

## TRUE RMS RF POWER DETECTOR

Check for Samples: [TRF1600](#)

### FEATURES

- RF True RMS Power Detector
- RMS to DC Conversion Up to 2 GHz
- Waveform and Modulation Independent (CW, GSM, WCDMA, TDMA, HSUPA)
- Linear-In-dB Output
- Input Dynamic Range of 28 dB (–29 dBm to –1 dBm)
- External Input Pin
- 6.7-mA Typical Operating Current
- 5- $\mu$ A Maximum Shutdown Current

- Operating Temperature Range: –20°C to 85°C
- Small 2-mm x 2-mm QFN 6 Pin Package

### APPLICATIONS

- Cellular Handsets (GSM, CDMA, TDMA)
- Power Amplifier Control Loops
- Transmitter Power Measurement and Control

### DESCRIPTION

The TRF1600 is a true RMS power detector with a 28-dB dynamic input range and a linear-to-dB DC output. It is intended for use in wireless handheld devices such as cell phones and PDAs to measure and control PA output power accurately independent of the modulation scheme.

The device is designed to operate off of a lithium-ion battery (2.7 V to 5.5 V, 6 V tolerant) or a regulated supply. A low input signal at the enable pin puts the device in shut-down mode and supply current consumption is reduced to <5  $\mu$ A. When asserted high the device enters active mode and outputs a DC voltage proportional to the RMS value of the input power expressed in dBm.

**Table 1. ORDERING INFORMATION<sup>(1)</sup>**

T <sub>A</sub>	PACKAGE <sup>(2)</sup>	ORDERABLE PART NUMBER
–20°C to 85°C	DRV	TRF1600DRV

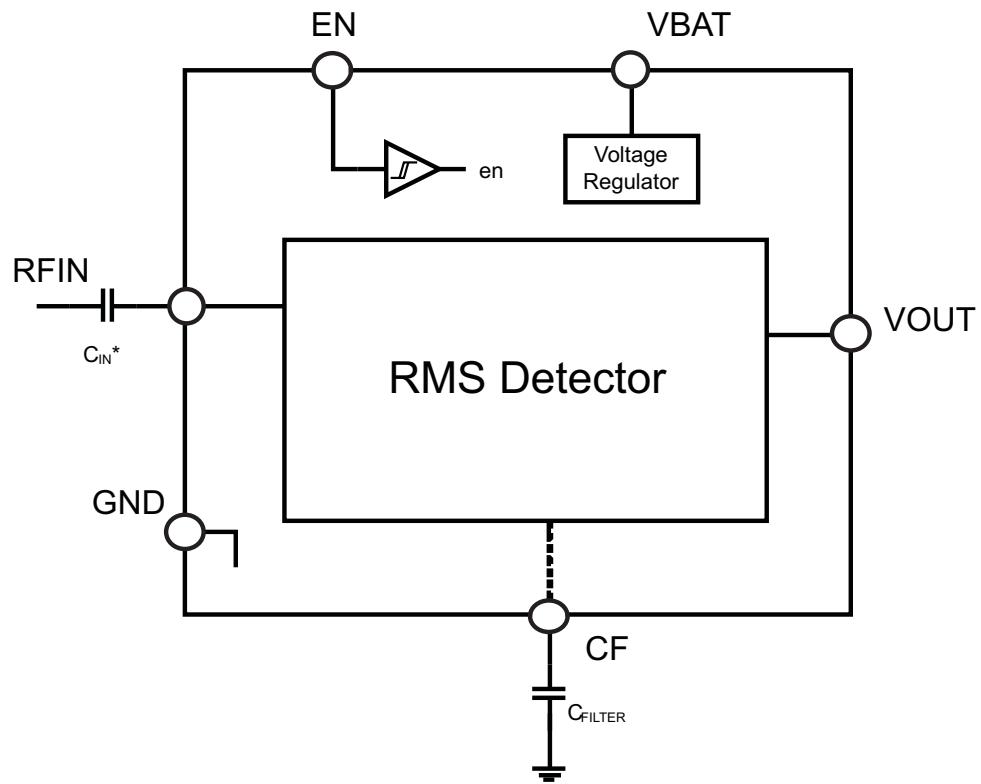
(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at [www.ti.com](http://www.ti.com).

(2) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).

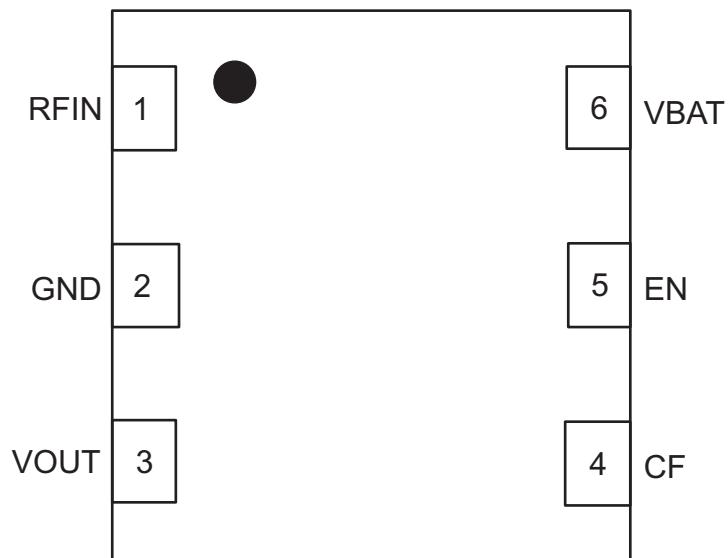


Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

## BLOCK DIAGRAM



\* $C_{IN}$  may be omitted if the DC level of the RF input signal is at ground.

**PINOUT**

**Table 2. TERMINAL FUNCTIONS**

TERMINAL		I/O	DESCRIPTION
NAME	NO.		
RFIN	1	I	RF input
GND	2		Ground
VOUT	3	O	Output of the device
CF	4	I	Filter capacitor. Pin needs to be connected to an off-chip filter capacitor in the application.
EN	5	I	Enable pin/Vprog
VBAT	6		Input supply pin to the device

**ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>**

All voltages values are with respect to GND. Over operating free-air temperature range (unless otherwise noted).

