

# MGA-31589

## 0.5 W High Gain Driver Amplifier



## Data Sheet

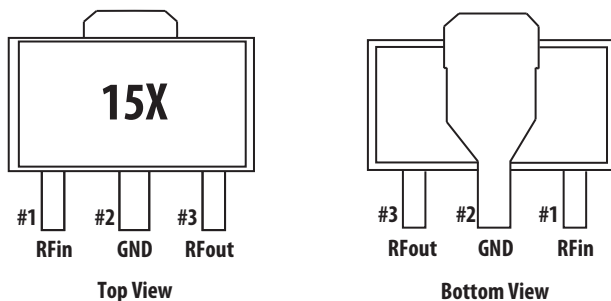
### Description

Avago Technologies' MGA-31589 is a 0.5 W, high Gain, high performance Driver Amplifier MMIC, housed in a standard SOT-89 plastic package. The device required simple matching components to achieve optimum performance within specific 100 to 200 MHz bandwidth.

MGA-31589 is especially ideal for wireless infrastructure applications that operate within the 450 MHz to 1.5 GHz frequency range. With high IP3 and low noise figure, the MGA-31589 may be utilized as a driver amplifier in the transmit chain and as second or third stage LNA in the receive chain. For optimum performance at higher frequency from 1.5 GHz to 3.0 GHz, MGA-31689 is recommended.

MGA-31589's high gain and high linearity features are achieved through the use of Avago Technologies' proprietary 0.25  $\mu\text{m}$  GaAs Enhancement-mode pHEMT process.

### Pin connections and Package Marking



Note:  
Top View: Package marking provides orientation and identification  
"15" = Device Code  
"X" = Date Code character identifies month of manufacturing



**Attention: Observe precautions for handling electrostatic sensitive devices.**  
ESD Machine Model = 150 V  
ESD Human Body Model = 650 V  
Refer to Avago Application Note A004R: Electrostatic Discharge, Damage and Control.

### Features

- ROHS compliant
- Halogen free
- High linearity at low DC bias power<sup>[1]</sup>
- High Gain
- Low noise figure
- High OIP3
- Advanced enhancement mode PHEMT Technology
- Excellent uniformity in product specification
- SOT-89 standard package

### Specifications

**At 0.9 GHz, Vdd = 5 V, Idd = 146 mA (typical) at 25° C**

- OIP3 = 45.3 dBm
- Noise Figure = 1.9 dB
- Gain = 20.4 dB
- P1dB = 27.2 dBm
- IRL = 14.0 dB, ORL = 11.6 dB

Note:

1. The MGA-31589 has a superior LFOM of 16. Linearity Figure of Merit (LFOM) is essentially OIP3 divided by DC bias power.

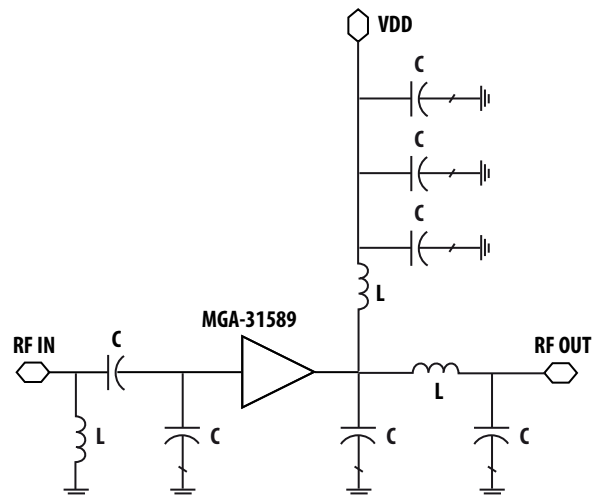


Figure 1. Simplified Schematic diagram

### MGA-31589 Absolute Maximum Rating <sup>[1]</sup>

| Symbol               | Parameter                          | Units | Absolute Max. |
|----------------------|------------------------------------|-------|---------------|
| V <sub>dd, max</sub> | Drain Voltage, RF output to ground | V     | 5.5           |
| P <sub>d</sub>       | Power Dissipation <sup>(2)</sup>   | mW    | 1050          |
| P <sub>in</sub>      | CW RF Input Power                  | dBm   | 17            |
| T <sub>j</sub>       | Junction Temperature               | °C    | 150           |
| T <sub>STG</sub>     | Storage Temperature                | °C    | -65 to 150    |

### Thermal Resistance

#### Thermal Resistance <sup>[3]</sup>

(V<sub>dd</sub> = 5.0 V, I<sub>dd</sub> = 146 mA, T<sub>c</sub> = 85° C),  
θ<sub>jc</sub> = 44° C/W

Notes:

1. Operation of this device in excess of any of these limits may cause permanent damage.
2. Source lead temperature is 25° C. Derate 22.7 mW/° C for T<sub>L</sub> > 103.8° C.
3. Thermal resistance measured using 150° C Infra-Red Microscopy Technique.

### MGA-31589 Electrical Specification <sup>[1]</sup>

T<sub>c</sub> = 25° C, Z<sub>o</sub> = 50 Ω, V<sub>dd</sub> = 5 V, unless specified.

| Symbol          | Parameter and Test Condition          | Frequency (MHz)                          | Units | Min. | Typ.         | Max. |
|-----------------|---------------------------------------|------------------------------------------|-------|------|--------------|------|
| I <sub>ds</sub> | Quiescent Current                     | NA                                       | mA    | 115  | 146          | 175  |
| NF              | Noise Figure                          | 700<br>900                               | dB    |      | 2.35<br>1.92 | 2.8  |
| Gain            | Gain                                  | 700<br>900                               | dB    |      | 20.5<br>20.4 | 22.0 |
| OIP3            | Output Third Order Intercept Point    | 700 <sup>[2]</sup><br>900 <sup>[2]</sup> | dBm   |      | 45.2<br>45.3 |      |
| P1dB            | Output Power at 1 dB Gain Compression | 700<br>900                               | dBm   |      | 26.4<br>26.3 | 27.2 |
| PAE             | Power Added Efficiency at P1dB        | 700<br>900                               | %     |      | 43.6<br>45.0 |      |
| IRL             | Input Return Loss                     | 700<br>900                               | dB    |      | 20.0<br>14.0 |      |
| ORL             | Output Return Loss                    | 700<br>900                               | dB    |      | 10.4<br>11.6 |      |
| ISOL            | Isolation                             | 700<br>900                               | dB    |      | 28.0<br>27.5 |      |

Note :

1. Measurements obtained from a test circuit described in Figure 27.
2. OIP3 test condition: F1 - F2 = 1.0 MHz, with input power of -8 dBm per tone measured at worst case side band.

