50 MHz to 750 MHz CASCADEABLE AMPLIFIER

Check for Samples: THS9001

FEATURES

- **High Dynamic Range**
  - **OIP_3 = 36 dBm**
  - **NF < 4.5 dB**
- **Single-Supply Voltage**
- **High Speed**
  - **V_S = 3 V to 5 V**
  - **I_S = Adjustable**
- **Input/Output Impedance**
  - **50 Ω**

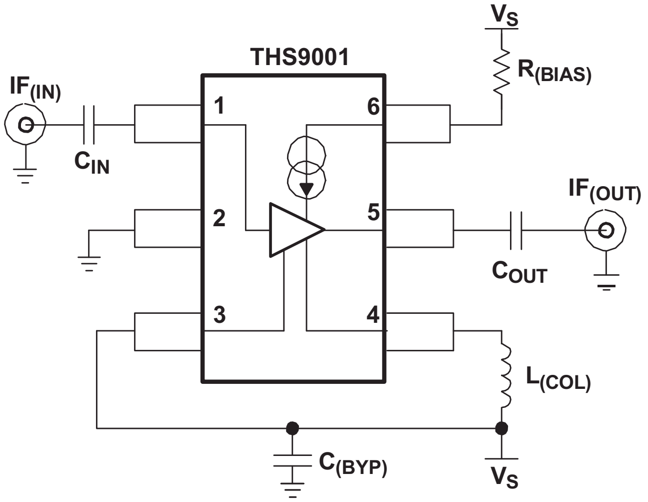
APPLICATIONS

- **IF Amplifiers**
  - **TDMA: GSM, IS-136, EDGE/UWE-136**
  - **CDMA: IS-95, UMTS, CDMA2000**
  - **Wireless Local Loops**
  - **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 Ω, 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 Ω, $L_{(COL)}$ = 470 nH. Design requires only 2 dc-blocking capacitors, 1 power-supply bypass capacitor, 1 RF choke, and 1 bias resistor.

Function Block Diagram



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 DEVICE[1]	PACKAGE TYPE	TRANSPORT MEDIA, QUANTITY
THS9001DBVT	SOT-23-6	Tape and Reel, 250
THS9001DBVR		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_S		5.5
V_I	Input voltage		GND to V_S
	Continuous power dissipation		See Dissipation Rating table
T_J	Maximum junction temperature		150°C
T_J	Maximum junction temperature, continuous operation, long term reliability [2]		125°C
T_{stg}	Storage temperature		–65 to 150°C
:	ESD Ratings	HBM	2000
		CDM	1500
		MM	100

(1) 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.

(2) 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.

DISSIPATION RATING TABLE

PACKAGE	θ_{JC} (°C/W)	θ_{JA} (°C/W)	POWER RATING[1]	
			T_A ≤ 25°C	T_A = 85°C
DBV[2]	70.1	215	463 W	185 mW

(1) 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.

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

RECOMMENDED OPERATING CONDITIONS

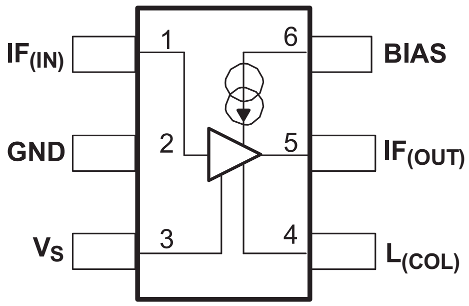
		MIN	NOM	MAX	UNIT
V_{SS}	Supply voltage	2.7		5	V
T_A	Operating free-air temperature,	–40		85	°C
I_S	Supply current		100		mA

ELECTRICAL CHARACTERISTICS

Typical Performance (V_S = 5 V, $R_{(BIAS)}$ = 237 Ω, $L_{(COL)}$ = 470 nH) (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gain	f = 50 MHz		15.8		dB
	f = 350 MHz		15		
OIP_3	f = 50 MHz		35		dBm
	f = 350 MHz		37		
1-dB compression	f = 50 MHz		20.6		dBm
	f = 350 MHz		20.6		
Input return loss	f = 50 MHz		15.4		dB
	f = 350 MHz		16.6		
Output return loss	f = 50 MHz		17		dB
	f = 350 MHz		15		
Reverse isolation	f = 50 MHz		20.7		dB
	f = 350 MHz		20.7		
Noise figure	f = 50 MHz		3.7		dB
	f = 350 MHz		4		

PIN ASSIGNMENT



Terminal Functions

PIN NUMBERS	NAME	DESCRIPTION
1	$IF_{(IN)}$	Signal input
2	GND	Negative power-supply input
3	V_S	Positive power-supply input
4	$L_{(COL)}$	Output transistor load inductor
5	$IF_{(OUT)}$	Signal output
6	BIAS	Bias current input

SIMPLIFIED SCHEMATIC

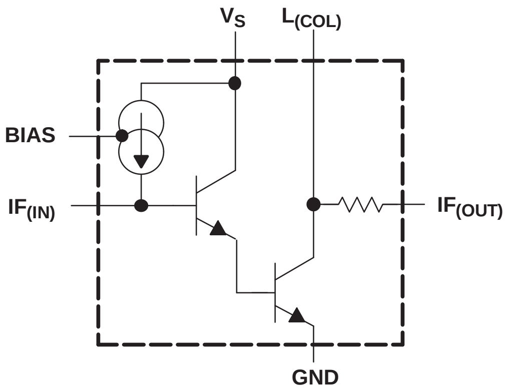


TABLE OF GRAPHS

			FIGURE
	S21 Frequency response		1
	S22 Frequency response		2
	S11 Frequency response		3
	S12 Frequency response		4
	S21	vs $R_{(Bias)}$	5
	Noise figure	vs Frequency	6
I_S	Supply current	vs $R_{(Bias)}$	7
	Output power vs Input power		8
	Adjacent channel (ACPR) and Alternate channel (AltCPR) protection ratios	vs Input power	9
	OIP_2	vs Frequency	10
	OIP_3	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_2 vs Frequency		17
	Output power	vs Input power	18
	OIP_3	vs Frequency	19

TYPICAL CHARACTERISTICS

S-Parameters of THS9000 as mounted on the EVM with V_S = 5 V, $R_{(BIAS)}$ = 237 Ω, and $L_{(COL)}$ = 68 nH to 470 nH at room temperature.

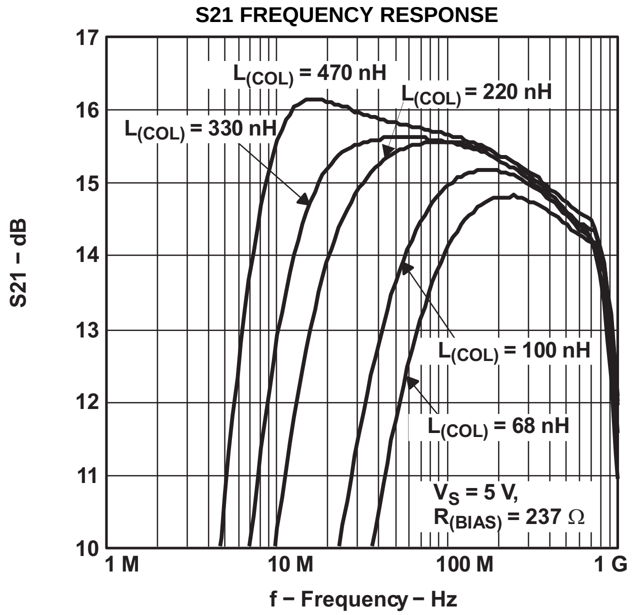


Figure 1.

