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

August 2003

FEATURES

- **Temperature Compensated Internal Schottky Diode RF Detector**
- **Wide Input Frequency Range: 300MHz to 7GHz**
- **Wide Input Power Range: –32dBm to 8dBm**
- **Buffered Detector Output with External Gain Control**
- **Precision V_{OUT} Offset Control**
- **Low Offset Voltage: 120mV ±35mV for Gain = 2x**
- **Wide V_{CC} Range of 2.7V to 6V**
- Low Operating Current: 500µA
- Available in a Low Profile (1mm) SOT-23 Package

APPLICATIONS

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

DESCRIPTION

The LTC®5532 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.

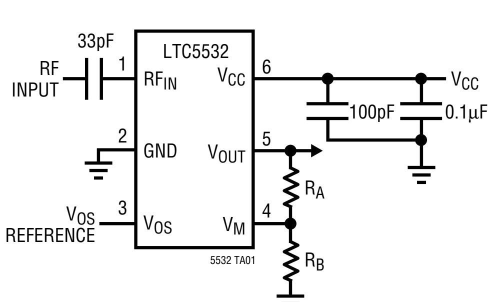
The RF input voltage is peak detected using an on-chip Schottky diode. The detected voltage is buffered and supplied to the V_{OUT} pin.

The LTC5532 output buffer gain is set via external resistors. The initial offset voltage of 120mV ±35mV can be precisely adjusted using the V_{OS} pin.

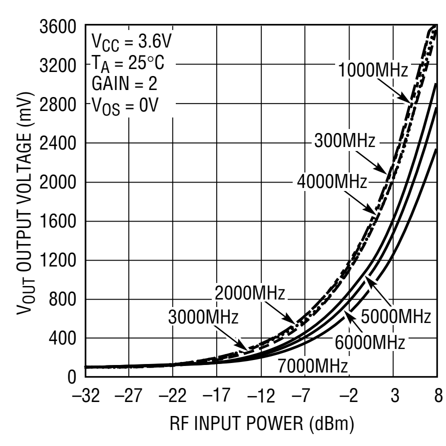
The LTC5532 operates with input power levels from –32dBm to 8dBm.

TYPICAL APPLICATION

300MHz to 7GHz RF Power Detector



Output Voltage vs RF Input Power

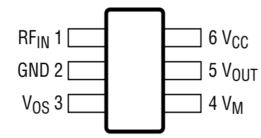


ABSOLUTE MAXIMUM RATINGS

(Note 1)

V_{CC}, V_{OUT}, V_M, V_{OS} .... −0.3V to 6.5V
RF_{IN} Voltage .... (V_{CC} ± 1V) to 7V
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

	ORDER PART NUMBER
TOP VIEW  S6 PACKAGE 6-LEAD PLASTIC TSOT-23 T_{JMAX} = 125°C, θ_{JA} = 250°C/W	LTC5532ES6
	S6 PART MARKING
	LTAFS

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, RF Input Signal is Off, R_A = R_B = 1k, V_{OS} = 0V 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
V_{OUT} V_{OL} (No RF Input)	R_{LOAD} = 2k, V_{OS} = 0V	●	85	100 to 140	155	mV
V_{OUT} Output Current	V_{OUT} = 1.75V, V_{CC} = 2.7V, ΔV_{OUT} < 10mV	●	2	4		mA
V_{OUT} Bandwidth	C_{LOAD} = 33pF, R_{LOAD} = 2k (Note 4)			2		MHz
V_{OUT} Load Capacitance	(Note 6)	●			33	pF
V_{OUT} Slew Rate	V_{RFIN} = 1V Step, C_{LOAD} = 33pF, Total R_{LOAD} = 2k (Note 3)			3		V/µs
V_{OUT} Noise	V_{CC} = 3V, Noise BW = 1.5MHz, 50Ω RF Input Termination, 50Ω AC Output Termination			1		mV_{P-P}
V_{OS} Voltage Range		●	0		1	V
V_{OS} Input Current	V_{OS} = 1V	●	–0.5		0.5	µA
V_M Voltage Range		●	0		V_{CC} -1. 8	V
V_M Input Current	V_M = 3.6V	●	–0.5		0.5	µA
RF_{IN} Input Frequency Range				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 8		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.

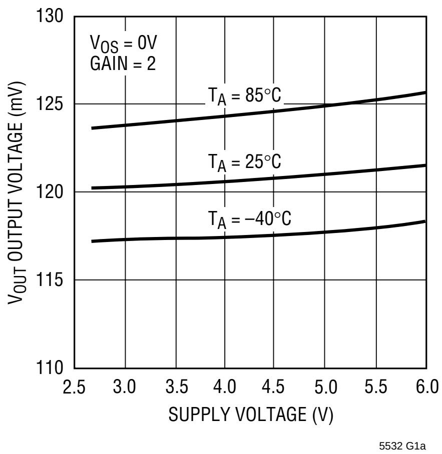
Note 4: Bandwidth is calculated based on the 10% to 90% rise time equation: BW = 0.35/rise time.

