

# MGA-645T6

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



### Data Sheet

#### Description

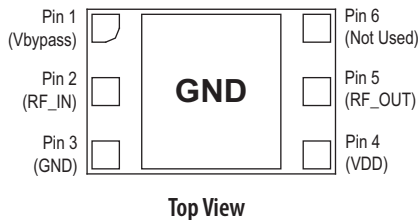
Avago Technologies' MGA-645T6 is an economical, easy-to-use GaAs MMIC Low Noise Amplifier (LNA) with Bypass/ Shutdown mode. The LNA has low noise and high linearity achieved through the use of Avago Technologies' proprietary 0.5um GaAs Enhancement-mode pHEMT process. The Bypass/Shutdown mode enables 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 0.4mm 6-pin Ultra Thin Package. The compact footprint and low profile coupled with low noise, high linearity make the MGA-645T6 an ideal choice as a low noise amplifier for mobile receiver in the WiMax, WLAN(802.11b/g), WiBro and DMB applications.

#### Component Image

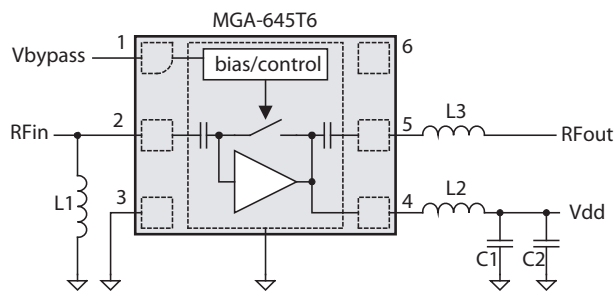


Note:  
Package marking provides orientation and identification  
"4F" = Product Code  
"Y" = Year of manufacture  
"M" = Month of manufacture

#### Pin Configuration



#### Simplified Schematic



#### Features

- 2.0 x 1.3 x 0.4 mm<sup>3</sup> 6-lead Ultra Thin Package
- Low bias current
- Simple matching network
- 1.5 GHz – 3 GHz operating range
- Adjustable bias current
- Low Noise Figure
- Bypass/Shutdown Mode using a single pin
- Low current consumption in Bypass Mode, <100uA
- Fully matched to 50 ohm in Bypass Mode
- High Linearity (LNA and Bypass Mode)
- Low profile package

#### Typical Performance

2.4 GHz; 3V, 7mA (typ):

- 15 dB Gain
- 1.1 dB Noise Figure with 9dB Input Return Loss
- +7 dBm Input IP3
- -5 dBm Input Power at 1dB gain compression
- 4.5 dB Insertion Loss in Bypass Mode
- 16dBm IIP3 in Bypass Mode (Pin = -20dBm)
- <100uA current consumption in Bypass & Shutdown Mode

#### Applications

- Low noise amplifier for GPS, WiMax, WLAN, WiBro and DMB applications.
- Other ultra low noise applications in the 1.5 – 3 GHz band



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

ESD Machine Model = 60 V  
ESD Human Body Model = 200 V  
Refer to Avago Application Note A004R:  
*Electrostatic Discharge, Damage and Control.*

## Absolute Maximum Rating <sup>[1]</sup> TA=25°C

Symbol	Parameter	Units	Absolute Max.
V <sub>dd</sub>	Device Voltage	V	4
V <sub>bypass</sub>	Control Voltage	V	(V <sub>dd</sub> -0.3)
P <sub>in,max</sub>	CW RF Input Power	dBm	+15
P <sub>diss</sub>	Total Power Dissipation <sup>[3]</sup>	mW	80
T <sub>j</sub>	Junction Temperature	°C	150
T <sub>STG</sub>	Storage Temperature	°C	-65 to 150

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

(V<sub>dd</sub> = 3.0V, I<sub>d</sub>=7mA), θ<sub>jc</sub> = 60 °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. Board temperature T<sub>B</sub> is 25 °C , for T<sub>B</sub> >146 °C derate the device power at 14mW per °C rise in Board (package belly) temperature.

## Product Consistency Distribution Charts <sup>[4]</sup>

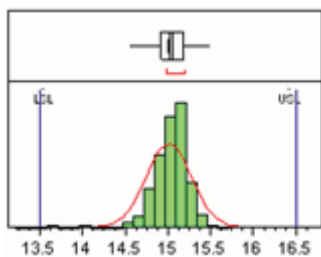


Figure 1. Gain @ 2.4 GHz , V<sub>d</sub> 3V; V<sub>bypass</sub> 1.8 V, LSL=13.5, Nominal=15.0, USL=16.5

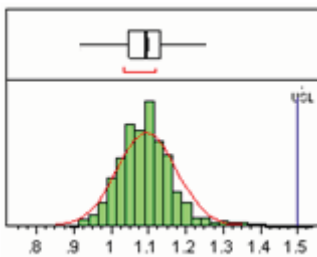


Figure 2. NF @ 2.4 GHz , V<sub>d</sub> 3V; V<sub>bypass</sub> 1.8 V, Nominal=1.1, USL=1.5

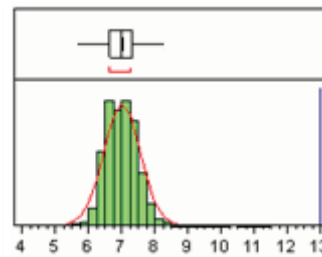


Figure 3. I<sub>ds</sub> @ 2.4 GHz , V<sub>d</sub> 3V; V<sub>bypass</sub> 1.8 V, Nominal=7.0, USL=13.0

Notes:

4. Distribution data sample size are 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 <sup>[5,7]</sup>

T<sub>A</sub> = 25 °C, V<sub>dd</sub> = 3V, V<sub>bypass</sub> = 1.8V, RF measurement at 2.4 GHz, measured on demo board (see Fig. 4) unless otherwise specified.

Symbol	Parameter and Test Condition	Units	Min.	Typ.	Max.
I <sub>d</sub>	Bias Current	mA	-	7	13
Gain	Gain	dB	13.5	15	16.5
NF	Noise Figure (Typ.V <sub>bypass</sub> =1.8V)	dB	-	1.1	1.5
IIP3 <sup>[6]</sup>	Input Third Order Intercept Point	dBm	-	+7	-
OP1dB	Output Power at 1dB Gain Compression	dBm	-	+9	-
S11	Input Return Loss, 50Ω source	dB	-	-9	-
S22	Output Return Loss, 50Ω load	dB	-	-15	-
S12	Reverse Isolation	dB	-	-27	-
S21  <sub>2BYPASS</sub>	Bypass Mode Loss (V <sub>bypass</sub> = 0)	dB	-	-4.5	-
IIP3 <sub>BYPASS</sub>	Bypass Mode IIP3 (tested at -20dBm input Power)	dBm	-	16	-
I <sub>dBYPASS</sub>	Bypass Mode current	uA	-	80	-

Notes:

5. Measurements at 2.4GHz obtained using demo board described in Figure 1, with component values on Figure 2 (2.3 – 2.4 GHz)
6. 2.4GHz I<sub>IP3</sub> test condition: F<sub>RF1</sub> = 2.395 GHz, F<sub>RF2</sub> = 2.4 GHz with input power of -30dBm per tone.
7. Use proper bias, heatsink and derating to ensure maximum channel temperature is not exceeded. See absolute maximum ratings and application note for more details.

