

# MGA-655T6

## Low Noise Amplifier with Bypass Mode in Low Profile Package



### Data Sheet

#### Description

Avago Technologies' MGA-655T6 is an economical, easy-to-use GaAs MMIC Low Noise Amplifier (LNA) with Bypass mode. The LNA has low noise and high linearity achieved through the use of Avago Technologies' proprietary 0.5  $\mu\text{m}$  GaAs Enhancement-mode pHEMT process. The Bypass mode enables the LNA to be bypassed during high input signal power and reduce current consumption. It is housed in a low profile 2 x 1.3 x 0.4 mm 6-pin Ultra Thin Package. The compact footprint and low profile coupled with low noise, high linearity make the MGA-655T6 an ideal choice as a low noise amplifier for mobile and CPE receivers in the WiMax and WLL (2.5-4) GHz band.

#### Component Image

2.0 x 1.3 x 0.4 mm<sup>3</sup> 6-Lead Ultra Thin Package



Note:

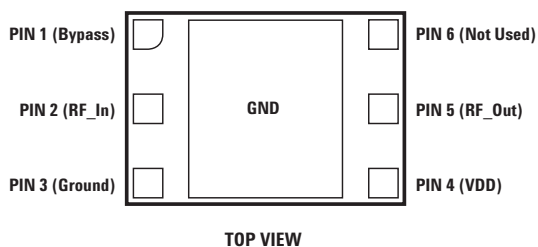
Package marking provides orientation and identification

"5F" = Product Code

"Y" = Year of Manufacture

"M" = Month of Manufacture

#### Pin Configuration



**Attention: Observe precautions for handling electrostatic sensitive devices.**

ESD Machine Model = 50 V

ESD Human Body Model = 200 V

Refer to Avago Technologies Application Note A004R:  
*Electrostatic Discharge, Damage and Control.*

#### Features

- Low nominal operating current
- Simple input/output matching network
- Broadband operation (2.5 – 4) GHz
- Adjustable bias current for gain/IP3 optimization
- Very low noise figure
- Bypass mode using a single pin
- Low current consumption in bypass mode, <100  $\mu\text{A}$
- Fully matched to 50 ohm in bypass mode
- High Linearity in LNA and bypass mode
- GaAs E-pHEMT Technology<sup>[1]</sup>
- Low profile package size: 2.0 x 1.3 x 0.4 mm<sup>3</sup>
- Excellent uniformity in product specifications
- Tape-and-reel packaging option available

#### Typical Performance

- 3.5 GHz;  $V_{\text{dd}} = 3\text{ V}$ ,  $V_{\text{bypass}} = 2.7\text{ V}$  (typ.),  $I_{\text{ds}} = 10\text{ mA}$  (typ.)
- 14.7 dB gain
- 1.2 dB noise figure
- +5.5 dBm Input IP3
- -2 dBm input power at 1 dB gain compression
- 4.2 dB insertion loss in bypass mode
- 19 dBm IIP3 in bypass mode (pin = -20 dBm)
- <104  $\mu\text{A}$  current consumption in bypass & shutdown mode

#### Applications

- Low noise amplifier for Wimax, Wireless Local Loop
- Other ultra low noise applications in the (2.5 – 4) GHz band

Note:

1. Enhancement mode technology employs positive  $V_{\text{gs}}$ , thereby eliminating the need of negative gate voltage associated with conventional depletion mode devices.

## Absolute Maximum Rating<sup>[1]</sup> $T_A = 25^\circ\text{C}$

| Symbol       | Parameter                              | Units            | Absolute Max. |
|--------------|----------------------------------------|------------------|---------------|
| $V_{dd}$     | Device Voltage, RF Output to Ground    | V                | 4             |
| $V_{bypass}$ | Control Voltage                        | V                | 4             |
| $P_{in,max}$ | CW RF Input Power                      | dBm              | +14           |
| $P_{diss}$   | Total Power Dissipation <sup>[3]</sup> | mW               | 66            |
| $T_j$        | Junction Temperature                   | $^\circ\text{C}$ | 150           |
| $T_{STG}$    | Storage Temperature                    | $^\circ\text{C}$ | -65 to 150    |

## Thermal Resistance<sup>[2,3]</sup>

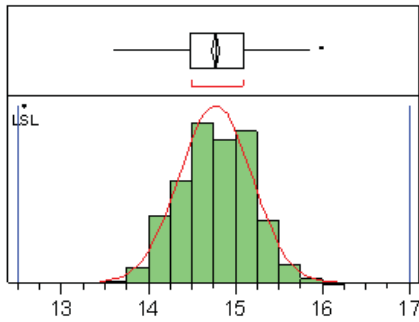
( $V_{dd} = 3.0\text{ V}$ ,  $I_d = 10\text{ mA}$ ),  $\theta_{jc} = 75^\circ\text{C/W}$

### Notes:

1. Operation of this device in excess of any of these limits may cause permanent damage.
2. Thermal resistance measured using Infra-Red Measurement Technique.
3. For module substrate temperature,  $T_{sub}$ ,  $>94^\circ\text{C}$  derate the device power at 50 mW per  $^\circ\text{C}$  rise in board (module belly) temperature.

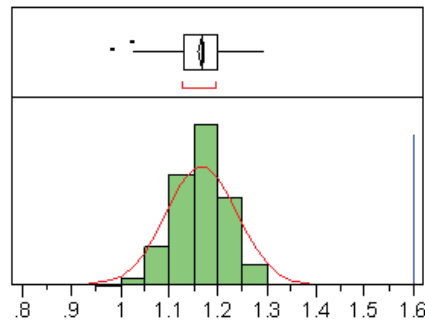
## Product Consistency Distribution Charts

**Process Capability for Gain**  
LSL=12.8, Nominal=14.7, USL=17



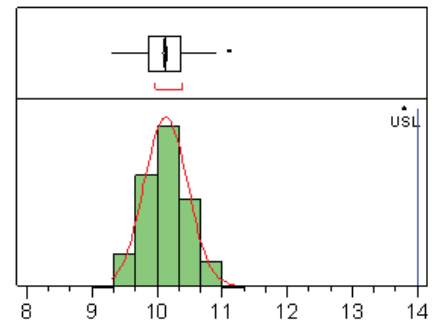
**Figure 1. Gain @ 3.5 GHz,  $V_d=3\text{V}$ ,  $V_{bypass}=2.7\text{V}$**

**Process Capability for NF**  
Nominal=1.2, USL=1.6



**Figure 2. NF @ 3.5 GHz,  $V_d=3\text{V}$ ,  $V_{bypass}=2.7\text{V}$**

**Process Capability for  $I_{ds}$**   
Nominal=10.1, USL=14



**Figure 3.  $I_{ds}$  @ 3.5 GHz,  $V_d=3\text{V}$ ,  $V_{bypass}=2.7\text{V}$**

### Note:

Distribution data sample size is 500 samples taken from 3 different wafers and 3 different lots. Future wafers allocated to this product may have nominal values anywhere between the upper and lower limits.

