Filtronic



# 12.7-16GHz MMIC Power Amplifier

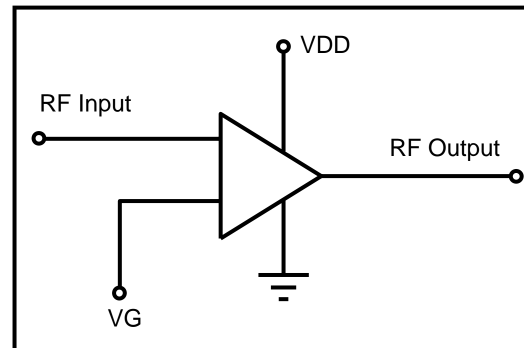
## Features:

- Balanced Topology
- 37dBm OIP3
- 30dB Gain
- Input Return Loss <-15dB
- Output Return Loss <-15dB

## General Description:

The FMA3011 is a high performance 12.7-16GHz Gallium Arsenide monolithic power amplifier with sufficiently high gain to ensure that IMD products from preceding stages can be kept to an absolute minimum. Coupled with the low IMD of this device, highly linear system performance can be achieved, while preserving the overall system gain requirements. It is suitable for use in digital microwave radios and electronic warfare applications. Balanced configuration using Lange couplers ensures excellent return losses and tolerance to external loads. The input stage is self-biased.

## Functional Schematic:




## Typical Applications:

- Electronic Warfare
- Broadband Communication Infrastructure
- Cellular Backhaul
- Point-to-Point Radio

## Electrical Specifications (on-wafer):

| Parameter | Conditions (VDD=6.8V, ID=450mA) | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Small Signal Gain | 13 GHz, pulsed<br>15 GHz, pulsed | 27.7<br>25.2 | 30.5<br>28.5 | 32.3<br>31.7 | dB<br>dB |
| Input Return Loss | 12.5 – 15.5 GHz, Vdd=5V, Vg=-0.5V | | -13 | -10.7 | dB |
| Output Return Loss | 12.5 – 15.5 GHz, Vdd=5V, Vg=-0.5V | | -14 | -13.7 | dB |
| $P_{1dB}$ | 13 – 15 GHz, pulsed | 26 | 29.2 | 32 | dBm |
| 3rd Order Output Intercept Point (OIP3) (jig measurement) | 13GHz (measured at 22dBm total output power)<br>15GHz (measured at 22dBm total output power) | 35.5<br>35.5 | 37<br>37 | | dBm<br>dBm |
| Noise Figure (jig measurement) | 13 GHz<br>15 GHz | | 4.1<br>4.7 | 4.5<br>5.3 | dB<br>dB |
| Self-bias Current | Total for both input stages | 40 | 60 | 100 | mA |

Note: $T_{AMBIENT}$ = +25°C, $Z_0$ = 50



*Specifications subject to change without notice*

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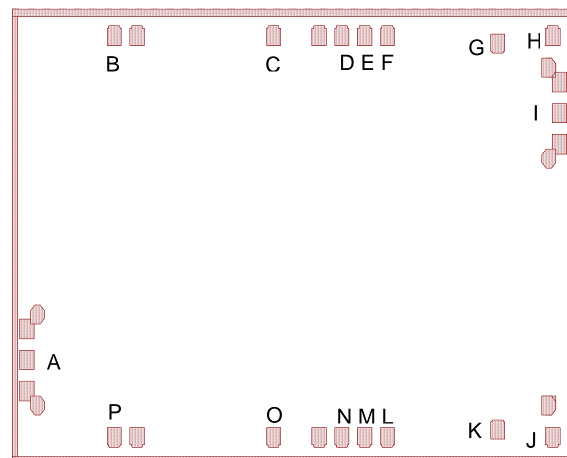
## Absolute Maximum Ratings:

| Parameter | Symbol | Absolute Maximum |
|---|---|---|
| Max Input Power | Pin | +25dBm |
| Gate Voltage | VG1 | -2V |
| Drain Voltage | VDD | +10V |
| Power Dissipation | Pdiss | 3.5W |
| Operating Temp | Toper | -40°C to +85°C |
| Storage Temp | Tstor | -55°C to +150°C |

Note: Exceeding any one of these absolute maximum ratings may cause permanent damage to the device.

