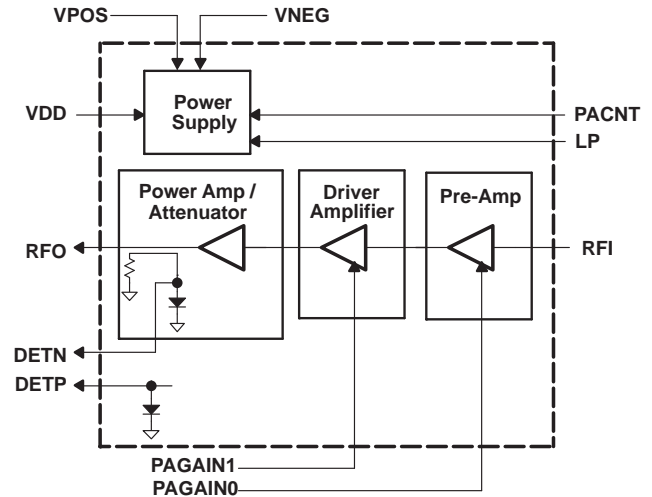


## 3.3-GHz To 3.8-GHz 1-W Power Amplifier

### FEATURES

- 1 W P-1dB Linear, 30-dB Gain Transmitter
- Operates Over the 3300-MHz to 3800-MHz Range
- Two TTL Controlled, 1-Bit, 16-dB Gain Steps for 32 dB of Total Gain Control
- Superior Linearity (+45 dBm IP3) Over the Entire Frequency Range
- Auto-Bias Design With PA Enable
- Temperature Compensated Directional Coupler Detector
- Low Power Bias Mode
- Internally Matched 50-Ω Input and Output



### DESCRIPTION

The TRF1223 is a highly integrated linear transmitter / power amplifier (PA) MMIC. The chip has two 16-dB gain steps that provide a total of 32-dB gain control via 1-bit TTL control signals. The chip also integrates a TTL mute function that turns off the amplifiers for power critical or TDD applications. A temperature compensated detector is included for output power monitor or ALC applications. The chip has a  $P_{1dB}$  of +30 dBm and a third order intercept of +45 dBm.

The TRF1223 is designed to function as a part of Texas Instruments complete 3.5-GHz chip set. The TRF1223 is the output power amplifier or a driver amplifier for higher power applications. The linear nature of the transmitter makes it ideal for complex modulations schemes such as high order QAM or OFDM.

### KEY SPECIFICATIONS

- $OP_{1dB} = +30$  dBm
- Output IP3 = +45 dBm, Typical
- Gain = 30 dB, Typical
- Gain Flatness over Transmit Band  $\pm 2$  dB
- Frequency Range = 3300 MHz to 3800 MHz
- $\pm 0.5$ -dB Detected Output Voltage vs Temperature

### BLOCK DIAGRAM

The detailed block diagram and the pin-out of the ASIC are shown in [Figure 1](#).



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.

