

## LOW NOISE HIGH LINEARITY PACKAGED PHEMT

### FEATURES (1850MHz):

- 27 dBm Output Power (P1dB)
- 18 dB Small-Signal Gain (SSG)
- 1.2 dB Noise Figure
- 42 dBm Output IP3
- 45% Power-Added Efficiency
- RoHS compliant (Directive 2002/95/EC)

### PACKAGE:



### GENERAL DESCRIPTION:

The FPD1500DFN is a packaged depletion mode AlGaAs/InGaAs pseudomorphic High Electron Mobility Transistor (pHEMT). It utilizes a 0.25  $\mu\text{m}$  x 750  $\mu\text{m}$  Schottky barrier Gate, defined by high-resolution stepper-based photolithography. The recessed and offset Gate structure minimizes parasitics to optimize performance, with an epitaxial structure designed for improved linearity over a range of bias conditions and input power levels.

### TYPICAL APPLICATIONS:

- Drivers or output stages in PCS/Cellular base station transmitter amplifiers
- High intercept-point LNAs
- WLL and WLAN systems, and other types of wireless infrastructure systems.

### ELECTRICAL SPECIFICATIONS:

| PARAMETER                                                          | SYMBOL | CONDITIONS                                                                    | MIN | TYP      | MAX | UNITS         |
|--------------------------------------------------------------------|--------|-------------------------------------------------------------------------------|-----|----------|-----|---------------|
| Power at 1dB Gain Compression                                      | P1dB   | VDS = 5 V; IDS = 50% IDSS                                                     |     | 27       |     | dBm           |
| Small-Signal Gain                                                  | SSG    | VDS = 5 V; IDS = 50% IDSS                                                     |     | 18       |     | dB            |
| Power-Added Efficiency                                             | PAE    | VDS = 5 V; IDS = 50% IDSS;<br>POUT = P1dB                                     |     | 45       |     | %             |
| Noise Figure                                                       | NF     | VDS = 5 V; IDS = 50% IDSS                                                     |     | 1.2      |     | dB            |
| Output Third-Order Intercept Point<br>(from 15 to 5 dB below P1dB) | IP3    | VDS = 5V; IDS = 50% IDSS<br>Matched for optimal power<br>Matched for best IP3 |     | 40<br>42 |     | dBm           |
| Saturated Drain-Source Current                                     | IDSS   | VDS = 1.3 V; VGS = 0 V                                                        | 375 | 465      | 550 | mA            |
| Maximum Drain-Source Current                                       | IMAX   | VDS = 1.3 V; VGS = +1 V                                                       |     | 750      |     | mA            |
| Transconductance                                                   | GM     | VDS = 1.3 V; VGS = 0 V                                                        |     | 400      |     | mS            |
| Gate-Source Leakage Current                                        | IGSO   | VGS = -5 V                                                                    |     | 1        | 15  | $\mu\text{A}$ |
| Pinch-Off Voltage                                                  | VP     | VDS = 1.3 V; IDS = 1.5 mA                                                     | 0.7 | 0.9      | 1.3 | V             |
| Gate-Source Breakdown Voltage                                      | VBDGS  | IGS = 1.5 mA                                                                  | 12  | 16       |     | V             |
| Gate-Drain Breakdown Voltage                                       | VBDGD  | IGD = 1.5 mA                                                                  | 12  | 16       |     | V             |

Note: T<sub>AMBIENT</sub> = 22°; RF specification measured at f = 1850 MHz using CW signal (except as noted)

