



## 50 MHz to 350 MHz CASCADEABLE AMPLIFIER

### 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
  - $50 \Omega$

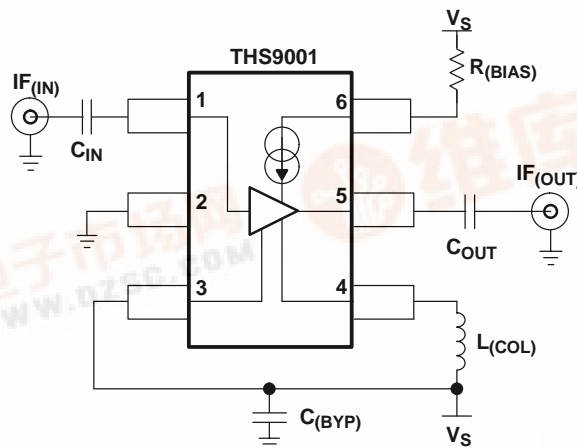
### APPLICATIONS

- IF Amplifier
  - TDMA: GSM, IS-136, EDGE/UWE-136
  - CDMA: 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





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 | PACKAGE TYPE | TRANSPORT MEDIA, QUANTITY |
|------------------|--------------|---------------------------|
| THS9001DBVT      | SOT-23-6     | Tape and Reel, 250        |
| THS9001DBVR      |              | Tape and Reel, 3000       |

**ABSOLUTE MAXIMUM RATINGS**

over operating free-air temperature (unless otherwise noted)<sup>(1)</sup>

|  | UNIT                          |      |
|--|-------------------------------|------|
| Supply voltage, GND to V <sub>S</sub>  | 5.5 V                         |      |
| Input voltage  | GND to V <sub>S</sub>         |      |
| Continuous power dissipation   | See Dissipation Ratings Table |      |
| Maximum junction temperature, T <sub>J</sub>   | 150°C                         |      |
| Maximum junction temperature, continuous operation, long term reliability, T <sub>J</sub> <sup>(2)</sup> | 125°C                         |      |
| Storage temperature, T <sub>stg</sub>  | -65°C to 150°C                |      |
| Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds   | 300°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 <sub>JC</sub><br>(°C/W) | Θ <sub>JA</sub><br>(°C/W) | POWER RATING <sup>(1)</sup> |                       |
|--------------------|---------------------------|---------------------------|-----------------------------|-----------------------|
|                    |                           |                           | T <sub>A</sub> ≤ 25°C       | T <sub>A</sub> = 85°C |
| DBV <sup>(2)</sup> | 70.1                      | 216                       | 463 mW                      | 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.

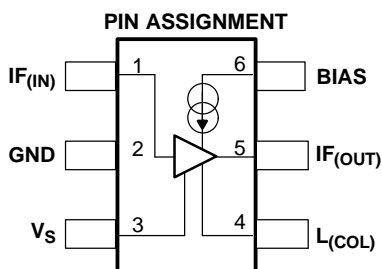
**RECOMMENDED OPERATING CONDITIONS**

|  | MIN | NOM | MAX | UNIT |
|--|-----|-----|-----|------|
| Supply voltage                                 | 2.7 |     | 5   | V    |
| Operating free-air temperature, T <sub>A</sub> | -40 |     | 85  | °C   |
| Supply current                                 |     | 100 |     | mA   |

**ELECTRICAL CHARACTERISTICS**

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

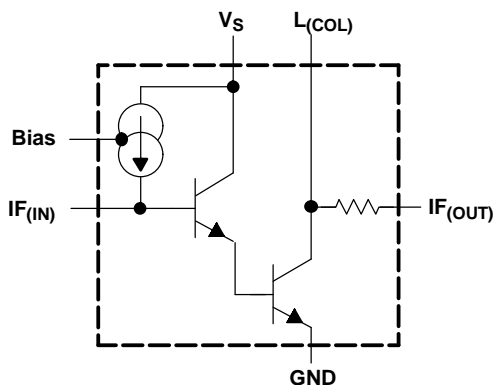
| PARAMETER          | TEST CONDITIONS | MIN | TYP  | MAX | UNITS |
|--------------------|-----------------|-----|------|-----|-------|
| Gain               | f = 50 MHz      |     | 15.8 |     | dB    |
|                    | f = 350 MHz     |     | 15.0 |     |       |
| OIP <sub>3</sub>   | f = 50 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    |     |       |



**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 $R_{(Bias)}$                  | 5      |
| Output power vs Input power          | 6      |
| OIP <sub>2</sub> vs Frequency        | 7      |
| Noise figure vs Frequency            | 8      |
| OIP <sub>3</sub> vs Frequency        | 9      |
| $I_S$ Supply current vs $R_{(Bias)}$ | 10     |
| S21 Frequency response               | 11     |
| S22 Frequency response               | 12     |
| S11 Frequency response               | 13     |
| S12 Frequency response               | 14     |
| Noise figure vs Frequency            | 15     |
| OIP <sub>2</sub> vs Frequency        | 16     |
| Output power vs Input power          | 17     |
| OIP <sub>3</sub> vs Frequency        | 18     |

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

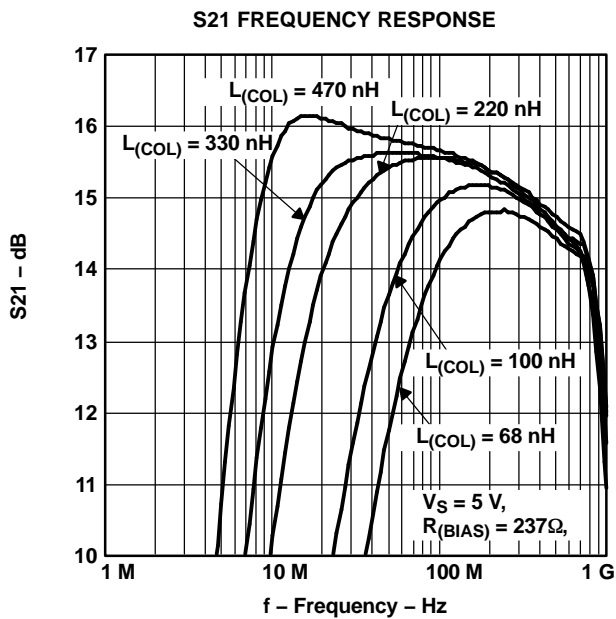


Figure 1.

