

Matched Dual-Channel 6GHz RMS Power Detector

FEATURES

- Frequency Range: 40MHz to 6GHz
- Linear Dynamic Range: Up to 60dB
- $\pm 0.5\text{dB}$ (Typ) Accuracy Over Temperature
- 40dB Channel-to-Channel Isolation at 2GHz Even with Single-Ended RF Inputs
- Matched Dual-Channel Outputs: $< 1.25\text{dB}$ (Typ)
- Single-Ended RF Inputs—No Transformer Required
- Accurate RMS Power Measurement of High Crest Factor Modulated Waveforms
- Difference Output Provides VSWR Measurement
- Fast Envelope Detector Outputs
- Fast Response Time: 140ns Rise Time
- Small $4\text{mm} \times 4\text{mm}$ QFN24 Package

APPLICATIONS

- VSWR Monitor
- MIMO Transmit Power Control
- Basestation PA Control
- Transmit and Receive Gain Control
- RF Instrumentation

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DESCRIPTION

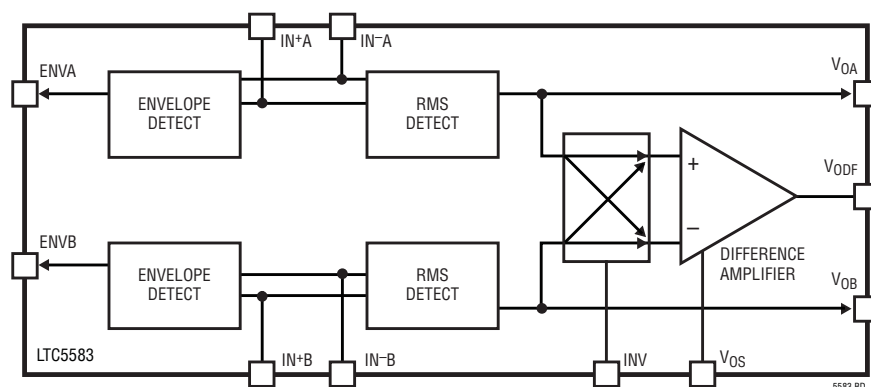
The LTC[®]5583 is a dual-channel RMS power detector, capable of measuring two AC signals with wide dynamic range, from -59dBm to 4dBm , depending on frequency. Each AC signal's power in decibel-scaled value is precisely converted to a DC voltage on a linear scale, independent of the crest factor of the input signal waveforms. The LTC5583 is suitable for precision power measurement and level control for a variety of RF standards, including LTE, EDGE, W-CDMA, CDMA2000, TD-SCDMA, and WiMAX.

Good channel-to-channel isolation is necessary for operating the dual channels simultaneously. For applications where the two input signals are at the same frequency (e.g. measuring VSWR), the LTC5583 provides 40dB isolation at 2.14GHz even with single-ended inputs. No baluns are needed. When the two input signals are at different frequencies, the isolation can be as high as 50dB. The isolation can be improved to $>55\text{dB}$ with differential inputs.

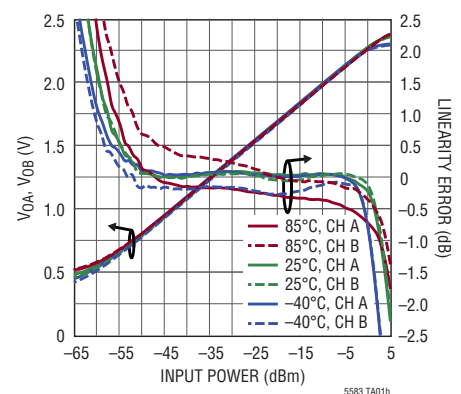
The power difference of the two input signals is provided at a difference output pin. Each channel also has a fast envelope detector, which tracks the RF input signal's envelope and outputs a voltage directly proportional to the signal's instantaneous power. The envelope detectors can be disabled to reduce power consumption.

TYPICAL APPLICATION

Block Diagram



Output Voltage and Linearity Error vs RF Input Power, 2140MHz CW Inputs, Single-Ended Drive

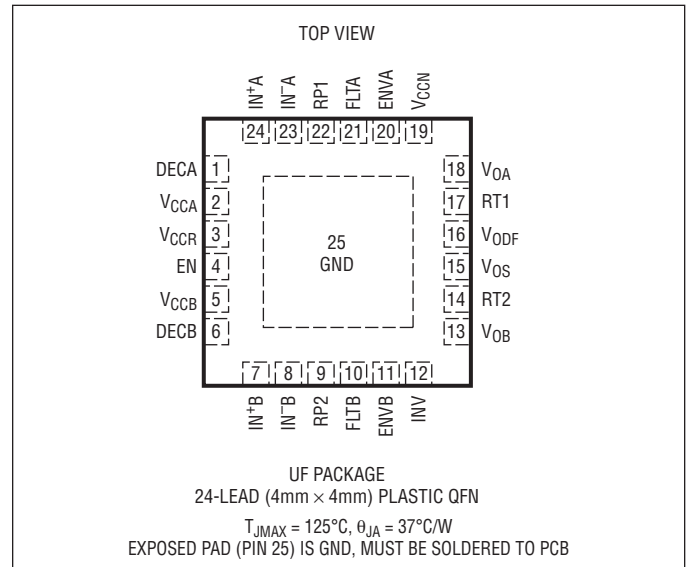


ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage	3.8V
Enable Voltage	-0.3V to $V_{CC} + 0.3V$
V_{OS} Voltage	-0.3V to $V_{CC} + 0.3V$
INV Voltage	-0.3V to 3.6V
Input Signal Power (Single-Ended, 50 Ω)	18dBm
Input Signal Power (Differential, 50 Ω)	24dBm
T_{JMAX}	125°C
Operating Temperature Range	-40°C to 85°C
Storage Temperature Range	-65°C to 125°C

PIN CONFIGURATION



ORDER INFORMATION

LEAD FREE FINISH	TAPE AND REEL	PART MARKING	PACKAGE DESCRIPTION	TEMPERATURE RANGE
LTC5583IUF#PBF	LTC5583IUF#TRPBF	5583	24-Lead (4mm × 4mm) Plastic QFN	-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 The ● denotes the specifications which apply over the full operating temperature range, -40°C to 85°C , otherwise specifications are at $T_A = 25^{\circ}\text{C}$, $V_{CC} = 3.3\text{V}$, $EN = 3.3\text{V}$. Test circuits are shown in Figures 1 and 2 (Note 2).

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
AC Input					
Input Frequency Range	(Note 4)		40 to 6000		MHz
Input Impedance	Differential		400/0.5		Ω/pF
$f_{RF} = 450\text{MHz}$ (Single-Ended Inputs)					
Linear Dynamic Range	CW, 50 Ω , $\pm 1\text{dB}$ Linearity Error (Note 5)		63		dB
		●	57		dB
RF Input Power Range	CW, 50 Ω , $\pm 1\text{dB}$ Linearity Error (Note 5)		-59 to 4		dBm
Output Slope			29.6		mV/dB
Logarithmic Intercept	(Note 3)		-78.5		dBm
Deviation from CW Response	11dB Peak to Average Ratio (3-Carrier CDMA2K) 12dB Peak to Average Ratio (4-Carrier WCDMA)		0.7		dB
			0.4		dB
Input A to Input B Isolation	Single-Ended Inputs		77		dB
Input A to Output B Isolation	Single-Ended Inputs (Notes 6, 7)	Frequency Separation = 0Hz Frequency Separation = 1MHz Frequency Separation = 10MHz	50		dB
Input B to Output A Isolation			>55		dB
Input B to Output A Isolation			>55		dB
$f_{RF} = 880\text{MHz}$ (Single-Ended Inputs)					
Linear Dynamic Range	CW, 50 Ω , $\pm 1\text{dB}$ Linearity Error (Note 5)		61		dB
		●	56		dB
RF Input Power Range	CW, 50 Ω , $\pm 1\text{dB}$ Linearity Error (Note 5)		-58 to 3		dBm
Output Slope			29.7		mV/dB
Logarithmic Intercept	(Note 3)		-77.8		dBm
Deviation from CW Response	11dB Peak to Average Ratio (3-Carrier CDMA2K) 12dB Peak to Average Ratio (4-Carrier WCDMA)		0.7		dB
			0.4		dB
Input A to Input B Isolation	Single-Ended inputs		68		dB
Input A to Output B Isolation	Single-Ended inputs (Notes 6, 7)	Frequency Separation = 0Hz Frequency Separation = 1MHz Frequency Separation = 10MHz	41		dB
Input B to Output A Isolation			52		dB
Input B to Output A Isolation			51		dB
$f_{RF} = 2140\text{MHz}$ (Single-Ended Inputs)					
Linear Dynamic Range	CW, 50 Ω , $\pm 1\text{dB}$ Linearity Error (Note 5)		50	60	dB
		●	55		dB
RF Input Power Range	CW, 50 Ω , $\pm 1\text{dB}$ Linearity Error (Note 5)		-58 to 2		dBm
Output Slope		26	29.6	34	mV/dB
Logarithmic Intercept	(Note 3)	-90	-77.4	-64	dBm
Channel Mismatch	Input Power = 0dBm to Both Channels		<1.25		dB
Deviation from CW Response	11dB Peak to Average Ratio (3-Carrier CDMA2K) 12dB Peak to Average Ratio (4-Carrier WCDMA)		0.6		dB
			0.3		dB
Input A to Input B Isolation	Single-Ended Inputs		54		dB
Input A to Output B Isolation	Single-Ended Inputs (Notes 6, 7)	Frequency Separation = 0Hz Frequency Separation = 1MHz Frequency Separation = 10MHz	40		dB
Input B to Output A Isolation			52		dB
Input B to Output A Isolation			51		dB
Input A to Output B Isolation	Differential Inputs (Notes 6, 7)	Frequency Separation = 0Hz Frequency Separation = 1MHz Frequency Separation = 10MHz	>55		dB
			>55		dB
			>55		dB

ELECTRICAL CHARACTERISTICS The ● denotes the specifications which apply over the full operating temperature range, -40°C to 85°C , otherwise specifications are at $T_A = 25^{\circ}\text{C}$, $V_{CC} = 3.3\text{V}$, $EN = 3.3\text{V}$. Test circuits are shown in Figures 1 and 2 (Note 2).

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
$f_{RF} = 2700\text{MHz}$ (Single-Ended Inputs)						
Linear Dynamic Range	CW, 50 Ω , $\pm 1\text{dB}$ Linearity Error (Note 5)			59		dB
			●	52		dB
RF Input Power Range	CW, 50 Ω , $\pm 1\text{dB}$ Linearity Error (Note 5)			-56 to 3		dBm
Output Slope				30.0		mV/dB
Logarithmic Intercept	(Note 3)			-74.9		dBm
Deviation from CW Response	12dB Peak to Average Ratio (WiMAX OFDM)			0.6		dB
Input A to Input B Isolation	Single-Ended Inputs			52		dB
Input A to Output B Isolation Input B to Output A Isolation	Singled-Ended Inputs (Notes 6, 7)	Frequency Separation = 0Hz		33		dB
		Frequency separation = 1MHz		45		dB
		Frequency separation = 10MHz		44		dB
	Differential Inputs (Notes 6, 7)	Frequency Separation = 0Hz		50		dB
		Frequency separation = 1MHz		>55		dB
		Frequency separation = 10MHz		>55		dB
$f_{RF} = 3600\text{MHz}$ (Differential Inputs)						
Linear Dynamic Range	CW, 50 Ω , $\pm 1\text{dB}$ Linearity Error (Note 5)			56		dB
			●	49		dB
RF Input Power Range	CW, 50 Ω , $\pm 1\text{dB}$ Linearity Error (Note 5)			-53 to 3		dBm
Output Slope				30.2		mV/dB
Logarithmic Intercept	(Note 3)			-73.1		dBm
Deviation from CW Response	12dB Peak to Average Ratio (WiMAX OFDM)			0.4		dB
Input A to Input B Isolation	Differential Inputs			70		dB
Input A to Output B Isolation Input B to Output A Isolation	Differential Inputs (Notes 6, 7)	Frequency Separation = 0Hz		47		dB
		Frequency Separation = 1MHz		>55		dB
		Frequency Separation = 10MHz		>55		dB
$f_{RF} = 5800\text{MHz}$ (Differential Inputs)						
Linear Dynamic Range	CW, 50 Ω , $\pm 1\text{dB}$ Linearity Error (Note 5)			49		dB
			●	44		dB
RF Input Power Range	CW, 50 Ω , $\pm 1\text{dB}$ Linearity Error (Note 5)			-44 to 5		dBm
Output Slope				31.3		mV/dB
Logarithmic Intercept	(Note 3)			-63.2		dBm
Deviation from CW Response	12dB Peak to Average Ratio (WiMAX OFDM)			0.5		dB
Input A to Input B Isolation	Differential Inputs			50		dB
Input A to Output B Isolation Input B to Output A Isolation	Differential Inputs (Notes 6, 7)	Frequency Separation = 0Hz		30		dB
		Frequency Separation = 1MHz		42		dB
		Frequency Separation = 10MHz		41		dB
Output Interface						
V_{OA} , V_{OB}	Output DC Voltage	No RF Signal Present		0.45		V
	Output Impedance			50		Ω
	I_{OUT}	Source/Sink		5/5		mA
	Rise Time, 10% to 90%	0.5V to 2.2V, $f_{RF} = 100\text{MHz}$, $C_{FLTRA} = C_{FLTRB} = 8.2\text{nF}$		140		ns
	Fall Time, 90% to 10%	2.2V to 0.5V, $f_{RF} = 100\text{MHz}$, $C_{FLTRA} = C_{FLTRB} = 8.2\text{nF}$		3.5		μs

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, -40°C to 85°C , otherwise specifications are at $T_A = 25^{\circ}\text{C}$, $V_{CC} = 3.3\text{V}$, $EN = 3.3\text{V}$. Test circuits are shown in Figures 1 and 2 (Note 2).