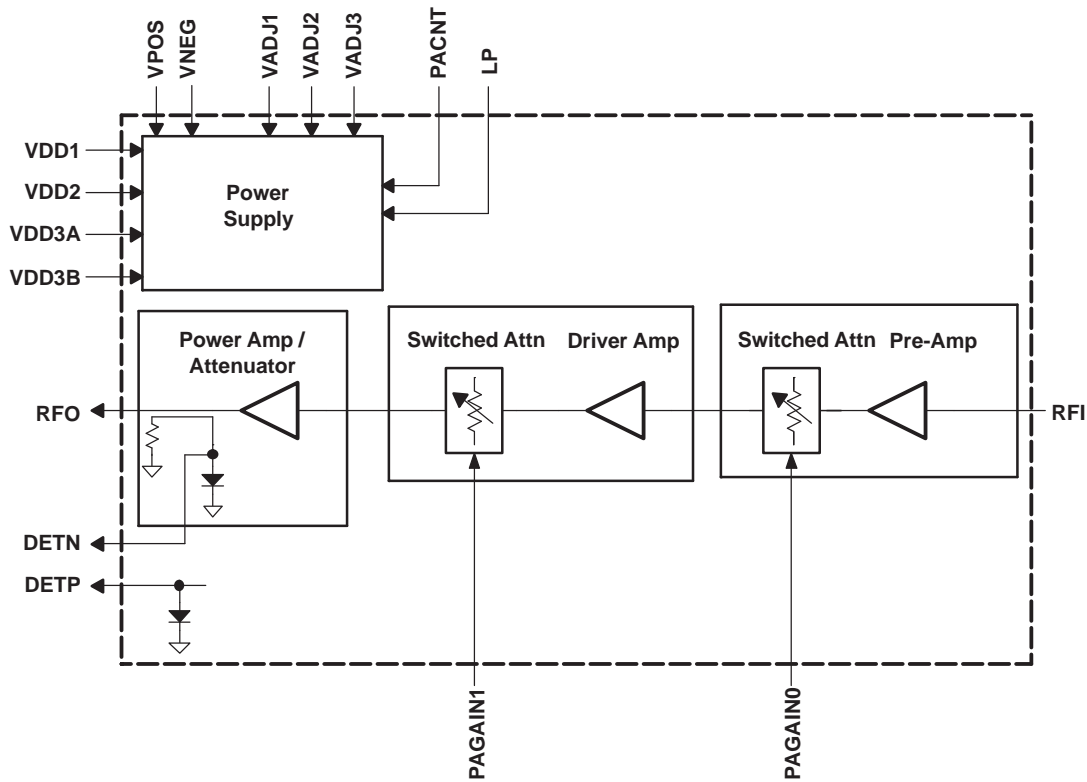


Figure 1. Detailed Block Diagram of TRF1223

**ELECTROSTATIC DISCHARGE NOTE**

The TRF1223 contain Class 1 devices. The following electrostatic discharge (ESD) precautions are recommended:

- Protective outer garments
- Handling in ESD safeguarded work area
- Transporting in ESD shielded containers
- Frequent monitoring and testing all ESD protection equipment
- Treating the TRF1223 as extremely sensitive to ESD

**PINOUT TABLE**

Table 1. Pin Out of TRF1223<sup>(1)</sup>

PIN #	PIN NAME	I/O	TYPE	DESCRIPTION
1	VDD1	I	Power	Stage 1 dc drain supply power. The dc current through this pin is typically 5% of $I_{DD}$ .
2	VADJ1	I	Analog	No connection required for normal operation. May be used to adjust FET1 bias. DO NOT GROUND THIS PIN OR CONNECT TO ANY OTHER PIN.
3	GND	-	-	Ground
4	RFI	I	Analog	RF input to power amplifier, dc blocked internally
5	RFI	I	Analog	RF input to power amplifier, dc blocked internally
6	VNEG	I	Power	Negative power supply $-5$ V. Used to set gate voltage. This voltage must be sequenced with $V_{DD}$ . See <sup>(1)</sup> .
7	VPOS	I	Power	Positive power supply for bias circuits. Bias is $+5$ V. Used to set gate bias and logic input level.

(1) Proper sequencing: In order to avoid permanent damage to the power amplifier, the supply voltages must be sequenced. The proper power up sequence is  $V_{NEG}$ , then  $V_{POS}$ , and then  $V_{DD}$ . The proper power down sequence is remove  $V_{DD}$ , then  $V_{POS}$ , and then  $V_{NEG}$ .

