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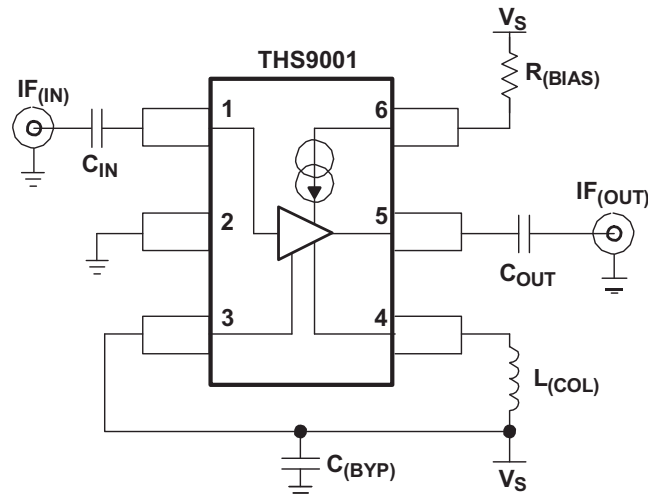
These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

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

Product Folder Links: *THS9001*

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
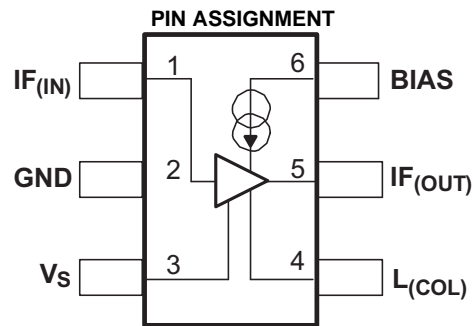
Terminal Functions

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
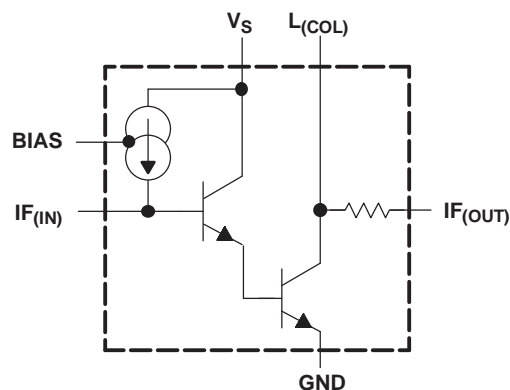
TABLE OF GRAPHS

			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

Product Folder Links: *THS9001*

![Texas Instruments logo] **TEXAS INSTRUMENTS**

THS9001

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.
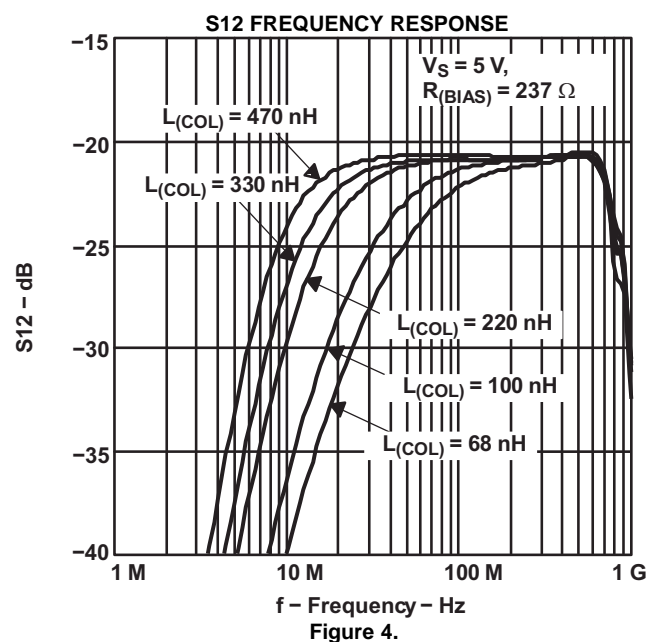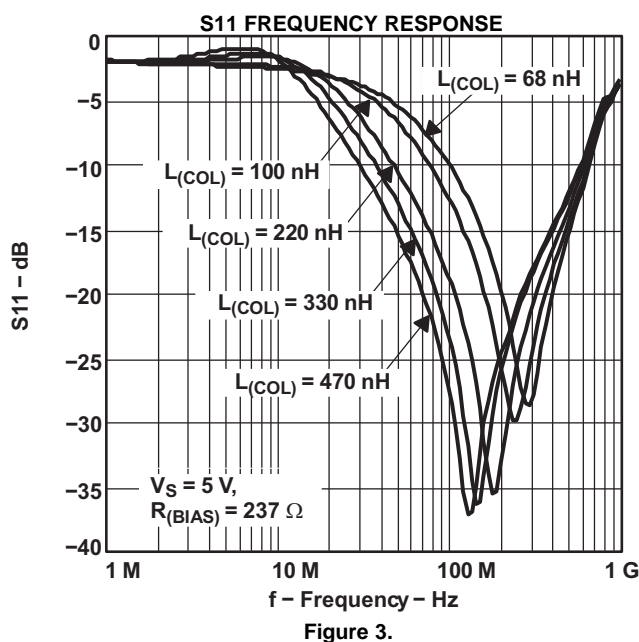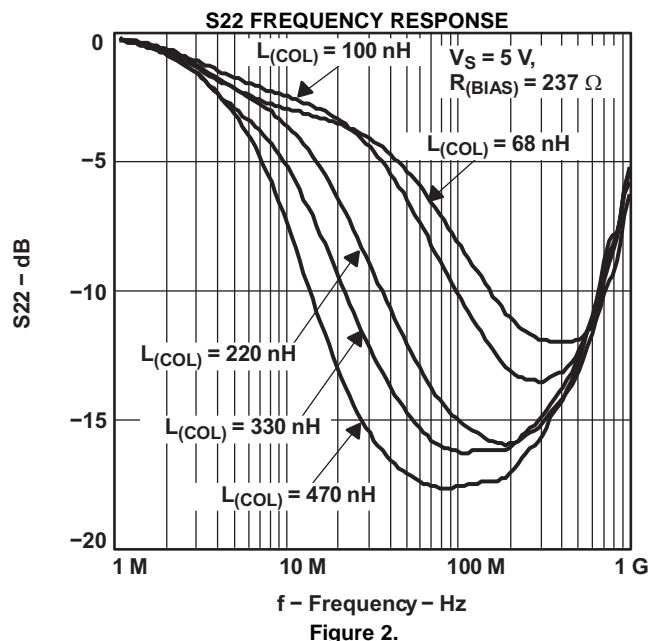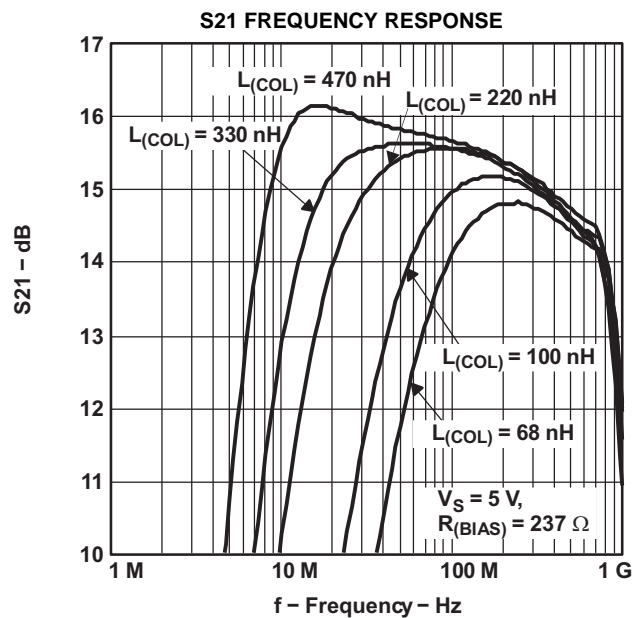
Figure 1.