## MGA-31589 Consistency Distribution Chart [1,2]

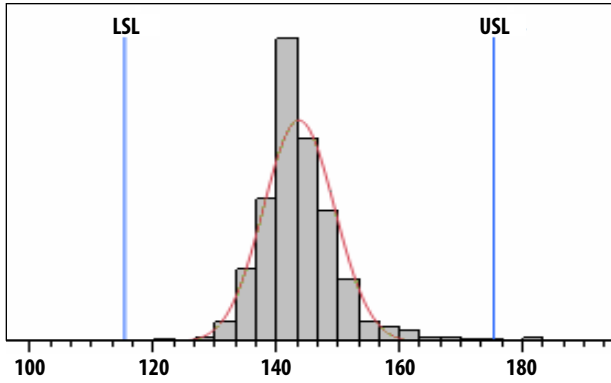


Figure 2. Idd at Vdd = 5 V, LSL = 115 mA, Nominal = 146 mA, USL = 175 mA

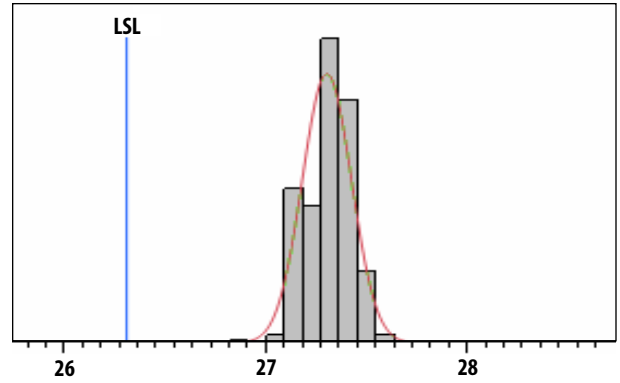


Figure 3. OP1dB at 900 MHz, Vdd = 5 V, LSL = 26.3 dBm, Nominal = 27.2 dBm

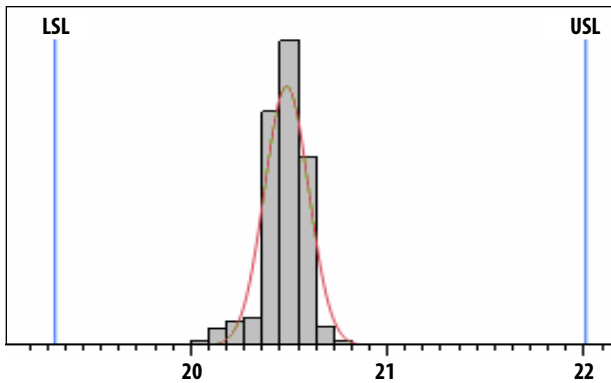


Figure 4. Gain at 900 MHz, Vdd = 5 V, LSL = 19.3 dB, Nominal = 20.4 dB, USL = 22.0 dB

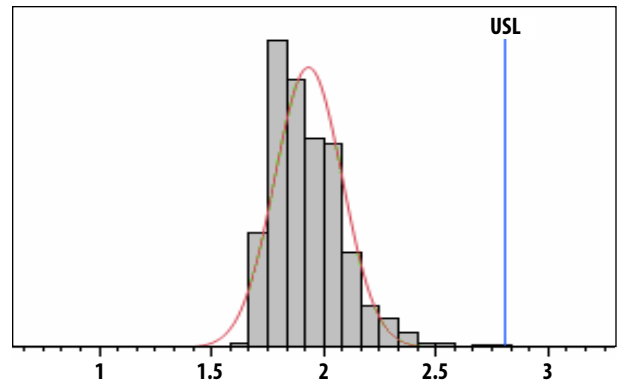


Figure 5. NF at 900 MHz, Vdd = 5 V, Nominal = 1.92 dB, USL = 2.8 dB

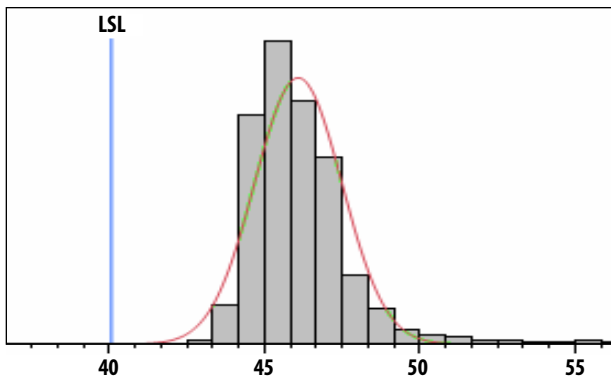


Figure 6. OIP3 at 900 MHz, Vdd = 5 V, LSL = 40.0 dBm, Nominal = 45.3 dBm

### Notes:

1. Data sample size is 2500 samples taken from 5 wafers and 3 different wafer lots. Future wafers allocated to this product may have nominal values anywhere between the upper and lower limits.
2. Measurements are made on production test board which represents a trade off between nominal Gain, NF, OIP3, and OP1dB. Circuit losses have been de-embedded from actual measurements.