## Electrical Specifications

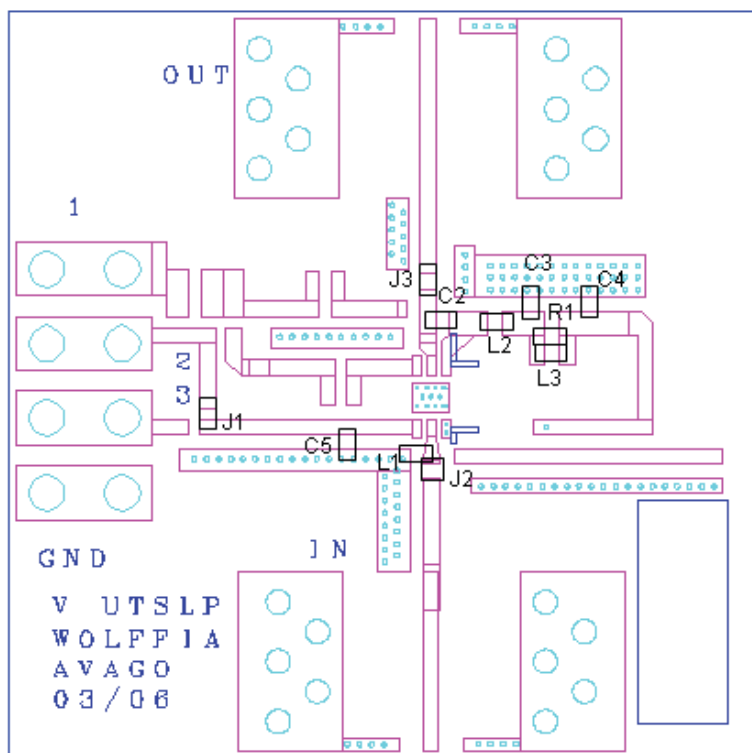
$T_A = 25^\circ\text{C}$ ,  $V_{dd} = 3\text{ V}$ ,  $V_{bypass} = 2.7\text{ V}$ ,  $I_{ds} = 10\text{ mA}$  (typ), RF measurement at 3.5 GHz, measured on demo board (see Fig. 4) unless otherwise specified.

| Symbol                | Parameter and Test Condition                    | Units | Min. | Typ.  | Max. |
|-----------------------|-------------------------------------------------|-------|------|-------|------|
| Gain                  | Gain                                            | dB    | 12.8 | 14.7  | 17.0 |
| $I_d$                 | Bias Current                                    | mA    | -    | 10    | 14.0 |
| IIP3 [8]              | Input Third Order Intercept Point               | dBm   | -    | +5.5  | -    |
| NF [9]                | Noise Figure (Typ. $V_{bypass}=2.7\text{V}$ )   | dB    | -    | 1.2   | 1.6  |
| OP1dB                 | Output Power at 1dB Gain Compression            | dBm   | -    | +12   | -    |
| S11                   | Input Return Loss, 50Ω source                   | dB    | -    | -9    | -    |
| S22                   | Output Return Loss, 50Ω load                    | dB    | -    | -13.5 | -    |
| S12                   | Reverse Isolation                               | dB    | -    | -24.7 | -    |
| $ S_{21} ^2_{BYPASS}$ | Bypass Mode Loss ( $V_{bypass} = 0$ )           | dB    | -    | 4.2   | -    |
| IIP3 BYPASS           | Bypass Mode IIP3 (tested at -20dBm input Power) | dBm   | -    | + 19  | -    |
| $I_d$ BYPASS          | Bypass Mode current ( $V_{bypass} = 0$ )        | μA    | -    | 100   | -    |

Notes:

1. Measurements at 3.5 GHz obtained using demo board described in Figure 4, with component values on Figure 5.
2. 3.5 GHz IIP3 test condition:  $F_{RF1} = 3.50\text{ GHz}$ ,  $F_{RF2} = 3.505\text{ GHz}$  with input power of -20 dBm per tone.
3. Bypass Mode IIP3 test condition:  $F_{RF1} = 3.50\text{ GHz}$ ,  $F_{RF2} = 3.505\text{ GHz}$  with input power of -20 dBm per tone.

## Demo Board Layout



| Part     | Size | Value   | P/N                   |
|----------|------|---------|-----------------------|
| L1       | 0402 | 1.2 nH  | LLP1005 Series (TOKO) |
| L2       | 0402 | 1.0 nH  | LLP1005 Series (TOKO) |
| L3       | 0402 | 10.0 nH | LLP1005 Series (TOKO) |
| C2       | 0402 | 4.7 pF  | C1005C0G1H4R7C (TDK)  |
| C3       | 0402 | 4.7 pF  | C1005C0G1H4R7C (TDK)  |
| C4       | 0402 | 0.1 uF  | MCH155 Series (Rohm)  |
| C5       | 0402 | 1000 pF | MCH155 Series (Rohm)  |
| R1       | 0402 | 5.1 ohm | MCR Series (Rohm)     |
| J1*      | 0402 | 0 ohm   | RK73Z1E000 (KOA)      |
| J2*, J3* |      |         | Copper Foil           |

\*Jumpers indicated in the demo board drawing are not needed in actual application board; this is because generic demo boards were used for development.

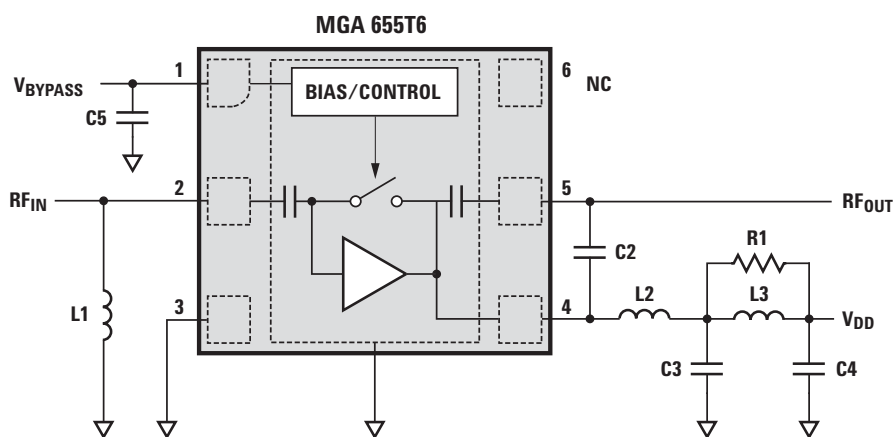
Figure 4. Demo board layout diagram\*

### \*Application Notes:

- Performance in a specified frequency band can be optimized by changing component values in the demoboard above to suit the application at that frequency. The following graphs show components used to demonstrate performance at the (3 - 4) GHz band.
- Operational Logic of Bypass pin (Pin 1):
  - Normal LNA operation: [2 to 2.7] volt,
  - Bypass mode: [0 to 0.2] volt

Pin 1 voltage in LNA mode can be varied to enable the LNA bias current to be adjusted.

