



# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed for GSM and GSM EDGE base station applications with frequencies from 869 to 960 MHz. Suitable for TDMA, CDMA, and multicarrier amplifier applications.

### GSM Application

- Typical GSM Performance:  $V_{DD} = 26$  Volts,  $I_{DQ} = 600$  mA,  $P_{out} = 80$  Watts CW, Full Frequency Band (869-894 MHz or 921-960 MHz).  
 Power Gain — 18.5 dB  
 Drain Efficiency — 60%

### GSM EDGE Application

- Typical GSM EDGE Performance:  $V_{DD} = 26$  Volts,  $I_{DQ} = 550$  mA,  $P_{out} = 36$  Watts Avg., Full Frequency Band (869-894 MHz or 921-960 MHz).  
 Power Gain — 19 dB  
 Drain Efficiency — 42%  
 Spectral Regrowth @ 400 kHz Offset = -63 dBc  
 Spectral Regrowth @ 600 kHz Offset = -78 dBc  
 EVM — 2.5% rms

- Capable of Handling 10:1 VSWR, @ 26 Vdc, 960 MHz, 80 Watts CW Output Power

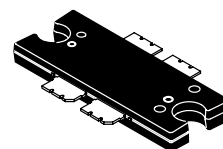
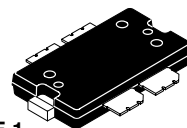
### Features

- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 32  $V_{DD}$  Operation
- Integrated ESD Protection
- 200°C Capable Plastic Package
- RoHS Compliant
- In Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.

**MRF5S9080NR1**  
**MRF5S9080NBR1**

**869-960 MHz, 80 W, 26 V**  
**GSM/GSM EDGE**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**

**CASE 1486-03, STYLE 1**  
**TO-270 WB-4**  
**PLASTIC**  
**MRF5S9080NR1**



**CASE 1484-04, STYLE 1**  
**TO-272 WB-4**  
**PLASTIC**  
**MRF5S9080NBR1**

**Table 1. Maximum Ratings**

| Rating                         | Symbol    | Value        | Unit |
|--------------------------------|-----------|--------------|------|
| Drain-Source Voltage           | $V_{DSS}$ | -0.5, +65    | Vdc  |
| Gate-Source Voltage            | $V_{GS}$  | -0.5, +15    | Vdc  |
| Storage Temperature Range      | $T_{stg}$ | - 65 to +150 | °C   |
| Operating Junction Temperature | $T_J$     | 200          | °C   |

**Table 2. Thermal Characteristics**

| Characteristic                       | Symbol          | Value (1,2) | Unit |
|--------------------------------------|-----------------|-------------|------|
| Thermal Resistance, Junction to Case | $R_{\theta JC}$ |             | °C/W |
| Case Temperature 79°C, 80 W CW       |                 | 0.50        |      |
| Case Temperature 80°C, 36 W CW       |                 | 0.54        |      |

1. MTF calculator available at <http://www.freescale.com/rtf>. Select Tools/Software/Application Software/Calculators to access the MTF calculators by product.
2. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rtf>. Select Documentation/Application Notes - AN1955.

**Table 3. ESD Protection Characteristics**

| Test Methodology                      | Class        |
|---------------------------------------|--------------|
| Human Body Model (per JESD22-A114)    | 1B (Minimum) |
| Machine Model (per EIA/JESD22-A115)   | A (Minimum)  |
| Charge Device Model (per JESD22-C101) | IV (Minimum) |

**Table 4. Moisture Sensitivity Level**

| Test Methodology                      | Rating | Package Peak Temperature | Unit |
|---------------------------------------|--------|--------------------------|------|
| Per JESD 22-A113, IPC/JEDEC J-STD-020 | 3      | 260                      | °C   |

**Table 5. Electrical Characteristics** ( $T_C = 25^\circ\text{C}$  unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|----------------|--------|-----|-----|-----|------|
|----------------|--------|-----|-----|-----|------|

**Off Characteristics**

|   |           |   |   |     |                 |
|---|-----------|---|---|-----|-----------------|
| Zero Gate Voltage Drain Leakage Current<br>( $V_{DS} = 65\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ ) | $I_{DSS}$ | — | — | 10  | $\mu\text{Adc}$ |
| Zero Gate Voltage Drain Leakage Current<br>( $V_{DS} = 26\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ ) | $I_{DSS}$ | — | — | 1   | $\mu\text{Adc}$ |
| Gate-Source Leakage Current<br>( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )              | $I_{GSS}$ | — | — | 500 | nAdc            |

**On Characteristics**

|  |              |     |      |     |     |
|--|--------------|-----|------|-----|-----|
| Gate Threshold Voltage<br>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 400\ \mu\text{Adc}$ )                            | $V_{GS(th)}$ | 2   | 2.8  | 3.5 | Vdc |
| Gate Quiescent Voltage<br>( $V_{DS} = 26\text{ Vdc}$ , $I_D = 600\ \text{mAdc}$ , Measured in Functional Test) | $V_{GS(Q)}$  | 3.5 | 3.9  | 4.5 | Vdc |
| Drain-Source On-Voltage<br>( $V_{GS} = 10\text{ Vdc}$ , $I_D = 2\ \text{Adc}$ )                                | $V_{DS(on)}$ | —   | 0.27 | 0.3 | Vdc |

**Dynamic Characteristics** (1)

|  |           |   |     |   |    |
|--|-----------|---|-----|---|----|
| Reverse Transfer Capacitance<br>( $V_{DS} = 26\text{ Vdc} \pm 30\ \text{mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ ) | $C_{rss}$ | — | 1.8 | — | pF |
| Output Capacitance<br>( $V_{DS} = 26\text{ Vdc} \pm 30\ \text{mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )           | $C_{oss}$ | — | 600 | — | pF |

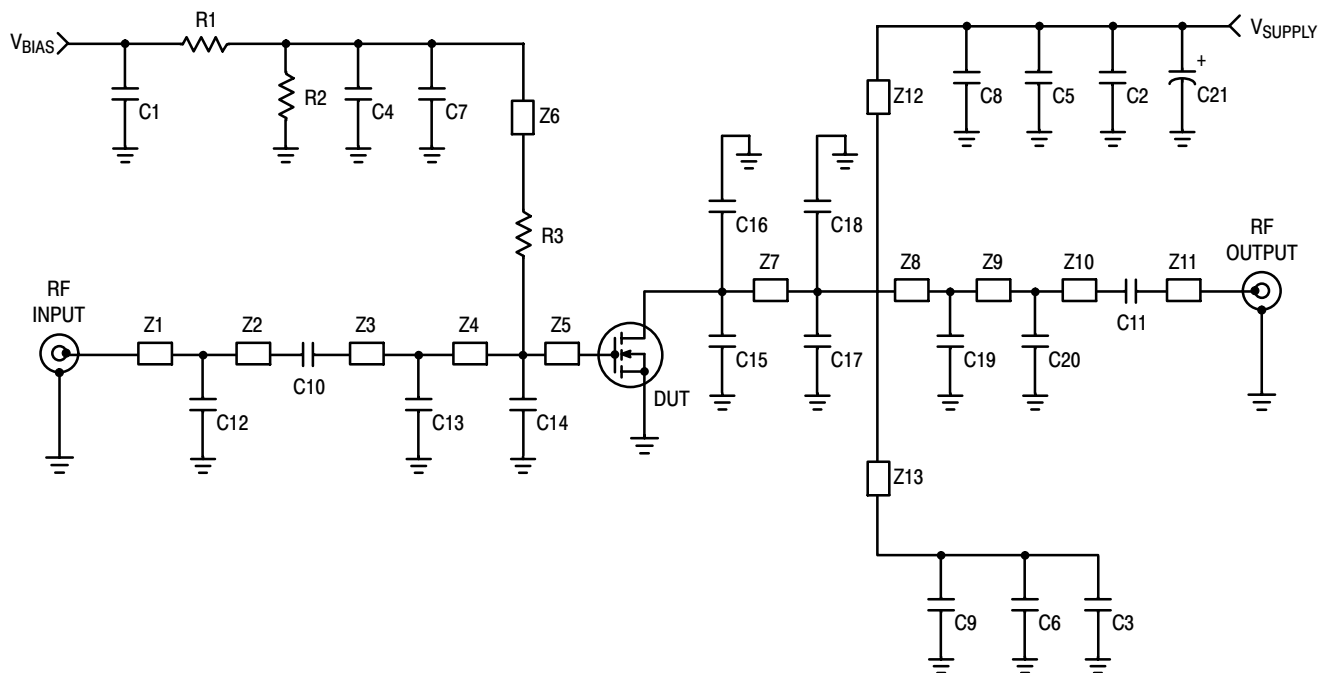
**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 26\text{ Vdc}$ ,  $I_{DQ} = 600\ \text{mA}$ ,  $P_{out} = 80\ \text{W CW}$ ,  $f = 960\ \text{MHz}$ 

|                                    |          |    |      |    |    |
|------------------------------------|----------|----|------|----|----|
| Power Gain                         | $G_{ps}$ | 17 | 18.5 | 20 | dB |
| Drain Efficiency                   | $\eta_D$ | 55 | 60   | —  | %  |
| Input Return Loss                  | IRL      | —  | -15  | -9 | dB |
| $P_{out}$ @ 1 dB Compression Point | P1dB     | 80 | 90   | —  | W  |