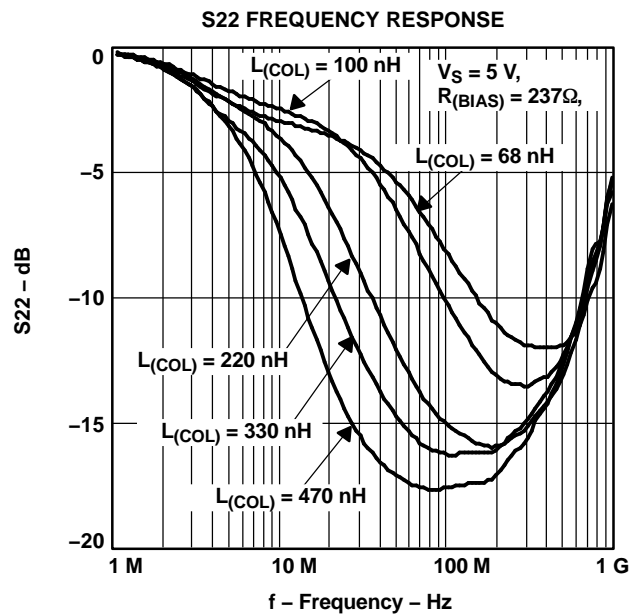


Figure 2.

**TYPICAL CHARACTERISTICS (continued)**

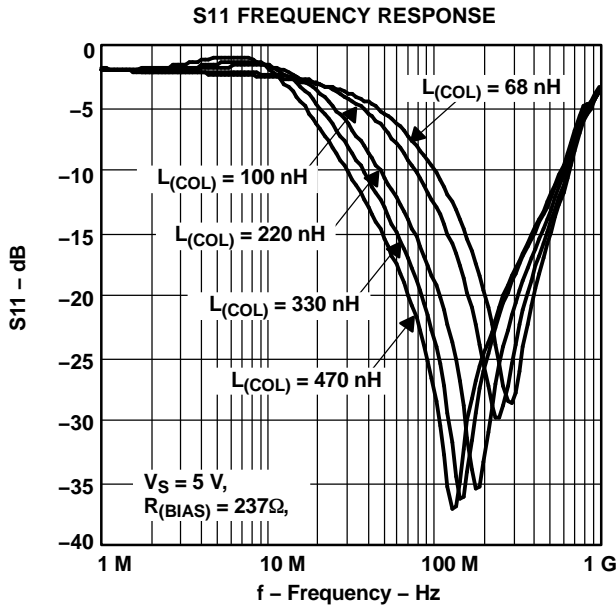


Figure 3.

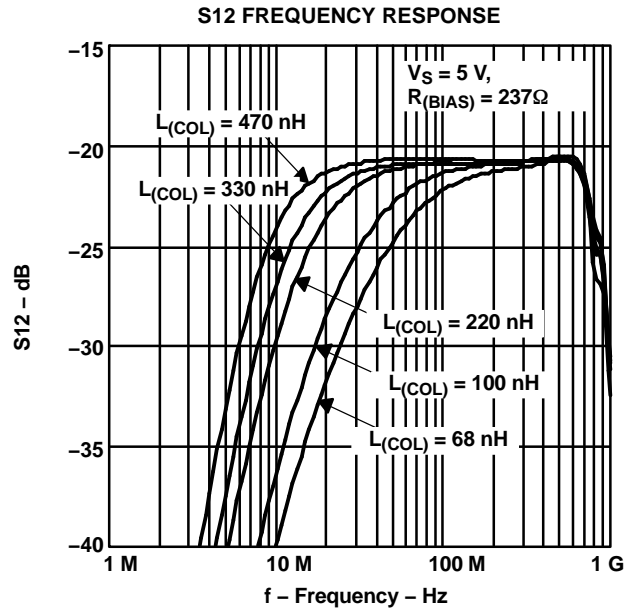


Figure 4.

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

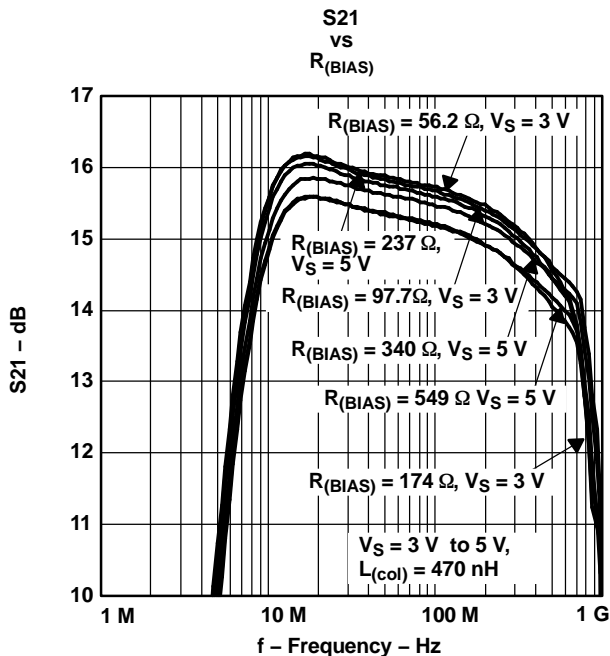


Figure 5.