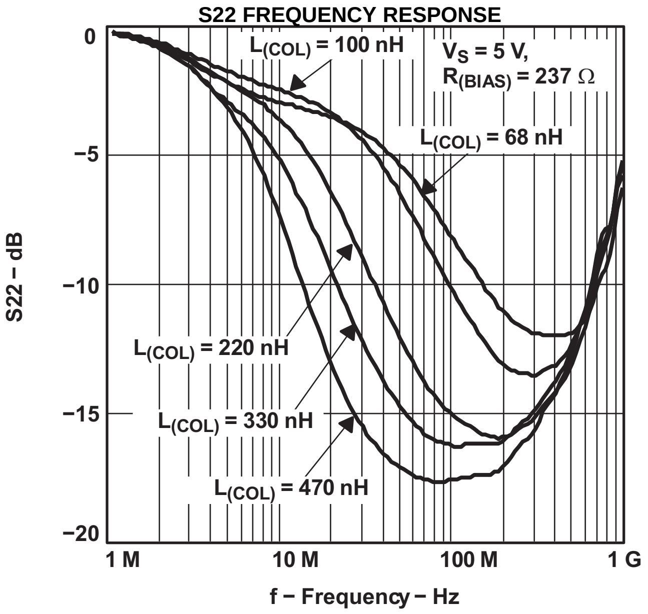


Figure 2.

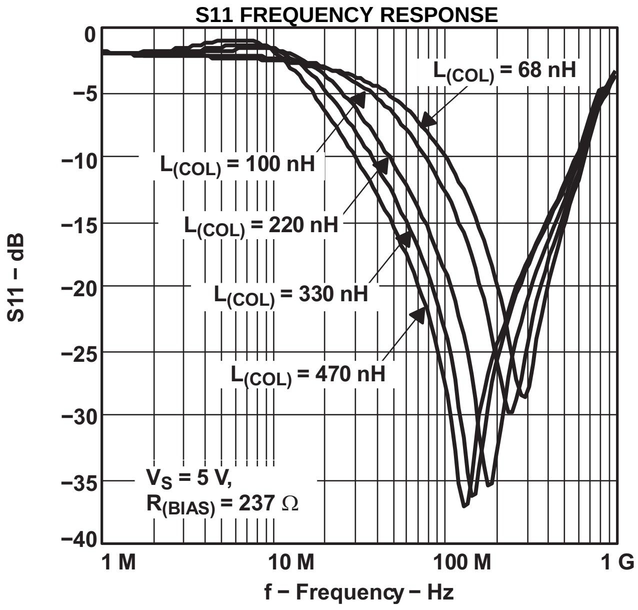


Figure 3.

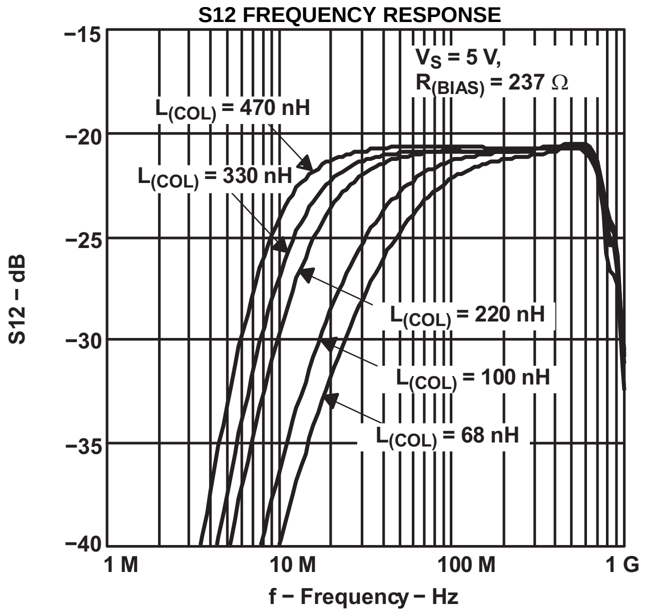


Figure 4.

TYPICAl CHARACTERISTICS

S-Parameters of THS9000 as mounted on the EVM with V_S = 3 V and 5 V, $R_{(BIAS)}$ = various, and $L_{(COL)}$ = 470 nH at room temp.

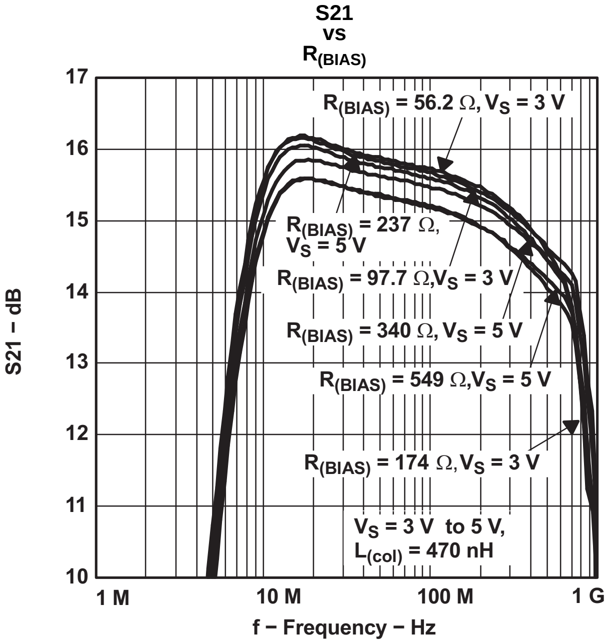


Figure 5.

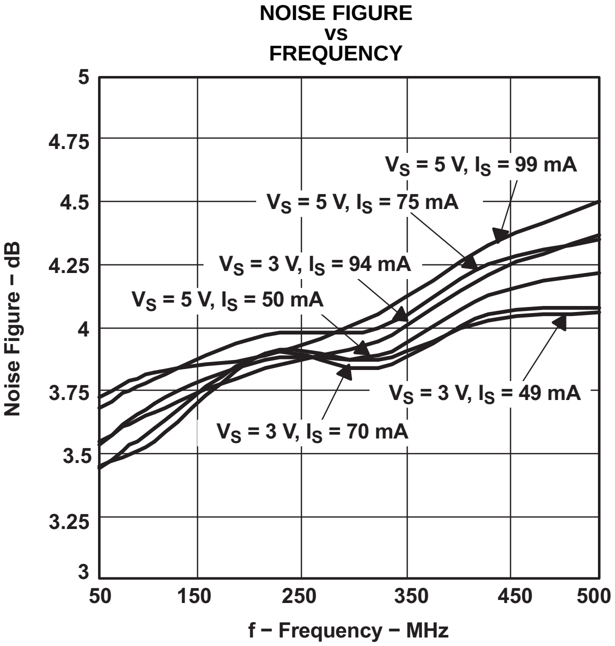


Figure 6.

