

# MGA-13316

## High Gain, High Linearity Low Noise Amplifier



### Data Sheet

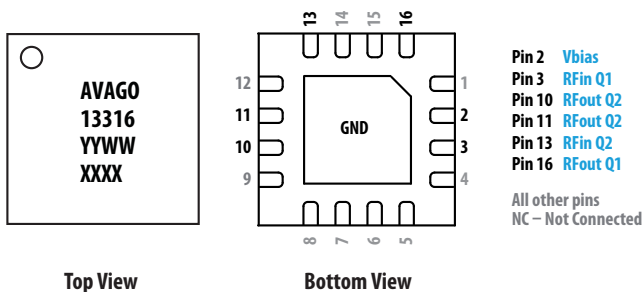
#### Description

Avago Technologies' MGA-13316 is a two stage, easy-to-use GaAs MMIC Low Noise Amplifier (LNA). The LNA has low noise with good input return loss and high linearity achieved through the use of Avago Technologies' proprietary 0.25  $\mu\text{m}$  GaAs Enhancement-mode pHEMT process. Minimum matching needed for input, output and the inter-stage between the two LNA.

It is designed for optimum use between 2.2 GHz to 4 GHz. For optimum performance at lower frequency from 400 MHz to 1.5 GHz, MGA-13116 is recommended. For optimum performance at frequency from 1.5 GHz to 2.5 GHz, the MGA-13216 is recommended. All these 3 products, MGA-13116, MGA-13216 and MGA-13316 share the same package and pinout configuration.

#### Pin Configuration and Package Marking

4.0 x 4.0 x 0.85 mm<sup>3</sup> 16-lead QFN



Note:  
 Package marking provides orientation and identification  
 "13316" = Product Code  
 "YYWW" = Year and Work Week of Manufacture  
 "XXXX" = Lot Number

**Attention: Observe precautions for handling electrostatic sensitive devices.**  
 ESD Machine Model = 90 V  
 ESD Human Body Model = 600 V  
 Refer to Avago Application Note A004R:  
 Electrostatic Discharge, Damage and Control.

#### Features

- Low noise figure
- High gain
- High linearity performance
- Excellent isolation
- GaAs E-pHEMT Technology [1]
- Low cost small package size: 4.0 x 4.0 x 0.85 mm<sup>3</sup>
- Excellent uniformity in product specifications
- Meets MSL1, Lead-free and halogen free

#### Specifications

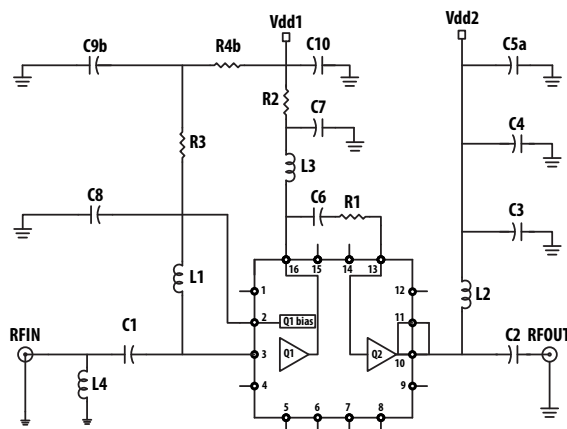
**2.5 GHz; Q1: 5 V, 53 mA (typ) Q2: 5 V, 116 mA (typ)**

- 0.76 dB Noise Figure
- 34.3 dB Gain
- 50.3 dB RFout Q1 to RFin Q2 Isolation
- 41.8 dBm Output IP3
- 23.5 dBm Output Power at 1dB gain compression

#### Applications

- Low noise amplifier for cellular infrastructure including GSM, CDMA, TD-LTE, and W-CDMA.
- Other very low noise applications.

#### Simplified Schematic



Notes: Enhancement mode technology employs positive gate bias, thereby eliminating the need of negative gate voltage associated with conventional depletion mode devices.

## MGA-13316 Absolute Maximum Rating <sup>[1]</sup> T<sub>A</sub> = 25° C

| Symbol              | Parameter                        | Units | Absolute Maximum |
|---------------------|----------------------------------|-------|------------------|
| V <sub>dd1</sub>    | Device Voltage                   | V     | 5.5              |
| V <sub>dd2</sub>    | Device Voltage                   | V     | 5.5              |
| I <sub>dd1</sub>    | Q1 Drain Current                 | mA    | 90               |
| P <sub>d</sub>      | Power Dissipation <sup>[2]</sup> | W     | 1.19             |
| P <sub>in,max</sub> | CW RF Input Power                | dBm   | 20               |
| T <sub>j,max</sub>  | Junction Temperature             | °C    | 150              |
| T <sub>stg</sub>    | Storage Temperature              | °C    | -65 to 150       |

## Thermal Resistance

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

(V<sub>dd1</sub> = 5.0 V, I<sub>dd1</sub> = 53 mA, V<sub>dd2</sub> = 5.0 V, I<sub>dd2</sub> = 116 mA),  $\theta_{jc} = 39.59^\circ \text{C/W}$

Notes:

1. Operation of this device in excess of any of these limits may cause permanent damage.
2. This is limited by maximum V<sub>d</sub> and I<sub>d</sub>. Board temperature (T<sub>c</sub>) is 25° C. For T<sub>c</sub> > 103° C, derate the device power at 25 mW per °C rise in board temperature adjacent to package bottom.
3. Thermal resistance measured using Infra-Red Microscopy Technique.

## Electrical Specifications <sup>[1]</sup>

RF performance at V<sub>dd1</sub> = 5 V, V<sub>dd2</sub> = 5 V, 2.5 GHz, T<sub>A</sub> = 25° C, measured on the demo board.

| Symbol              | Parameter and Test Condition              | Units | Min. | Typ.  | Max. |
|---------------------|---|-------|------|-------|------|
| I <sub>dd1</sub>    | Current at Q1                             | mA    | 40   | 53    | 68   |
| I <sub>dd2</sub>    | Current at Q2                             | mA    | 96   | 116   | 138  |
| NF                  | Noise Figure                              | dB    | –    | 0.76  | 1.1  |
| Gain                | Gain                                      | dB    | 33   | 34.3  | 36.3 |
| OIP3 <sup>[2]</sup> | Output Third Order Intercept Point        | dBm   | 37   | 41.8  | –    |
| OP1dB               | Output Power at 1 dB Gain Compression     | dBm   | 22.1 | 23.5  | –    |
| IRL                 | Input Return Loss, 50 Ω source            | dB    | –    | -19.5 | –    |
| ORL                 | Output Return Loss, 50 Ω load             | dB    | –    | -10.5 | –    |
| S <sub>12</sub>     | Reverse Isolation                         | dB    | –    | 50    | –    |
| ISOL <sub>1-2</sub> | Isolation between Output pin to Input pin | dB    | –    | 50.3  | –    |

Notes:

1. Measurements obtained using demo board described in Figure 7 with component list in Table 1. Input and Output trace loss is not de-embedded from the measurement.
2. OIP3 test condition: f<sub>tone1</sub> = 2500 MHz, f<sub>tone2</sub> = 2501 MHz with input power of -27 dBm per tone.
3. Use proper bias, heatsink and derating to ensure maximum channel temperature is not exceeded. See absolute maximum ratings and application note for more details.