Note 5: RF performance is tested at 1800MHz

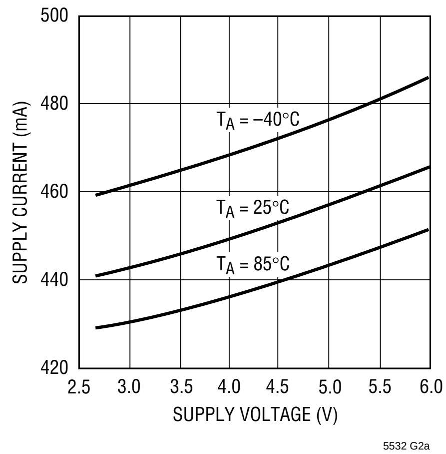
Note 6: Guaranteed by design.

TYPICAL PERFORMANCE CHARACTERISTICS (R_{LOAD} = 20k)

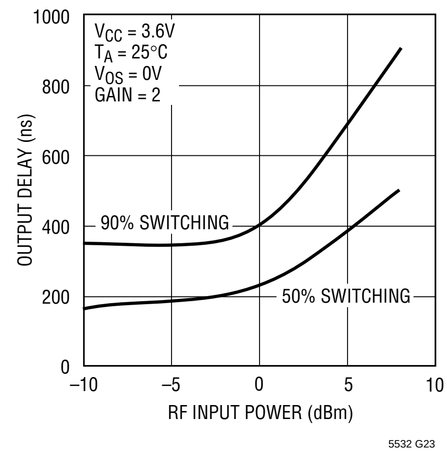
Output Voltage vs Supply Voltage (RF Input Signal Off)



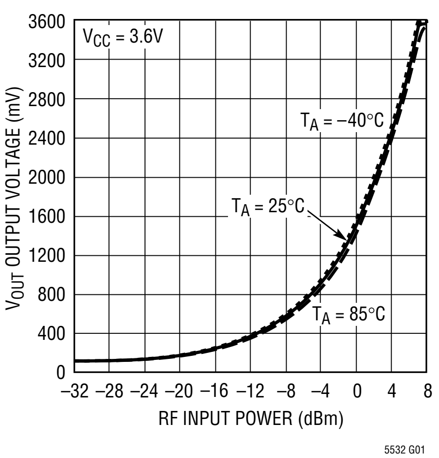
Supply Current vs Supply Voltage (RF Input Signal Off)



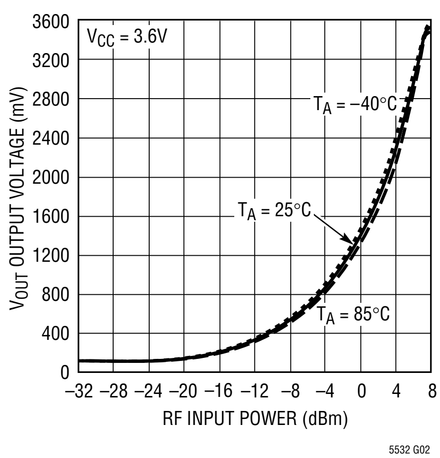
Output Delay vs RF Input Power



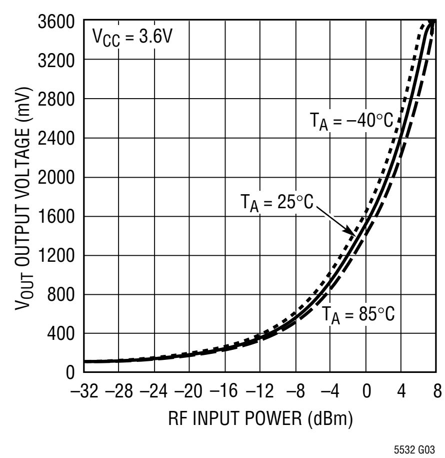
Typical Detector Characteristics, 300MHz, Gain = 2, V_{OS} = 0V



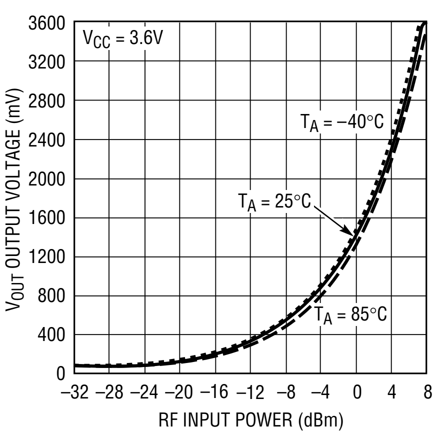
Typical Detector Characteristics, 1000MHz, Gain = 2, V_{OS} = 0V



