#### 50 MHz to 350 MHz CASCADEABLE AMPLIFIER

#### **FEATURES**

- High Dynamic Range
  - OIP<sub>3</sub> = 36 dBm
  - NF < 4.5 dB
- Single Supply Voltage
- High Speed
  - V<sub>S</sub> = 3 V to 5 V
  - I<sub>S</sub> = Adjustable
- Input / Output Impedance
  - 50 Ω

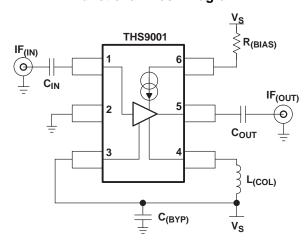
#### **APPLICATIONS**

- IF Amplifier
  - TDMA: GSM, IS-136, EDGE/UWE-136CDMA: IS-95, UMTS, CDMA2000
  - Wireless Local Loop
  - Wireless LAN: IEEE802.11

#### **DESCRIPTION**

The THS9001 is a medium power, cascadeable, gain block optimized for high IF frequencies. The amplifier incorporates internal impedance matching to 50  $\Omega$ , and achieves greater than 15-dB input, and output return loss from 50 MHz to 350 MHz with  $V_S = 5$  V,  $R_{(BIAS)} = 237$   $\Omega$ ,  $L_{(COL)} = 470$  nH. Design requires only 2 dc-blocking capacitors, 1 power-supply bypass capacitor, 1 RF choke, and 1 bias resistor.

#### **Functional Block Diagram**





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.





These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

#### **AVAILABLE OPTIONS**

PACKAGED DEVICES <sup>(1)</sup>	PACKAGE TYPE	TRANSPORT MEDIA, QUANTITY		
THS9001DBVT	SOT-23-6	Tape and Reel, 250		
THS9001DBVR	301-23-0	Tape and Reel, 3000		

(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.

#### **ABSOLUTE MAXIMUM RATINGS**

over operating free-air temperature (unless otherwise noted)(1)

			UNIT
$V_{SS}$	Supply voltage, GND to V <sub>S</sub>		5.5 V
VI	Input voltage		GND to V <sub>S</sub>
	Continuous power dissipation		See Dissipation Ratings Table
$T_J$	Maximum junction temperature		150°C
$T_J$	Maximum junction temperature, continuous op	eration, long term reliability (2)	125°C
T <sub>stg</sub>	Storage temperature		-65°C to 150°C
		НВМ	2000
	ESD Ratings	CDM	1500
		MM	100

<sup>(1)</sup> The absolute maximum ratings under any condition is limited by the constraints of the silicon process. Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

#### **DISSIPATION RATING TABLE**

	BACKAGE	ΘJC	$\Theta_{JA}$	POWER RATING <sup>(1)</sup>			
	PACKAGE	(°CĬŴ)	(°C/W)	T <sub>A</sub> ≤ 25°C	T <sub>A</sub> = 85°C		
Ī	DBV <sup>(2)</sup>	70.1	216	463 mW	185 mW		

<sup>(1)</sup> Power rating is determined with a junction temperature of 125°C. Thermal management of the final PCB should strive to keep the junction temperature at or below 125°C for best performance.

#### RECOMMENDED OPERATING CONDITIONS

		MIN	NOM MAX	UNIT
$V_{SS}$	Supply voltage	2.7		5 V
T <sub>A</sub>	Operating free-air temperature,	-40	8	°C
Is	Supply current		100	mA

<sup>(2)</sup> The maximum junction temperature for continuous operation is limited by package constraints. Operation above this temperature may result in reduced reliability and/or lifetime of the device.

<sup>(2)</sup> This data was taken using the JEDEC standard High-K test PCB.