**Typical GSM EDGE Performances** (In Freescale GSM EDGE Test Fixture, 50 ohm system)  $V_{DD} = 26\text{ Vdc}$ ,  $I_{DQ} = 550\ \text{mA}$ ,  $P_{out} = 36\ \text{W Avg.}$ , 869-894 MHz, 920-960 MHz GSM EDGE Modulation

|                                     |          |   |     |   |       |
|-------------------------------------|----------|---|-----|---|-------|
| Power Gain                          | $G_{ps}$ | — | 19  | — | dB    |
| Drain Efficiency                    | $\eta_D$ | — | 42  | — | %     |
| Error Vector Magnitude              | EVM      | — | 2.5 | — | % rms |
| Spectral Regrowth at 400 kHz Offset | SR1      | — | -63 | — | dBc   |
| Spectral Regrowth at 600 kHz Offset | SR2      | — | -77 | — | dBc   |

1. Part is internally matched on input.



|    |                            |          |  |
|----|----------------------------|----------|--|
| Z1 | 1.220" x 0.087" Microstrip | Z8       | 0.138" x 0.087" Microstrip                     |
| Z2 | 1.110" x 0.087" Microstrip | Z9       | 0.411" x 0.087" Microstrip                     |
| Z3 | 0.536" x 0.087" Microstrip | Z10      | 0.403" x 0.087" Microstrip                     |
| Z4 | 0.310" x 0.087" Microstrip | Z11      | 0.560" x 0.087" Microstrip                     |
| Z5 | 0.430" x 0.591" Microstrip | Z12, Z13 | 1.693" x 0.087" Microstrip                     |
| Z6 | 1.567" x 0.059" Microstrip | PCB      | Taconic TLX8-0300, 0.030", $\epsilon_r = 2.55$ |
| Z7 | 0.734" x 0.788" Microstrip |          |  |

**Figure 1. MRF5S9080NR1(NBR1) Test Circuit Schematic — 900 MHz**

**Table 6. MRF5S9080NR1(NBR1) Test Circuit Component Designations and Values — 900 MHz**

| Part          | Description                                     | Part Number     | Manufacturer |
|---------------|---|-----------------|--------------|
| C1, C2, C3    | 4.7 $\mu$ F Chip Capacitors (1812)              | C4532X5R1H475MT | TDK          |
| C4, C5, C6    | 10 nF 200B Chip Capacitors                      | 200B103MW       | ATC          |
| C7, C8, C9    | 33 pF 600B Chip Capacitors                      | 600B330JW       | ATC          |
| C10, C11      | 22 pF 600B Chip Capacitors                      | 600B220FW       | ATC          |
| C12           | 1.8 pF 600B Chip Capacitor                      | 600B1R8BW       | ATC          |
| C13           | 9.1 pF 600B Chip Capacitor                      | 600B9R1BW       | ATC          |
| C14, C17, C18 | 8.2 pF 600B Chip Capacitors                     | 600B8R2BW       | ATC          |
| C15, C16      | 10 pF 600B Chip Capacitors                      | 600B100FW       | ATC          |
| C19           | 4.7 pF 600B Chip Capacitor                      | 600B4R7BW       | ATC          |
| C20           | 3.6 pF 600B Chip Capacitor                      | 600B3R6BW       | ATC          |
| C21           | 220 $\mu$ F, 63 V Electrolytic Capacitor, Axial | 13668221        | Philips      |
| R1, R2        | 10 k $\Omega$ , 1/4 W Chip Resistors (1206)     |                 |              |
| R3            | 10 $\Omega$ , 1/4 W Chip Resistor (1206)        |                 |              |

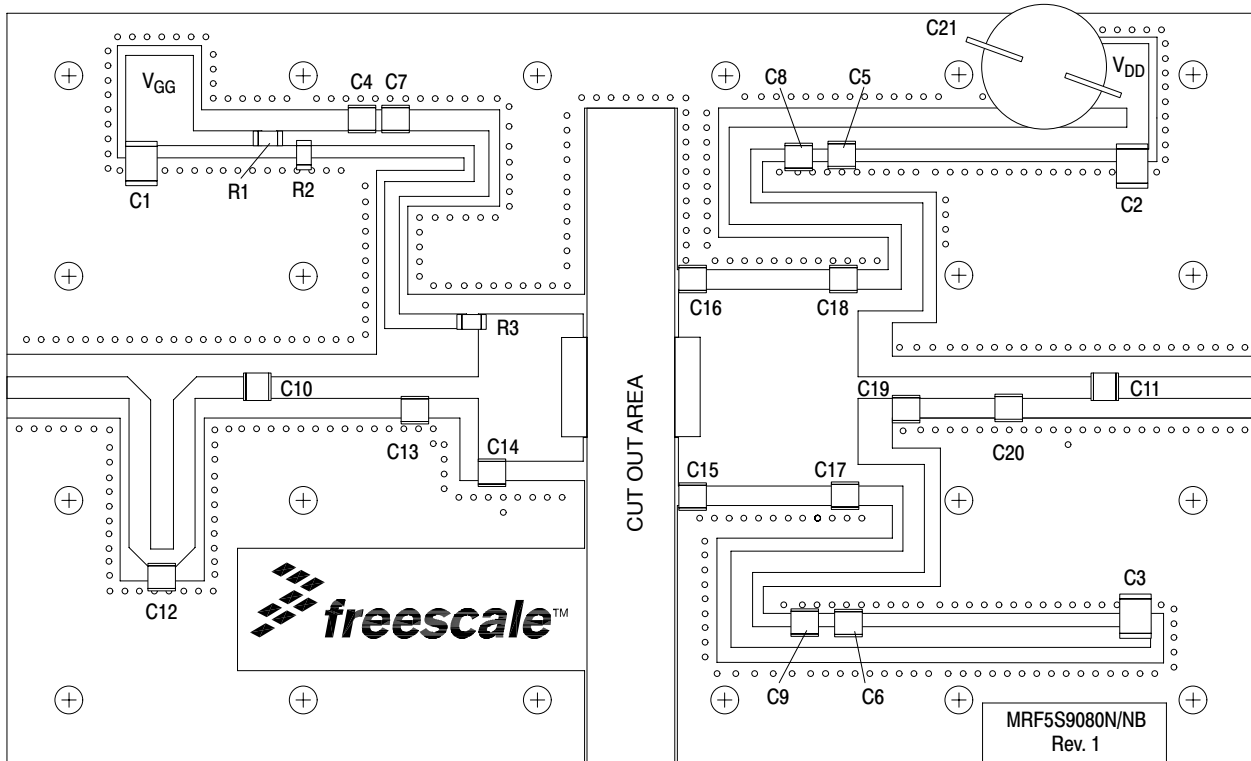


Figure 2. MRF5S9080NR1 (NBR1) Test Circuit Component Layout — 900 MHz

### TYPICAL CHARACTERISTICS - 900 MHz

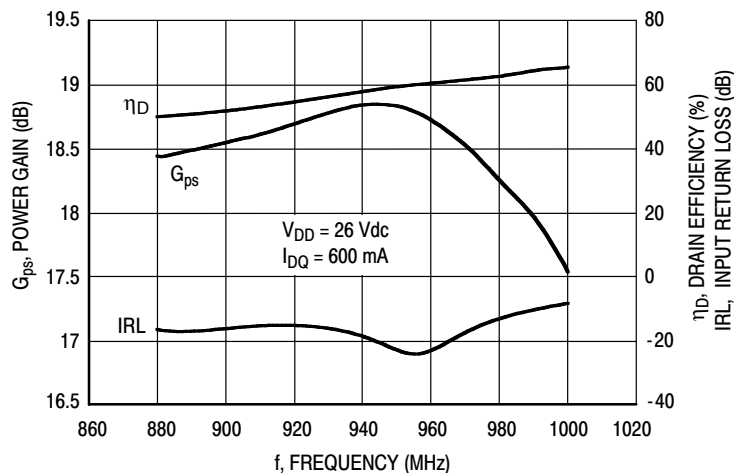


Figure 3. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @  $P_{out} = 80$  Watts CW

