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**

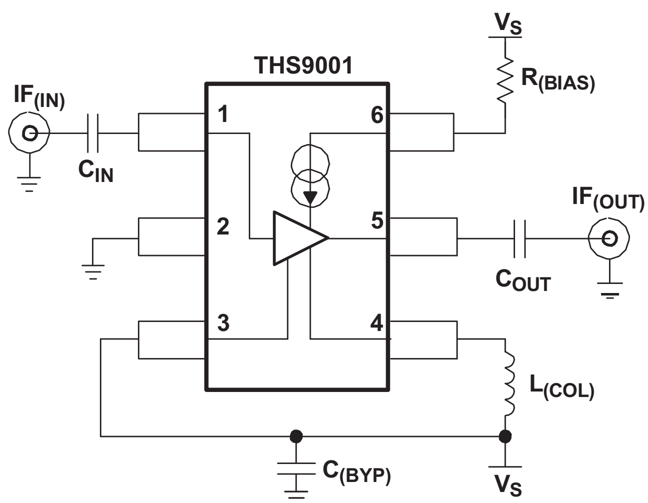
APPLICATIONS

- **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]	
			$T_A \leq 25°C$	$T_A = 85°C$
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

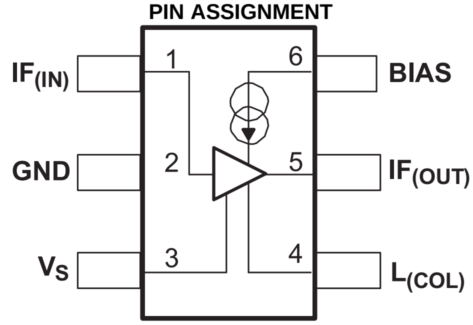
		MIN	NOM	MAX	UNIT
V_{SS}	Supply voltage	2.7		5	V
T_A	Operating free-air temperature,	–40		85	°C
I_S	Supply current		100		mA

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

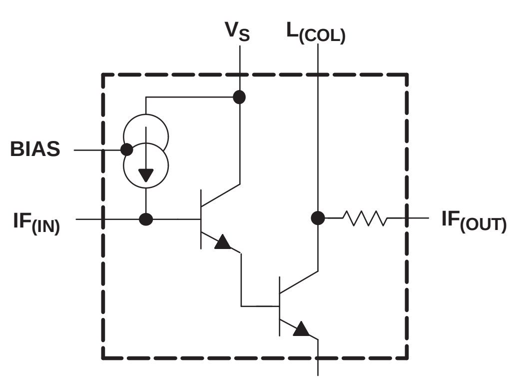


TABLE OF GRAPHS

			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.

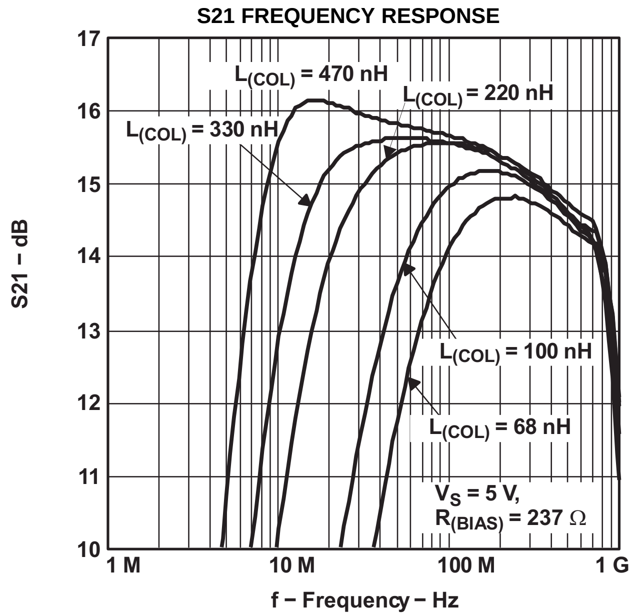


Figure 1.

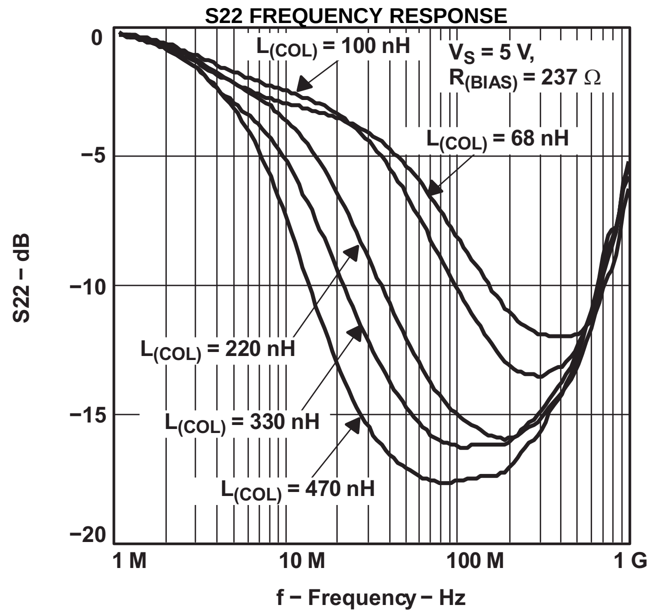


Figure 2.

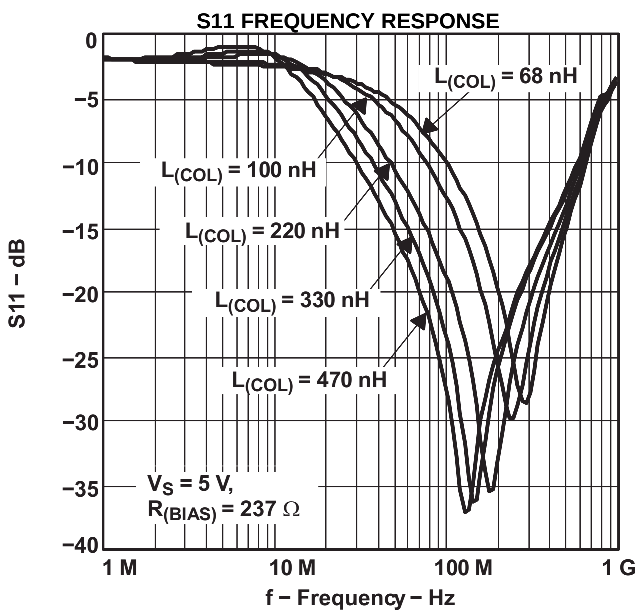


Figure 3.