**ABSOLUTE MAXIMUM RATING<sup>1</sup>:**

| PARAMETER                                       | SYMBOL | TEST CONDITIONS                 | ABSOLUTE MAXIMUM |
|-------------------------------------------------|--------|---------------------------------|------------------|
| Drain-Source Voltage                            | VDS    | -3V < VGS < +0V                 | 8V               |
| Gate-Source Voltage                             | VGS    | 0V < VDS < +8V                  | -3V              |
| Drain-Source Current                            | IDS    | For VDS > 2V                    | IDSS             |
| Gate Current                                    | IG     | Forward or reverse current      | 15mA             |
| RF Input Power <sup>2</sup>                     | PIN    | Under any acceptable bias state | 350mW            |
| Channel Operating Temperature                   | TCH    | Under any acceptable bias state | 175°C            |
| Storage Temperature                             | TSTG   | Non-Operating Storage           | -40°C to 150°C   |
| Total Power Dissipation                         | PTOT   | See De-Rating Note below        | 2.2W             |
| Gain Compression                                | Comp.  | Under any bias conditions       | 5dB              |
| Simultaneous Combination of Limits <sup>3</sup> |        | 2 or more Max. Limits           |                  |

**Notes:**

<sup>1</sup>T<sub>Ambient</sub> = 22°C unless otherwise noted; exceeding any one of these absolute maximum ratings may cause permanent damage to the device

<sup>2</sup>Max. RF Input Limit must be further limited if input VSWR > 2.5:1

<sup>3</sup>Users should avoid exceeding 80% of 2 or more Limits simultaneously

<sup>4</sup>Total Power Dissipation defined as:  $P_{TOT} \equiv (P_{DC} + P_{IN}) - P_{OUT}$ ,  
where P<sub>DC</sub>: DC Bias Power, P<sub>IN</sub>: RF Input Power, P<sub>OUT</sub>: RF Output Power

Total Power Dissipation to be de-rated as follows above 22°C:

$$P_{TOT} = 2.2 - (0.0167W/°C) \times T_{PACK}$$

where T<sub>PACK</sub> = source tab lead temperature above 22°C

(coefficient of de-rating formula is the Thermal Conductivity)

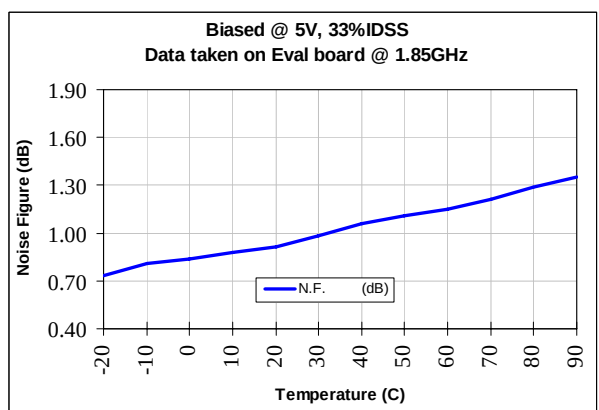
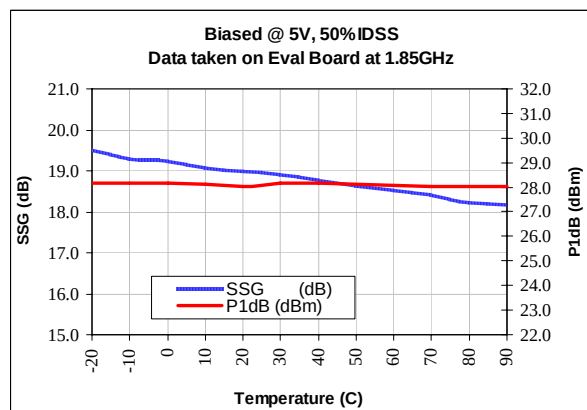
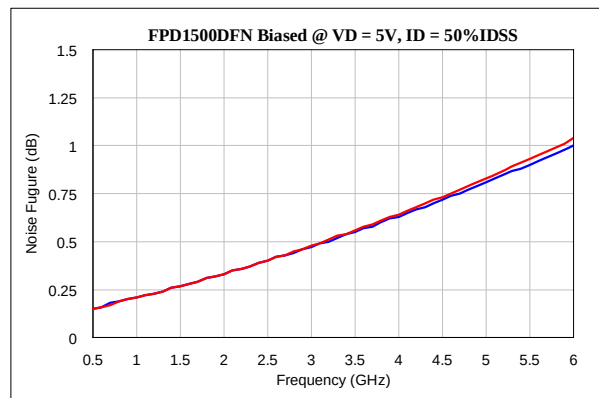
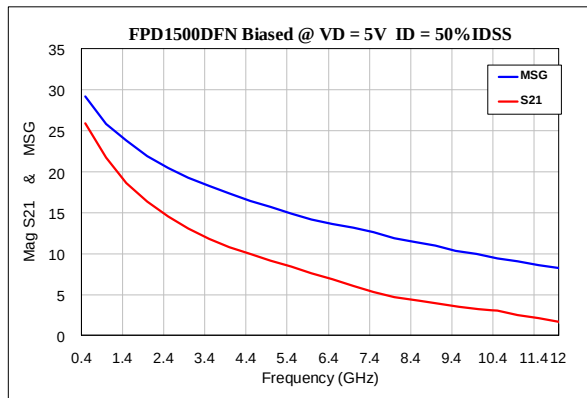
Example: For a 65°C carrier temperature:  $P_{TOT} = 2.2W - (0.0167 \times (65 - 22)) = 1.48mW$