PARAMETER		CONDITIONS	MIN	TYP	MAX	UNITS
V_{ODF}	Output DC Voltage	No RF Signal Present, $V_{OS} = 0\text{V}$		0.05		V
	Output Impedance			5		Ω
	I_{OUT}	Source/Sink		5/5		mA
	Rise Time, 10% to 90%	50mV to 1.8V, $f_{RF} = 100\text{MHz}$, $C_{FLTRA} = C_{FLTRB} = 8.2\text{nF}$		170		ns
	Fall Time, 90% to 10%	1.8V to 50mV, $f_{RF} = 100\text{MHz}$, $C_{FLTRA} = C_{FLTRB} = 8.2\text{nF}$		3.5		μs
ENVA ENVB	Output DC Voltage	No RF Signal Present		2.15		V
	Output Impedance			140		Ω
	I_{OUT}	Source/Sink		4.0/1.8		mA
	Rise Time, 10% to 90%	0.9V to 2.1V		11		ns
	Fall Time, 90% to 10%	2.1V to 0.9V		11		ns
	-3dB Bandwidth			50		MHz

Control Interface

EN	Input High Voltage		●	2		V
	Input Low Voltage		●		0.3	V
	Input Current	Applied Voltage = 3.3V		100	180	μA
INV	Input High Voltage			2		V
	Input Low Voltage				1	V
	Input Current	Applied Voltage = 3.3V		0		μA
V_{OS}	Input Voltage Range			0	2.4	V
	Input Current	Applied Voltage = 2.4V		77		μA

Power Supply

Supply Voltage			3.1	3.3	3.5	V
Supply Current	Envelope Detectors Turned Off			80.5	100	mA
Supply Current	Envelope Detectors Turned On			90.1		mA
Shutdown Current	$EN = 0\text{V}$, $V_{CC} = 3.5\text{V}$			0.1	20	μA

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: The LTC5583 is guaranteed functional over the temperature range from -40°C to 85°C .

Note 3: Logarithmic Intercept is an extrapolated input power level from the best-fit log-linear straight line, where the output voltage is 0V.

Note 4: Operation over a wider frequency range is possible with reduced performance. Consult the factory for information and assistance.

Note 5: Linearity error is the difference in dB between the actual output and the best-fit straight line at 25°C (using linear regression between $P_{IN} = -50\text{dBm}$ and 0dBm for 450MHz, 880MHz, 2140MHz, 2700MHz;

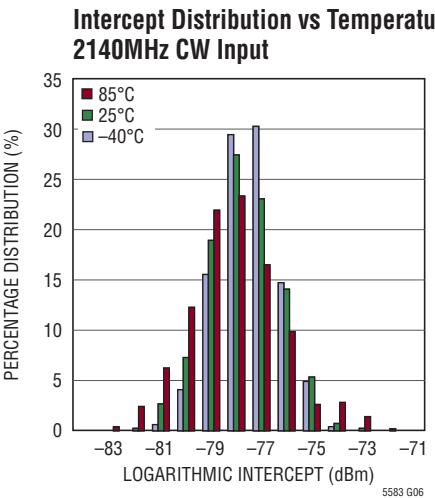
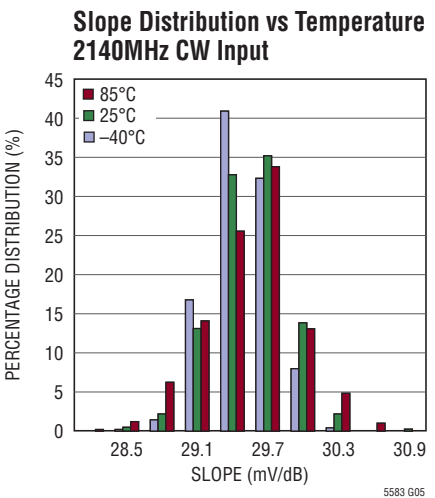
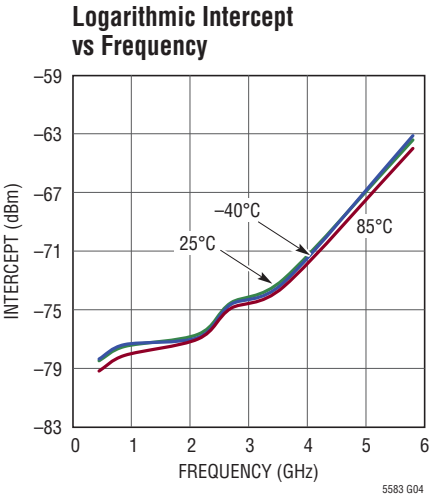
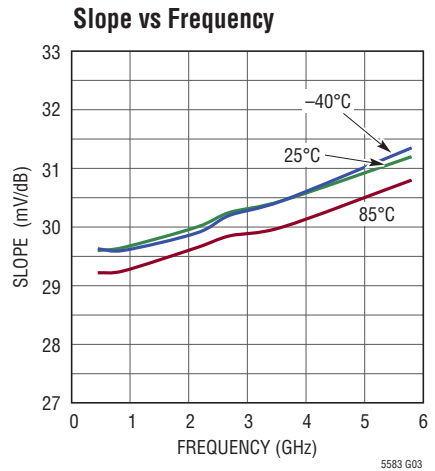
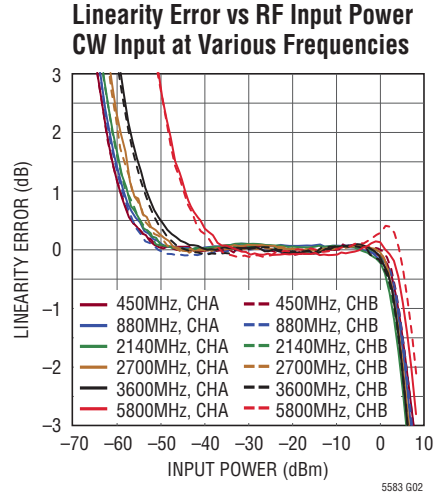
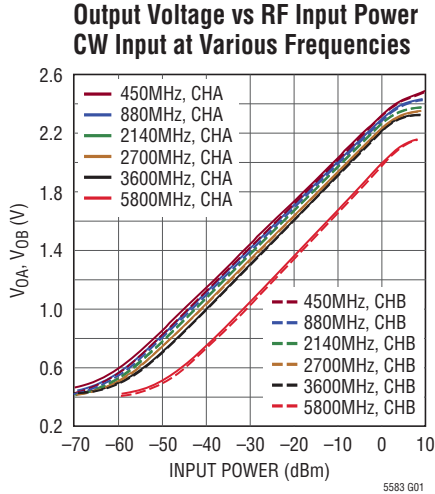
between $P_{IN} = -40\text{dBm}$ and 0dBm for 3600MHz, 5800MHz). The dynamic range is defined as the range of input power over which the linearity error is within $\pm 1\text{dB}$.

Note 6: Input A to Output B (Channel A to Channel B) isolation is defined as the ratio of input power levels at the two channels when the interfering channel (Channel A with higher power) results in a 1dB output deviation in the interfered channel (Channel B with lower power) and vice versa. Sweep one channel input power level while holding the other channel input at -45dBm for 450MHz, 880MHz, 2140MHz, 2700MHz, 3600MHz, and at -35dBm for 5800MHz.

Note 7: For frequency separation = 0Hz between the two input signals, channel-to-channel isolation is a function of the phase difference between these two signals. The worst-case isolation is assumed.

TYPICAL PERFORMANCE CHARACTERISTICS

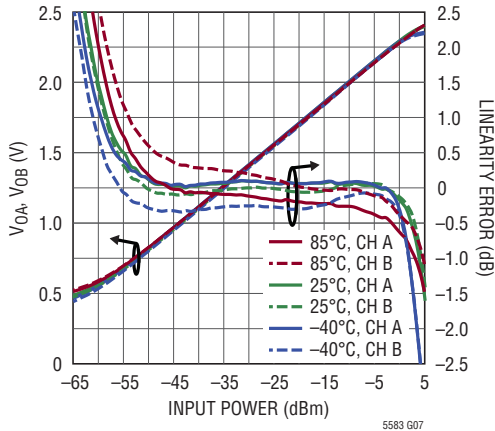
$V_{CC} = 3.3V$, $EN = 3.3V$, $T_A = 25^\circ C$, unless otherwise noted. Test circuits shown in Figures 1 and 2.



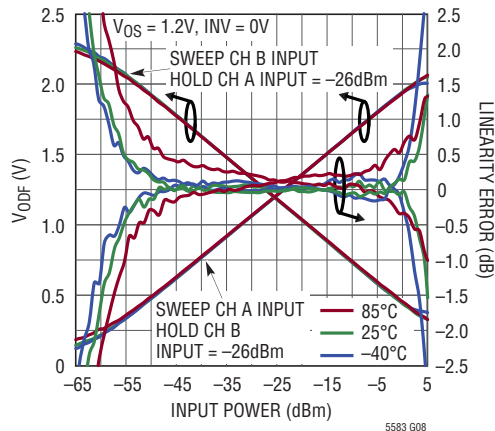
TYPICAL PERFORMANCE CHARACTERISTICS

$V_{CC} = 3.3V$, $EN = 3.3V$, $T_A = 25^\circ C$, unless otherwise noted. For temperature compensation of logarithmic intercept at 880MHz, set $R_{P1} = \text{Open}$, $R_{P2} = 0$, $R_{T1} = 11.5k\Omega$, $R_{T2} = 1.13k\Omega$. See Figure 1.

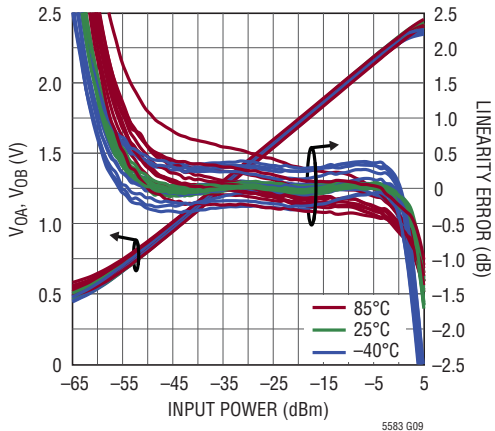
Output Voltage and Linearity Error vs RF Input Power, 880MHz CW Inputs, Single-Ended Drive



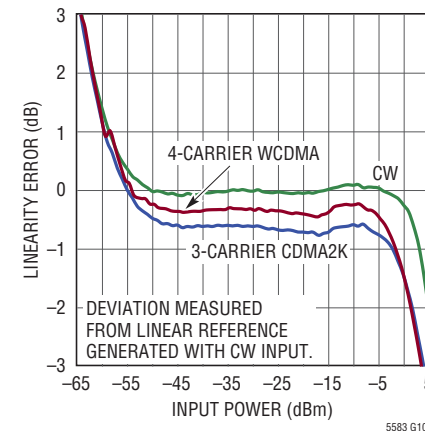
Difference Output and Linearity Error vs RF Input Power, 880MHz CW Inputs, Single-Ended Drive



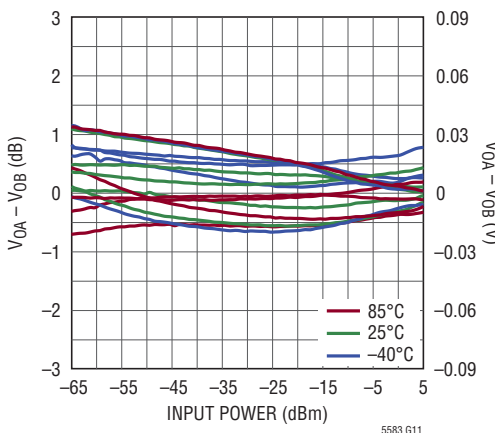
Output Voltage and Linearity Error vs RF Input Power, 880MHz CW Inputs, Single-Ended Drive, 5 Devices