## Pad Layout:

| Pad Ref | Pad Name | Description | Pin Coordinates (µm) |
|---|---|---|---|
| A | I | RF in | (96,503) |
| B | D1A | 1st Stage Drain | (671,2068) |
| C | G23A | 2nd and 3rd Gate | (1721, 2068) |
| D | D2AA | 2nd Drain Direct | (2171,2068) |
| E | D2AB | 2nd Drain With Resistor | (2321,2068) |
| F | D3AB | 3rd Drain With Resistor | (2471,2068) |
| G | D3AC | Alt 3rd Drain Direct | (3198,2040) |
| H | D3AA | 3rd Stage Drain Direct | (3560,2068) |
| I | O | RF Output | (3604,1698) |
| J | D3BA | 3rd Stage Drain Direct | (3560,132) |
| K | D3BC | Alt 3rd Drain Direct | (3198,160) |
| L | D3BB | 3rd Drain With Resistor | (2471,132) |
| M | D2BB | 2nd Drain With Resistor | (2321,132) |
| N | D2BA | 2nd Drain Direct | (2171,132) |
| O | G23B | 2nd and 3rd Gate | (1721,132) |
| P | D1B | 1st Stage Drain | (671,132) |




Note: Co-ordinates are referenced from the bottom left hand corner of the die to the centre of bond pad opening. Pads without identifiers are ground connections used in wafer testing.

| Die Size (µm) | Die Thickness (µm) | Min. Bond Pad Pitch (µm) | Min. Bond pad Opening (µm x µm ) |
|---|---|---|---|
| 3700 x 2200 | 100 | 150um | 100 x 100 |



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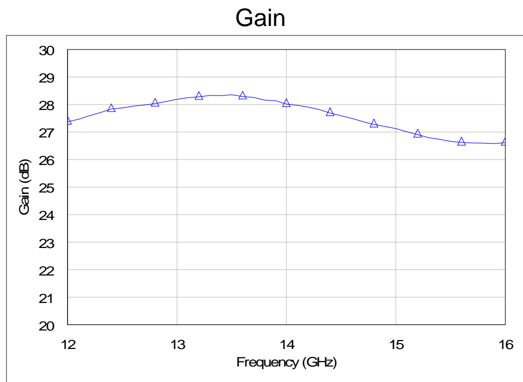
## TYPICAL PERFORMANCE FOR ON WAFER MEASUREMENTS:

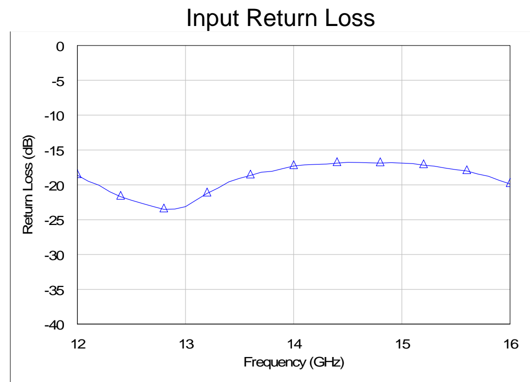
Note: RF on wafer measurements conducted at a lower bias point. Gain increases to the typical value at full bias.

Measurement Conditions: $V_{G1}$= -0.5V, $I_D$= 180mA, $V_{DD}$= 5V, $T_{AMBIENT}$ = 25°C