## Demo Board Layout

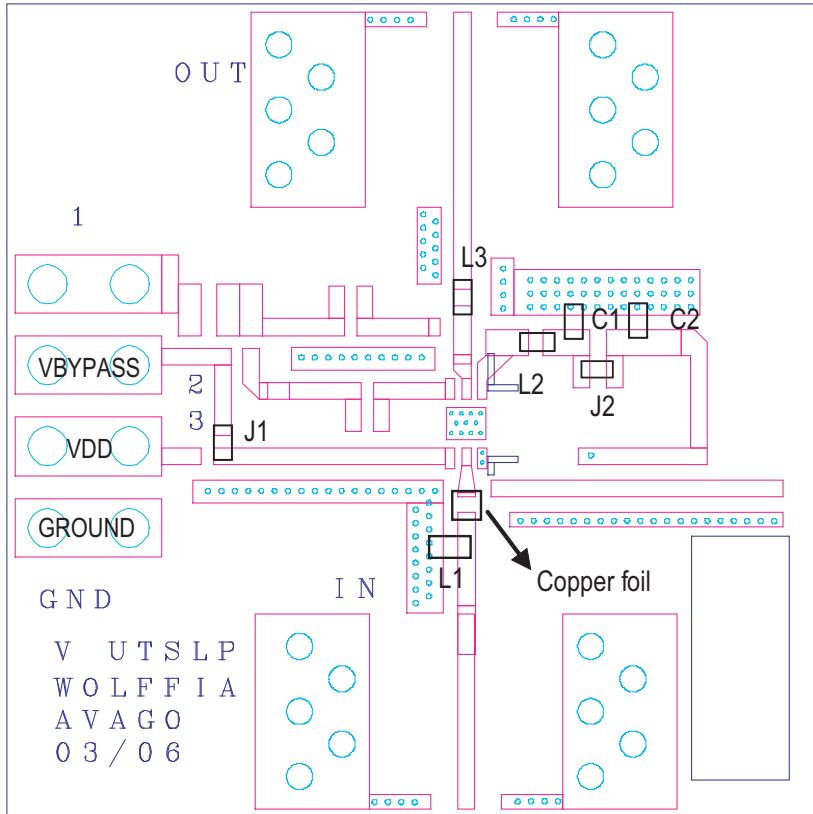


Figure 4. Demo Board Layout Diagram \*

## \*Application Notes: -

1. 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 schematic on page 4 and 7 show two sets of components used to demonstrate performance at the (2.3 - 2.4) GHz Wibro band and (2.5 - 2.7) GHz Wimax/DMB band.
  2. Operational Logic of Bypass/Shutdown pin (Pin 1)
    - Normal LNA operation : [1.2 to (Vdd-0.3)] Volt,
    - Bypass/Shutdown mode : 0 Volt or Open
- Pin 1 voltage in LNA mode can be varied to enable the LNA bias current to be adjusted, refer to next graph:

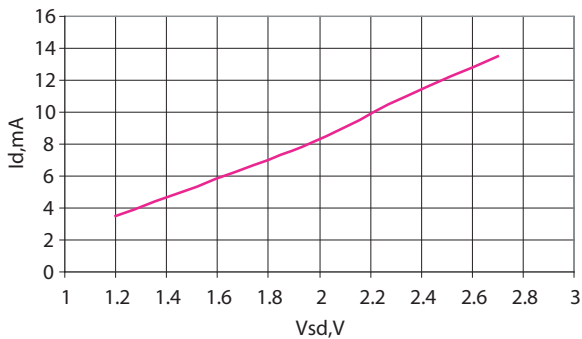


Figure 5. Id vs Vbypass (Vdd=3V)

## Demo Board Schematic for 2.3–2.4 GHz tuning

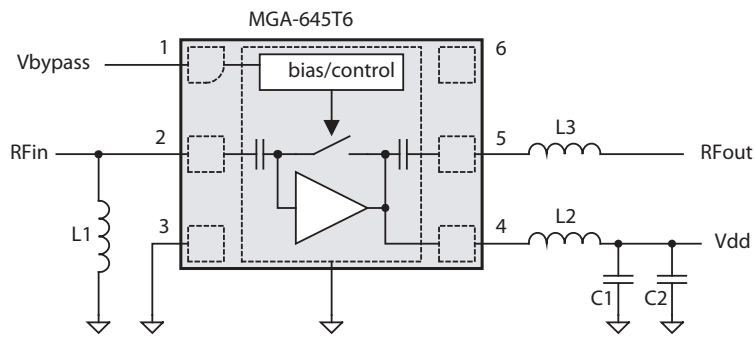


Figure 6. Demo Board Schematic Diagram

Part	Size	Value	P/N
L1	0402	2.7nH	LL1005FH2N7B (TOKO)
L2	0402	3.9nH	LL1005FH3N9C (TOKO)
L3	0402	4.7nH	LL1005FH4N7C (TOKO)
C1	0402	11pF	MCH155A110JK(ROHM)
C2	0402	0.1uF	CM05X7R104K10AHF
J1,J2 <sup>[8]</sup>	0402	0 ohm	RK73Z1E000 (KOA)

### Notes

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

## MGA-645T6 Typical Performance (2.3 – 2.4 GHz match)

TA = +25 °C, Vdd = 3V, Ids = 7mA (Vbypass = 1.8V), RF measurement at 2.4 GHz, Input Signal=CW unless stated otherwise.

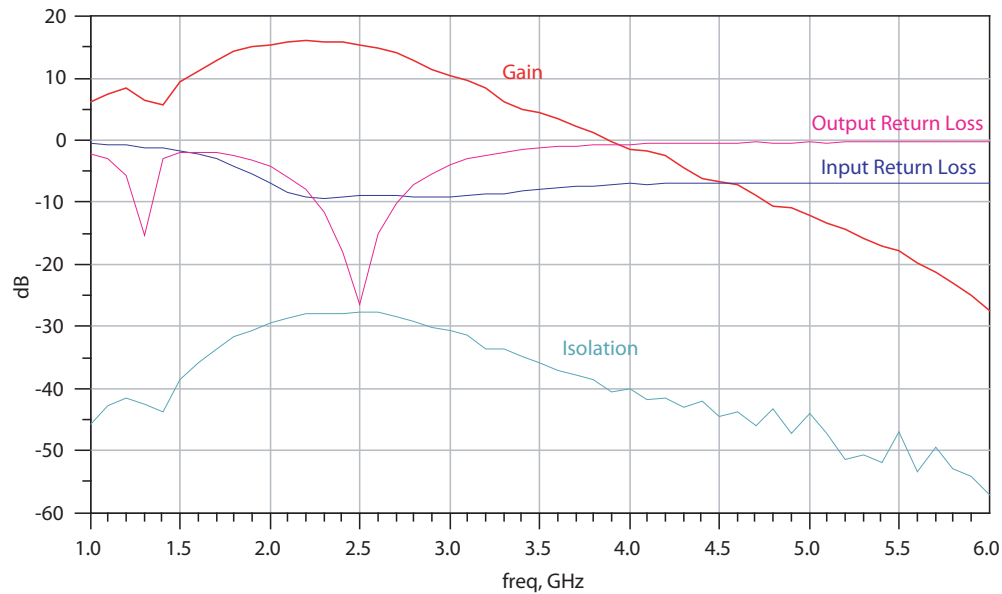
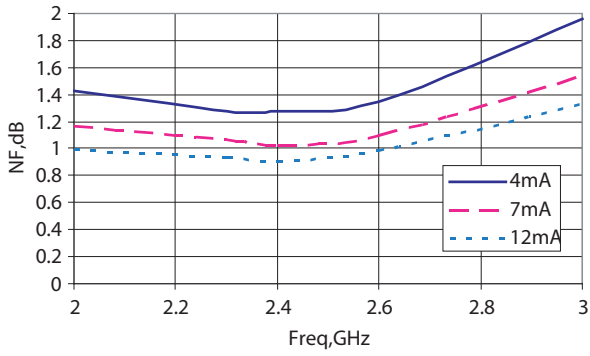
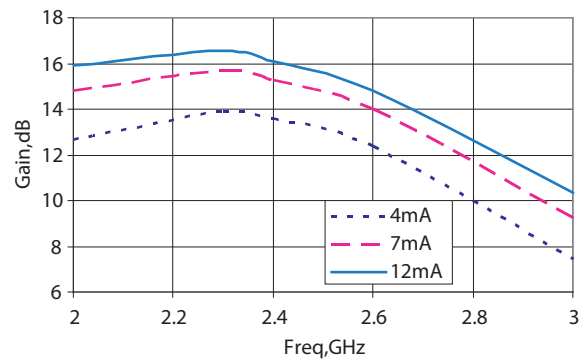


Figure 7. LNA Mode S21,S11,S22, S12 vs Frequency

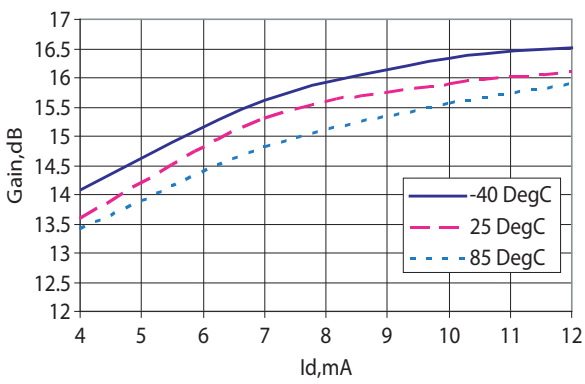
**LNA Mode Plots (2.3 – 2.4 GHz match) ; Vdd = 3V**