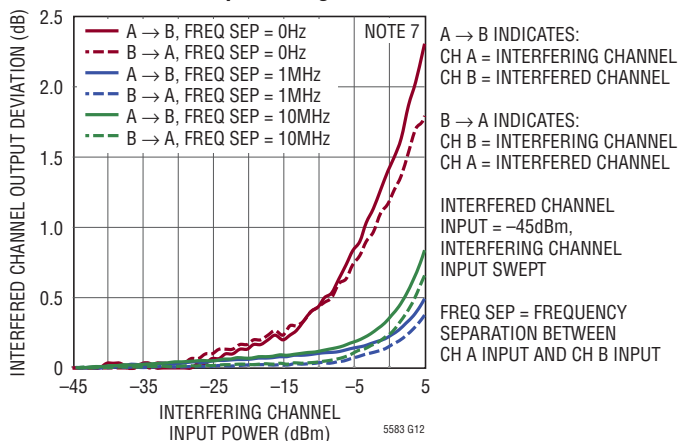
Modulation Deviation vs RF Input Power, 880MHz Inputs, Single-Ended Drive



Channel Matching vs RF Input Power, 880MHz CW Inputs, Single-Ended Drive, 5 Devices



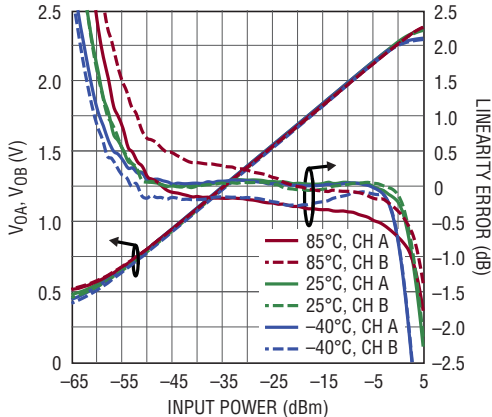
Input A to Output B Isolation, Input B to Output A Isolation, 880MHz CW Inputs, Single-Ended Drive



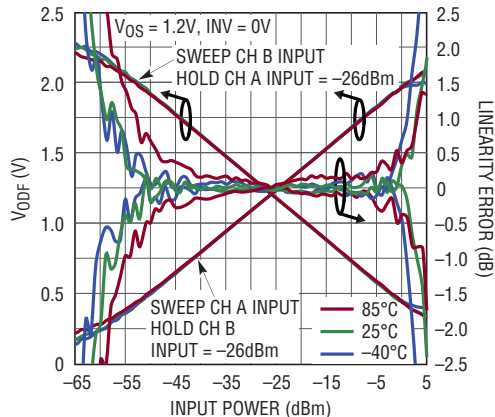
TYPICAL PERFORMANCE CHARACTERISTICS

$V_{CC} = 3.3V$, $EN = 3.3V$, $T_A = 25^\circ C$, unless otherwise noted. For temperature compensation of logarithmic intercept at 2140MHz, set $R_{P1} = \text{Open}$, $R_{P2} = 0$, $R_{T1} = 9.76k\Omega$, $R_{T2} = 1.1k\Omega$. See Figure 1.

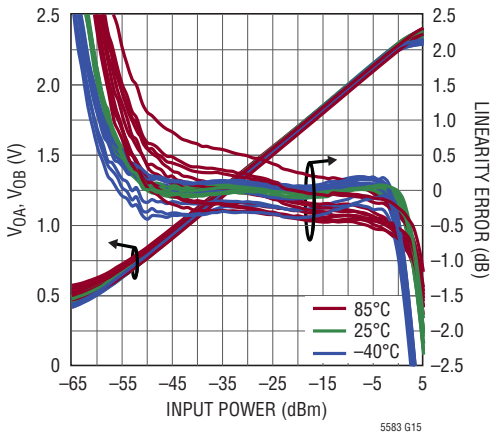
Output Voltage and Linearity Error vs RF Input Power, 2140MHz CW Inputs, Single-Ended Drive



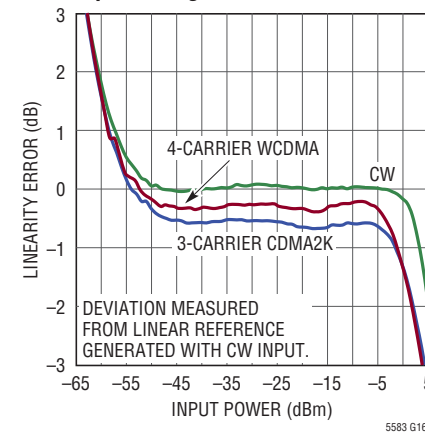
Difference Output and Linearity Error vs RF Input Power, 2140MHz CW Inputs, Single-Ended Drive



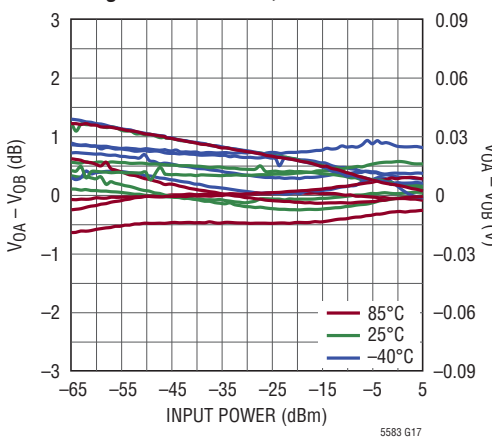
Output Voltage and Linearity Error vs RF Input Power, 2140MHz CW Inputs, Single-Ended Drive, 5 Devices



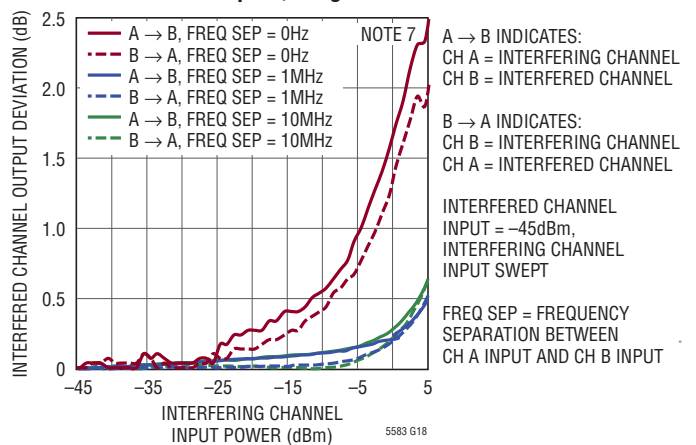
Modulation Deviation vs RF Input Power, 2140MHz Inputs, Single-Ended Drive



Channel Matching vs RF Input Power, 2140MHz CW Inputs, Single-Ended Drive, 5 Devices



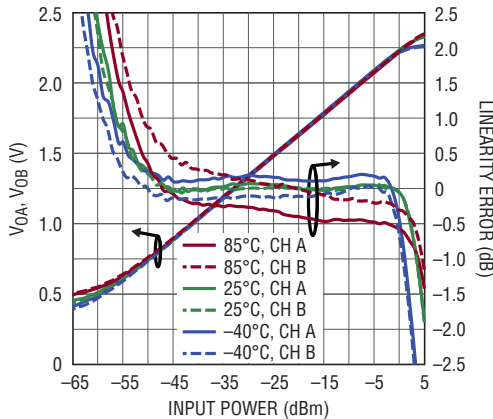
Input A to Output B Isolation, Input B to Output A Isolation, 2140MHz CW Inputs, Single-Ended Drive



TYPICAL PERFORMANCE CHARACTERISTICS

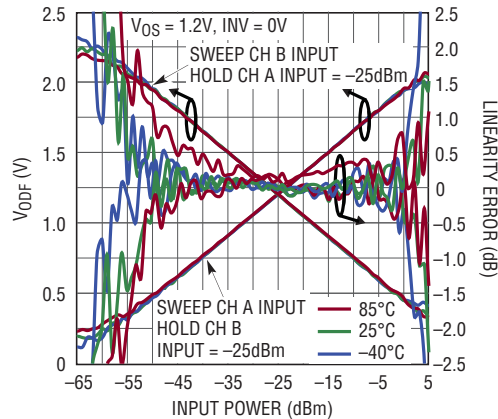
$V_{CC} = 3.3V$, $EN = 3.3V$, $T_A = 25^\circ C$, unless otherwise noted. For temperature compensation of logarithmic intercept at 2700MHz, set $R_{P1} = \text{Open}$, $R_{P2} = 0$, $R_{T1} = 8.87k\Omega$, $R_{T2} = 1.21k\Omega$. See Figure 1.

Output Voltage and Linearity Error vs RF Input Power, 2700MHz CW Inputs, Single-Ended Drive



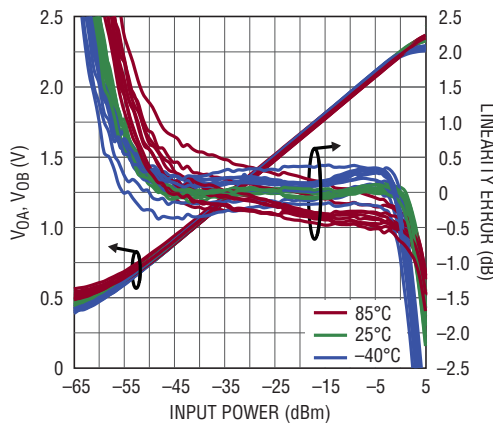
5583 G19

Difference Output and Linearity Error vs RF Input Power, 2700MHz CW Inputs, Single-Ended Drive



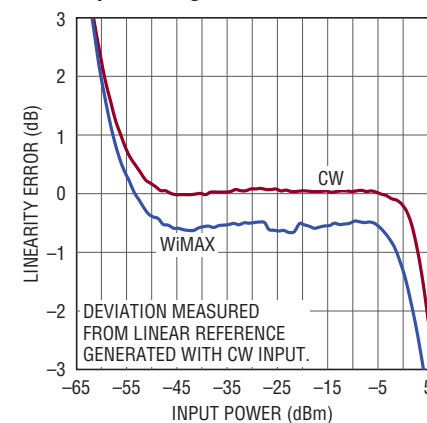
5583 G20

Output Voltage and Linearity Error vs RF Input Power, 2700MHz CW Inputs, Single-Ended Drive, 5 Devices



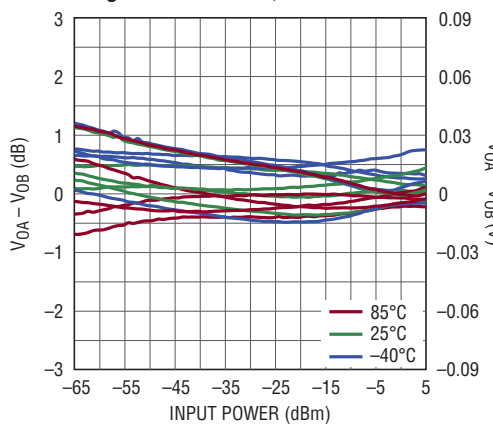
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Modulation Deviation vs RF Input Power, 2700MHz Inputs, Single-Ended Drive



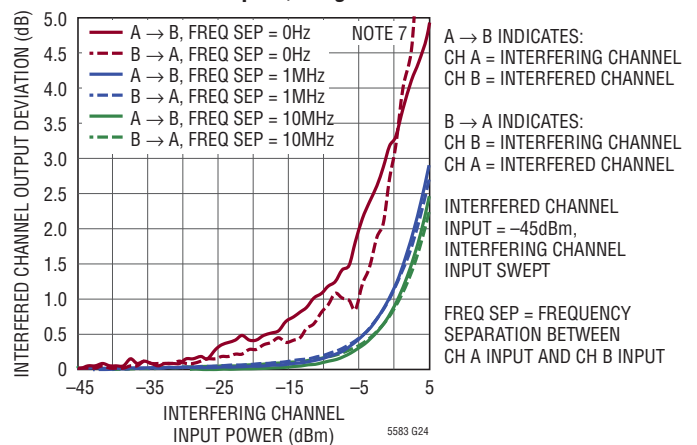
5583 G22

Channel Matching vs RF Input Power, 2700MHz CW Inputs, Single-Ended Drive, 5 Devices



5583 G23

Input A to Output B Isolation, Input B to Output A Isolation, 2700MHz CW Inputs, Single-Ended Drive

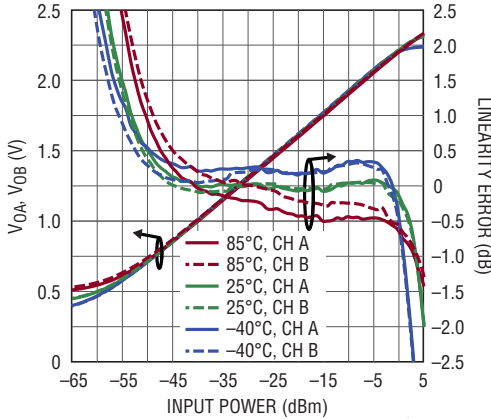


5583 G24

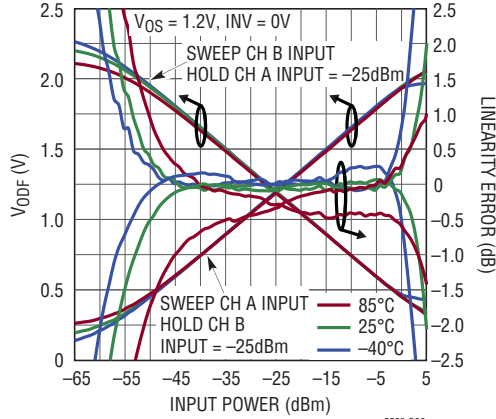
TYPICAL PERFORMANCE CHARACTERISTICS

$V_{CC} = 3.3V$, $EN = 3.3V$, $T_A = 25^\circ C$, unless otherwise noted. For temperature compensation of logarithmic intercept at 3600MHz, set $R_{P1} = \text{Open}$, $R_{P2} = 0$, $R_{T1} = 10.2k\Omega$, $R_{T2} = 1.65k\Omega$. See Figure 2.