Figure 2.

Figure 3.

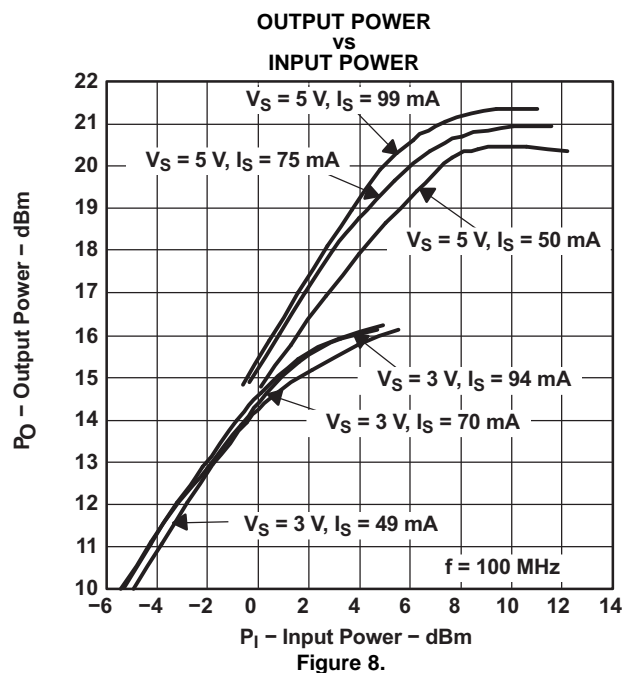Figure 4.

Product Folder Links: THS9001

TYPICAI 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.

S21
vs
R(BIAS)

Figure 5.

NOISE FIGURE
vs
FREQUENCY

Figure 6.

SUPPLY CURRENT
vs
R(BIAS)

Figure 7.

OUTPUT POWER
vs
INPUT POWER

Figure 8.

Product Folder Links: *THS9001*
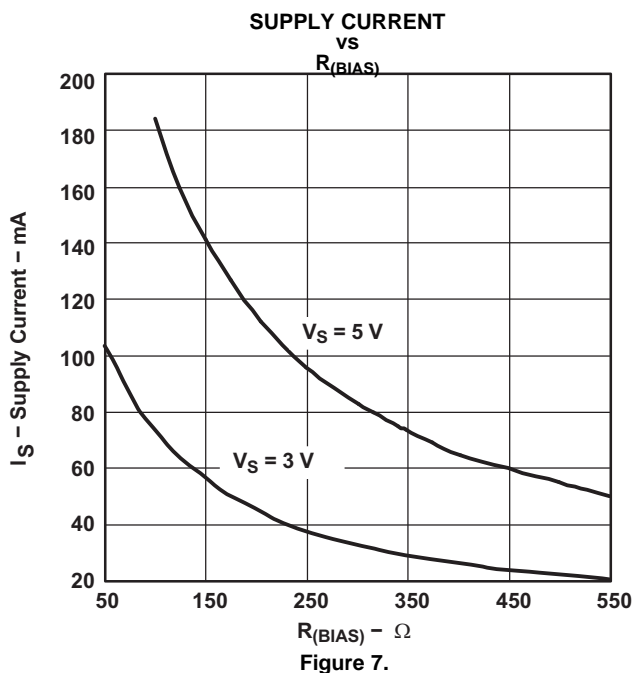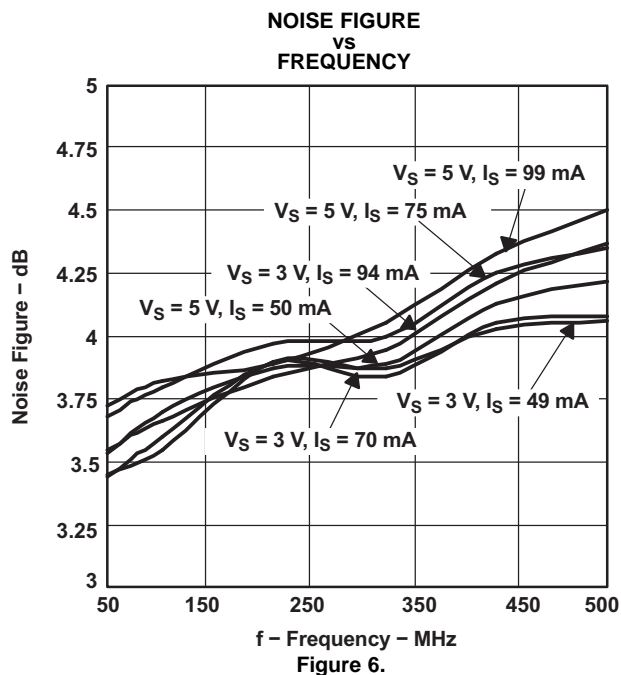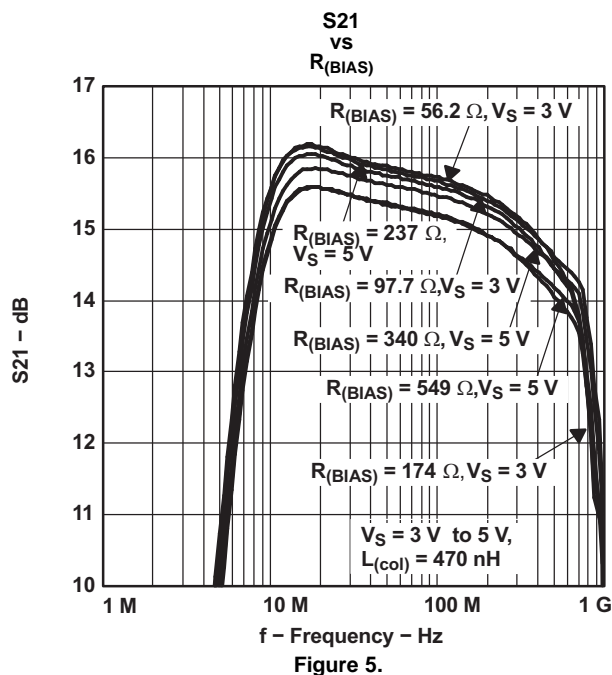
TYPICAl CHARACTERISTICS (continued)