## MGA-31589 Application Circuit Data for 700 MHz

$T_A = 25^\circ\text{C}$ ,  $V_{dd} = 5\text{ V}$ ,  $I_{dd} = 146\text{ mA}$

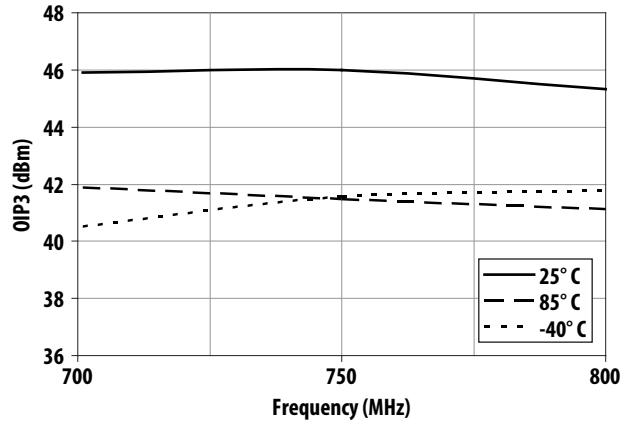


Figure 7. Over Temperature OIP3 vs Frequency

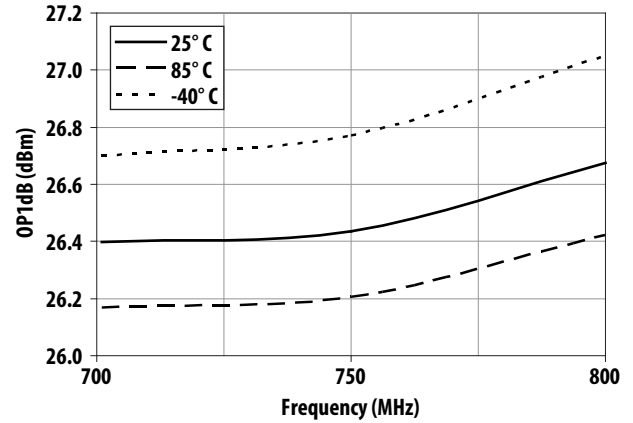


Figure 8. Over Temperature OP1dB vs Frequency

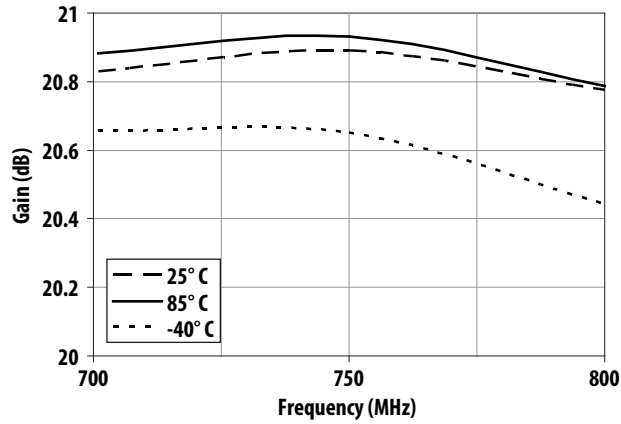


Figure 9. Over Temperature Gain vs Frequency

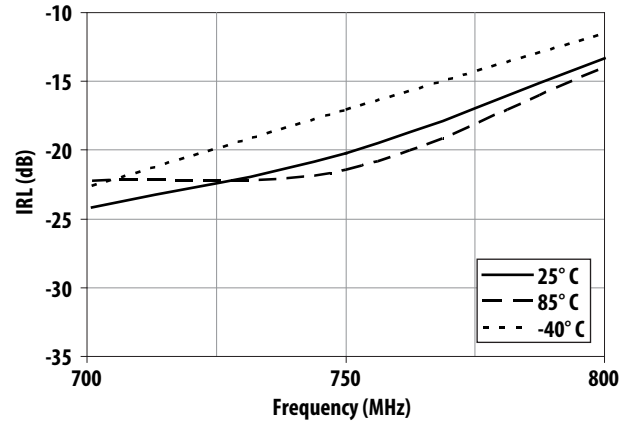


Figure 10. Over Temperature IRL vs Frequency

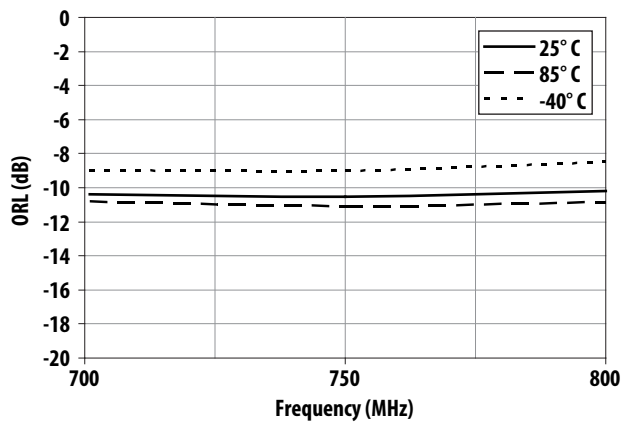


Figure 11. Over Temperature ORL vs Frequency

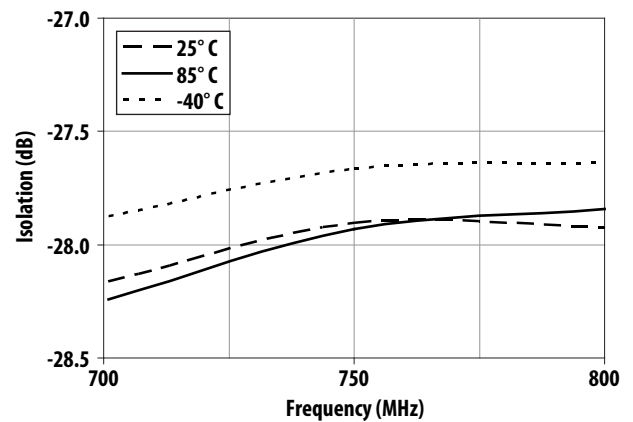


Figure 12. Over Temperature Isolation vs Frequency

## MGA31589 Application Circuit Data for 700 MHz (continued)

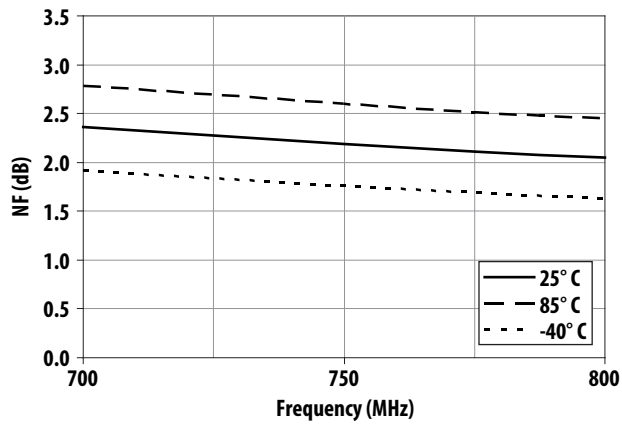


Figure 13. Over Temperature Noise Figure vs Frequency

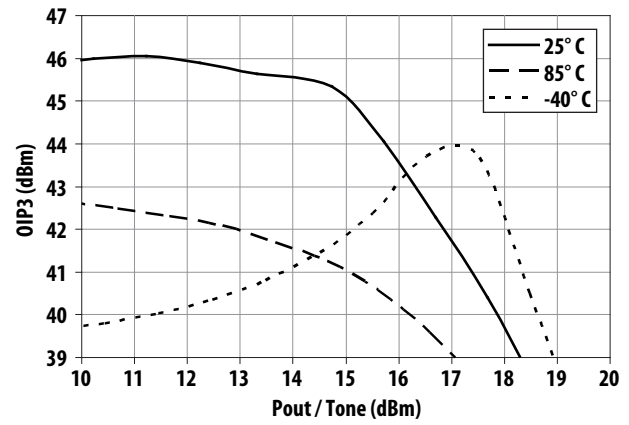


Figure 14. Over Temperature OIP3 at 700 MHz vs Pout

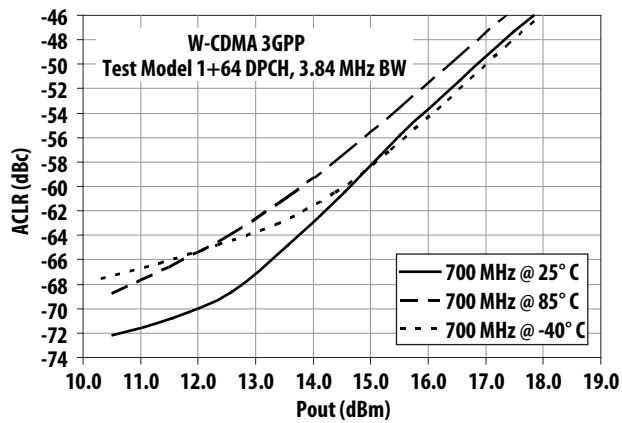


Figure 15. Over Temperature ACLR vs Pout at 700 MHz

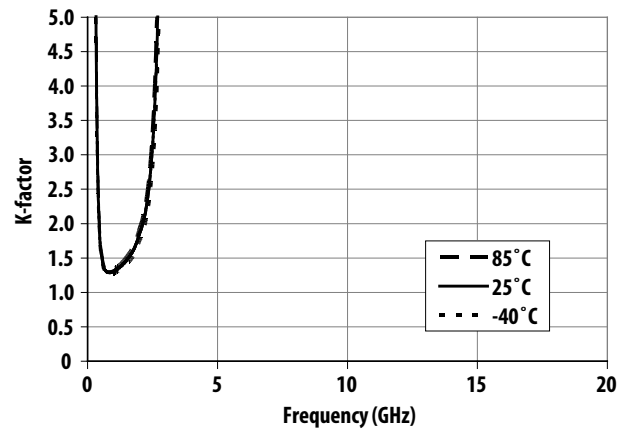


Figure 16. Over Temperature K-factor vs Frequency

## MGA-31589 Application Circuit Data for 900 MHz

$T_A = 25^\circ\text{C}$ ,  $V_{dd} = 5\text{ V}$ ,  $I_{dd} = 146\text{ mA}$

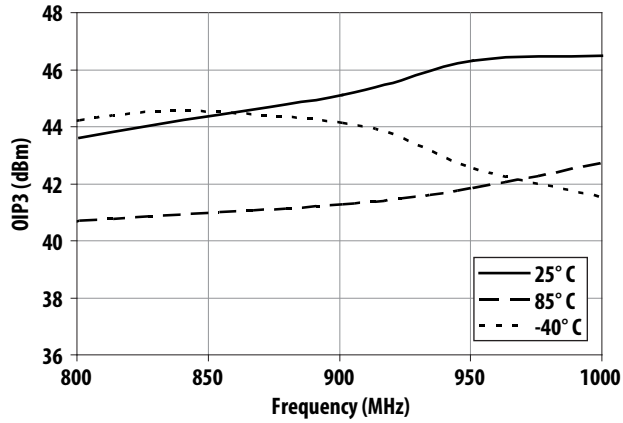


Figure 17. Over Temperature OIP3 vs Frequency

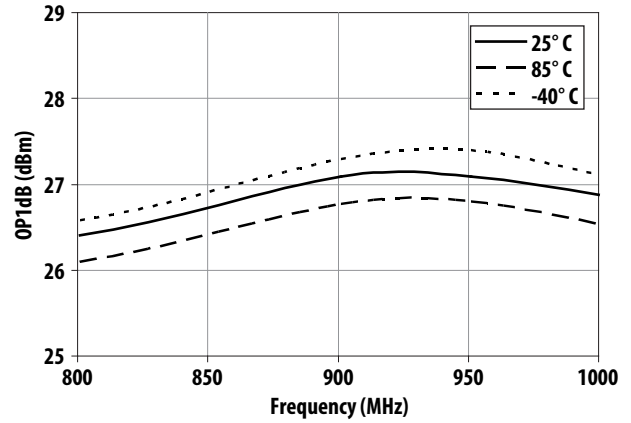


Figure 18. Over Temperature OP1dB vs Frequency

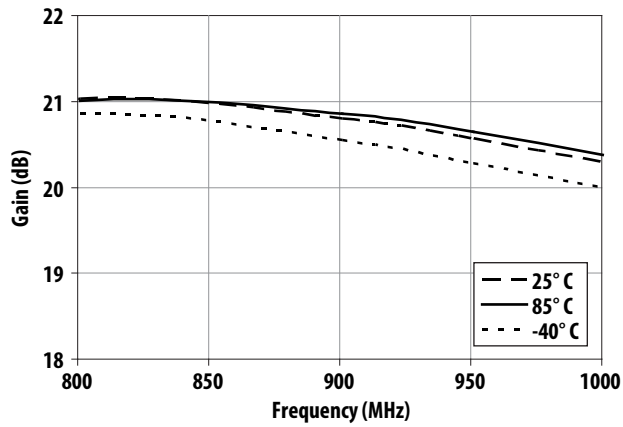


Figure 19. Over Temperature Gain vs Frequency

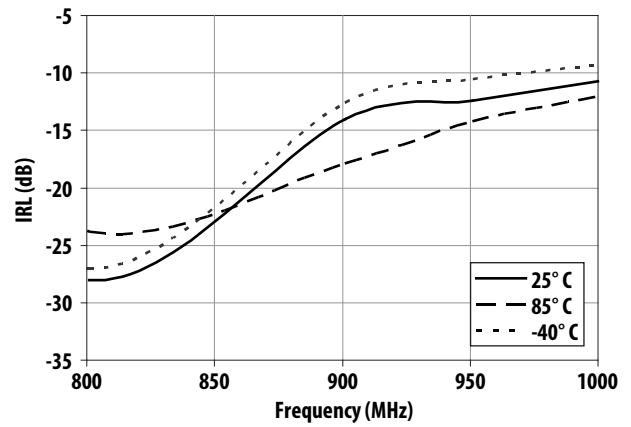


Figure 20. Over Temperature IRL vs Frequency

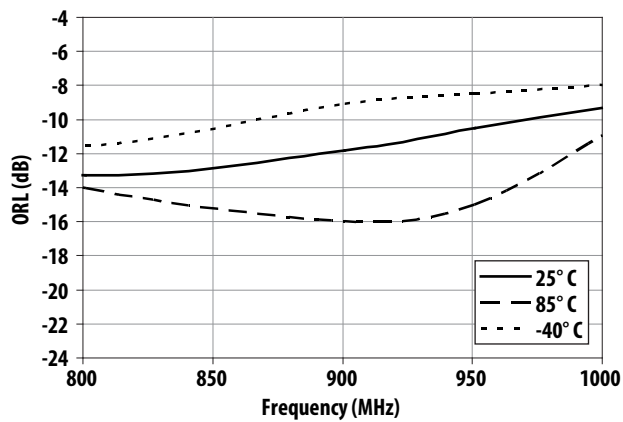


Figure 21. Over Temperature ORL vs Frequency

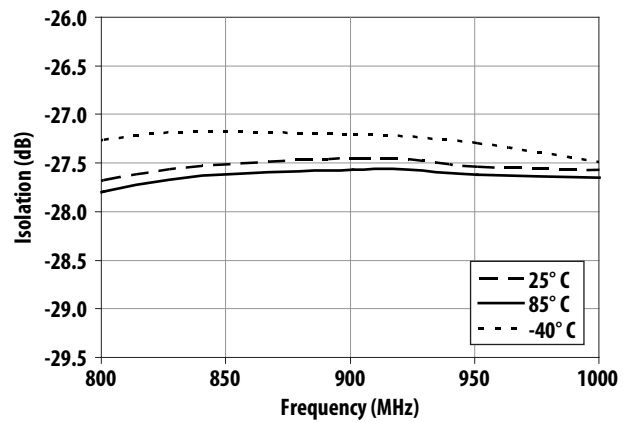


Figure 22. Over Temperature Isolation vs Frequency