		VALUE	UNIT
	Unregulated input battery voltage	-0.5 to 6.0	V
EN		-0.5 to 3.6	V
V <sub>OUT</sub>		-0.5 to 3.6	V
P <sub>RFIN</sub> (max RF input power)		6	dBm
θ <sub>JA</sub>	Thermal resistance, junction to ambient	140	°C/W
P <sub>D</sub>	Continuous power dissipation	50	mW
ESD integrity	HBM (human body model)	2k	V
	CMD (charged device model)	500	
	IEC Contact – V <sub>CC</sub> pin <sup>(2)</sup>	8k	
	IEC Air – V <sub>CC</sub> pin <sup>(2)</sup>	15k	
T <sub>A</sub>	Operating ambient temperature	-40 to 125	°C
T <sub>J</sub>	Operating junction temperature	125	°C
T <sub>S</sub>	Storage temperature	-40 to 125	°C

(1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) IEC ESD tests performed on V<sub>CC</sub> pin with five shunt capacitors ranging from 10 pF to 10 µF. This is meant to evaluate the performance of the device when it is powered directly from a battery with these capacitors used as bypass capacitors on the same PC board.

**RECOMMENDED OPERATING CONDITIONS**

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V <sub>BAT</sub>	Unregulated input battery voltage	2.7	5.5	V	
f <sub>IN</sub>	Input frequency range	800	2000	MHz	
	EN pin voltage	0	3.3	V	
P <sub>D</sub>	Continuous power dissipation		35	mW	
T <sub>A</sub>	Operating ambient temperature	-20	85	°C	
C <sub>FILTER</sub>		0	3000	pF	

**ELECTRICAL CHARACTERISTICS**

V<sub>BAT</sub> = 3.0 ±5%, T<sub>A</sub> = -20 to 85°C, C<sub>FILTER</sub> = 820 pF ±10%, unless otherwise specified.

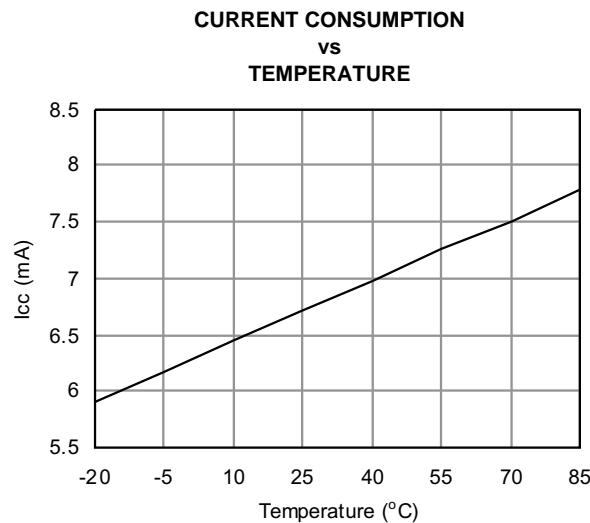
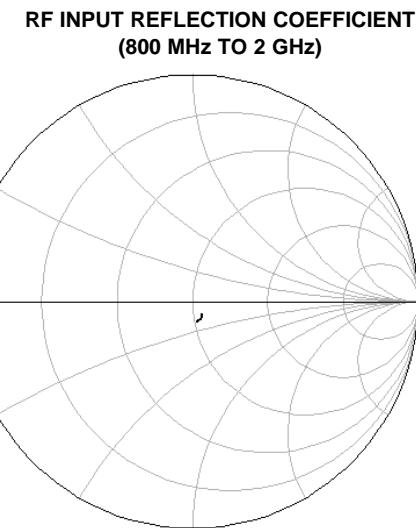
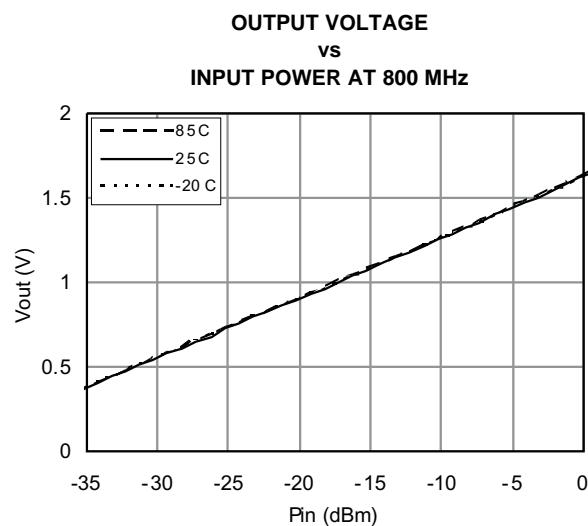
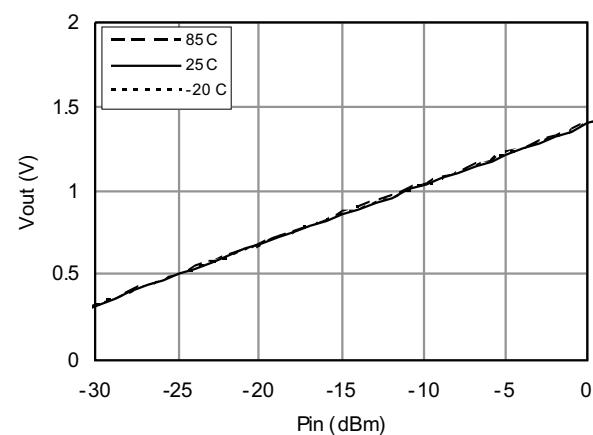
PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT	
<b>SUPPLY CURRENT</b>						
V <sub>BAT</sub>	Battery voltage	2.7	5.5	V		
I <sub>BAT, ACTIVE</sub>	Supply current	EN = HIGH	6.7	8.5	mA	
I <sub>BAT, IDLE</sub>	Supply current, idle	EN = LOW RF input power present		10	µA	
I <sub>BAT, S/D</sub>	Supply current, shutdown	EN = LOW No RF input power present		5	µA	
<b>INPUT</b>						
f <sub>IN</sub>	Input frequency	800	2000	MHz		
P <sub>RFIN800</sub>	Input power, 800 MHz	Referred to 50-Ω Zin	-34	-1	dBm	
P <sub>RFIN2000</sub>	Input power, 2 GHz	Referred to 50-Ω Zin	-29	-1	dBm	
<b>OUTPUT</b>						
V <sub>OUT Max</sub>	Output voltage maximum	-1 dBm, 800 MHz	1.2	1.55	1.7	V
V <sub>OUT Max</sub>	Output voltage maximum	-1 dBm, 2 GHz	1	1.32	1.55	V
V <sub>OUT No RF</sub>	Output voltage no RF	No RF present	0	160	300	mV
V <sub>OUT Range</sub>	Output voltage range	Over specified dynamic range		1.27	V	