<sup>5</sup>The use of a filled via-hole directly beneath the exposed heatsink tab on the bottom of the package is strongly recommended to provide for adequate thermal management. Ideally the bottom of the circuit board is affixed to a heatsink or thermal radiator

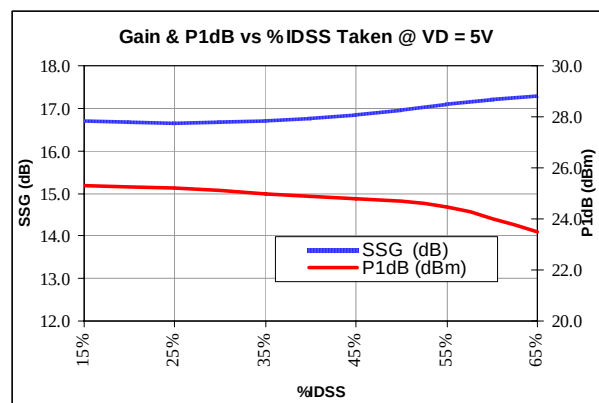
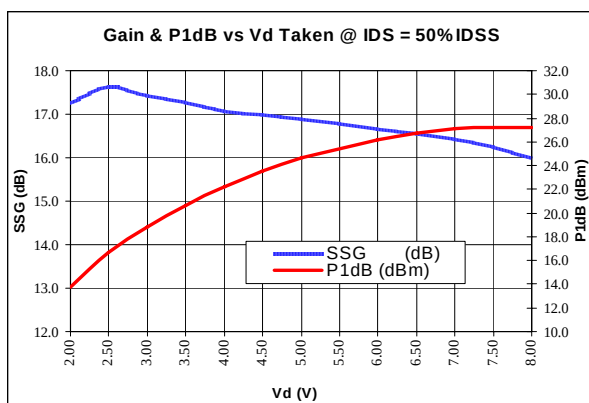
**BIASING GUIDELINES:**

- Active bias circuits provide good performance stabilization over variations of operating temperature, but require a larger number of components compared to self-bias or dual-biased. Such circuits should include provisions to ensure that Gate bias is applied before Drain bias, otherwise the pHEMT may be induced to self-oscillate
- Dual-bias circuits are relatively simple to implement, but will require a regulated negative voltage supply for depletion-mode devices.
- For standard Class A operation, a 50% of IDSS bias point is recommended. A small amount of RF gain expansion prior to the onset of compression is normal for this operating point. Note that pHEMTs, since they are “quasi- E/D mode” devices, exhibit Class AB traits when operated at 50% of IDSS. To achieve a larger separation between P1dB and IP3, an operating point in the 25% to 33% of IDSS range is suggested. Such Class AB operation will not degrade the IP3 performance.