#### **ELECTRICAL CHARACTERISTICS**

Typical Performance (V  $_{\rm S}$  = 5 V, R  $_{\rm (BIAS)}$  = 237  $\Omega,$  L  $_{\rm (COL)}$  = 470 nH) (unless otherwise noted)

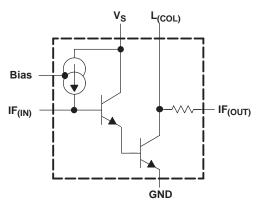
PARAMETER	TEST CONDITIONS	MIN TYP MAX	UNITS
Gain	f = 50 MHz	15.8	٩D
Gain	f = 350 MHz	15.0	dB
OID	f = 50 MHz	35	dBm
OIP <sub>3</sub>	f = 350 MHz	37	авті
1 dD compression	f = 50 MHz	20.6	dBm
1-dB compression	f = 350 MHz	f = 350 MHz 15.0 f = 50 MHz 35 f = 350 MHz 37 f = 50 MHz 20.6	авті
Langet actions I acc	f = 50 MHz	15.4	40
Input return loss	f = 350 MHz	16.6	dB
	f = 50 MHz	17	dB
Output return loss	f = 350 MHz	15	ив
Deverage includion	f = 50 MHz	20.7	40
Reverse isolation	f = 350 MHz	20.7	dB
Noise figure	f = 50 MHz	3.7	٩D
Noise figure	f = 350 MHz	4	dB

# PIN ASSIGNMENT IF(IN) 1 6 BIAS GND 2 5 IF(OUT) V<sub>S</sub> 3 4 L(COL)

#### **Terminal Functions**

Pin Numbers	Name	Description
1	IF <sub>(IN)</sub>	Signal input
2	GND	Negative power supply input
3	V <sub>S</sub>	Positive power supply input
4	L <sub>(COL)</sub>	Output transistor load inductor
5	IF <sub>(OUT)</sub>	Signal output
6	BIAS	Bias current input

#### SIMPLIFIED SCHEMATIC





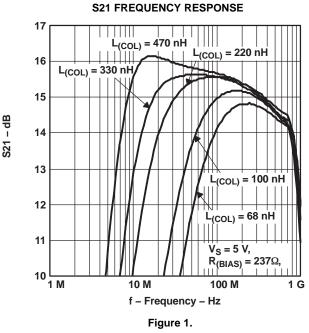
#### **TYPICAL CHARACTERISTICS**

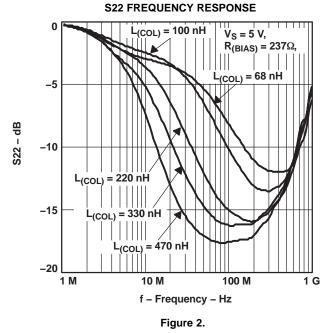
#### **TABLE OF GRAPHS**

			FIGURE
	S21 Frequency response		1
	S22 Frequency response		2
	S11 Frequency response		3
	S12 Frequency response		4
	S21	vs R <sub>(Bias)</sub>	5
	Noise figure	vs Frequency	6
I <sub>S</sub>	Supply current	vs R <sub>(Bias)</sub>	7
	Output power	vs Input power	8
	Adjacent channel (ACPR) and Alternate channel (AltCPR) protection ratios	vs Input power	9
	OIP <sub>2</sub>	vs Frequency	10
	OIP <sub>3</sub>	vs Frequency	11
	S21 Frequency response		12
	S22 Frequency response		13
	S11 Frequency response		14
	S12 Frequency response	vs Frequency	15
	Noise figure		16
	OIP <sub>2</sub>	vs Frequency	17
	Output power	vs Input power	18
	OIP <sub>3</sub>	vs Frequency	19

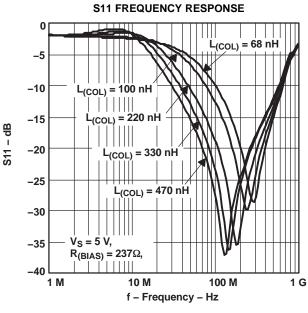


S-Parameters of THS9001 as mounted on the EVM with  $V_S$  = 5 V,  $R_{(BIAS)}$  = 237  $\Omega$ , and  $L_{(COL)}$  = 68 nH to 470 nH at room temperature.