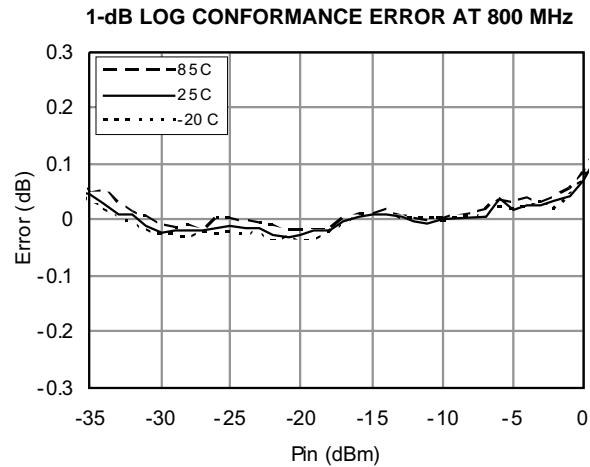
**ELECTRICAL CHARACTERISTICS (continued)**
 $V_{BAT} = 3.0 \pm 5\%$ ,  $T_A = -20$  to  $85^\circ\text{C}$ ,  $C_{FILTER} = 820 \text{ pF} \pm 10\%$ , unless otherwise specified.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{OUT,GAIN}$	Output voltage gain	30	35	40	$\text{mV}/\text{dB}$
	10-dB log conformance error over temperature <sup>(1)</sup>	See Appendix A.1	-1	1	$\text{dB}$
	1-dB log conformance error	Ideal 1-dB power step	-0.3	0.3	$\text{dB}$
	Straight line 5-dB step error <sup>(2)</sup>	See Appendix A.2	0.06		$\text{dB}$
	Output variation due to modulation at same input power	Anywhere in dynamic range. (AM modulation 100% modulation depth with a 1-MHz tone)	0.1	0.35	$\text{dB}$
$TC_{VOUT}$	Response temperature coefficient <sup>(1)</sup>	$P_{RFIN} = -4 \text{ dBm}$ See Appendix A.3	2.2		$\text{m}\text{dB}/^\circ\text{C}$
$\Delta TC_{VOUT}$	Response temperature sensitivity spread - $1\sigma$ <sup>(1)</sup>	$P_{RFIN} = -4 \text{ dBm}$ See Appendix A.3	4.1		$\text{m}\text{dB}/^\circ\text{C}$
$\Delta V_{OUT\_TEMP}$	Output voltage repeatability over temperature <sup>(1)</sup>		0.04	0.11	$\text{dB}$
PSRR	Power supply rejection ratio	$V_{BAT} = 2.7 \text{ V}$ to $5.5 \text{ V}$	30		$\text{dB}$
$V_{OUT, NOISE}$	Output referred noise	Integrated over bandwidth 1 kHz – 6.5 kHz	100	200	$\mu\text{V}_{\text{RMS}}$
$R_{OUT, EN1}$	Output impedance	EN = HIGH	9	50	$\Omega$
$I_{OUT, EN0}$	Output leakage	EN = LOW		3	$\mu\text{A}$
$t_{SAMPLE}$	Sampling time (time to valid output)	EN = HIGH $P_{RFIN} = \text{MAX}$ $V_{OUT}$ 10% to 90%		13	$\mu\text{s}$
$t_{WAKEUP}$	Wakeup time	EN LOW to HIGH No RF input $V_{OUT}$ to 90%		13	$\mu\text{s}$
<b>LOGIC LEVEL INPUTS (EN)</b>					
$V_{IL}$	Input low level			0.6	$\text{V}$
$V_{IH}$	Input high level		1.1		$\text{V}$
$I_{IH}, I_{IH}$	Input bias current		-1	1	$\mu\text{A}$

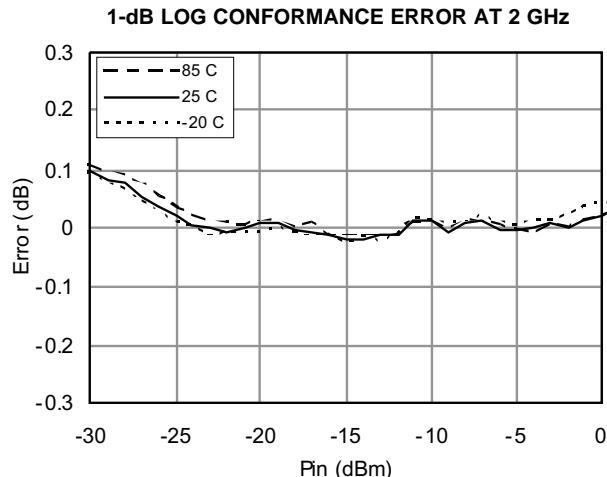
(1) Parameters require temperature testing. Limits based on  $3\sigma$  statistics characterized on a limited number of samples. Limits not guaranteed in production.

(2) Limits based on  $3\sigma$  statistics characterized on a limited number of samples. Limits not guaranteed in production.