## MGA-31589 Application Circuit Data for 900 MHz (continued)

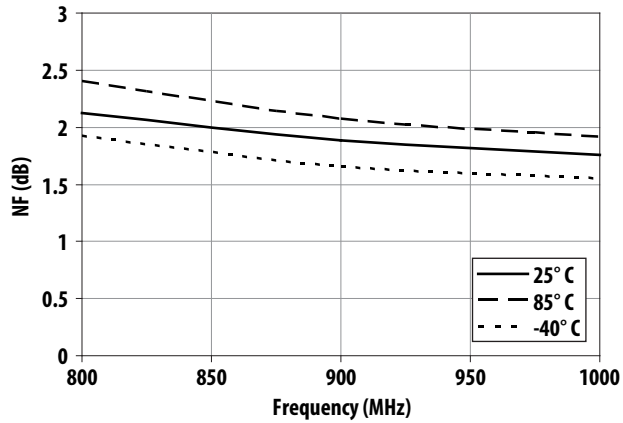


Figure 23. Over Temperature Noise Figure vs Frequency

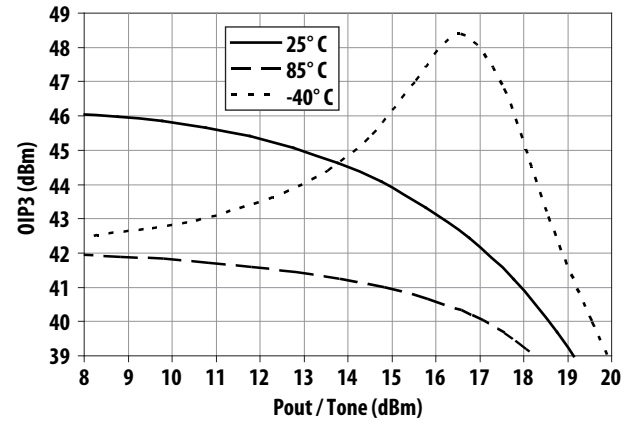


Figure 24. Over Temperature OIP3 vs Pout at 900 MHz

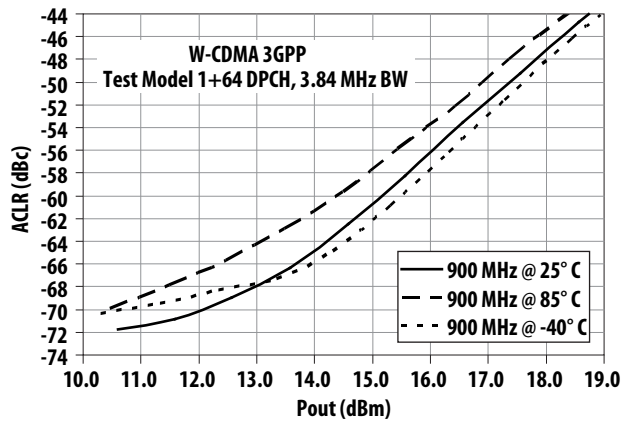


Figure 25. Over Temperature ACLR vs Pout at 900 MHz

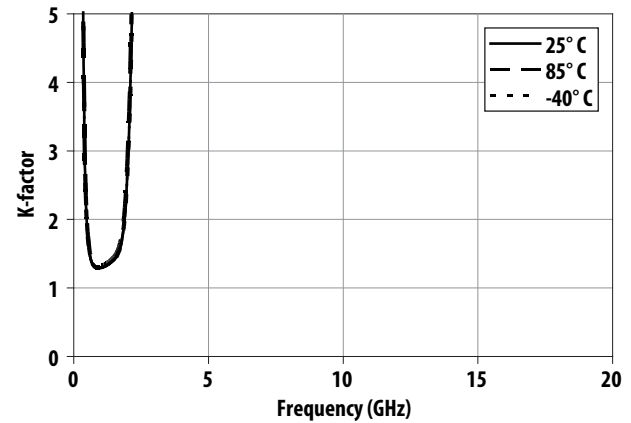


Figure 26. Over Temperature K-factor vs Frequency

## Application Circuit Description and Layout

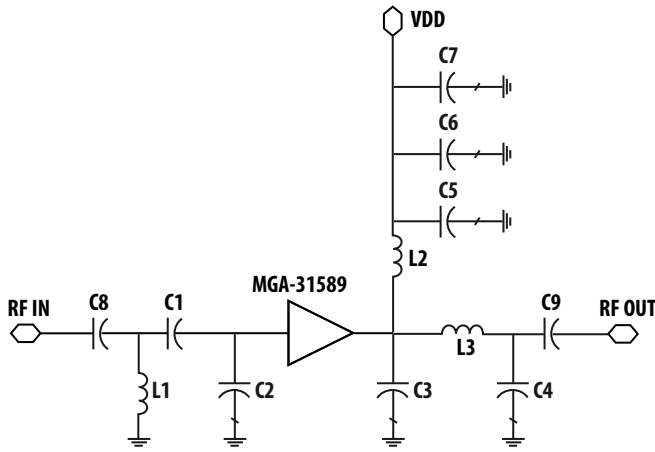


Figure 27. Circuit diagram

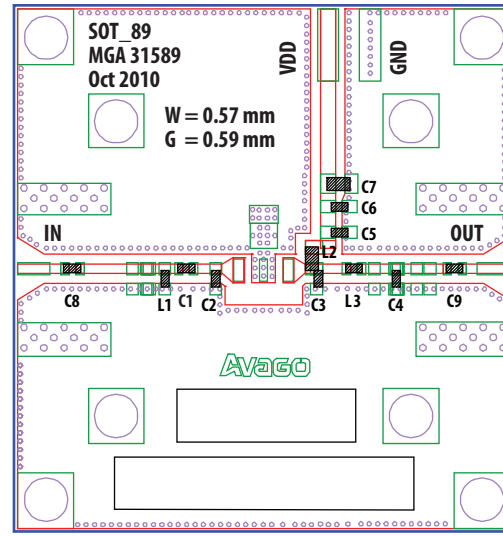


Figure 28. Demo board

## Bill of Materials

|                |      | Description       |                    |              | Description        |                    |              |
|----------------|------|-------------------|--------------------|--------------|--------------------|--------------------|--------------|
|                |      | For 700 – 800 MHz |                    |              | For 800 – 1000 MHz |                    |              |
| Circuit Symbol | Size | Value             | Part Number        | Manufacturer | Value              | Part Number        | Manufacturer |
| C1             | 0402 | 6.8 pF            | CM05CH6R8C50AH     | Kyocera      | 5.6 pF             | CM05CH5R6C50AH     | Kyocera      |
| C2             | 0402 | 3.3 pF            | CM05CH3R3C50AH     | Kyocera      | 5.1 pF             | CM05CH5R1C50AH     | Kyocera      |
| C3             | 0402 | 1.2 pF            | CM05CH1R2C50AH     | Kyocera      | 3.9 pF             | CM05CH3R9C50AH     | Kyocera      |
| C4             | 0402 | 3.6 pF            | CM05CH3R6C50AH     | Kyocera      | 3.0 pF             | GJM1555C1H3R0BB01D | Murata       |
| C5             | 0402 | 100 pF            | GRM1555C1H101JA01B | Murata       | 100 pF             | GRM1555C1H101JA01B | Murata       |