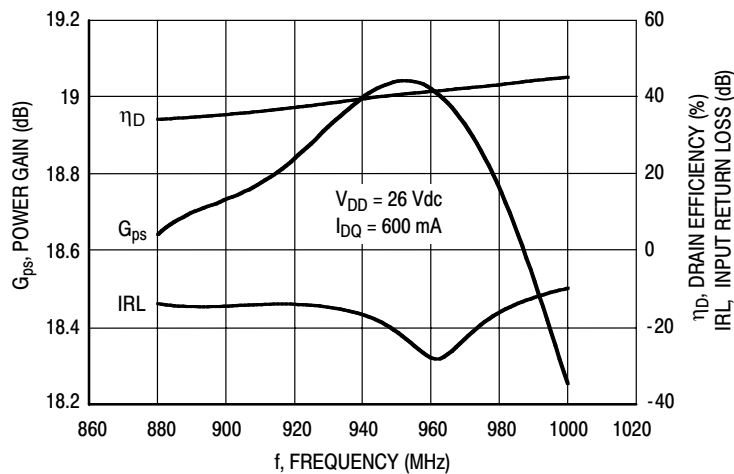


Figure 4. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @  $P_{out} = 36$  Watts CW

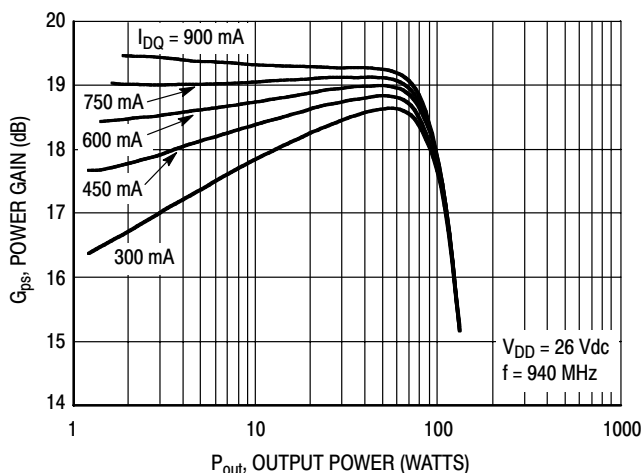


Figure 5. Power Gain versus Output Power

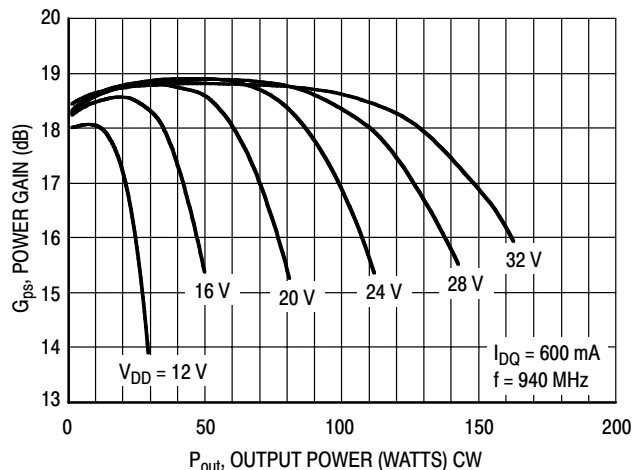
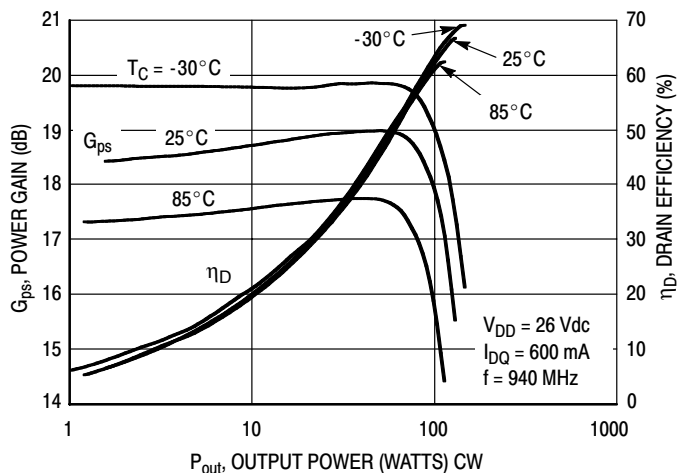
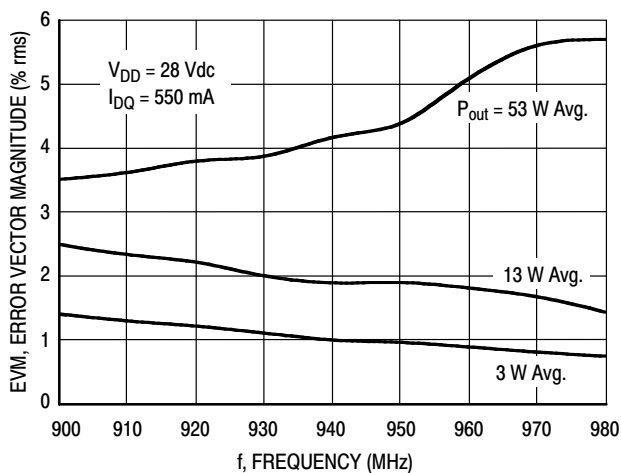


Figure 6. Power Gain versus Output Power

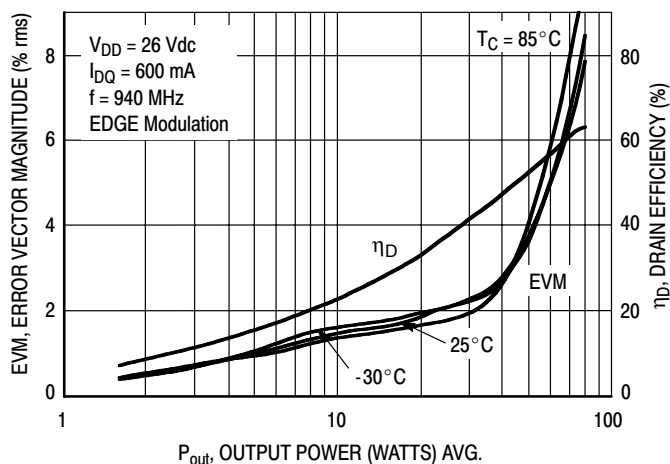
## TYPICAL CHARACTERISTICS - 900 MHz



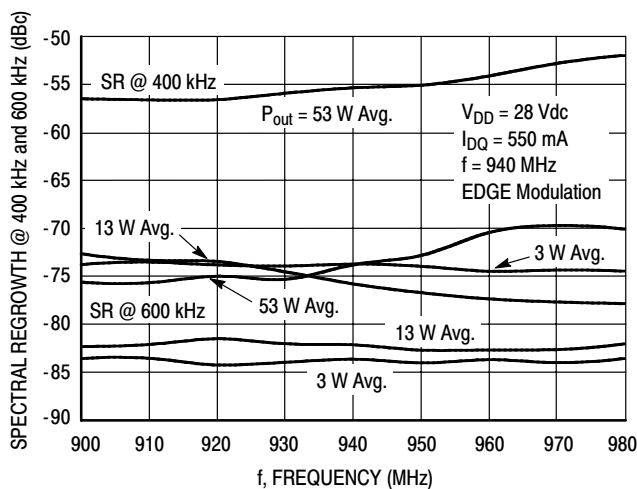
**Figure 7. Power Gain and Drain Efficiency versus CW Output Power**