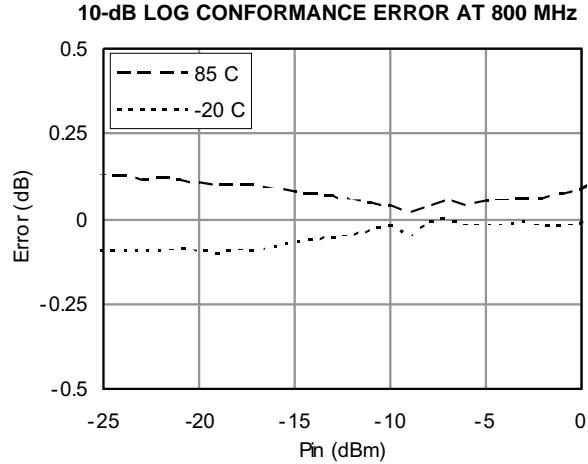
**TYPICAL PERFORMANCE CHARACTERISTICS****Figure 1.****Figure 2.****Figure 3.****Figure 4.**



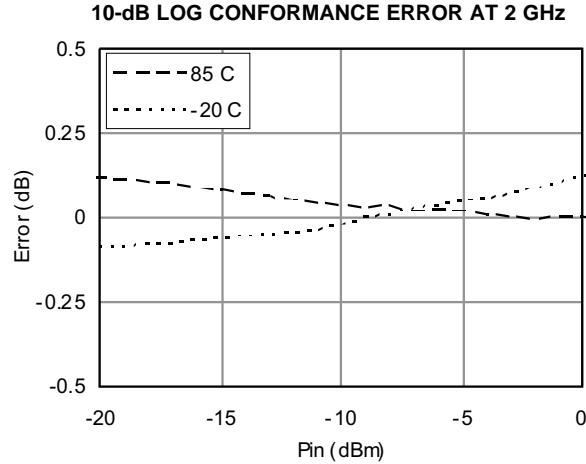
**Figure 5.**



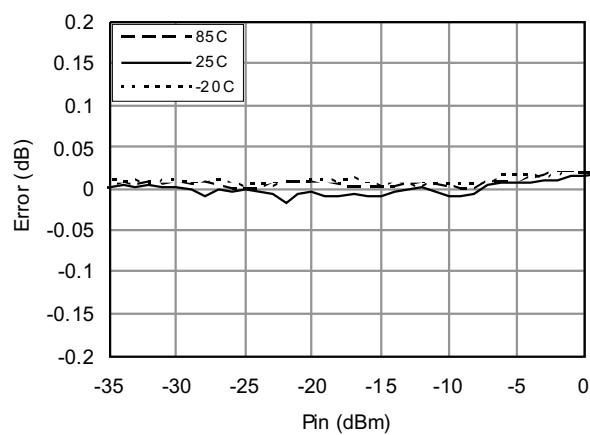
**Figure 6.**



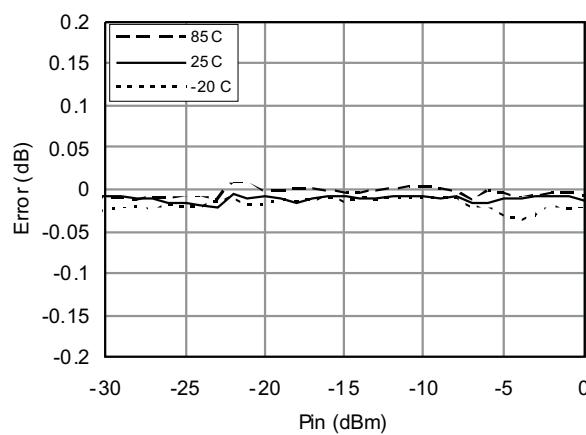
**Figure 7.**



**Figure 8.**



**Figure 9.**



**Figure 10.**

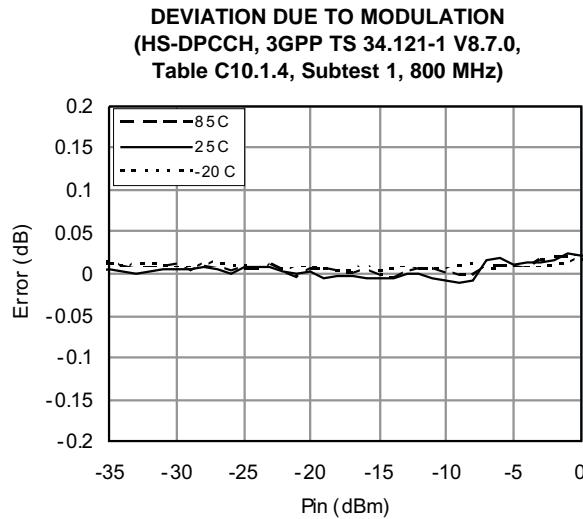


Figure 11.

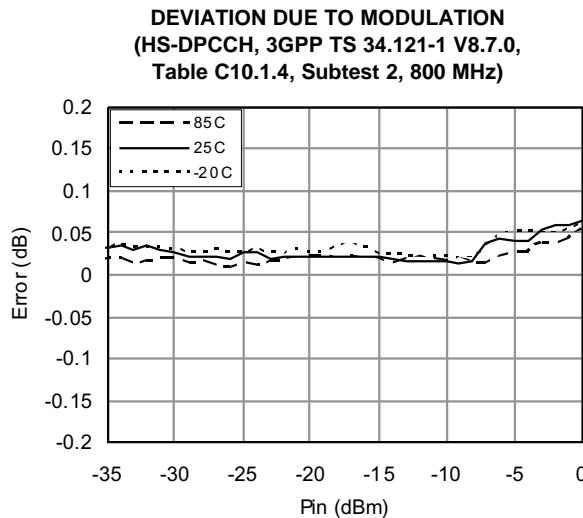


Figure 13.

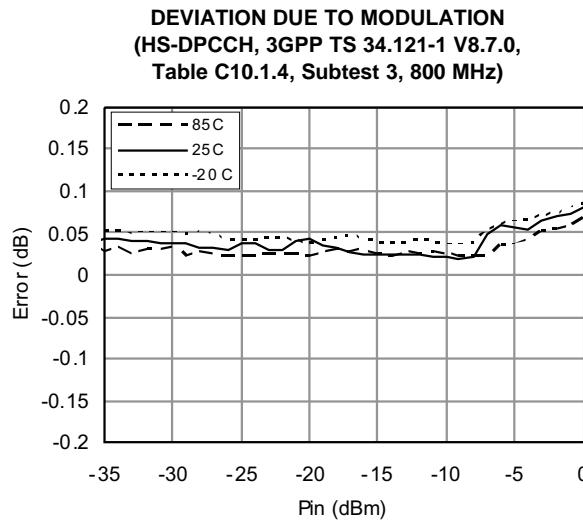


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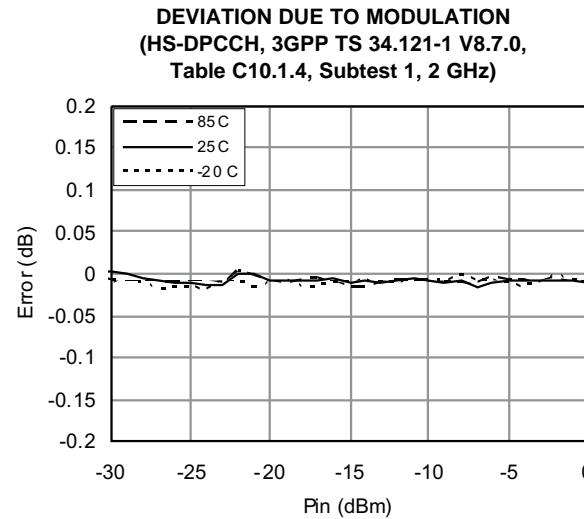