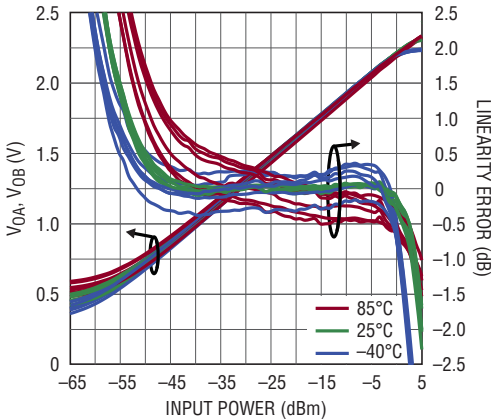
Output Voltage and Linearity Error vs RF Input Power, 3600MHz CW Inputs, Differential Drive



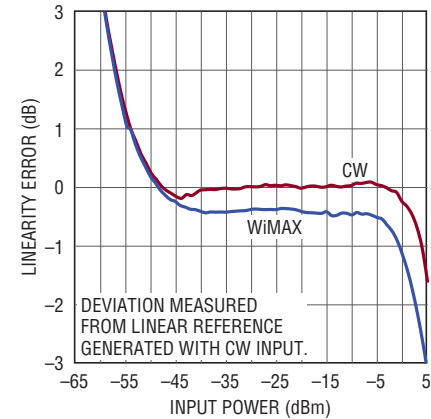
Difference Output and Linearity Error vs RF Input Power, 3600MHz CW Inputs, Differential Drive



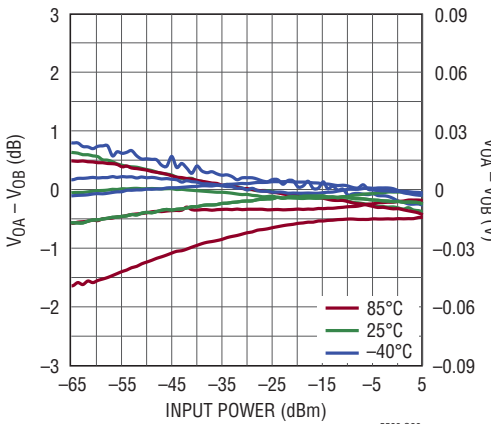
Output Voltage and Linearity Error vs RF Input Power, 3600MHz CW Inputs, Differential Drive, 3 Devices



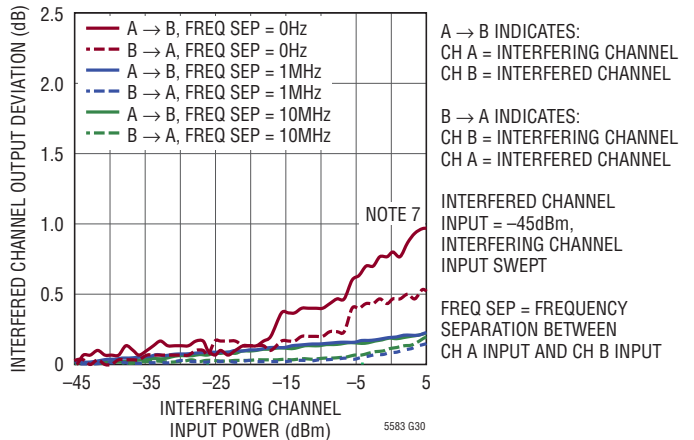
Modulation Deviation vs RF Input Power, 3600MHz Inputs, Differential Drive



Channel Matching vs RF Input Power, 3600MHz CW Inputs, Differential Drive, 3 Devices



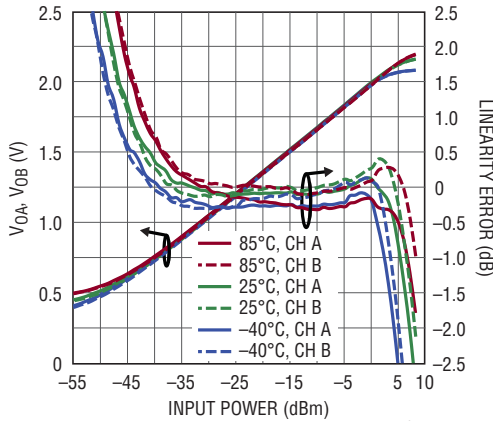
Input A to Output B Isolation, Input B to Output A Isolation, 3600MHz CW Inputs, Differential Drive



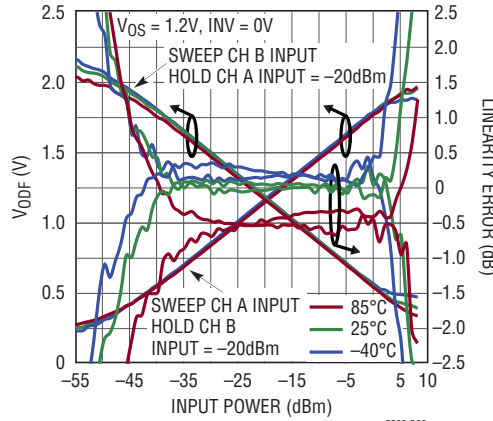
TYPICAL PERFORMANCE CHARACTERISTICS

$V_{CC} = 3.3V$, $EN = 3.3V$, $T_A = 25^\circ C$, unless otherwise noted. For temperature compensation of logarithmic intercept at 5800MHz, set $R_{P1} = \text{Open}$, $R_{P2} = 0$, $R_{T1} = 10k\Omega$, $R_{T2} = 1.47k\Omega$. See Figure 2.

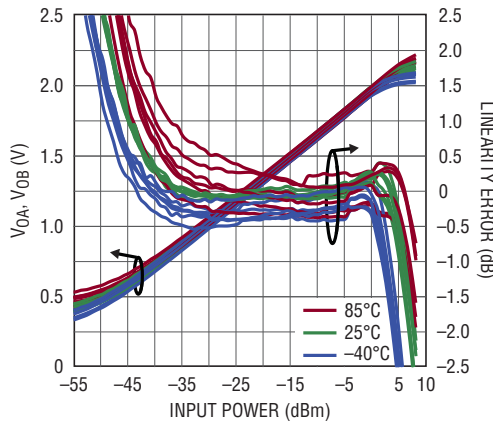
Output Voltage and Linearity Error vs RF Input Power, 5800MHz CW Inputs, Differential Drive



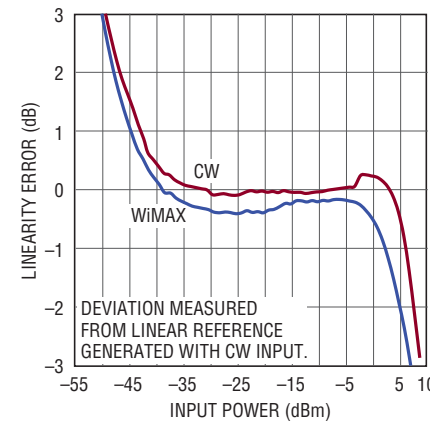
Difference Output and Linearity Error vs RF Input Power, 5800MHz CW Inputs, Differential Drive



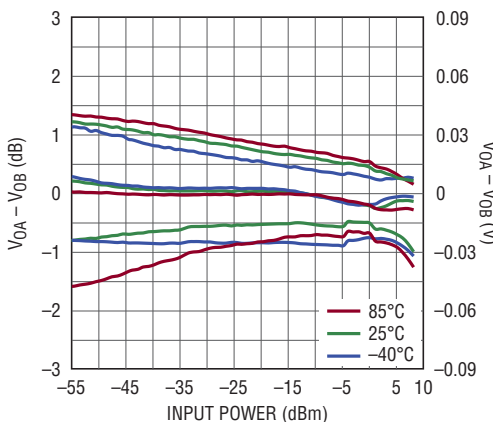
Output Voltage and Linearity Error vs RF Input Power, 5800MHz CW Inputs, Differential Drive, 3 Devices



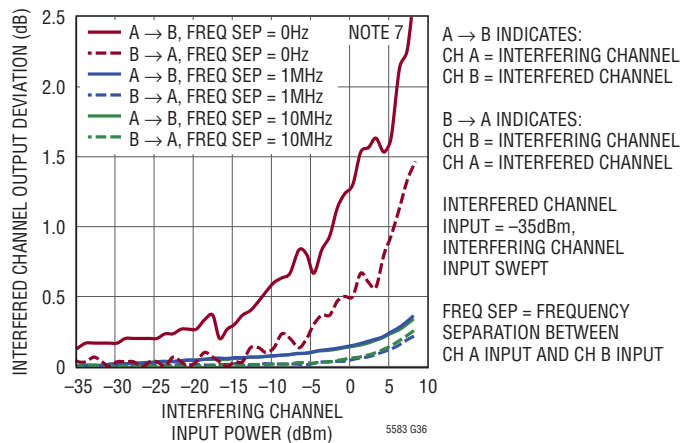
Modulation Deviation vs RF Input Power, 5800MHz Inputs, Differential Drive



Channel Matching vs RF Input Power, 5800MHz CW Inputs, Differential Drive, 3 Devices



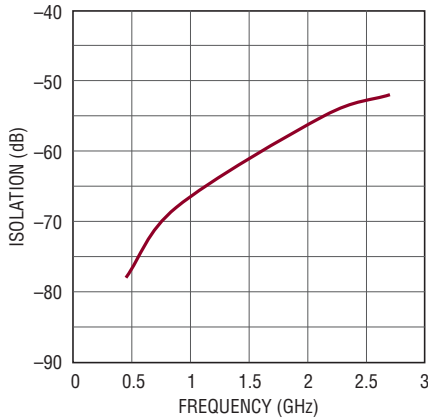
Input A to Output B Isolation, Input B to Output A Isolation, 5800MHz CW Inputs, Differential Drive



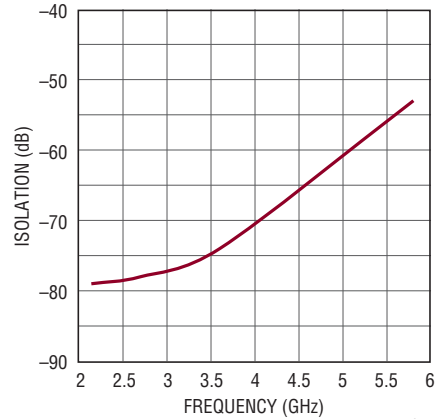
TYPICAL PERFORMANCE CHARACTERISTICS

$V_{CC} = 3.3V$, $EN = 3.3V$, $T_A = 25^\circ C$, unless otherwise noted. Test circuits shown in Figures 1 and 2.