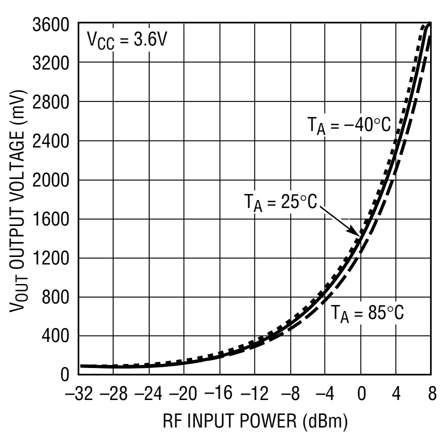
Typical Detector Characteristics, 2000MHz, Gain = 2, V_{OS} = 0V



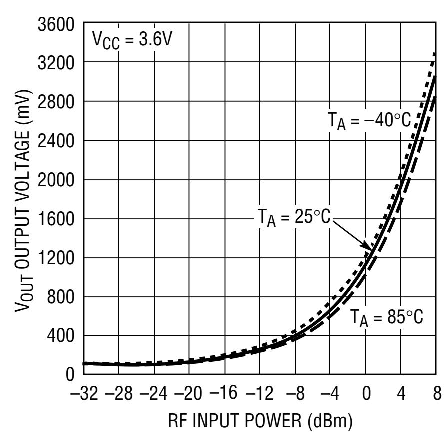
Typical Detector Characteristics, 3000MHz, Gain = 2, V_{OS} = 0V



Typical Detector Characteristics, 4000MHz, Gain = 2, V_{OS} = 0V

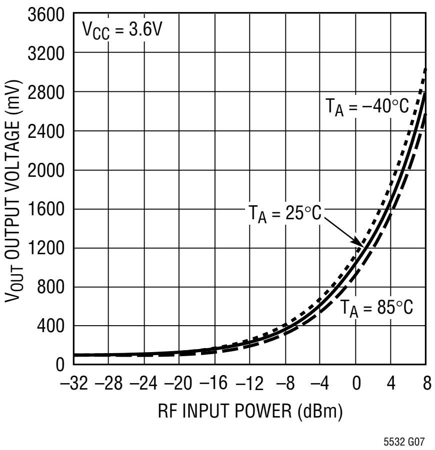


Typical Detector Characteristics, 5000MHz, Gain = 2, V_{OS} = 0V

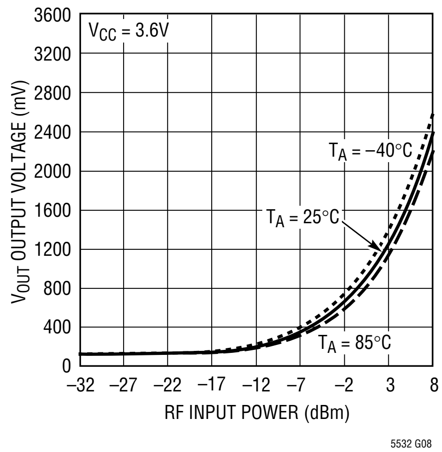


TYPICAL PERFORMANCE CHARACTERISTICS (R_{LOAD} = 20k)

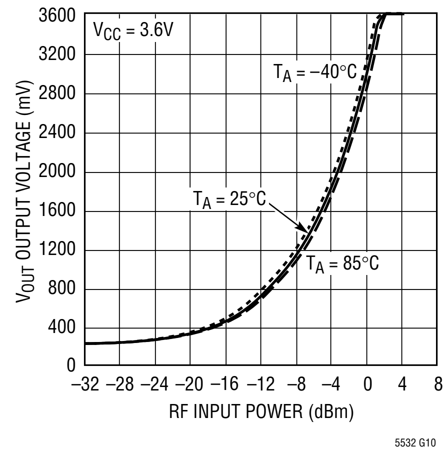
Typical Detector Characteristics, 6000MHz, Gain = 2, V_{OS} = 0V



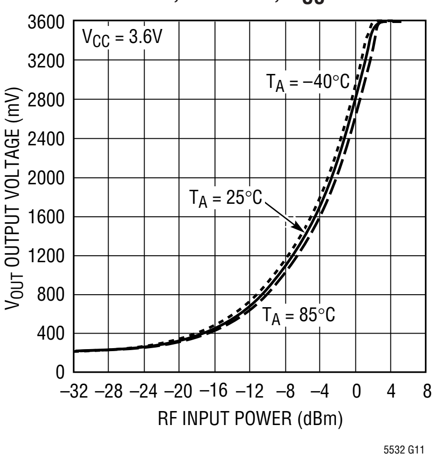
Typical Detector Characteristics, 7000MHz, Gain = 2, V_{OS} = 0V



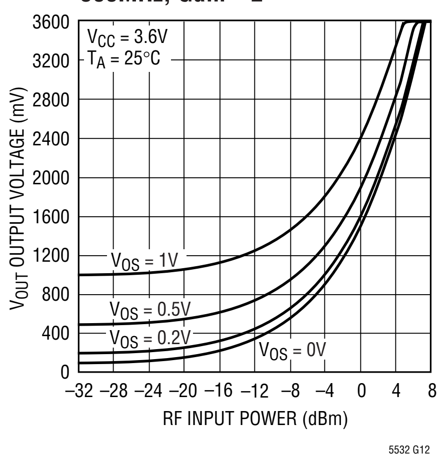
Typical Detector Characteristics, 300MHz, Gain = 4, V_{OS} = 0V