| C6             | 0402 | 0.1 μF            | GRM155R71C104KA88D | Murata       | 0.1 μF             | GRM155R71C104KA88D | Murata       |
| C7             | 0805 | 2.2 μF            | GRM21BR61A225KA01L | Murata       | 2.2 μF             | GRM21BR61A225KA01L | Murata       |
| C8*            | 0402 | 100 pF            | GRM1555C1H101JA01B | Murata       | 100 pF             | GRM1555C1H101JA01B | Murata       |
| C9*            | 0402 | 100 pF            | GRM1555C1H101JA01B | Murata       | 100 pF             | GRM1555C1H101JA01B | Murata       |
| L1             | 0402 | 5.6 nH            | MLK1005S5N6DT000   | TDK          | 5.6 nH             | LLP1005-FH5N6C     | Toko         |
| L2             | 0603 | 22 nH             | 0603CS-22NXJLW     | CoilCraft    | 22 nH              | 0603CS-22NXJLW     | CoilCraft    |
| L3             | 0402 | 2.7 nH            | LLP1005-FH2N7C     | Toko         | 4.3 nH             | HK10054N3S-T       | TaiyoYuden   |

Note: \* as blocking capacitor, not required in actual application circuit.

For best performance, MGA-31589 requires only simple input and output matching network. The C3, C4, and L3 act as the output tuning circuitry for matching and OIP3 optimization. Bandpass network C1, C2, and L1 forms the input matching network. To bias MGA-31589, a +5 V supply (Vdd) is connected to the output pin thru a RF choke, L2 (which isolates the inband signal from the DC supply). The low frequency bypass capacitors C6 and C7 help to eliminate low frequency signals from power supply. Blocking capacitors are required for its input (C8) and output (C9), to isolate the supply voltage from succeeding circuits. The recommended output tuning is for achieving wideband best OIP3, while meeting typical specifications for other parameters.