## Demo Board Schematic for 3.5 GHz Application



### Notes:

- L1 is an input matching inductor.
- L2 and C2 form the output matching network.
- R1&L3 is a network that isolates the measurement demoboard from external disturbances. C4 and C5 migrate the effect of external noise pickup on the V<sub>dd</sub> and V<sub>bypass</sub> lines. These components are not required in actual operation.
- C3 is a RF bypass capacitor.

Figure 5. Demo board schematic diagram

## MGA-655T6 Typical Performance (3.5 GHz Match)

$T_A = +25^\circ\text{C}$ ,  $V_{dd} = 3\text{ V}$ ,  $I_{ds} = 10\text{ mA}$  ( $V_{bypass} = 2.7\text{ V}$ ),

RF measurement at 3. GHz, input signal = CW unless stated otherwise.

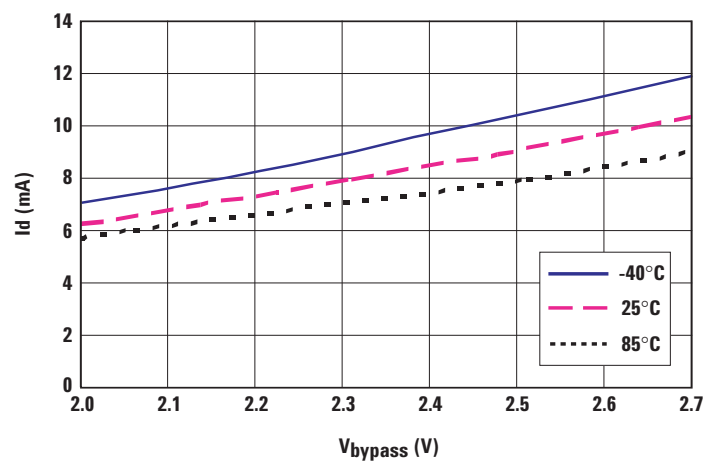


Figure 6.  $I_d$  vs.  $V_{bypass}$  vs. temperature ( $V_{dd} = 3\text{ V}$ )