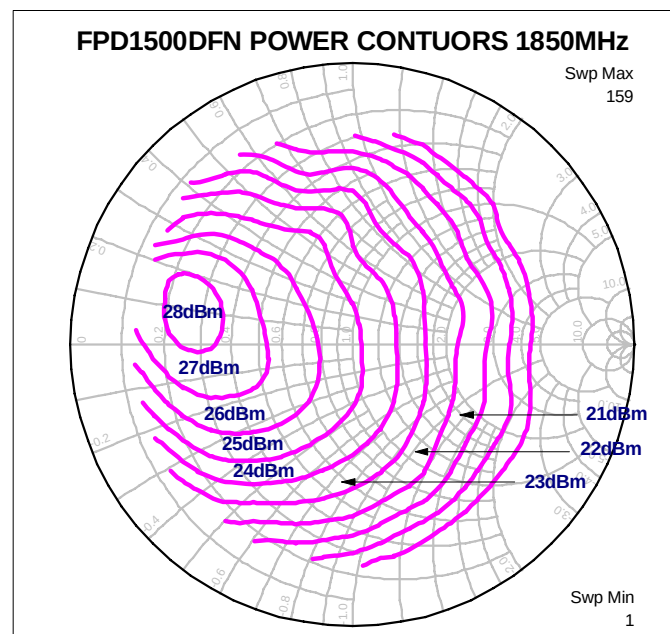
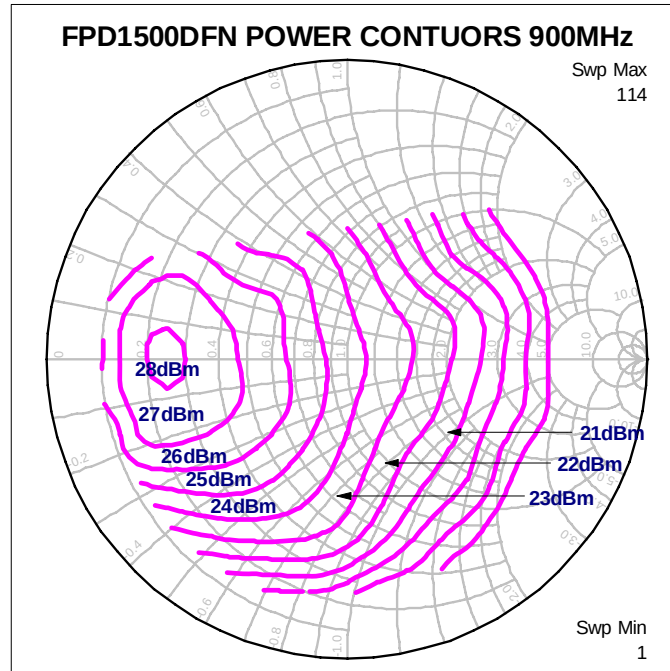
### TYPICAL TUNED RF PERFORMANCE:

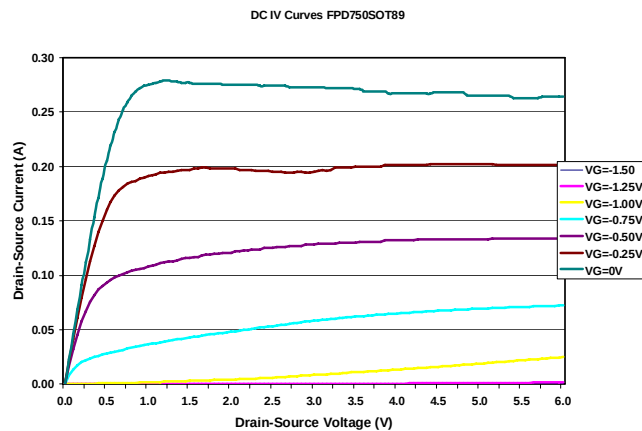


### BIAS RESPONSE:



TYPICAL OUTPUT PLANE CONTOURS (VDS = 5V, IDS = 50%IDSS):



**TYPICAL I-V CHARACTERISTICS:**


Note: The recommended method for measuring  $I_{DSS}$ , or any particular  $I_{DS}$ , is to set the Drain-Source voltage ( $V_{DS}$ ) at 1.3V. This measurement point avoids the onset of spurious self-oscillation which would normally distort the current measurement (this effect has been filtered from the I-V curves presented above). Setting the  $V_{DS} > 1.3V$  will generally cause errors in the current measurements, even in stabilized circuits.