**Table 1. Pin Out of TRF1223 (continued)**

PIN #	PIN NAME	I/O	TYPE	DESCRIPTION
8	PAGAIN0	I	Digital	First 16-dB attenuator gain control. Logic high is high gain and logic low is low gain.
9	PAGAIN1	I	Digital	Second 16-dB gain control. Logic high is high gain and logic low is low gain.
10	VADJ2	I	Analog	No connection required for normal operation. May be used to adjust FET2 bias. DO NOT GROUND THIS PIN OR CONNECT TO ANY OTHER PIN.
11-14	GND	-	-	Ground
15	VADJ3	I	Analog	No connection required for normal operation. May be used to adjust FET3 bias. DO NOT GROUND THIS PIN OR CONNECT TO ANY OTHER PIN.
16	LP	I	Digital	Low power mode: Active high. Low power mode is lower dc and P <sub>OUT</sub> mode.
17	PACNT	I	Digital	Power amplifier enable, High is PA on, logic low is PA off (low current)
18	VDD3B	I	Power	Stage 3 dc-drain supply power. This pin is internally dc connected to pin 23 (VDD3A). Bias must be provided to both pins for optimal performance. The total dc-current through these two pins is typically 70% of I <sub>DD</sub> .
19	GND	-	-	Ground
20	RFO	O	Analog	RF output, internal dc block
21	RFO	O	Analog	RF output, internal dc block
22	GND	-	-	Ground
23	VDD3A	I	Power	Stage 3 dc-rain supply power. This pin is internally dc connected to pin 18 (VDD3B). Bias must be provided to both pins for optimal performance. The total dc-current through these two pins is typically 70% of I <sub>DD</sub> .
24	DETP	O	Analog	Detector output, positive. Voltage will be 0.5 V with/without RF output
25	DETN	O	Analog	Detector output, negative. Voltage is 0.5 V with no RF and decreases with increasing RF output power.
26-31	GND	-	-	Ground
32	VDD2	I	Power	Stage 2 dc-drain supply power. The dc current through this pin is typically 25% of I <sub>DD</sub> .
	Back	-	-	Back of package has a metal base which must be grounded for thermal and RF performance.

## SPECIFICATIONS

### ABSOLUTE MAXIMUM RATINGS

PARAMETER	TEST CONDITION	MIN	MAX	UNIT	
VDD	DC supply voltage	0	8	V	
VPOS		0	5.5	V	
VNEG		-5.5	0	V	
I <sub>DD</sub>	Current consumption		1300	mA	
P <sub>in</sub>	RF input power		20	dBm	
T <sub>j</sub>	Junction temperature		175	°C	
P <sub>d</sub>	Power dissipation		6.5	W	
	Digital input pins	-0.3	5.5		
Θ <sub>jc</sub>	Thermal resistance junction to case <sup>(1)</sup>		20	°C/W	
T <sub>stg</sub>	Storage temperature	-40	105	°C	
T <sub>op</sub>	Operating temperature	Maximum case temperature derate for PCB thermal resistance	-40	85	°C
	Lead temperature	40 sec maximum		220	°C

(1) Thermal resistance is junction to case assuming thermal pad with 25 thermal vias under package metal base. See the recommended layout [Figure 6](#) and application note RA1005 for more detail.

**DC CHARACTERISTICS**

PARAMETER		CONDITIONS	MIN	TYP	MAX	UNIT
V <sub>DD</sub>	VDD supply voltage	-40°C, PACNTRL = High, V <sub>DD</sub> = 5 V, LP = Low		5	7	V
I <sub>DD</sub>	VDD supply current high power	25°C, PACNTRL = High, V <sub>DD</sub> = 5 V, LP = Low		875		mA
				925		
				950		
I <sub>DD</sub>	VDD supply current low power	85°C, PACNTRL = High, V <sub>DD</sub> = 5 V, LP = Low		475		mA
				550		
				600		
V <sub>NEG</sub>	Negative supply voltage	-40°C, PACNTRL = High, V <sub>DD</sub> = 5 V, LP = High, 25°C	-5.25	-5	-4.75	V
I <sub>NEG</sub>	Negative supply current	25°C, PACNTRL = High, V <sub>DD</sub> = 5 V, LP = High, 25°C		15	25	mA
V <sub>POS</sub>	Positive supply digital voltage	85°C, PACNTRL = High, V <sub>DD</sub> = 5 V, LP = High, 25°C	4.75	5	5.25	V
I <sub>POS</sub>	Positive supply digital current			35	50	mA
V <sub>IH</sub>	Input high voltage		2.5		5	V
V <sub>IL</sub>	Input low voltage				0.8	V
I <sub>IH</sub>	Input high current				300	μA
I <sub>IL</sub>	Input low current				-50	μA

**POWER AMPLIFIER CHARACTERISTICS**

Unless otherwise stated: V<sub>DD</sub> = 5 V<sub>S</sub>, I<sub>DD</sub> = 1050 mA, V<sub>POS</sub> = 5 V, V<sub>NEG</sub> = -5 V, PAGAIN0 = 1, PAGAIN1 = 1, PACNT = 1, T = 25°C