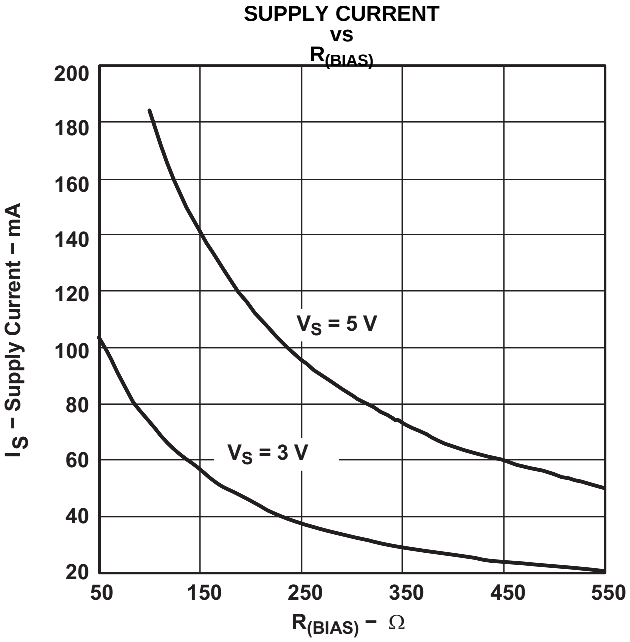


Figure 7.

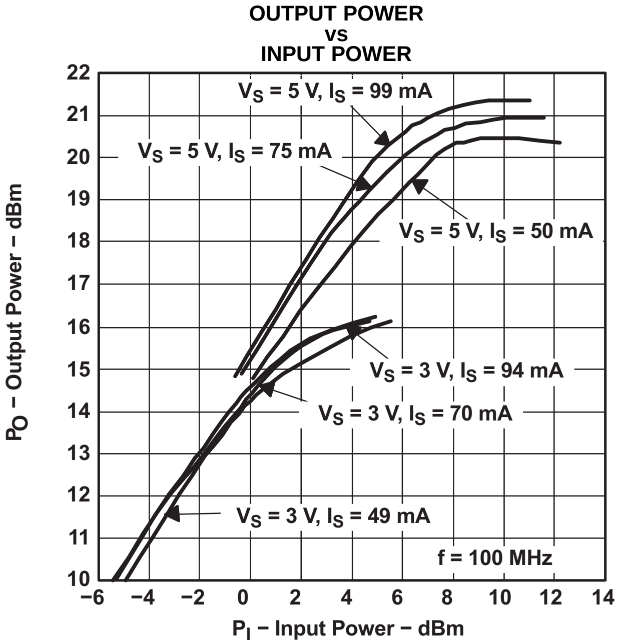


Figure 8.

TYPICAl CHARACTERISTICS (continued)

S-Parameters of THS9000 as mounted on the EVM with V_S = 3 V and 5 V, $R_{(BIAS)}$ = various, and $L_{(COL)}$ = 470 nH at room temp.

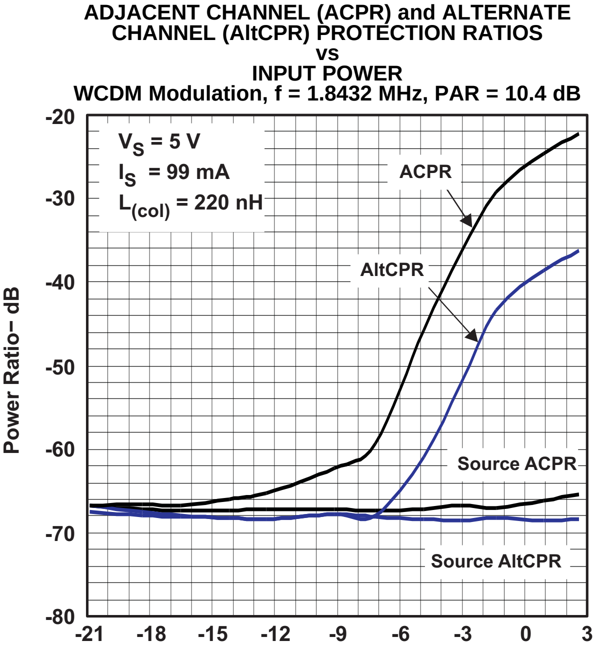


Figure 9.

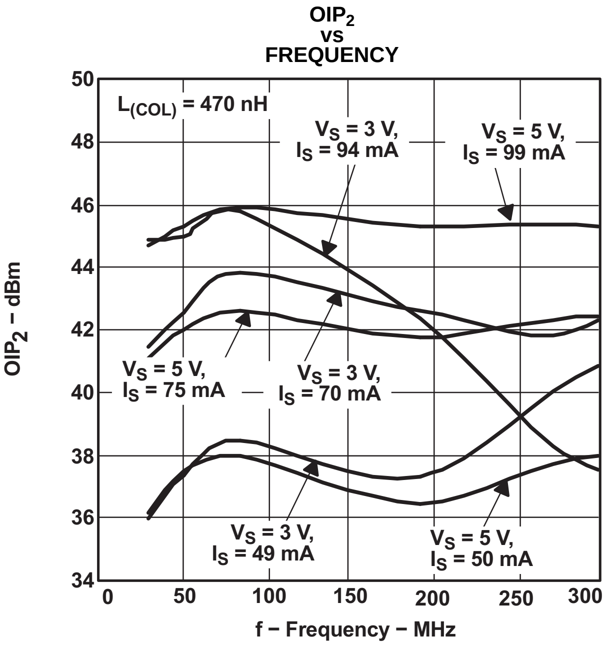


Figure 10.

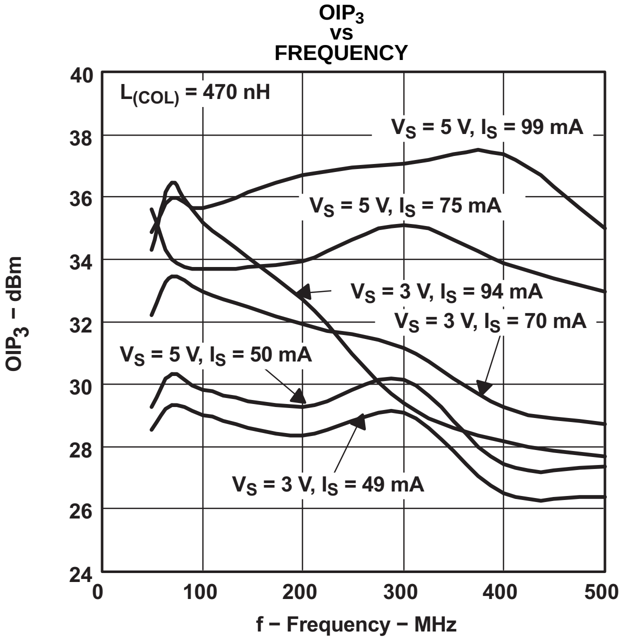


Figure 11.

TYPICAL CHARACTERISTICS

THS9000 as mounted on the EVM with V_S = 3 V and 5 V, $R_{(BIAS)}$ = 237 Ω, and $L_{(COL)}$ = 470 nH at –40°C, 25°C, and 85°C.