## Product consistency Distribution Charts [1,2]

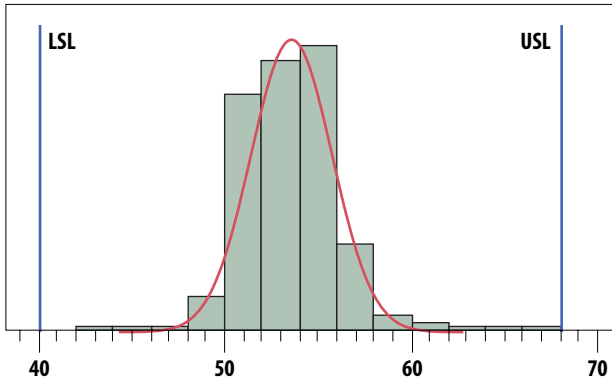


Figure 1. Idd1 @ 2.5 GHz, Vdd1 = 5 V, LSL = 40 mA, Nominal = 53 mA, USL = 68 mA

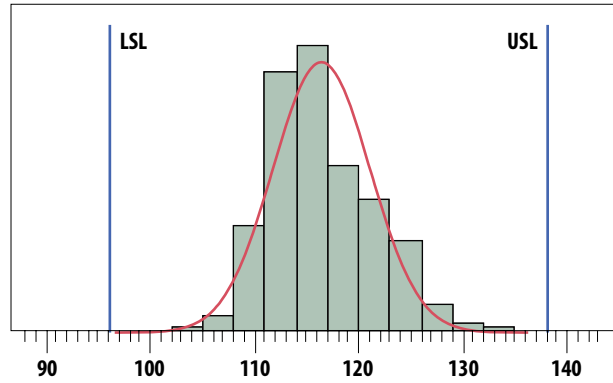


Figure 2. Idd2 @ 2.5 GHz, Vdd2 = 5 V, LSL = 96 mA, Nominal = 116 mA, USL = 138 mA

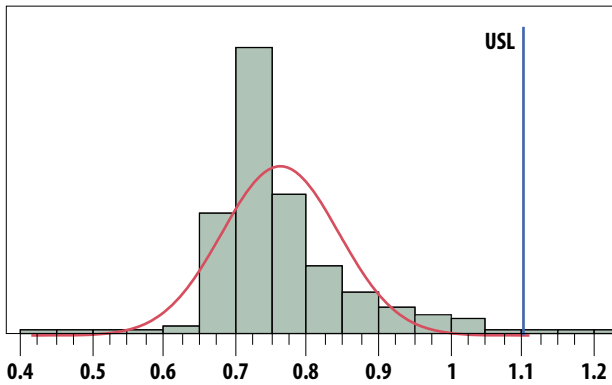


Figure 3. Noise Figure @ 2.5 GHz, Vdd1 = 5 V, Vdd2 = 5 V, Nominal = 0.76 dB, USL = 1.1 dB

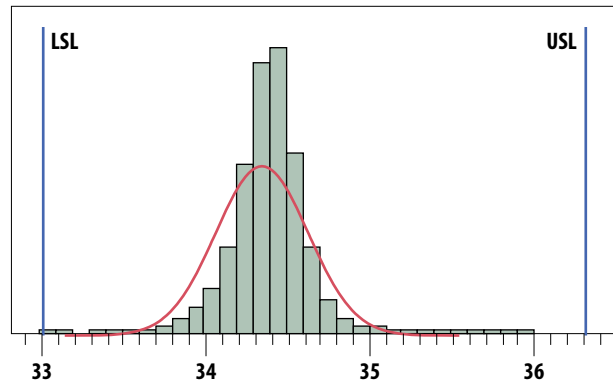


Figure 4. Gain @ 2.5 GHz, Vdd1 = 5 V, Vdd2 = 5 V, LSL = 33 dB, Nominal = 34.3 dB, USL = 36.3 dB

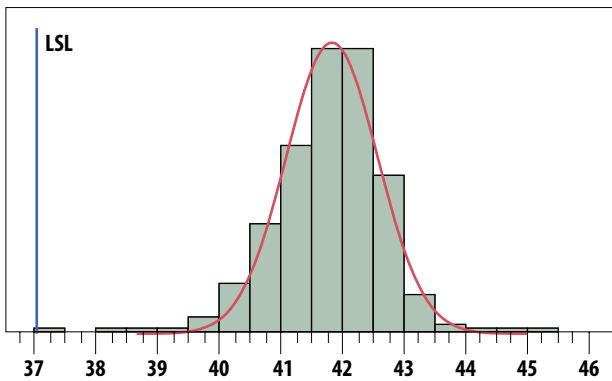


Figure 5. OIP3 @ 2.5 GHz, Vdd1 = 5 V, Vdd2 = 5 V, LSL = 37 dBm, Nominal = 41.8 dBm

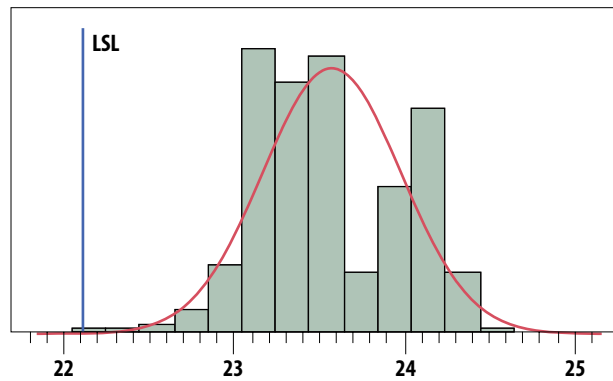


Figure 6. OP1dB @ 2.5 GHz, Vdd1 = 5 V, Vdd2 = 5 V, LSL = 22.1 dBm, Nominal = 23.5 dBm

### Notes:

1. Data sample size is 11 Kpcs samples taken from 3 different wafers. 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 optimal Gain, NF, OIP3 and OP1dB. Circuit losses have been de-embedded from actual measurements.

## Demo Board Layout

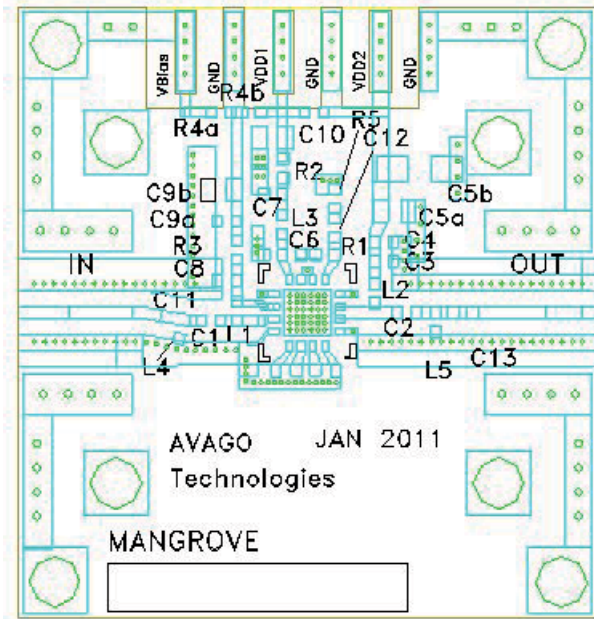


Figure 7. Demo Board layout diagram.

- Recommended PCB material is 10 mils Rogers R04350.
- Suggested component values may vary according to layout and PCB material.