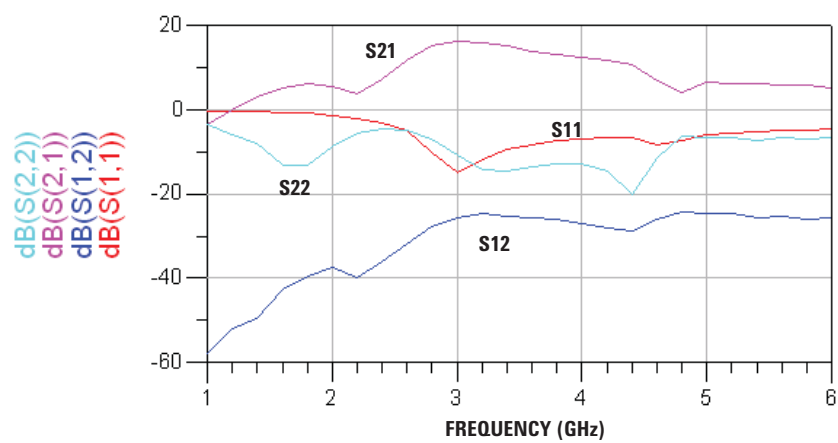


Figure 7. LNA mode  $S_{21}$ ,  $S_{11}$ ,  $S_{22}$ ,  $S_{12}$  vs. frequency

## LNA Mode Plots (3.5 GHz Match); $V_{dd} = 3\text{ V}$

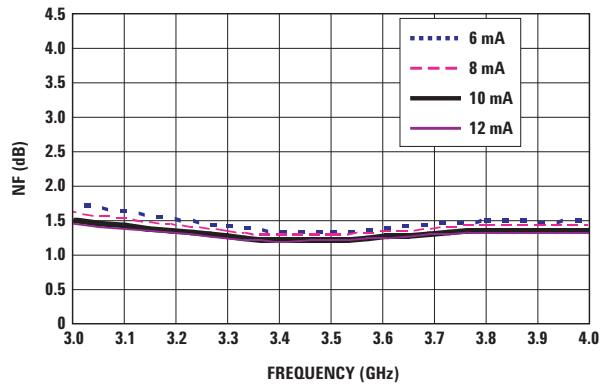


Figure 8. LNA mode noise figure vs. frequency vs  $I_d$

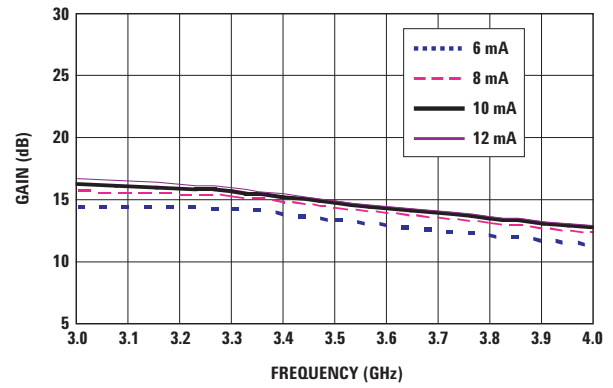


Figure 9. LNA mode gain vs. frequency vs.  $I_d$

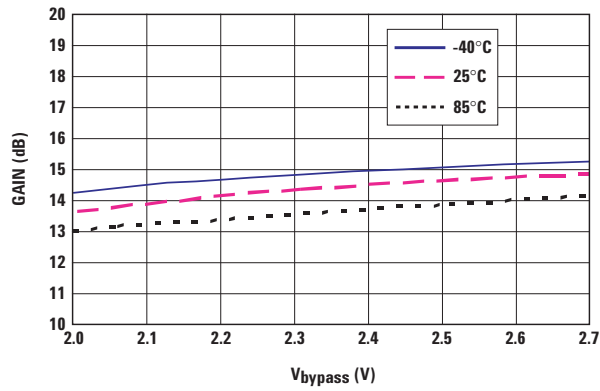


Figure 10. LNA mode gain vs.  $V_{bypass}$  vs. temperature

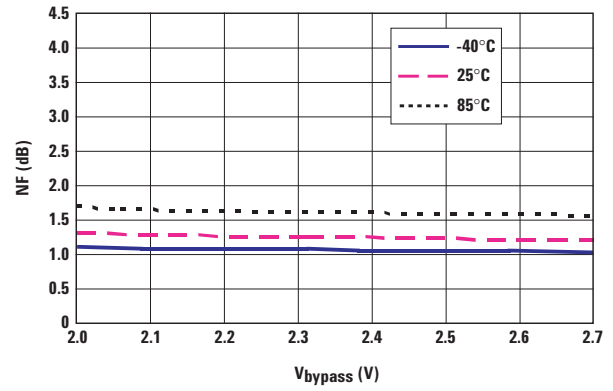


Figure 11. LNA noise figure vs.  $V_{bypass}$  vs. Temperature

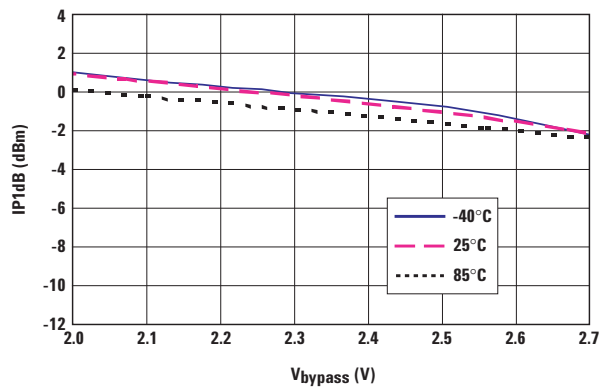


Figure 12. LNA mode IP1dB vs.  $V_{bypass}$  vs. temperature

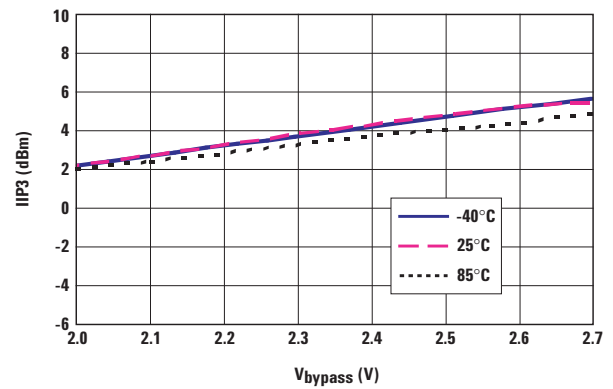


Figure 13. LNA mode IIP3 vs.  $V_{bypass}$  vs. temperature

## Bypass Mode Plots (3.5 GHz match) ( $V_{dd} = 3\text{ V}$ ; $V_{bypass} = 0\text{ V}$ )

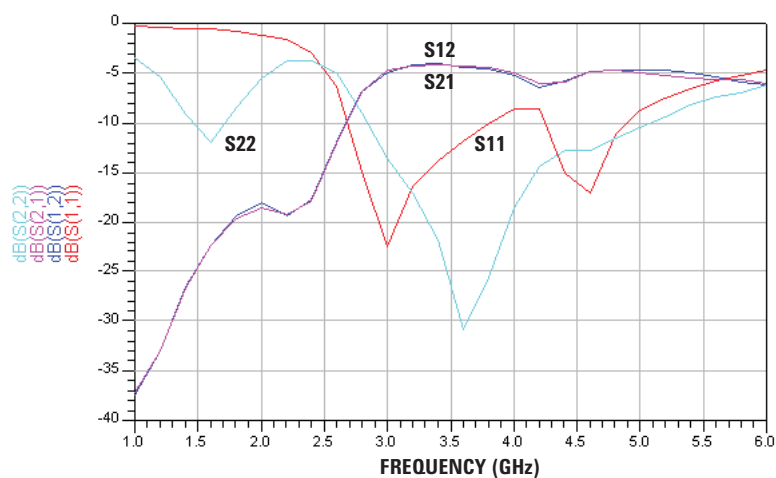


Figure 14. Bypass mode S21, S11, S22, S12 vs. frequency

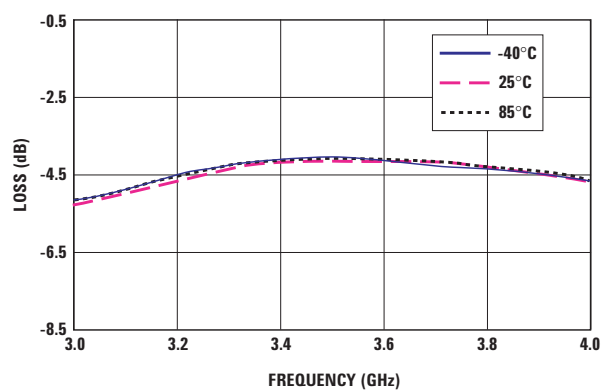


Figure 15. Bypass mode loss vs. frequency vs. temperature

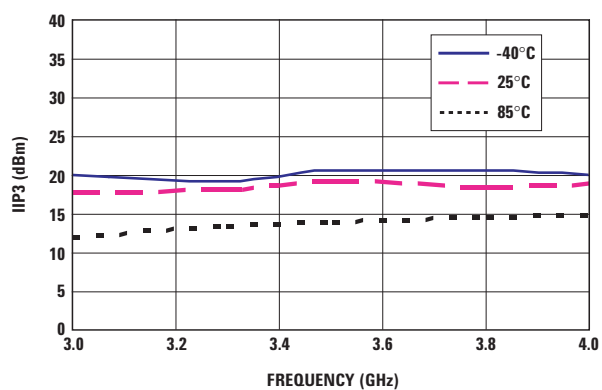


Figure 16. Bypass mode IIP3 vs. frequency vs. temperature

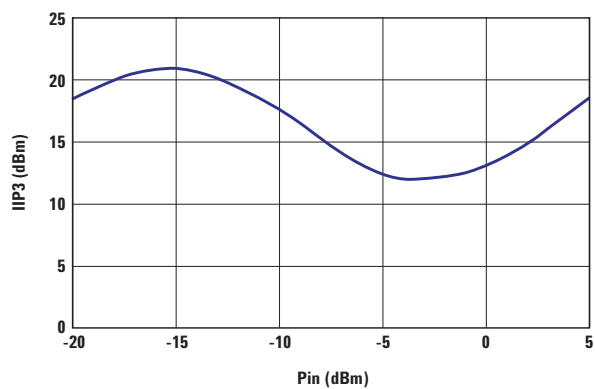
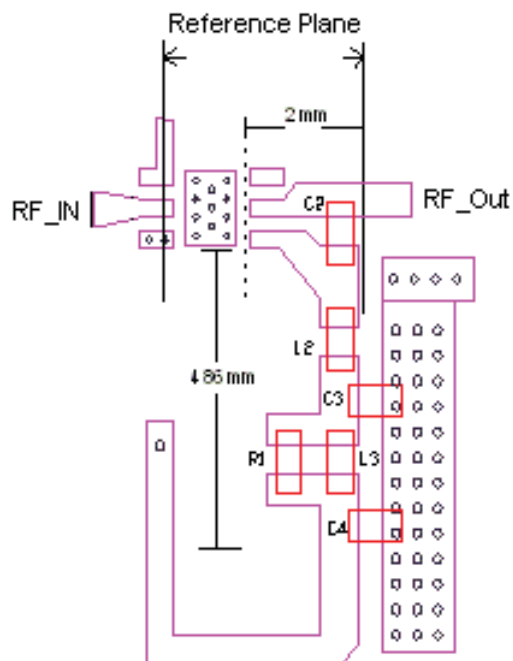