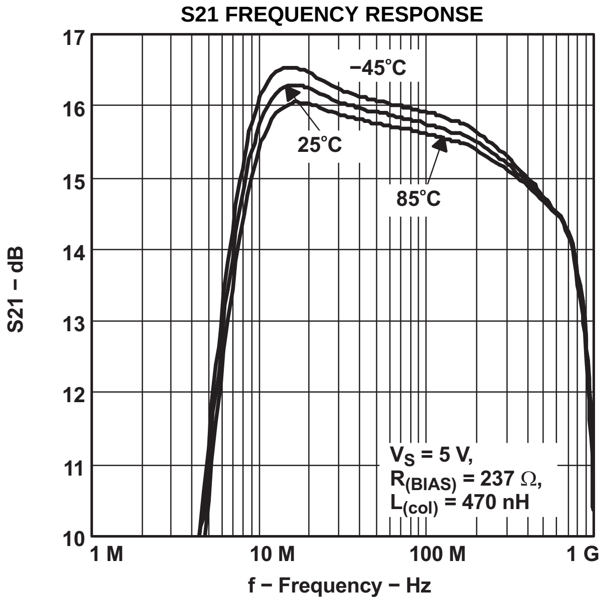


Figure 12.

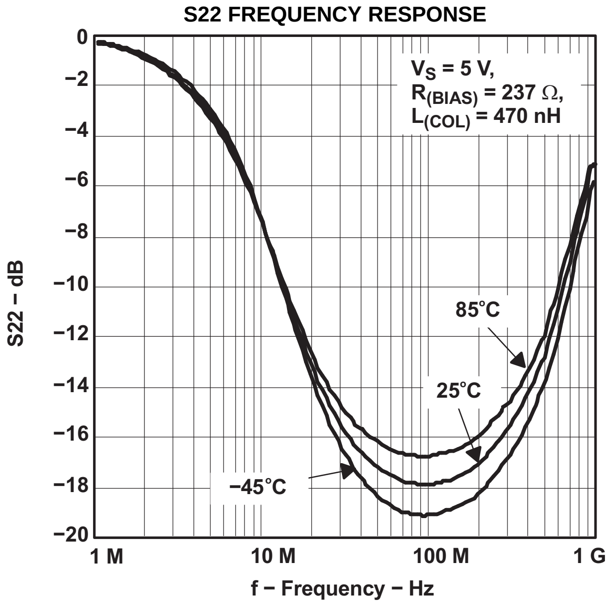


Figure 13.

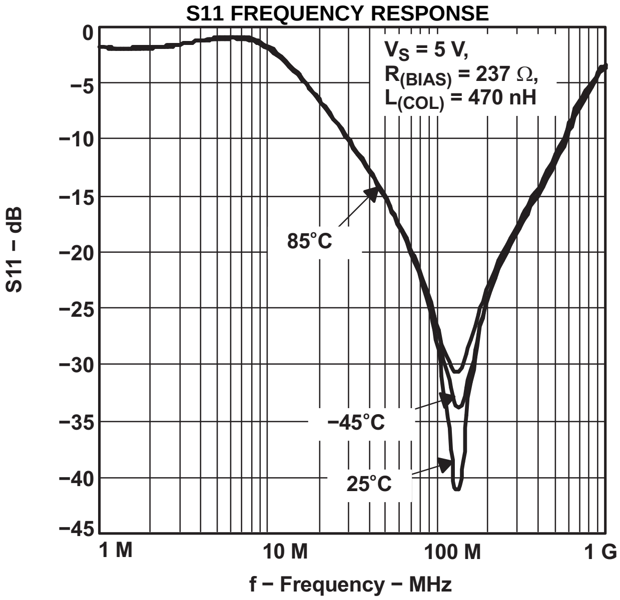


Figure 14.

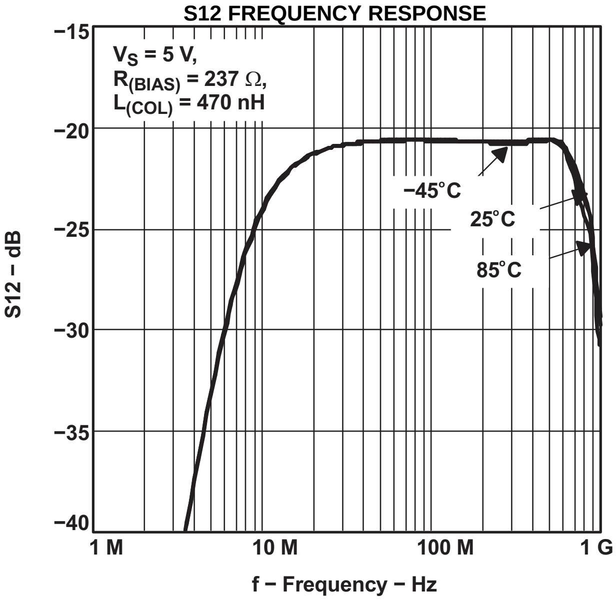


Figure 15.

TYPICAL CHARACTERISTICS (continued)

THS9000 as mounted on the EVM with V_S = 3 V and 5 V, $R_{(BIAS)}$ = 237 Ω, and $L_{(COL)}$ = 470 nH at –40°C, 25°C, and 85°C.

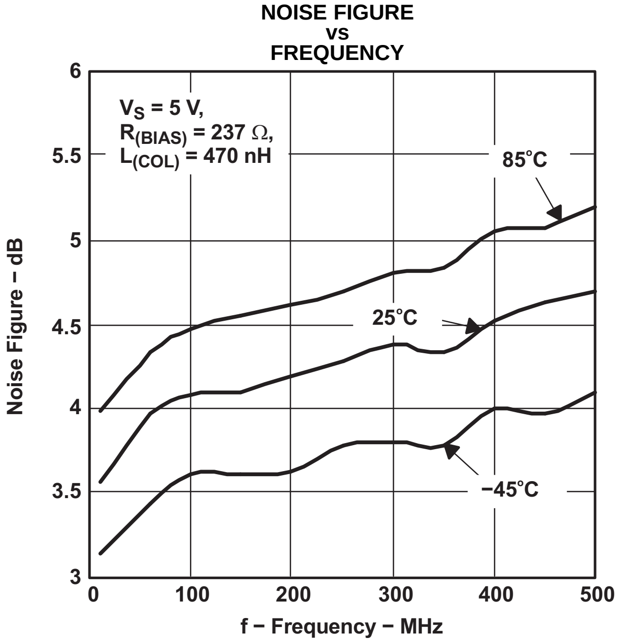


Figure 16.

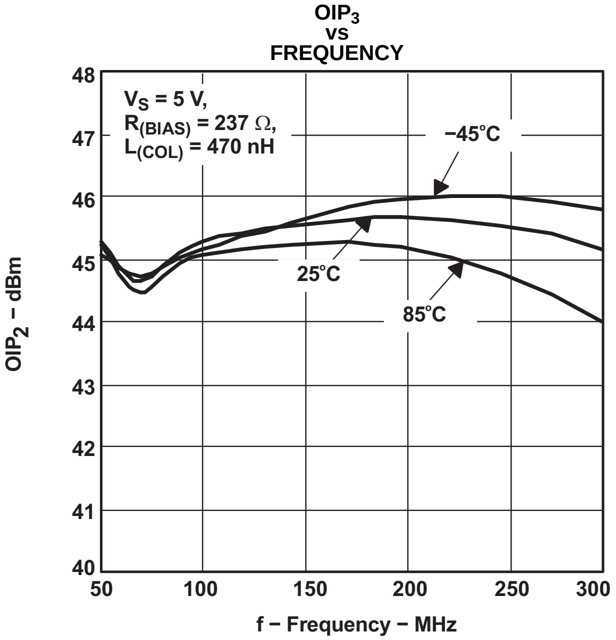


Figure 17.