## Demo Board Schematic

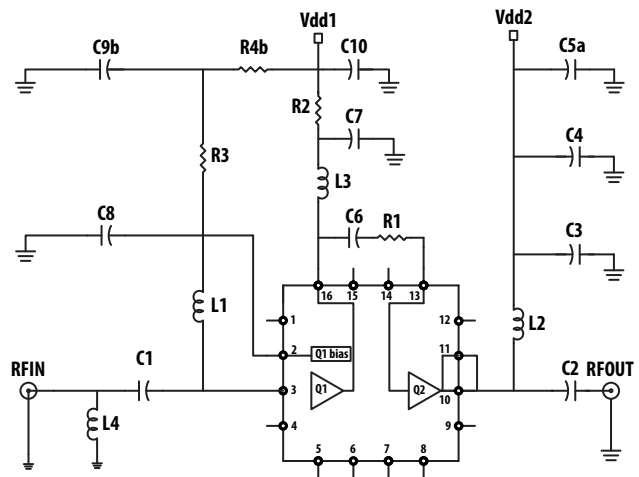


Figure 8. Demo Board schematic diagram.

Table 1. Component list for 2.5 GHz matching

| Part   | Size | Value              | Detail Part Number | Notes                       |
|--------|------|--------------------|--------------------|-----------------------------|
| C1     | 402  | 1.8 pF (Murata)    | GRM1555C1H1R8CZ01D | DC Blocking Capacitor       |
| C2     | 402  | 100 pF (Murata)    | GRM1555C1H101JD01E | DC Blocking Capacitor       |
| C3     | 402  | 2.7 pF (Murata)    | MCH155A2R7JK       | Bypass Capacitor            |
| C4     | 402  | 0.1 uF (Murata)    | GRM155R61A104KA01D | Bypass Capacitor            |
| C5a    | 603  | 2.2 uF (Murata)    | GRM188R61A225KE34D | Bypass Capacitor            |
| C5b    | N/A  | N/A                | N/A                | Not Used                    |
| C6     | 402  | 1000 pF (Murata)   | GRM155R71H102KA01E | DC Blocking Capacitor       |
| C7     | 402  | 10 pF (Murata)     | GRM1555C1H100JZ01E | Bypass Capacitors           |
| C8     | 402  | 10 pF (Murata)     | GRM1555C1H100JZ01E | Bypass Capacitors           |
| C9a    | N/A  | N/A                | N/A                | Not Used                    |
| C9b    | 402  | 4.7 uF (Murata)    | GRM155R60E475ME760 | Bypass Capacitors           |
| C10    | 402  | 4.7 uF (Murata)    | GRM155R60E475ME760 | Bypass Capacitors           |
| C11    | N/A  | N/A                | N/A                | Not Used                    |
| C12    | N/A  | N/A                | N/A                | Not Used                    |
| C13    | N/A  | N/A                | N/A                | Not Used                    |
| L1     | 402  | 6.8 nH (Coilcraft) | 0402CS-6N8XJBW     | Input match for NF          |
| L2     | 402  | 3.3 nH (Toko)      | LL1005-FHL3N3S     | Output match for Q2         |
| L3     | 402  | 6.8 nH (Toko)      | LL1005-FHL6N8J     | Output match for Q1         |
| L4     | 402  | 3.6 nH (Coilcraft) | 0402CS-3N6XJBW     | Input match for Q1          |
| L5     | N/A  | N/A                | N/A                | Not Used                    |
| R1, R2 | 402  | 0 ohm (Koa)        | RK73Z1ELTP         | Bridging Resistors          |
| R3     | 402  | 49.9 ohm (Koa)     | RK73H1ELTP49R9F    | Stabilizing Resistor for Q1 |
| R4a    | N/A  | N/A                | N/A                | Not Used                    |
| R4b    | 402  | 3.6 Kohm (Rohm)    | MCR01J362          | Biasing Resistor for Q1     |
| R5     | N/A  | N/A                | N/A                | Not Used                    |

## MGA-13316 Typical Performance in Demoboard for 2.5 GHz

$T_A = 25^\circ\text{C}$ ,  $V_{dd1} = 5.0\text{V}$ ,  $V_{dd2} = 5.0\text{V}$ ,  $I_{dd1} = 53\text{mA}$ ,  $I_{dd2} = 116\text{mA}$