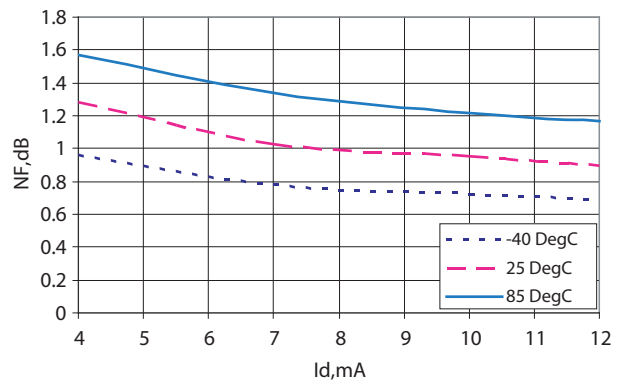
**Figure 8. LNA Mode Noise Figure vs Frequency vs Id**



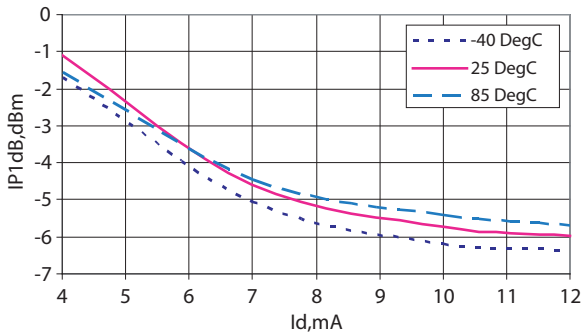
**Figure 9. LNA Mode Gain vs Frequency vs Id**



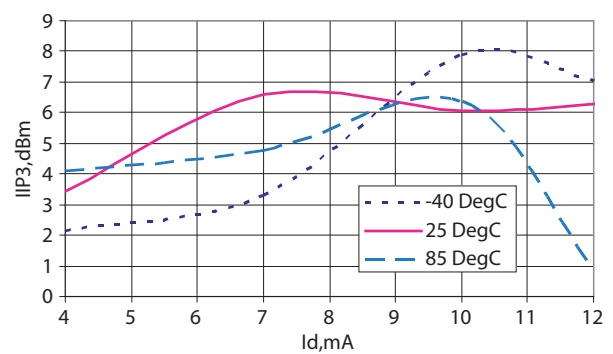
**Figure 10. LNA Mode Gain vs Id vs Temperature**



**Figure 11. LNA Noise Figure vs Id vs Temperature**

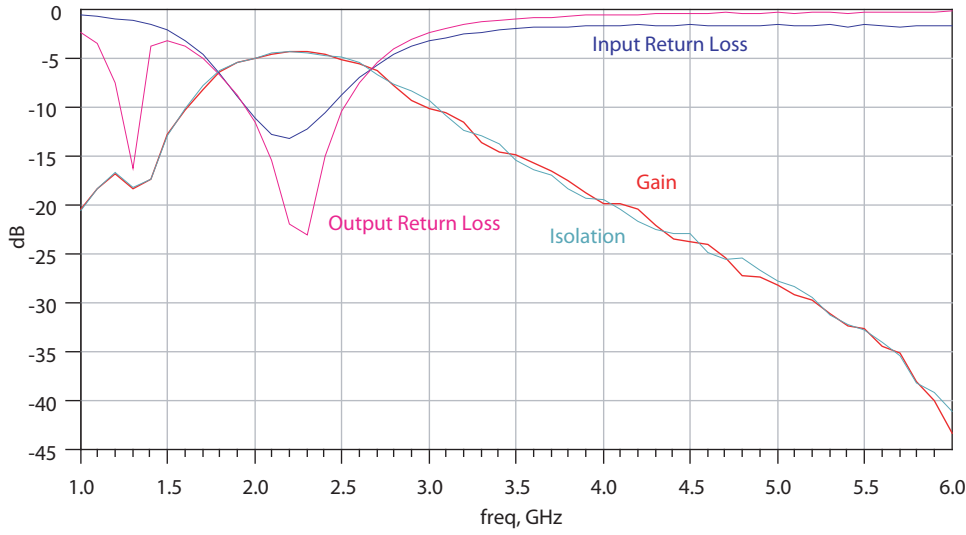


**Figure 12. LNA Mode IP1dB vs Id vs Temperature**

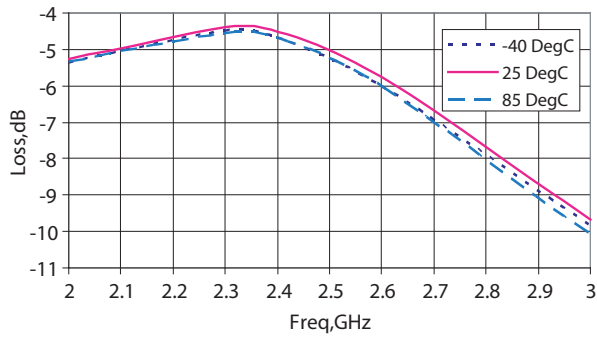


**Figure 13. LNA Mode IIP3 vs Id vs Temperature**

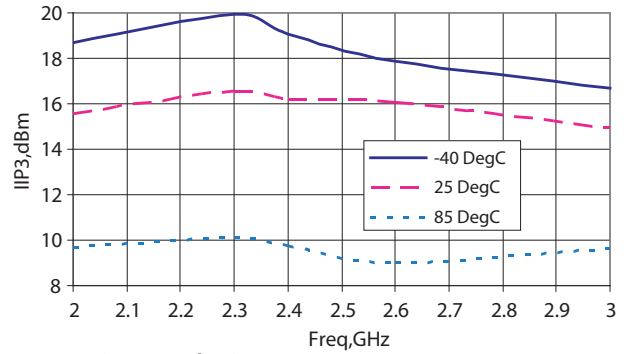
**Bypass Mode Plots (2.3 – 2.4 GHz match) (Vdd = 3V ; Vbypass = 0V)**



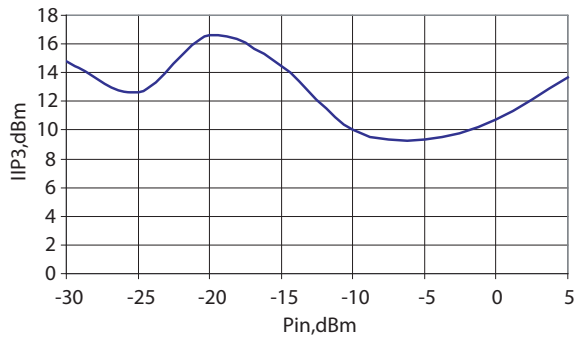
**Figure 14. Bypass Mode S21, S11, S22, S12 vs Frequency**



**Figure 15. Bypass Mode Loss vs Frequency vs Temperature**

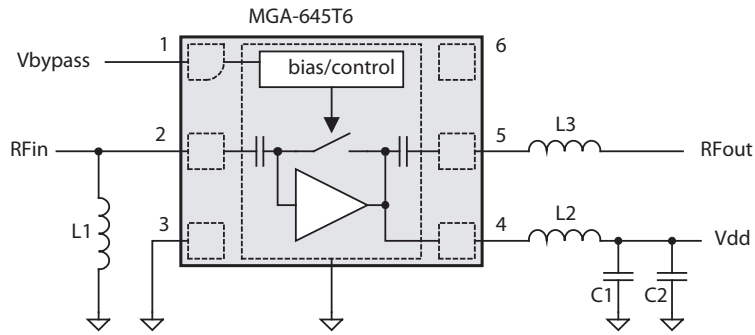


**Figure 16. Bypass Mode IIP3 vs Frequency vs Temperature**



**Figure 17. Bypass Mode IIP3 vs Input Power**

## Demo Board Schematic for 2.5 – 2.7 GHz tuning



Part	Size	Value	P/N
L1	0402	1.8nH	LL1005FH1N8B (TOKO)
L2	0402	3.9nH	LL1005FH3N9C (TOKO)
L3	0402	3.9nH	LL1005FH3N9C (TOKO)
C1	0402	11pF	MCH155A110JK(ROHM)
C2	0402	0.1uF	CM05X7R104K10AHF
J1,J2 <sup>[9]</sup>	0402	0 ohm	RK73Z1E000 (KOA)

Notes:

9. 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 18. Demo Board Schematic Diagram

## MGA-645T6 Typical Performance (2.5 GHz – 2.7 GHz match)

TA = +25 °C, Vdd = 3V, Ids = 7mA (Vbypass = 1.8V), RF measurement at 2.6 GHz, Input Signal=CW unless stated otherwise.