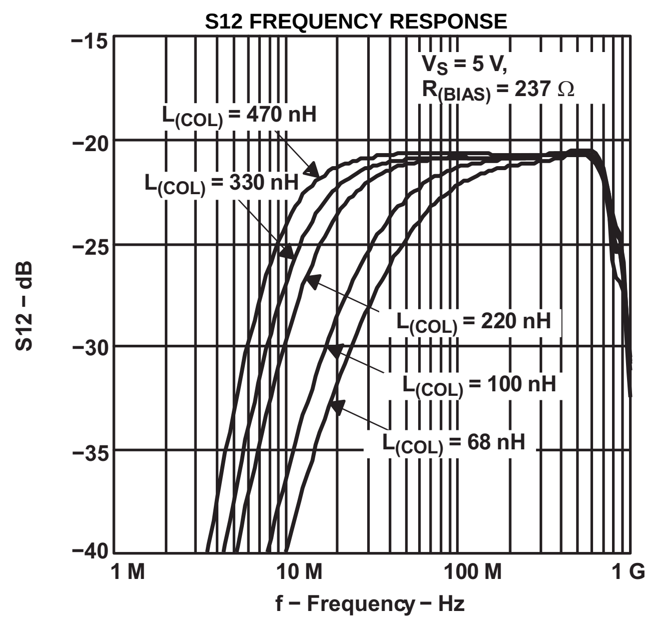


Figure 4.

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.

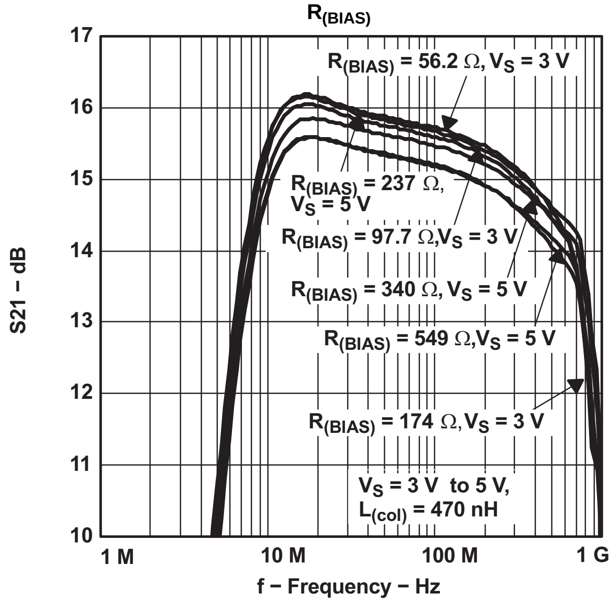


Figure 5.

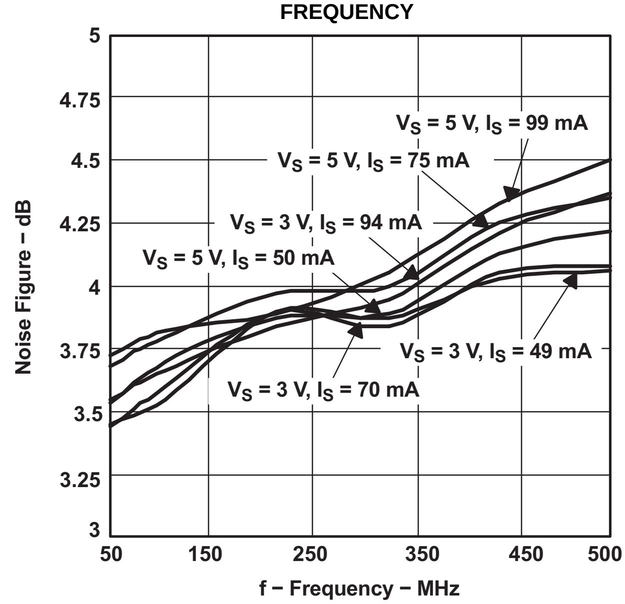


Figure 6.

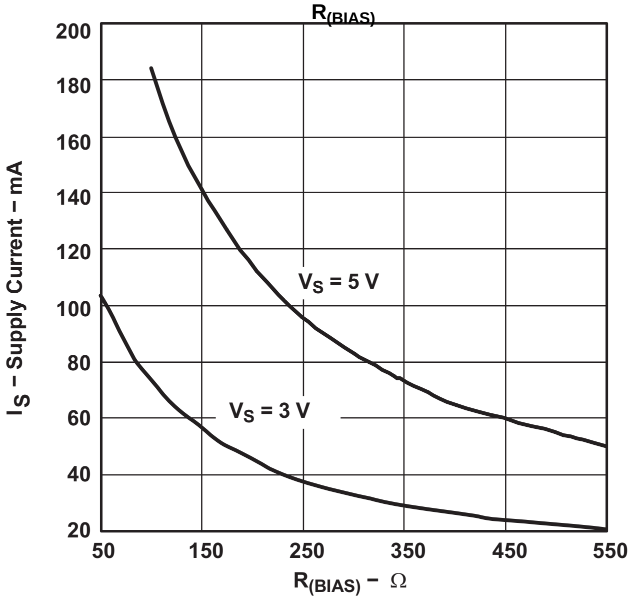


Figure 7.

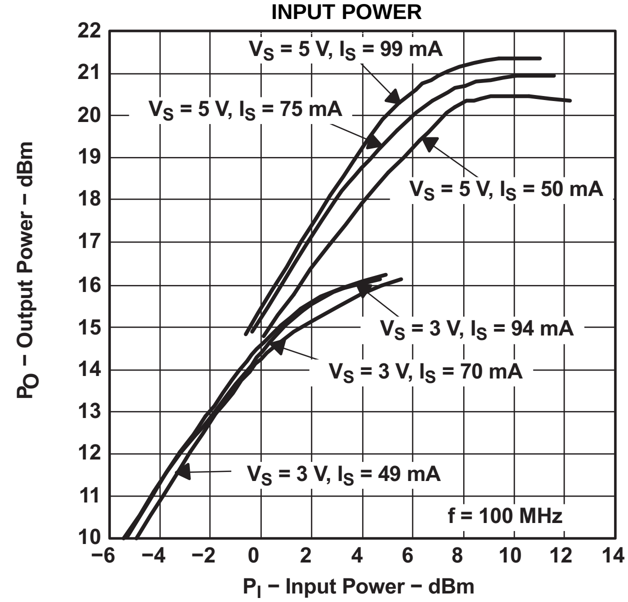


Figure 8.

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.