Recommendation: Traditionally a device's  $I_{DSS}$  rating ( $I_{DS}$  at  $V_{GS} = 0V$ ) was used as a predictor of RF power, and for MESFETs there is a correlation between  $I_{DSS}$  and  $P_{1dB}$  (power at 1dB gain compression). For pHEMTs it can be shown that there is *no* meaningful statistical correlation between  $I_{DSS}$  and  $P_{1dB}$ ; specifically a linear regression analysis shows  $r^2 < 0.7$ , and the regression fails the F-statistic test.  $I_{DSS}$  is sometimes useful as a guide to circuit tuning, since the  $S_{22}$  does vary with the quiescent operating point  $I_{DS}$ .

**NOISE PARAMETERS:**

Bias 3V, 50%IDSS

| Freq<br>(GHz) | $\Gamma_{opt}$ |          | Rn/50 |
|---------------|----------------|----------|-------|
|               | Mag            | Angle    |       |
| 0.900         | 0.345          | 18.350   | 0.029 |
| 1.800         | 0.384          | 86.350   | 0.043 |
| 2.000         | 0.401          | 97.050   | 0.039 |
| 2.200         | 0.448          | 116.200  | 0.032 |
| 2.400         | 0.463          | 129.200  | 0.031 |
| 2.600         | 0.483          | 137.900  | 0.034 |
| 2.800         | 0.482          | 146.800  | 0.022 |
| 3.000         | 0.503          | 149.850  | 0.022 |
| 3.500         | 0.487          | 160.750  | 0.023 |
| 4.000         | 0.513          | 172.500  | 0.020 |
| 4.500         | 0.506          | 177.500  | 0.035 |
| 5.000         | 0.521          | -172.250 | 0.027 |
| 5.500         | 0.563          | -160.450 | 0.031 |
| 6.000         | 0.570          | -153.650 | 0.041 |

Bias 5V, 25%IDSS

| Freq<br>(GHz) | $\Gamma_{opt}$ |          | Rn/50 |
|---------------|----------------|----------|-------|
|               | Mag            | Angle    |       |
| 0.900         | 0.367          | 27.250   | 0.030 |
| 1.800         | 0.416          | 75.400   | 0.046 |
| 2.000         | 0.445          | 80.800   | 0.042 |
| 2.200         | 0.454          | 103.150  | 0.035 |
| 2.400         | 0.450          | 125.500  | 0.034 |
| 2.600         | 0.502          | 129.550  | 0.028 |
| 2.800         | 0.467          | 135.950  | 0.023 |
| 3.000         | 0.475          | 142.050  | 0.023 |
| 3.500         | 0.478          | 151.550  | 0.024 |
| 4.000         | 0.495          | 163.200  | 0.020 |
| 4.500         | 0.490          | 168.500  | 0.034 |
| 5.000         | 0.497          | 179.700  | 0.024 |
| 5.500         | 0.544          | -168.300 | 0.023 |
| 6.000         | 0.558          | -161.200 | 0.028 |