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.

ADJACENT CHANNEL (ACPR) and ALTERNATE CHANNEL (AltCPR) PROTECTION RATIOS vs INPUT POWER
WCDM Modulation, f = 1.8432 MHz, PAR = 10.4 dB

Figure 9.

OIP$_2$ vs FREQUENCY

Figure 10.

OIP$_3$ vs FREQUENCY

Figure 11.

Submit Documentation Feedback   7

Product Folder Links: *THS9001*
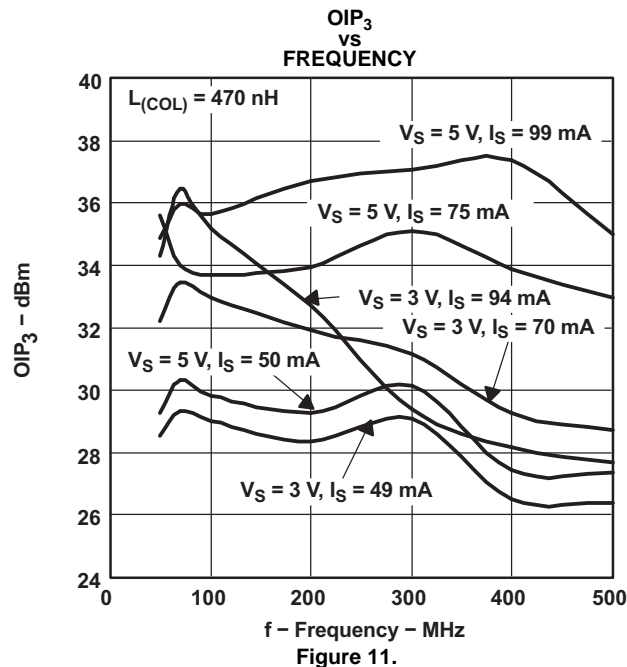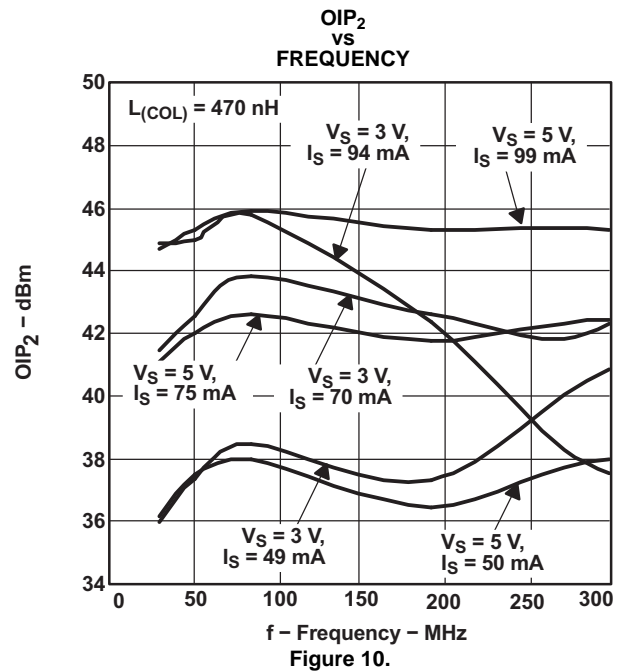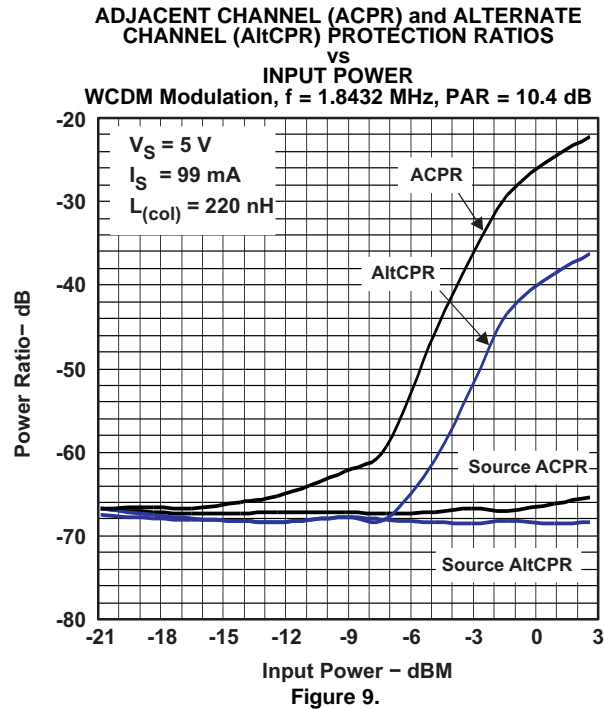
TYPICAL CHARACTERISTICS

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.