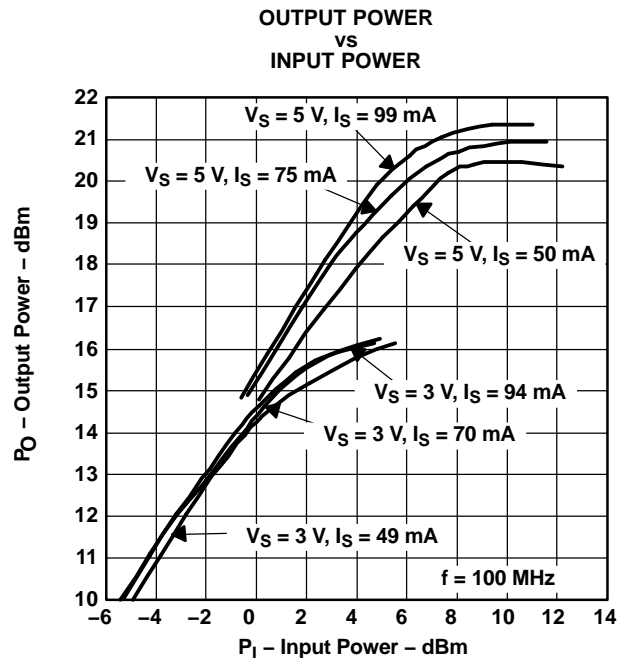


Figure 6.

TYPICAL CHARACTERISTICS (continued)

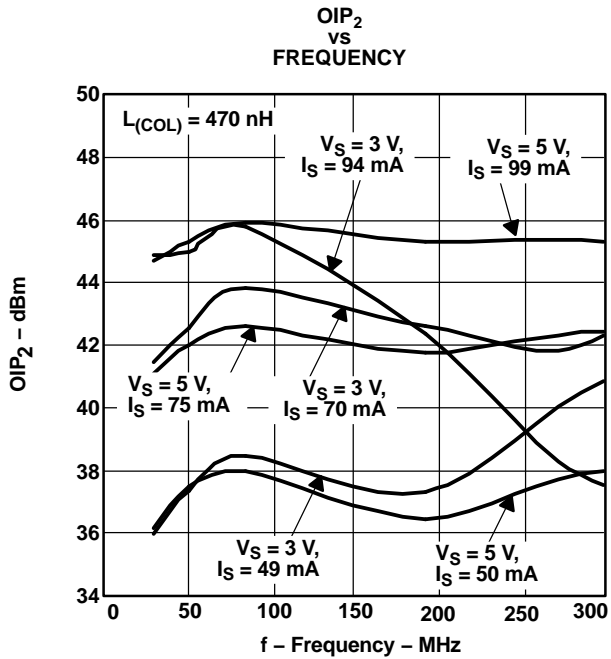


Figure 7.

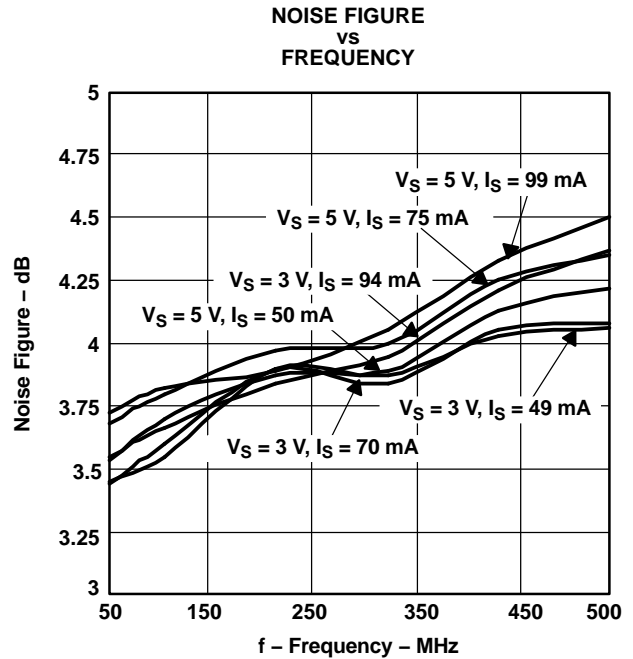


Figure 8.

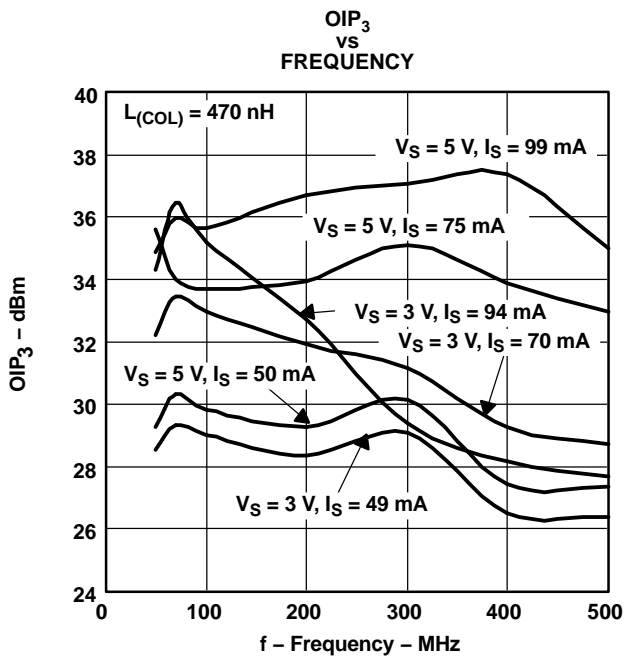


Figure 9.