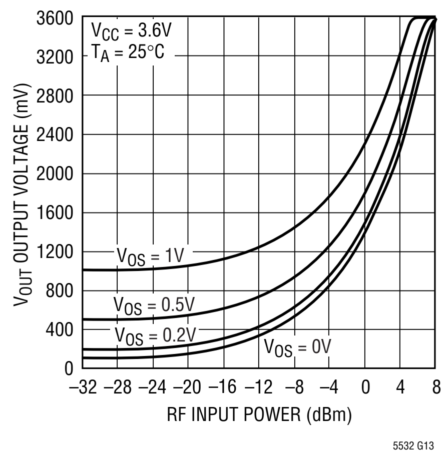
Typical Detector Characteristics, 1000MHz, Gain = 4, V_{OS} = 0V



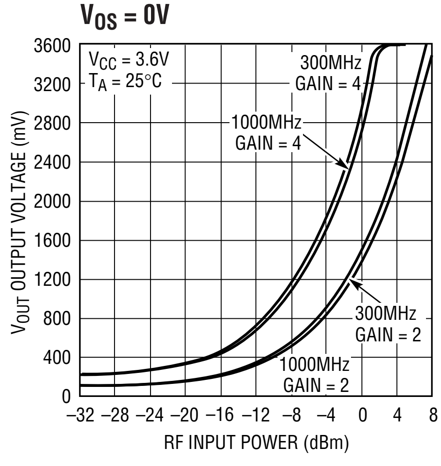
V_{OUT} vs RF Input Power and V_{OS}, 300MHz, Gain = 2



V_{OUT} vs RF Input Power and V_{OS}, 1000MHz, Gain = 2

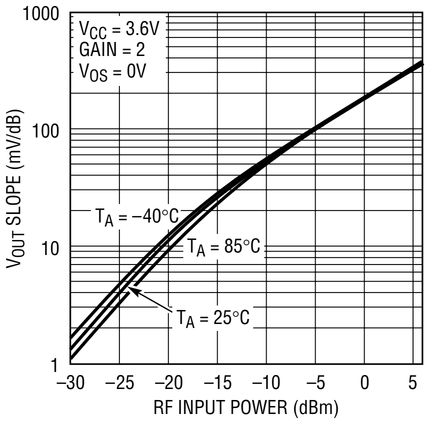


V_{OUT} vs RF Input Power, 300MHz and 1000MHz, Gain = 2 and 4, V_{OS} = 0V



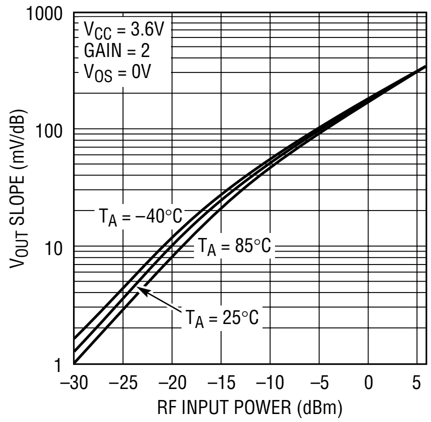
TYPICAL PERFORMANCE CHARACTERISTICS (R_{LOAD} = 20k)