S21 FREQUENCY RESPONSE

Figure 12.

S22 FREQUENCY RESPONSE

Figure 13.

S11 FREQUENCY RESPONSE

Figure 14.

S12 FREQUENCY RESPONSE

Figure 15.

Product Folder Links: THS9001
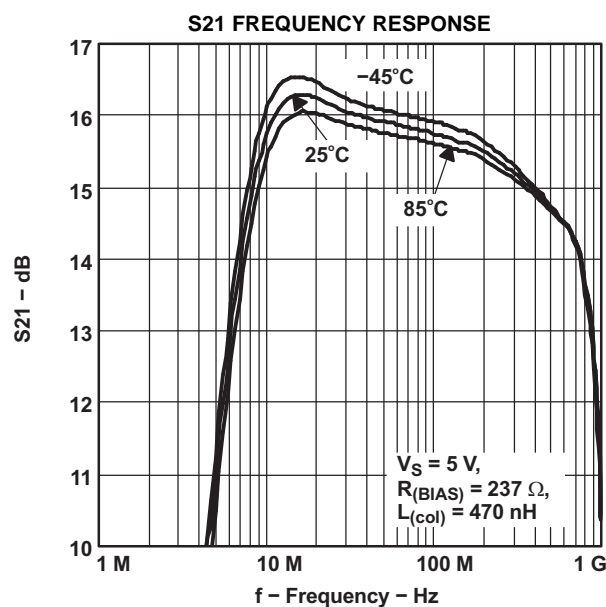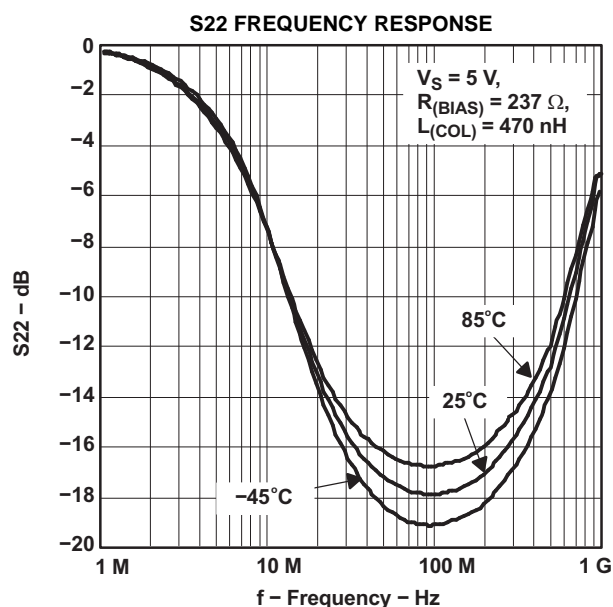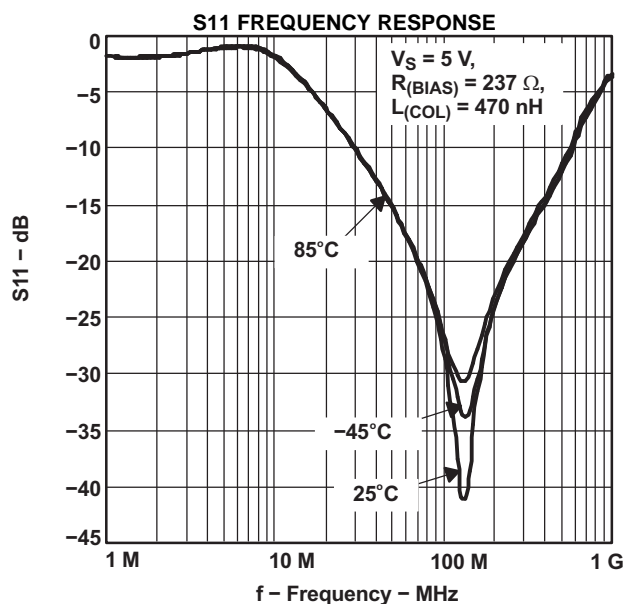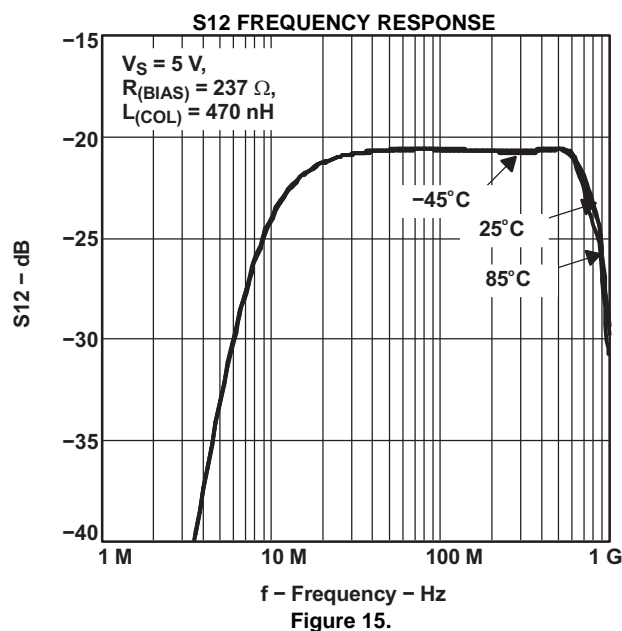
TYPICAL CHARACTERISTICS (continued)

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.