Figure 17. Bypass mode IIP3 vs. input power

## Test Circuit for S Parameters Measurement



| Part | Size | Value   | P/N                   |
|------|------|---------|-----------------------|
| L2   | 0402 | 1.0 nH  | LLP1005Series (TOKO)  |
| L3   | 0402 | 10.0 nH | LLP1005 Series (TOKO) |
| R1   | 0402 | 5.1 ohm | MCR Series (Rohm)     |
| C2   | 0402 | 4.7 pF  | C1005C0G1H4R7C (TDK)  |
| C3   | 0402 | 4.7 pF  | C1005C0G1H4R7C (TDK)  |
| C4   | 0402 | 0.1 uF  | MCH155 Series (Rohm)  |

**Figure 18. S parameters test circuit on demo board**

\*PCB material is 10 mils Rogers RO4850.

Notes:

1. L2 and C2 form the output matching network.
2. R1&L3 is a network that isolates the measurement demoboard from external disturbances. C4 migrate the effect of external noise pickup on the  $V_{dd}$  and  $V_{bypass}$  lines. These components are not required in actual operation.
3. C3 is a RF bypass capacitor.

**MGA-655T6 LNA Mode Typical Scattering Parameters at 25°C,  $V_{dd} = 3\text{ V}$ ;  $V_{bypass} = 2.7\text{ V}$**

| Freq. (GHz) | MagS11 | AngS11  | MagS21 | AngS21  | MagS12 | AngS12 | MagS22 | AngS22  |
|-------------|--------|---------|--------|---------|--------|--------|--------|---------|
| 0.1         | 0.99   | -4.82   | 0.18   | -54.73  | 0.00   | 77.31  | 0.99   | -20.98  |
| 0.3         | 0.98   | -14.42  | 0.76   | -83.55  | 0.00   | 23.69  | 0.95   | -60.34  |
| 0.5         | 0.96   | -23.81  | 1.46   | -102.99 | 0.00   | 151.21 | 0.88   | -92.87  |
| 0.7         | 0.94   | -32.62  | 2.20   | -121.88 | 0.00   | 143.03 | 0.80   | -119.52 |
| 0.9         | 0.92   | -41.29  | 2.82   | -140.82 | 0.00   | 135.98 | 0.70   | -140.63 |
| 1.1         | 0.89   | -49.96  | 3.47   | -159.52 | 0.01   | 128.42 | 0.58   | -159.80 |
| 1.3         | 0.86   | -57.98  | 3.92   | -179.83 | 0.01   | 126.33 | 0.42   | -174.01 |
| 1.5         | 0.82   | -65.62  | 4.00   | 160.17  | 0.01   | 111.41 | 0.26   | -172.61 |
| 1.7         | 0.79   | -72.45  | 3.65   | 138.96  | 0.01   | 92.17  | 0.23   | -132.69 |
| 1.9         | 0.75   | -78.10  | 2.89   | 123.85  | 0.01   | 81.46  | 0.39   | -127.32 |
| 2.1         | 0.73   | -81.96  | 1.97   | 118.21  | 0.01   | 75.86  | 0.54   | -139.26 |
| 2.3         | 0.73   | -85.91  | 1.50   | 143.58  | 0.01   | 95.80  | 0.65   | -160.85 |
| 2.5         | 0.74   | -91.52  | 2.32   | 158.05  | 0.01   | 116.62 | 0.65   | 174.95  |
| 2.7         | 0.74   | -98.87  | 3.47   | 150.47  | 0.02   | 120.27 | 0.61   | 146.38  |
| 2.9         | 0.73   | -107.65 | 4.42   | 132.71  | 0.03   | 107.58 | 0.49   | 114.20  |
| 3.1         | 0.68   | -116.58 | 4.87   | 114.06  | 0.04   | 89.55  | 0.36   | 78.57   |
| 3.3         | 0.61   | -124.52 | 4.96   | 97.21   | 0.05   | 76.76  | 0.28   | 40.12   |
| 3.5         | 0.55   | -132.98 | 4.83   | 82.27   | 0.05   | 66.58  | 0.24   | 2.25    |
| 3.7         | 0.49   | -141.40 | 4.63   | 68.74   | 0.05   | 55.35  | 0.24   | -26.25  |
| 3.9         | 0.43   | -151.13 | 4.43   | 55.98   | 0.05   | 46.06  | 0.24   | -47.04  |
| 4.1         | 0.38   | -162.66 | 4.23   | 42.61   | 0.05   | 39.66  | 0.21   | -62.70  |
| 4.3         | 0.32   | -175.73 | 3.93   | 25.12   | 0.04   | 38.84  | 0.13   | -58.34  |
| 4.5         | 0.24   | -178.79 | 2.73   | -2.09   | 0.04   | 56.68  | 0.30   | -7.47   |
| 4.7         | 0.31   | -175.14 | 1.56   | 31.48   | 0.06   | 40.04  | 0.55   | -51.67  |
| 4.9         | 0.36   | 169.19  | 2.18   | 32.22   | 0.06   | 23.95  | 0.54   | -76.97  |
| 5.1         | 0.38   | 158.40  | 2.31   | 23.56   | 0.06   | 16.88  | 0.51   | -91.54  |
| 5.3         | 0.41   | 150.23  | 2.28   | 15.38   | 0.06   | 10.31  | 0.50   | -101.47 |
| 5.5         | 0.43   | 144.80  | 2.20   | 8.28    | 0.06   | 6.63   | 0.51   | -110.21 |
| 5.7         | 0.45   | 140.98  | 2.11   | 1.99    | 0.06   | 1.99   | 0.51   | -117.67 |
| 5.9         | 0.47   | 138.93  | 2.00   | -3.58   | 0.05   | -1.49  | 0.52   | -125.32 |
| 6           | 0.48   | 138.24  | 1.96   | -6.31   | 0.05   | -2.33  | 0.53   | -128.66 |