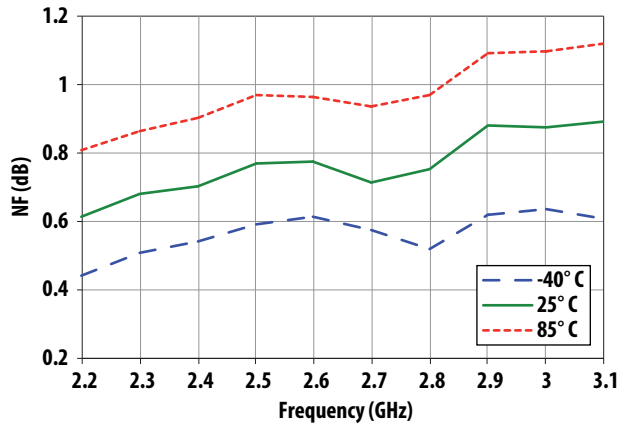


Figure 9. NF vs Frequency and Temperature

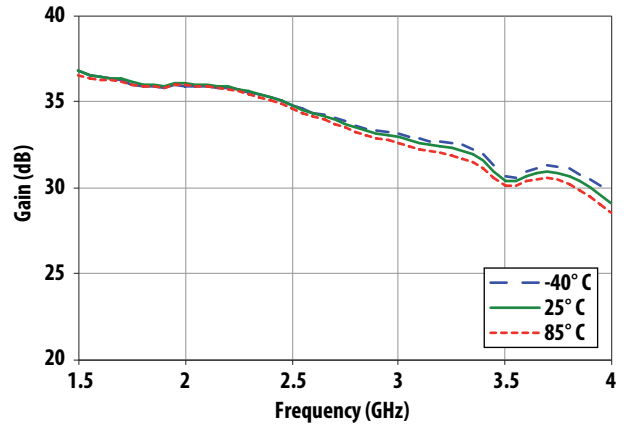


Figure 10. Gain vs Frequency and Temperature

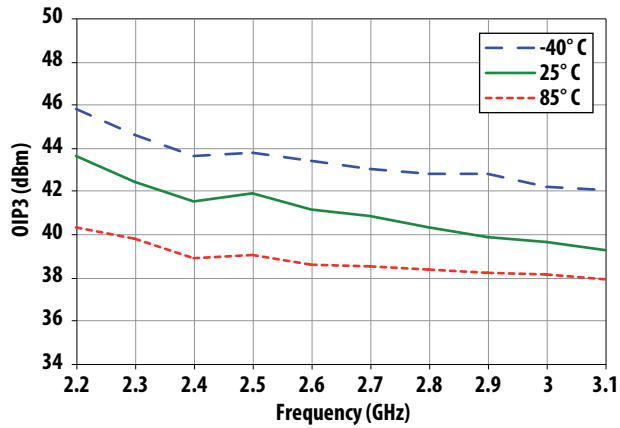


Figure 11. OIP3 vs Frequency and Temperature

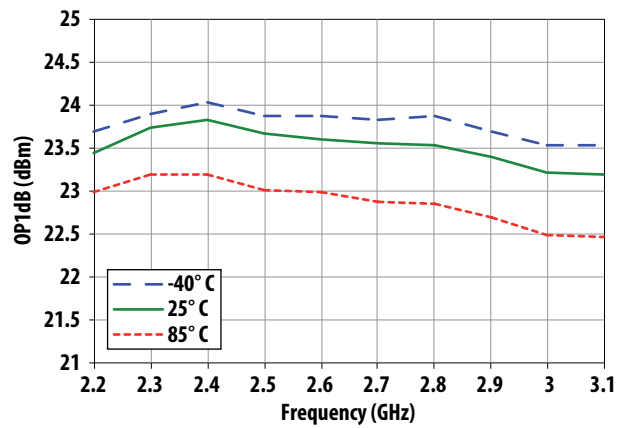


Figure 12. OP1dB vs Frequency and Temperature

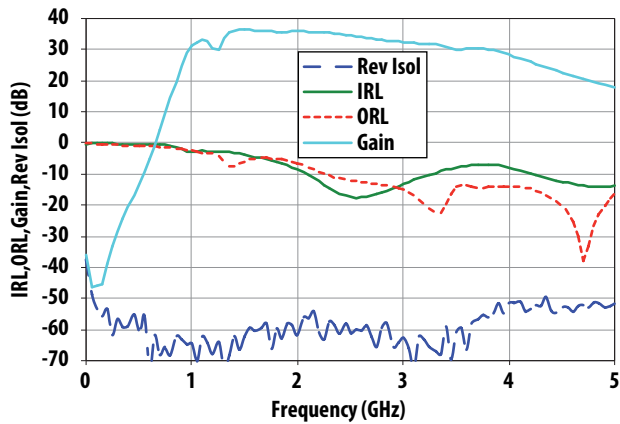


Figure 13. Input Return Loss, Output Return Loss, Gain, & Reverse Isolation vs Frequency

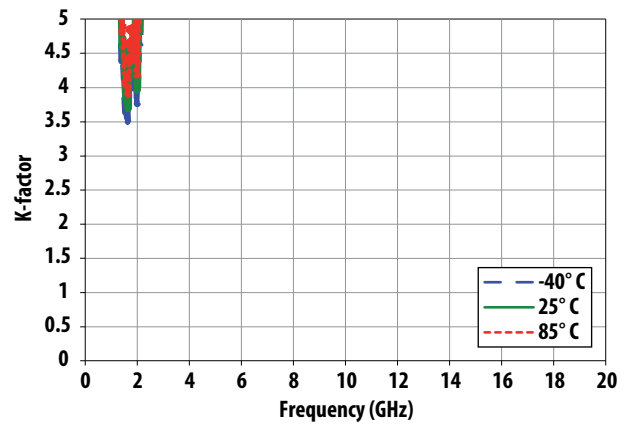


Figure 14. K-factor vs Frequency and Temperature

## MGA-13316 Typical Performance in Demoboard for 2.5GHz

$T_A = 25^\circ\text{C}$ ,  $V_{dd1} = 5.0\text{V}$ ,  $V_{dd2} = 5.0\text{V}$ ,  $I_{dd1} = 53\text{mA}$ ,  $I_{dd2} = 116\text{mA}$