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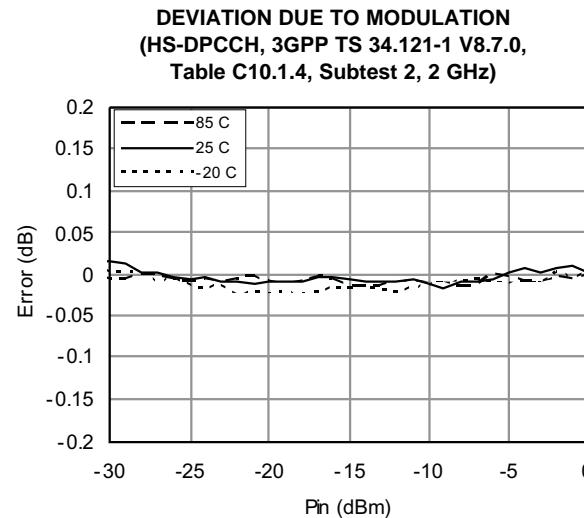


Figure 14.

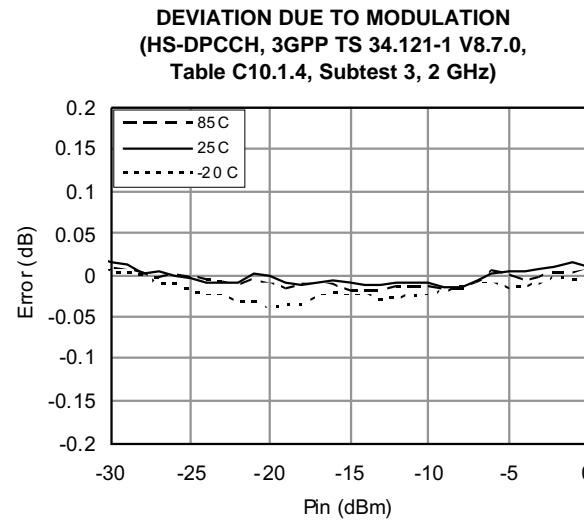
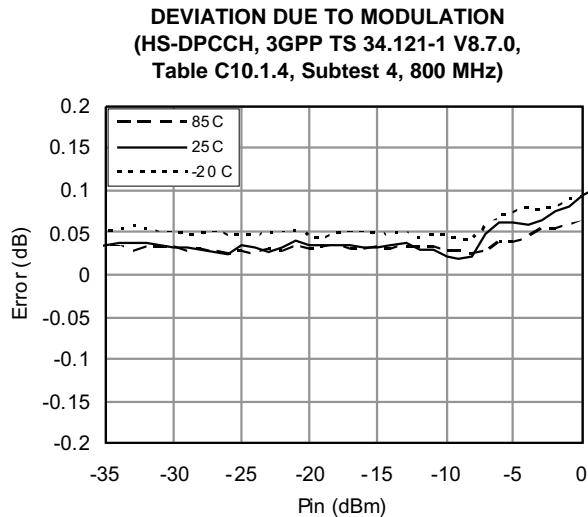
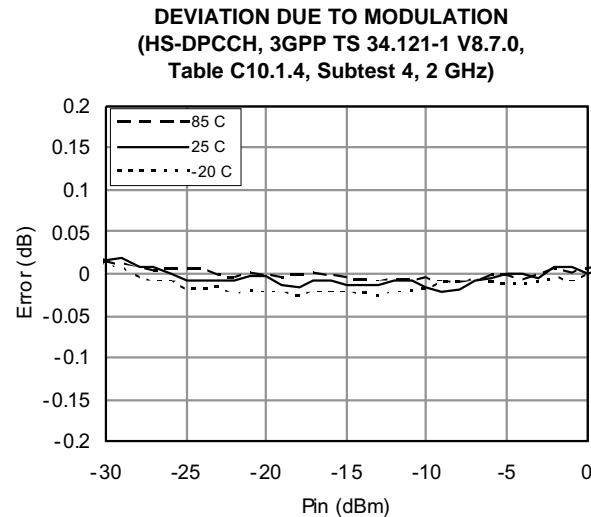
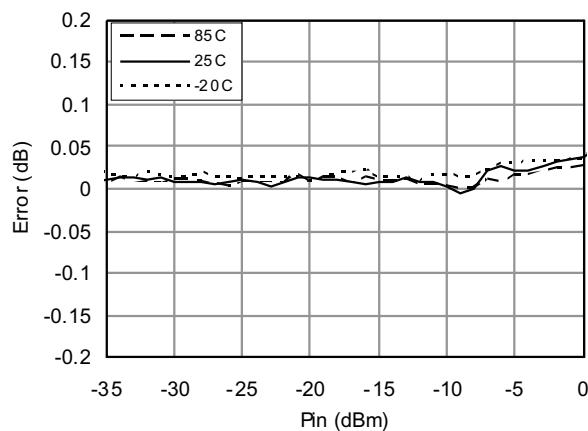
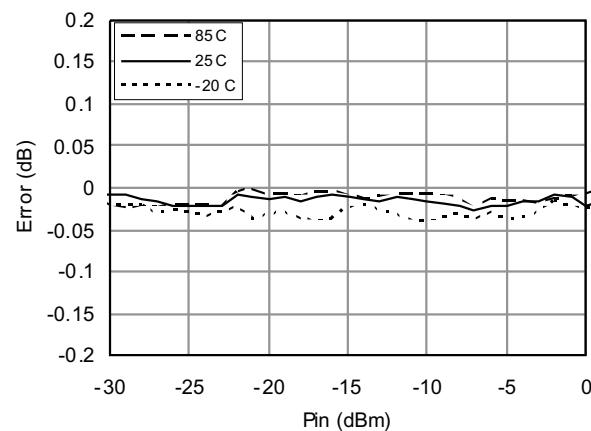
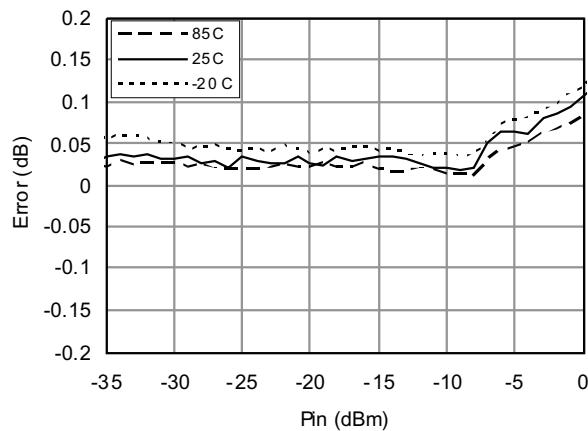
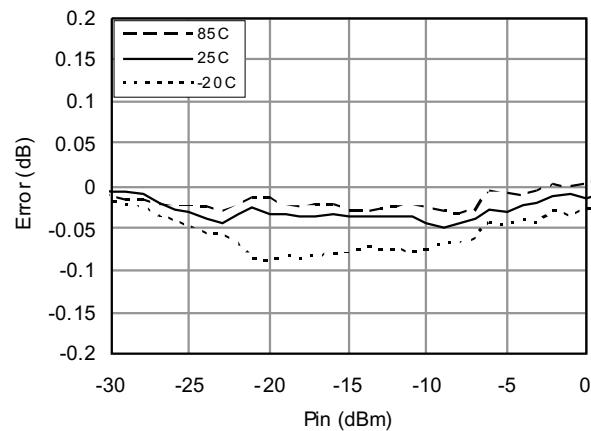