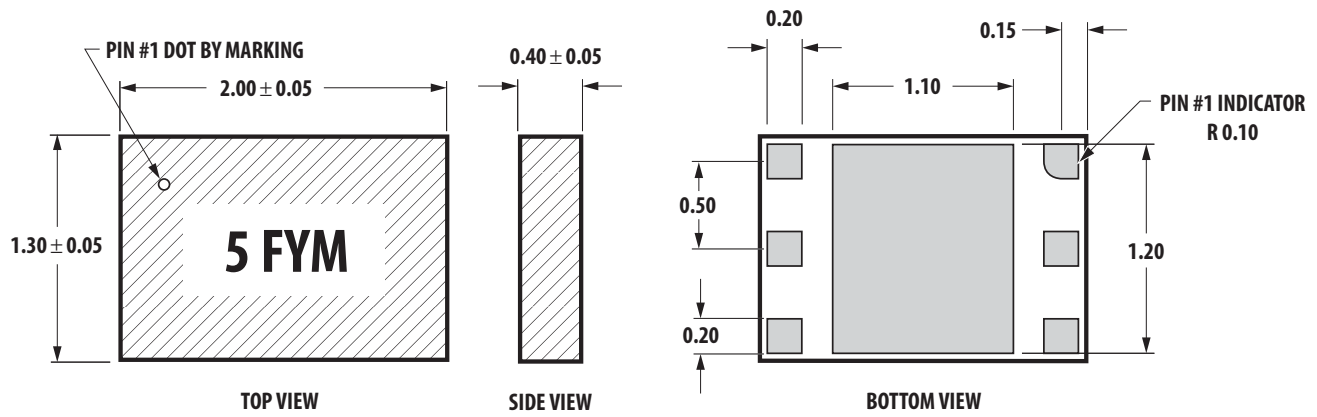
**MGA-655T6 Bypass Mode Typical Scattering Parameters at 25°C,  $V_{dd} = 3\text{ V}$ ;  $V_{bypass} = 0\text{ V}$**

| Freq. (GHz) | MagS11 | AngS11  | MagS21 | AngS21 | MagS12 | AngS12 | MagS22 | AngS22  |
|-------------|--------|---------|--------|--------|--------|--------|--------|---------|
| 0.1         | 0.97   | -7.28   | 0.01   | 142.97 | 0.01   | 139.82 | 0.99   | -22.80  |
| 0.3         | 0.91   | -17.17  | 0.05   | 89.30  | 0.05   | 89.03  | 0.94   | -63.94  |
| 0.5         | 0.86   | -25.14  | 0.07   | 59.94  | 0.07   | 59.38  | 0.88   | -96.63  |
| 0.7         | 0.84   | -32.80  | 0.07   | 44.98  | 0.07   | 45.21  | 0.81   | -122.42 |
| 0.9         | 0.82   | -40.43  | 0.06   | 45.87  | 0.06   | 45.70  | 0.71   | -142.61 |
| 1.1         | 0.80   | -48.28  | 0.06   | 66.44  | 0.06   | 66.09  | 0.60   | -160.38 |
| 1.3         | 0.78   | -55.55  | 0.10   | 75.80  | 0.10   | 76.00  | 0.44   | -172.95 |
| 1.5         | 0.76   | -62.57  | 0.14   | 69.63  | 0.14   | 70.17  | 0.29   | -171.26 |
| 1.7         | 0.74   | -68.26  | 0.18   | 54.17  | 0.18   | 53.81  | 0.28   | -137.48 |
| 1.9         | 0.73   | -73.76  | 0.19   | 38.40  | 0.18   | 38.92  | 0.43   | -129.99 |
| 2.1         | 0.73   | -79.18  | 0.16   | 26.89  | 0.15   | 26.88  | 0.58   | -142.11 |
| 2.3         | 0.74   | -85.61  | 0.11   | 33.02  | 0.11   | 33.66  | 0.67   | -161.21 |
| 2.5         | 0.73   | -94.09  | 0.13   | 76.20  | 0.13   | 76.50  | 0.66   | 173.91  |
| 2.7         | 0.69   | -102.95 | 0.25   | 80.80  | 0.25   | 80.80  | 0.57   | 147.09  |
| 2.9         | 0.62   | -110.91 | 0.39   | 64.78  | 0.39   | 64.63  | 0.38   | 113.30  |
| 3.1         | 0.54   | -115.41 | 0.48   | 45.90  | 0.48   | 45.74  | 0.20   | 68.94   |
| 3.3         | 0.48   | -118.05 | 0.53   | 29.54  | 0.53   | 29.38  | 0.12   | -4.82   |
| 3.5         | 0.44   | -122.23 | 0.55   | 16.01  | 0.55   | 15.66  | 0.18   | -57.68  |
| 3.7         | 0.40   | -129.27 | 0.56   | 4.25   | 0.56   | 3.85   | 0.23   | -80.22  |
| 3.9         | 0.34   | -140.30 | 0.56   | -6.59  | 0.56   | -6.57  | 0.27   | -92.92  |
| 4.1         | 0.23   | -155.48 | 0.54   | -16.23 | 0.54   | -16.47 | 0.30   | -101.53 |
| 4.3         | 0.10   | -110.11 | 0.50   | -21.91 | 0.50   | -22.06 | 0.33   | -109.33 |
| 4.5         | 0.28   | -107.58 | 0.52   | -24.79 | 0.52   | -25.18 | 0.36   | -117.51 |
| 4.7         | 0.33   | -132.89 | 0.54   | -32.18 | 0.54   | -32.62 | 0.37   | -123.92 |
| 4.9         | 0.35   | -151.60 | 0.54   | -40.12 | 0.54   | -40.45 | 0.39   | -130.16 |
| 5.1         | 0.37   | -166.62 | 0.53   | -47.41 | 0.52   | -47.10 | 0.41   | -136.46 |
| 5.3         | 0.39   | -178.39 | 0.51   | -53.78 | 0.51   | -53.41 | 0.44   | -142.63 |
| 5.5         | 0.41   | 173.20  | 0.49   | -59.62 | 0.49   | -59.08 | 0.47   | -149.13 |
| 5.7         | 0.44   | 166.81  | 0.48   | -64.30 | 0.48   | -64.19 | 0.49   | -155.36 |
| 5.9         | 0.47   | 162.70  | 0.46   | -68.22 | 0.46   | -68.22 | 0.52   | -162.14 |
| 6           | 0.48   | 161.30  | 0.45   | -70.39 | 0.46   | -70.11 | 0.53   | -165.23 |