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
F	Frequency		3300		3800	MHz
G	Gain		26	30	32.5	dB
σ <sub>G</sub>	Standard deviation part-to-part gain	At a single frequency, full gain		0.3		dB
G <sub>HG</sub>	Gain flatness full band	F = 3300 MHz to 3800 MHz		4	6	dB
G <sub>NB</sub>	Gain flatness / 2 MHz			0.2		dB
OP-1dB	Output power at 1-dB compression	High power bias mode	30	31		dBm
OP-1dB	Output power at 1-dB compression	Low power bias mode		27		dBm
OIP3	Output third order intercept point	High power bias mode	43	48		dBm
OIP3	Output third order intercept point	Low power bias mode		38		dBm
Vdet	Detector voltage output, differential (DETP-DETN)	At POUT = 27 ±0.75 dBm, F = 3300 MHz to 3800 MHz at 25°C		150		mV
	Detector accuracy vs temperature	F = 3550 MHz, -30 to 75°C,		±0.5		dB
	Gain step size 1st step	PAGAIN0 = Low, PAGAIN1 = High	13	16	19	dB
	Gain step size 2nd step	PAGAIN0 = Low, PAGAIN1 = Low	26	32	38	dB
t <sub>STEP</sub>	Gain step response time			1	5	μs
P <sub>ON/OFF</sub>	On to Off Power ratio	Max gain-to-gain with PACNT = Low	35			dB
NF <sub>HG</sub>	Noise figure, max gain	PAGAIN0 = High, PAGAIN1 = High		6	7	dB
NF <sub>LG</sub>	Noise figure min gain	PAGAIN0 = Low, PAGAIN1 = Low			20	dB
S <sub>12</sub>	Reverse isolation		30			dB
S <sub>11</sub>	Input return loss	Z = 50 Ω	-10	-12		dB
S <sub>22</sub>	Output return loss	Z = 50 Ω		-8		dB

### TYPICAL PERFORMANCE

All data was taken on parts mounted on PCBs using the pad layout specified in [Figure 6](#) and the filled via process illustrated in [Figure 7](#).