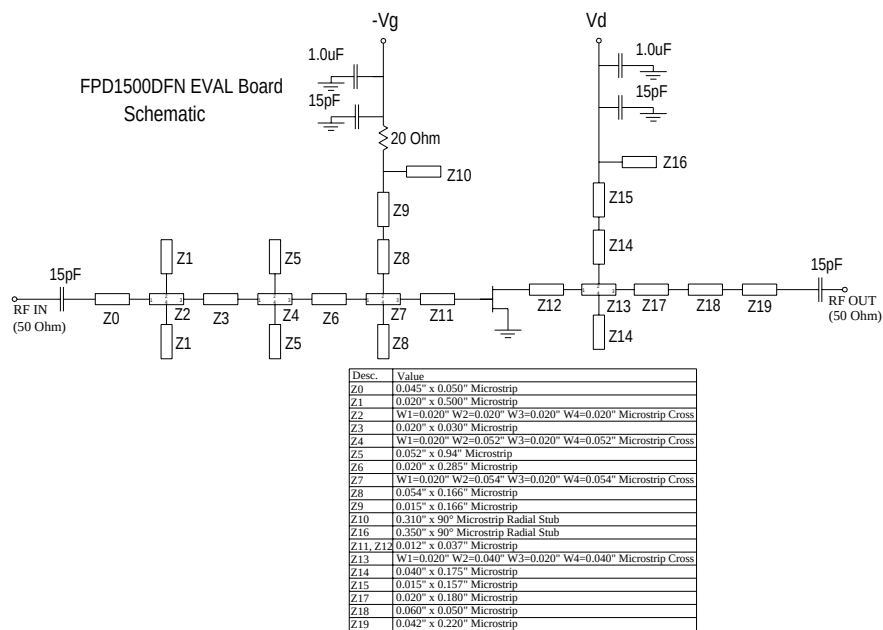
Bias 5V, 50%IDSS

| Freq<br>(GHz) | $\Gamma_{opt}$ |          | Rn/50 |
|---------------|----------------|----------|-------|
|               | Mag            | Angle    |       |
| 0.900         | 0.181          | 73.550   | 0.038 |
| 1.800         | 0.283          | 91.250   | 0.051 |
| 2.000         | 0.346          | 100.550  | 0.047 |
| 2.200         | 0.400          | 119.700  | 0.038 |
| 2.400         | 0.426          | 131.450  | 0.036 |
| 2.600         | 0.450          | 136.800  | 0.039 |
| 2.800         | 0.445          | 148.400  | 0.028 |
| 3.000         | 0.485          | 156.550  | 0.026 |
| 3.500         | 0.470          | 163.800  | 0.029 |
| 4.000         | 0.492          | 175.300  | 0.026 |
| 4.500         | 0.500          | -178.800 | 0.042 |
| 5.000         | 0.509          | -169.350 | 0.036 |
| 5.500         | 0.554          | -158.100 | 0.042 |
| 6.000         | 0.568          | -150.900 | 0.054 |