S12 FREQUENCY RESPONSE



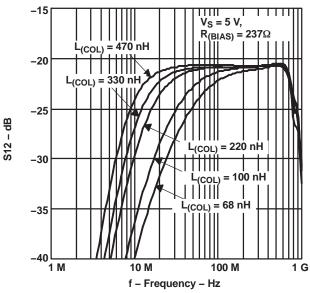
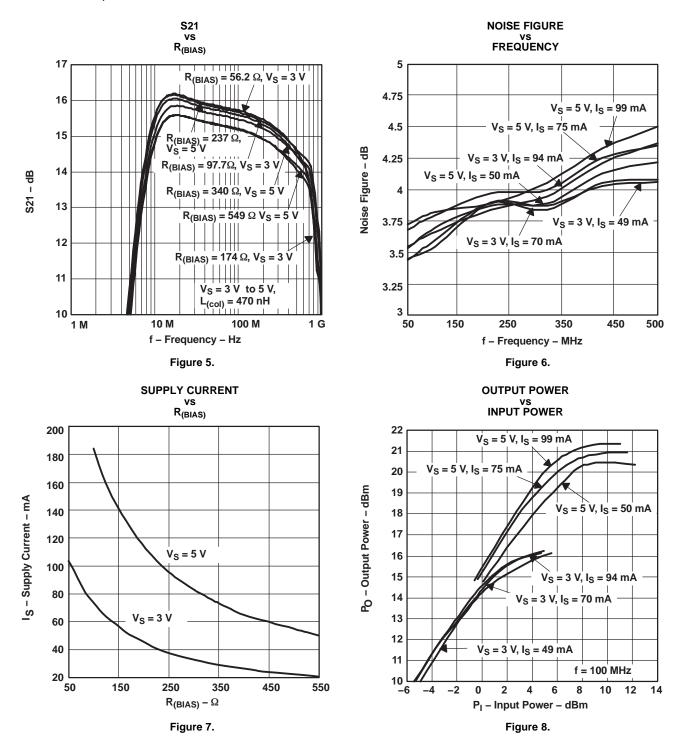


Figure 4.



S-Parameters of THS9001 as mounted on the EVM with  $V_S = 3$  V and 5 V,  $R_{(BIAS)} = various$ , and  $L_{(COL)} = 470$  nH at room temp.





# ADJACENT CHANNEL (ACPR) and ALTERNATE CHANNEL (AltCPR) PROTECTION RATIOS vs INPUT POWER WCDMA Modulation, f = 184.32 MHz, PAR = 10.4 dB

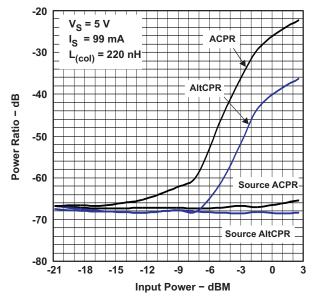


Figure 9.

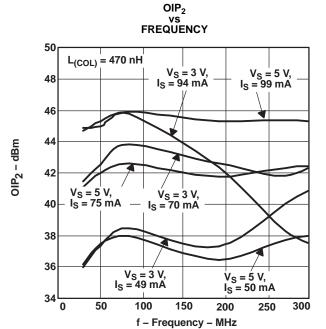


Figure 10.

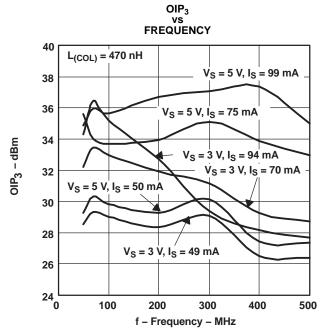
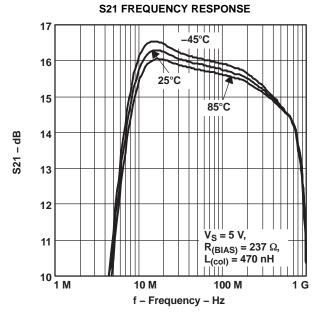


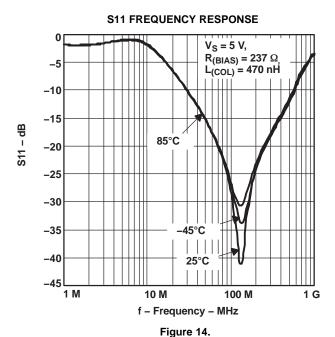
Figure 11.