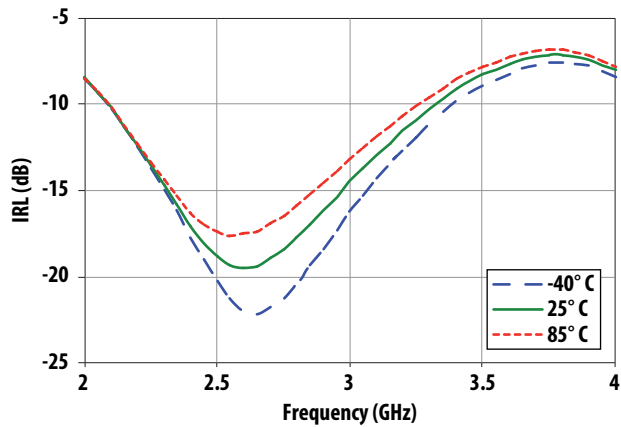


Figure 15. IRL vs Frequency and Temperature

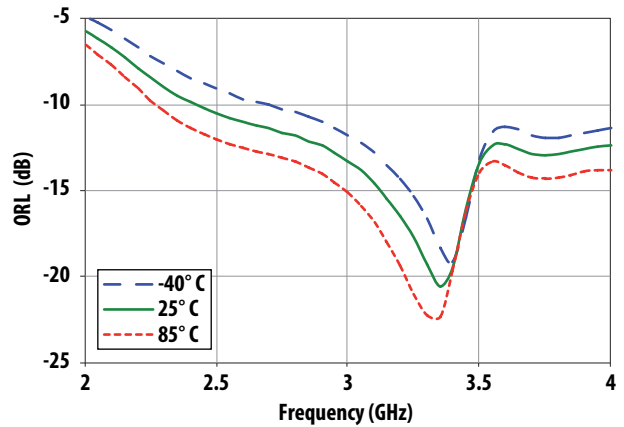


Figure 16. ORL vs Frequency and Temperature

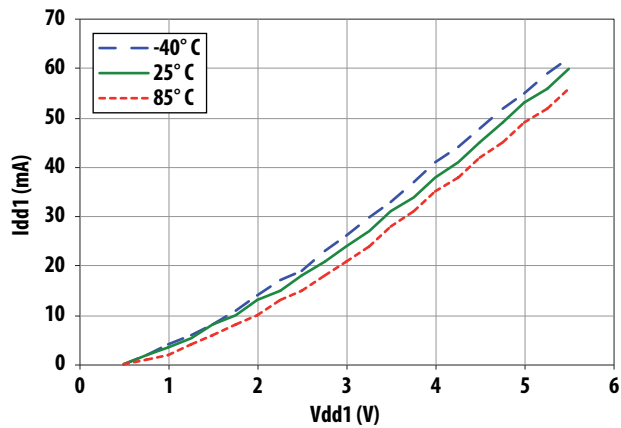


Figure 17. Idd1 vs Vdd1 and Temperature

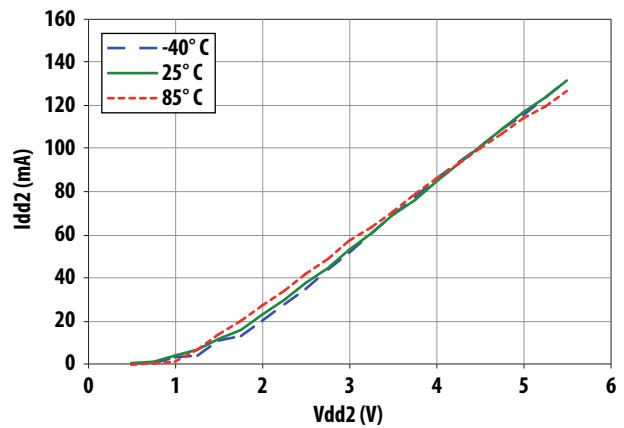


Figure 18. Idd2 vs Vdd2 and Temperature

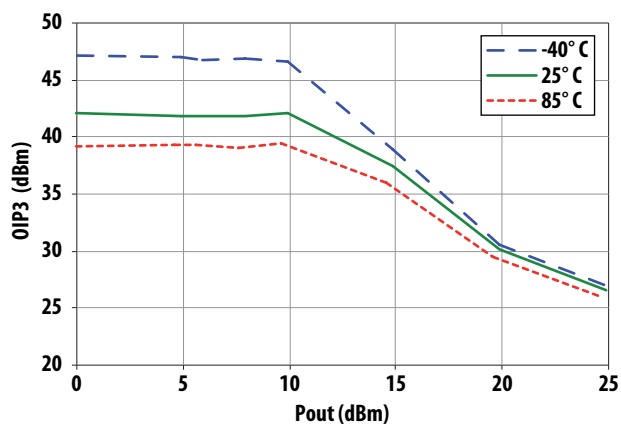


Figure 19. OIP3 vs Output Power and Temperature at 2.5 GHz

**MGA-13316 Q1 Typical Scattering Parameters, Vdd1 = 5 V, Idd1 = 50 mA**

| Freq<br>GHz | S11    |           | S21     |           | S12    |           | S22    |           |
|-------------|--------|-----------|---------|-----------|--------|-----------|--------|-----------|
|             | Mag.   | Ang.      | Mag.    | Ang.      | Mag.   | Ang.      | Mag.   | Ang.      |
| 0.1         | 0.9476 | -12.2632  | 34.5057 | 160.7532  | 0.0047 | 11.7831   | 0.5890 | -19.3593  |
| 0.5         | 0.7044 | -47.1391  | 21.9467 | 122.3275  | 0.0042 | 57.5859   | 0.3650 | -23.2918  |
| 0.9         | 0.5242 | -68.5640  | 15.4283 | 98.9990   | 0.0082 | 67.2825   | 0.3377 | -27.1103  |
| 1.0         | 0.4951 | -72.7375  | 14.2599 | 94.3046   | 0.0090 | 71.7130   | 0.3295 | -28.6361  |
| 1.5         | 0.3999 | -90.7648  | 10.3743 | 74.9007   | 0.0135 | 73.4180   | 0.2990 | -38.7699  |
| 1.7         | 0.3773 | -97.0091  | 9.3573  | 68.1636   | 0.0156 | 74.2662   | 0.2845 | -44.4387  |
| 1.9         | 0.3628 | -102.5217 | 8.5296  | 61.7988   | 0.0171 | 73.3113   | 0.2709 | -51.0121  |
| 2.0         | 0.3568 | -105.3332 | 8.1756  | 58.6806   | 0.0185 | 74.7631   | 0.2648 | -54.4426  |
| 2.5         | 0.3462 | -117.1978 | 6.7358  | 43.8914   | 0.0241 | 73.9083   | 0.2413 | -74.2707  |
| 3.0         | 0.3480 | -125.6487 | 5.7740  | 29.9534   | 0.0300 | 72.3617   | 0.2386 | -96.7672  |
| 4.0         | 0.3658 | -137.1290 | 4.5433  | 3.0393    | 0.0458 | 66.7425   | 0.2715 | -139.7999 |
| 5.0         | 0.4085 | -153.2931 | 3.7927  | -25.8685  | 0.0650 | 56.1926   | 0.3428 | 176.4105  |
| 6.0         | 0.4702 | -176.1741 | 3.1671  | -57.5236  | 0.0866 | 40.6304   | 0.4772 | 127.2305  |
| 7.0         | 0.5235 | 160.4259  | 2.4253  | -89.2923  | 0.1022 | 22.5904   | 0.6697 | 93.7068   |
| 8.0         | 0.5567 | 142.9302  | 1.7724  | -117.9984 | 0.1099 | 6.0176    | 0.7884 | 71.4942   |
| 9.0         | 0.5652 | 128.2157  | 1.3338  | -143.5986 | 0.1175 | -9.2834   | 0.8651 | 53.9815   |
| 10.0        | 0.5764 | 112.2267  | 1.0609  | -169.8542 | 0.1303 | -26.3840  | 0.9135 | 33.9307   |
| 11.0        | 0.6110 | 94.0142   | 0.8212  | 162.0386  | 0.1380 | -46.0835  | 0.9153 | 9.5407    |
| 12.0        | 0.6359 | 74.4400   | 0.5789  | 137.9581  | 0.1302 | -62.5887  | 0.9319 | -4.7026   |
| 13.0        | 0.6909 | 61.5493   | 0.4055  | 119.0601  | 0.1192 | -74.3752  | 1.0008 | -6.4422   |
| 14.0        | 0.7561 | 55.5470   | 0.2934  | 102.1102  | 0.1122 | -85.6306  | 0.9811 | -8.8053   |
| 15.0        | 0.7687 | 49.0968   | 0.2247  | 82.2629   | 0.1099 | -100.4473 | 0.9427 | -20.3955  |
| 16.0        | 0.7709 | 25.7908   | 0.1633  | 55.9850   | 0.0967 | -125.5991 | 0.9539 | -37.7405  |
| 17.0        | 0.7710 | -16.0165  | 0.0954  | 39.5175   | 0.0439 | -147.7475 | 0.9593 | -46.7449  |
| 18.0        | 0.1200 | -24.7870  | 0.1282  | 27.9369   | 0.1451 | -96.9288  | 0.9194 | -57.6137  |
| 19.0        | 0.6142 | 21.6007   | 0.0644  | 10.0400   | 0.1137 | -170.9741 | 0.9265 | -68.6984  |
| 20.0        | 0.6121 | -12.3158  | 0.0749  | -32.7215  | 0.0722 | -140.1984 | 0.8915 | -78.5449  |

**MGA-13316 Q1 Typical Noise Parameters, Vdd1= 5 V, Idd1 = 50 mA**

| Freq<br>GHz | NFMin<br>dB | GammaOpt<br>mag | PhiOpt<br>deg | Rn/50 |
|-------------|-------------|-----------------|---------------|-------|
| 1.50        | 0.46        | 0.29            | 43.20         | 0.06  |
| 1.70        | 0.45        | 0.30            | 63.30         | 0.06  |
| 1.90        | 0.58        | 0.27            | 66.60         | 0.06  |
| 2.00        | 0.54        | 0.26            | 84.50         | 0.06  |
| 2.20        | 0.53        | 0.21            | 88.20         | 0.05  |
| 2.50        | 0.60        | 0.17            | 112.90        | 0.05  |
| 2.70        | 0.67        | 0.17            | 160.50        | 0.04  |
| 2.90        | 0.68        | 0.17            | 157.80        | 0.05  |
| 3.30        | 0.68        | 0.24            | -172.20       | 0.05  |
| 3.50        | 0.72        | 0.29            | 170.90        | 0.05  |
| 4.00        | 0.78        | 0.40            | 179.40        | 0.03  |

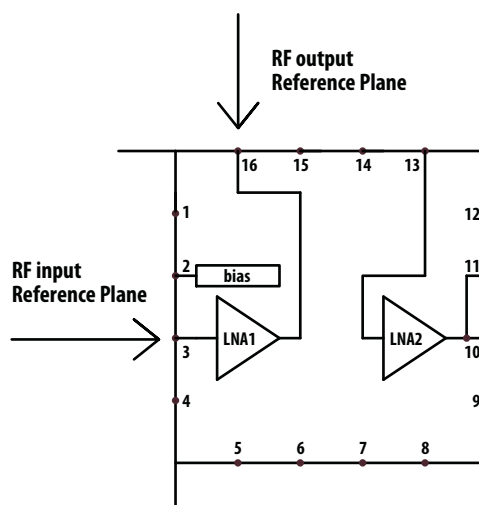


Figure 20.

Notes: Measurements are made on 10 mils Rogers R04350 TRL Board. Figure 20 shows the input and output reference plane for Q1.