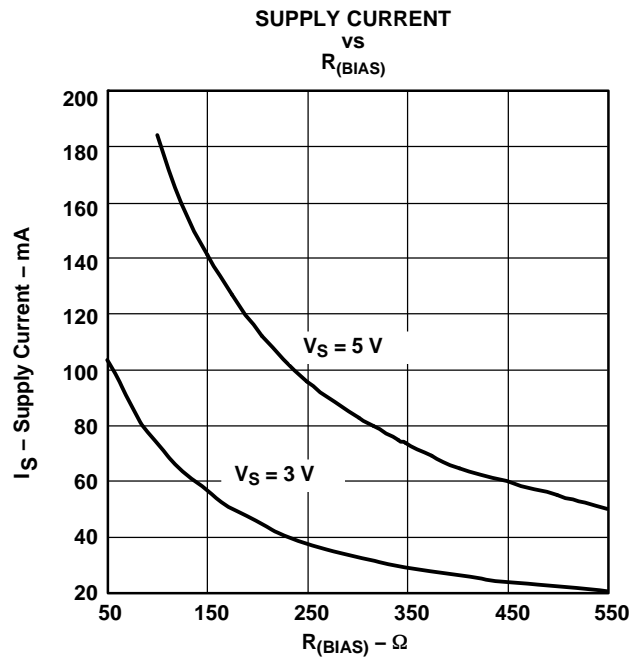


Figure 10.

**TYPICAL CHARACTERISTICS (continued)**

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

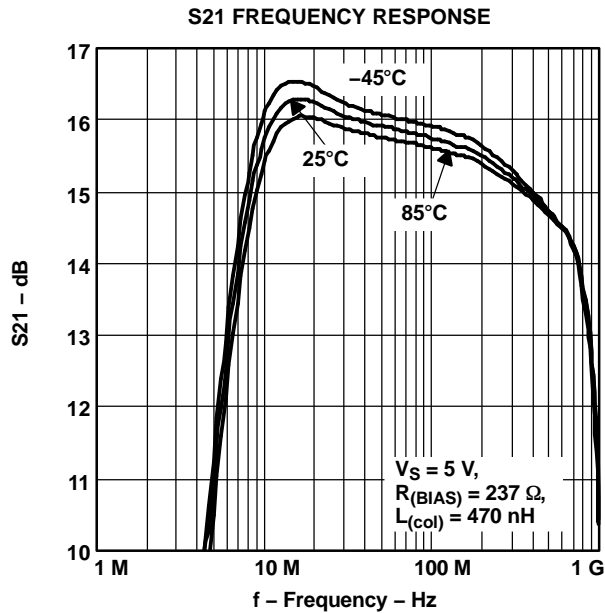


Figure 11.

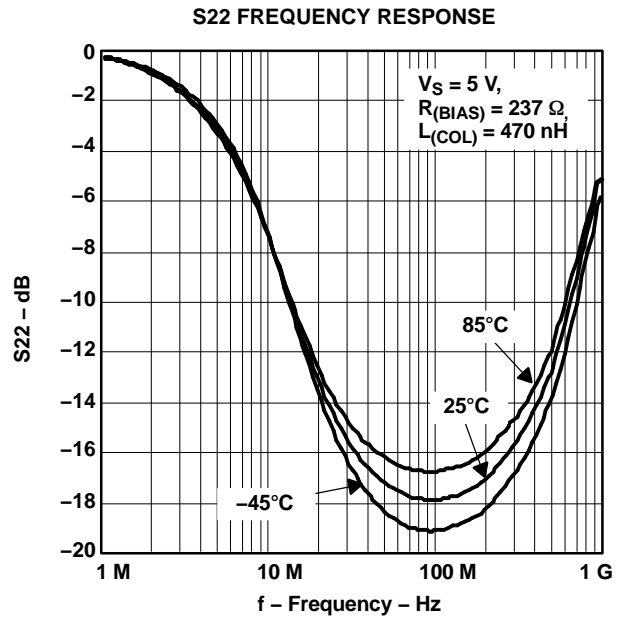


Figure 12.

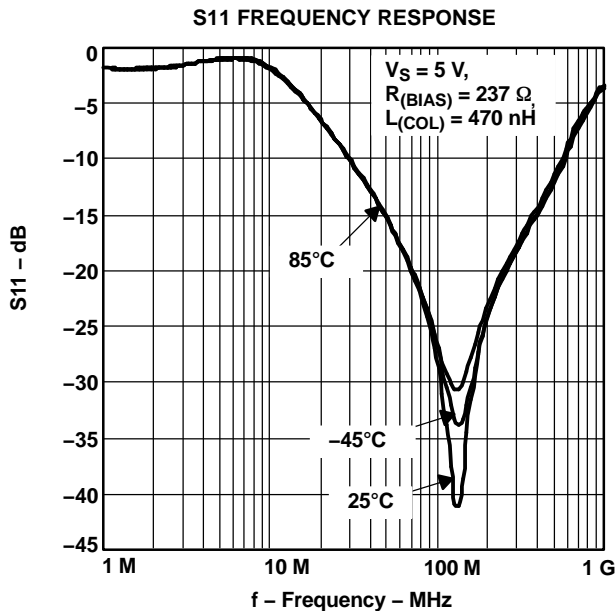


Figure 13.

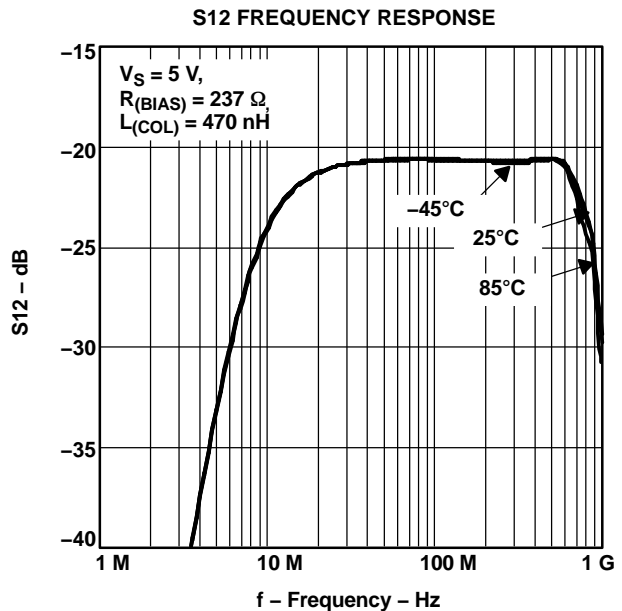


Figure 14.