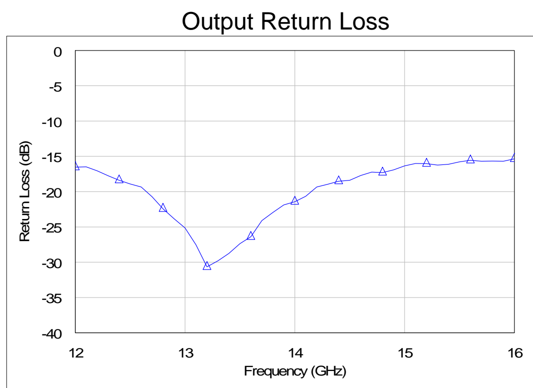
Gain



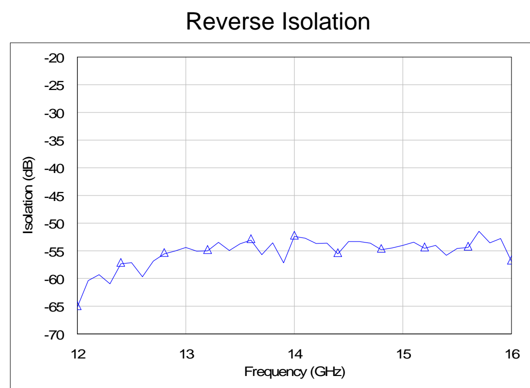

Input Return Loss



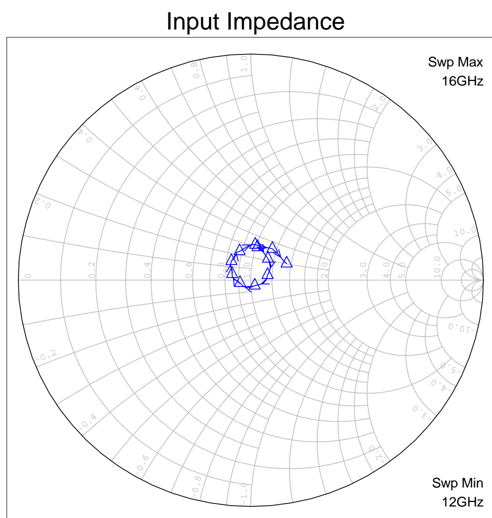

Output Return Loss



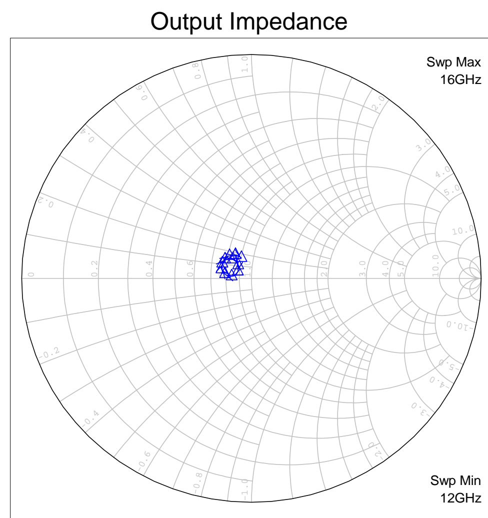

Reverse Isolation




Input Impedance




Output Impedance



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## TYPICAL PERFORMANCE FOR ON WAFER MEASUREMENTS:

Note: RF on wafer measurements conducted at a lower bias point. Gain increases to the typical value at full bias.

Measurement Conditions: $V_{G1}$= -0.5V, $I_D$= 180mA, $V_{DD}$= 5V, $T_{AMBIENT}$ = 25°C