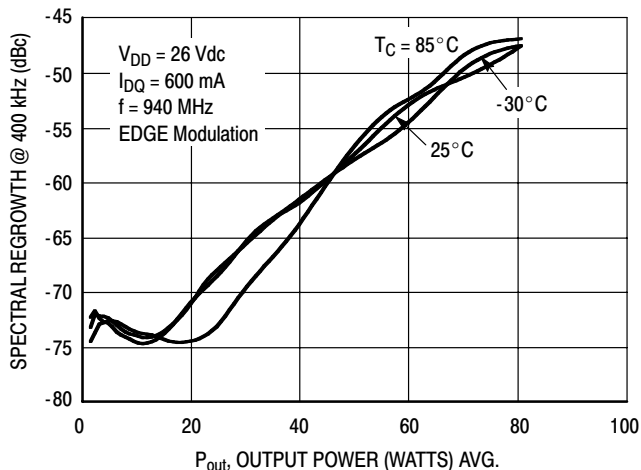
**Figure 8. EVM versus Frequency**



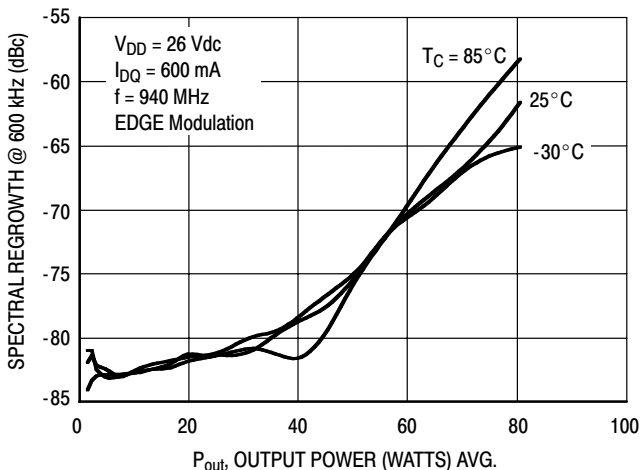
**Figure 9. EVM and Drain Efficiency versus Output Power**



**Figure 10. Spectral Regrowth at 400 kHz and 600 kHz versus Frequency**

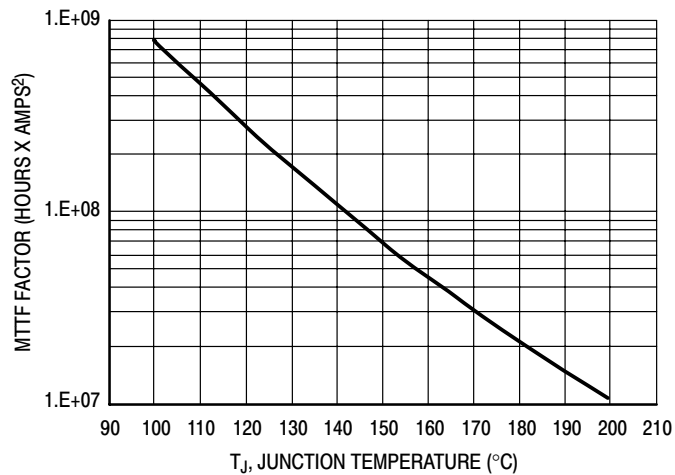


**Figure 11. Spectral Regrowth @ 400 kHz versus Output Power**



**Figure 12. Spectral Regrowth @ 600 kHz versus Output Power**

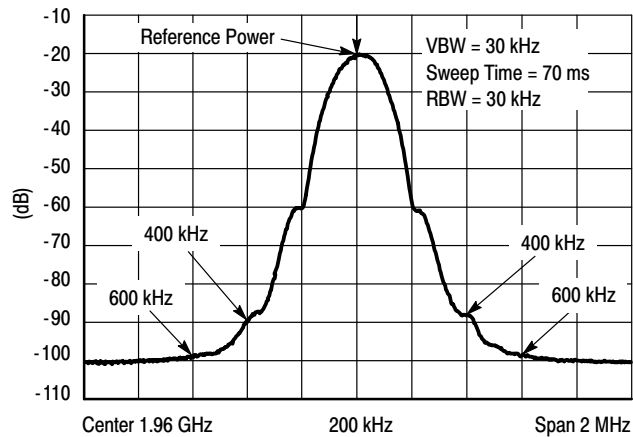
## TYPICAL CHARACTERISTICS



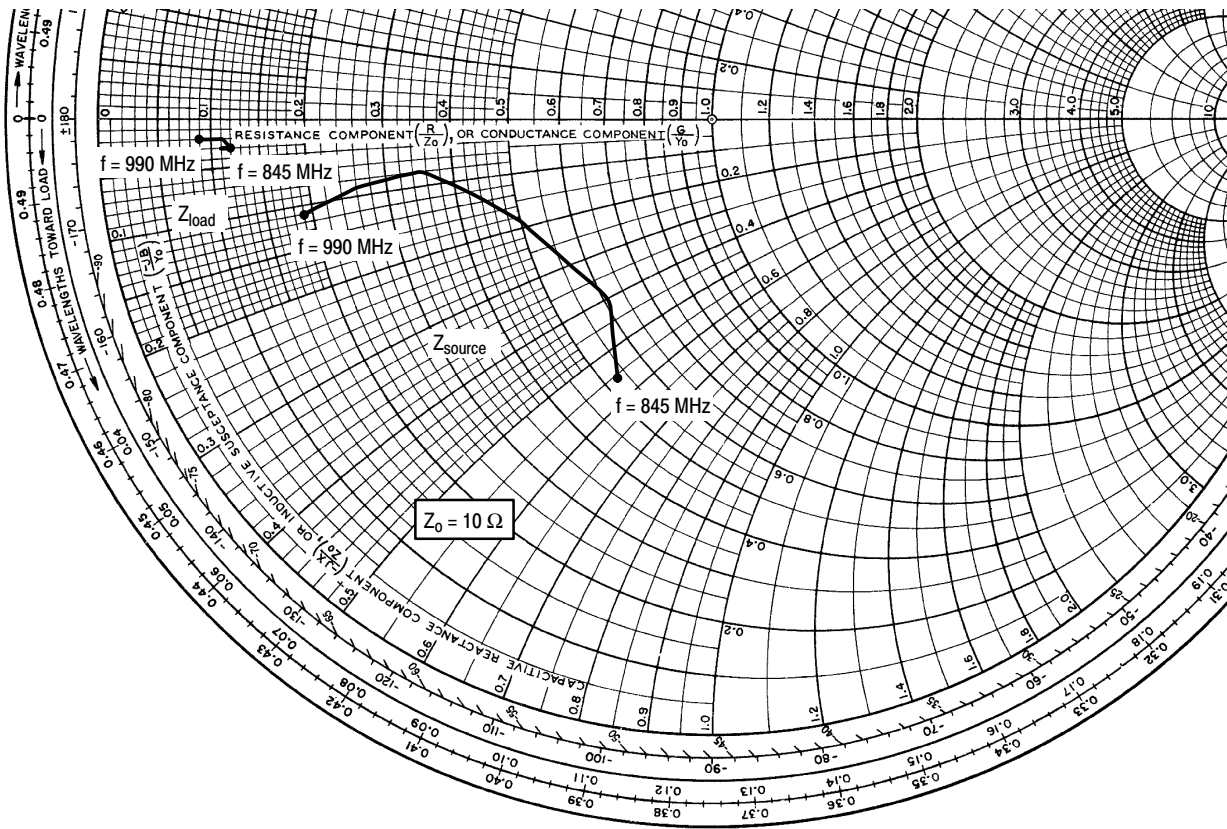
This above graph displays calculated MTTF in hours x ampere<sup>2</sup> drain current. Life tests at elevated temperatures have correlated to better than  $\pm 10\%$  of the theoretical prediction for metal failure. Divide MTTF factor by  $I_D^2$  for MTTF in a particular application.

**Figure 13. MTTF Factor versus Junction Temperature**

## GSM TEST SIGNAL



**Figure 14. EDGE Spectrum**



$V_{DD} = 26 \text{ Vdc}$ ,  $I_{DQ} = 600 \text{ mA}$ ,  $P_{out} = 80 \text{ W CW}$

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 845      | $5.31 - j5.59$           | $1.18 - j0.34$         |
| 865      | $6.07 - j4.16$           | $1.09 - j0.29$         |
| 890      | $5.05 - j1.99$           | $1.22 - j0.29$         |
| 920      | $3.47 - j0.81$           | $1.10 - j0.21$         |
| 960      | $2.64 - j0.88$           | $1.05 - j0.15$         |
| 990      | $1.89 - j1.14$           | $0.91 - j0.18$         |

$Z_{source}$  = Test circuit impedance as measured from gate to ground.

$Z_{load}$  = Test circuit impedance as measured from drain to ground.