THS9001 as mounted on the EVM with  $V_S$  = 5 V,  $R_{(BIAS)}$  = 237  $\Omega$ , and  $L_{(COL)}$  = 470 nH at 40°C, 25°C, and 85°C.



#### Figure 12.



S22 FREQUENCY RESPONSE

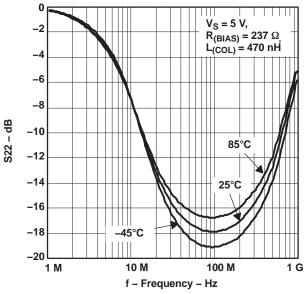


Figure 13.

#### **S12 FREQUENCY RESPONSE**

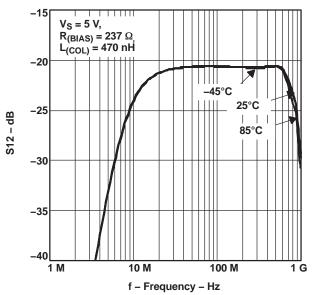
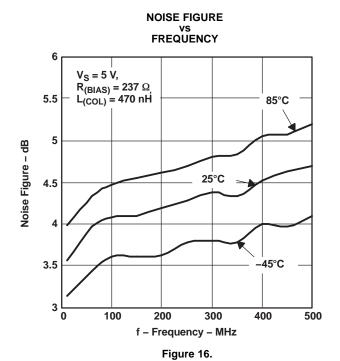
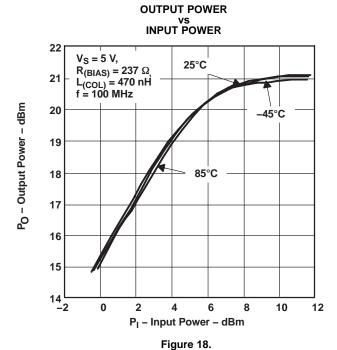


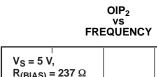
Figure 15.











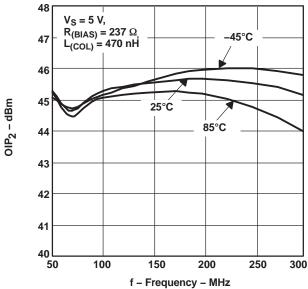


Figure 17.

#### OIP<sub>3</sub> vs FREQUENCY

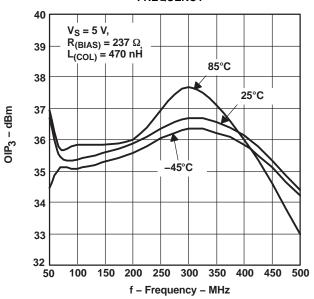


Figure 19.