| Frequency | ReS11 | ImS11 | ReS21 | ImS21 | ReS12 | ImS12 | ReS22 | ImS22 |
|---|---|---|---|---|---|---|---|---|
| 12.000000 | 0.02862 | 0.14634 | -6.67930 | 22.40440 | -0.00002 | -0.00055 | -0.08042 | 0.08541 |
| 12.100000 | 0.04739 | 0.14199 | -3.50866 | 23.34877 | 0.00065 | -0.00070 | -0.06926 | 0.08047 |
| 12.200000 | 0.05071 | 0.13091 | -0.24776 | 23.97320 | 0.00030 | -0.00104 | -0.06486 | 0.07525 |
| 12.300000 | 0.05901 | 0.11523 | 3.18014 | 24.08470 | 0.00038 | -0.00081 | -0.05980 | 0.06616 |
| 12.400000 | 0.07374 | 0.09515 | 6.72798 | 23.70643 | 0.00028 | -0.00133 | -0.05717 | 0.05895 |
| 12.500000 | 0.08162 | 0.07863 | 10.21719 | 22.56068 | 0.00054 | -0.00128 | -0.05739 | 0.05220 |
| 12.600000 | 0.08652 | 0.06465 | 13.39561 | 21.06022 | 0.00018 | -0.00102 | -0.05660 | 0.04683 |
| 12.700000 | 0.08131 | 0.04328 | 16.42668 | 18.92982 | 0.00102 | -0.00101 | -0.05818 | 0.03881 |
| 12.800000 | 0.07224 | 0.02250 | 19.08678 | 16.47102 | 0.00107 | -0.00128 | -0.05909 | 0.03077 |
| 12.900000 | 0.06434 | -0.00163 | 21.43423 | 13.71294 | 0.00135 | -0.00114 | -0.06285 | 0.02316 |
| 13.000000 | 0.05353 | -0.01339 | 23.36681 | 10.66305 | 0.00138 | -0.00131 | -0.06789 | 0.01570 |
| 13.100000 | 0.03684 | -0.02027 | 24.87215 | 7.07652 | 0.00152 | -0.00090 | -0.07716 | 0.01088 |
| 13.200000 | 0.01690 | -0.02392 | 25.72424 | 3.35031 | 0.00157 | -0.00083 | -0.08625 | 0.00932 |
| 13.300000 | -0.00248 | -0.03228 | 26.09245 | -0.53323 | 0.00209 | -0.00036 | -0.09435 | 0.00948 |
| 13.400000 | -0.01801 | -0.03173 | 25.70407 | -4.42088 | 0.00170 | -0.00056 | -0.10434 | 0.01258 |
| 13.500000 | -0.03347 | -0.02676 | 24.80453 | -8.34490 | 0.00205 | -0.00013 | -0.11028 | 0.01474 |
| 13.600000 | -0.04619 | -0.01233 | 23.09648 | -11.90000 | 0.00219 | -0.00038 | -0.11522 | 0.01902 |
| 13.700000 | -0.06234 | -0.00087 | 21.00504 | -15.11085 | 0.00164 | 0.00006 | -0.12067 | 0.02500 |
| 13.800000 | -0.07110 | 0.00140 | 18.32389 | -17.87180 | 0.00200 | 0.00062 | -0.12163 | 0.02956 |
| 13.900000 | -0.07895 | 0.01599 | 15.46391 | -20.31469 | 0.00136 | 0.00027 | -0.12588 | 0.03534 |
| 14.000000 | -0.08032 | 0.02743 | 12.11258 | -22.07279 | 0.00233 | 0.00054 | -0.13015 | 0.04070 |
| 14.100000 | -0.08049 | 0.04620 | 8.78339 | -23.44850 | 0.00222 | 0.00064 | -0.13013 | 0.04824 |
| 14.200000 | -0.08831 | 0.06197 | 5.16222 | -24.30297 | 0.00178 | 0.00106 | -0.12897 | 0.05541 |
| 14.300000 | -0.08713 | 0.07151 | 1.55327 | -24.54886 | 0.00197 | 0.00069 | -0.12704 | 0.06067 |
| 14.400000 | -0.08305 | 0.08453 | -2.05811 | -24.14934 | 0.00129 | 0.00105 | -0.12680 | 0.06672 |
| 14.500000 | -0.07201 | 0.09639 | -5.39476 | -23.34800 | 0.00180 | 0.00118 | -0.12620 | 0.07174 |
| 14.600000 | -0.06335 | 0.11361 | -8.61700 | -22.07628 | 0.00192 | 0.00099 | -0.12231 | 0.07730 |
| 14.700000 | -0.06197 | 0.12273 | -11.48291 | -20.37179 | 0.00166 | 0.00126 | -0.11860 | 0.08131 |
| 14.800000 | -0.04812 | 0.12781 | -14.12595 | -18.29621 | 0.00163 | 0.00080 | -0.11485 | 0.08523 |
| 14.900000 | -0.03018 | 0.13962 | -16.44033 | -15.96085 | 0.00146 | 0.00120 | -0.11173 | 0.09098 |
| 15.000000 | -0.00996 | 0.15195 | -18.40505 | -13.31864 | 0.00124 | 0.00156 | -0.10638 | 0.09579 |
| 15.100000 | 0.00530 | 0.15823 | -19.86278 | -10.37735 | 0.00121 | 0.00175 | -0.10103 | 0.09968 |
| 15.200000 | 0.01873 | 0.15667 | -20.88333 | -7.40515 | 0.00121 | 0.00143 | -0.09553 | 0.10018 |
| 15.300000 | 0.03561 | 0.15014 | -21.43556 | -4.37013 | 0.00093 | 0.00176 | -0.08894 | 0.10282 |
| 15.400000 | 0.05833 | 0.14512 | -21.67941 | -1.27367 | 0.00029 | 0.00159 | -0.08270 | 0.10265 |
| 15.500000 | 0.07723 | 0.14294 | -21.46588 | 1.79864 | 0.00053 | 0.00179 | -0.07516 | 0.10419 |
| 15.600000 | 0.09221 | 0.13881 | -20.88945 | 4.79123 | 0.00064 | 0.00179 | -0.06926 | 0.10464 |
| 15.700000 | 0.10365 | 0.12732 | -19.93439 | 7.75941 | 0.00080 | 0.00255 | -0.06143 | 0.10268 |
| 15.800000 | 0.12069 | 0.11209 | -18.55769 | 10.59434 | -0.00001 | 0.00210 | -0.05579 | 0.10057 |
| 15.900000 | 0.13756 | 0.08919 | -16.75654 | 13.19331 | 0.00010 | 0.00229 | -0.04917 | 0.09557 |
| 16.000000 | 0.15418 | 0.07345 | -14.71157 | 15.56911 | -0.00011 | 0.00142 | -0.04345 | 0.09163 |