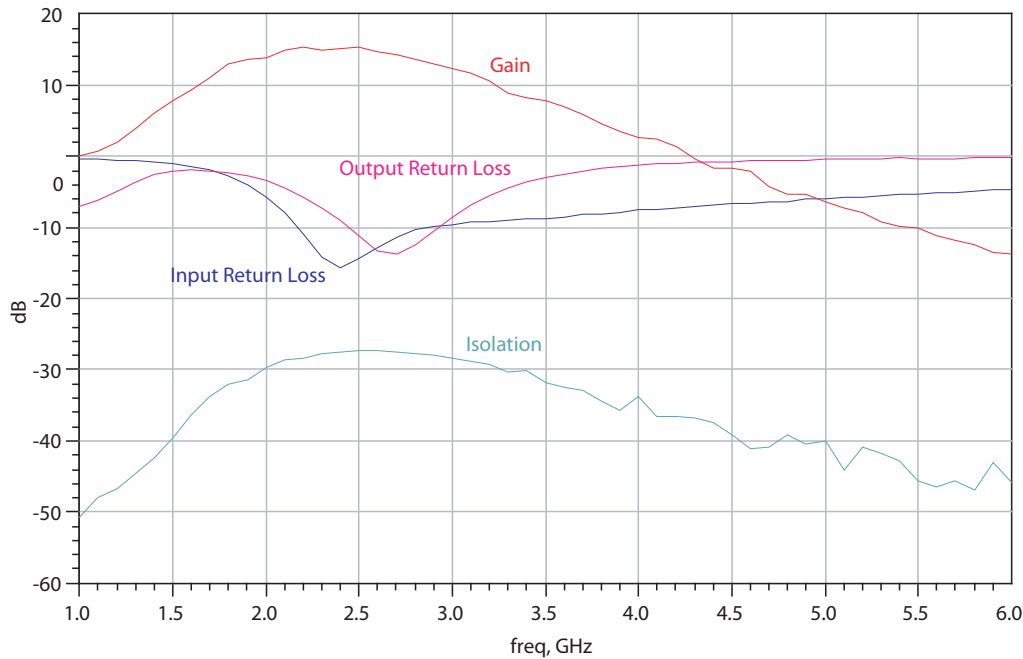
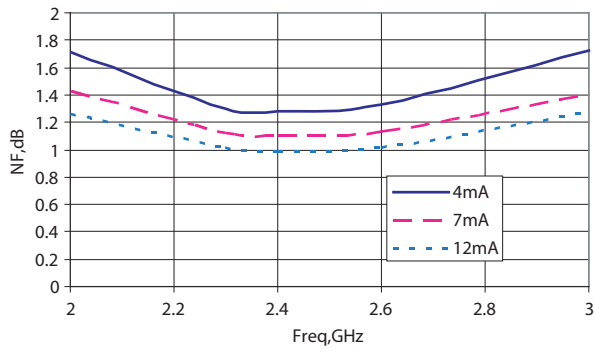
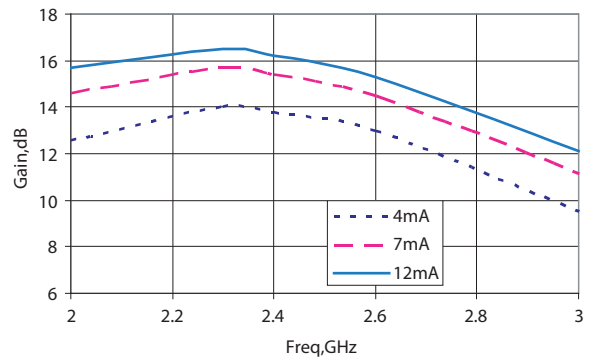


Figure 19. LNA Mode S21,S11,S22, S12 vs Frequency

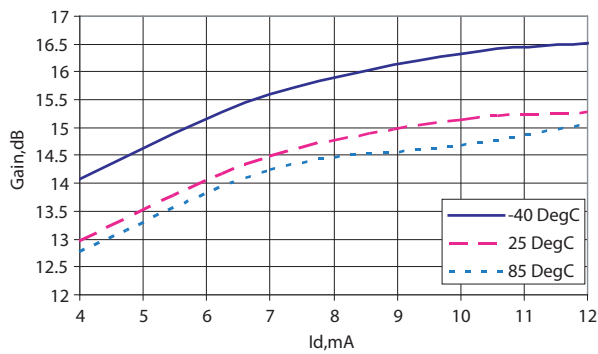
**LNA Mode Plots (2.5 – 2.7 GHz match) ; Vdd = 3V**



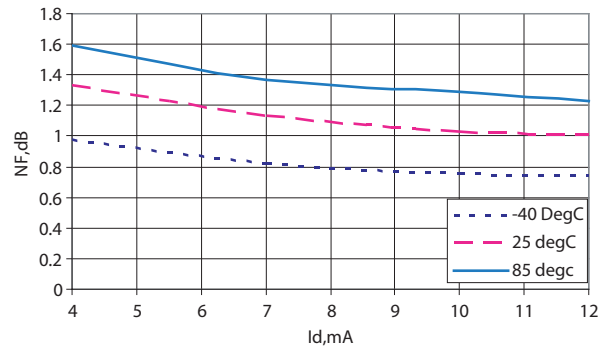
**Figure 20. LNA Mode Noise Figure vs Frequency vs Id**



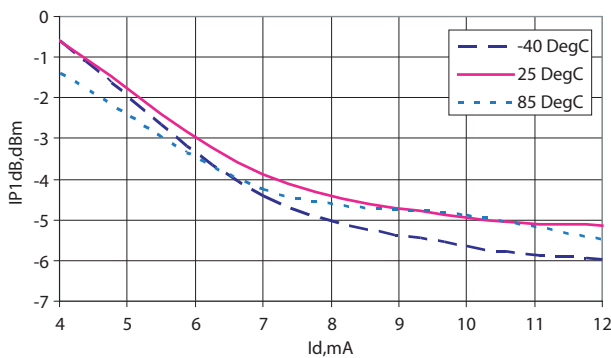
**Figure 21. LNA Mode Gain vs Frequency vs Id**



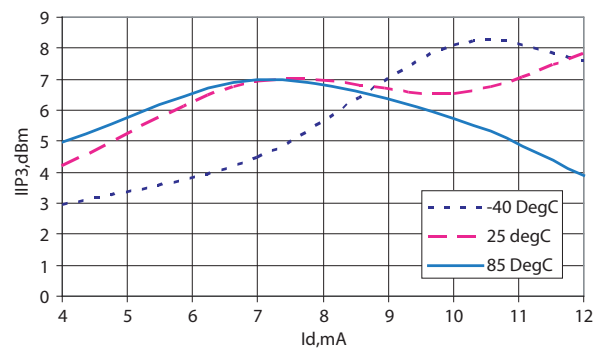
**Figure 22. LNA Mode Gain vs Id vs Temperature**



