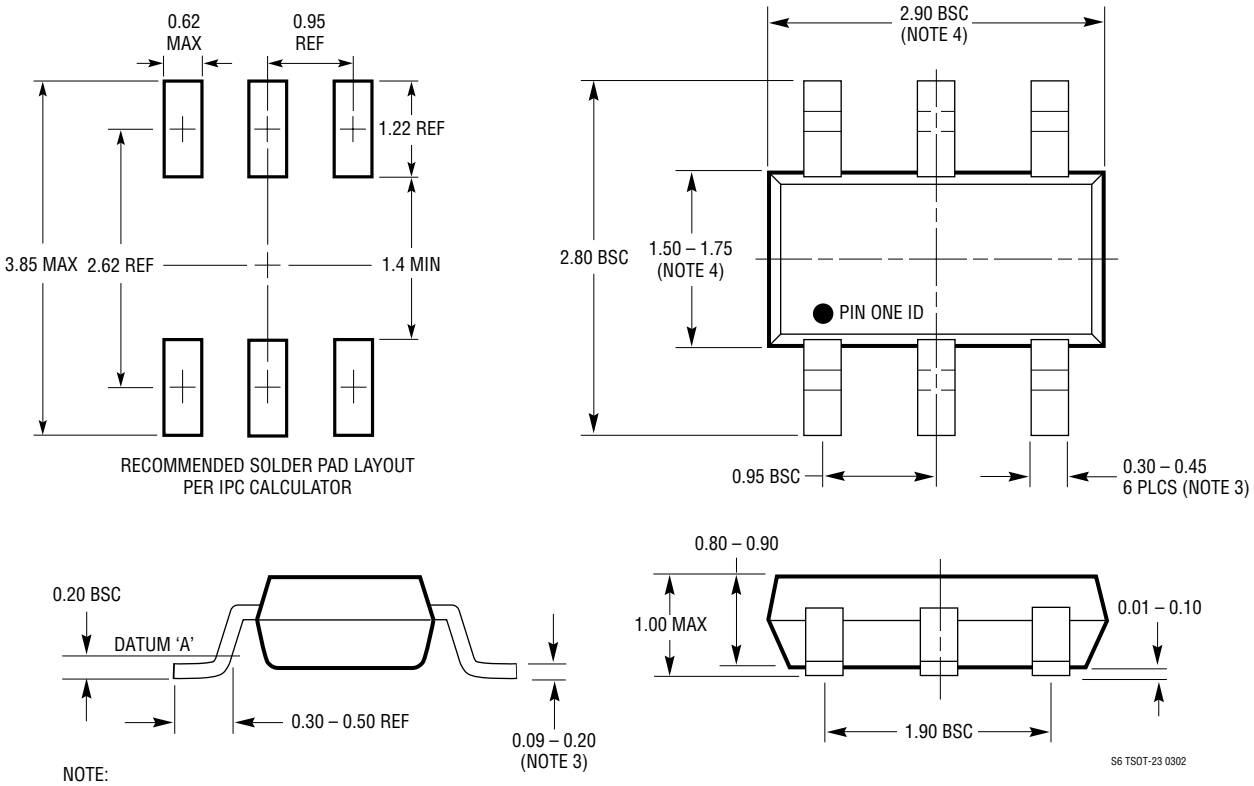


Figure 1. Mobile Phone Tx Power Control Application with a Capacitive Tap

PACKAGE DESCRIPTION

S6 Package
6-Lead Plastic TSOT-23
(Reference LTC DWG # 05-08-1636)



NOTE:
1. DIMENSIONS ARE IN MILLIMETERS
2. DRAWING NOT TO SCALE
3. DIMENSIONS ARE INCLUSIVE OF PLATING
4. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH AND METAL BURR
5. MOLD FLASH SHALL NOT EXCEED 0.254mm
6. JEDEC PACKAGE REFERENCE IS MO-193