## MG31589 Typical Scattering Parameter<sup>[1]</sup>

T<sub>A</sub> = 25° C, V<sub>dd</sub> = 5.0 V, I<sub>dd</sub> = 146 mA, Z<sub>o</sub> = 50 Ω

| Freq<br>(GHz) | S11<br>(dB) | S11<br>(ang) | S21<br>(dB) | S21<br>(ang) | S12<br>(dB) | S12<br>(ang) | S22<br>(dB) | S22<br>(ang) | k       |
|---------------|-------------|--------------|-------------|--------------|-------------|--------------|-------------|--------------|---------|
| 0.1           | -1.77       | -176.55      | 19.58       | 136.19       | -34.90      | 8.42         | -3.27       | -170.20      | 0.972   |
| 0.2           | -1.67       | 177.54       | 16.85       | 145.31       | -35.04      | 7.22         | -3.22       | -177.59      | 1.244   |
| 0.3           | -1.72       | 173.67       | 16.41       | 149.08       | -34.65      | 10.46        | -2.82       | 179.75       | 1.275   |
| 0.4           | -1.77       | 170.76       | 16.37       | 147.43       | -34.05      | 11.21        | -2.29       | 174.84       | 1.212   |
| 0.5           | -1.83       | 168.30       | 16.34       | 143.00       | -33.53      | 9.91         | -2.07       | 169.34       | 1.177   |
| 0.6           | -1.87       | 165.91       | 16.23       | 138.05       | -33.16      | 8.33         | -2.02       | 164.14       | 1.166   |
| 0.7           | -1.90       | 163.53       | 16.08       | 133.00       | -32.88      | 6.93         | -2.06       | 159.35       | 1.168   |
| 0.8           | -1.94       | 161.13       | 15.93       | 127.98       | -32.61      | 5.62         | -2.14       | 154.89       | 1.176   |
| 0.9           | -1.98       | 158.73       | 15.76       | 123.03       | -32.38      | 4.31         | -2.25       | 150.65       | 1.189   |
| 1.0           | -2.05       | 155.91       | 15.71       | 117.78       | -32.03      | 2.68         | -2.42       | 146.01       | 1.201   |
| 1.5           | -2.30       | 143.20       | 15.13       | 94.05        | -30.80      | -5.20        | -3.26       | 126.15       | 1.269   |
| 2.0           | -2.58       | 131.24       | 14.79       | 71.01        | -29.78      | -15.44       | -4.42       | 106.91       | 1.339   |
| 2.5           | -2.97       | 119.80       | 14.64       | 46.54        | -29.03      | -29.02       | -6.37       | 85.09        | 1.432   |
| 3.0           | -3.38       | 109.13       | 14.52       | 20.10        | -28.80      | -45.16       | -9.78       | 59.67        | 1.563   |
| 3.5           | -3.66       | 99.38        | 14.28       | -8.36        | -29.30      | -62.45       | -17.08      | 28.50        | 1.750   |
| 4.0           | -3.67       | 89.65        | 13.76       | -38.65       | -30.76      | -78.63       | -23.37      | -158.95      | 2.051   |
| 4.5           | -3.35       | 78.37        | 12.79       | -70.05       | -33.36      | -87.86       | -11.25      | 161.18       | 2.557   |
| 5.0           | -2.72       | 69.55        | 11.22       | -99.35       | -35.92      | -78.23       | -7.01       | 133.77       | 2.926   |
| 5.5           | -2.25       | 54.25        | 9.39        | -127.96      | -35.02      | -63.36       | -4.96       | 106.20       | 2.228   |
| 6.0           | -1.90       | 37.98        | 7.35        | -154.25      | -32.62      | -63.92       | -3.73       | 81.48        | 1.420   |
| 6.5           | -1.66       | 22.07        | 5.23        | -178.40      | -30.75      | -73.57       | -2.92       | 59.47        | 0.964   |
| 7.0           | -1.49       | 6.75         | 3.14        | 158.99       | -29.45      | -86.55       | -2.40       | 39.44        | 0.726   |
| 7.5           | -1.37       | -8.46        | 1.07        | 137.02       | -28.55      | -101.24      | -2.10       | 20.23        | 0.634   |
| 8.0           | -1.31       | -23.53       | -1.12       | 115.64       | -28.08      | -116.73      | -1.99       | 1.07         | 0.763   |
| 8.5           | -1.24       | -38.62       | -3.42       | 94.86        | -27.89      | -132.58      | -1.99       | -18.26       | 1.040   |
| 9.0           | -1.15       | -52.86       | -5.90       | 75.16        | -28.05      | -148.05      | -2.00       | -37.13       | 1.491   |
| 9.5           | -1.04       | -65.05       | -8.51       | 57.37        | -28.46      | -162.13      | -1.93       | -54.51       | 2.003   |
| 10.0          | -0.93       | -74.79       | -11.10      | 41.67        | -28.88      | -174.70      | -1.75       | -69.74       | 2.471   |
| 10.5          | -0.88       | -83.14       | -13.57      | 27.46        | -29.23      | 173.83       | -1.51       | -82.60       | 2.966   |
| 11.0          | -0.87       | -91.24       | -15.94      | 14.15        | -29.46      | 162.64       | -1.26       | -93.38       | 3.480   |
| 11.5          | -0.87       | -99.83       | -18.27      | 1.08         | -29.63      | 151.89       | -1.08       | -102.57      | 4.186   |
| 12.0          | -0.89       | -108.98      | -20.69      | -12.23       | -29.72      | 140.81       | -0.99       | -110.85      | 5.464   |
| 12.5          | -0.90       | -118.43      | -23.36      | -26.45       | -29.77      | 128.66       | -1.07       | -119.52      | 8.527   |
| 13.0          | -0.90       | -127.25      | -26.67      | -42.33       | -30.04      | 114.68       | -1.36       | -130.22      | 16.497  |
| 13.5          | -0.79       | -134.85      | -31.56      | -55.65       | -30.86      | 102.56       | -1.82       | -144.24      | 36.982  |
| 14.0          | -0.66       | -142.23      | -37.35      | -61.23       | -31.33      | 93.78        | -2.25       | -161.00      | 76.824  |
| 14.5          | -0.64       | -149.26      | -47.45      | -58.90       | -31.61      | 84.09        | -2.33       | -176.91      | 255.376 |
| 15.0          | -0.66       | -156.32      | -48.66      | 73.73        | -31.91      | 75.57        | -2.04       | 171.92       | 284.336 |
| 15.5          | -0.71       | -163.50      | -40.13      | 79.58        | -31.96      | 69.43        | -1.64       | 166.22       | 96.597  |
| 16.0          | -0.79       | -170.94      | -35.71      | 75.52        | -31.36      | 64.76        | -1.27       | 164.25       | 47.911  |
| 16.5          | -0.85       | -178.86      | -32.13      | 66.97        | -29.97      | 58.14        | -0.97       | 163.32       | 23.387  |
| 17.0          | -0.94       | 171.97       | -29.15      | 54.52        | -28.27      | 47.58        | -0.83       | 160.50       | 13.048  |
| 17.5          | -1.05       | 162.04       | -26.61      | 39.34        | -26.63      | 33.70        | -1.09       | 152.54       | 11.264  |
| 18.0          | -1.18       | 151.96       | -24.66      | 20.98        | -25.34      | 16.84        | -2.03       | 137.49       | 14.322  |
| 18.5          | -1.35       | 142.56       | -23.66      | 1.12         | -24.79      | -1.31        | -3.78       | 116.75       | 20.654  |
| 19.0          | -1.50       | 134.05       | -23.71      | -15.16       | -25.17      | -15.72       | -5.58       | 99.74        | 29.409  |
| 19.5          | -1.72       | 127.31       | -23.25      | -26.68       | -24.89      | -25.23       | -4.69       | 87.70        | 27.596  |
| 20.0          | -1.98       | 122.16       | -24.07      | -36.24       | -25.77      | -32.73       | -6.17       | 75.97        | 43.126  |