**MGA-13316 Q2 Typical Scattering Parameters, Vdd2 = 5 V, Idd2 = 116 mA**

| Freq<br>GHz | S11    |          | S21    |           | S12    |          | S22    |           |
|-------------|--------|----------|--------|-----------|--------|----------|--------|-----------|
|             | Mag.   | Ang.     | Mag.   | Ang.      | Mag.   | Ang.     | Mag.   | Ang.      |
| 0.1         | 0.8724 | 172.0353 | 0.1413 | -112.7154 | 0.0036 | 65.3831  | 0.8292 | 174.6930  |
| 0.5         | 0.8474 | 140.1052 | 1.5607 | -80.8803  | 0.0085 | 97.0757  | 0.7645 | 149.3051  |
| 0.9         | 0.6825 | 97.0606  | 5.6920 | -123.6645 | 0.0248 | 87.8937  | 0.5485 | 118.0392  |
| 1.0         | 0.5865 | 84.1827  | 7.0773 | -139.4571 | 0.0314 | 80.4474  | 0.4499 | 109.9115  |
| 1.5         | 0.1423 | 121.2420 | 9.6368 | 140.8404  | 0.0481 | 30.1766  | 0.2033 | 151.0622  |
| 1.7         | 0.2352 | 127.2011 | 9.0963 | 118.4115  | 0.0478 | 15.1099  | 0.2422 | 152.5525  |
| 1.9         | 0.2848 | 115.3972 | 8.5861 | 99.9577   | 0.0472 | 3.1298   | 0.2483 | 147.5974  |
| 2.0         | 0.2958 | 108.3752 | 8.3840 | 91.7925   | 0.0461 | -2.5589  | 0.2433 | 145.1175  |
| 2.5         | 0.2456 | 63.8963  | 7.8317 | 54.1684   | 0.0418 | -32.2292 | 0.1619 | 141.3232  |
| 3.0         | 0.1638 | -29.4140 | 7.7532 | 16.1359   | 0.0323 | -73.1124 | 0.1204 | -176.1177 |
| 4.0         | 0.6964 | 177.8403 | 6.1643 | -73.8377  | 0.0279 | 140.3060 | 0.2679 | 173.3761  |
| 5.0         | 0.9402 | 119.6485 | 2.6318 | -158.0828 | 0.0383 | 76.6959  | 0.2333 | -125.8671 |
| 6.0         | 0.9483 | 86.9076  | 0.8464 | 145.2466  | 0.0472 | 52.2933  | 0.4868 | -153.4601 |
| 7.0         | 0.9468 | 63.6793  | 0.3393 | 111.7191  | 0.0506 | 33.7091  | 0.4904 | -173.3753 |
| 8.0         | 0.9714 | 46.0950  | 0.1877 | 77.8816   | 0.0547 | 20.9620  | 0.5367 | 176.2551  |
| 9.0         | 0.9301 | 27.7972  | 0.1149 | 41.1122   | 0.0547 | 4.2118   | 0.6319 | 162.5823  |
| 10.0        | 0.8606 | 17.9019  | 0.0705 | 16.9907   | 0.0470 | -5.3221  | 0.7125 | 149.2561  |
| 11.0        | 0.9721 | 14.0126  | 0.0539 | 1.3504    | 0.0437 | -13.1746 | 0.7438 | 137.7980  |
| 12.0        | 0.9895 | 1.8829   | 0.0390 | -18.8103  | 0.0355 | -30.2990 | 0.7126 | 120.6736  |
| 13.0        | 0.9504 | -6.3036  | 0.0253 | -32.1307  | 0.0244 | -43.2860 | 0.7159 | 94.6400   |
| 14.0        | 0.9976 | -15.2859 | 0.0102 | -36.7154  | 0.0105 | -59.8362 | 0.7653 | 74.7833   |
| 15.0        | 1.0065 | -24.3699 | 0.0098 | 103.9489  | 0.0089 | 122.0001 | 0.7641 | 64.9085   |
| 16.0        | 0.9938 | -32.7298 | 0.0351 | 103.0363  | 0.0351 | 107.6657 | 0.7375 | 50.6656   |
| 17.0        | 0.9802 | -44.7104 | 0.0714 | 86.2511   | 0.0713 | 88.0832  | 0.7318 | 25.3774   |
| 18.0        | 0.9647 | -57.3892 | 0.1406 | 55.3523   | 0.1406 | 55.7281  | 0.7347 | -9.4297   |
| 19.0        | 0.9158 | -61.5557 | 0.1291 | -26.7187  | 0.1285 | -26.7652 | 0.2011 | -33.2109  |
| 20.0        | 0.9422 | -62.6624 | 0.1319 | 50.0625   | 0.1307 | 49.6143  | 0.5420 | 4.8232    |

**MGA-13316 Q2 Typical Noise Parameters, Vdd2 = 5 V, Idd2 = 116 mA**

| Freq<br>GHz | NFMin<br>dB | GammaOpt<br>mag | PhiOpt<br>deg | Rn/50 |
|-------------|-------------|-----------------|---------------|-------|
| 1.50        | 2.17        | 0.31            | -87.10        | 0.30  |
| 1.70        | 2.11        | 0.21            | -89.90        | 0.27  |
| 1.90        | 2.09        | 0.21            | -95.10        | 0.25  |
| 2.00        | 2.00        | 0.19            | -94.70        | 0.24  |
| 2.20        | 1.93        | 0.16            | -105.80       | 0.23  |
| 2.50        | 2.06        | 0.14            | -112.40       | 0.22  |
| 2.70        | 2.08        | 0.16            | -129.40       | 0.21  |
| 2.90        | 2.08        | 0.15            | -148.20       | 0.20  |
| 3.50        | 2.15        | 0.34            | 178.80        | 0.13  |
| 4.00        | 2.42        | 0.57            | -163.60       | 0.09  |

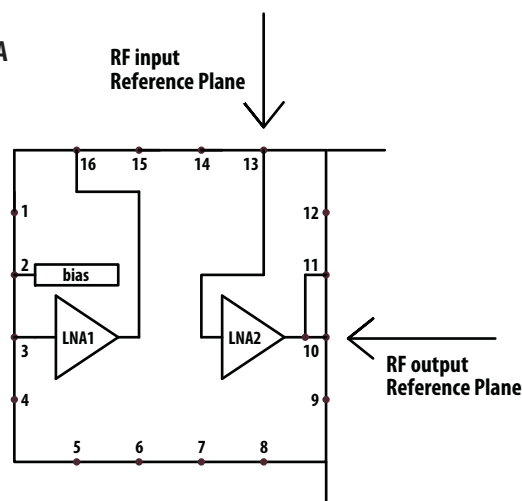
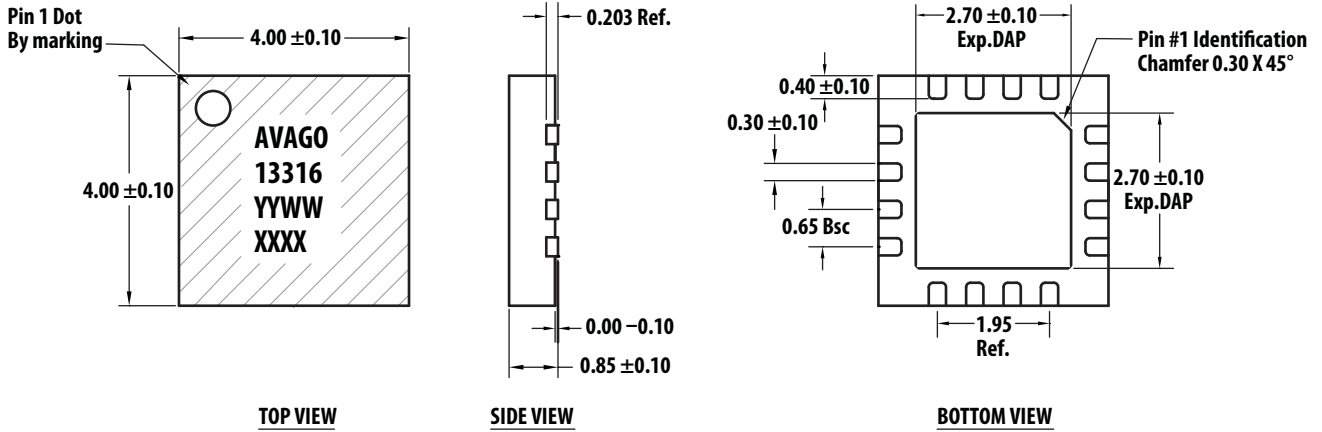


Figure 21.