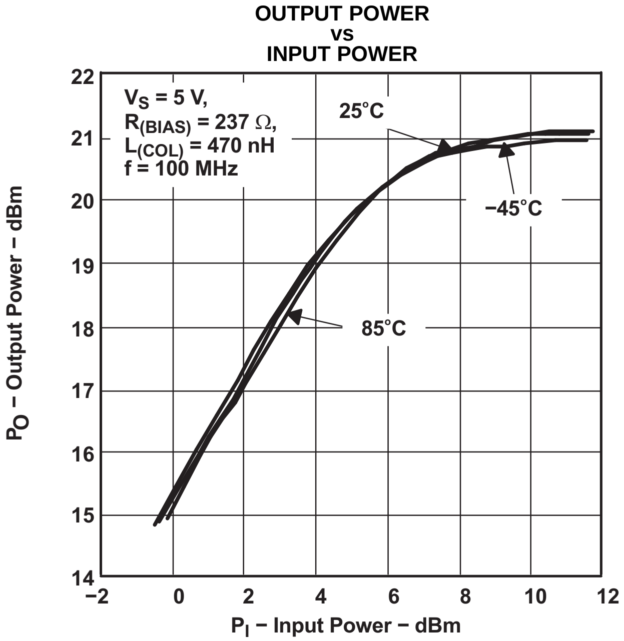


Figure 18.

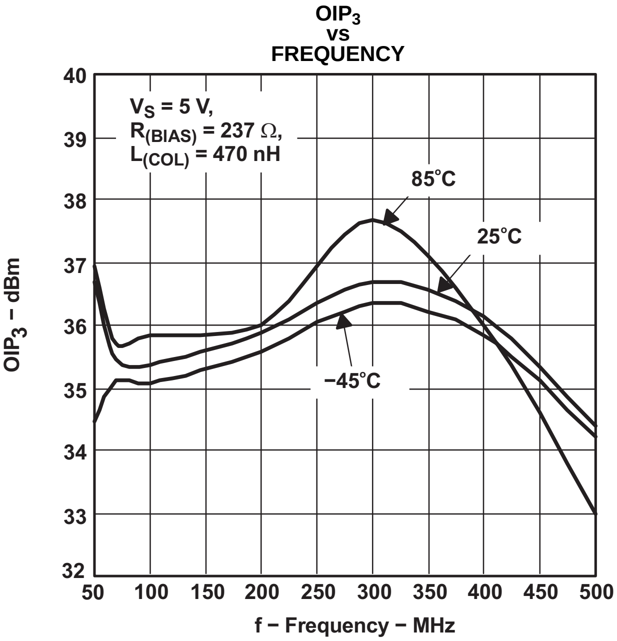


Figure 19.

TYPICAL CHARACTERISTICS

Table 1. S-Parameters Tables of THS9001 with EVM De-Embedded

V_S = 5 V, $R_{(BIAS)}$ = 237 , $L_{(COL)}$ = 470 nH								
	S21		**S11**		**S22**		**S12**	
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 the design requires only 2 dc-blocking capacitors, 1 power-supply bypass capacitor, 1 RF choke, and 1 bias resistor. Refer to Figure 25 for the circuit diagram.

The THS901 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 14. 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 Ω that can be adjusted for various frequencies of operation by proper selection of $L_{(COL)}$.

Figure 20 shows the s-parameters of the part mounted on the standard EVM with V_S = 5 V, $R_{(BIAS)}$ = 237 Ω, 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.

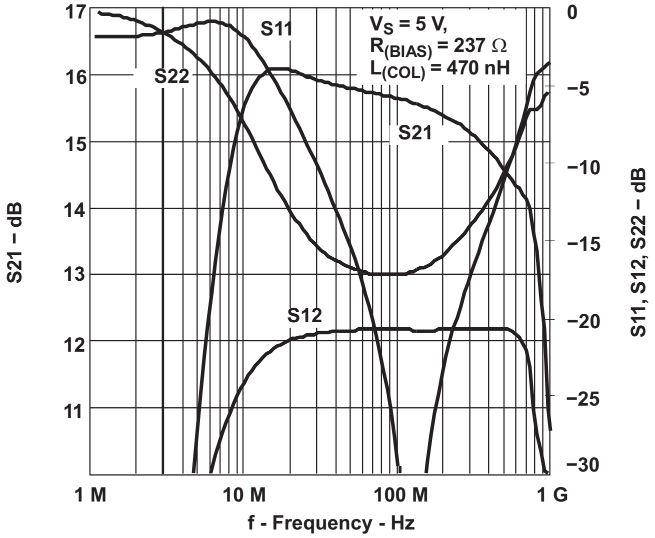


Figure 20. S-Parameters of THS9001 Mounted on the Standard EVM with V_S = 5 V, $R_{(BIAS)}$ = 237 Ω, and $L_{(COL)}$ = 470 nH

