Document Number: MRF5S9101
Rev. 3, 5/2006

Replaced by MRF5S9101NR1/NBR1. There are no form, fit or function changes with this part replacement. N suffix added to part number to indicate transition to lead-free terminations.

# 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 multicarrier amplifier applications.

**GSM Application**

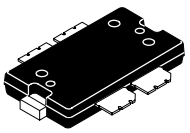
- Typical GSM Performance: $V_{DD}$ = 26 Volts, $I_{DQ}$ = 700 mA, $P_{out}$ = 100 Watts CW, Full Frequency Band (869-894 MHz and 921-960 MHz)
  Power Gain - 17.5 dB
  Drain Efficiency - 60%

**GSM EDGE Application**

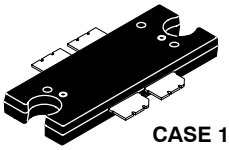
- Typical GSM EDGE Performance: $V_{DD}$ = 28 Volts, $I_{DQ}$ = 650 mA, $P_{out}$ = 50 Watts Avg., Full Frequency Band (869-894 MHz and 921-960 MHz)
  Power Gain — 18 dB
  Spectral Regrowth @ 400 kHz Offset = -63 dBc
  Spectral Regrowth @ 600 kHz Offset = -78 dBc
  EVM — 2.3% rms
- Capable of Handling 10:1 VSWR, @ 26 Vdc, @ 100 W CW Output Power, @ f = 960 MHz
- 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
- In Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.

**MRF5S9101MR1**
**MRF5S9101MBR1**

**869-960 MHz, 100 W, 26 V**
**GSM/GSM EDGE**
**LATERAL N-CHANNEL**
**RF POWER MOSFETs**



**CASE 1486-03, STYLE 1**
**TO-270 WB-4**
**PLASTIC**
**MRF5S9101MR1**



**CASE 1484-04, STYLE 1**
**TO-272 WB-4**
**PLASTIC**
**MRF5S9101MBR1**

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**Table 1. Maximum Ratings**

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Drain-Source Voltage | $V_{DSS}$ | -0.5, +68 | Vdc |
| Gate-Source Voltage | $V_{GS}$ | -0.5, +15 | Vdc |
| Total Device Dissipation @ $T_C$ = 25°C<br>Derate above 25°C | $P_D$ | 427<br>2.44 | W<br>W/°C |
| 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<br>Case Temperature 80°C, 100 W CW<br>Case Temperature 80°C, 50 W CW | $R_{\theta JC}$ | <br>0.41<br>0.47 | °C/W |

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

NOTE - **CAUTION** - MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

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**Table 3. ESD Protection Characteristics**

| Test Methodology | Class |
|---|---|
| Human Body Model (per JESD22-A114) | 1C (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°C unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Zero Gate Voltage Drain Leakage Current ($V_{DS}$ = 68 Vdc, $V_{GS}$ = 0 Vdc) | $I_{DSS}$ | — | — | 10 | μAdc |
| Zero Gate Voltage Drain Leakage Current ($V_{DS}$ = 26 Vdc, $V_{GS}$ = 0 Vdc) | $I_{DSS}$ | — | — | 1 | μAdc |
| Gate-Source Leakage Current ($V_{GS}$ = 5 Vdc, $V_{DS}$ = 0 Vdc) | $I_{GSS}$ | — | — | 1 | μAdc |
| **On Characteristics** | | | | | |
| Gate Threshold Voltage ($V_{DS}$ = 10 Vdc, $I_D$ = 400 μAdc) | $V_{GS(th)}$ | 2 | 2.8 | 3.5 | Vdc |
| Gate Quiescent Voltage ($V_{DS}$ = 26 Vdc, $I_D$ = 700 mAdc) | $V_{GS(Q)}$ | — | 3.7 | — | Vdc |
| Drain-Source On-Voltage ($V_{GS}$ = 10 Vdc, $I_D$ = 2 Adc) | $V_{DS(on)}$ | — | 0.21 | 0.3 | Vdc |
| Forward Transconductance ($V_{DS}$ = 10 Vdc, $I_D$ = 6 Adc) | $g_{fs}$ | — | 7 | — | S |
| **Dynamic Characteristics** (1) | | | | | |
| Output Capacitance ($V_{DS}$ = 26 Vdc ± 30 mV(rms)ac @ 1 MHz, $V_{GS}$ = 0 Vdc) | $C_{oss}$ | — | 70 | — | pF |
| Reverse Transfer Capacitance ($V_{DS}$ = 26 Vdc ± 30 mV(rms)ac @ 1 MHz, $V_{GS}$ = 0 Vdc) | $C_{rss}$ | — | 2.2 | — | pF |
| **Functional Tests** (In Freescale Test Fixture, 50 ohm system) $V_{DD}$ = 26 Vdc, $P_{out}$ = 100 W, $I_{DQ}$ = 700 mA, f = 960 MHz | | | | | |
| Power Gain | $G_{ps}$ | 16 | 17.5 | 19 | dB |
| Drain Efficiency | $\eta_D$ | 56 | 60 | — | % |
| Input Return Loss | IRL | — | -15 | -9 | dB |
| $P_{out}$ @ 1 dB Compression Point, CW | P1dB | 100 | 110 | — | W |