**S-PARAMETERS:**

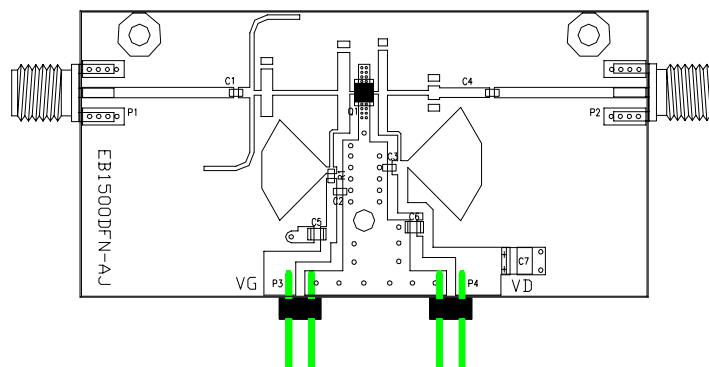
Biased @ 5V, 50%IDSS

| <b>FREQ[GHz]</b> | <b>S11m</b> | <b>S11a</b> | <b>S21m</b> | <b>S21a</b> | <b>S12m</b> | <b>S12a</b> | <b>S22m</b> | <b>S22a</b> |
|------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 0.500            | 0.841       | -91.2       | 19.661      | 126.2       | 0.023       | 51.0        | 0.294       | -137.3      |
| 1.000            | 0.770       | -134.6      | 12.134      | 102.2       | 0.031       | 41.1        | 0.308       | -159.7      |
| 1.500            | 0.770       | -157.8      | 8.561       | 87.3        | 0.037       | 38.0        | 0.317       | -168.0      |
| 2.000            | 0.760       | -173.0      | 6.590       | 77.3        | 0.040       | 35.6        | 0.324       | -175.2      |
| 2.500            | 0.775       | 176.0       | 5.303       | 68.3        | 0.045       | 38.0        | 0.339       | 179.6       |
| 3.000            | 0.773       | 168.8       | 4.514       | 61.0        | 0.051       | 35.7        | 0.345       | 173.0       |
| 3.500            | 0.768       | 163.2       | 3.898       | 53.4        | 0.056       | 35.0        | 0.349       | 166.4       |
| 4.000            | 0.765       | 158.2       | 3.471       | 46.6        | 0.064       | 32.2        | 0.355       | 159.1       |
| 4.500            | 0.759       | 152.8       | 3.160       | 39.0        | 0.069       | 32.4        | 0.365       | 154.0       |
| 5.000            | 0.753       | 145.2       | 2.878       | 32.1        | 0.076       | 29.2        | 0.372       | 148.1       |
| 5.500            | 0.751       | 138.5       | 2.625       | 24.9        | 0.084       | 24.8        | 0.377       | 145.1       |
| 6.000            | 0.761       | 131.1       | 2.407       | 17.7        | 0.089       | 20.4        | 0.380       | 140.3       |
| 6.500            | 0.766       | 124.7       | 2.204       | 10.3        | 0.092       | 14.8        | 0.385       | 135.0       |
| 7.000            | 0.769       | 118.9       | 2.018       | 3.7         | 0.097       | 10.3        | 0.388       | 129.1       |
| 7.500            | 0.760       | 113.7       | 1.845       | -2.6        | 0.100       | 6.7         | 0.392       | 123.8       |
| 8.000            | 0.756       | 108.6       | 1.717       | -7.8        | 0.105       | 6.2         | 0.396       | 120.8       |
| 8.500            | 0.759       | 103.5       | 1.643       | -13.6       | 0.113       | 3.1         | 0.408       | 117.8       |
| 9.000            | 0.771       | 97.8        | 1.573       | -19.1       | 0.121       | -1.7        | 0.418       | 114.3       |
| 9.500            | 0.768       | 93.1        | 1.510       | -25.8       | 0.136       | -5.3        | 0.428       | 110.0       |
| 10.000           | 0.775       | 87.6        | 1.453       | -32.5       | 0.145       | -12.3       | 0.451       | 104.3       |
| 10.500           | 0.803       | 82.4        | 1.419       | -39.8       | 0.155       | -17.9       | 0.465       | 97.9        |
| 11.000           | 0.800       | 76.0        | 1.328       | -47.2       | 0.164       | -22.5       | 0.475       | 91.1        |
| 11.500           | 0.808       | 69.5        | 1.275       | -53.2       | 0.170       | -27.9       | 0.489       | 86.5        |
| 12.000           | 0.817       | 63.9        | 1.208       | -59.7       | 0.177       | -32.2       | 0.502       | 79.2        |

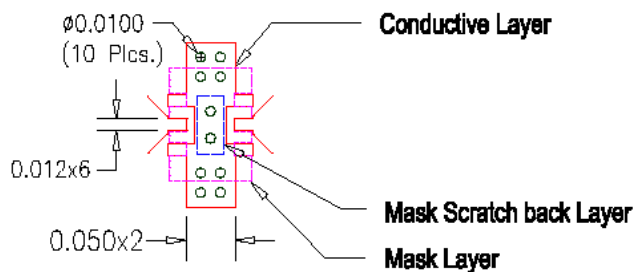
**REFERENCE DESIGN (5.3 – 5.9GHz)**


| PARAMETER | UNIT | PERFORMANCE  |
|-----------|------|--------------|
| Frequency | GHz  | 5.3 to 5.9   |
| Gain      | dB   | 10.5         |
| P1dB      | dBm  | 27           |
| N.F.      | dB   | 1.5          |
| OIP3      | dBm  | 40           |
| S11       | dB   | -10          |
| S22       | dB   | -9           |
| Vd        | V    | 5            |
| Vg        | V    | -0.4 to -0.7 |
| Id        | mA   | 200          |