**Figure 23. LNA Mode Noise Figure vs Id vs Temperature**



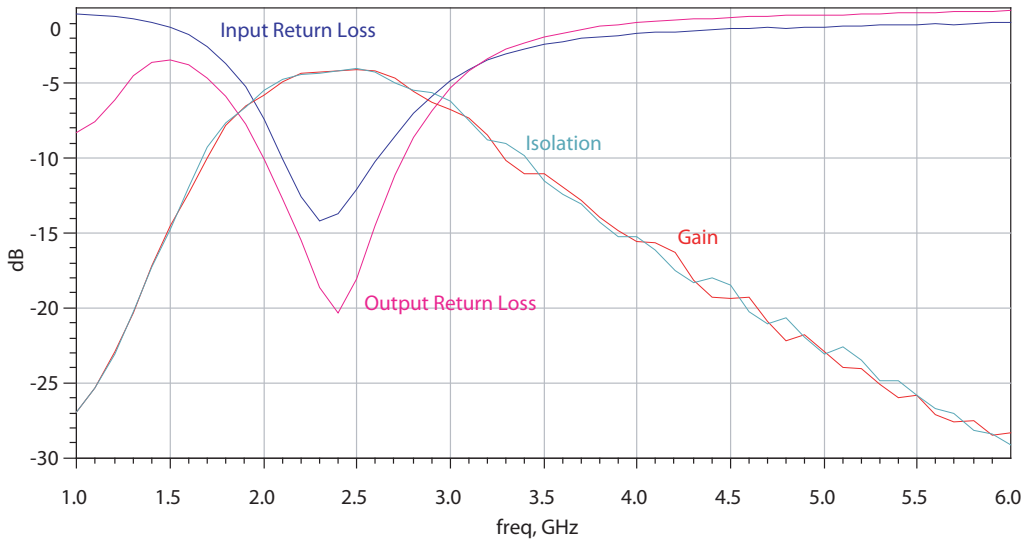
**Figure 24. LNA Mode IP1dB vs Id vs Temperature**



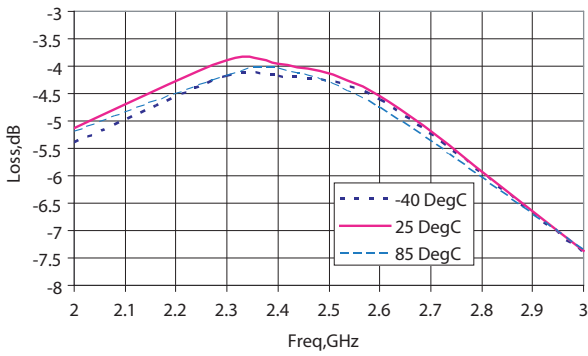
**Figure 25. LNA Mode IIP3 vs Id vs Temperature**



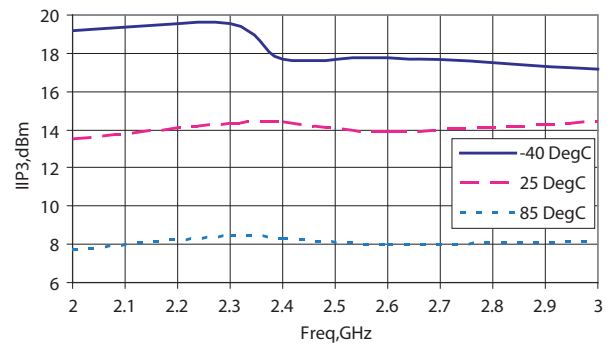
**Bypass Mode Plots (2.5 – 2.7 GHz match) (Vdd=3V; Vbypass = 0V)**



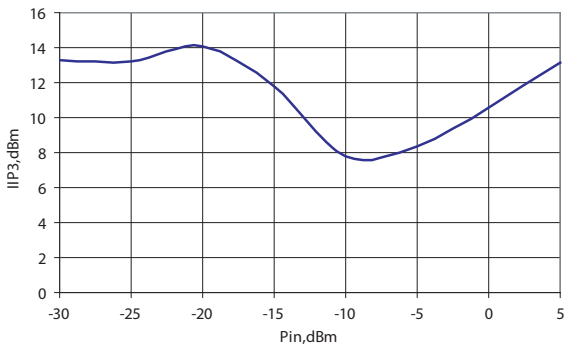
**Figure 26. Bypass Mode S21, S11, S22, S12 vs Frequency**



**Figure 27. Bypass Mode Loss vs Frequency vs Temperature**

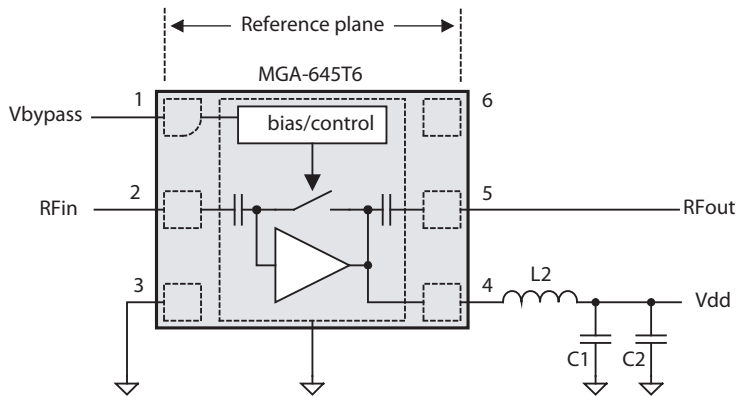


**Figure 28. Bypass Mode IIP3 vs Frequency vs Temperature**



**Figure 29. Bypass Mode IIP3 vs Input Power**

## Test Circuit For S and Noise parameter measurement<sup>[10]</sup>



Part	Size	Value	P/N
L2	0402	3.9nH	LL1005FH3N9C (TOKO)
C1	0402	11pF	MCH155A110JK(ROHM)
C2	0402	0.1uF	CM05X7R104K10AHF

Note:

10. The measurement is calibrated up to the input (RFin) and output (RFout) pin of the package

Figure 30. S parameter and Noise parameter test circuit in an automated measurement system

### MGA-645T6 LNA Mode typical scattering parameters at 25C, Vdd = 3V ; Id = 7mA

Freq. (GHz)	S11			S21			S12			S22	
	Mag	Ang	(dB)	Mag	Ang	(dB)	Mag	Ang	Mag	Ang	
0.5	0.967	-24.335	7.88	2.4761	-75.33	-45.04	0.0056	-138.21	0.9085	-122.31	
1	0.8861	-49.8342	13.58	4.7744	-171.657	-38.06	0.0125	128.9233	0.432	35.0635	
1.5	0.8251	-69.8995	12.45	4.191	-157.794	-34.61	0.0186	156.2124	0.6571	85.1871	
2	0.7269	-85.9353	11.73	3.8582	174.2387	-32.01	0.0251	132.069	0.6749	17.7274	
2.1	0.7122	-88.7111	11.44	3.7313	171.389	-33.23	0.0218	130.7848	0.6811	10.4895	
2.2	0.7006	-91.1084	11.21	3.6365	168.6844	-31.9	0.0254	128.8968	0.6819	4.1974	
2.3	0.6845	-93.5463	11.01	3.5538	165.0165	-32.08	0.0249	127.6959	0.683	-2.0684	
2.4	0.6713	-96.327	10.55	3.3705	161.92	-31.24	0.0274	127.563	0.6865	-7.48	
2.5	0.6601	-98.4295	10.37	3.2988	161.3186	-31.4	0.0269	128.1856	0.691	-12.2626	
2.6	0.6513	-100.828	10.23	3.246	159.714	-31.18	0.0276	130.7351	0.6867	-16.6168	
2.7	0.6362	-102.875	9.99	3.1576	158.2845	-31.15	0.0277	128.1521	0.6901	-20.8737	
2.8	0.6249	-105.268	9.53	2.9943	157.1203	-30.96	0.0283	124.8959	0.696	-24.8411	
2.9	0.6152	-107.135	9.32	2.9234	156.0789	-31.7	0.026	132.4548	0.6926	-28.5477	
3	0.6029	-108.961	8.95	2.8011	155.2783	-31.7	0.026	133.5121	0.6876	-32.1859	
3.5	0.5491	-118.1	8.28	2.5942	151.9711	-30.49	0.0299	139.3989	0.6816	-49.8308	
4	0.5013	-126.979	7.61	2.4026	146.6674	-30.2	0.0309	139.6368	0.6597	-70.0219	
4.5	0.448	-136.942	6.63	2.1452	140.82	-29.55	0.0333	147.2432	0.6719	-93.7765	
5	0.4005	-148.164	5.64	1.9149	135.5389	-29.82	0.0323	149.2084	0.6943	-118.882	
5.5	0.3674	-160.461	4	1.5849	129.9475	-31.18	0.0276	154.87	0.7417	-139.598	
6	0.3646	-175.708	2.14	1.279	125.6513	-30.75	0.029	162.4089	0.7978	-156.427	
6.5	0.3856	169.0618	-0.11	0.9878	122.9896	-32.08	0.0249	166.7983	0.8348	-170.871	
7	0.4261	155.8448	-2.91	0.7156	121.385	-35.97	0.0159	-177.345	0.8606	175.0569	
7.5	0.4897	144.9997	-7.72	0.411	117.9594	-36.95	0.0142	-161.329	0.8771	157.9701	
8	0.5128	139.1313	-20.71	0.0922	152.3853	-41.01	0.0089	-145.616	0.8565	136.2647	
8.5	0.5981	138.3684	-8.88	0.3597	-97.8518	-36.89	0.0143	-61.0845	0.8059	106.3384	
9	0.6552	135.8053	-1.62	0.8295	-110.242	-33.19	0.0219	-38.4428	0.7041	67.8904	
9.5	0.6801	133.4826	1.94	1.2505	-124.174	-27.64	0.0415	-36.5714	0.5465	18.5069	
10	0.6354	134.38	3.94	1.5743	-144.52	-25.9	0.0507	-72.2	0.3212	-48.88	