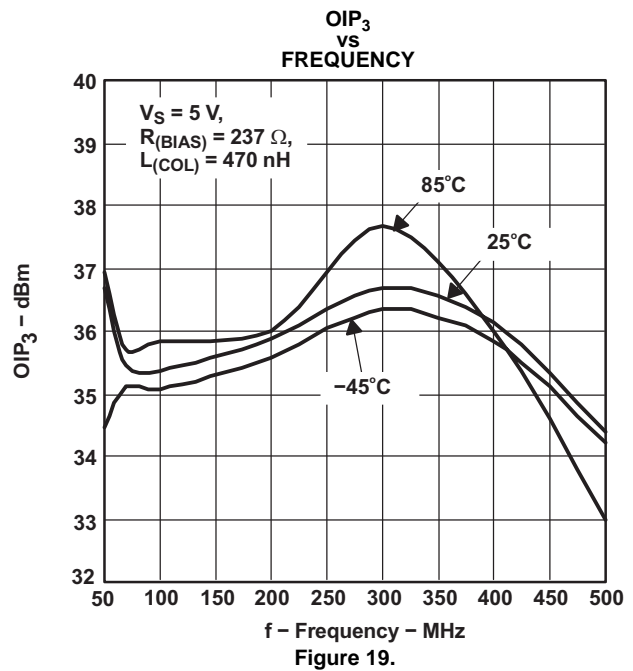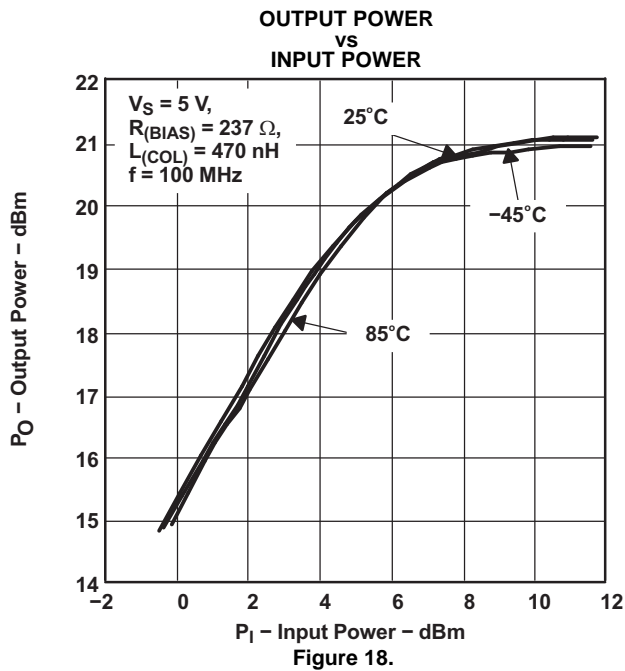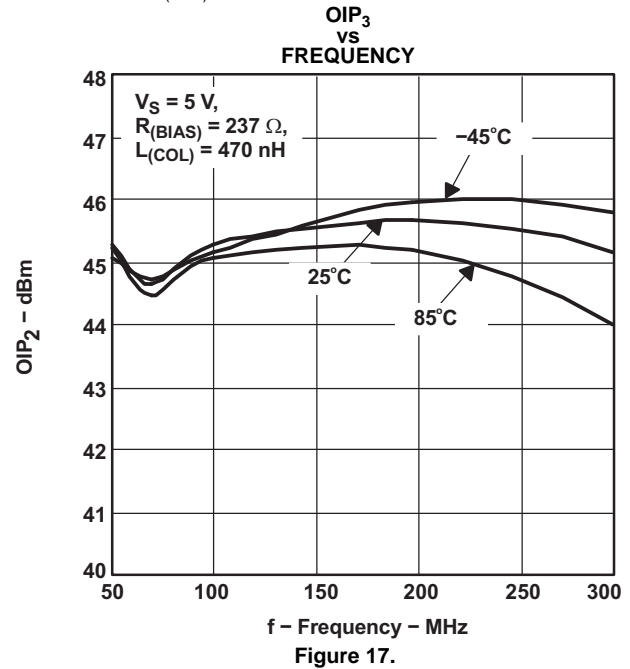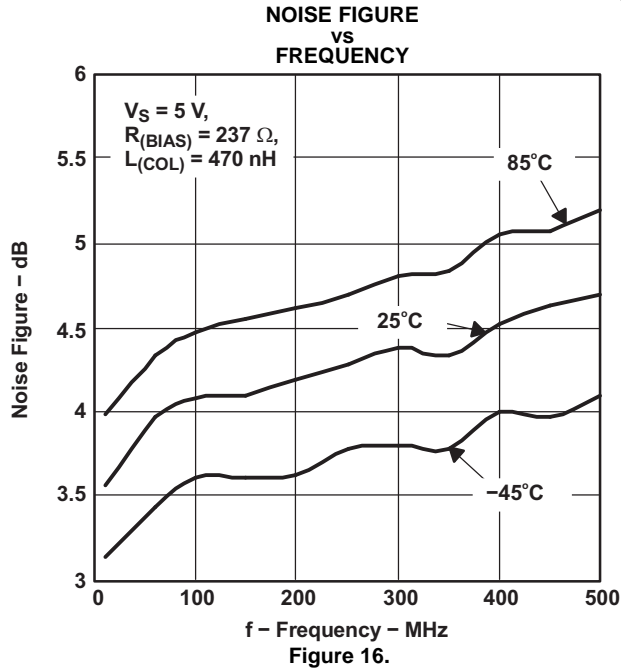**OIP$_3$ vs FREQUENCY**

Figure 17.

OUTPUT POWER vs INPUT POWER

Figure 18.