Figure 16.


**Figure 17.**

**Figure 18.**

**Figure 19.**

**Figure 20.**

**Figure 21.**

**Figure 22.**

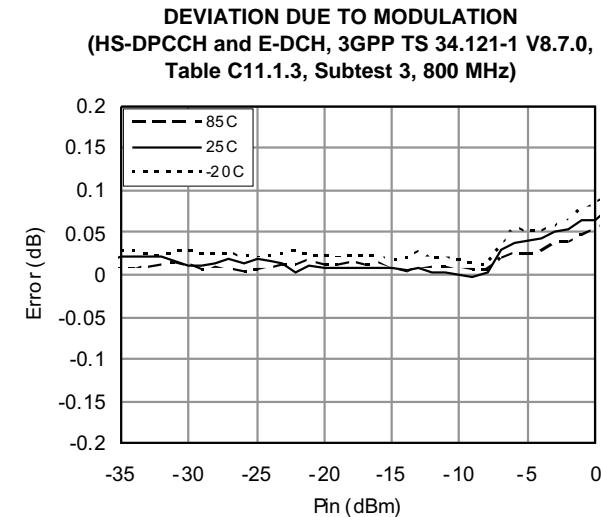


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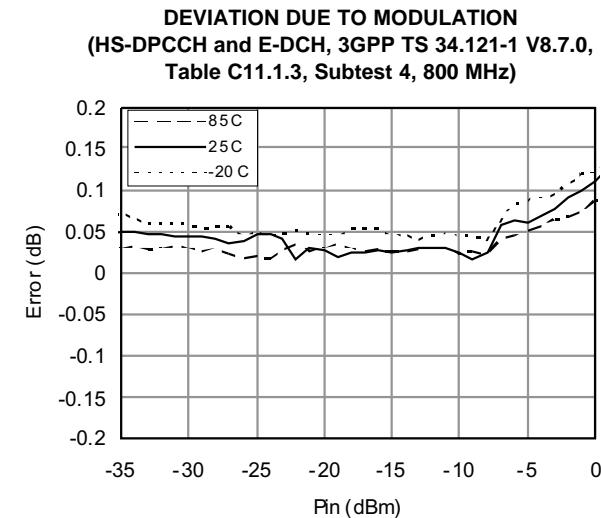


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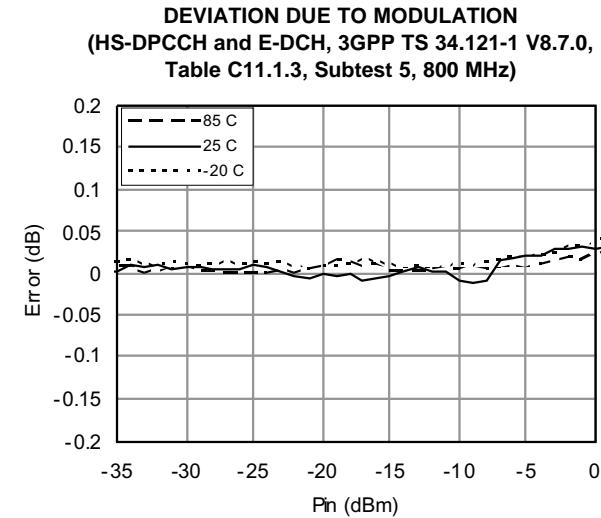


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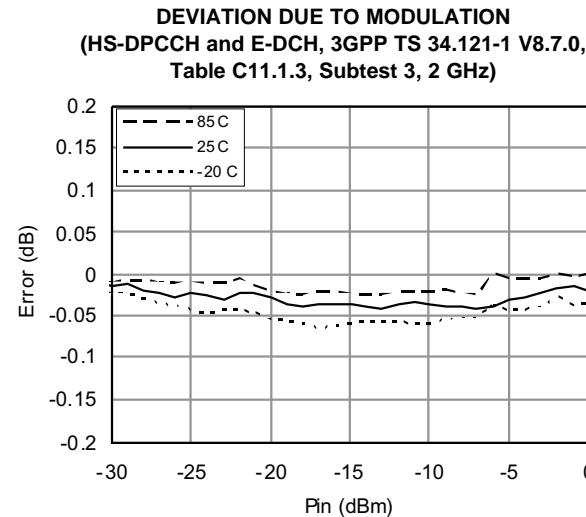