## MGA-31589 Typical Noise Parameters<sup>[1]</sup>

$T_A = 25^\circ \text{C}$ ,  $V_{dd} = 5.0 \text{ V}$ ,  $I_{dd} = 146 \text{ mA}$ ,  $Z_0 = 50 \Omega$

| Freq<br>(GHz) | $F_{min}$<br>(dB) | $\Gamma_{opt}$<br>Mag | $\Gamma_{opt}$<br>Ang | $R_n/Z_0$ | Ga<br>(dB) |
|---------------|-------------------|-----------------------|-----------------------|-----------|------------|
| 0.5           | 1.80              | 0.59                  | -163.70               | 0.08      | 22.27      |
| 0.8           | 1.75              | 0.59                  | -157.40               | 0.07      | 21.69      |
| 0.9           | 1.54              | 0.59                  | -158.60               | 0.06      | 21.39      |
| 1.0           | 1.53              | 0.59                  | -151.30               | 0.07      | 21.11      |
| 1.5           | 1.34              | 0.58                  | -143.30               | 0.09      | 19.79      |
| 2.0           | 1.23              | 0.57                  | -131.00               | 0.13      | 18.67      |
| 2.5           | 1.15              | 0.56                  | -119.80               | 0.19      | 17.84      |
| 3.0           | 1.30              | 0.54                  | -109.00               | 0.23      | 17.13      |
| 3.5           | 1.48              | 0.53                  | -99.50                | 0.34      | 16.60      |
| 4.0           | 1.93              | 0.52                  | -91.50                | 0.54      | 16.16      |
| 4.5           | 2.64              | 0.51                  | -78.50                | 0.81      | 15.76      |
| 5.0           | 3.68              | 0.50                  | -58.60                | 1.29      | 15.03      |
| 5.5           | 5.06              | 0.49                  | -22.80                | 1.98      | 13.26      |
| 6.0           | 6.70              | 0.48                  | -5.40                 | 2.68      | 11.93      |

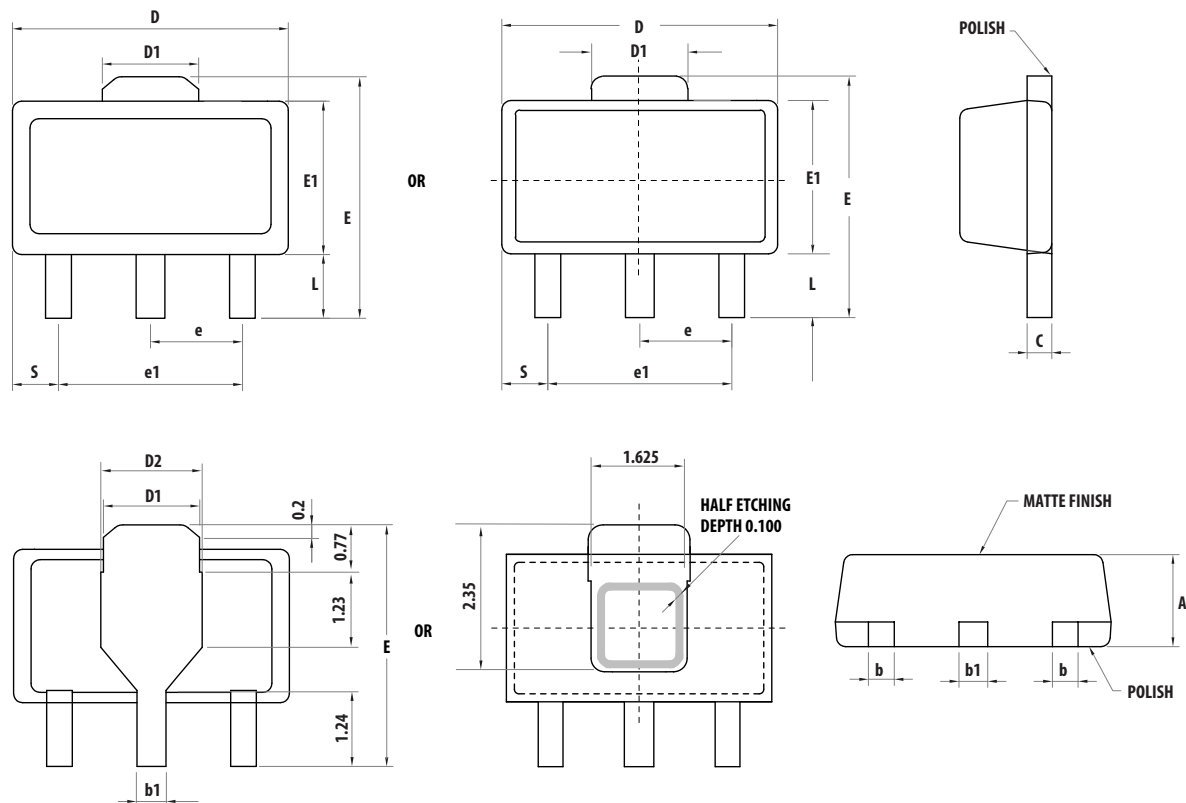
Note:

1. Measurements are made using 10 mils Rogers RO4350 TRL Board.

## Part Number Ordering Information

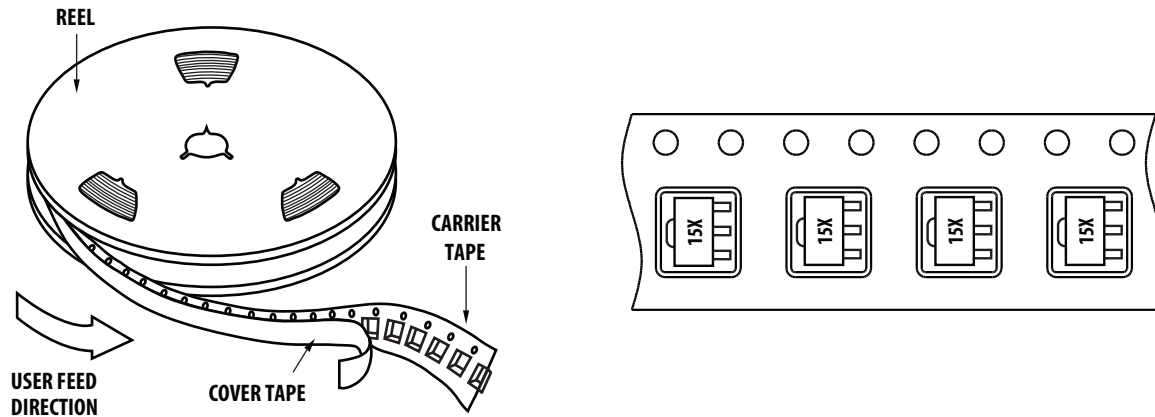
| Part Number    | No. of Devices | Container     |
|----------------|----------------|---------------|
| MGA-31589-BLKG | 100            | 7" Tape/Reel  |
| MGA-31589-TR1G | 3000           | 13" Tape/Reel |