OIP$_3$ 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

Product Folder Links: *THS9001*

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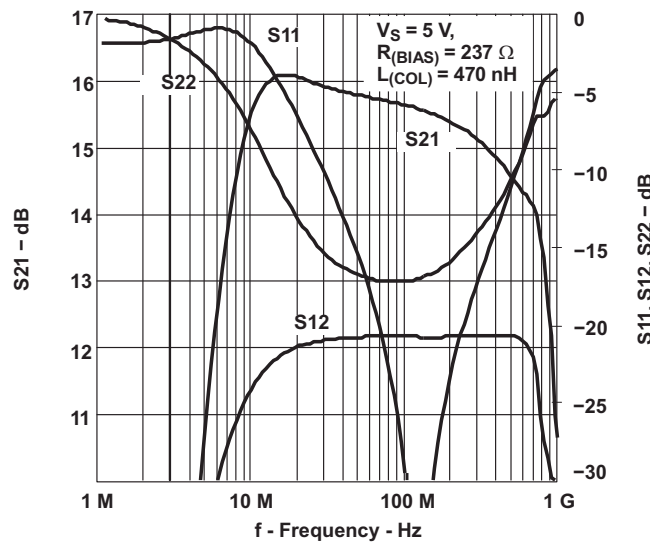
Figure 20. S-Parameters of THS9001 Mounted on the Standard EVM with V_S = 5 V, $R_{(BIAS)}$ = 237 Ω, and $L_{(COL)}$ = 470 nH

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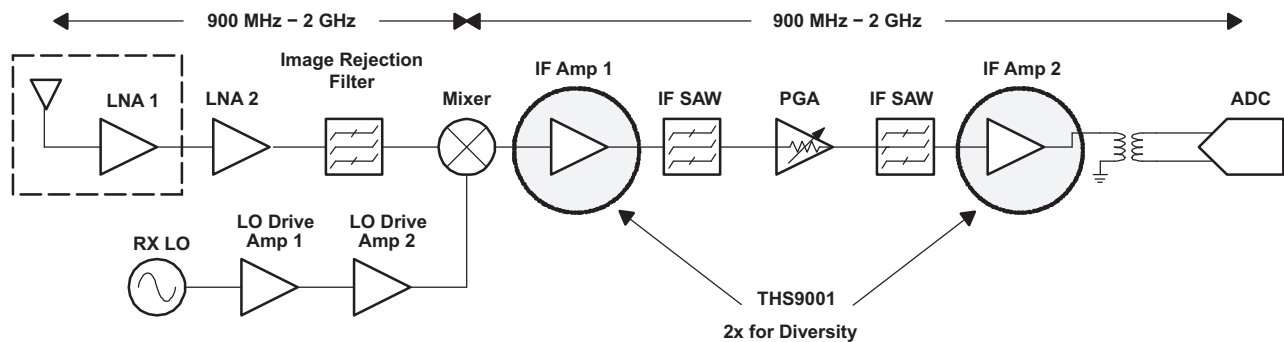
Figure 21. Example Single Conversion Receiver Architecture

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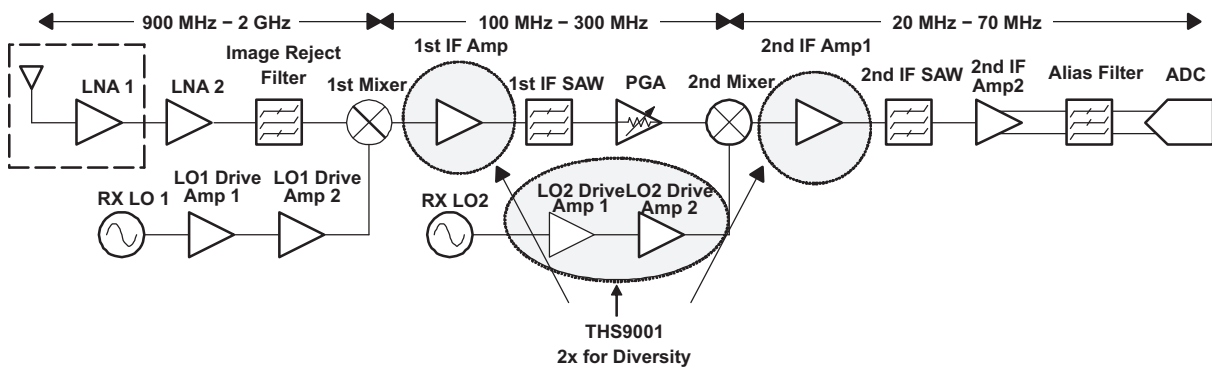
Figure 22. Example Dual Conversion Receiver Architecture

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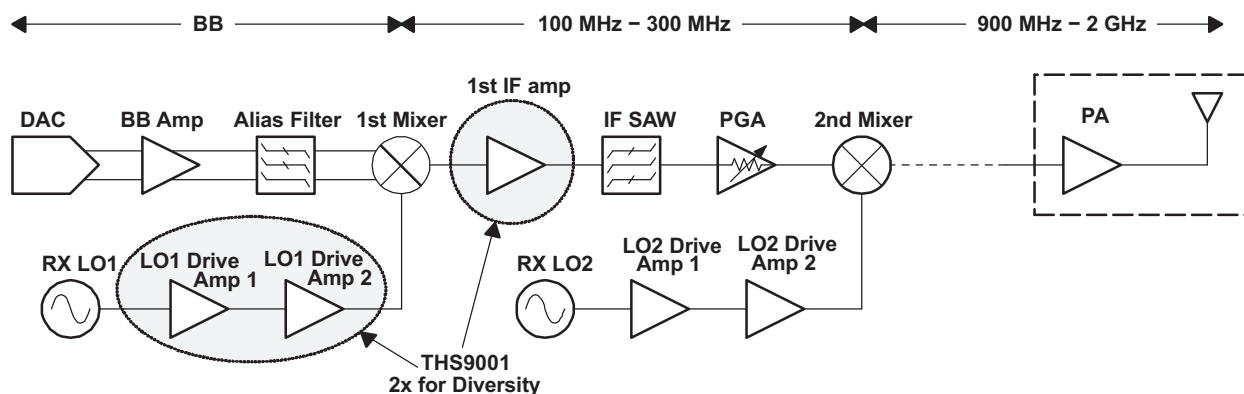
Figure 23. Example Dual Conversion Transmitter Architecture