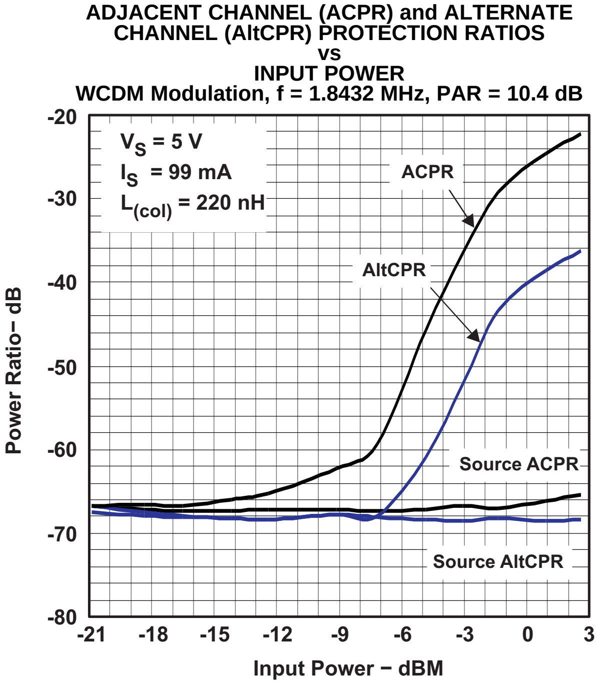


Figure 9.

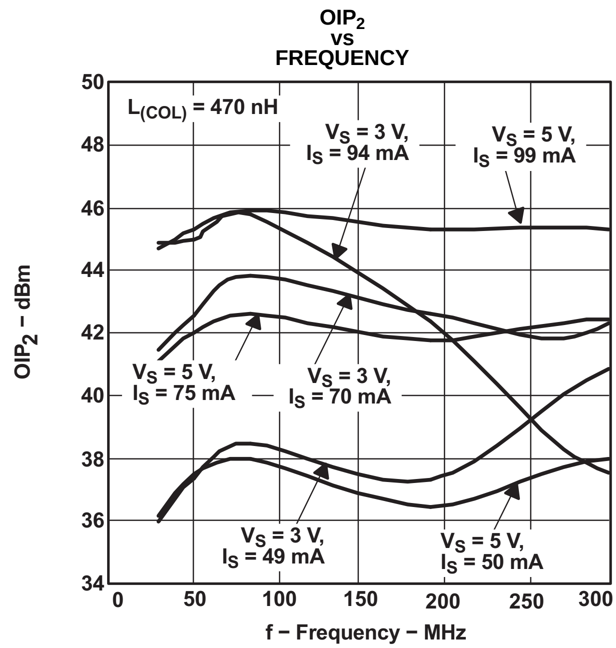


Figure 10.

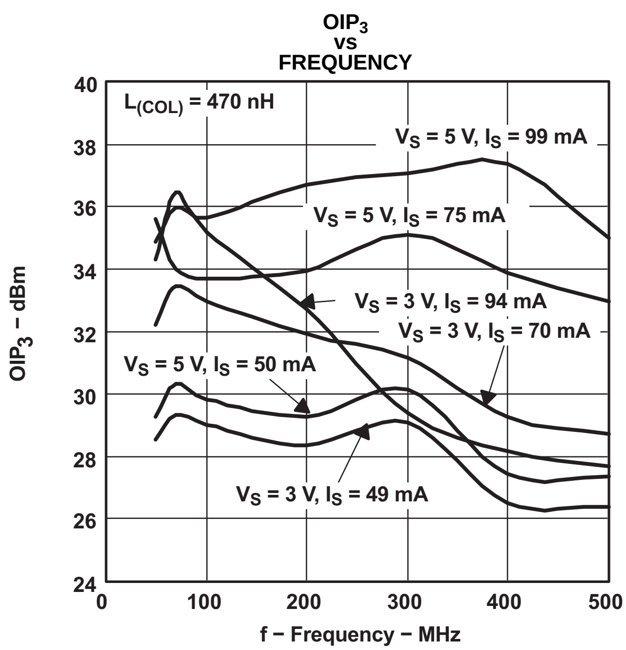


Figure 11.

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.

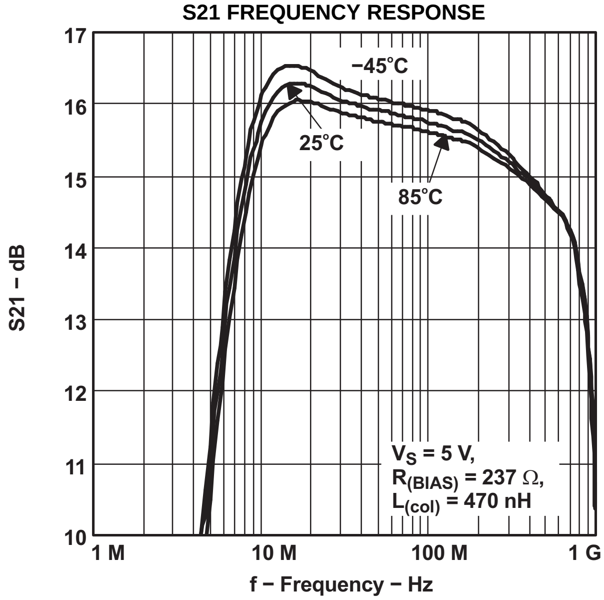


Figure 12.

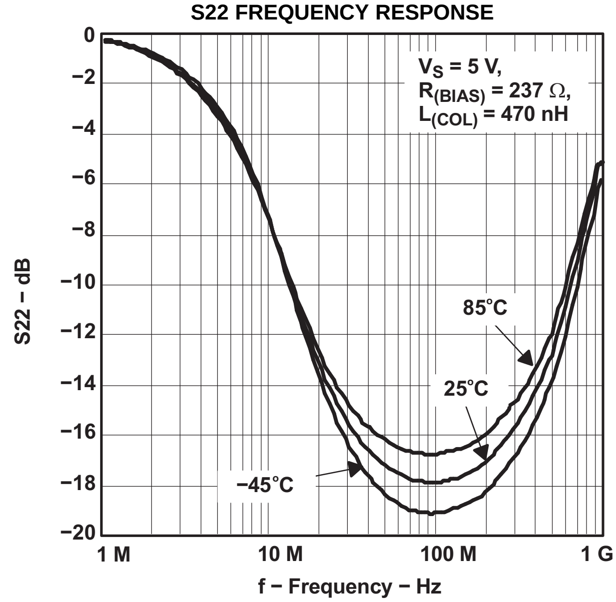


Figure 13.