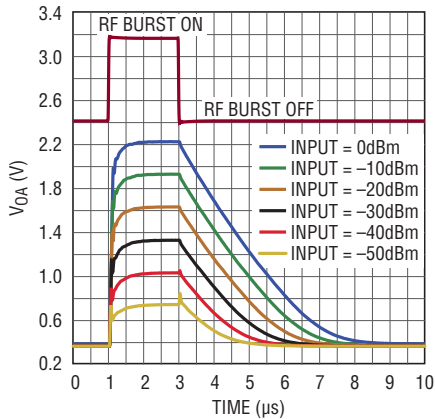
Input A to Input B Isolation, Single-Ended Inputs



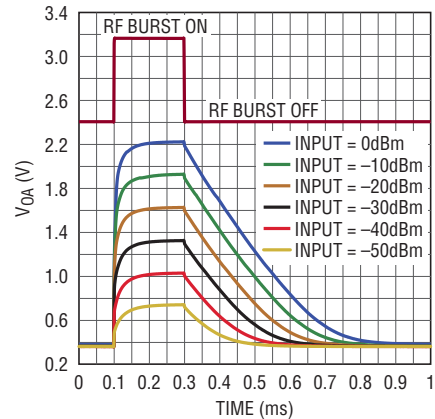
Input A to Input B Isolation, Differential Inputs



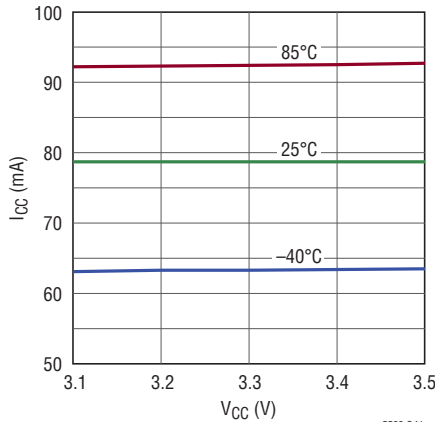
Output Response to RF Burst Input, 100MHz CW Input, $C_{FLTRA} = C_{FLTRB} = 8.2nF$



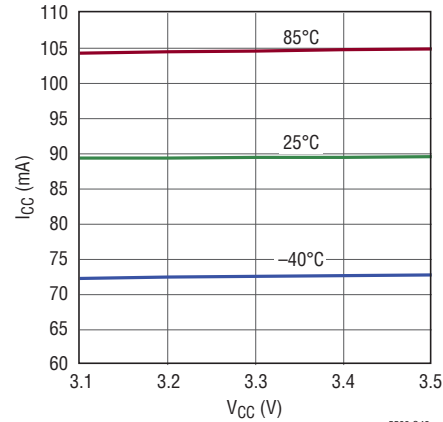
Output Response to RF Burst Input, 100MHz CW Input, $C_{FLTRA} = C_{FLTRB} = 1\mu F$



Supply Current vs Supply Voltage Envelope Detectors Disabled

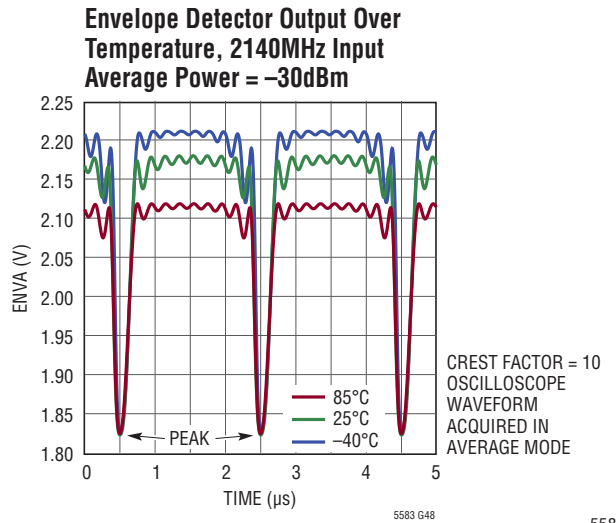
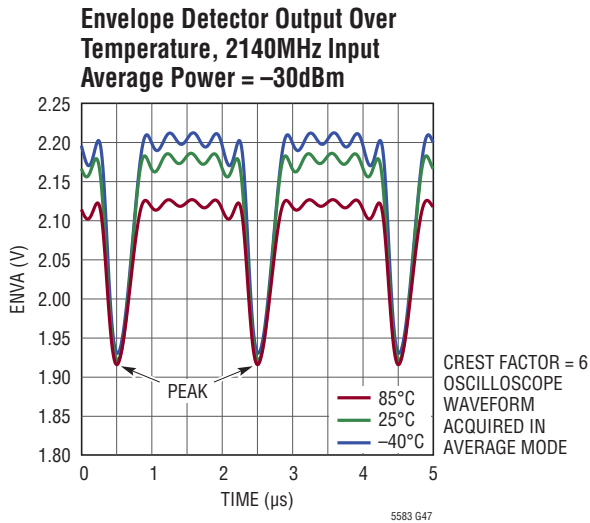
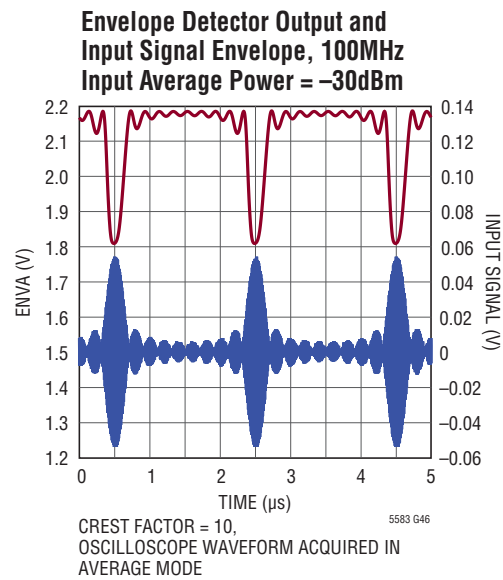
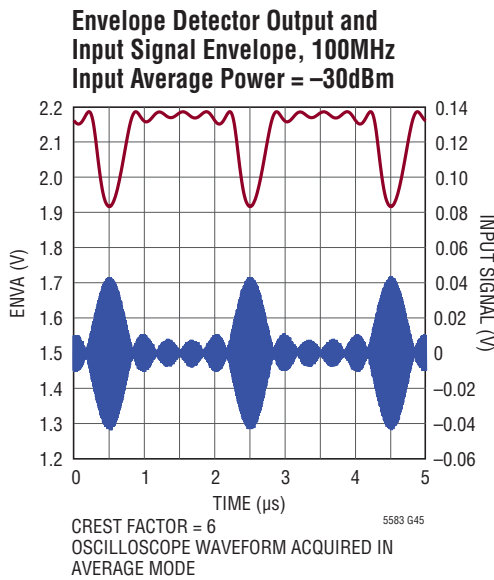
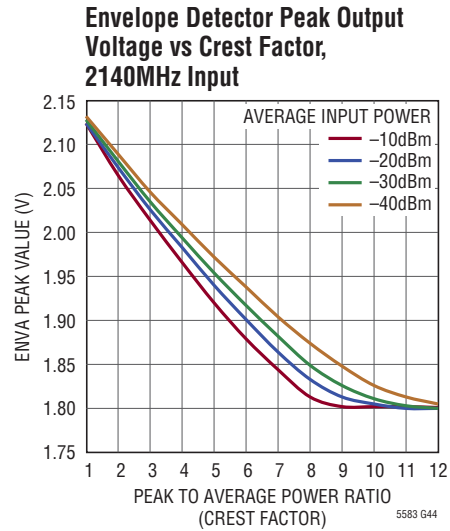
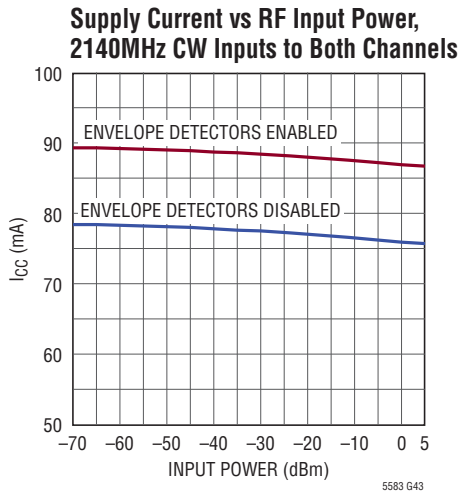


Supply Current vs Supply Voltage Envelope Detectors Enabled



TYPICAL PERFORMANCE CHARACTERISTICS

$V_{CC} = 3.3V$, $V_{EN} = 3.3V$, $T_A = 25^\circ C$, unless otherwise noted. Test circuits shown in Figures 1 and 2.



PIN FUNCTIONS

DECA, DECB (Pins 1, 6): Input Common Mode Decoupling Pins for Channel A and Channel B. These pins are internally biased to 1.6V. The input impedance is 1.75k Ω in parallel with a 40pF internal shunt capacitor to ground. The impedance between DECA and IN⁺A (or IN⁻A) is 200 Ω . The pin can be connected to the center tap of an external balun or to a capacitor to ground.

V_{CCA}, V_{CCB}, V_{CCR} (Pins 2, 5, 3): Power Supply Pins for Channel A, Channel B, and Bias Circuits. Typical total current consumption of these pins is 81mA. Each of these pins should be bypassed with 1nF and 1 μ F capacitors, placed as close to the IC as possible.

EN (Pin 4): Enable Input Pin. An applied voltage above 2V will activate the bias for the IC. For an applied voltage below 0.3V, the circuit will be shut down (disabled) with a corresponding reduction in power supply current. If the enable function is not required, then this pin can be connected to V_{CC}. The applied voltage to this pin should not exceed V_{CC} by more than 0.3V.

RP2 (Pin 9): Pin for Setting Polarity of Second Order Output Temperature Compensation. Connect this pin to ground to change the output voltage inversely proportional to ambient temperature. Float this pin to change the output voltage proportional to ambient temperature.

INV (Pin 12): Control Input Pin to Invert the Polarity of the Difference Output V_{ODF}.

RT2 (Pin 14): Second Order Output Temperature Compensation Pin for Both Channels. Connect this pin to ground to disable. The output voltage will increase or decrease with the ambient temperature by connecting this pin to ground via an off-chip resistor, depending on the polarity set by RP2 pin.

V_{OS} (Pin 15): Input Pin for Setting the DC Offset of the Difference Output V_{ODF}. It is recommended to set this DC offset such that V_{ODF} does not fall below 100mV.

V_{ODF} (Pin 16): DC Difference Output. This voltage is equal to the difference of the two channels' output voltages, plus a DC offset:

$$V_{ODF} = (V_{OA} - V_{OB}) + V_{OS}, \text{ if INV pin is held low, } (<1V)$$

$$V_{ODF} = (V_{OB} - V_{OA}) + V_{OS}, \text{ if INV pin is held high, } (>2V)$$

RT1 (Pin 17): First Order Output Temperature Compensation Pin for Both Channels. Connect this pin to ground to disable. The output voltage will increase or decrease with the ambient temperature by connecting this pin to ground via an off-chip resistor, depending on the polarity set by RP1 pin.

V_{OA}, V_{OB} (Pins 18, 13): DC Output of Channel A and Channel B, respectively.

V_{CCN} (Pin 19): Power Supply Pin for the Envelope Detectors in Both Channels. Typical total current consumption of this pin is 9.6mA. This pin should be bypassed with 1nF and 1 μ F capacitors. Connect this pin to ground to disable the envelope detectors.

ENVA, ENVB (Pins 20, 11): Envelope Detector Output Pins for Channel A and Channel B, respectively. Each output tracks the input signal's RF envelope and outputs a DC voltage directly proportional to the signal power, normalized to the average power.

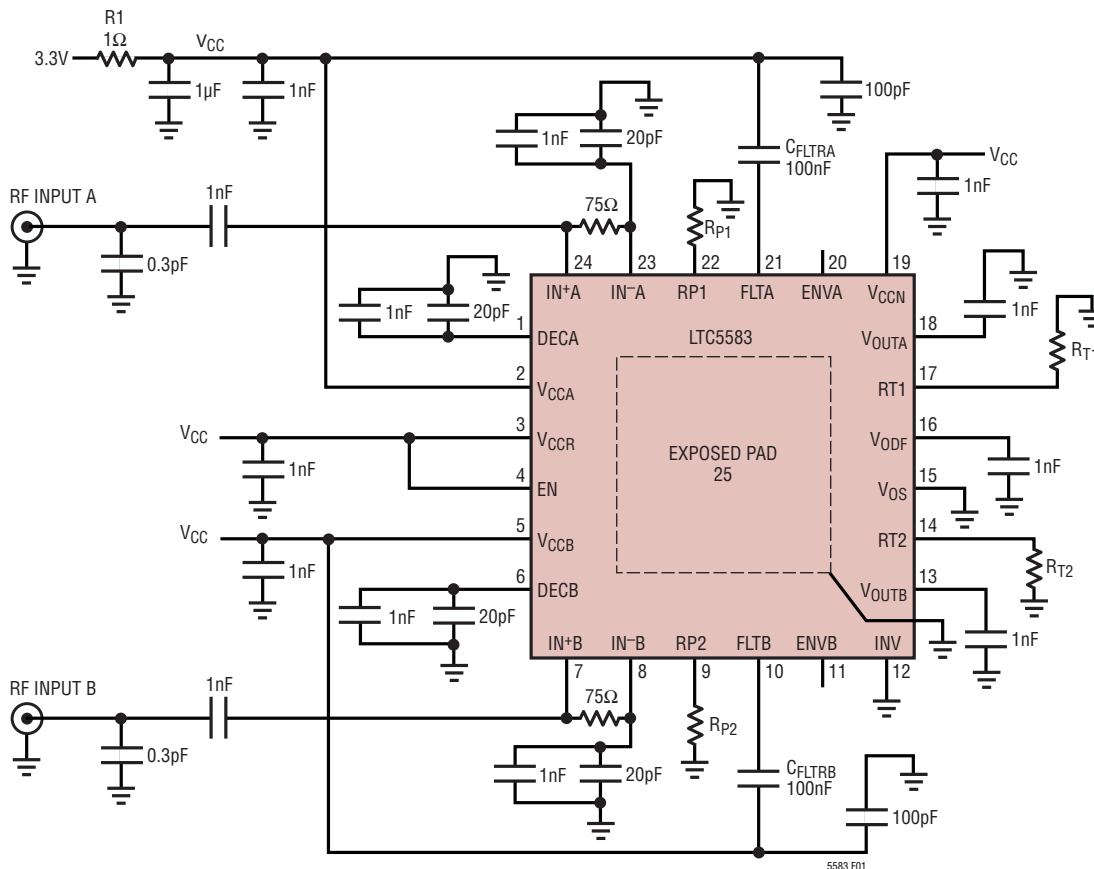
FLTA, FLTB (Pins 21, 10): Connection for an External Filtering Capacitor for Channel A and Channel B, respectively. A minimum 8nF capacitor is required for stable AC average power measurement. Each capacitor should be connected between FLTA and V_{CCA}, and between FLTB and V_{CCB}.