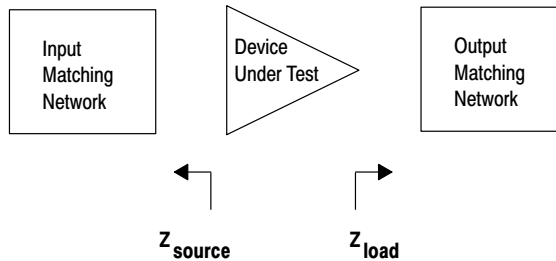
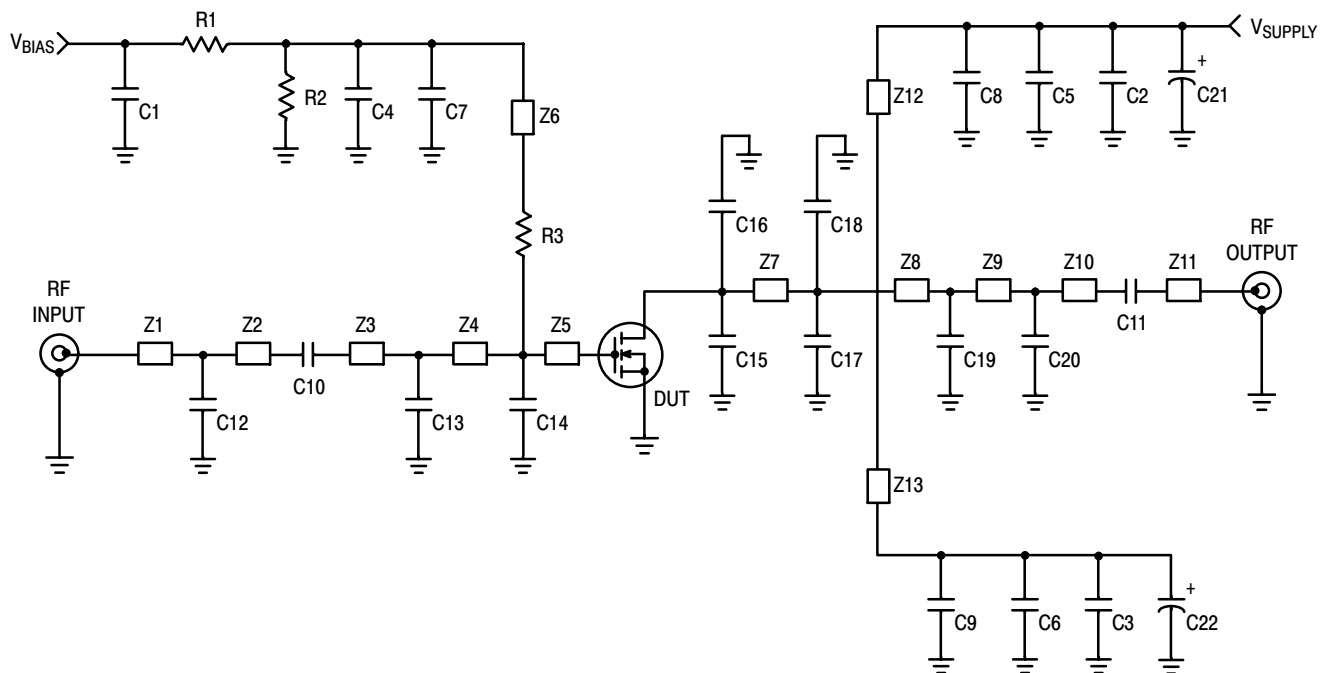


Figure 15. Series Equivalent Source and Load Impedance — 900 MHz





|    |                            |          |  |
|----|----------------------------|----------|--|
| Z1 | 1.220" x 0.087" Microstrip | Z8       | 0.138" x 0.087" Microstrip                     |
| Z2 | 1.110" x 0.087" Microstrip | Z9       | 0.411" x 0.087" Microstrip                     |
| Z3 | 0.536" x 0.087" Microstrip | Z10      | 0.403" x 0.087" Microstrip                     |
| Z4 | 0.310" x 0.087" Microstrip | Z11      | 0.560" x 0.087" Microstrip                     |
| Z5 | 0.430" x 0.591" Microstrip | Z12, Z13 | 1.693" x 0.087" Microstrip                     |
| Z6 | 1.567" x 0.059" Microstrip | PCB      | Taconic TLX8-0300, 0.030", $\epsilon_r = 2.55$ |
| Z7 | 0.734" x 0.788" Microstrip |          |  |

Figure 16. MRF5S9080NR1(NBR1) Test Circuit Schematic — 800 MHz

Table 7. MRF5S9080NR1(NBR1) Test Circuit Component Designations and Values — 800 MHz

| Part          | Description                                       | Part Number     | Manufacturer |
|---------------|---|-----------------|--------------|
| C1, C2, C3    | 4.7 $\mu$ F Chip Capacitors (1812)                | C4532X5R1H475MT | TDK          |
| C4, C5, C6    | 10 nF 200B Chip Capacitors                        | 200B103MW       | ATC          |
| C7, C8, C9    | 33 pF 600B Chip Capacitors                        | 600B330JW       | ATC          |
| C10, C11      | 22 pF 600B Chip Capacitors                        | 600B220FW       | ATC          |
| C12           | 1.8 pF 600B Chip Capacitor                        | 600B1R8BW       | ATC          |
| C13           | 9.1 pF 600B Chip Capacitor                        | 600B9R1BW       | ATC          |
| C14, C17, C18 | 8.2 pF 600B Chip Capacitors                       | 600B8R2BW       | ATC          |
| C15, C16      | 10 pF 600B Chip Capacitors                        | 600B100FW       | ATC          |
| C19           | 4.7 pF 600B Chip Capacitor                        | 600B4R7BW       | ATC          |
| C20           | 3.6 pF 600B Chip Capacitor                        | 600B3R6BW       | ATC          |
| C21, C22      | 220 $\mu$ F, 50 V Electrolytic Capacitors, Radial | 678D227M050DM3D | Vishay       |
| R1, R2        | 10 k $\Omega$ , 1/4 W Chip Resistors (1206)       |                 |              |
| R3            | 10 $\Omega$ , 1/4 W Chip Resistor (1206)          |                 |              |