**EVALUATION BOARD:**


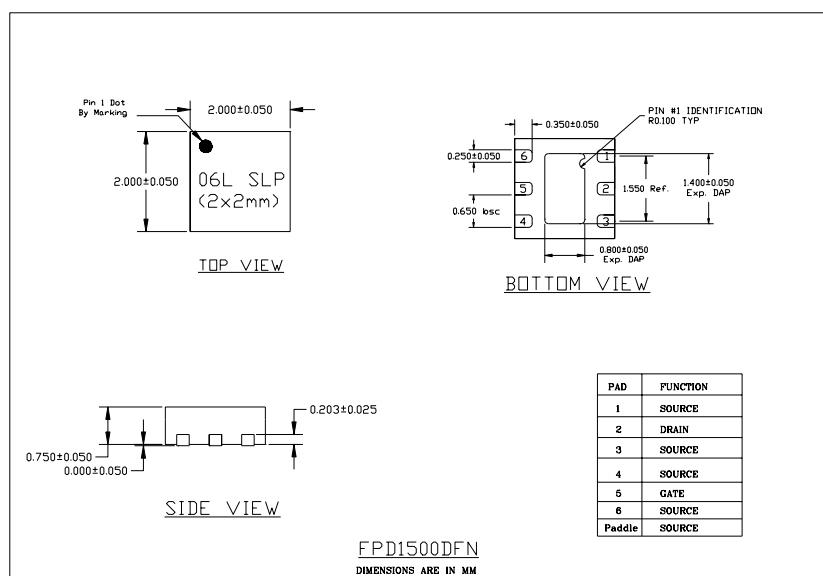
| Component      | Description                           |
|----------------|---------------------------------------|
| R1             | Resistor 0.06 x 0.03 20 $\Omega$ 1/4W |
| C1, C2, C3, C4 | Cap. 0.06 x 0.03 15pF                 |
| C5, C6         | Cap. 0.08 x 0.05 0.01uF               |
| C7             | Cap. SMD-B 1.0uF                      |
| P1, P2         | Edge Mount RF Connector               |
| P3, P4         | 2 Pin Header                          |
| Q1             | FPD1500DFN                            |
| PCB            | EV-SP-000051-002 (R4003, 20mil Thick) |
| Base Plate     | TF-SP-000055-001                      |

**PCB FOOTPRINT:**


**Dimensions are in Inches**

**PACKAGE OUTLINE:**

(dimensions in millimeters – mm)


**PREFERRED ASSEMBLY INSTRUCTIONS:**

Please contact Filtronic Compound Semiconductors Ltd for further details.

**DISCLAIMERS:**

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

**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 1A (0-500 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.


**ORDERING INFORMATION:**

| PART NUMBER  | DESCRIPTION                                |
|--------------|--------------------------------------------|
| FPD1500DFN   | Packaged pHEMT                             |
| EB1500DFN-BB | Packaged pHEMT eval board – 900MHz         |
| EB1500DFN-BA | Packaged pHEMT eval board – 1.85GHz        |
| EB1500DFN-BC | Packaged pHEMT eval board – 2.0GHz         |
| EB1500DFN-BE | Packaged pHEMT eval board – 2.4GHz         |
| EB1500DFN-AJ | Packaged pHEMT eval board – 5.3 to 5.75GHz |

**APPLICATION NOTES & DESIGN DATA:**

Application Notes and design data including S-parameters are available; please contact Filtronic Compound Semiconductors Ltd.