RP1 (Pin 22): Pin for Setting Polarity of First Order Output Temperature Compensation. Connect this pin to ground to change the output voltage proportional to ambient temperature. Float this pin to change the output voltage inversely proportional to ambient temperature.

IN⁺A, IN⁻A, IN⁺B, IN⁻B (Pins 24, 23, 7, 8): Differential RF Input Signal Pins for Channel A and Channel B. Each channel can be driven with a single-ended or differential signal. These pins are internally biased to 1.6V and should be DC-blocked externally. The differential impedance is 400 Ω .

GND (Exposed Pad Pin 25): Circuit Ground Return for the Entire IC. This must be soldered to the printed circuit board ground plane.

TEST CIRCUITS

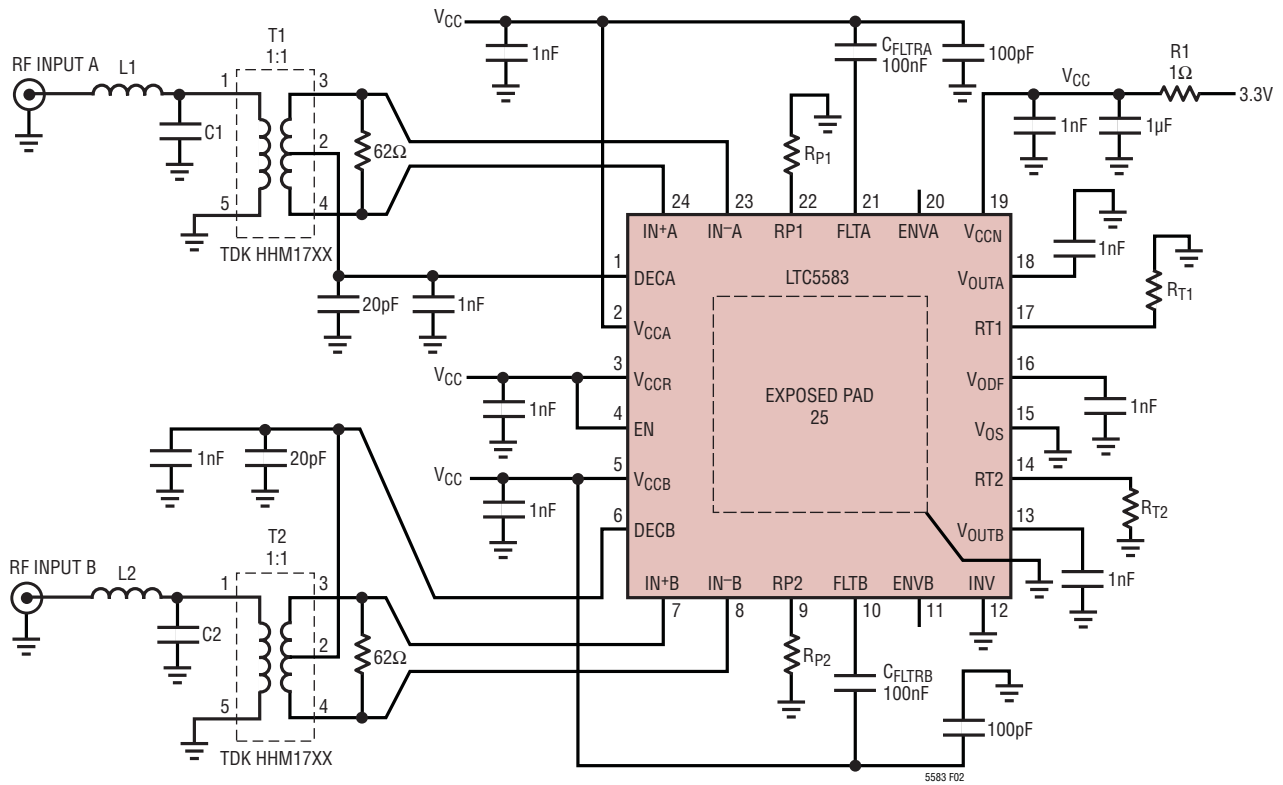


COMP	VALUE	SIZE	PART NUMBER
C	20pF	0402	Murata GRM1555CIH200JB01
C	100pF	0402	Murata GRM1555CIH101JD01B
C	1nF	0402	Murata GRM155R71H102KA01D
C	100nF	0402	Murata GRM155R61A104KA01
C	1μF	0402	Murata GRM155R60J105KE19
R	75Ω	0402	Vishay CRCW040275R0FKED

FREQUENCY	RP1	RP2	RT1	RT2	INPUT RETURN LOSS
450MHz	Open	0Ω	11.5kΩ	1.13kΩ	21dB
880MHz	Open	0Ω	11.5kΩ	1.13kΩ	14dB
2140MHz	Open	0Ω	9.76kΩ	1.10kΩ	14dB
2700MHz	Open	0Ω	8.87kΩ	1.21kΩ	14dB

Figure 1. Test Circuit Optimized for 40MHz to 3GHz Operation in Single-Ended Input Configuration

TEST CIRCUITS



COMP	VALUE	SIZE	PART NUMBER
C	20pF	0402	Murata GRM1555CIH200JB01
C	100pF	0402	Murata GRM1555CIH101JD01B
C	1nF	0402	Murata GRM155R71H102KA01D
C	100nF	0402	Murata GRM155R61A104KA01
C	1μF	0402	Murata GRM155R60J105KE19
R	62Ω	0402	Vishay CRCW040262R0FKED

FREQUENCY	L1, L2	C1, C2	T1, T2	RP1	RP2	RT1	RT2	INPUT RETURN LOSS
2140MHz	2.7nH	1pF	Murata LDB212G1005C-001	Open	0	9.76kΩ	1.10kΩ	15dB
2700MHz	1.5nH	X	TDK_HHM1710J1	Open	0	8.87kΩ	1.21kΩ	15dB
3600MHz	1.2nH	0.3pF	TDK_HHM1727D1	Open	0	10.2kΩ	1.65kΩ	17dB
5800MHz	Short	0.3pF	TDK_HHM1733B1	Open	0	10.0kΩ	1.47kΩ	11dB

Figure 2. Test Circuit Optimized for 2GHz to 6GHz Operation in Differential Input Configuration

TEST CIRCUITS

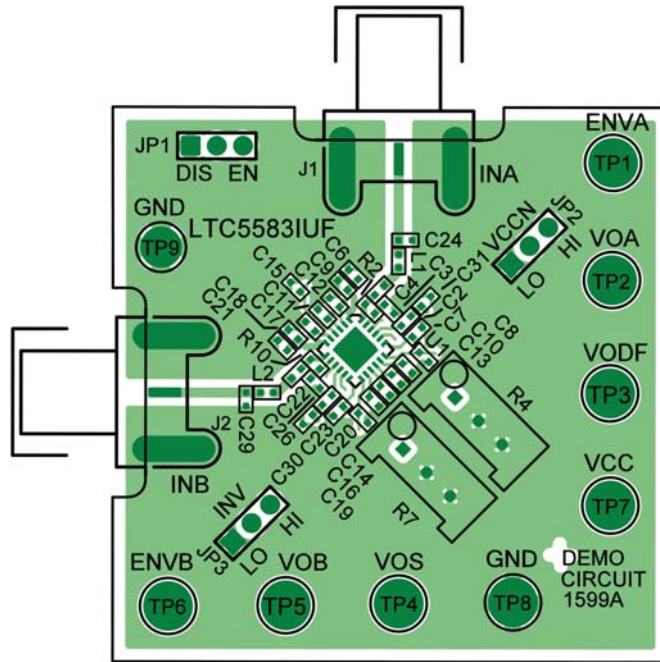


Figure 3. Top Side of Evaluation Board for Single-Ended Input Configuration

APPLICATIONS INFORMATION

The LTC5583 is a dual-channel true RMS power detector, capable of measuring two RF signals over the frequency range from 40MHz to 6GHz, independent of input waveforms with different crest factors such as CW, CDMA2K, WCDMA, LTE and WiMAX signals. Up to 60dB dynamic range is achieved with very stable output over the full temperature range from -40°C to 85°C . Input sensitivity can be as low as -56dBm up to 2.7GHz even with single-ended 50Ω input termination.

RF Inputs

The differential RF inputs are internally biased at 1.6V. The differential impedance is about 400Ω . These pins should be DC blocked when connected to ground or other matching components.

The LTC5583 can be driven in a single-ended configuration. The single-ended input impedance vs frequency is given in Table 1. Figure 4 shows the simplified circuit of this single-ended configuration for each channel. The DECA pin can be either left floating or AC-coupled to ground via an external capacitor. While the RF signal is applied to the IN^+A (or IN^-A) pin, the other pin, IN^-A (or IN^+A), should be AC-coupled to ground. By simply terminating the signal side of the inputs with a 75Ω resistor in front of the AC-blocking capacitor and coupling the other side to ground using a 1nF capacitor, a broadband 50Ω input match can be achieved with typical input return loss better than 14dB from 40MHz to 2.7GHz. At higher RF frequencies, additional matching components may be needed. Contact LTC Applications for more information.

Table 1. Single-Ended Input Impedance

FREQUENCY (MHz)	INPUT IMPEDANCE (Ω)	S11	
		MAG	ANGLE ($^{\circ}$)
40	207.4 – j15.5	0.613	-2.2
100	193.0 – j34.0	0.599	-5.4
200	188.9 – j56.8	0.611	-8.9
400	151.6 – j68.7	0.576	-15.2
600	127.8 – j62.8	0.530	-19.5
800	107.6 – j66.0	0.513	-26.2
1000	96.1 – j61.5	0.485	-30.3
1200	85.6 – j59.2	0.467	-35.4
1400	76.2 – j57.4	0.455	-41.0
1600	67.7 – j55.0	0.445	-47.1
1800	60.4 – j52.0	0.435	-53.5
2000	54.9 – j48.7	0.423	-59.4
2200	50.3 – j45.6	0.414	-65.2
2400	46.5 – j42.7	0.406	-70.8
2600	43.7 – j39.8	0.396	-76.0
2800	41.6 – j37.0	0.384	-80.8
3000	40.2 – j34.5	0.371	-84.9
3200	39.3 – j32.0	0.356	-88.8
3400	37.8 – j30.1	0.350	-93.1
3600	35.6 – j26.4	0.336	-101.5
3800	35.0 – j23.3	0.314	-107.4
4000	34.4 – j19.8	0.291	-115.0
4200	33.6 – j16.7	0.275	-123.2
4400	32.9 – j14.2	0.264	-130.6
4600	31.7 – j11.1	0.260	-141.0
4800	30.5 – j8.0	0.261	-152.0
5000	29.3 – j5.1	0.268	-162.5
5200	28.0 – j2.1	0.283	-173.0
5400	26.7 + j0.5	0.304	178.4
5600	25.4 + j2.7	0.328	171.7
5800	24.2 + j4.8	0.353	165.8
6000	23.1 + j6.6	0.377	161.1