#### **TYPICAL CHARACTERISTICS**

#### S-Parameters Tables of THS9001 with EVM De-Embedded

-5 - 5 t, 13(BIA	$L_{(S)} = 237 \Omega, L_{(C)}$	,	-	11		22		612
_	_	21	S11 S22  hase (deg)					1
Frequency (MHz)	Gain (dB)	Phase (deg)	Gain (dB)	Phase (deg)	Gain (dB)	Phase (deg)	Gain (dB)	Phase (deg)
1.0	-3.5	-165.0	-2.3	-1.1	-2.6	174.8	-64.4	-121.7
5.0	11.7	-127.1	-1.5	-14.9	-2.8	140.4	-32.4	123.0
10.2	15.8	-150.1	-2.2	-42.3	-5.3	99.8	-23.6	79.5
19.7	16.3	-170.8	-6.6	-69.3	-10.7	64.5	-21.1	40.7
50.1	15.9	175.7	-16.2	-90.3	-16.2	33.9	-20.6	14.5
69.7	15.8	171.5	-21.1	-95.4	-16.9	26.4	-20.6	9.4
102.4	15.7	165.7	-32.3	-86.5	-17.1	19.9	-20.6	5.3
150.5	15.6	158.2	-28.0	45.9	-16.8	14.7	-20.7	2.1
198.1	15.5	151.1	-21.9	46.8	-16.2	10.8	-20.7	0.1
246.9	15.3	144.1	-18.9	37.2	-15.3	6.0	-20.7	-1.4
307.6	15.2	135.3	-16.0	27.8	-14.2	-1.8	-20.6	-3.9
362.8	15.0	127.8	-14.2	17.4	-13.3	-9.2	-20.6	-5.9
405.0	14.9	121.9	-12.8	10.9	-12.6	-16.0	-20.6	-8.2
452.2	14.7	115.4	-11.6	3.0	-11.8	-23.9	-20.6	-10.8
504.7	14.5	108.4	-10.3	-6.0	-10.9	-33.0	-20.7	-14.2
563.4	14.4	100.3	-8.9	-17.4	-9.8	-45.2	-20.9	-19.3
595.3	14.2	96.0	-8.2	-23.3	-9.2	-52.2	-21.0	-22.6
664.5	14.1	87.0	-6.7	-36.9	-8.0	-68.3	-21.7	-30.5
702.1	14.0	80.9	-5.9	-44.6	-7.3	-79.1	-22.5	-38.6
741.8	13.9	76.5	-5.1	-54.0	-6.8	-91.4	-24.0	-44.9
828.1	13.5	62.2	-4.3	-76.1	-6.3	-113.2	-26.5	-35.0
874.9	13.0	54.0	-4.1	-84.6	-5.9	-126.0	-27.0	-49.0
924.4	12.8	44.9	-3.6	-93.1	-5.1	-136.8	-28.0	-62.9
976.7	11.6	35.9	-3.5	-104.4	-5.3	-157.8	-34.0	-104.4
1031.9	11.1	33.0	-3.4	-115.7	-5.8	-172.3	-37.1	107.9
1090.3	10.4	29.2	-3.3	-122.0	-5.7	-173.4	-37.8	162.5
1151.9	10.3	22.2	-3.0	-131.3	-4.8	179.4	-31.1	169.5
1217.1	9.7	4.7	-2.9	-142.3	-3.9	161.9	-26.3	137.1
1285.9	8.6	0.7	-2.9	-151.7	-3.6	147.6	-22.7	121.9
1358.6	7.3	-8.3	-2.9	-161.2	-3.4	134.6	-20.6	116.5
1435.5	5.8	-14.5	-3.0	-170.1	-3.2	122.6	-18.8	105.2
1516.6	4.6	-22.7	-3.1	-178.6	-3.2	112.1	-17.2	96.0
1602.4	3.2	-28.4	-3.1	173.2	-3.1	101.7	-15.7	87.0
1693.0	1.5	-38.0	-3.1	165.1	-3.0	92.4	-14.3	79.2
1788.8	-0.5	-47.9	-3.1	157.6	-2.9	83.6	-13.1	68.8
1889.9	-2.5	-51.0	-3.2	148.8	-2.7	74.4	-12.4	56.9
1996.8	-4.1	-49.0	-3.4	139.5	-2.3	65.0	-12.2	48.2



#### **APPLICATION INFORMATION**

The THS9001 is a medium power, cascadeable, amplifier optimized for high intermediate frequencies in radios. The amplifier is unconditionally stable and design requires only 2 dc-blocking capacitors, 1 power-supply bypass capacitor, 1 RF choke, and 1 bias resistor. Refer to Figure 25 for circuit diagram.

The THS9001 operates with a power supply voltage ranging from 2.5 V to 5.5 V.

The value of  $R_{(BIAS)}$  sets the bias current to the amplifier. Refer to Figure 7. This allows the designer to trade-off linearity versus power consumption.  $R_{(BIAS)}$  can be removed without damage to the device.

Component selection of  $C_{(BYP)}$ ,  $C_{IN}$ , and  $C_{OUT}$  is not critical. The values shown in Figure 25 were used for all the data shown in this data sheet.

The amplifier incorporates internal impedance matching to 50  $\Omega$  that can be adjusted for various frequencies of operation by proper selection of L<sub>(COL)</sub>.

Figure 20 shows the s-parameters of the part mounted on the standard EVM with  $V_S$  = 5 V,  $R_{(BIAS)}$  = 237 $\Omega$ , and  $L_{(COL)}$  = 470 nH. With this configuration, the part is very broadband, and achieves greater than 15-dB input and output return loss from 50 MHz to 325 MHz.