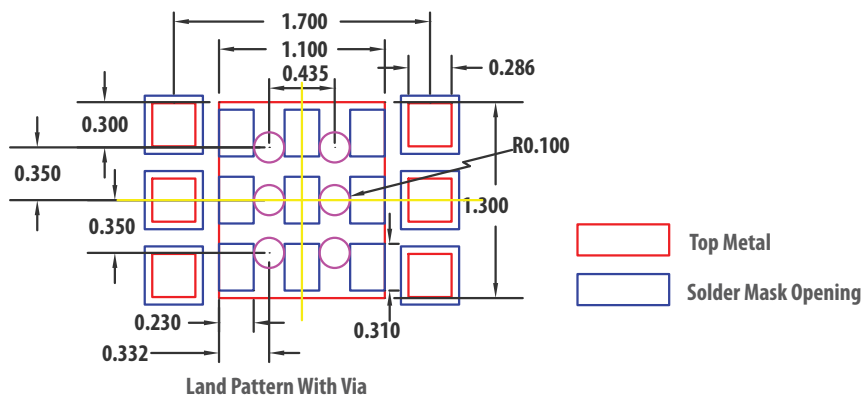
**MGA -655T6 LNA Mode typical Noise Parameters at 25 °C, Vdd=3V; Vbypass=2.7V; Idd=10mA**

| <b>Freq (GHz)</b> | <b>FMIN (dB)</b> | <b>GAMMA,Mag</b> | <b>OPT,Ang</b> | <b>Rn @ 50 Ohm</b> |
|-------------------|------------------|------------------|----------------|--------------------|
| 2                 | 0.96             | 0.55             | 71.4           | 0.25               |
| 2.4               | 0.92             | 0.59             | 83.2           | 0.29               |
| 2.6               | 0.85             | 0.51             | 81.2           | 0.25               |
| 3.3               | 0.815            | 0.36             | 99.4           | 0.22               |
| 3.5               | 0.745            | 0.47             | 105.8          | 0.21               |
| 3.8               | 0.715            | 0.46             | 111.5          | 0.2                |
| 4                 | 0.698            | 0.55             | 110.6          | 0.21               |
| 5                 | 0.9              | 0.3              | 145.2          | 0.17               |
| 5.5               | 0.97             | 0.39             | 178.4          | 0.14               |
| 5.8               | 1.07             | 0.29             | -173.1         | 0.13               |
| 6                 | 1.16             | 0.32             | -162.7         | 0.14               |

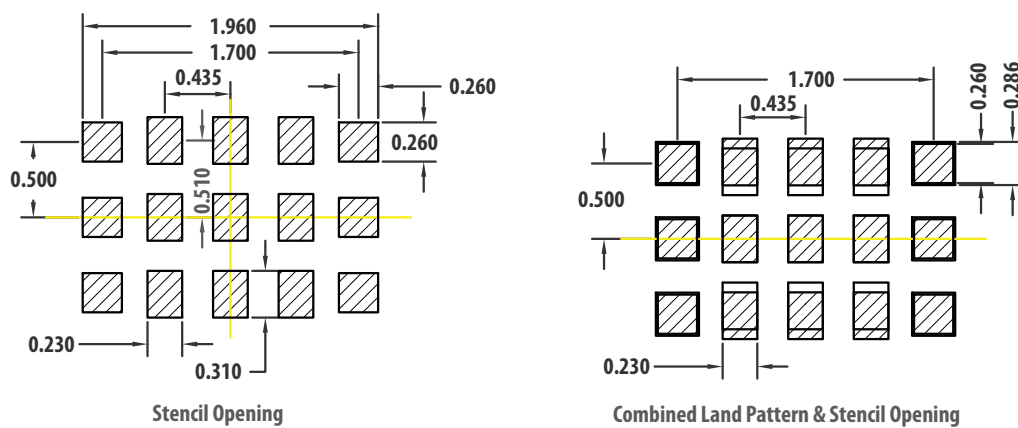
## Package Dimensions



## PCB Land Pattern



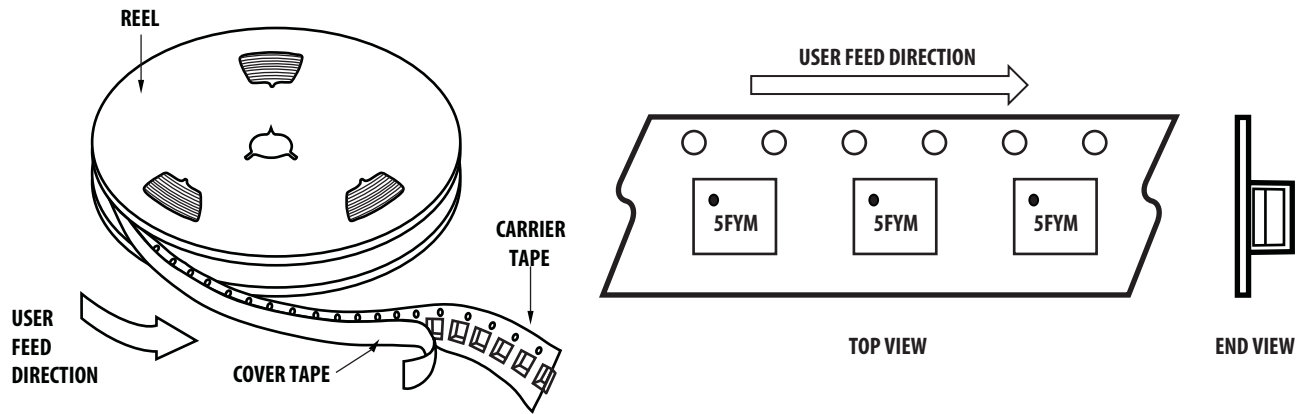
## Stencil Outline Drawing and Combined Land Pattern & Stencil Layout