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



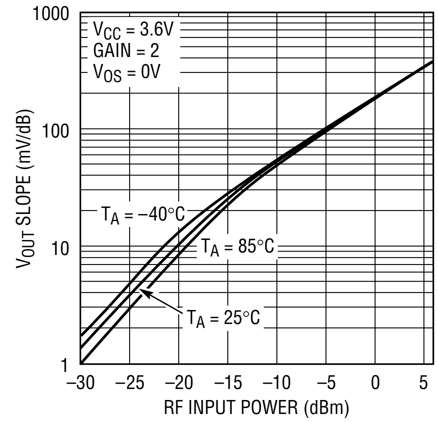
5532 G15

V_{OUT} Slope vs RF Input Power at 1GHz



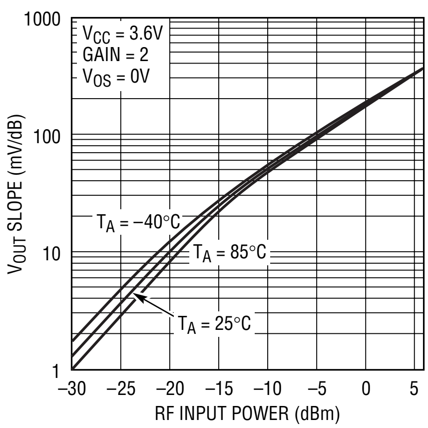
5532 G16

V_{OUT} Slope vs RF Input Power at 2GHz



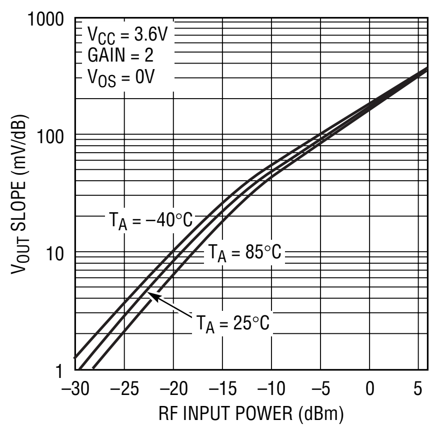
5532 G17

V_{OUT} Slope vs RF Input Power at 3GHz



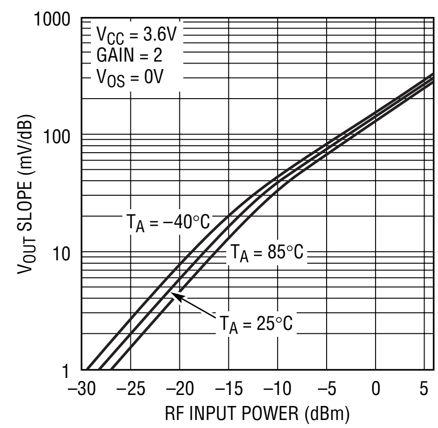
5532 G18

V_{OUT} Slope vs RF Input Power at 4GHz



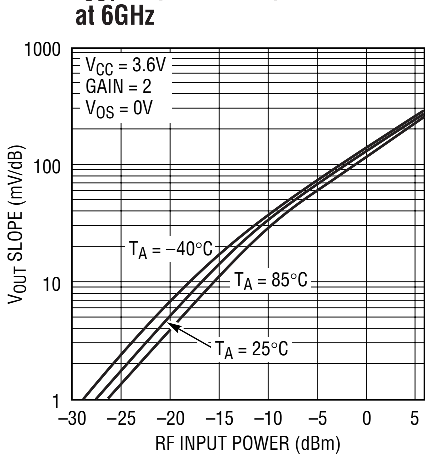
5532 G19

V_{OUT} Slope vs RF Input Power at 5GHz



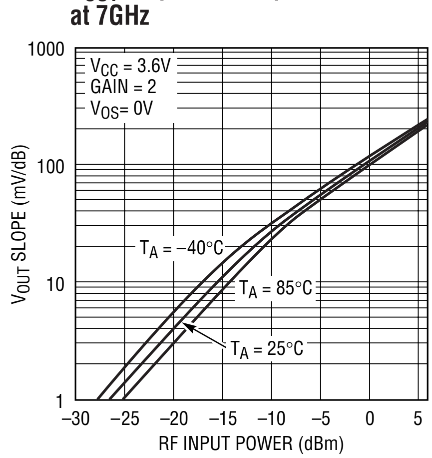
5532 G20

V_{OUT} Slope vs RF Input Power at 6GHz



5532 G21

V_{OUT} Slope vs RF Input Power at 7GHz



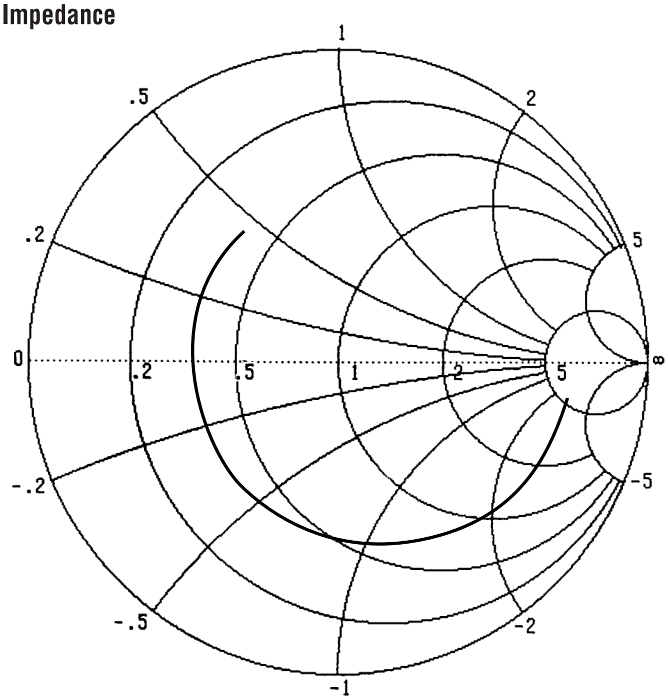