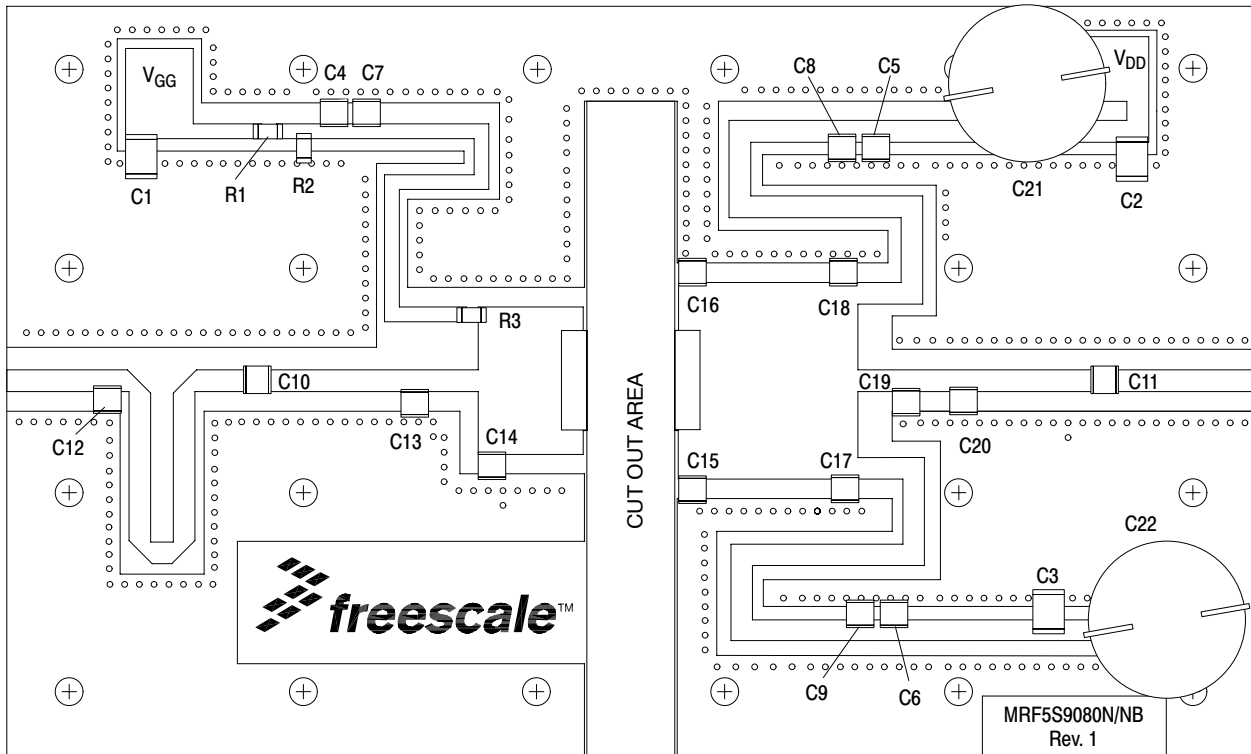


Figure 17. MRF5S9080NR1(NBR1) Test Circuit Component Layout — 800 MHz

## TYPICAL CHARACTERISTICS - 800 MHz

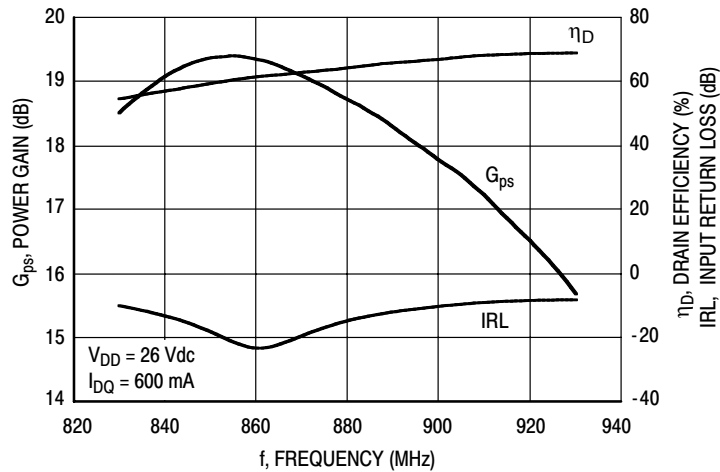


Figure 18. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @  $P_{out} = 80$  Watts

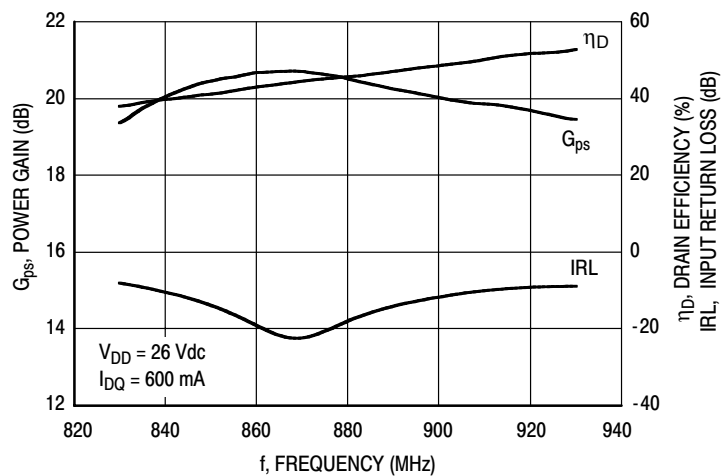


Figure 19. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @  $P_{out} = 36$  Watts