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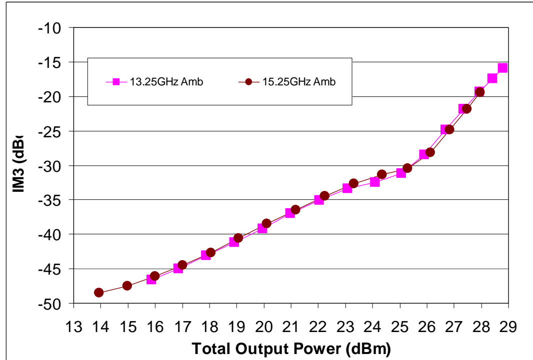
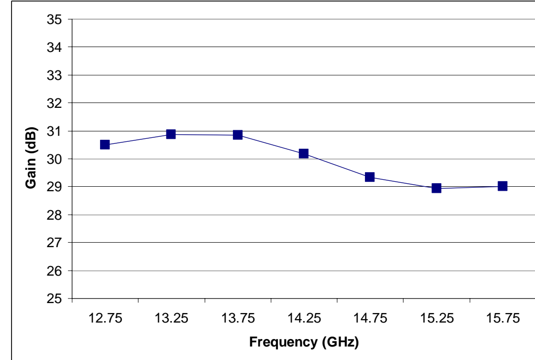
## TYPICAL PERFORMANCE FOR FULL BIAS JIG BASED MEASUREMENTS:

Note: Measurement Conditions: $V_G$= -0.35V, $V_{DD}$= 7V, Id=450mA

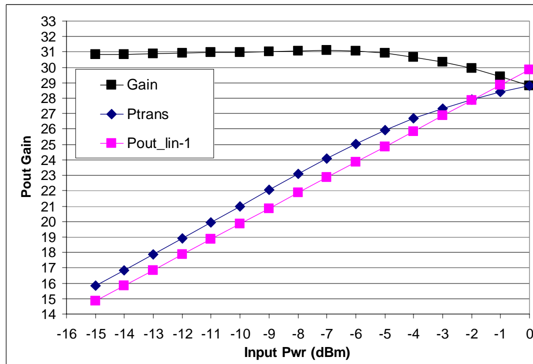
IM3 Level (dBc) vs Total Output Power (dBm)