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

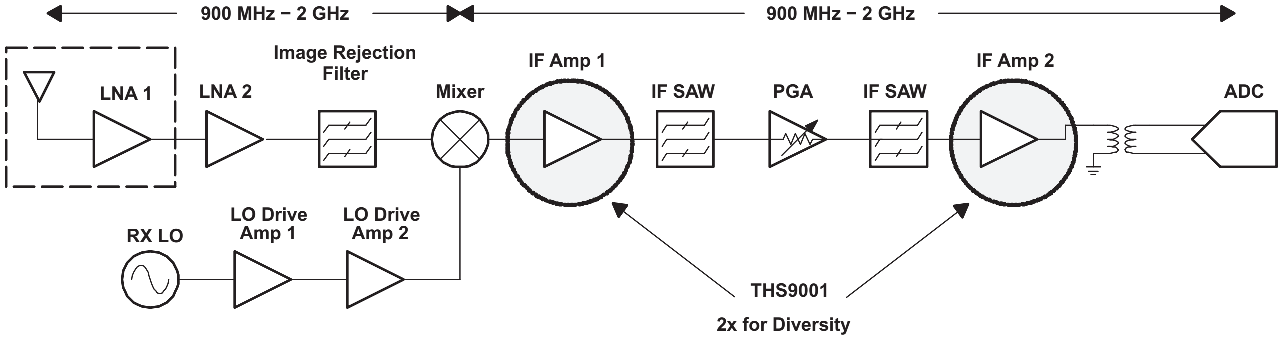


Figure 21. Example Single Conversion Receiver Architecture

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

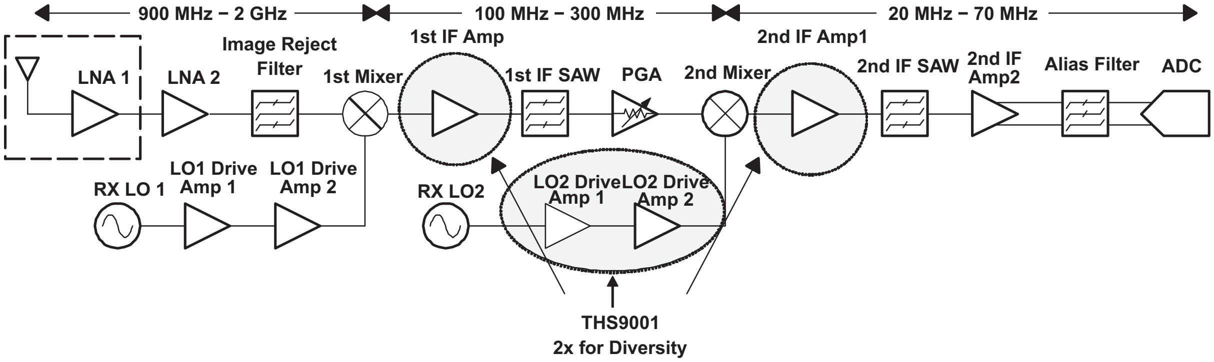


Figure 22. Example Dual Conversion Receiver Architecture

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

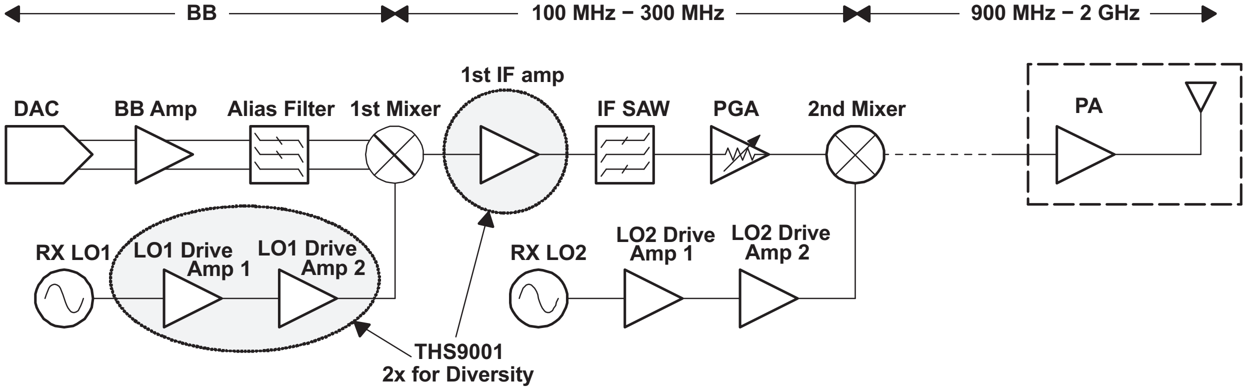
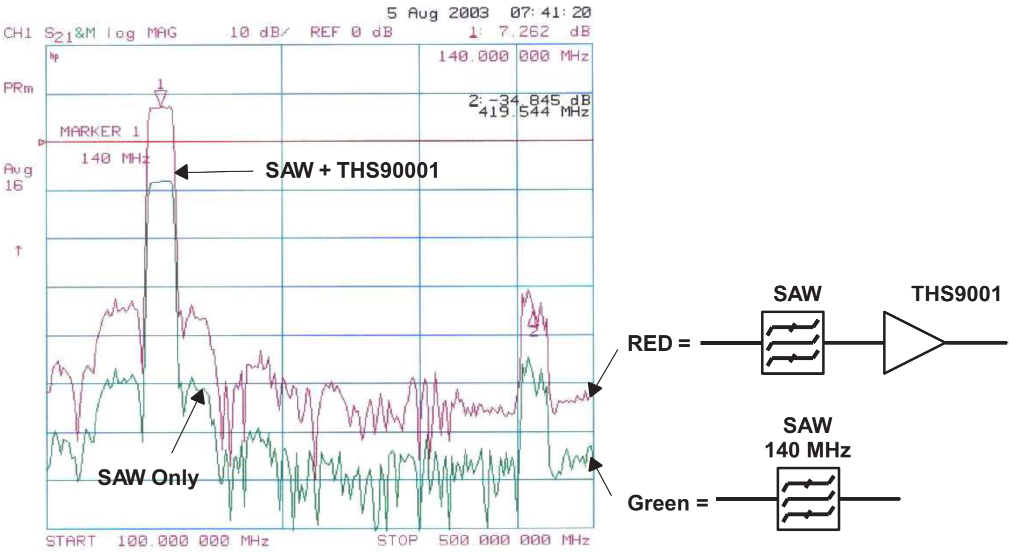


Figure 23. Example Dual Conversion Transmitter Architecture

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 V, $R_{(BIAS)}$ = 237 Ω, and $L_{(COL)}$ = 470 nH. Note the amplifier does not add artifacts to the signal.



140 MHZ SAW: Sawtek #854916

Figure 24. Frequency Response of the THS9000 and SAW Filter, and SAW Filter Only

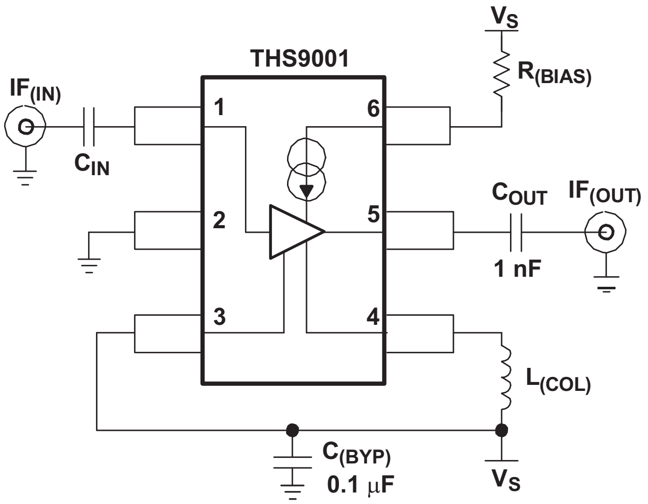


Figure 25. THS9000 Recommended Circuit (used for all tests)

Evaluation Module

Bill Of Materials 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[1]
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, THS90001	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.