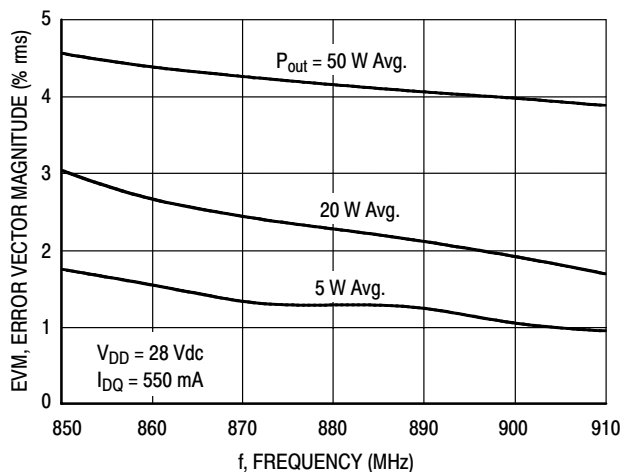


Figure 20. EVM versus Frequency

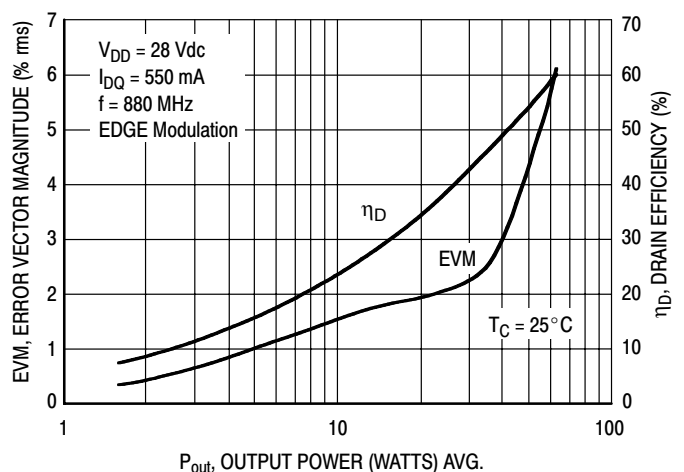


Figure 21. EVM and Drain Efficiency versus Output Power

MRF5S9080NR1 MRF5S9080NBR1

TYPICAL CHARACTERISTICS - 800 MHz

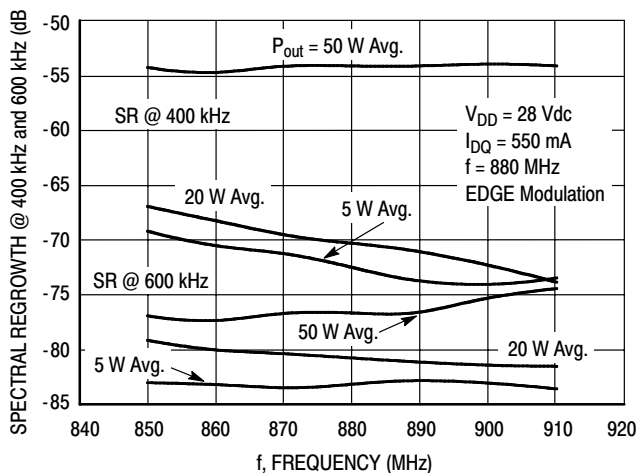


Figure 22. Spectral Regrowth at 400 kHz and 600 kHz versus Frequency

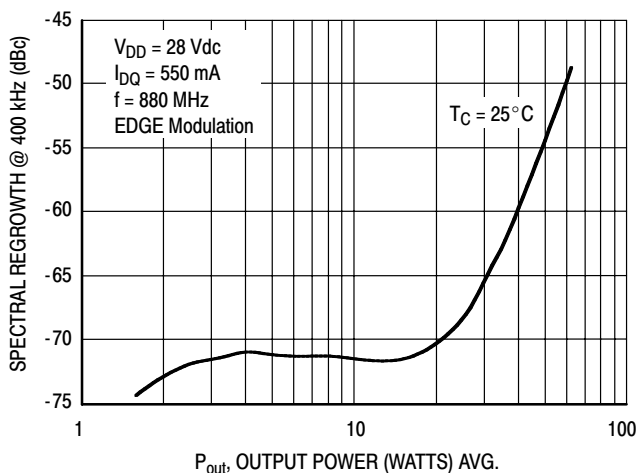


Figure 23. Spectral Regrowth @ 400 kHz versus Output Power

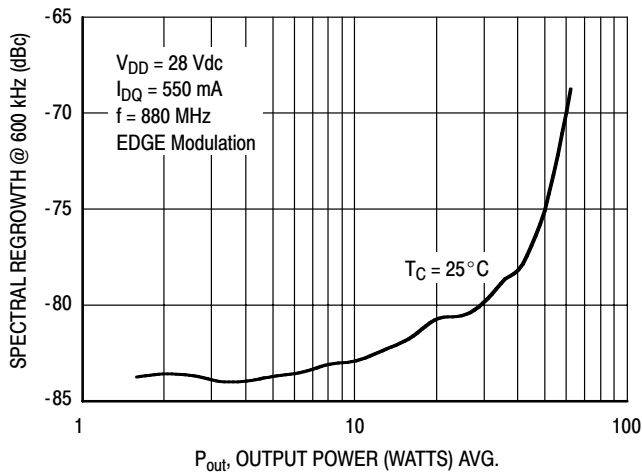


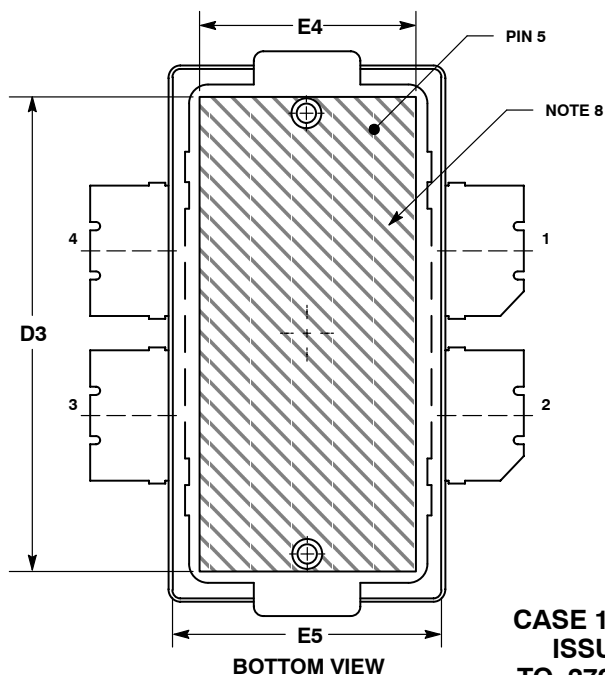
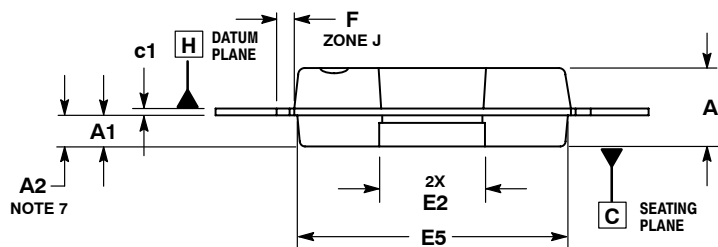
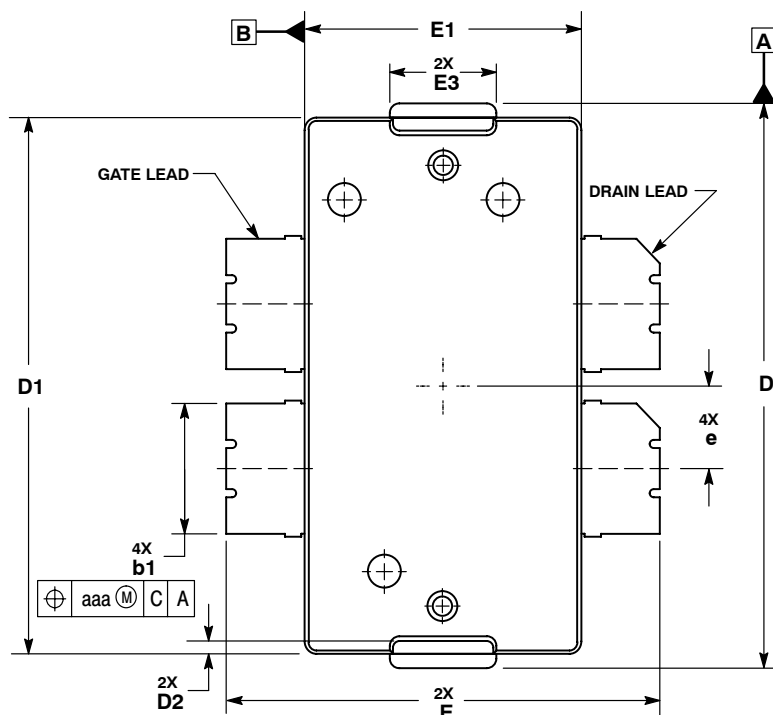
Figure 24. Spectral Regrowth @ 600 kHz versus Output Power

# NOTES

# NOTES

# NOTES

# PACKAGE DIMENSIONS



**NOTES:**

1. CONTROLLING DIMENSION: INCH.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
3. DATUM PLANE -H- IS LOCATED AT THE TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
4. DIMENSIONS "D" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 PER SIDE. DIMENSIONS "D" AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -H-.
5. DIMENSION "b1" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE "b1" DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUMS -A- AND -B- TO BE DETERMINED AT DATUM PLANE -H-.
7. DIMENSION A2 APPLIES WITHIN ZONE "J" ONLY.
8. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG.

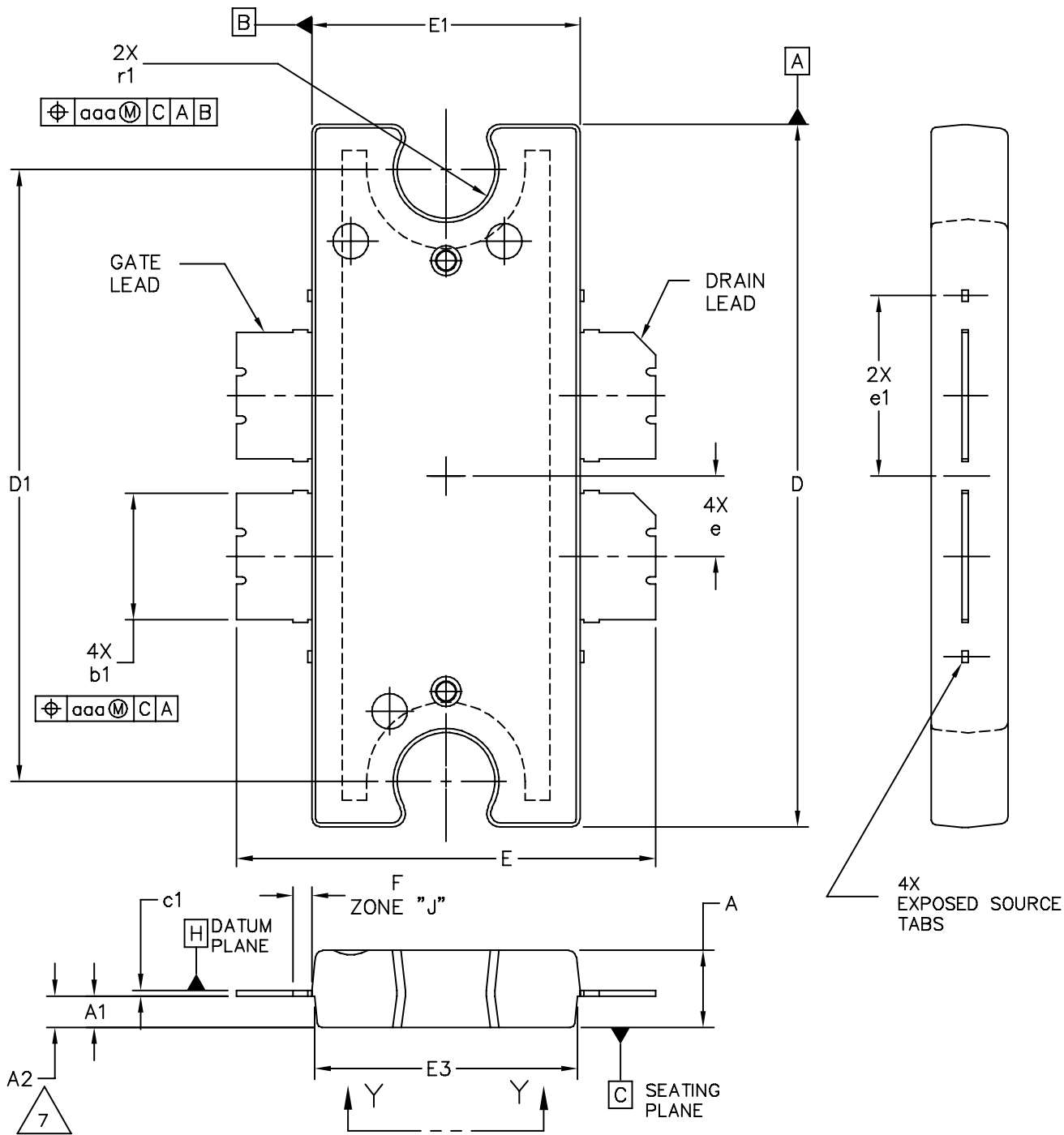
| DIM | INCHES   |      | MILLIMETERS |       |
|-----|----------|------|-------------|-------|
|     | MIN      | MAX  | MIN         | MAX   |
| A   | .100     | .104 | 2.54        | 2.64  |
| A1  | .039     | .043 | 0.99        | 1.09  |
| A2  | .040     | .042 | 1.02        | 1.07  |
| D   | .712     | .720 | 18.08       | 18.29 |
| D1  | .688     | .692 | 17.48       | 17.58 |
| D2  | .011     | .019 | 0.28        | 0.48  |
| D3  | .600     | ---  | 15.24       | ---   |
| E   | .551     | .559 | 14          | 14.2  |
| E1  | .353     | .357 | 8.97        | 9.07  |
| E2  | .132     | .140 | 3.35        | 3.56  |
| E3  | .124     | .132 | 3.15        | 3.35  |
| E4  | .270     | ---  | 6.86        | ---   |
| E5  | .346     | .350 | 8.79        | 8.89  |
| F   | .025 BSC |      | 0.64 BSC    |       |
| b1  | .164     | .170 | 4.17        | 4.32  |
| c1  | .007     | .011 | 0.18        | 0.28  |
| e   | .106 BSC |      | 2.69 BSC    |       |
| aaa | .004     |      | 0.10        |       |