Product Folder Links: *THS9001*

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.
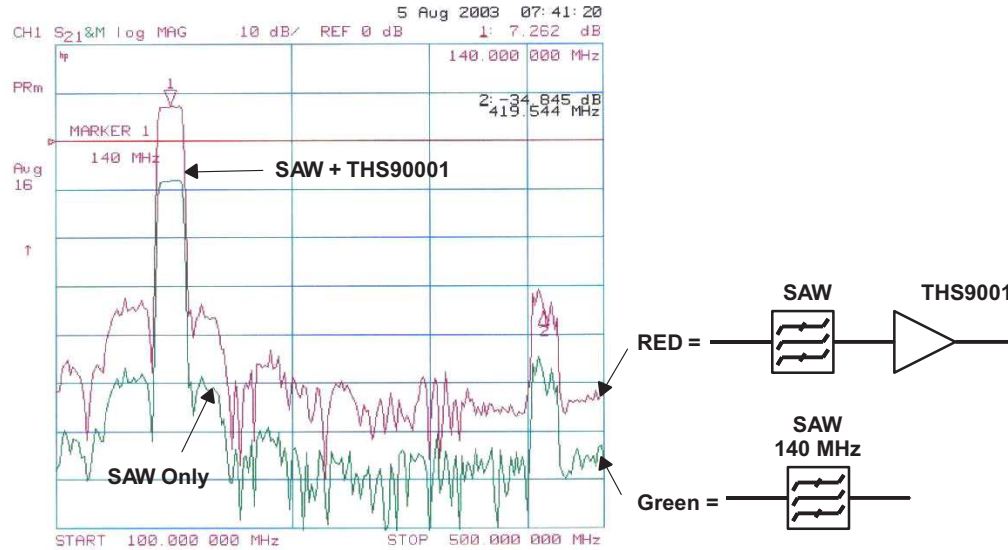
Figure 24. Frequency Response of the THS9000 and SAW Filter, and SAW Filter Only
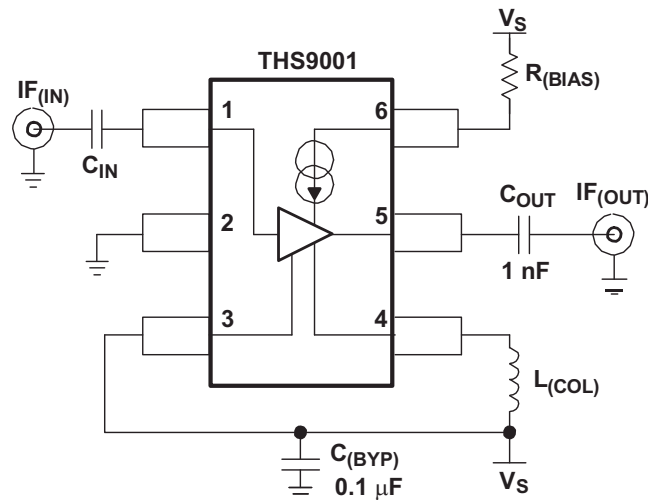
Figure 25. THS9000 Recommended Circuit (used for all tests)

Product Folder Links: *THS9001*

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.
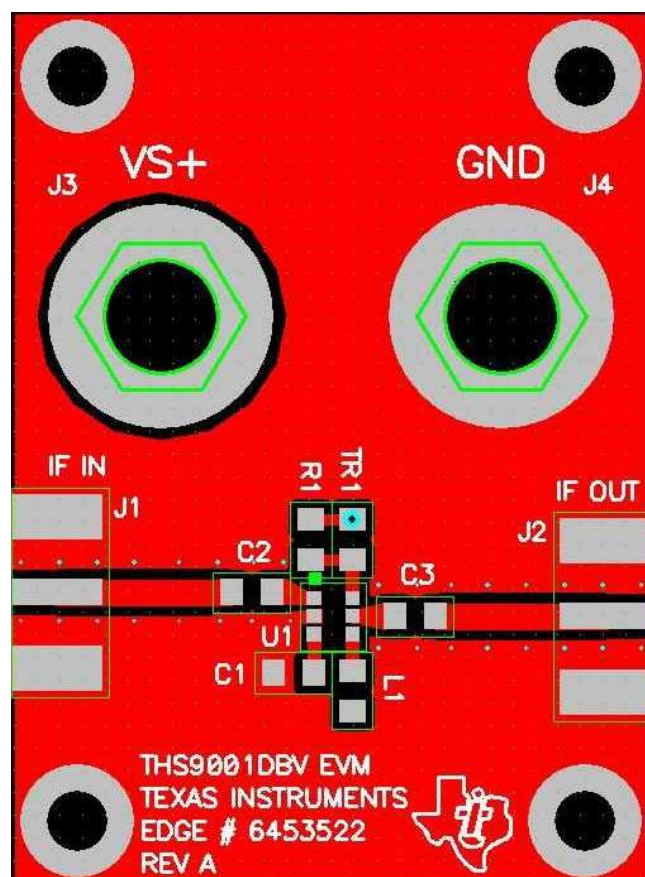
Figure 26. EVM Top Layout
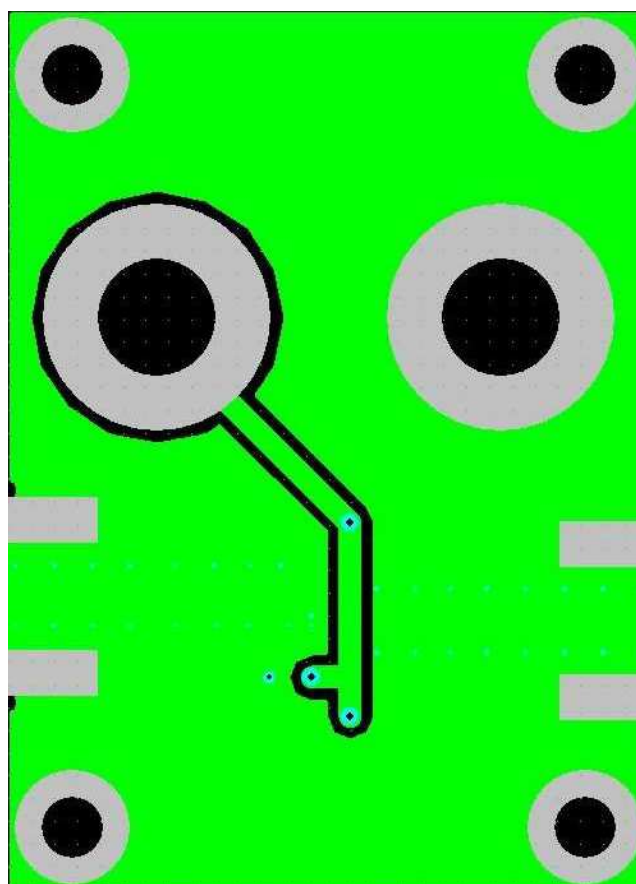
Figure 27. EVM Bottom Layout