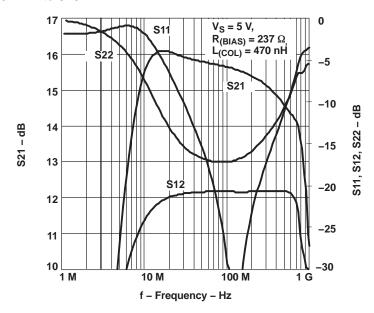


Figure 20. S-Parameters of THS9001 Mounted on the Standard EVM With  $V_S$  = 5 V,  $R_{(BIAS)}$  = 237  $\Omega$ , and  $L_{(COL)}$  = 470 nH



#### **APPLICATION INFORMATION (continued)**

Figure 21 Shows an example of a single conversion receiver architecture and where the THS9001 would typically be used.

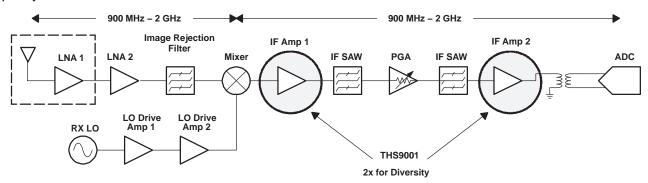


Figure 21. Example Single Conversion Receiver Architecture

Figure 22 shows an example of a dual conversion receiver architecture and where the THS9001 would typically be used.

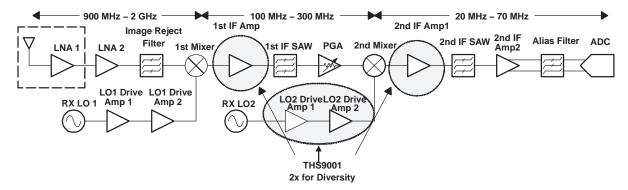


Figure 22. Example Dual Conversion Receiver Architecture

Figure 23 shows an example of a dual conversion transmitter architecture and where the THS9001 would typically be used.

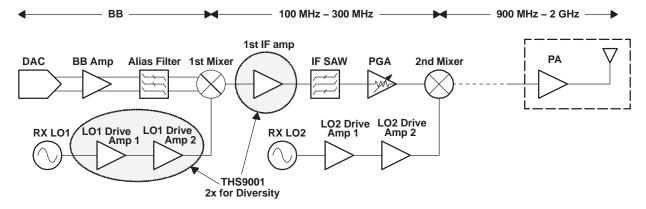


Figure 23. Example Dual Conversion Transmitter Architecture



#### **APPLICATION INFORMATION (continued)**

Figure 24 shows the THS9001 and Sawtek #854916 SAW filter frequency response along with the frequency response of the SAW filter alone. The SAW filter has a center frequency of 140 MHz with 10-MHz bandwidth and 8-dB insertion loss. It can be seen that the frequency response with the THS9001 is the same as with the SAW except for a 15-dB gain. The THS9001 is mounted on the standard EVM with  $V_S = 5 \text{ V}$ ,  $R_{(BIAS)} = 237 \Omega$ , and  $L_{(COL)} = 470 \text{ nH}$ . Note the amplifier does not add artifacts to the signal.

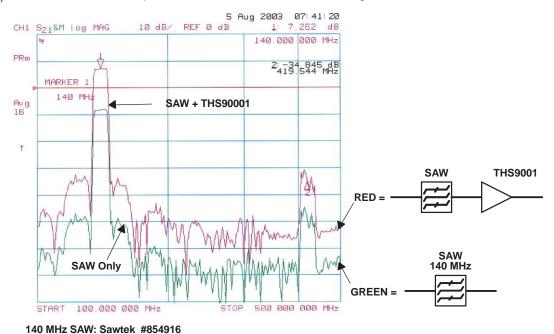


Figure 24. Frequency Response of the THS9001 and SAW Filter, and SAW Filter Only

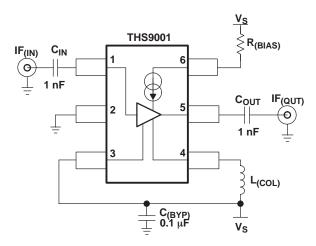


Figure 25. THS9001 Recommended Circuit (Used for all Tests)



#### **APPLICATION INFORMATION (continued)**

#### **Evaluation Module**

Table 1 is the bill of materials, and Figure 26 and Figure 27 show the EVM layout.