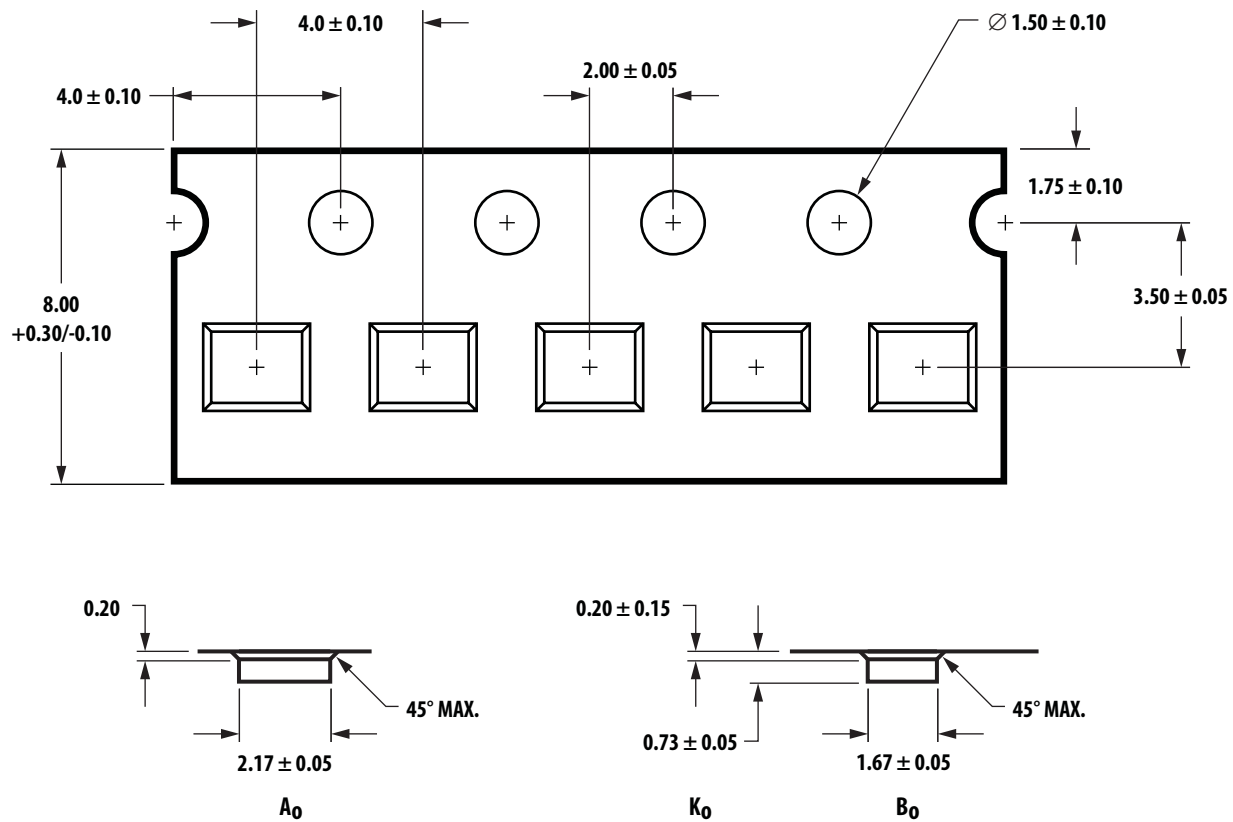
### Notes:

1. All dimension are in MM
2. Via hole is optional.
3. Recommend to use standard 4 mils Stencil thickness

## Device Orientation



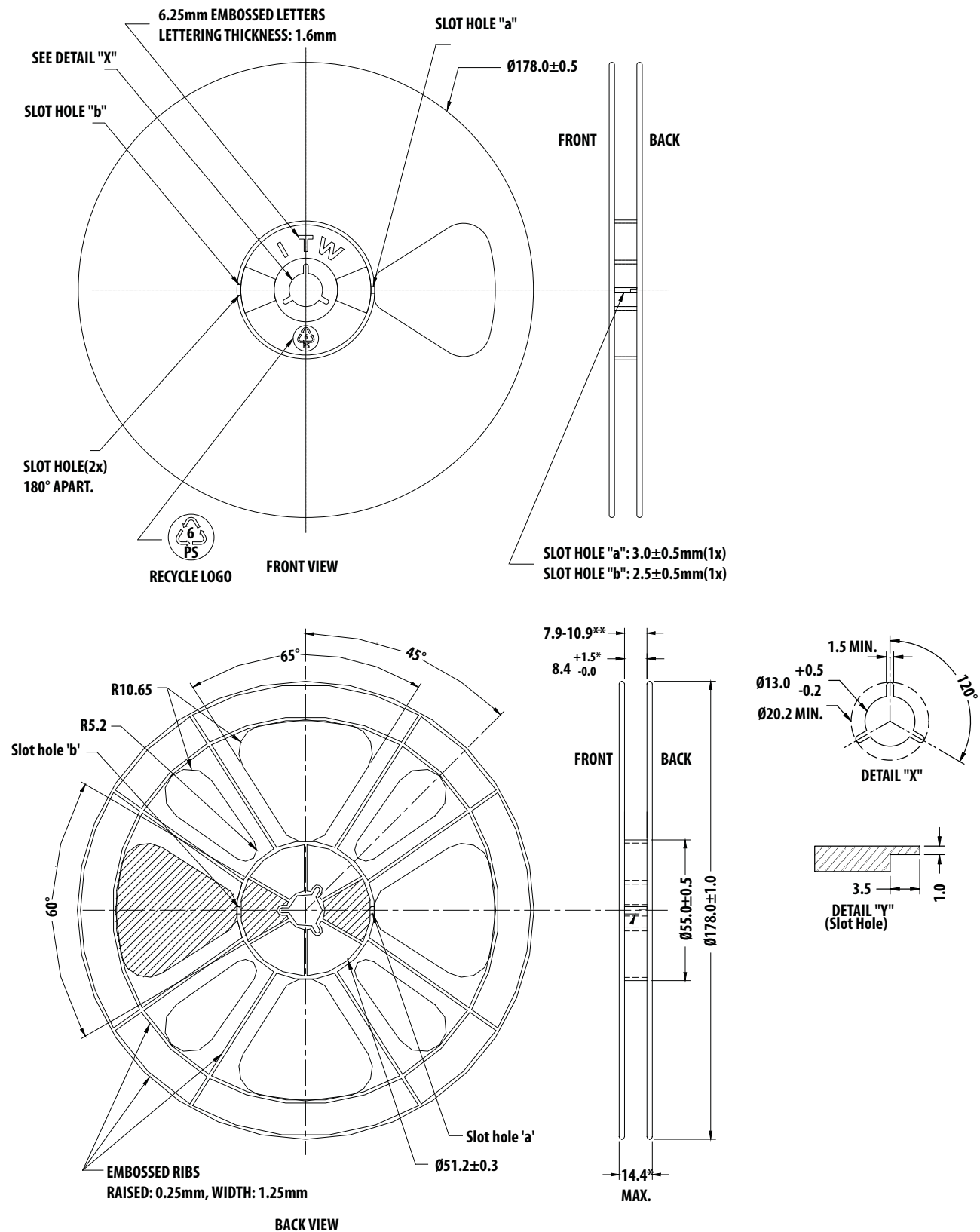
## Tape Dimensions



## Part Number Ordering Information

| Part Number    | Quantity | Container      |
|----------------|----------|----------------|
| MGA-655T6-BLKG | 100      | Antistatic Bag |
| MGA-655T6-TR1G | 3000     | 7" Reel        |
| MGA-655T6-TR2G | 10000    | 13" Reel       |

## Reel Dimensions



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

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