## SOT89 Package Dimensions

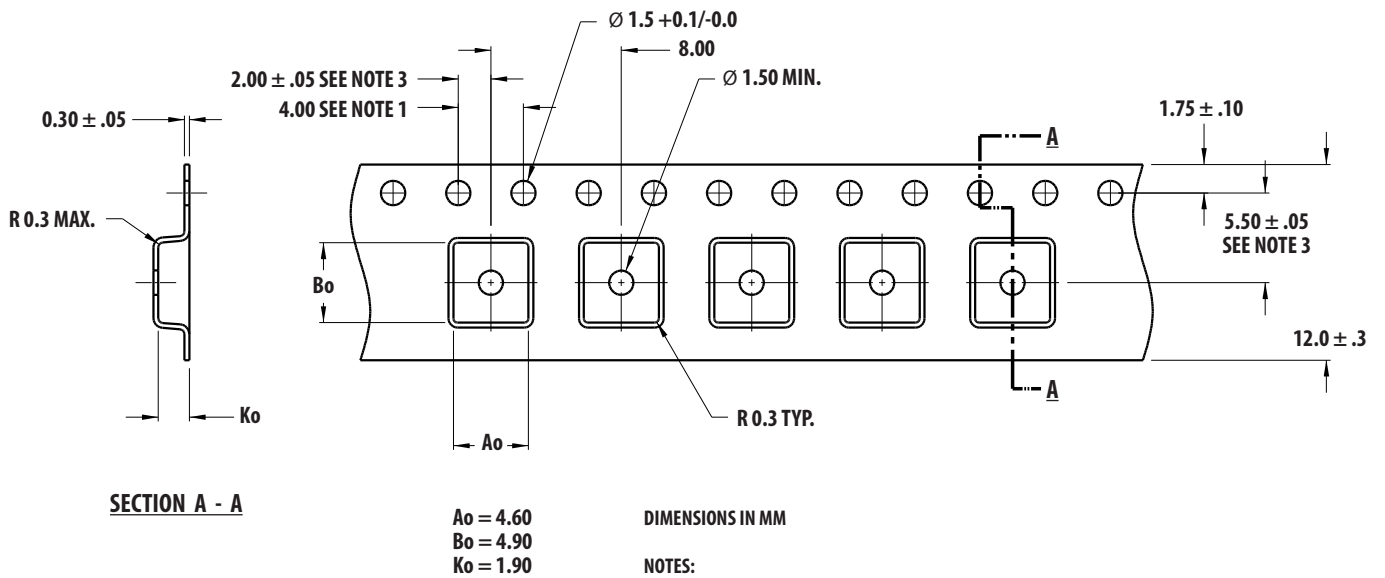


| Symbols | Dimensions in mm |         |         | Dimensions in inches |         |         |
|---------|------------------|---------|---------|----------------------|---------|---------|
|         | Minimum          | Nominal | Maximum | Minimum              | Nominal | Maximum |
| A       | 1.40             | 1.50    | 1.60    | 0.055                | 0.059   | 0.063   |
| L       | 0.89             | 1.04    | 1.20    | 0.0350               | 0.041   | 0.047   |
| b       | 0.36             | 0.42    | 0.48    | 0.014                | 0.016   | 0.018   |
| b1      | 0.41             | 0.47    | 0.53    | 0.016                | 0.018   | 0.030   |
| C       | 0.38             | 0.40    | 0.43    | 0.014                | 0.015   | 0.017   |
| D       | 4.40             | 4.50    | 4.60    | 0.173                | 0.177   | 0.181   |
| D1      | 1.40             | 1.60    | 1.75    | 0.055                | 0.062   | 0.069   |
| D2      | 1.45             | 1.65    | 1.80    | 0.055                | 0.062   | 0.069   |
| E       | 3.94             | -       | 4.25    | 0.155                | -       | 0.167   |
| E1      | 2.40             | 2.50    | 2.60    | 0.094                | 0.098   | 0.102   |
| e1      | 2.90             | 3.00    | 3.10    | 0.114                | 0.118   | 0.122   |
| S       | 0.65             | 0.75    | 0.85    | 0.026                | 0.030   | 0.034   |
| e       | 1.40             | 1.50    | 1.60    | 0.054                | 0.059   | 0.063   |

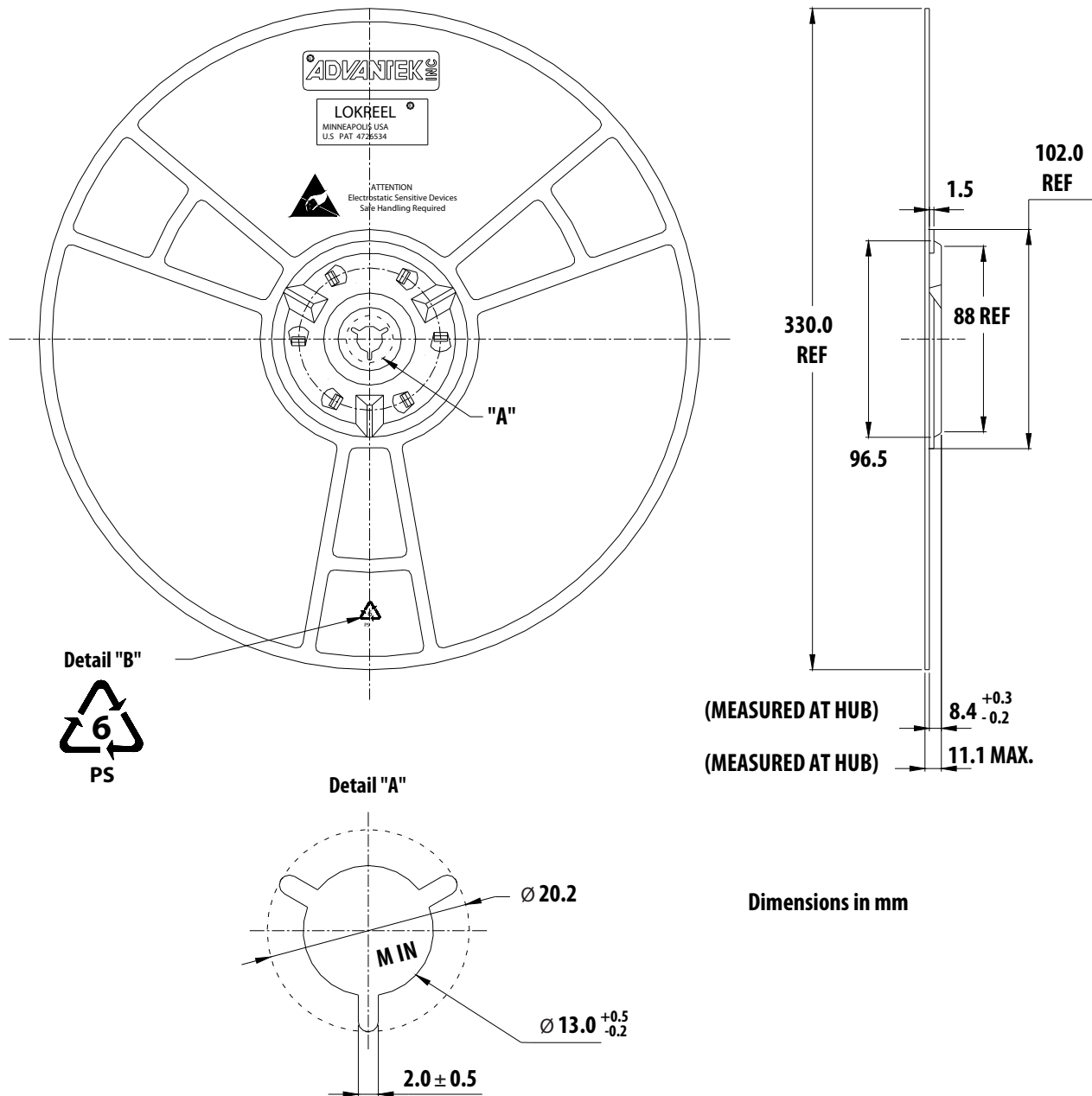
## Device Orientation



## Tape Dimensions



## Reel Dimensions – 13" Reel



Dimensions in mm

For product information and a complete list of distributors, please go to our web site: [www.avagotech.com](http://www.avagotech.com)

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