#### **Bill Of Materials**

ITEM	DESCRIPTION	REF DES	QTY	PART NUMBER <sup>(1)</sup>
1	Cap, 0.1 μF, ceramic, X7R, 50 V	C1	1	(AVX) 08055C104KAT2A
2	Cap, 1000 pF, ceramic, NPO, 100 V	C2, C3	2	(AVX) 08051A102JAT2A
3	Inductor, 470 nH, 5%	L1	1	(Coilcraft) 0805CS-471XJBC
4	Resistor, 237 Ω, 1/8 W, 1%	R1	1	(Phycomp) 9C08052A2370FKHFT
5	Open	TR1	1	
6	Jack, banana receptance, 0.25" dia.	J3, J4	2	(SPC) 813
7	Connector, edge, SMA PCB jack	J1, J2	2	(Johnson) 142-0701-801
8	Standoff, 4-40 Hex, 0.625" Length		4	(KEYSTONE) 1808
9	Screw, Phillips, 4-40, .250"		4	SHR-0440-016-SN
10	IC, THS9001	U1	1	(TI) THS9001DBV
11	Board, printed-circuit		1	(TI) EDGE # 6453522 Rev.A

(1) The manufacturer's part numbers are used for test purposes only.

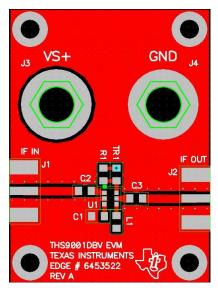


Figure 26. EVM Top Layout

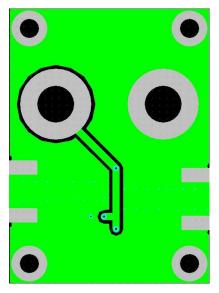


Figure 27. EVM Bottom Layout



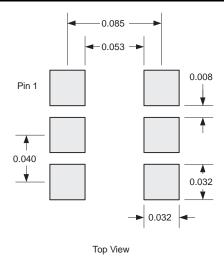


Figure 28. THS9001 Recommended Footprint (dimensions in inches)



#### PACKAGE OPTION ADDENDUM

24-Jan-2013

#### **PACKAGING INFORMATION**

www.ti.com

Orderable Device	Status	Package Type	_		Package Qty	Eco Plan	Lead/Ball Finish		Op Temp (°C)	.,	Samples
	(1)		Drawing			(2)		(3)		(4)	
THS9001DBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	NWL	Samples
THS9001DBVTG4	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	NWL	Samples

(1) 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.

(2) 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)

(3) 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.

<sup>&</sup>lt;sup>(4)</sup> Only one of markings shown within the brackets will appear on the physical device.

#### PACKAGE MATERIALS INFORMATION

www.ti.com 26-Jan-2013

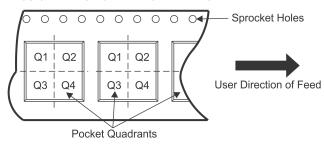
#### TAPE AND REEL INFORMATION





A0	
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

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



#### \*All dimensions are nominal

Device	Package Type	Package Drawing			Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
THS9001DBVT	SOT-23	DBV	6	250	180.0	9.0	3.15	3.2	1.4	4.0	8.0	Q3

**PACKAGE MATERIALS INFORMATION** 

www.ti.com 26-Jan-2013



#### \*All dimensions are nominal

ĺ	Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
	THS9001DBVT	SOT-23	DBV	6	250	182.0	182.0	20.0

## DBV (R-PDSO-G6)

#### PLASTIC SMALL-OUTLINE PACKAGE



NOTES:

- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
- D. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
- Falls within JEDEC MO-178 Variation AB, except minimum lead width.



## DBV (R-PDSO-G6)

#### PLASTIC SMALL OUTLINE



NOTES:

- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
- D. Publication IPC-7351 is recommended for alternate designs.
- E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.



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