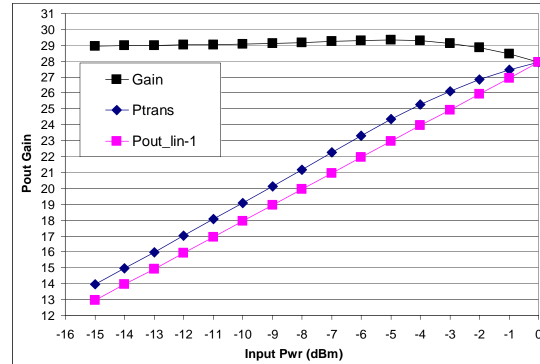

Gain




Power Transfer Characteristic 13GHz P-1dB




Power Transfer Characteristic 15GHz P-1dB



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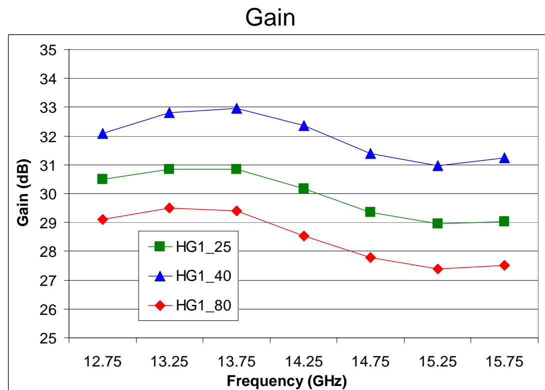
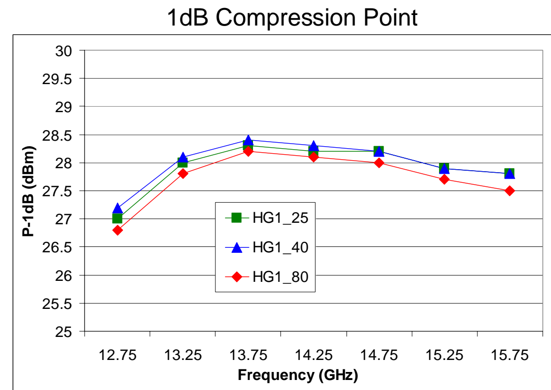
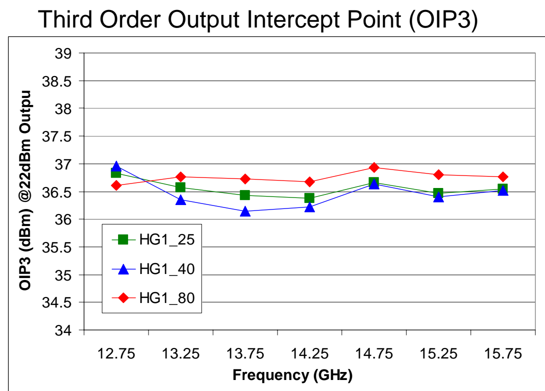
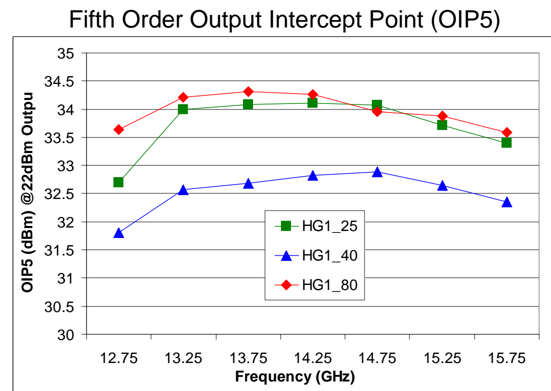
## TYPICAL PERFORMANCE FOR FULL BIAS JIG BASED TEMPERATURE MEASUREMENTS:

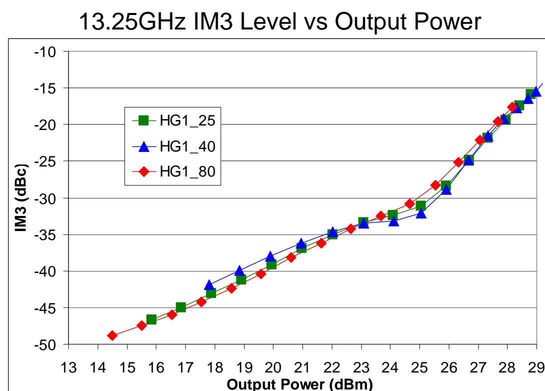
Note: Measurement Conditions: $V_G$= -0.35V, $V_{DD}$= 7V, Id=450mA $T_{AMBIENT}$ = -40°C, +25°C and +80°C