TYPICAL CHARACTERISTICS (continued)

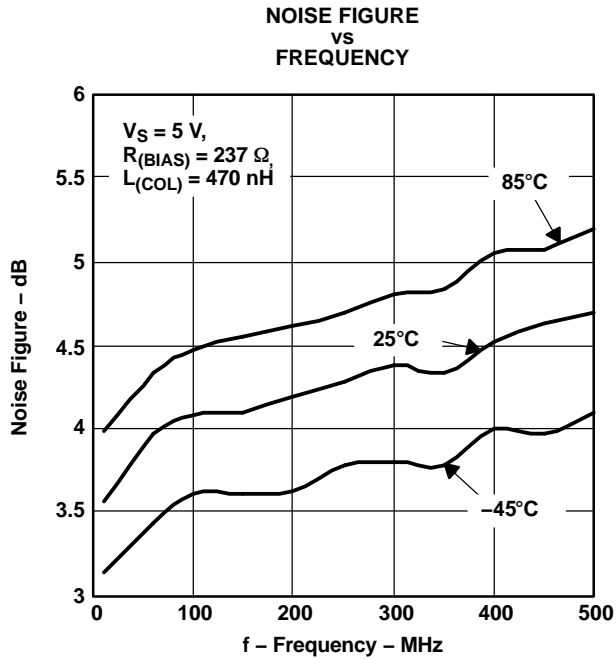


Figure 15.

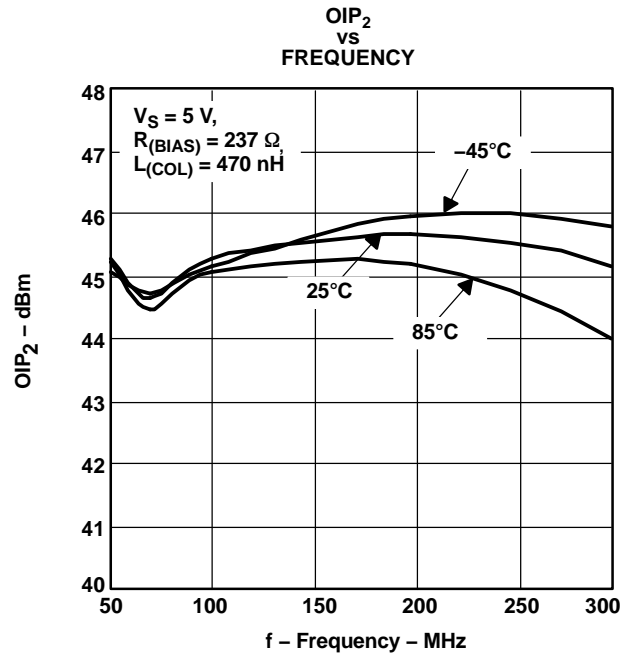


Figure 16.

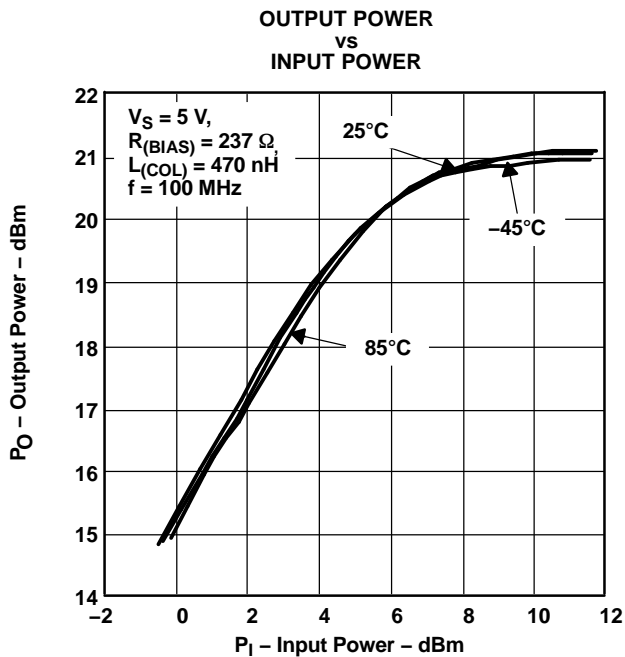


Figure 17.

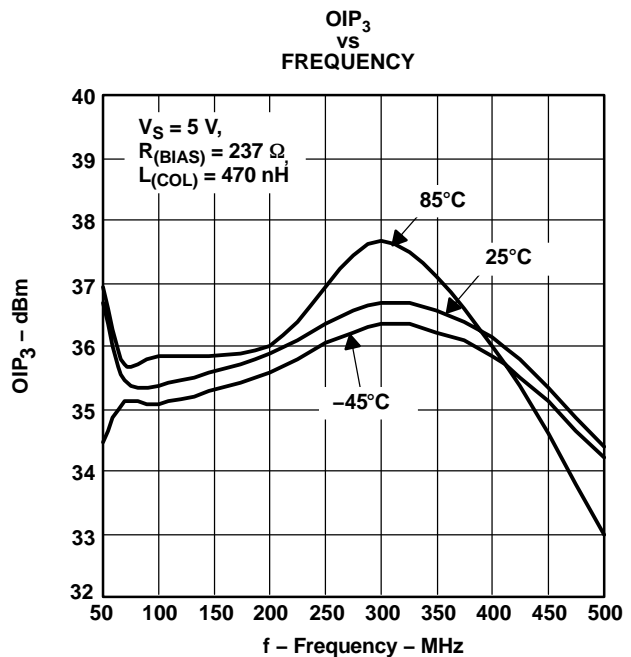


Figure 18.