1. Part is internally input matched.

(continued)

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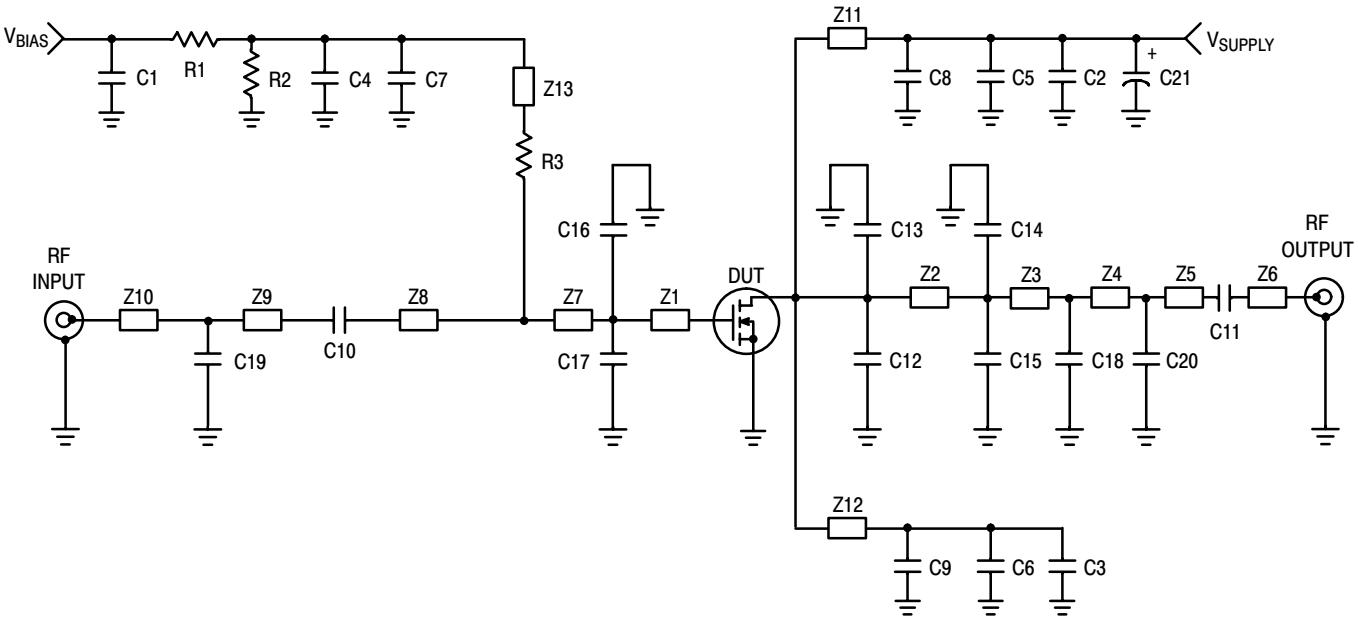
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**Table 5. Electrical Characteristics** ($T_C$ = 25°C unless otherwise noted) **(continued)**

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Typical GSM EDGE Performances** (In Freescale GSM EDGE Test Fixture, 50 ohm system) $V_{DD}$ = 28 Vdc, $P_{out}$ = 50 W Avg., $I_{DQ}$ = 650 mA, 869 MHz<Frequency<894 MHz, 920 MHz<Frequency<960 MHz | | | | | |
| Power Gain | $G_{ps}$ | — | 18 | — | dB |
| Drain Efficiency | $\eta_D$ | — | 42 | — | % |
| Error Vector Magnitude | EVM | — | 2.3 | — | % rms |
| Spectral Regrowth at 400 kHz Offset | SR1 | — | -63 | — | dBc |
| Spectral Regrowth at 600 kHz Offset | SR2 | — | -78 | — | dBc |

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| | | | |
|---|---|---|---|
| Z1 | 0.698″ x 0.827″ Microstrip | Z10 | 1.491″ x 0.087″ Microstrip |
| Z2 | 0.720″ x 0.788″ Microstrip | Z11, Z12* | 1.6″ x 0.089″ Microstrip (quarter wave length for supply purpose) |
| Z3 | 0.195″ x 0.087″ Microstrip | | |
| Z4 | 0.524″ x 0.087″ Microstrip | Z13* | 1.2″ x 0.059″ Microstrip (quarter wave length for bias purpose) |
| Z5 | 0.233″ x 0.087″ Microstrip | | |
| Z6 | 0.560″ x 0.087″ Microstrip | PCB | Taconic TLX8-0300, 0.030″, $\varepsilon_r$ = 2.55 |
| Z7 | 0.095″ x 0.827″ Microstrip | | |
| Z8 | 0.472″ x 0.087″ Microstrip | *Variable for tuning | |
| Z9 | 0.384″ x 0.087″ Microstrip | | |