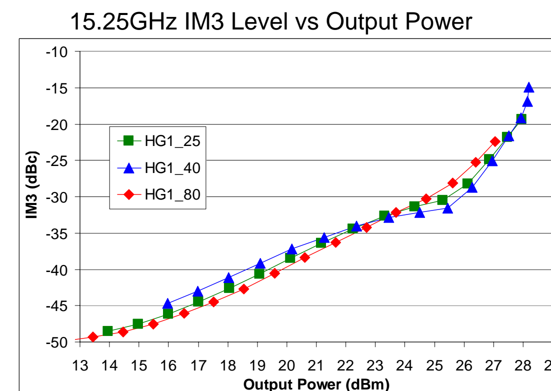


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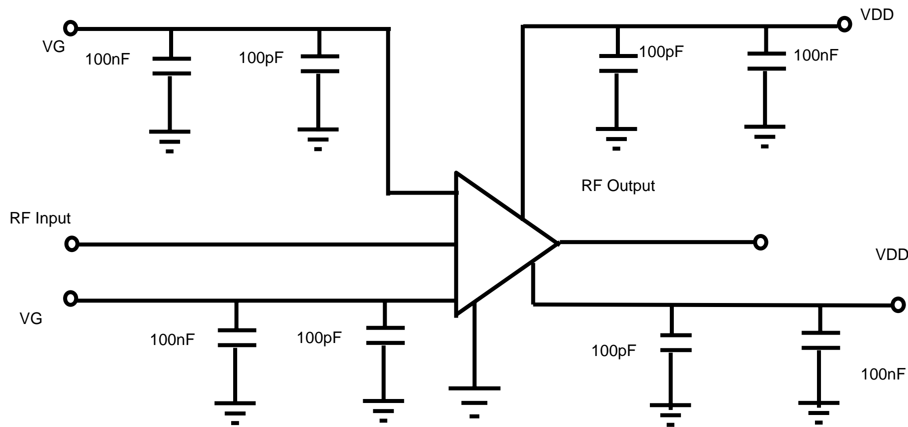
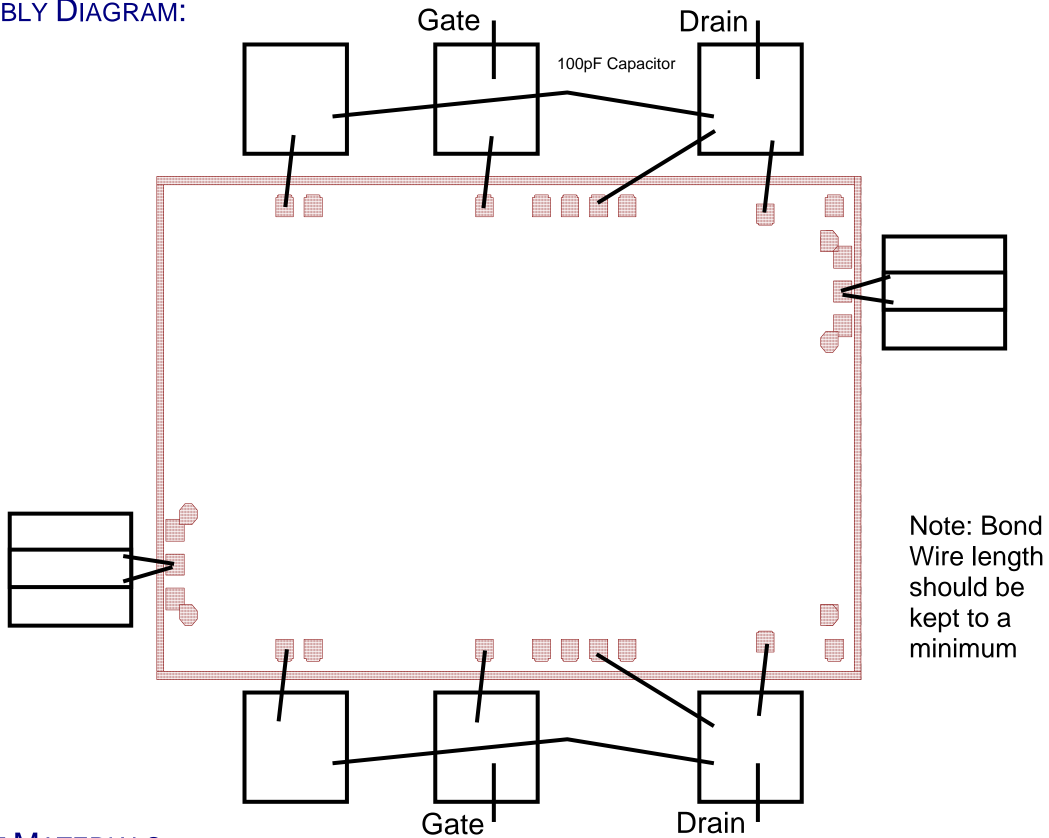
## Biasing Circuit Schematic:




## Assembly Diagram:




## Bill of Materials:

| Label | Component |
|---|---|
| Board | All RF tracks should be 50Ω characteristic material |
| C1 | Capacitor, 100pF, chip capacitor |
| C2 | Capacitor, 100nF, 0402 |



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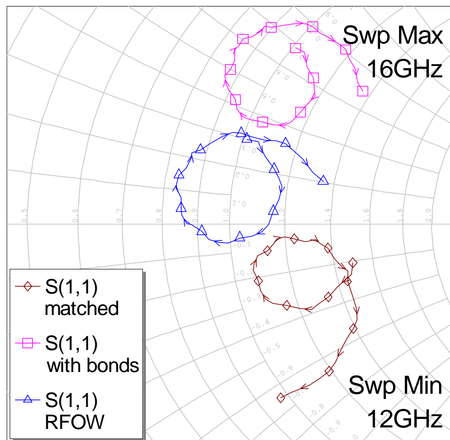
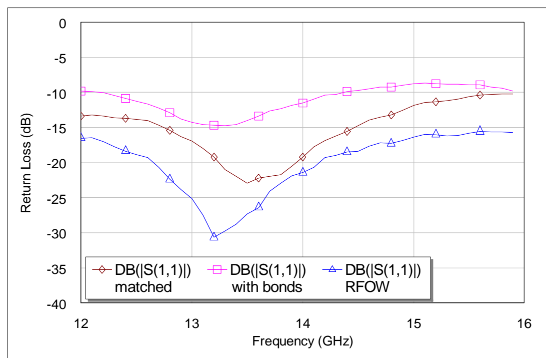
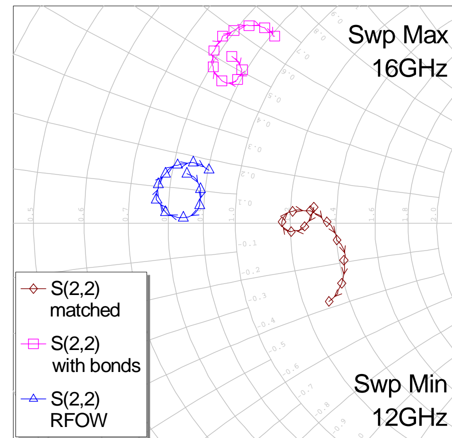
## EFFECT OF BONDWIRES AND BOND COMPENSATION:

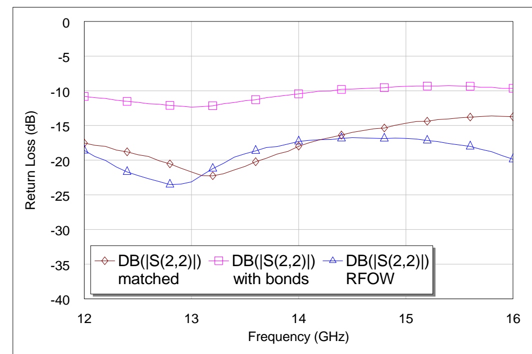
A pair of bondwires in the 'V' formation shown in the figure above, should if kept reasonably short, yield a combined inter-connect inductance of below 0.25nH. The FMA3011 has excellent return losses (blue triangles) and these are modified by the addition of a 0.25nH bondwire inductance (pink squares) as shown in the figures below.



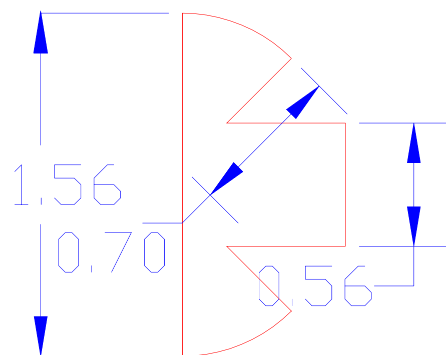




Once bonded the return losses are still at a reasonable level. They can be improved with a simple compensation network. The figures also show the effect of this bondwire compensation network (brown diamonds). The network is shown at the end of this section.




Dimensions in mm. Material is 10 thou 4350 Er=3.38



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## PREFERRED ASSEMBLY INSTRUCTIONS:

GaAs devices are fragile and should be handled with great care. Specially designed collets should be used where possible.

The back of the die is metallised and the recommended mounting method is by the use of conductive epoxy or solder. If Conductive Epoxy is used it should be applied to the attachment surface uniformly and sparingly to avoid encroachment of epoxy on to the top face of the die and ideally should not exceed half the chip height. For automated and manual dispense Ablebond 8350M is recommended. Ablestick 84-1 can be used as an alternative. These should be cured at a temperature of 150°C for 1 hour in an oven especially set aside for epoxy curing only. If possible the curing oven should be flushed with dry nitrogen.

This part has gold (Au) bond pads requiring the use of gold (99.99% pure) bondwire. It is recommended that 25.4µm diameter gold wire is used. For thermosonic ball bonding a nominal stage temperature of 150°C and a bonding force of 40g has been shown to give effective results for 25µm wire. Ultrasonic energy shall be kept to a minimum. For this bonding technique, stage temperature should not be raised above 200°C and bond force should not be raised above 60g. Thermosonic wedge bonding and thermocompression wedge bonding can also be used to achieve good wire bonds.

Bonds should be made from the die first and then to the mounting substrate or package. The physical length of the bondwires should be minimised especially when making RF or ground connections.

## HANDLING PRECAUTIONS:

To avoid damage to the devices care should be exercised during handling. Proper Electrostatic Discharge (ESD) precautions should be observed at all stages of storage, handling, assembly, and testing. These devices should be treated as Class 0 (0-250 V) as defined in JEDEC Standard No. 22-A114. Further information on ESD control measures can be found in MIL-STD-1686 and MIL-HDBK-263.

## APPLICATION NOTES & DESIGN DATA:

Application Notes and design data including S-parameters, noise data and large-signal models are available on request.

## DISCLAIMERS:

This product is not designed for use in any space based or life sustaining/supporting equipment.

## ORDERING INFORMATION:

| PART NUMBER | DESCRIPTION |
|---|---|
| FMA3011 | Die in Waffle-pack<br>(Gel-pak available on request) |



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