5532 G22

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

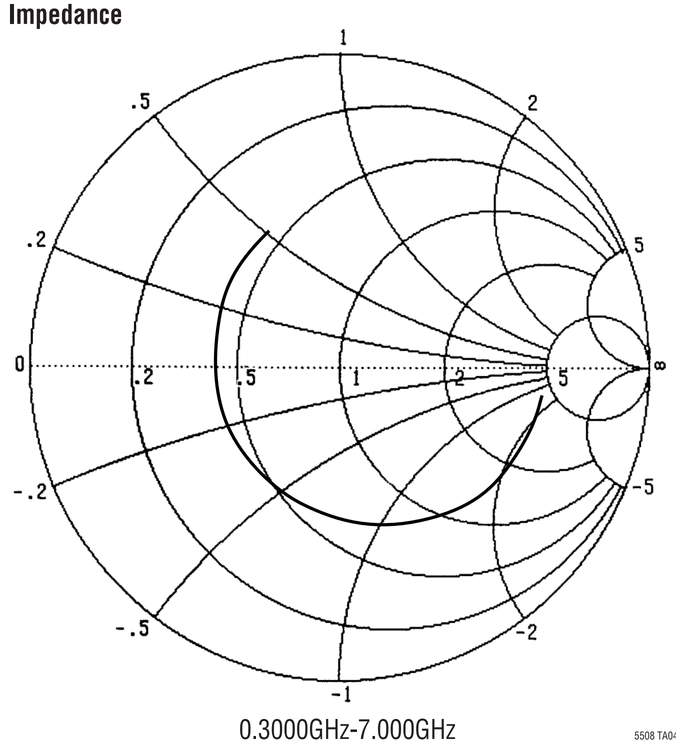
5508 TA03

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



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.

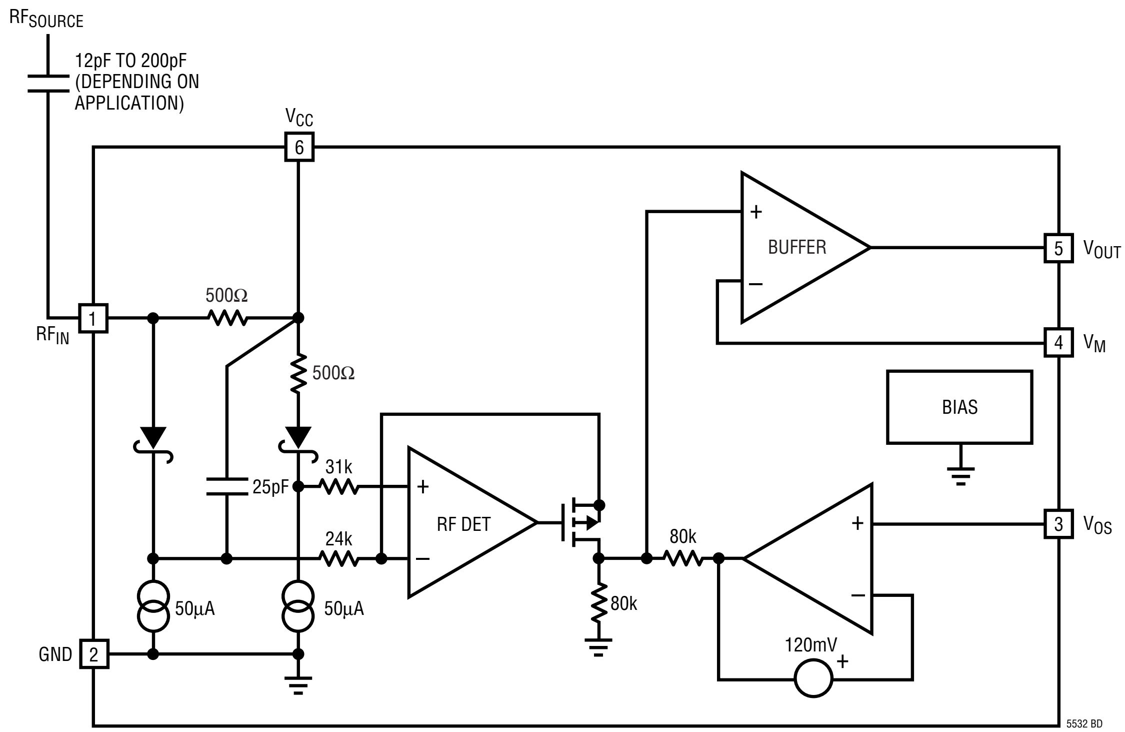
V_{OS} (Pin 3): V_{OUT} Offset Voltage Adjustment. From 0V to 120mV, V_{OUT} does not change. Above 120mV, V_{OUT} will track V_{OS}.

V_M (Pin 4): Negative Input to Buffer Amplifier.

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 LTC5532 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 a level shift amplifier to convert the RF input signal to DC. The LTC5532 has both gain setting and voltage offset adjustment capabilities.