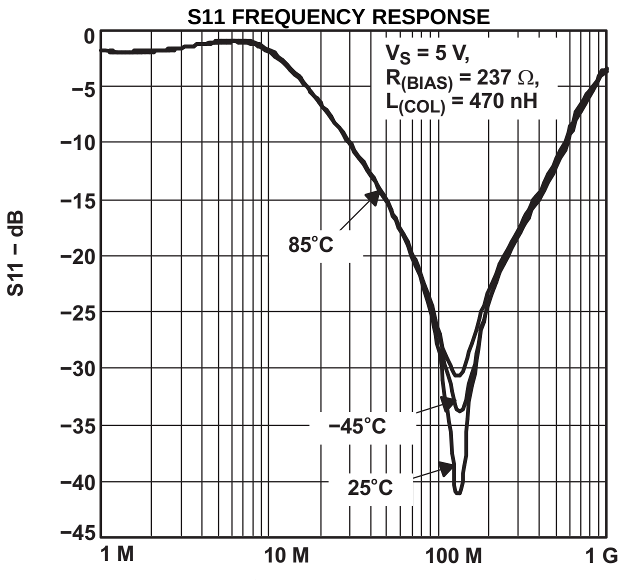


Figure 14.

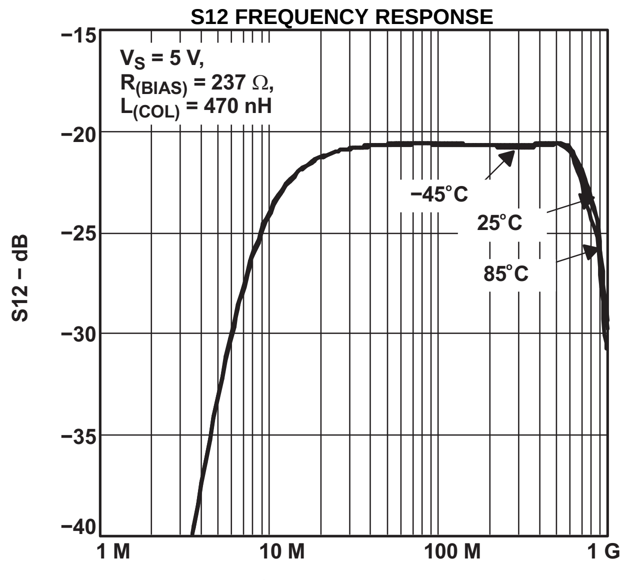


Figure 15.

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.

NOISE FIGURE vs FREQUENCY

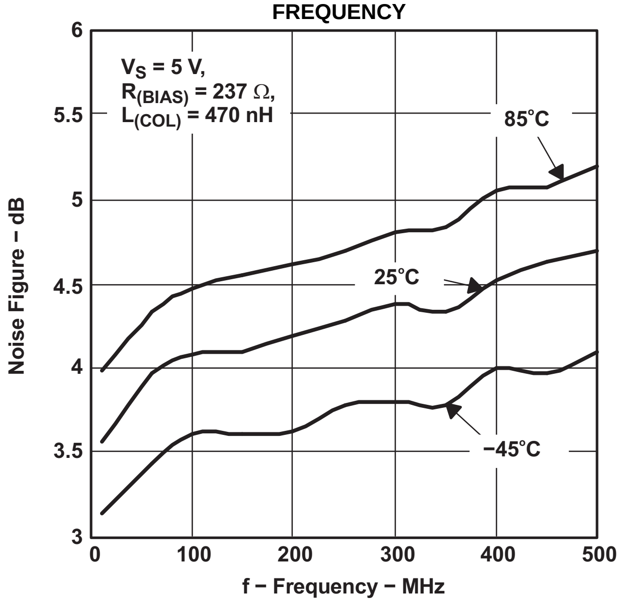


Figure 16.

OIP3 vs FREQUENCY

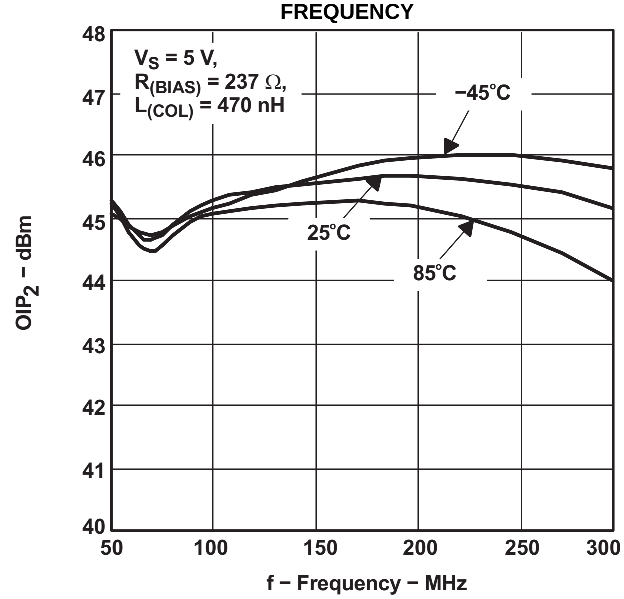


Figure 17.

OUTPUT POWER vs INPUT POWER

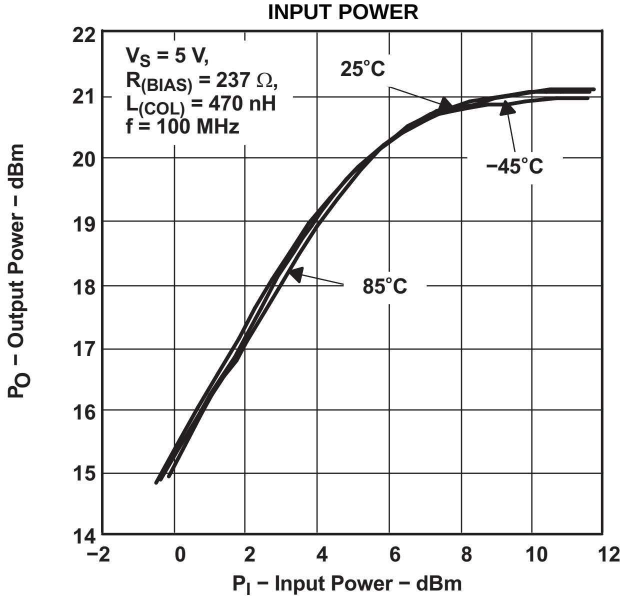


Figure 18.

OIP3 vs FREQUENCY

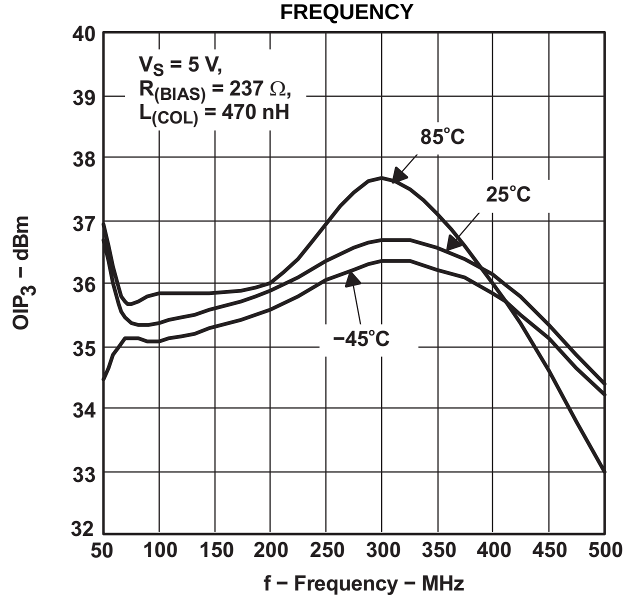


Figure 19.