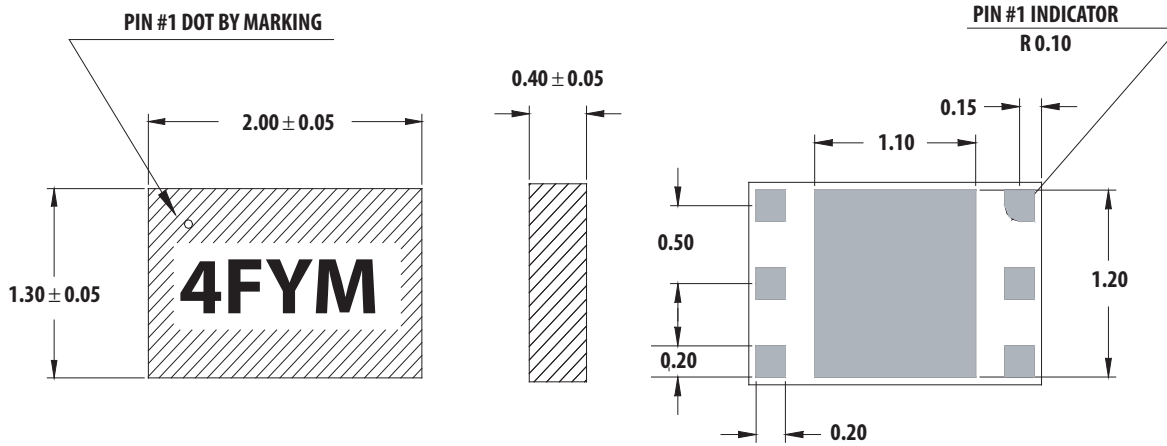
**MGA-645T6 LNA Mode typical noise parameters at 25 °C, Vdd = 3V ; Id = 7mA**

Freq.(GHz)	Fmin (dB)	$\Gamma_{opt}$ Mag	$\Gamma_{opt}$ Ang	Rn/50
2	0.55	0.76	67.8	0.23
2.1	0.57	0.76	71.04	0.22
2.2	0.59	0.75	74.29	0.21
2.3	0.62	0.75	77.54	0.21
2.4	0.72	0.69	79.72	0.2
2.5	0.75	0.68	82.9	0.2
2.6	0.78	0.67	86.08	0.2
2.7	0.8	0.66	89.11	0.19
2.8	0.83	0.65	92.14	0.18
2.9	0.85	0.63	95.17	0.18
3	0.88	0.62	98.2	0.17
3.1	0.91	0.61	100.88	0.16
3.2	0.95	0.6	103.56	0.16
3.3	0.98	0.59	106.24	0.15
3.4	1.02	0.58	108.92	0.14
3.5	1.06	0.57	111.6	0.14
3.6	1.09	0.56	114.08	0.13
3.7	1.12	0.56	116.56	0.13
3.8	1.15	0.55	119.04	0.12
3.9	1.18	0.55	121.52	0.12
4	1.21	0.54	124	0.11

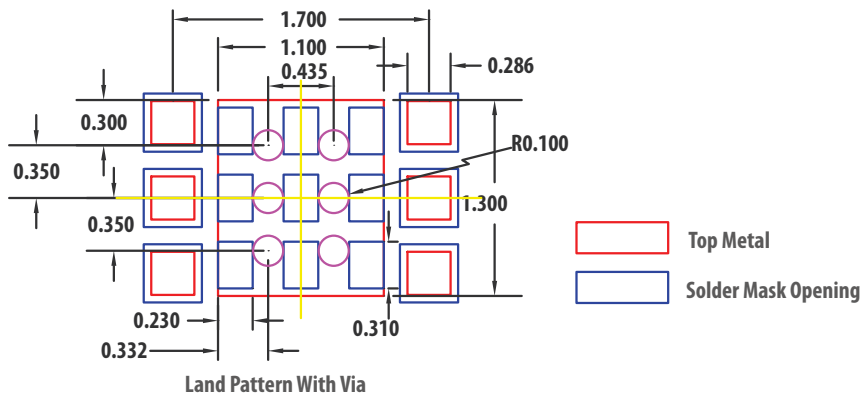
**MGA-645T6 Bypass Mode typical scattering parameters at 25 °C, Vdd = 3V ; Vbypass = 0V**

Freq. (GHz)	S11		S21			S12			S22	
	Mag	Ang	(dB)	Mag	Ang	(dB)	Mag	Ang	Mag	Ang
0.5	0.95	-31.2	-11.77	0.258	127.45	-11.77	0.258	125.95	0.568	111.9
1	0.925	-48.1	-10.96	0.283	100.5	-10.96	0.283	99.5	0.613	75.4
1.5	0.9	-65	-10.23	0.308	73.55	-10.23	0.308	73.05	0.658	38.9
2	0.875	-81.9	-9.55	0.333	46.6	-9.55	0.333	46.6	0.703	2.4
2.1	0.87	-85.28	-9.42	0.338	41.21	-9.42	0.338	41.31	0.712	-4.9
2.2	0.855	-88.66	-9.29	0.343	36.12	-9.29	0.343	36.22	0.722	-11
2.3	0.849	-91.44	-9.22	0.346	31.43	-9.22	0.345	31.63	0.734	-16.8
2.4	0.842	-94.52	-9.12	0.35	26.94	-9.12	0.349	27.14	0.741	-21.9
2.5	0.838	-97.2	-9.07	0.352	22.55	-9.07	0.352	22.65	0.741	-26.6
2.6	0.831	-100.18	-9	0.355	18.56	-9	0.354	18.76	0.749	-30.8
2.7	0.829	-102.56	-9	0.355	14.67	-9	0.356	14.77	0.745	-35.1
2.8	0.83	-105.14	-8.92	0.358	10.88	-8.92	0.358	10.98	0.74	-39.1
2.9	0.829	-107.52	-8.9	0.359	7.19	-8.9	0.359	7.39	0.739	-43
3	0.829	-109.9	-8.85	0.361	3.6	-8.85	0.361	3.8	0.73	-46.9
3.5	0.838	-120.9	-8.85	0.361	-12.35	-8.85	0.36	-12.15	0.69	-67
4	0.825	-130.8	-9	0.355	-27	-9	0.354	-26.7	0.694	-88.3
4.5	0.82	-139.2	-9.37	0.34	-41.85	-9.37	0.339	-41.65	0.717	-108.6
5	0.826	-148.4	-10.01	0.316	-56.6	-10.01	0.316	-56.4	0.74	-127.5
5.5	0.827	-161.3	-10.81	0.288	-71.55	-10.81	0.288	-71.55	0.778	-142.8
6	0.83	-176.4	-12.08	0.249	-84.4	-12.08	0.249	-84.2	0.829	-150.8
6.5	0.878	166.8	-13.76	0.205	-99.65	-13.76	0.204	-99.35	0.873	-160.3
7	0.895	154.4	-16.65	0.147	-114.9	-16.65	0.147	-114.7	0.893	-169.8
7.5	0.912	147	-21.21	0.087	-127.95	-21.21	0.087	-127.65	0.913	178.1
8	0.898	144.4	-33.56	0.021	-120.9	-33.56	0.021	-120.5	0.928	161.9
8.5	0.938	148.4	-22.38	0.076	-26.95	-22.38	0.076	-26.85	0.811	137
9	0.995	150.9	-22.05	0.079	-74.8	-22.05	0.08	-74.6	0.563	130.3
9.5	0.992	148.2	-32.77	0.023	-4.05	-32.77	0.023	-3.85	0.6	124.7
10	0.887	136.8	-15.34	0.171	8.8	-15.34	0.171	9.2	0.621	108.3