Buffer Amplifier

The output buffer amplifier is capable of supplying typically 4mA into a load. The negative terminal V_M is brought out to a pin for gain selection. External resistors connected between V_{OUT} and V_M (R_A) and V_M to ground (R_B) will set the gain of this amplifier.

$$\text{Gain} = 1 + R_A/R_B$$

The amplifier is unity gain stable; however a minimum gain of two is recommended to improve low output voltage accuracy. The amplifier has a bandwidth of 2MHz with a gain of 2. For increased gain applications, the bandwidth is reduced according to the formula:

$$\text{Bandwidth} = 4\text{MHz}/(\text{Gain}) = 4\text{MHz} \bullet R_B/(R_A + R_B)$$

A capacitor can be placed across the feedback resistor R_A to shape the frequency response. In addition, the amplifier can be used as a comparator. V_M can be connected to a reference voltage. When the internal detector output voltage (which is connected to the positive input of the buffer amplifier) exceeds the external voltage on V_M, V_{OUT} will switch high.

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 120mV (Gain = 2x) with V_{OS} connected to ground.

The V_{OS} pin is used to change the initial V_{OUT} starting voltage. This function, in combination with gain adjustment enables the LTC5532 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 starting voltage at V_{OUT} for V_{OS} >120mV is:

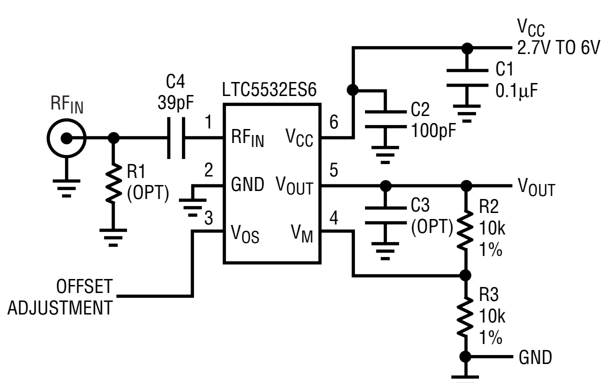
$$V_{OUT} = 0.5 \bullet V_{OS} \bullet \text{Gain}$$

where gain is the output buffer gain. For a buffer gain of 2x, 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.

Demo Board Schematic



APPLICATIONS INFORMATION

Applications

The LTC5532 can be used as a self-standing signal strength measuring receiver for a wide range of input signals from –32dBm to 8dBm for frequencies from 300MHz to 7GHz.

The LTC5532 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 LTC5532 can be used for RF power detection and control. Figure 1 is an example of a transmitter power control, using the LTC5532 with a capacitive tap to the power amplifier. A 0.5pF capacitor (C1) followed by a 200Ω resistor (R1) form a coupling circuit with about 20dB loss at 900MHz referenced to the LTC5532 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.

The LTC5532 can be configured as a comparator for RF power detection and RF power alarms. The characterization data includes a plot of the LTC5532 output delay in response to a positive input step of varying RF level.

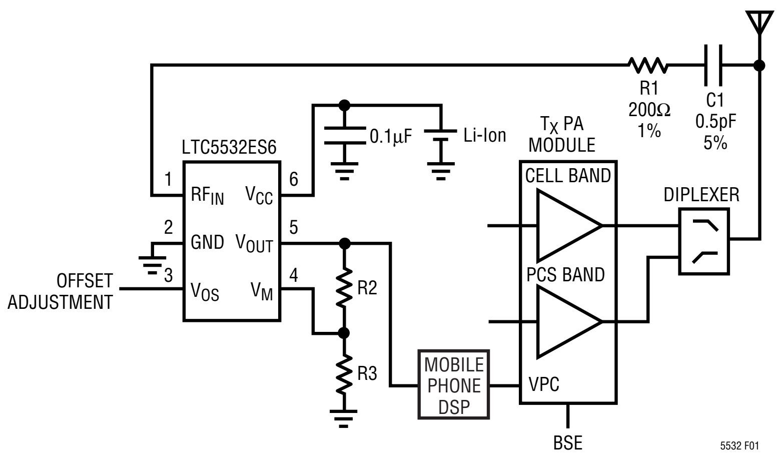
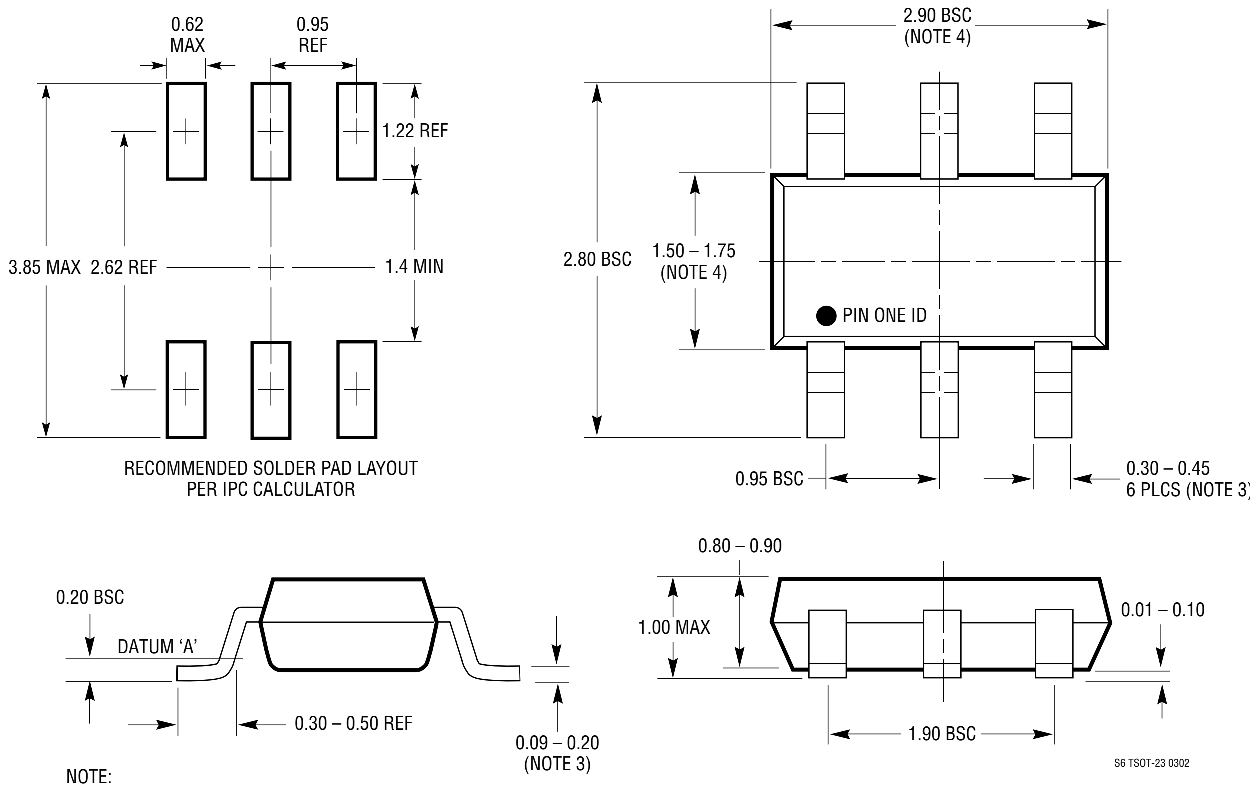