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.

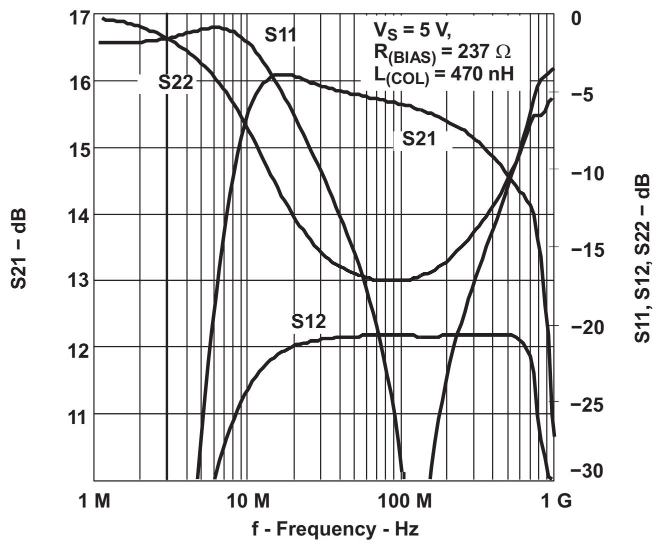


Figure 20. S-Parameters of THS9001 Mounted on the Standard EVM with V_S = 5 V, $R_{(BIAS)}$ = 237 Ω, and $L_{(COL)}$ = 470 nH

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

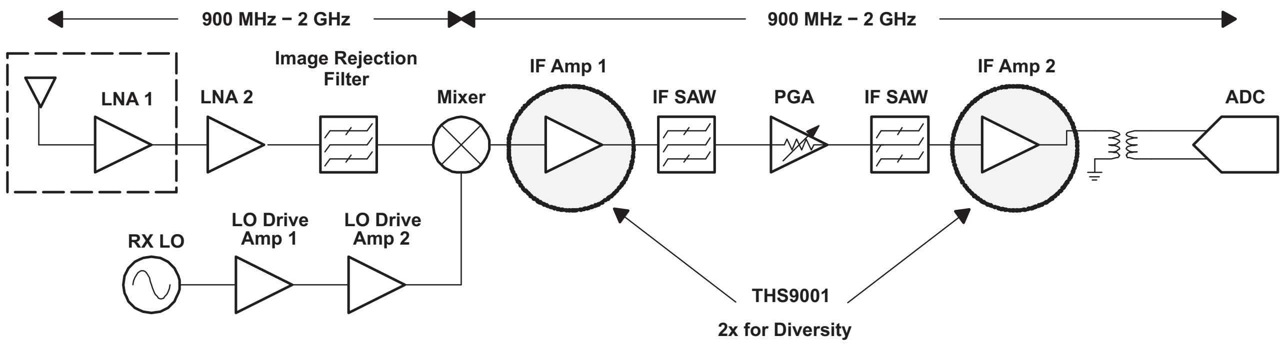


Figure 21. Example Single Conversion Receiver Architecture

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

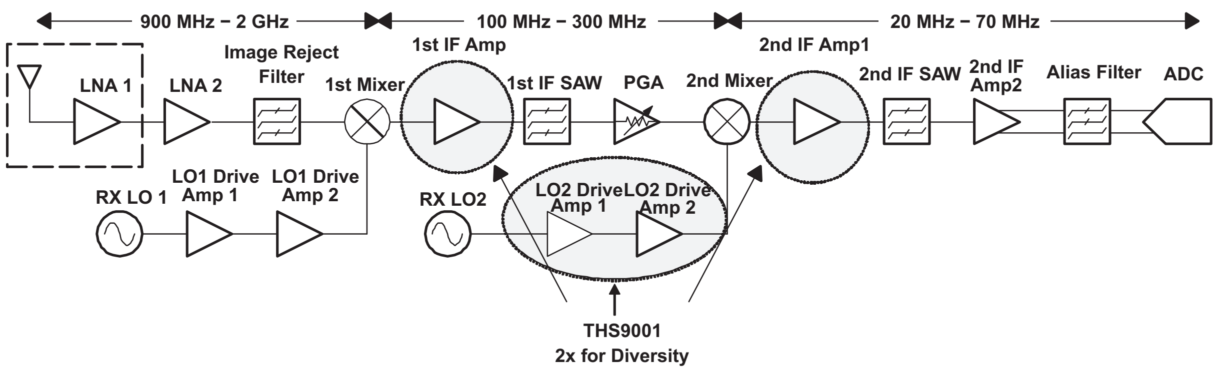


Figure 22. Example Dual Conversion Receiver Architecture

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

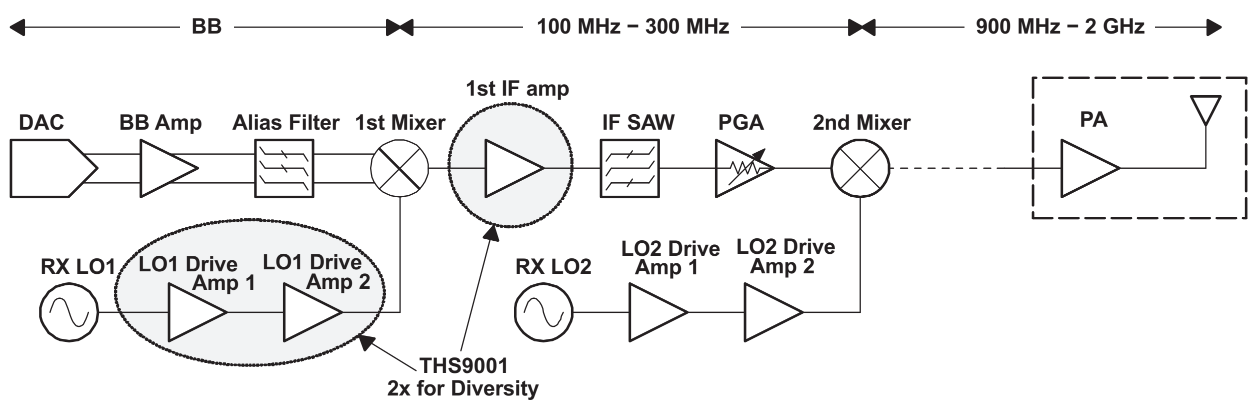


Figure 23. Example Dual Conversion Transmitter Architecture

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.