APPLICATIONS INFORMATION

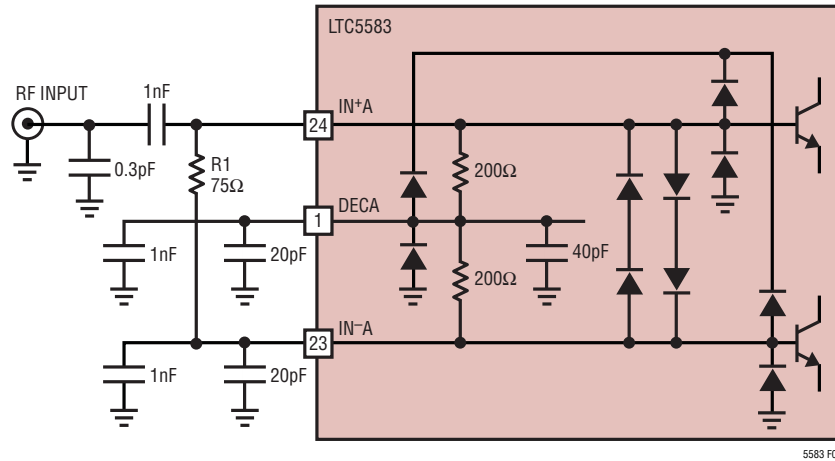


Figure 4. Single-Ended Input Configuration

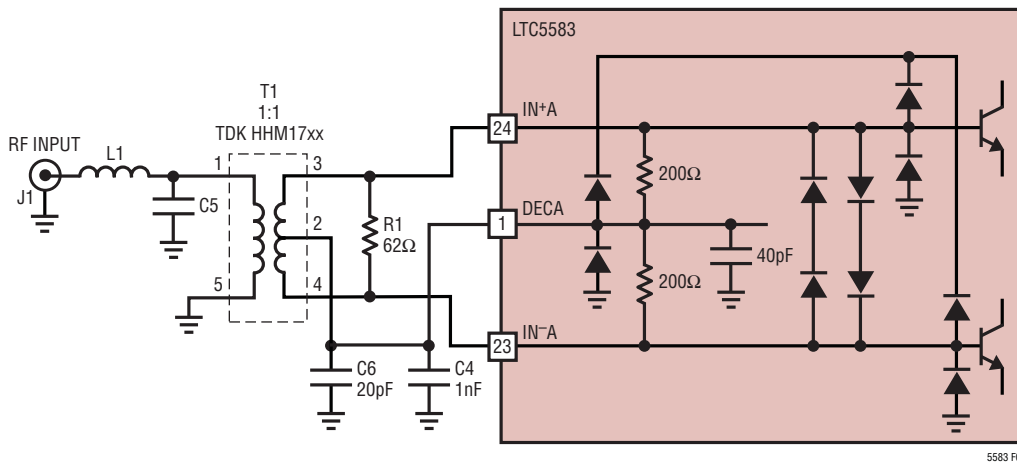


Figure 5. Differential Input Configuration

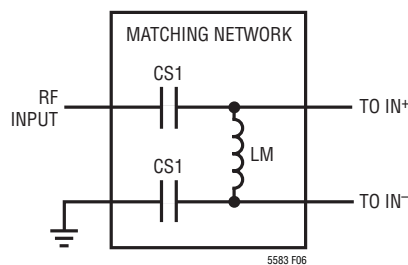


Figure 6. Single-Ended to Differential Conversion

APPLICATIONS INFORMATION

The LTC5583 differential inputs can also be driven from a fully balanced source as shown in Figure 5. When the two input sources are single-ended, conversion to differential signals can improve channel-to-channel isolation to obtain accurate outputs from the dual channels, particularly at very high frequencies (i.e. 3.6GHz and above). This can be achieved using a 1:1 balun to match the chip's internal 400Ω input impedance to the 50Ω source by adding a 62Ω resistor (R1) at the differential inputs as shown in Figure 5. Since there is no voltage conversion gain from impedance transformation in this case, the sensitivity of the detector is similar to the one using single-ended inputs as shown in Figure 4.

If better sensitivity is needed, a 1:4 balun can be used and R1 should be increased to 400Ω correspondingly to match 200Ω input impedance to the 50Ω source. This impedance transformation results in 6dB voltage gain, thus 6dB improvement in sensitivity is obtained while the overall dynamic range remains the same. At high frequency, additional LC elements may be needed for input impedance matching due to the parasitics of the transformer and PCB traces.

Alternatively, a narrowband LC matching network can be used for the conversion of a single-ended signal to a balanced signal. Such a matching network is shown in Figure 6. By this means, the sensitivity and overall linear dynamic range of the detector can be similar to the one using a 1:4 RF input balun, as described above.

For a 50Ω input termination, the approximate RF input power range of the LTC5583 is from -58dBm to 4dBm , even with high crest factor signals such as a 4-carrier W-CDMA waveform, but the minimum detectable RF power level varies as the input RF frequency increases. The linear

dynamic range can also be shifted to tailor to a particular application. By simply inserting an attenuator in front of the RF input, the power range is shifted higher by the amount of the attenuation.

The sensitivity of LTC5583 is dictated by the broadband input noise power, which also determines the output DC offset voltage. When the inputs are terminated differently, the DC output voltage may vary slightly. When the input noise power is minimized, the DC offset voltage is also reduced to a minimum, and the sensitivity and dynamic range are improved accordingly.

External Filtering Capacitors at FLTA and FLTB Pins

These pins are internally biased at $V_{CC} - 0.43\text{V}$ via a $1.2\text{k}\Omega$ resistor from the V_{CCA} and V_{CCB} voltage supply. To ensure stable operation of the LTC5583, an external capacitor with a value of 8nF or higher is required to connect the FLTA pin to V_{CCA} , and the FLTB pin to V_{CCB} , respectively. Do not connect these filter capacitors to ground or any other low voltage reference to prevent an abnormal start-up condition.

The value of these two filtering capacitors has a dominant effect on the output transient response. The lower the capacitance, the faster the output rise and fall times. For signals with AM content such as W-CDMA, ripple can be observed when the loop bandwidth set by the filtering capacitors is close to the modulation bandwidth of the signal.

In general, the LTC5583 output ripple remains relatively constant regardless of the RF input power level for a fixed filtering capacitor and modulation format of the RF signal. Typically, this capacitor must be selected to average out the ripple to achieve the desired accuracy of RF power measurement.

APPLICATIONS INFORMATION

RMS Power Detector Output: V_{OA} , V_{OB}

The output buffer amplifier of the LTC5583 is shown in Figure 7. This Class-AB buffer amplifier can output $\pm 5\text{mA}$ current to the load. The output impedance is determined primarily by the 50Ω series resistor connected to the buffer amplifier inside the chip. This will prevent any overstress on the internal devices in the event that the output is shorted to ground.

The -3dB small-signal bandwidth of the buffer amplifier is about 22.4MHz and the full-scale rise/fall time can be as fast as 140ns , limited by the slew rate of the internal circuit instead. 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. The rise time of the LTC5583 is about 140ns and the fall time is $3.5\mu\text{s}$, respectively, for full-scale pulsed RF input power with 8.2nF filtering capacitors. The speed of the output transient response is dictated mainly by the filtering capacitors (at least 8nF) at the FLTA and FLTB pins. See the detailed output transient response in the Typical Performance Characteristics section. When the RF input has AM content, residual ripple may be present at the output depending upon the low frequency content of the modulated RF signal. This ripple can be reduced with a larger filtering capacitor at the expense of a slower transient response.

Since the output buffer amplifier of the LTC5583 is capable of driving an arbitrary capacitive load, the residual ripple can be further filtered at the output with a series resistor R_{SS} and a large shunt capacitor C_{LOAD} (see Figure 7). This lowpass filter also reduces the output noise by limiting the output noise bandwidth. When this RC network is designed properly, a fast output transient response can be maintained with reduced residual ripple. For example, we can estimate C_{LOAD} with an output voltage swing of 1.7V at 2140MHz . In order to not allow the maximum 5mA sourcing current to limit the fall time (about $5\mu\text{s}$), the maximum value of C_{LOAD} can be chosen as follows:

$$C_{LOAD} \leq 5\text{mA} \cdot \text{Allowable Additional Time}/1.7\text{V} \\ = 5\text{mA} \cdot 0.25\mu\text{s}/1.7\text{V} = 735\text{pF}$$

Once C_{LOAD} is determined, R_{SS} can be chosen properly to form an RC low-pass filter with a corner frequency of $1/[2\pi \cdot (R_{SS} + 50) \cdot C_{LOAD}]$.

In general, the rise time of the LTC5583 is much shorter than the fall time. However, when the output RC filter is used, the rise time may be dominated by the time constant of this filter. Accordingly, the rise time becomes very similar to the fall time. Although the maximum sinking capability of the LTC5583 is 5mA , it is recommended that the output load resistance should be greater than $1.2\text{k}\Omega$ in order to achieve the full output voltage swing.

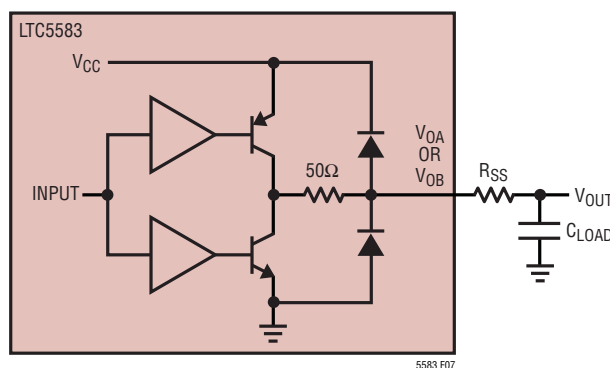


Figure 7. Simplified Circuit Schematic of the RMS Power Detector Output Interface

APPLICATIONS INFORMATION

Temperature Compensation of Logarithmic Intercept

The simplified interface schematics of the intercept temperature compensation are shown in Figure 8 and Figure 9. The adjustment of the output voltage can be described by the following equation with respect to the ambient temperature:

$$\Delta V_{OUT} = TC1 \cdot (T_A - t_{NOM}) + TC2 \cdot (T_A - t_{NOM})^2 + \text{detV1} + \text{detV2}$$

where TC1 and TC2 are the first order and second order temperature compensation coefficients, respectively; T_A is the actual ambient temperature; and t_{NOM} is the reference room temperature 25°C; detV1 and detV2 are the output voltage variation when R_{T1} and R_{T2} are not set to zero.

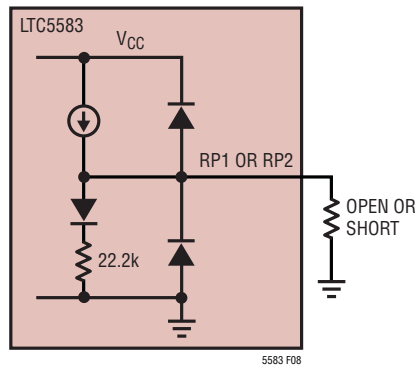


Figure 8. Simplified Interface Circuit Schematic of the Polarity Pins RP1 and RP2

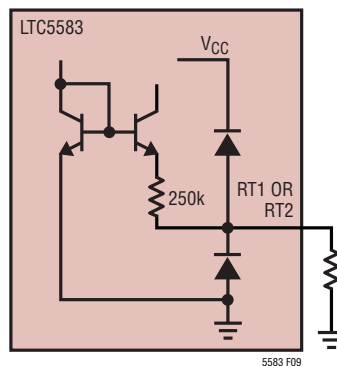


Figure 9. Simplified Interface Circuit Schematic of the Control Pins RT1 and RT2

APPLICATIONS INFORMATION

The temperature coefficients TC1 and TC2 are shown as functions of the tuning resistors R_{T1} and R_{T2} in Figure 10 and Figure 11.

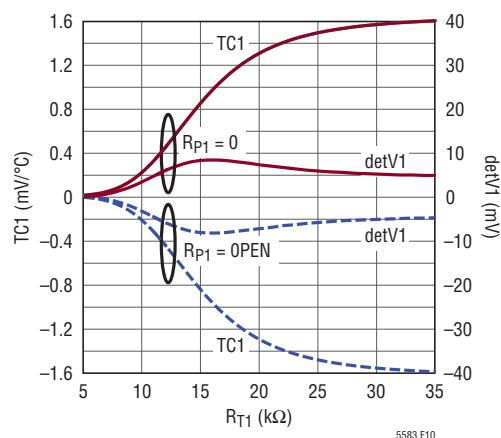


Figure 10. First Order Temperature Compensation Coefficient TC1 vs External RT1 Value

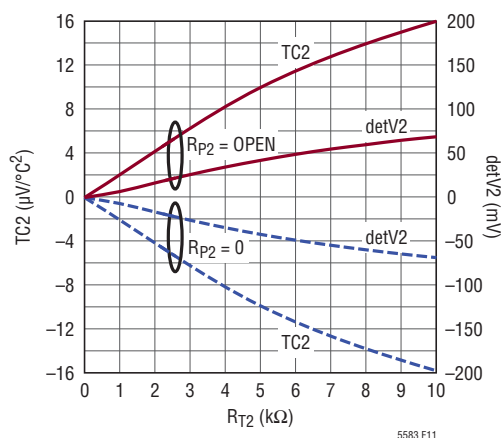


Figure 11. Second Order Temperature Compensation Coefficient TC2 vs External RT2 Value

When pins RT1 and RT2 are shorted to ground, the temperature compensation circuit is disabled automatically. Polarity of the temperature coefficient TC1 (or TC2), can be selected by either shorting the RP1 pin (or RP2 pin) to ground or leaving it open, while the coefficients' values can be controlled by external resistors R_{T1} and R_{T2} independently, according to Figures 10 and 11. At a given RF frequency, the polarities and optimal values of TC1 and TC2 can be chosen to ensure a stable output over the operating temperature range. Table 2 lists the suggested R_{P1} , R_{P2} , R_{T1} and R_{T2} values at various RF frequencies for the best output performance over temperature.

Table 2. Suggested R_P and R_T Values for Optimal Temperature Performance vs RF Frequency

Frequency (MHz)	R_{P1}	R_{T1} (kΩ)	R_{P2}	R_{T2} (kΩ)
450	Open	11.5	0	1.13
880	Open	11.5	0	1.13
2140	Open	9.76	0	1.10
2700	Open	8.87	0	1.21
3600	Open	10.2	0	1.65
5800	Open	10.0	0	1.47

APPLICATIONS INFORMATION

Envelope Detector Output: ENVA, ENVB

Each envelope detector output linearly follows the instantaneous input power level, tracking the input signal's RF envelope. ENVA and ENVB also indicate the peak-to-average power ratio (crest factor). Thus, reading both V_{OA} and ENVA provides the average power, peak-to-average power ratio, peak power, and RF envelope of the input signal to Channel A. Reading V_{OB} and ENVB provides the same information for Channel B.