Figure 1. Mobile Phone T_X Power Control Application Diagram with a Capacitive Tap

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

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC1757A	RF Power Controller	Single/Dual Band GSM/DCS/GPRS Mobile Phones
LTC1758	RF Power Controller	Single/Dual Band GSM/DCS/GPRS Mobile Phones
LTC1957	RF Power Controller	Single/Dual Band GSM/DCS/GPRS Mobile Phones
LTC4400	RF Power Controller in SOT-23 Package	Single/Dual Band GSM/DCS/GPRS Phones, 45dB Dynamic Range, 450kHz Loop BW
LTC4401	RF Power Controller in SOT-23 Package	Single/Dual Band GSM/DCS/GPRS Phones, 45dB Dynamic Range, 250kHz Loop BW
LTC4403	RF Power Controller for EDGE/TDMA	Multiband GSM/GPRS/EDGE Mobile Phones
LT5500	1.8GHz to 2.7GHz RF Front End	Dual LNA gain Setting +13.5dB/–14dB at 2.5GHz, Double-Balanced Mixer, $1.8V \le V_{SUPPLY} \le 5.25V$
LT5502	400MHz Quadrature Demodulator with RSSI	1.8V to 5.25V Supply, 70MHz to 400MHz IF, 84dB Limiting Gain, 90dB RSSI Range
LT5503	1.2GHz to 2.7GHz Direct IQ Modulator and Up Converting Mixer	1.8V to 5.25V Supply, Four-Step RF Power Control, 120MHz Modulation Bandwidth
LT5504	800MHz to 2.7GHz RF Measuring Receiver	80dB Dynamic Range, Temperature Compensated, 2.7V to 5.5V Supply
LTC5505	300MHz to 3.5GHz RF Power Detector	>40dB Dynamic Range, Temperature Compensated, 2.7V to 6V Supply
LT5506	500MHz Quadrature IF Demodulator with VGA	1.8V to 5.25V Supply, 40MHz to 500MHz IF, –4dB to 57dB Linear Power Gain
LTC5507	100kHz to 1GHz RF Power Detector	48dB Dynamic Range, Temperature Compensated, 2.7V to 6V Supply
LTC5508	300MHz to 7GHz RF Power Detector	SC70 Package
LTC5509	300MHz to 3GHz RF Power Detector	SC70 Package
LT5511	High Signal Level Up Converting Mixer	RF Output to 3GHz, 17dBm IIP3, Integrated LO Buffer
LT5512	High Signal Level Down Converting Mixer	DC-3GHz, 20dBm IIP3, Integrated LO Buffer
LTC5515	1.5GHz to 2.5GHz Direct Conversion Quadrature Demodulator	20dBm IIP3, Integrated LO Quadrature Generator
LTC5516	0.8GHz to 1.5GHz Direct Conversion Quadrature Demodulator	21.5dBm IIP3, Integrated LO Quadrature Generator

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