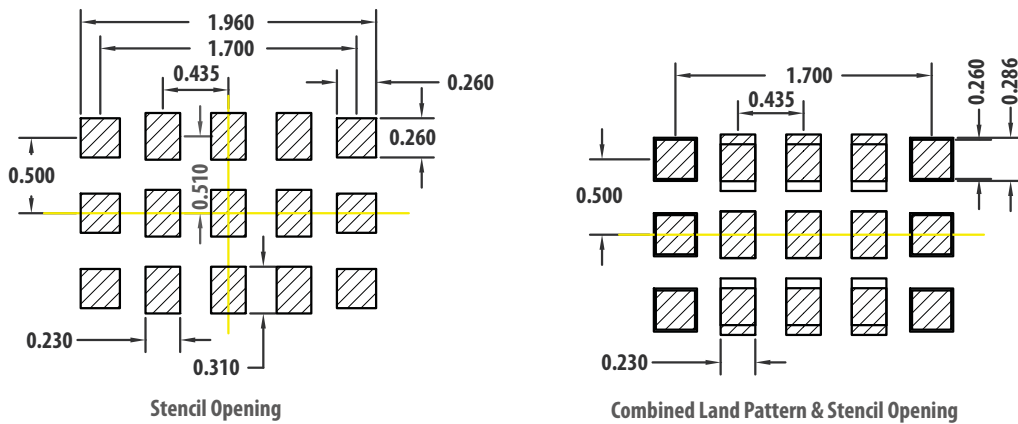
## Package Dimensions



## PCB Land Pattern



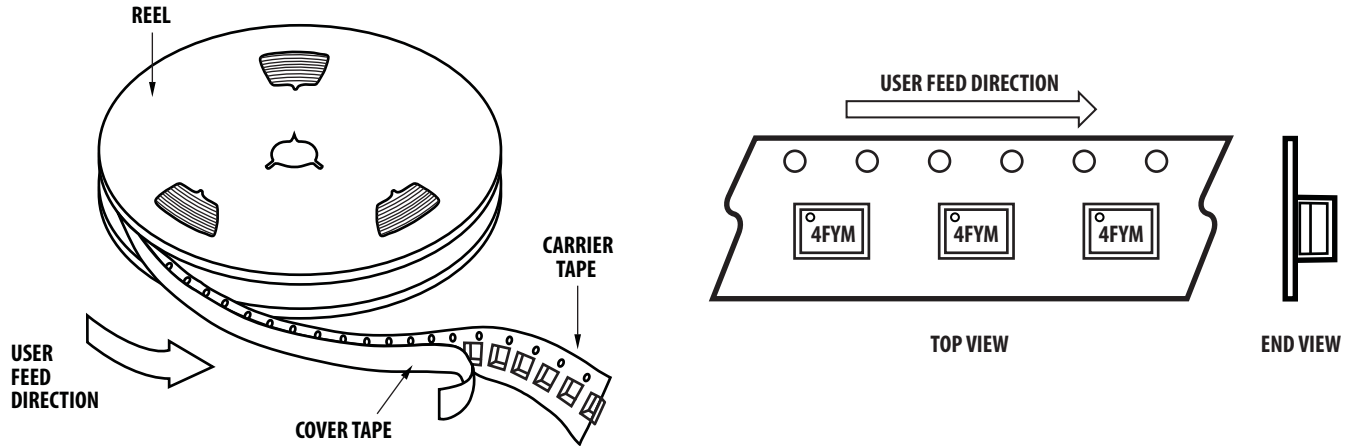
## Stencil Outline Drawing and Combined Land Pattern & Stencil Layout



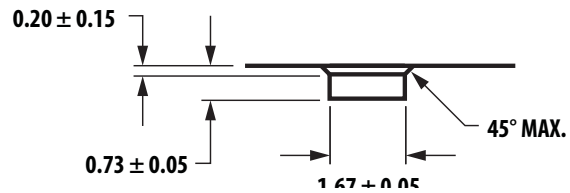
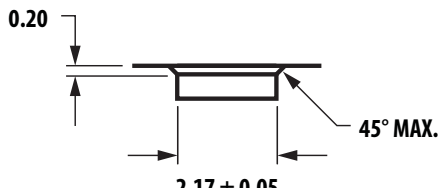
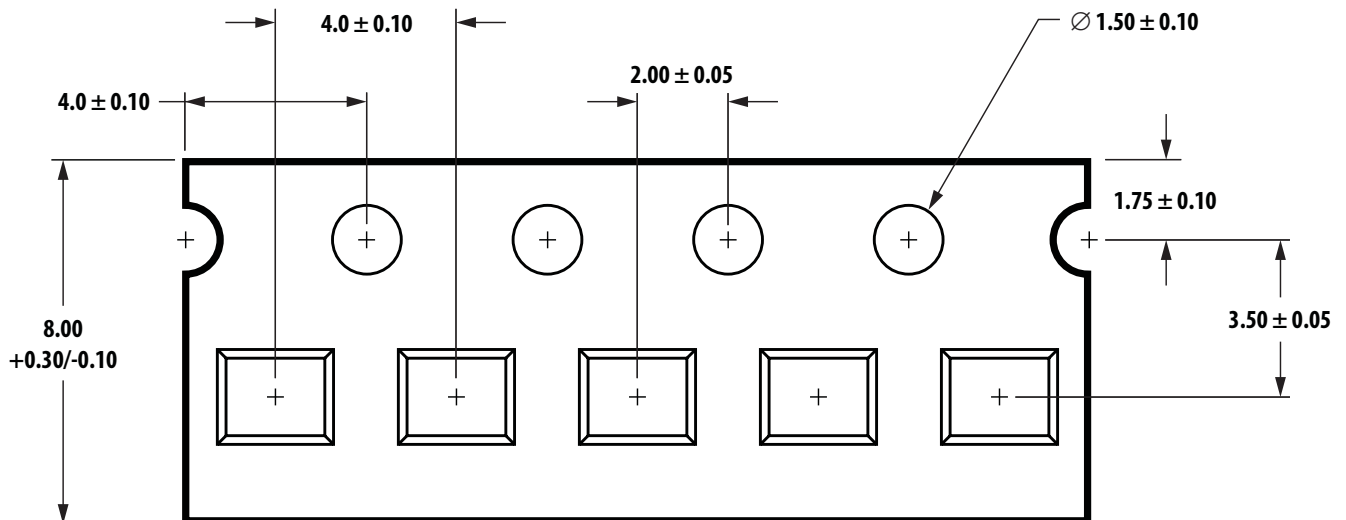
### Notes:

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

## Device Orientation



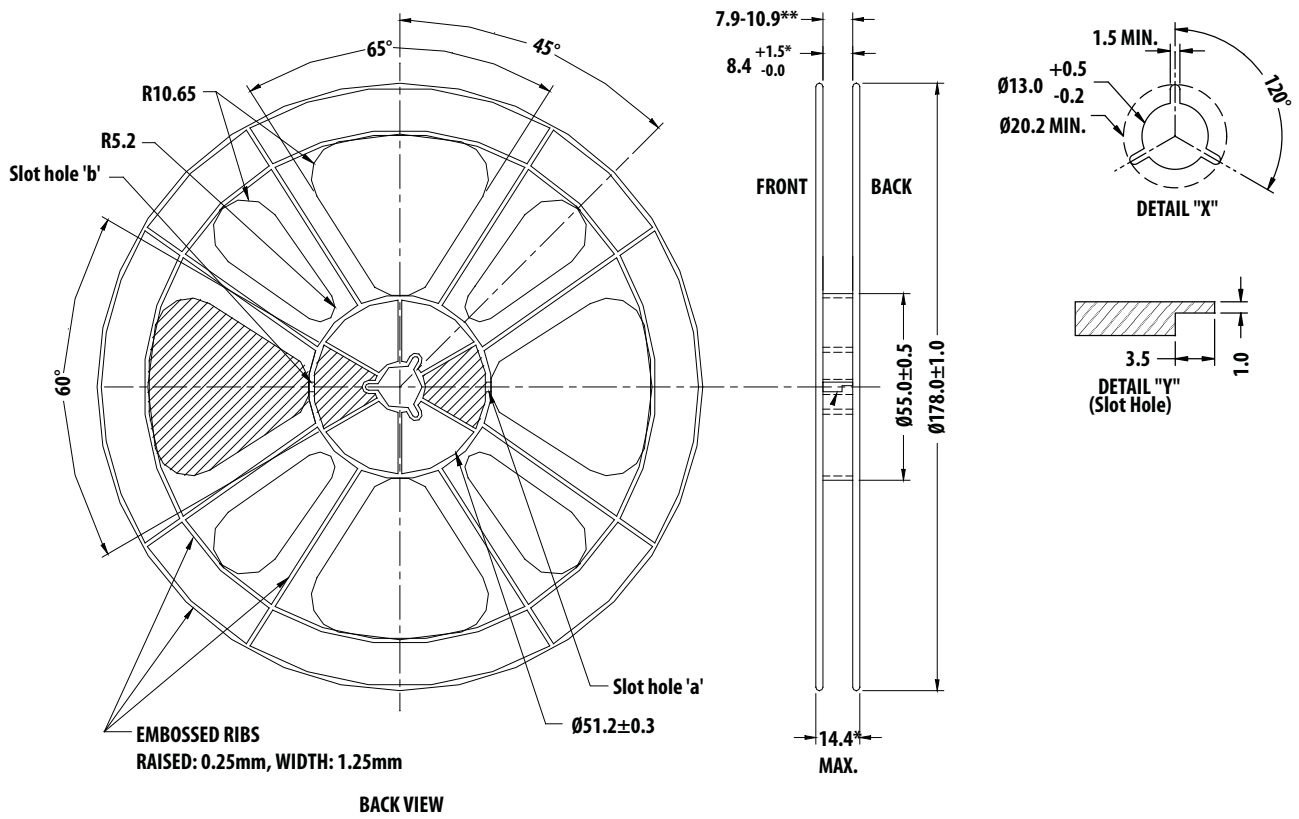
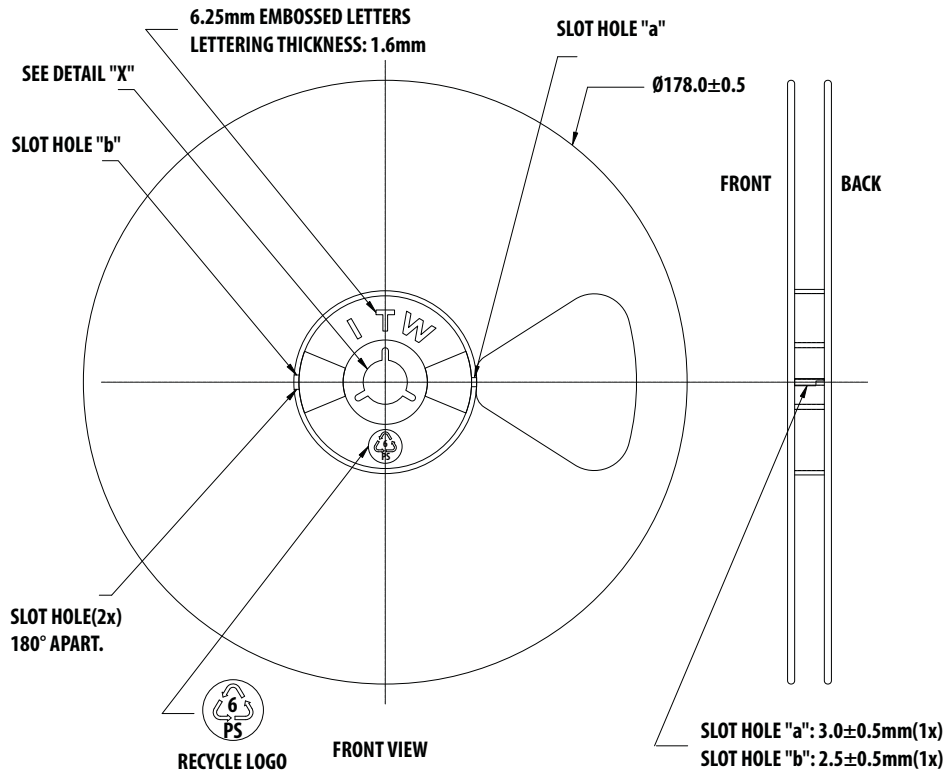
## Tape Dimensions



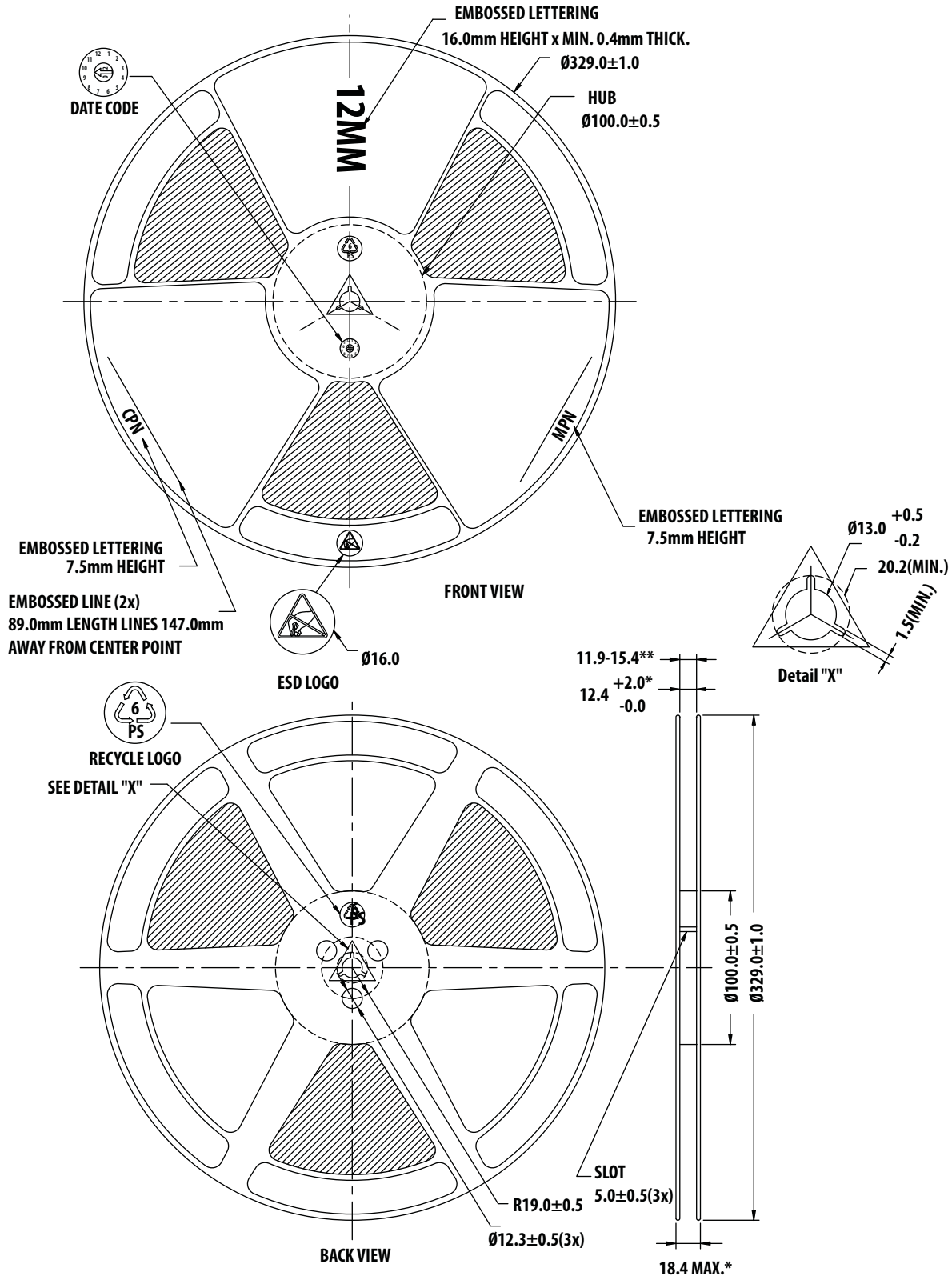
## Part Number Ordering Information

Part #	Qty	Container
MGA-645T6-BLKG	100	Antistatic Bag
MGA-645T6-TR1G	3000	7" Reel
MGA-645T6-TR2G	10000	13" Reel

# Reel Dimensions - 7 Inch



# Reel Dimensions - 13 Inch x 12mm



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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