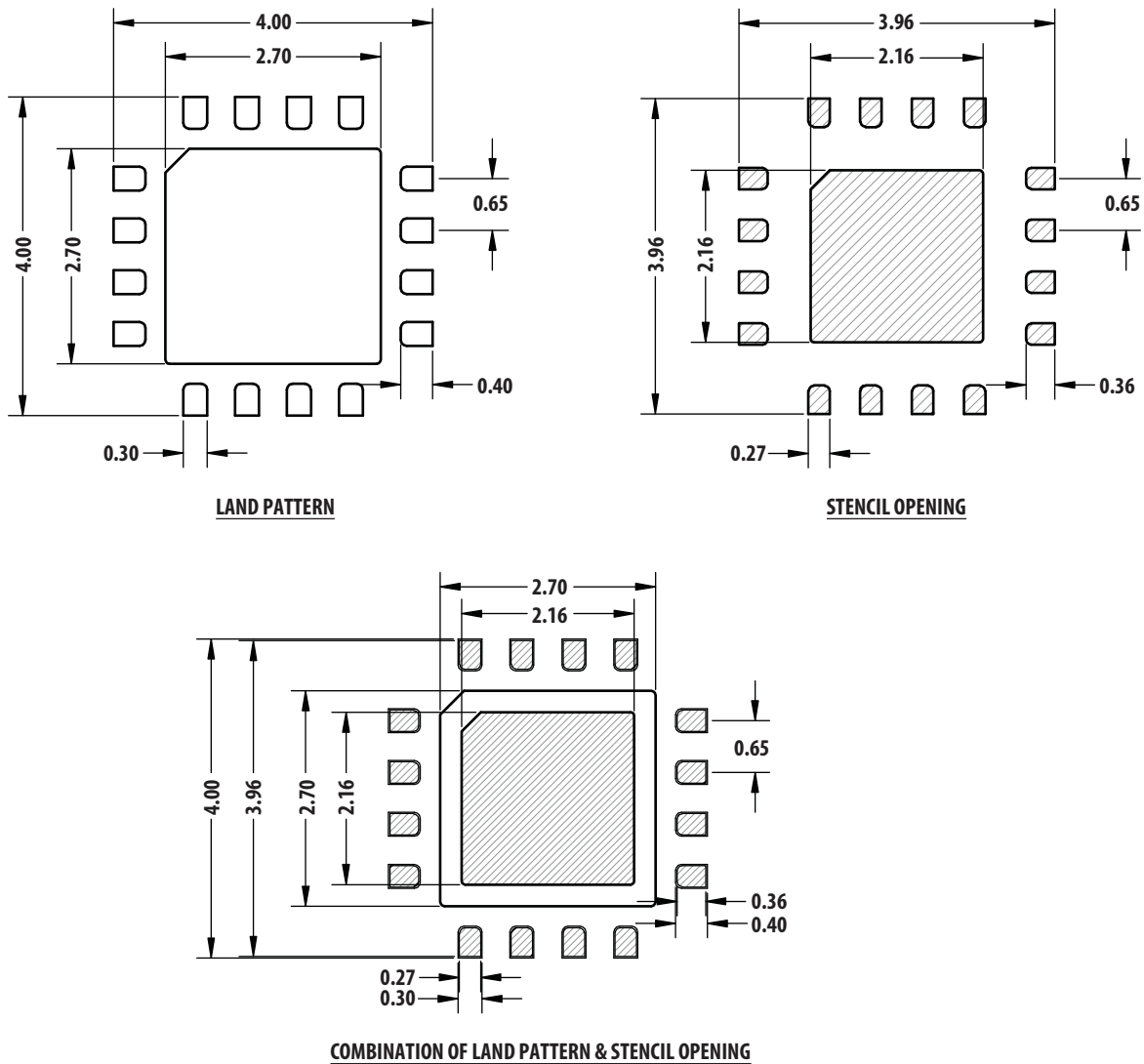
Notes: Measurements are made on 10 mils Rogers R04350 TRL Board. Figure 21 shows the input and output reference plane for Q2.