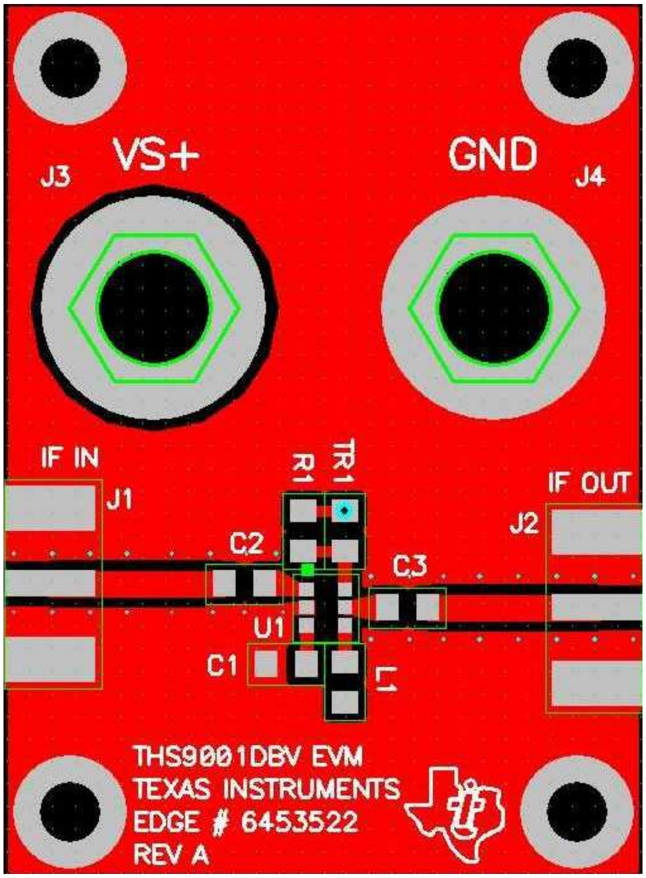


Figure 26. EVM Top Layout

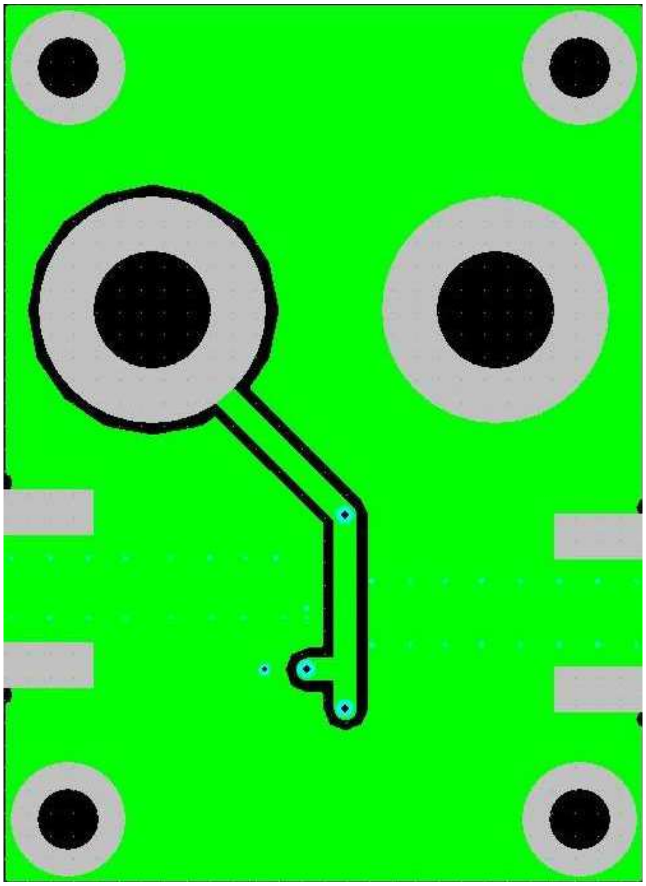


Figure 27. EVM Bottom Layout

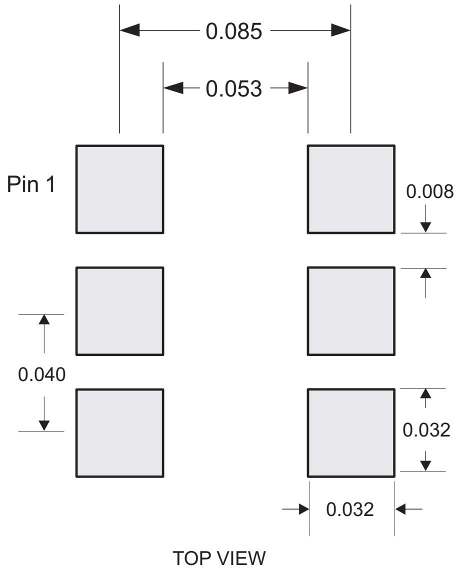


Figure 28. THS9000 Recommended Footprint dimensions are in inches (millimeters)

REVISION HISTORY

Changes from Revision B (January 2007) to Revision C **Page**

- Changed the data sheet title From: 50 MHz to 400 MHz CASCADEABLE AMPLIFIER To: 50 MHz to 750 MHz CASCADEABLE AMPLIFIER 1

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
THS9001DBVT	Active	Production	SOT-23 (DBV) | 6	250 | SMALL T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	NWL
THS9001DBVT.B	Active	Production	SOT-23 (DBV) | 6	250 | SMALL T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	NWL

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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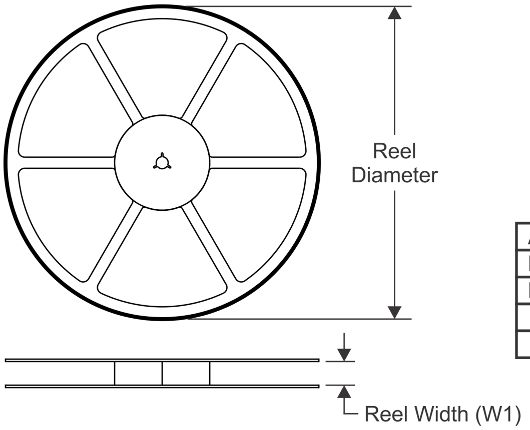
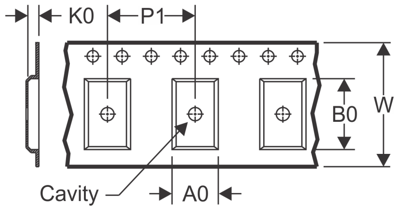
TAPE AND REEL INFORMATION

REEL DIMENSIONS

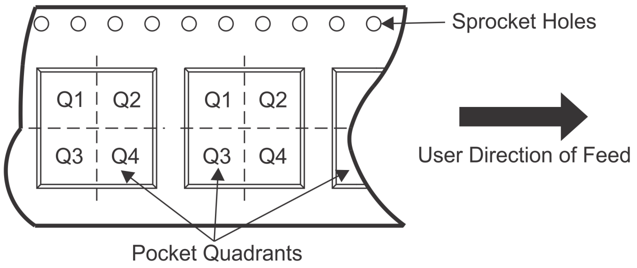


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
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

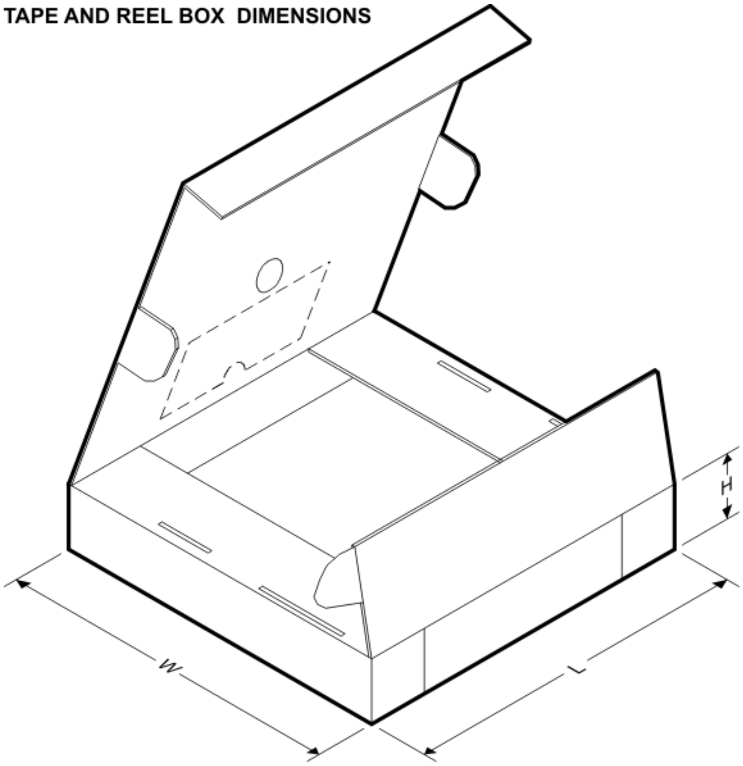
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	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