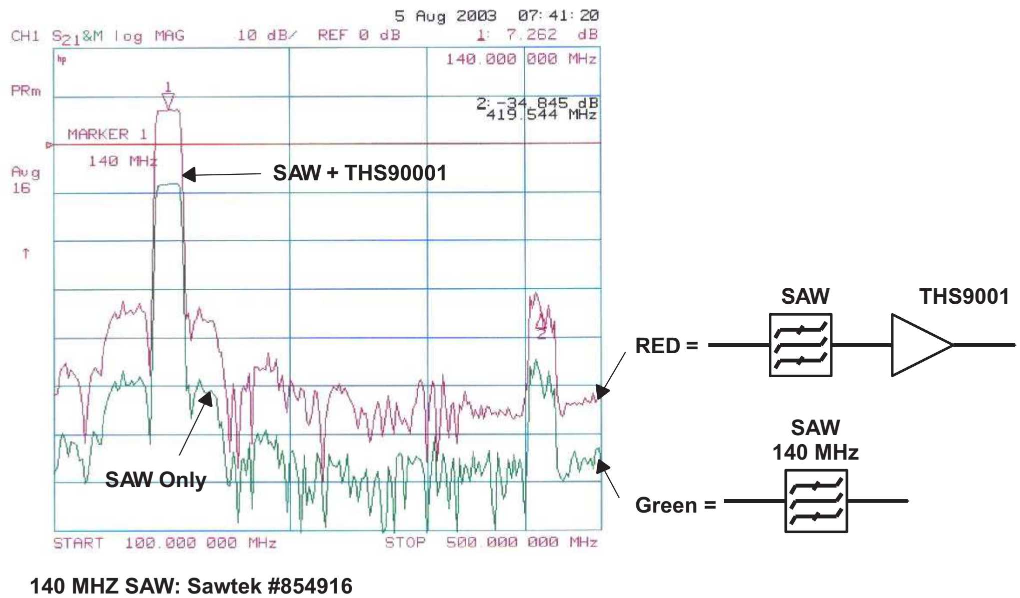


Figure 24. Frequency Response of the THS9000 and SAW Filter, and SAW Filter Only

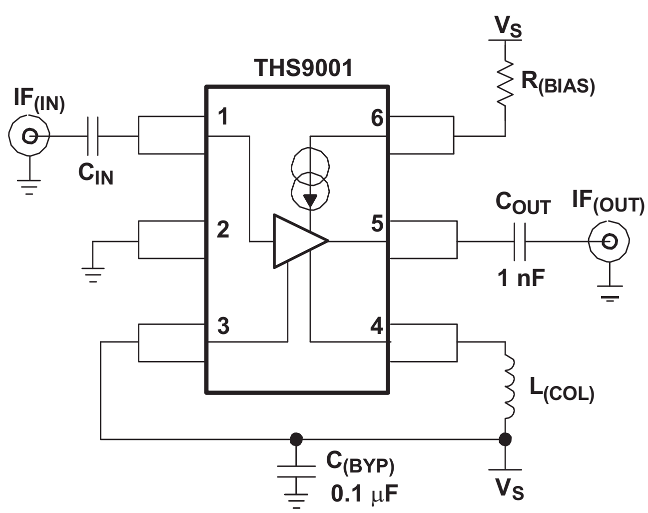


Figure 25. THS9000 Recommended Circuit (used for all tests)

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.