Enable: EN

A simplified schematic of the EN pin interface is shown in Figure 13. The enable voltage necessary to turn on the LTC5583 is 2V. To disable or turn off the chip, set this voltage below 0.3V. It is important that the voltage applied to the EN pin should never exceed V_{CC} by more than 0.3V. Otherwise, the supply current may be sourced through the upper ESD protection diode connected at the EN pin. Under no circumstances should voltage be applied to the EN pin before the supply pins (V_{CCA} , V_{CCB} , V_{CCR} , V_{CCN}). If this occurs, damage to the IC may result.

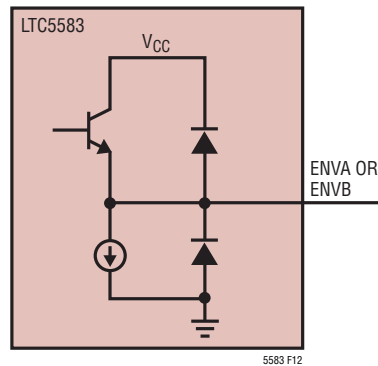


Figure 12. Simplified Schematic of the ENVA and ENVB Pin

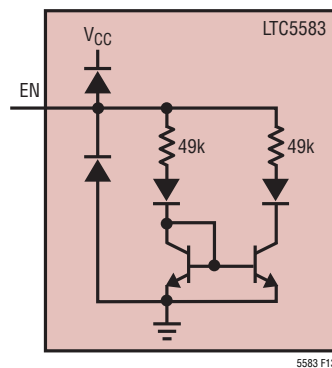


Figure 13. Simplified Schematic of the Enable Pin

APPLICATIONS INFORMATION

Difference Output: V_{ODF}

This voltage is equal to the difference of the two channels' output voltages, plus a DC offset:

$$V_{ODF} = (V_{OA} - V_{OB}) + V_{OS} \\ \text{if INV voltage} < 1V.$$

$$V_{ODF} = (V_{OB} - V_{OA}) + V_{OS} \\ \text{if INV voltage} > 2V.$$

A simplified schematic of the V_{ODF} interface is shown in Figure 14. The low 5Ω output impedance at this pin is due to internal feedback circuitry.

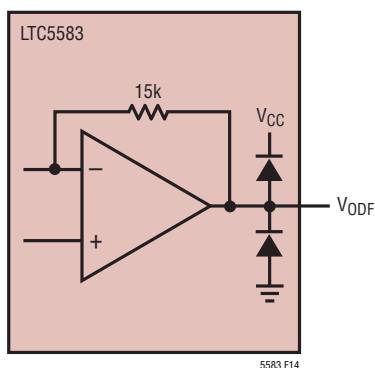


Figure 14. Simplified Schematic of the V_{ODF} Pin

Figure 15 shows a simplified schematic of the INV pin interface. INV determines the sign of the difference function at the V_{ODF} output.

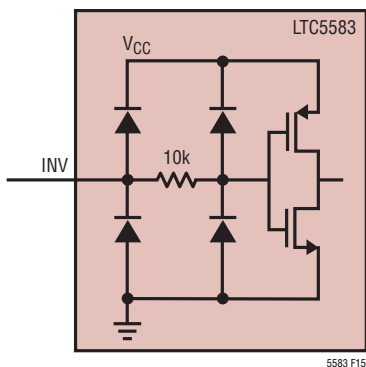


Figure 15. Simplified Schematic of the INV Pin

A simplified schematic of the V_{OS} pin interface is shown in Figure 16. The output range of V_{ODF} is from 50mV to $V_{CC} - 50mV$; it cannot go below 50mV. If $V_{OA} - V_{OB}$ is negative (for INV = low), a positive offset voltage V_{OS} is needed. Similarly, if $V_{OB} - V_{OA}$ is negative (for INV = high), a positive offset voltage V_{OS} is needed.

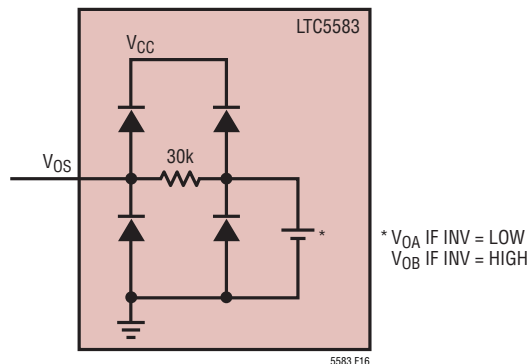


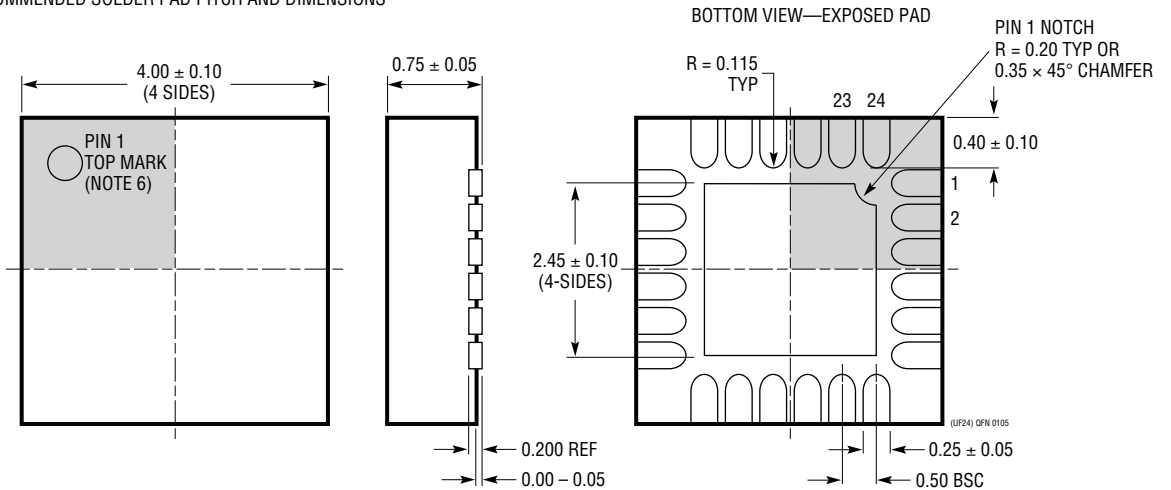
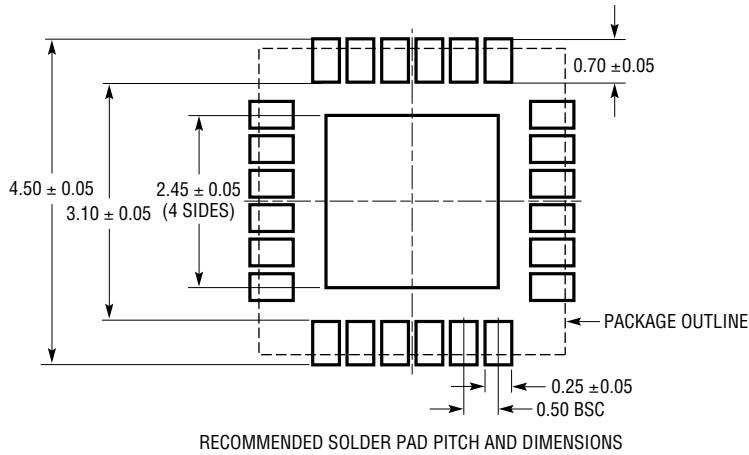
Figure 16. Simplified Schematic of the V_{OS} Pin

Supply Voltage Ramping

Fast ramping of the supply voltage can cause a current glitch in the internal ESD protection circuits. Depending on the supply inductance, this could result in a supply voltage overshoot at initial turn-on that exceeds the maximum rating. A supply voltage ramp time of greater than 1ms is recommended. In case this voltage ramp time is not controllable, a small (i.e. 1Ω) series resistor can be inserted between V_{CC} pin and the supply voltage source to mitigate the problem and protect the IC. The R1 shown in Figures 1 and 2 serves this purpose.

PACKAGE DESCRIPTION

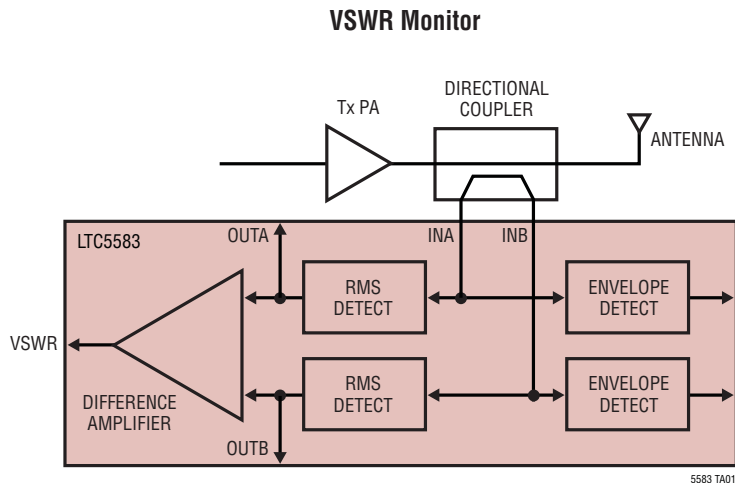
UF Package
24-Lead Plastic QFN (4mm × 4mm)
 (Reference LTC DWG # 05-08-1697)



REVISION HISTORY

REV	DATE	DESCRIPTION	PAGE NUMBER
A	12/10	Revised the maximum Shutdown Current value in the Electrical Characteristics section.	5

TYPICAL APPLICATION



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
Infrastructure		
LT5527	400MHz to 3.7GHz, 5V Downconverting Mixer	2.3dB Gain, 23.5dBm IIP3 and 12.5dB NF at 1900MHz, 5V/78mA Supply
LT5557	400MHz to 3.8GHz, 3.3V Downconverting Mixer	2.9dB Gain, 24.7dBm IIP3 and 11.7dB NF at 1950MHz, 3.3V/82mA Supply
LTC6400-X	300MHz Low Distortion IF Amp/ADC Driver	Fixed Gain of 8dB, 14dB, 20dB and 26dB; >36dBm OIP3 at 300MHz, Differential I/O
LTC6401-X	140MHz Low Distortion IF Amp/ADC Driver	Fixed Gain of 8dB, 14dB, 20dB and 26dB; >40dBm OIP3 at 140MHz, Differential I/O
LTC6416	2GHz 16-Bit ADC Buffer	40.25dBm OIP3 to 300MHz, Programmable Fast Recovery Output Clamping
LTC6412	31dB Linear Analog VGA	35dBm OIP3 at 240MHz, Continuous Gain Range -14dB to 17dB
LT5554	Ultralow Distort IF Digital VGA	48dBm OIP3 at 200MHz, 2dB to 18dB Gain Range, 0.125dB Gain Steps
LT5575	700MHz to 2.7GHz Direct Conversion I/Q Demodulator	Integrated Baluns, 28dBm IIP3, 13dBm P1dB, 0.03dB I/Q Amplitude Match, 0.4° Phase Match
LT5578	400MHz to 2.7GHz Upconverting Mixer	27dBm OIP3 at 900MHz, 24.2dBm at 1.95GHz, Integrated RF Transformer
LT5579	1.5GHz to 3.8GHz Upconverting Mixer	27.3dBm OIP3 at 2.14GHz, NF = 9.9dB, 3.3V Supply, Single-Ended LO and RF Ports
LTC5598	5MHz to 1.6GHz I/Q Modulator	27.7dBm OIP3 at 140MHz, 22.9dBm at 900MHz, -161.2dBm/Hz Noise Floor
LTC5588-1	200MHz to 6GHz I/Q Modulator with Ultra-High OIP3	31dBm Uncalibrated OIP3, Single-Pin Calibration to Optimize OIP3 to 35dBm, -158dBm/Hz Noise Floor, 3.3V Supply
RF Power Detectors		
LT5534	50MHz to 3GHz Log RF Power Detector with 60dB Dynamic Range	±1dB Output Variation over Temperature, 38ns Response Time, Log Linear Response
LT5537	Wide Dynamic Range Log RF/IF Detector	Low Frequency to 1GHz, 83dB Log Linear Dynamic Range
LT5581	6GHz Low Power RMS Detector	40dB Dynamic Range, ±1dB Accuracy Over Temperature, 1.5mA Supply Current
LTC5582	10GHz RMS Power Detector	57dB Dynamic Range, ±1dB Accuracy Over Temperature
ADCs		
LTC2208	16-Bit, 130MSPS ADC	78dBFS Noise Floor, >83dB SFDR at 250MHz
LTC2262-14	14-Bit, 150MSPS ADC Ultralow Power	72.8dB SNR, 88dB SFDR, 149mW Power Consumption
LTC2242-12	12-Bit, 250MSPS ADC	65.4dB SNR, 78dB SFDR, 740mW Power Consumption