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

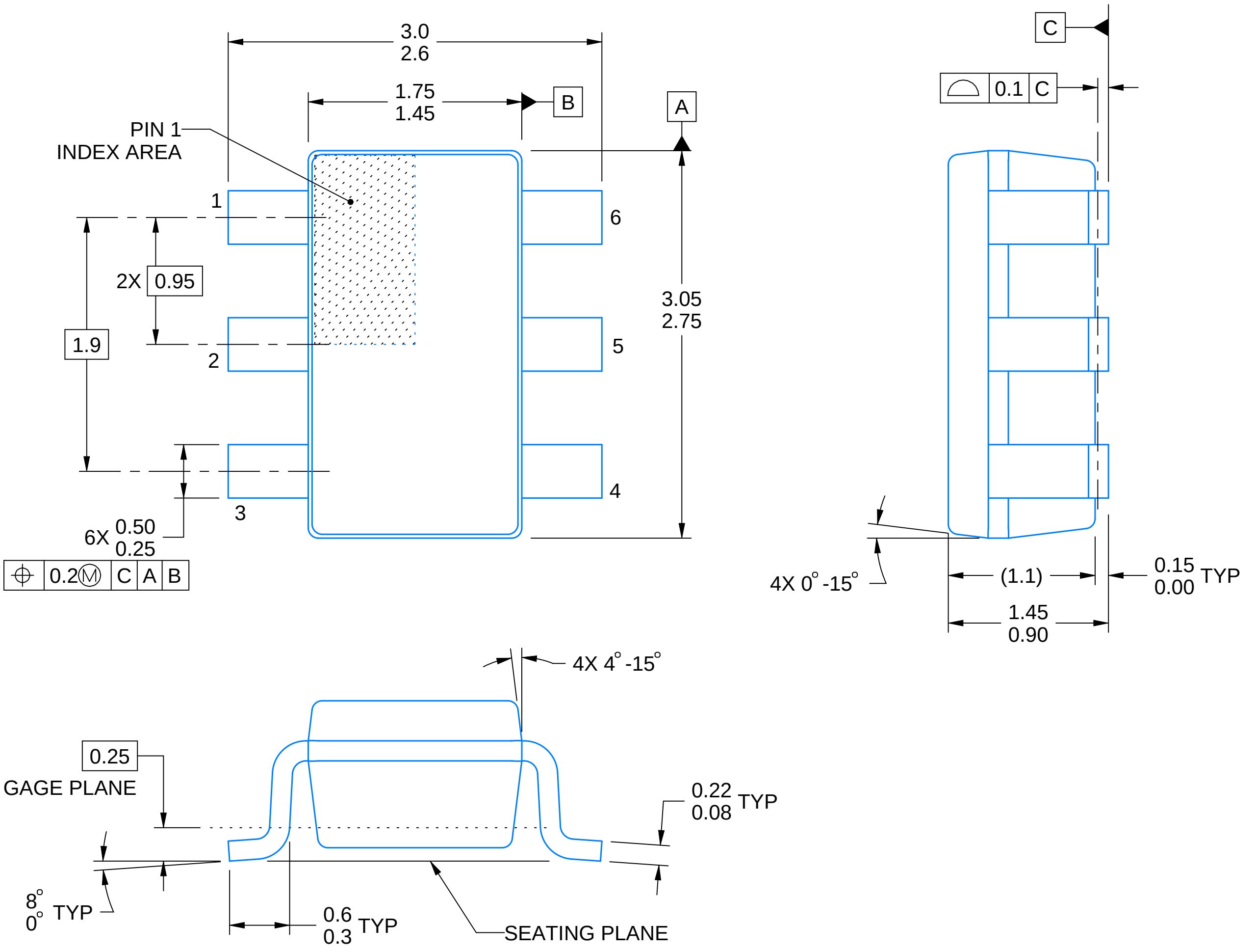
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
THS9001DBVT	SOT-23	DBV	6	250	182.0	182.0	20.0

DBV0006A

PACKAGE OUTLINE

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



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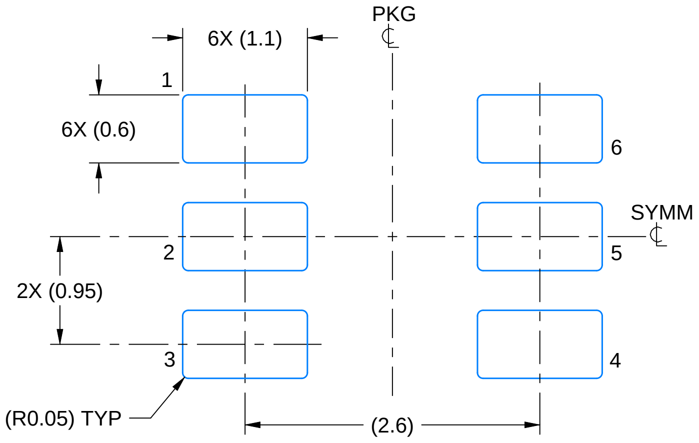
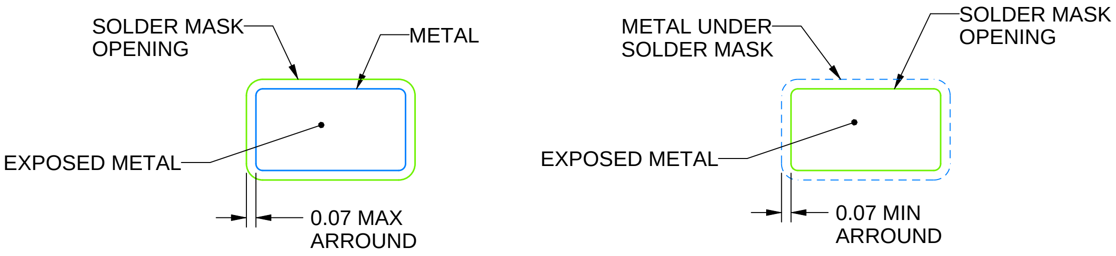
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.25 per side.
4. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
5. Refernce JEDEC MO-178.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



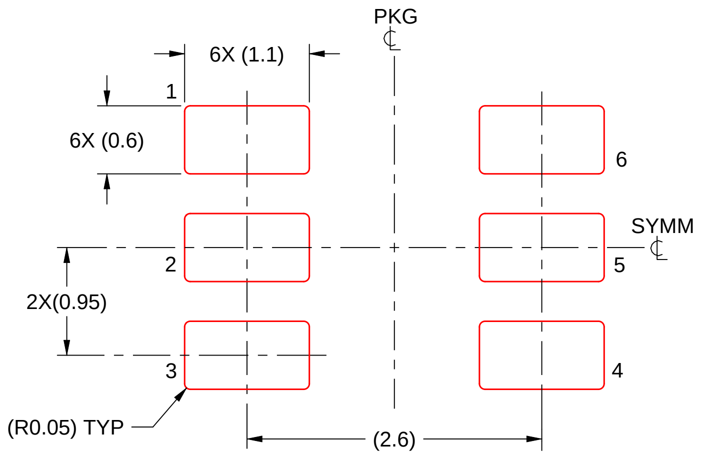
NON SOLDER MASK
DEFINED
(PREFERRED)

SOLDER MASK
DEFINED

SOLDER MASK DETAILS

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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