**TYPICAL CHARACTERISTICS**
**S-Parameters Tables of THS9001 with EVM De-Embedded**

| $V_S = 5\text{ V}$ , $R_{(\text{BIAS})} = 237\ \Omega$ , $L_{(\text{COL})} = 470\text{ nH}$ |           |             |           |             |           |             |           |             |
|---|-----------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|
| Frequency<br>(MHz)  | S21       |             | S11       |             | S22       |             | S12       |             |
|   | 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 24 for circuit diagram.

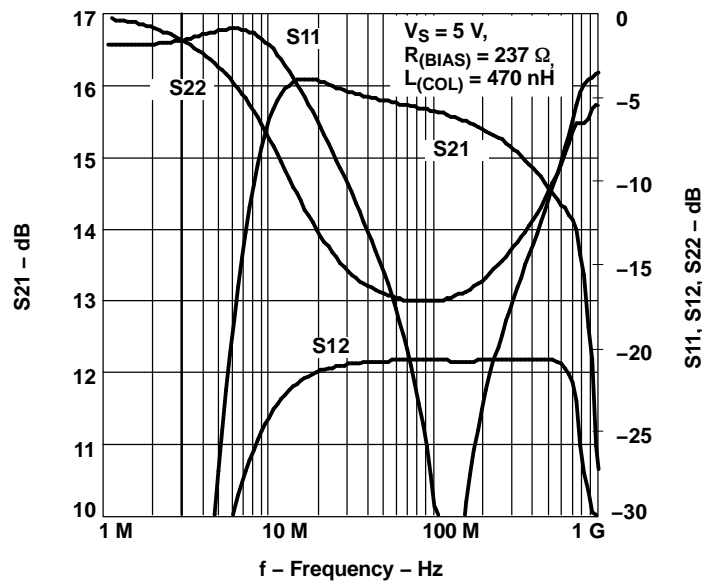
The THS9001 operates with a power supply voltage ranging from 2.5 V to 5.5 V.

The value of  $R_{(BIAS)}$  sets the bias current to the amplifier. Refer to Figure 10. 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 24 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  $L_{(COL)}$ .

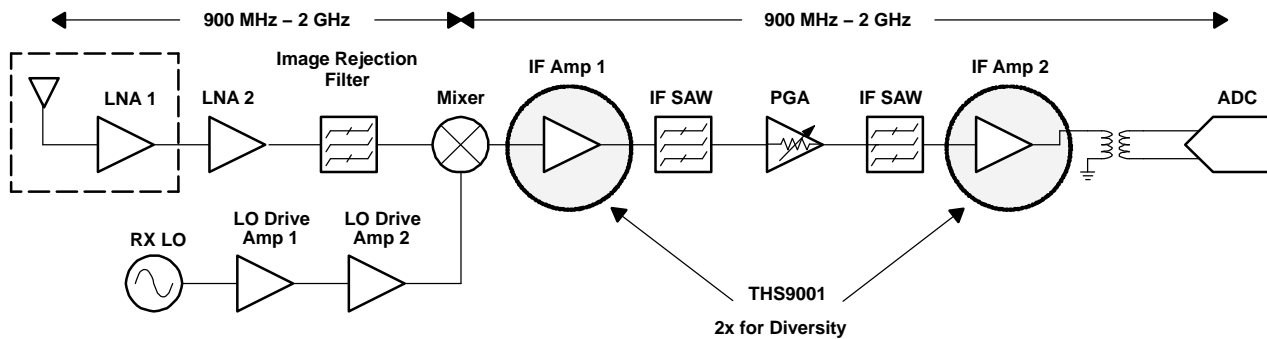
Figure 19 shows the s-parameters of the part mounted on the standard EVM with  $V_S = 5\ V$ ,  $R_{(BIAS)} = 237\ \Omega$ , and  $L_{(COL)} = 470\ nH$ . With this configuration, the part is very broadband, and achieves greater than 15-dB input and output return loss from 50 MHz to 325 MHz.



**Figure 19. S-Parameters of THS9001 Mounted on the Standard EVM With  $V_S = 5\ V$ ,  $R_{(BIAS)} = 237\ \Omega$ , and  $L_{(COL)} = 470\ nH$**

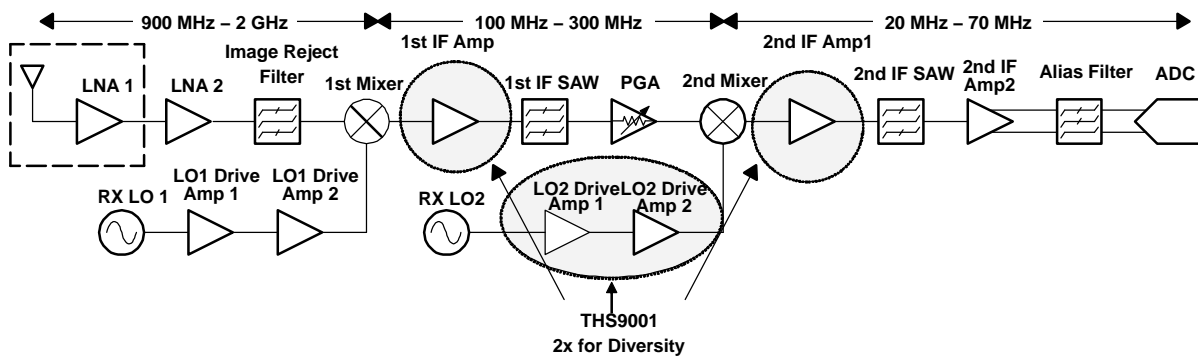
**APPLICATION INFORMATION (continued)**

Figure 20 Shows an example of a single conversion receiver architecture and where the THS9001 would typically be used.