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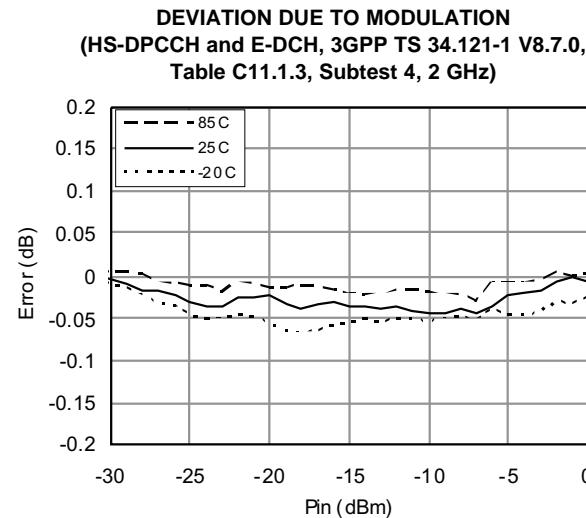


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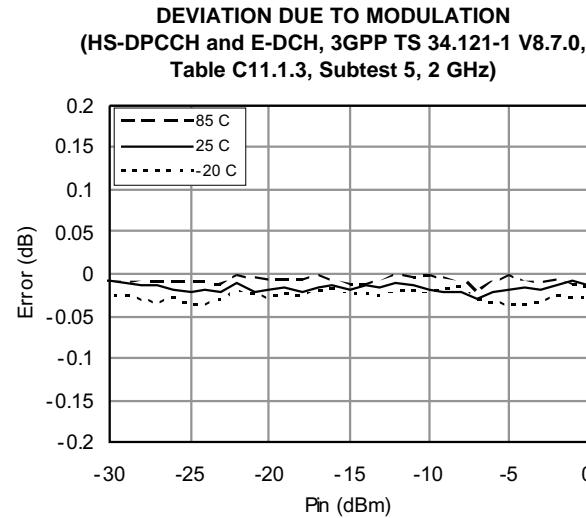
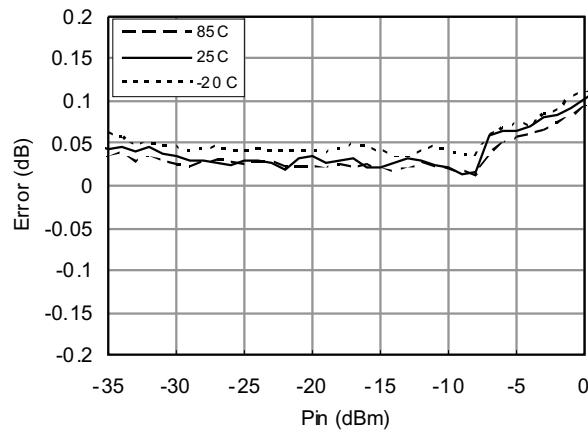


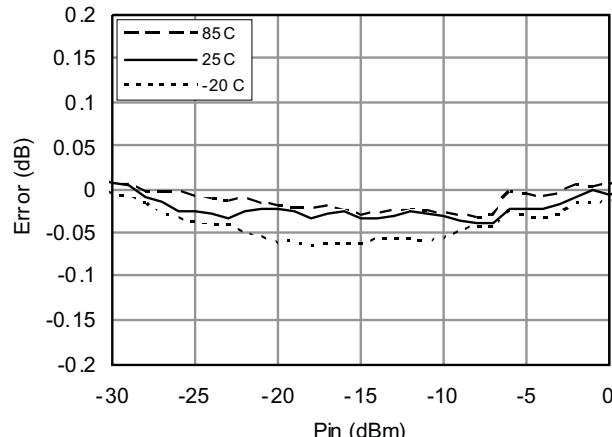
Figure 28.

**DEVIATION DUE TO MODULATION**  
**(HS-DPCCH and E-DCH with 16QAM , 3GPP TS 34.121-1**  
**V8.7.0,**  
**Table C11.1.4, 800 MHz)**

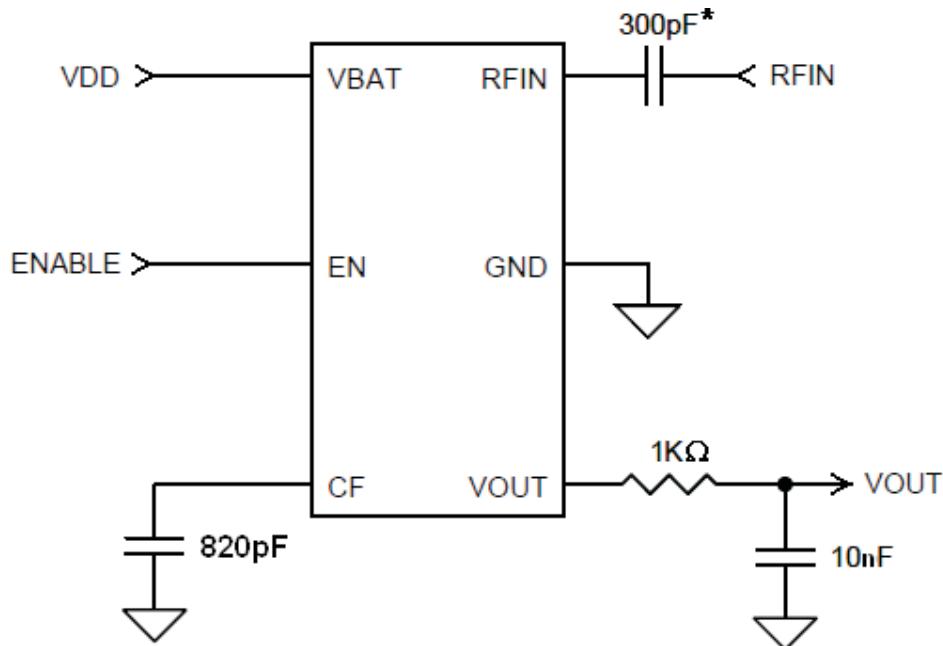


**Figure 29.**

**DEVIATION DUE TO MODULATION**  
**(HS-DPCCH and E-DCH with 16QAM , 3GPP TS 34.121-1**  
**V8.7.0,**  
**Table C11.1.4, 2 GHz)**



**Figure 30.**



\*The input coupling capacitor on the RF input pin may be omitted if the DC voltage on this pin is at ground.