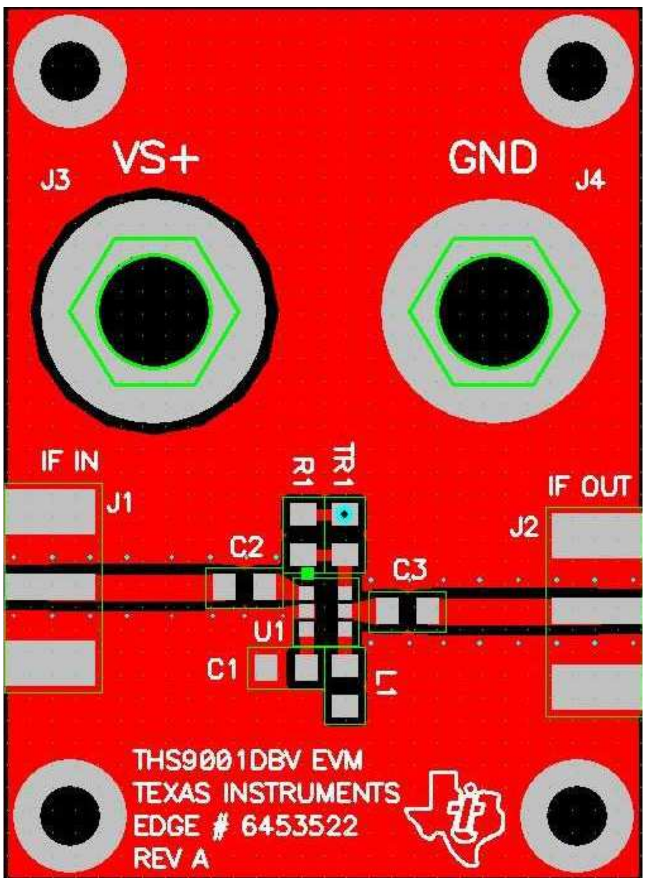


Figure 26. EVM Top Layout

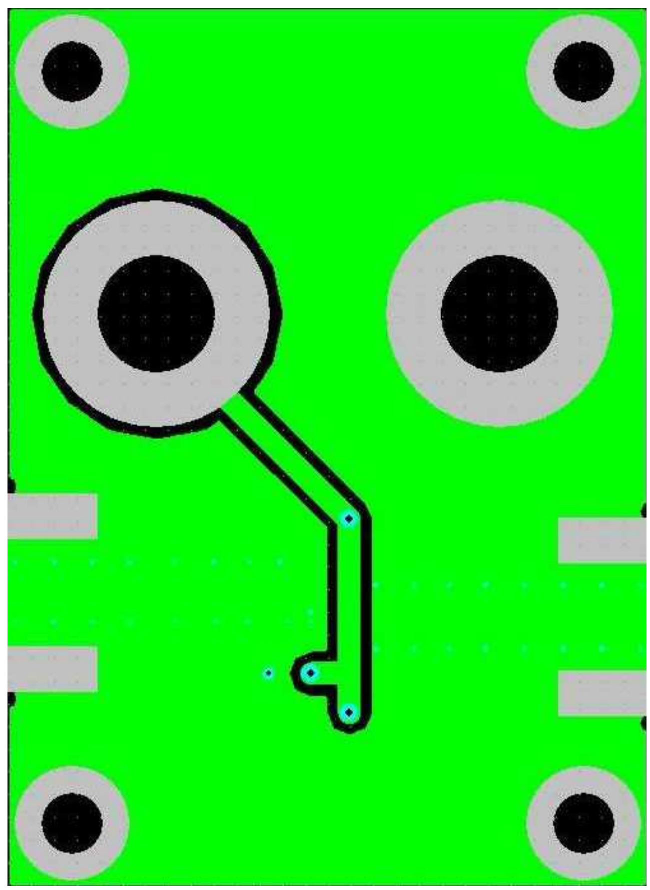


Figure 27. EVM Bottom Layout

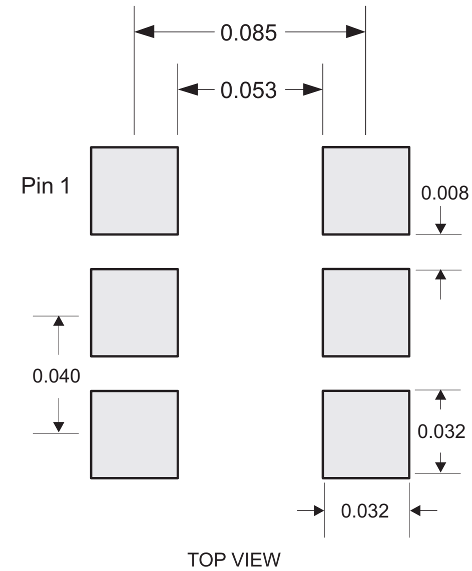


Figure 28. THS9000 Recommended Footprint dimensions are in inches (millimeters)

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 Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
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.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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

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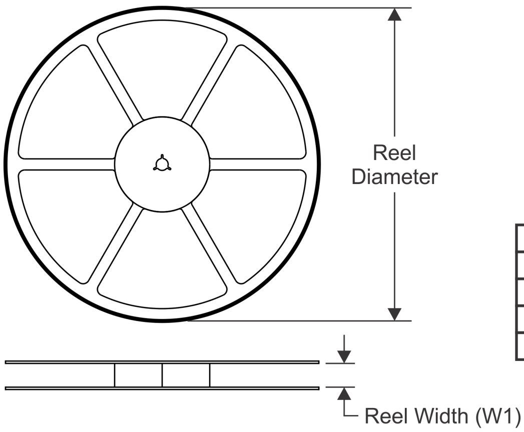
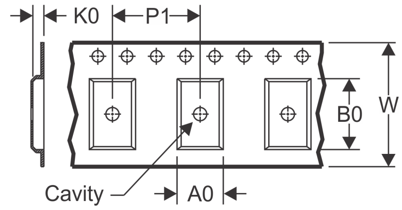
TAPE AND REEL INFORMATION

REEL DIMENSIONS

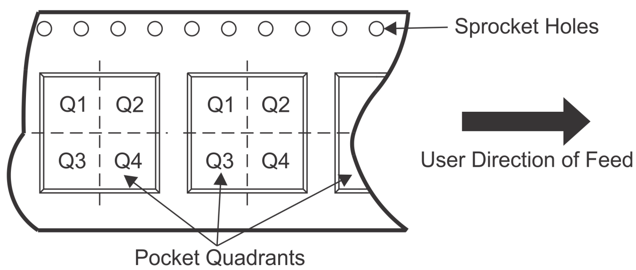


TAPE DIMENSIONS



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

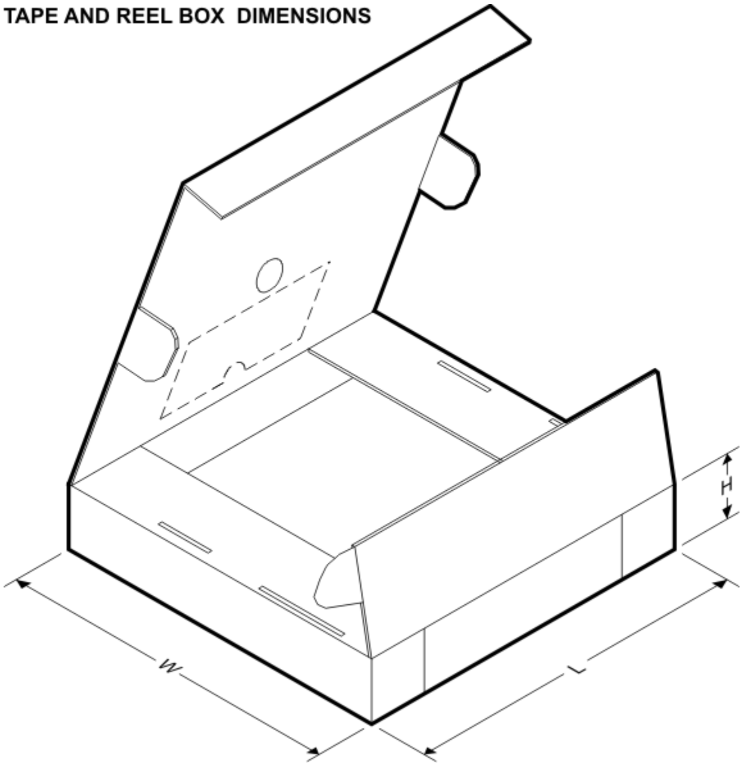
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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