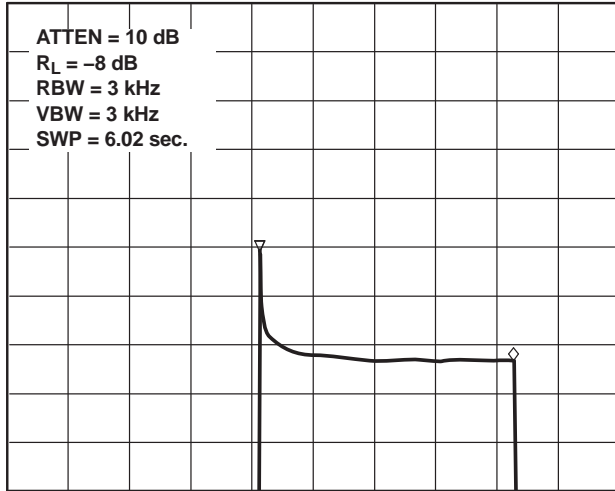


Figure 2. Pulse Drog

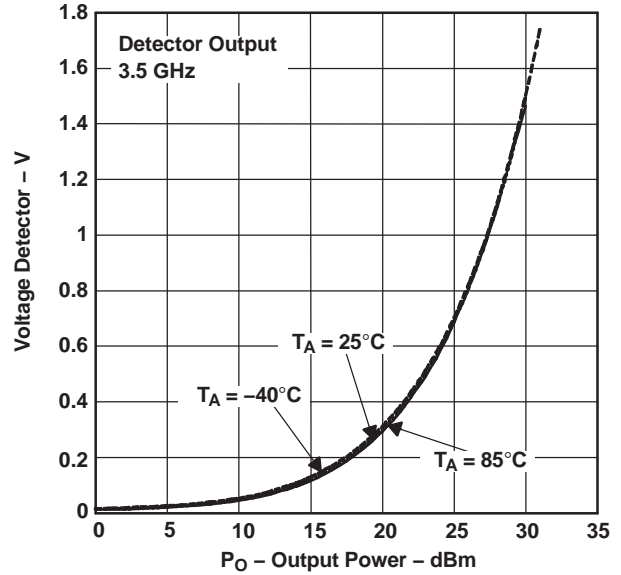


Figure 3. Detector vs Temperature

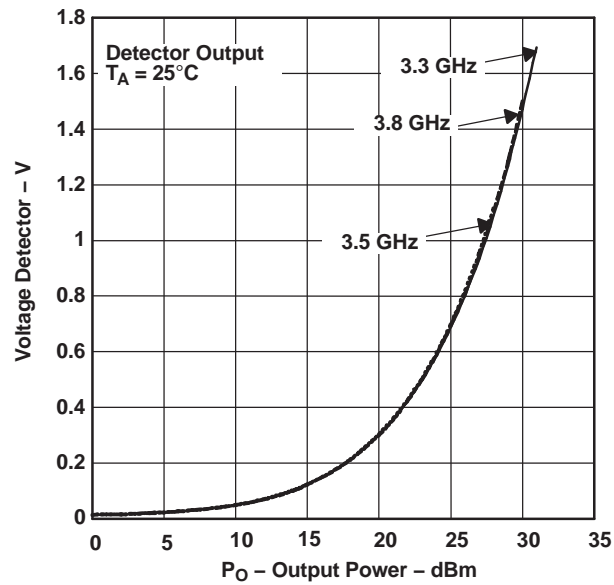
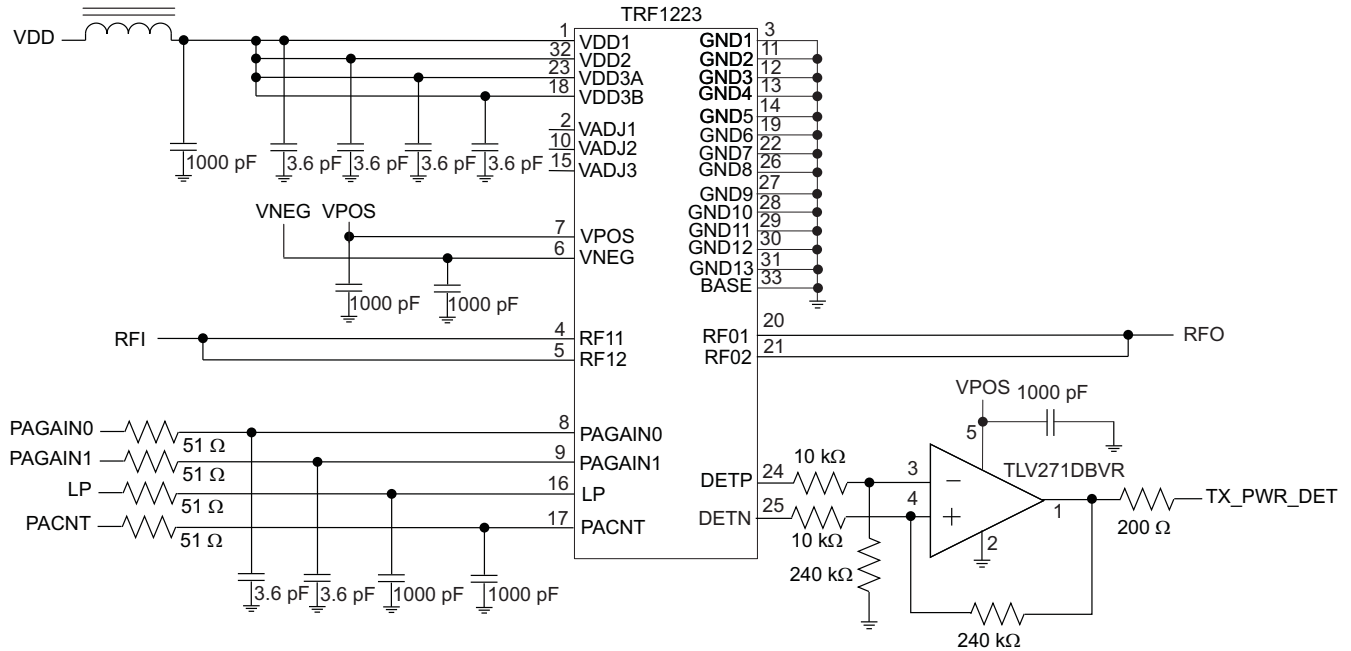


Figure 4. Detector Output vs Frequency

### APPLICATION INFORMATION

A typical application schematic is shown in [Figure 5](#).