**Figure 31. Application Circuit**

## APPENDIX A: MEASUREMENT PROCEDURES

### 10-dB Log Conformance Error Over Temperature

The 10-dB log conformance error over temperature is a measure of the change in slope of the rms detector output over temperature. The measurement is performed by taking an ideal 10-dB step in input power with a CW signal at room temperature and measuring the change in output voltage. The measurement is then repeated at a different temperature and the 10-dB log conformance error over temperature is given in dB by [Equation 1](#).

$$10\text{-dB log conformance error} = 10 \cdot \left( \frac{\Delta V_{OUT}(T)}{\Delta V_{OUT}(25^\circ C)} - 1 \right) \quad (1)$$

This measurement is taken on a statistical sample of parts. The  $3\sigma$  limits from these samples are within the limits provided in the Electrical Characteristics table.

### Straight Line 5-dB Step Error

The straight line 5-dB step error is a measure of the maximum error that results from fitting a straight line between two points of a 5-dB step as shown in [Figure 32](#). The straight line shown in bold represents a perfect 5-dB step, while the curved line represents the detector output (the curvature in this figure is exaggerated for explanation purposes). The maximum difference output voltage between these two curves is the straight line 5-dB step error.

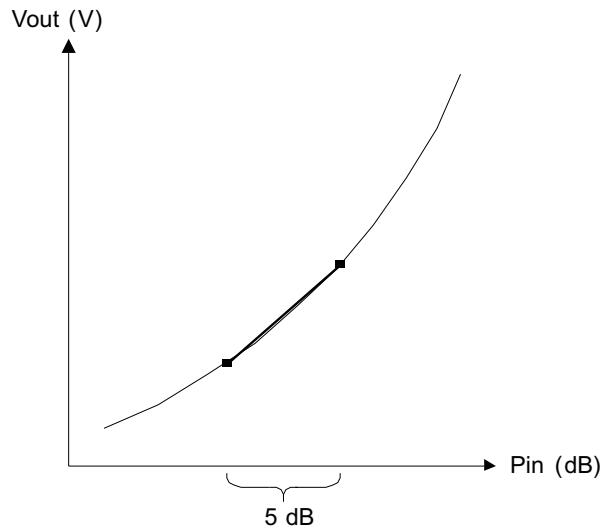


Figure 32. Straight Line 5-dB Step Error

### Response Temperature Coefficient & Response Temperature Sensitivity Spread - $1\sigma$

The response temperature coefficient is a measure of the change in detector output voltage for a given RF input power. The measurement is performed by measuring the detector output voltage over temperature for a set CW RF input power. The response temperature gain coefficient expressed in  $\text{mV}/^\circ\text{C}$  is given by [Equation 2](#).

$$\text{Response temperature gain coefficient} = 1000 \cdot \frac{\Delta V_{OUT}}{V_{OUT,GAIN} \cdot \Delta T} \quad (2)$$

Where  $V_{OUT,GAIN}$  is the output voltage gain expressed in  $\text{V}/\text{dB}$ . This measurement is taken on a statistical sample of parts. The mean of these samples are provided in the Electrical Characteristics table.

The response temperature sensitivity spread -  $1\sigma$ ,  $\Delta T_{VOUT}$ , is the  $1\sigma$  variation in  $T_{VOUT}$ .

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>	Samples (Requires Login)
TRF1600DRVR	PREVIEW	SON	DRV	6	3000	TBD	Call TI	Call TI	

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBsolete:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

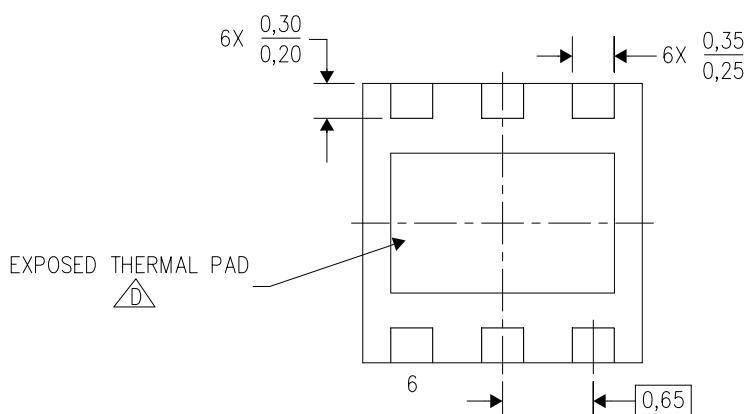
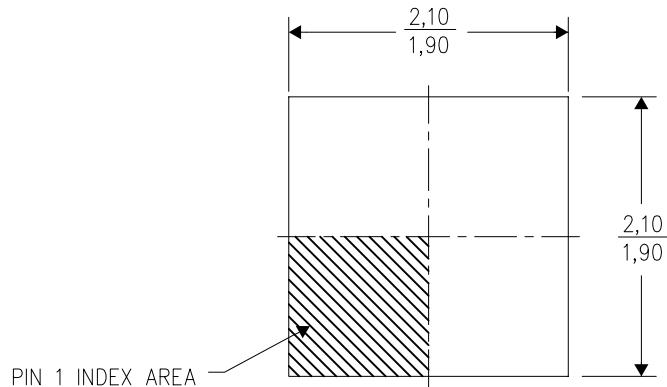
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## MECHANICAL DATA

DRV (S-PWSON-N6)

PLASTIC SMALL OUTLINE NO-LEAD



4206925/E 10/10

NOTES: A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.

B. This drawing is subject to change without notice.

C. Small Outline No-Lead (SON) package configuration.

 The package thermal pad must be soldered to the board for thermal and mechanical performance. See the Product Data Sheet for details regarding the exposed thermal pad dimensions.

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Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
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RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Mobile Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
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