**STYLE 1:**

1. DRAIN
2. DRAIN
3. GATE
4. GATE
5. SOURCE

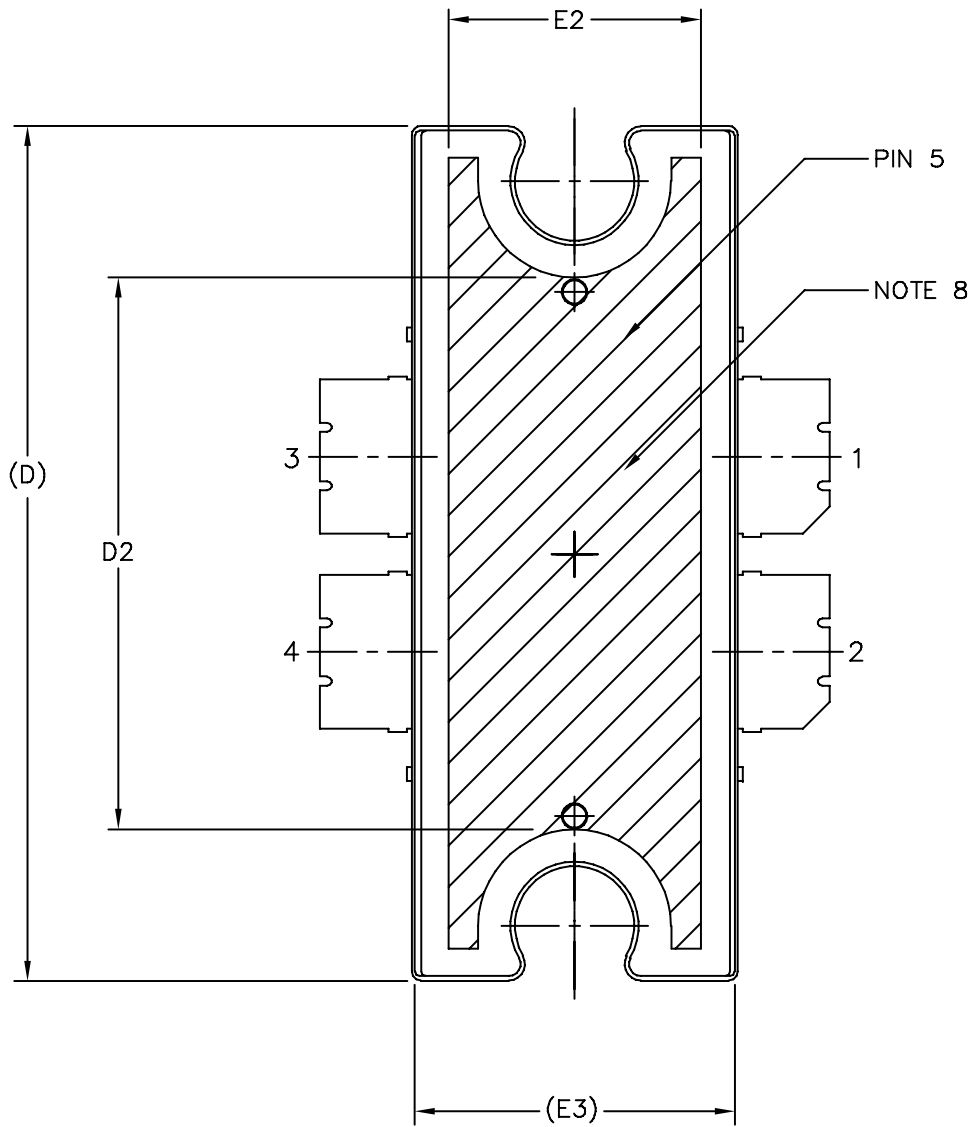
**CASE 1486-03  
ISSUE C  
TO-270 WB-4  
PLASTIC  
MRF5S9080NR1**





|   |                                       |                       |   |
|---|---------------------------------------|-----------------------|---|
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|   | TITLE:<br>TO-272<br>4 LEAD, WIDE BODY |                       | DOCUMENT NO: 98ASA10575D<br>CASE NUMBER: 1484-04<br>STANDARD: NON-JEDEC |
|   |                                       | REV: D<br>05 APR 2006 |   |

MRF5S9080NR1 MRF5S9080NBR1



|   |                           |                            |  |
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| TITLE:<br>TO-272<br>4 LEAD, WIDE BODY                   | DOCUMENT NO: 98ASA10575D  | REV: D                     |  |
|   | CASE NUMBER: 1484-04      | 05 APR 2006                |  |
|   | STANDARD: NON-JEDEC       |                            |  |

NOTES:

1. CONTROLLING DIMENSION: INCH
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
3. DATUM PLANE H IS LOCATED AT THE TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
4. DIMENSIONS "D" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 PER SIDE. DIMENSIONS "D" AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H.
5. DIMENSIONS "b1" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE "b1" DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUM A AND B TO BE DETERMINED AT DATUM PLANE H.
7. DIMENSION A2 APPLIES WITHIN ZONE "J" ONLY.
8. HATCHING REPRESENTS EXPOSED AREA OF THE HEAT SLUG. HATCHED AREA SHOWN IS ON THE SAME PLANE.

STYLE 1:

PIN 1 - DRAIN      PIN 2 - DRAIN  
 PIN 3 - GATE      PIN 4 - GATE  
 PIN 5 - SOURCE

| DIM | INCH     |      | MILLIMETER |       | DIM | INCH           |      | MILLIMETER     |      |
|-----|----------|------|------------|-------|-----|----------------|------|----------------|------|
|     | MIN      | MAX  | MIN        | MAX   |     | MIN            | MAX  | MIN            | MAX  |
| A   | .100     | .104 | 2.54       | 2.64  | b1  | .164           | .170 | 4.17           | 4.32 |
| A1  | .039     | .043 | 0.99       | 1.09  | c1  | .007           | .011 | .18            | .28  |
| A2  | .040     | .042 | 1.02       | 1.07  | r1  | .063           | .068 | 1.60           | 1.73 |
| D   | .928     | .932 | 23.57      | 23.67 | e   | .106 BSC       |      | 2.69 BSC       |      |
| D1  | .810 BSC |      | 20.57 BSC  |       | e1  | .239 INFO ONLY |      | 6.07 INFO ONLY |      |
| D2  | .600     | ---  | 15.24      | ---   | aaa | .004           |      | .10            |      |
| E   | .551     | .559 | 14         | 14.2  |     |                |      |                |      |
| E1  | .353     | .357 | 8.97       | 9.07  |     |                |      |                |      |
| E2  | .270     | ---  | 6.86       | ---   |     |                |      |                |      |
| E3  | .346     | .350 | 8.79       | 8.89  |     |                |      |                |      |
| F   | .025 BSC |      | 0.64 BSC   |       |     |                |      |                |      |

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**MECHANICAL OUTLINE**

PRINT VERSION NOT TO SCALE

|  |                          |             |
|--|--------------------------|-------------|
| TITLE:<br><br>TO-272<br>4 LEAD WIDE BODY | DOCUMENT NO: 98ASA10575D | REV: D      |
|  | CASE NUMBER: 1484-04     | 05 APR 2006 |
|  | STANDARD: NON-JEDEC      |             |

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