Product Folder Links: THS9001
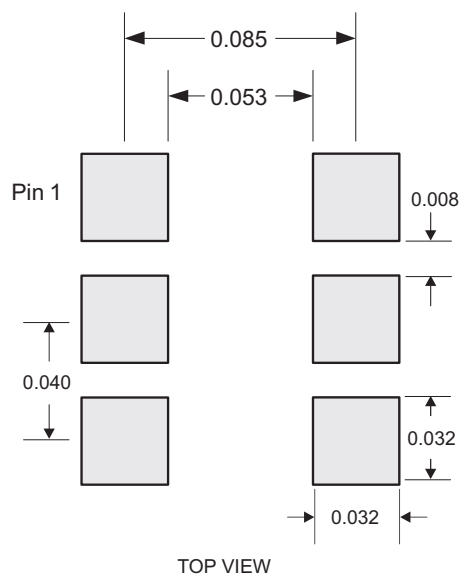
Figure 28. THS9000 Recommended Footprint dimensions are in inches (millimeters)

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

Product Folder Links: *THS9001*

![Texas Instruments logo]

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

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(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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PACKAGE MATERIALS INFORMATION

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

3.0
2.6

1.75
1.45

B

A

PIN 1
INDEX AREA

1

2X 0.95

1.9

2

6X 0.50
0.25

3

⊕ 0.2 Ⓜ C A B

6

5

4

3.05
2.75

C

⌒ 0.1 C

1.45 MAX

(1.1)

0.15 TYP
0.00

0.25

GAGE PLANE

0.22 TYP
0.08

8°
0° TYP

0.6 TYP
0.3

SEATING PLANE

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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 0.15 per side.
4. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
5. Refernce JEDEC MO-178.

TEXAS INSTRUMENTS

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6X (1.1)

PKG ℄

1

6X (0.6)

6

2X (0.95)

2

SYMM ℄

5

3

4

(R0.05) TYP

(2.6)

LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X

SOLDER MASK
OPENING

METAL

EXPOSED METAL

0.07 MAX
ARROUND

NON SOLDER MASK
DEFINED
(PREFERRED)

METAL UNDER
SOLDER MASK

SOLDER MASK
OPENING

EXPOSED METAL

0.07 MIN
ARROUND

SOLDER MASK
DEFINED
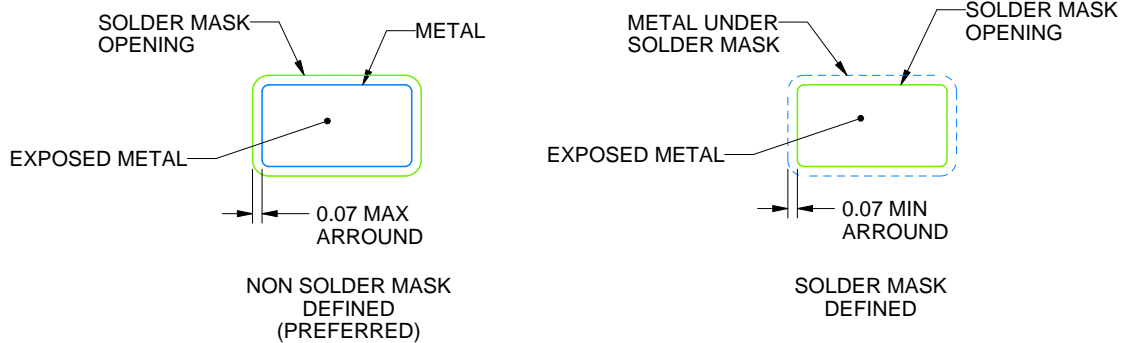
SOLDER MASK DETAILS

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NOTES: (continued)

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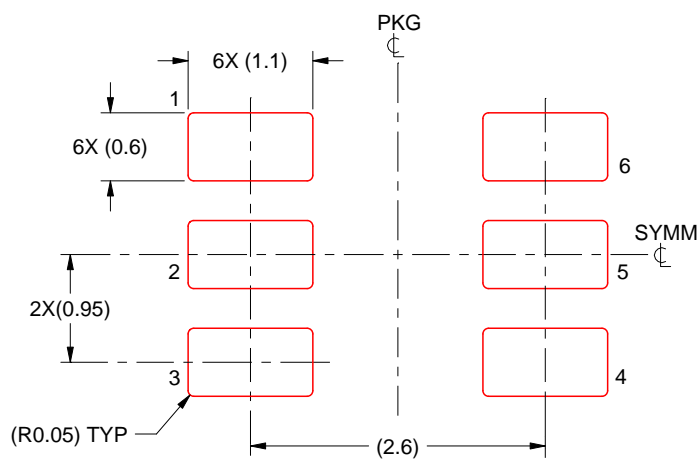7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

PKG

6X (1.1)

1

6X (0.6)

6

2

SYMM

5

2X(0.95)

3

4

(R0.05) TYP

(2.6)

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

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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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