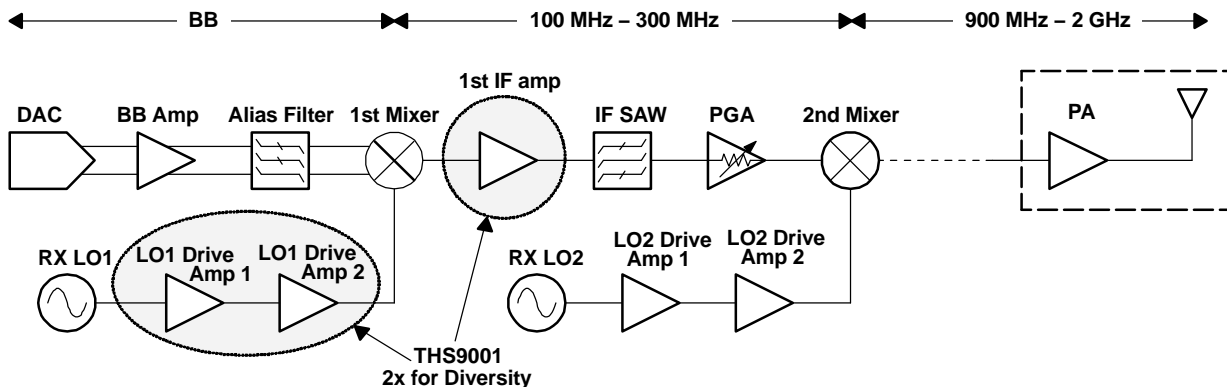
**Figure 20. Example Single Conversion Receiver Architecture**

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



**Figure 21. Example Dual Conversion Receiver Architecture**

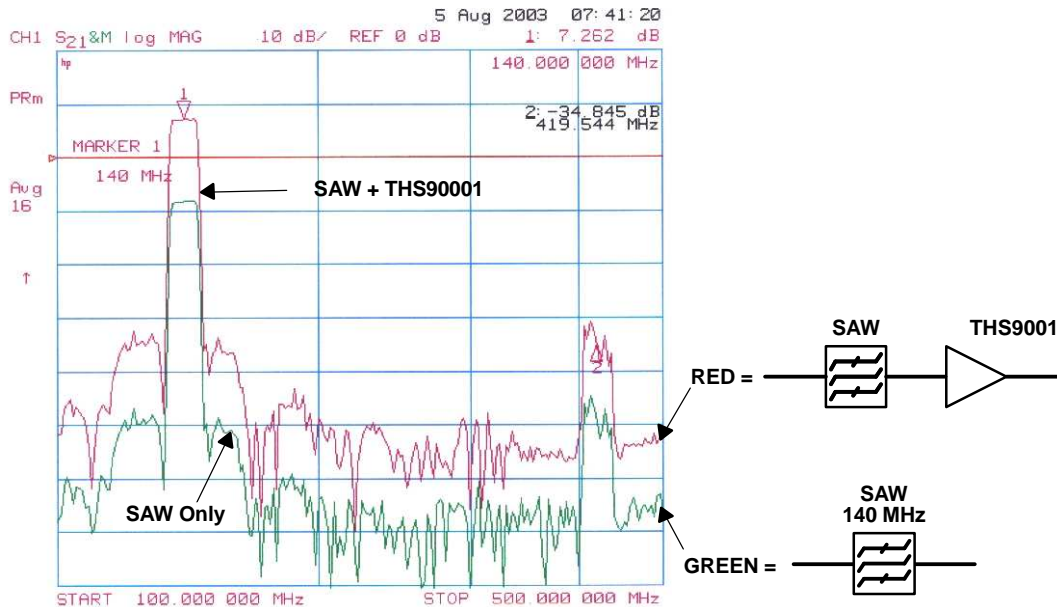
Figure 22 shows an example of a dual conversion transmitter architecture and where the THS9001 would typically be used.



**Figure 22. Example Dual Conversion Transmitter Architecture**

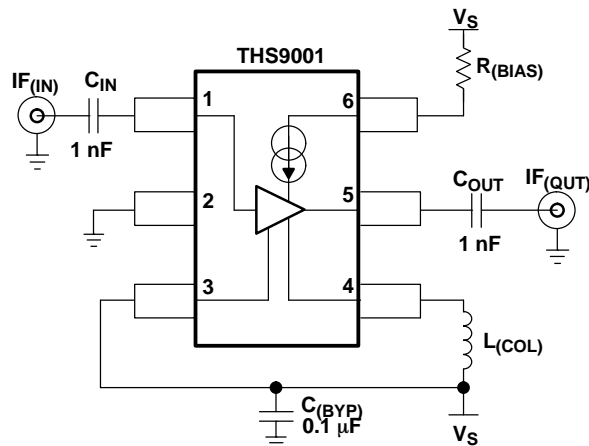
**APPLICATION INFORMATION (continued)**

Figure 23 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.



140 MHz SAW: Sawtek #854916

**Figure 23. Frequency Response of the THS9001 and SAW Filter, and SAW Filter Only**



**Figure 24. THS9001 Recommended Circuit (Used for all Tests)**

**APPLICATION INFORMATION (continued)**

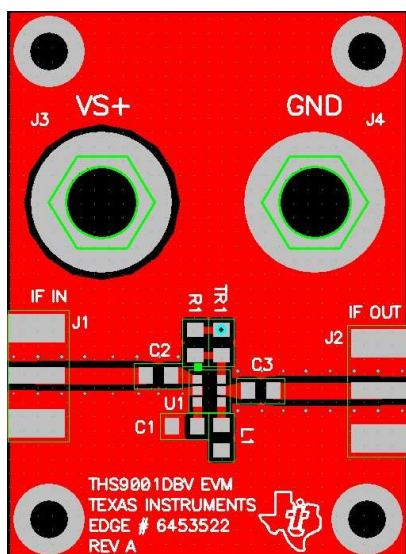
**Evaluation Module**

Table 1 is the bill of materials, and Figure 25 and Figure 26 show the EVM layout.