The recommended PCB layout mask is shown in [Figure 6](#), along with recommendations on the board material in [Table 2](#) and construction in [Figure 7](#).



**Figure 5. Recommended TRF1223 Application Schematic**

**Table 2. PCB Recommendations**

Board Material	FR4
Board Material Core Thickness	10 mil
Copper Thickness (starting)	1 oz
Prepreg Thickness	8 mil
Recommended Number of Layers	4
Via Plating Thickness	0.5 oz
Final Plate	White immersion tin
Final Board Thickness	33 to 37 mil

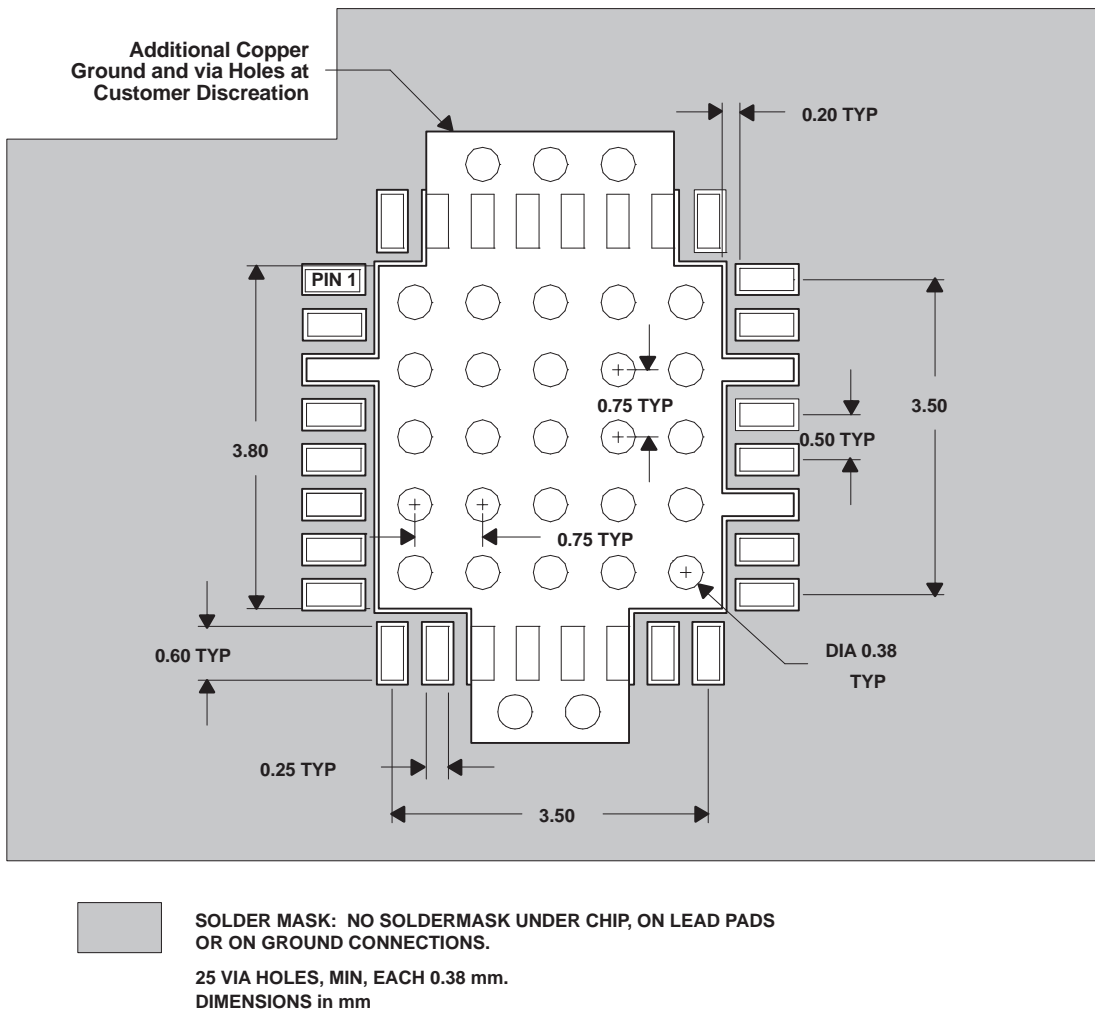


Figure 6. Recommended Pad Layout

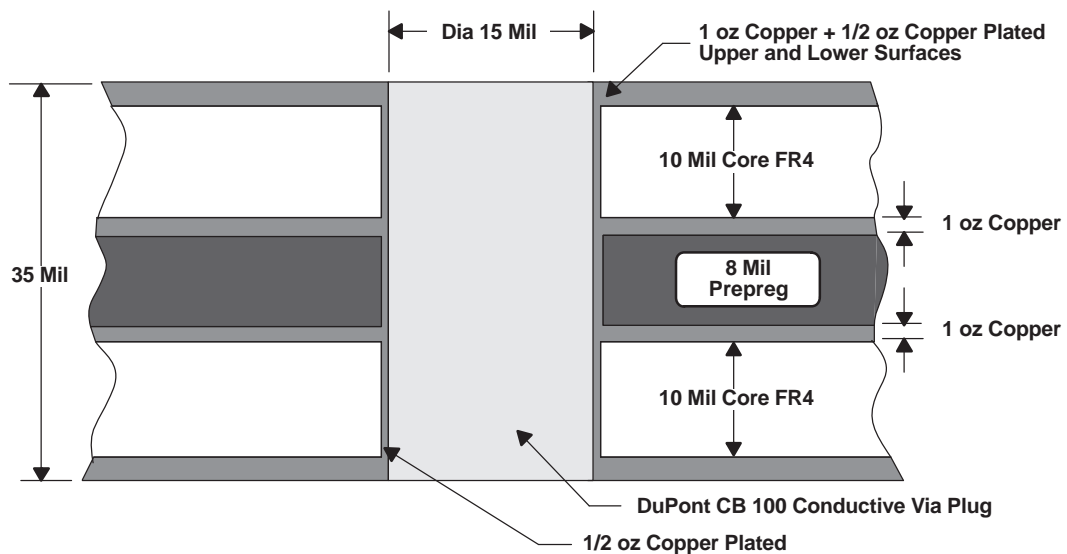


Figure 7. Via Cross Section

### Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from B Revision (September 2006) to C Revision	Page
• Changed pin names for pins 22 - 25 .....	2
• Changed Figure 5 .....	6

---



**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>
TRF1223IRTMR	ACTIVE	QFN	RTM	32	3000	Green (RoHS & no Sb/Br)	CU SN	Level-3-260C-168 HR
TRF1223IRTMRG3	ACTIVE	QFN	RTM	32	3000	Green (RoHS & no Sb/Br)	CU SN	Level-3-260C-168 HR
TRF1223IRTMT	ACTIVE	QFN	RTM	32	250	Green (RoHS & no Sb/Br)	CU SN	Level-3-260C-168 HR
TRF1223IRTMTG3	ACTIVE	QFN	RTM	32	250	Green (RoHS & no Sb/Br)	CU SN	Level-3-260C-168 HR

<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.

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**TAPE AND REEL INFORMATION**



**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TRF1223IRTMR	QFN	RTM	32	3000	330.0	12.4	5.3	5.3	1.5	8.0	12.0	Q2
TRF1223IRTMT	QFN	RTM	32	250	330.0	12.4	5.3	5.3	1.5	8.0	12.0	Q2