## Package Dimensions



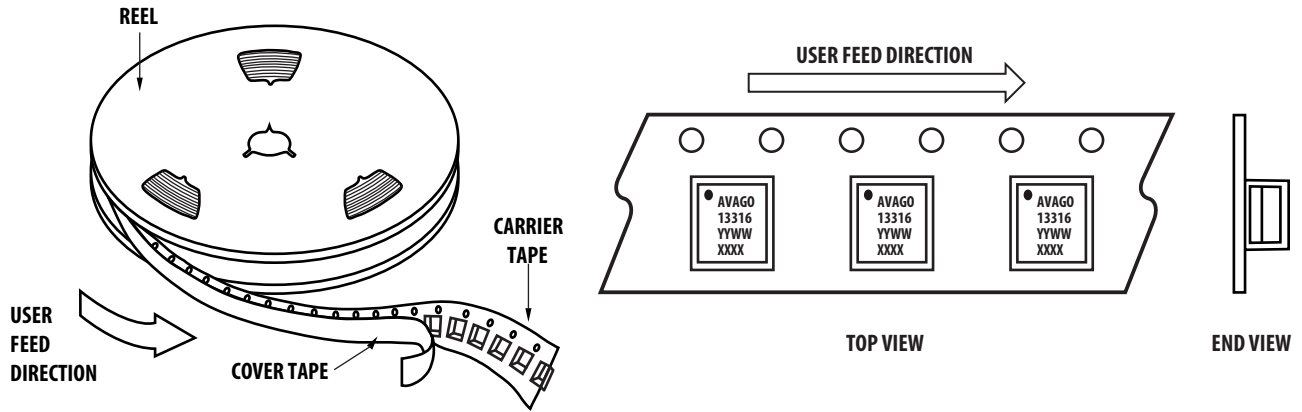
## PCB Land Patterns and Stencil Design



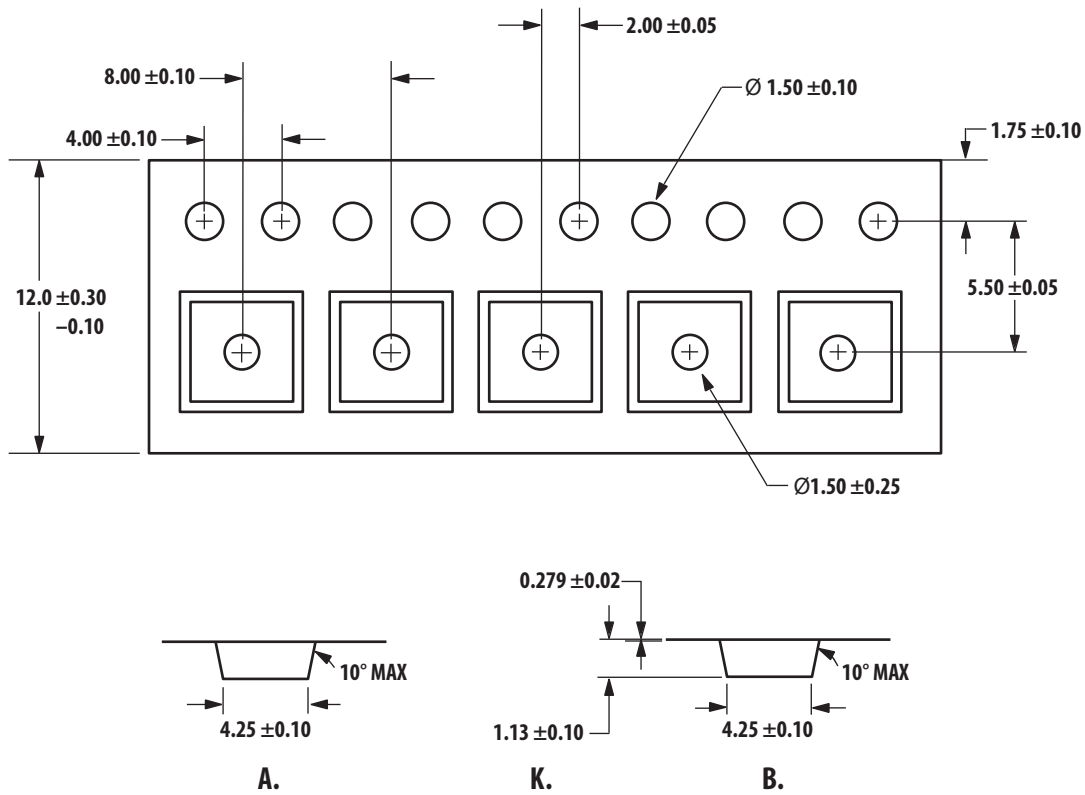
### Notes:

1. All dimensions are in millimeters.
2. 4 mil stencil thickness recommended.

### Device Orientation



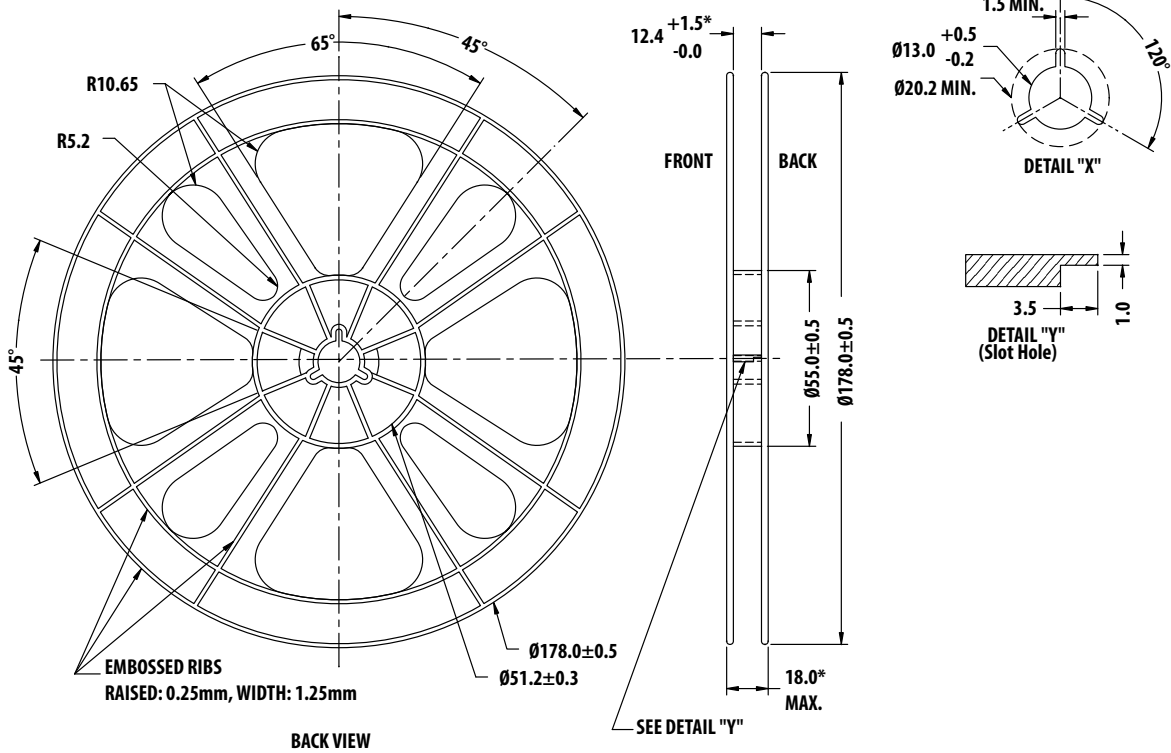
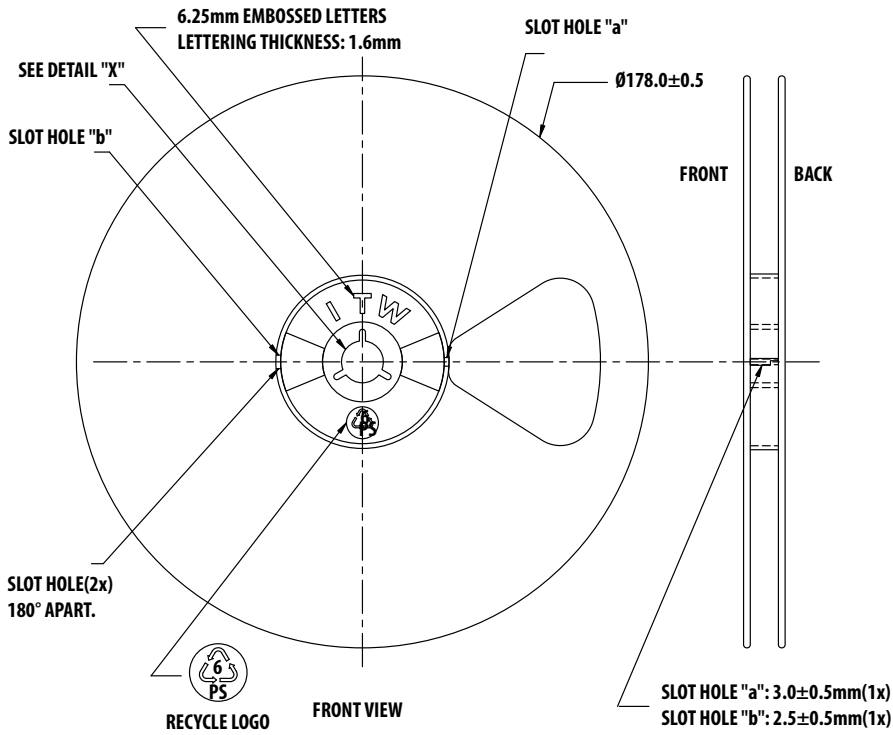
### Tape Dimensions



### Part Number Ordering Information

| Part Number    | No. of Devices | Container      |
|----------------|----------------|----------------|
| MGA-13316-TR1G | 1000           | 7" Reel        |
| MGA-13316-BLKG | 100            | antistatic bag |

# Reel Dimensions (7 inch reel)



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AV02-3239EN - December 23, 2011

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