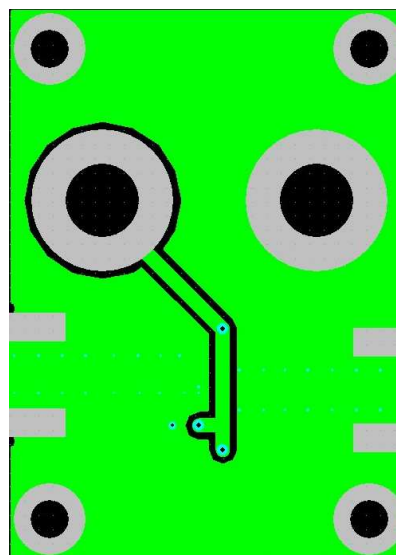
**Bill Of Materials**

| ITEM | DESCRIPTION                          | REF DES | QTY | PART NUMBER <sup>(1)</sup>  |
|------|--------------------------------------|---------|-----|-----------------------------|
| 1    | Cap, 0.1 $\mu$ F, 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 $\Omega$ , 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 25. EVM Top Layout**



**Figure 26. EVM Bottom Layout**

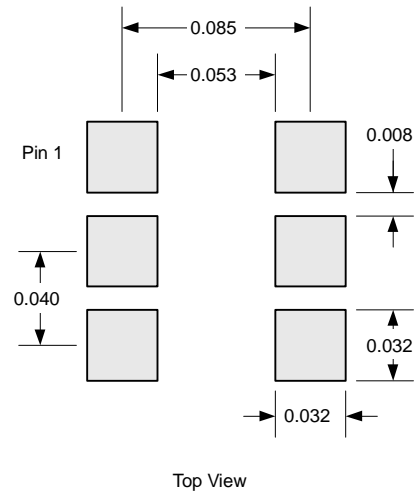


Figure 27. THS9001 Recommended Footprint (dimensions in inches)

**PACKAGING INFORMATION**

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| THS9001DBVR      | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| THS9001DBVT      | ACTIVE                | SOT-23       | DBV             | 6    | 250         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS) 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.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

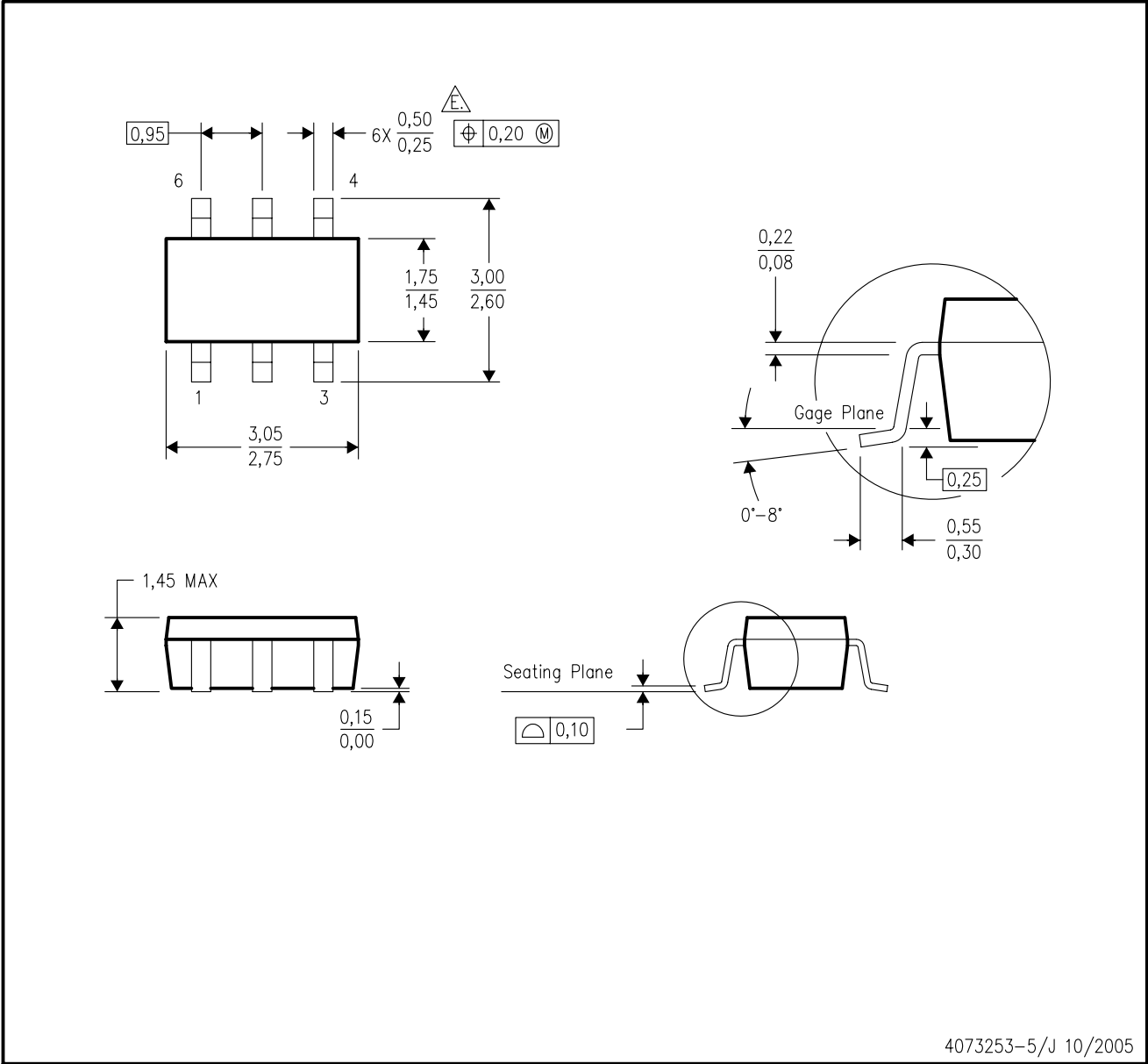
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MECHANICAL DATA

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.
  - $\triangle$  Falls within JEDEC MO-178 Variation AB, except minimum lead width.



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