**TAPE AND REEL BOX DIMENSIONS**

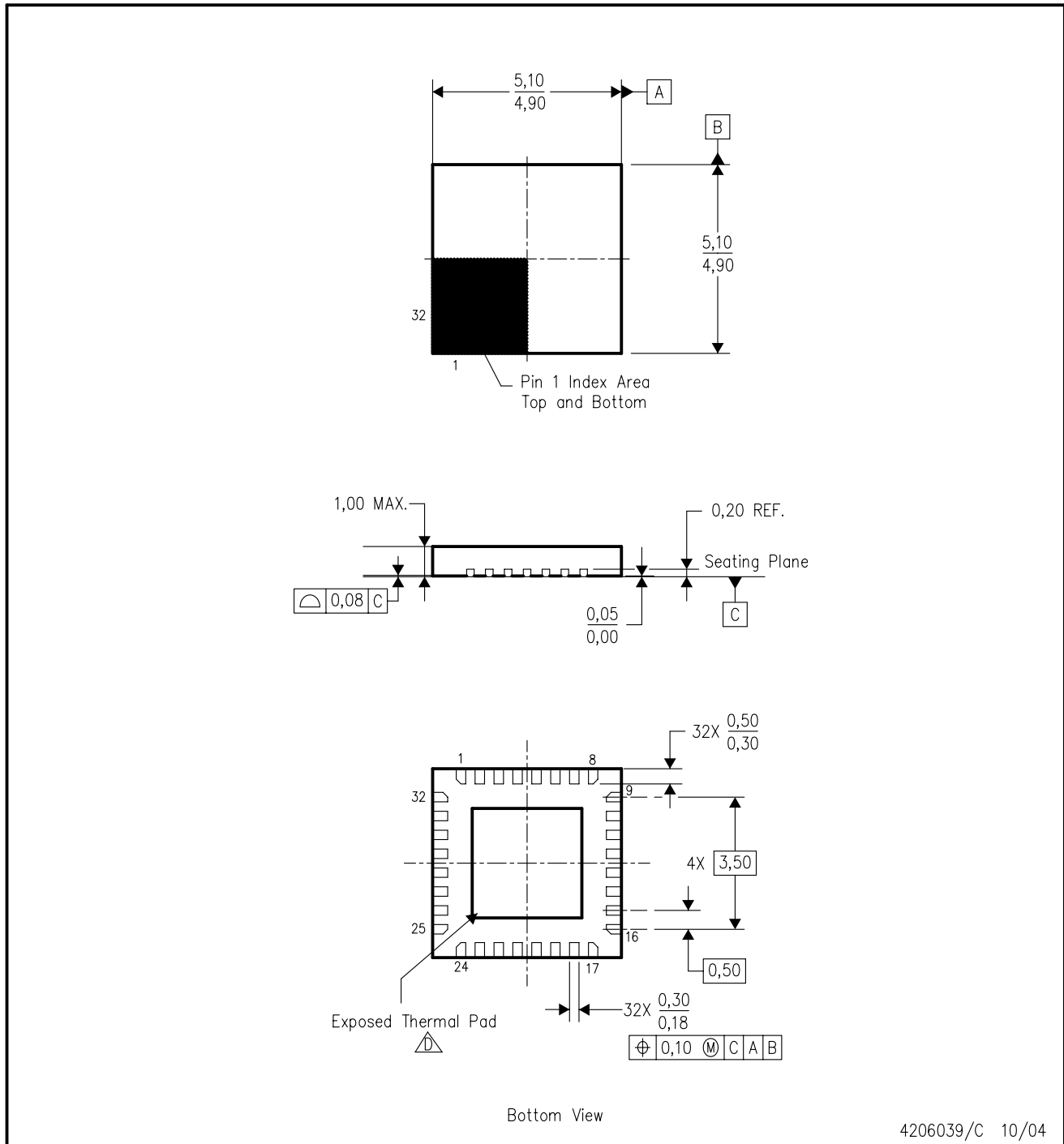



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TRF1223IRTMR	QFN	RTM	32	3000	340.5	333.0	20.6
TRF1223IRTMT	QFN	RTM	32	250	340.5	333.0	20.6

RTM (S-PQFP-N32)

PLASTIC QUAD FLATPACK



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. QFN (Quad Flatpack No-Lead) Package configuration.
  -  The Package thermal pad must be soldered to the board for thermal and mechanical performance. See product data sheet for details regarding the exposed thermal pad dimensions.
  - E. Package complies to JEDEC MO-220.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
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>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>

### Applications

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
Wireless	<a href="http://www.ti.com/wireless">www.ti.com/wireless</a>

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2009, Texas Instruments Incorporated