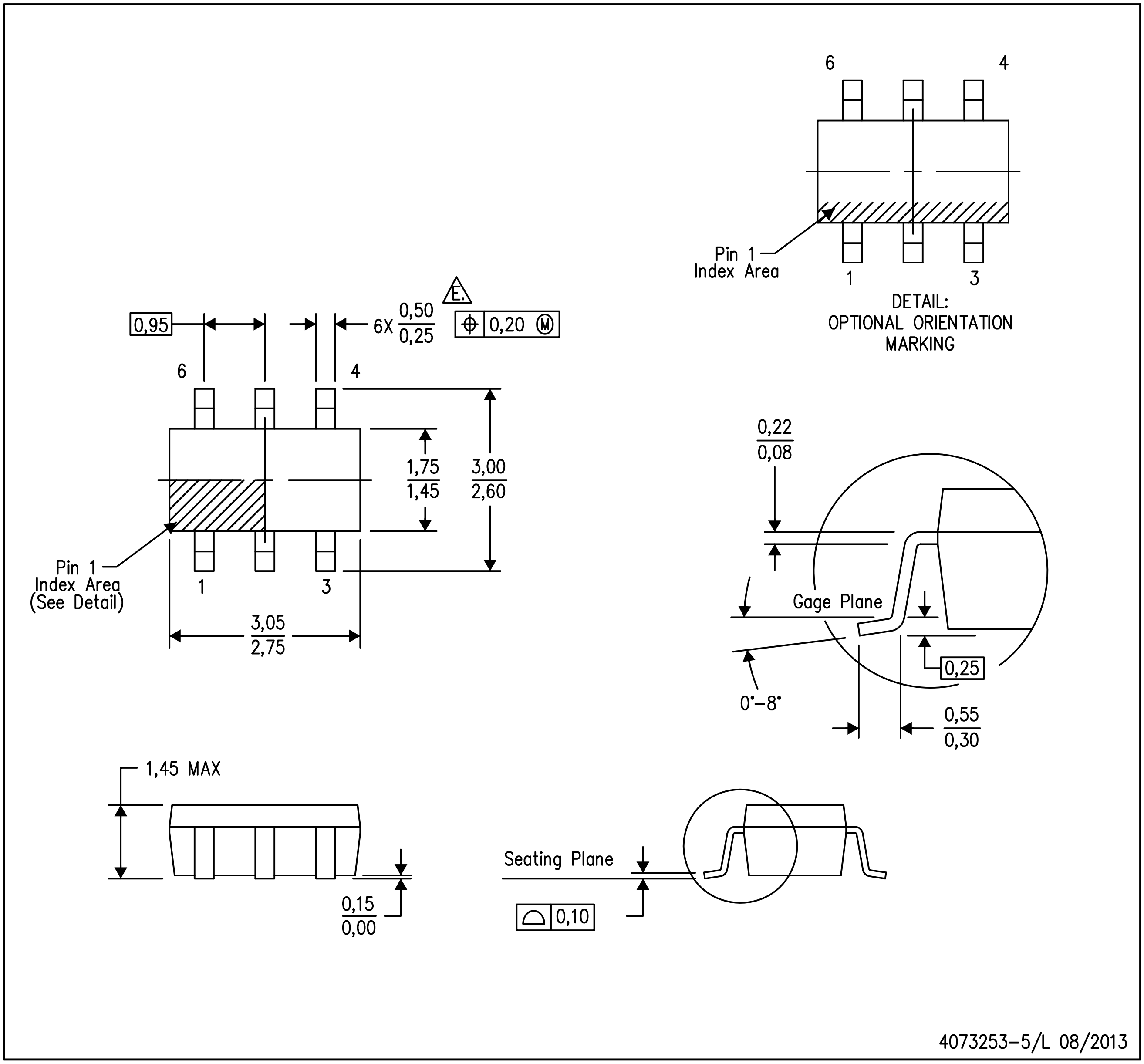
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

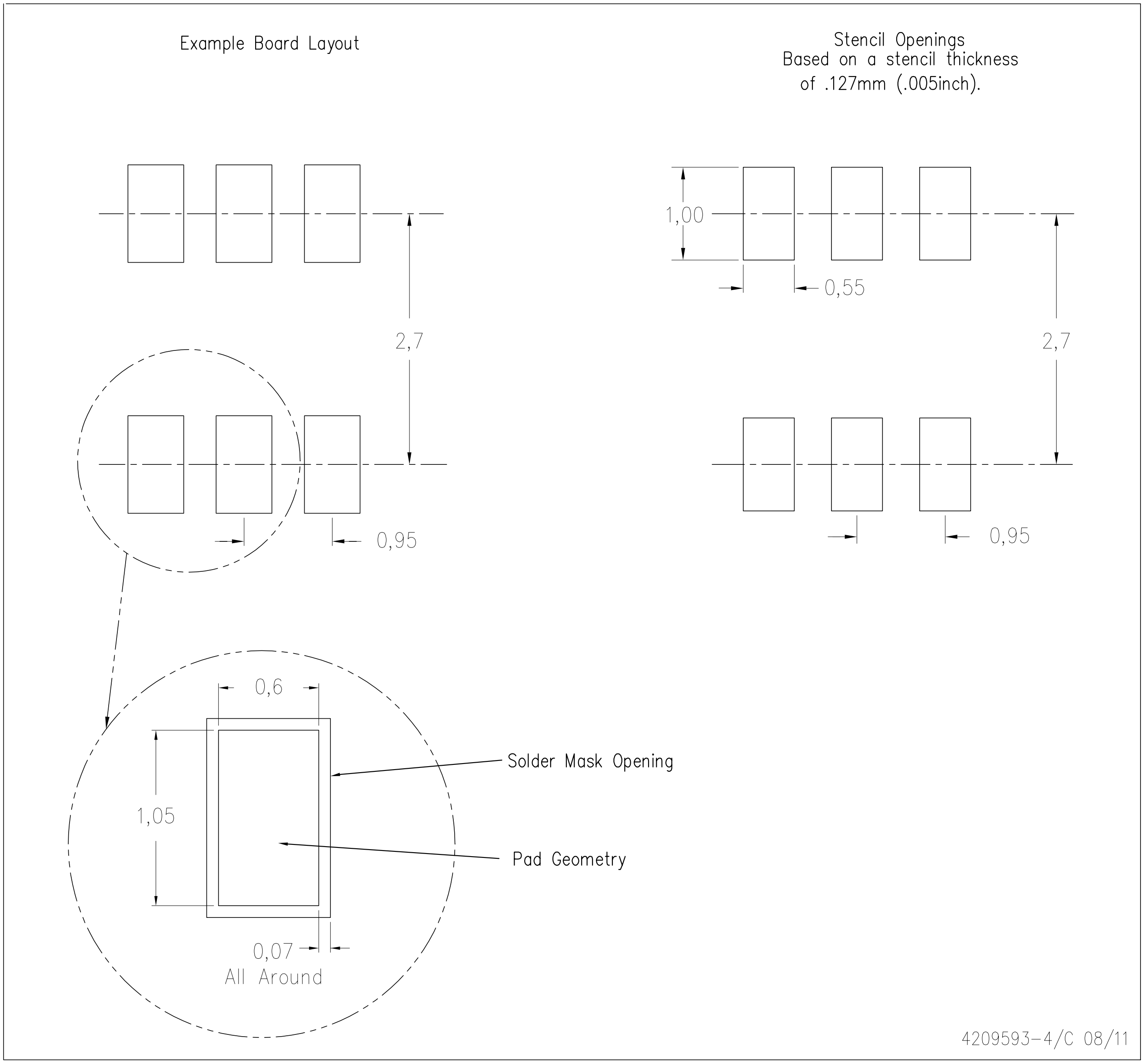
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
THS9001DBVT	SOT-23	DBV	6	250	182.0	182.0	20.0

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.
- E. 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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