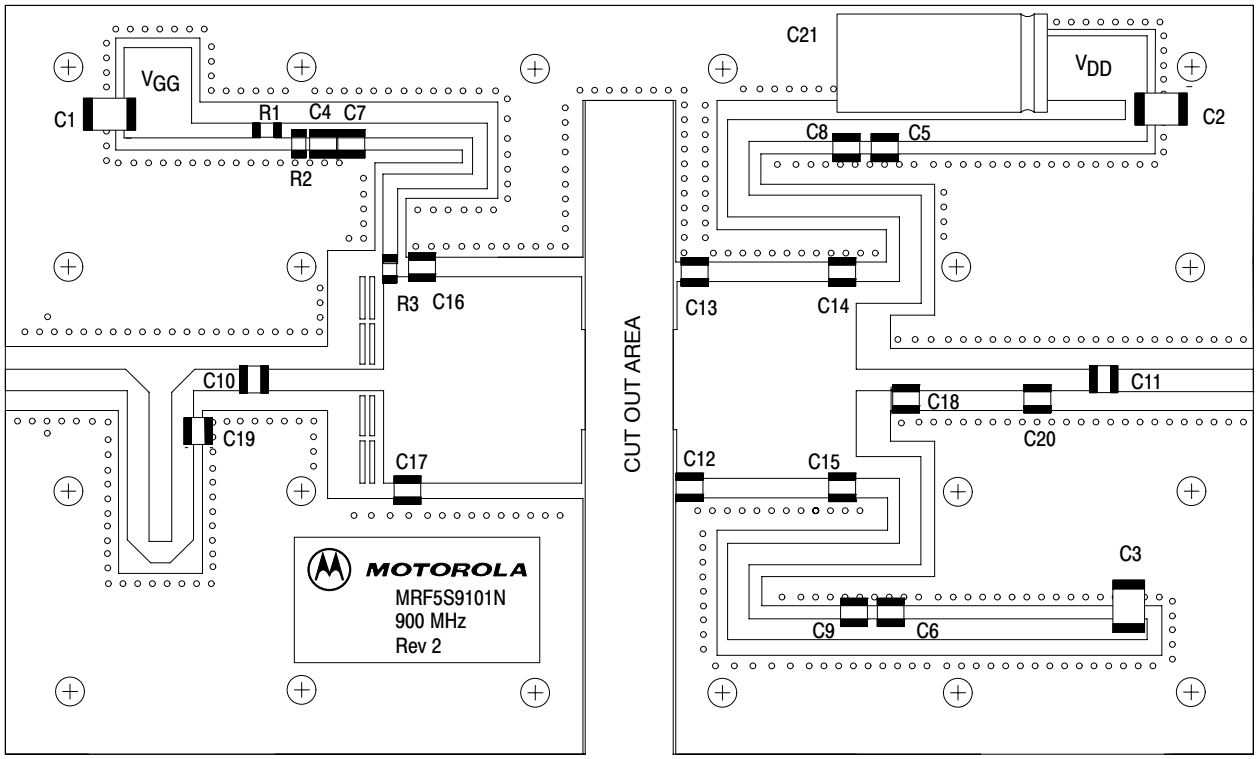
**Figure 1. MRF5S9101MR1(MBR1) 900 MHz Test Circuit Schematic**

**Table 6. MRF5S9101MR1(MBR1) 900 MHz Test Circuit Component Designations and Values**

| Part | Description | Part Number | Manufacturer |
|---|---|---|---|
| C1, C2, C3 | 4.7 μF Chip Capacitors (2220) | GRM55ER7H475KA01 | Murata |
| C4, C5, C6 | 10 nF 200B Chip Capacitors | 200B103MW | ATC |
| C7, C8, C9 | 33 pF 100B Chip Capacitors | 100B330JW | ATC |
| C10, C11 | 22 pF 100B Chip Capacitors | 100B220GW | ATC |
| C12, C13 | 10 pF 100B Chip Capacitors | 100B100GW | ATC |
| C14, C15, C16, C17 | 8.2 pF 100B Chip Capacitors | 100B8R2CW | ATC |
| C18 | 5.6 pF 100B Chip Capacitor | 100B5R6CW | ATC |
| C19 | 4.7 pF 100B Chip Capacitor | 100B4R7BW | ATC |
| C20 | 3.9 pF 100B Chip Capacitor | 100B3R9BW | ATC |
| C21 | 220 μF, 50 V Electrolytic Capacitor, Axial | 516D227M050NP7B | Sprague |
| R1, R2 | 10 kΩ, 1/4 W Chip Resistors (1206) | | |
| R3 | 10 Ω, 1/4 W Chip Resistor (1206) | | |

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Freescale has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescale Semiconductor signature/logo. PCBs may have either Motorola or Freescale markings during the transition period. These changes will have no impact on form, fit or function of the current product.

**Figure 2. MRF5S9101MR1(MBR1) 900 MHz Test Circuit Component Layout**

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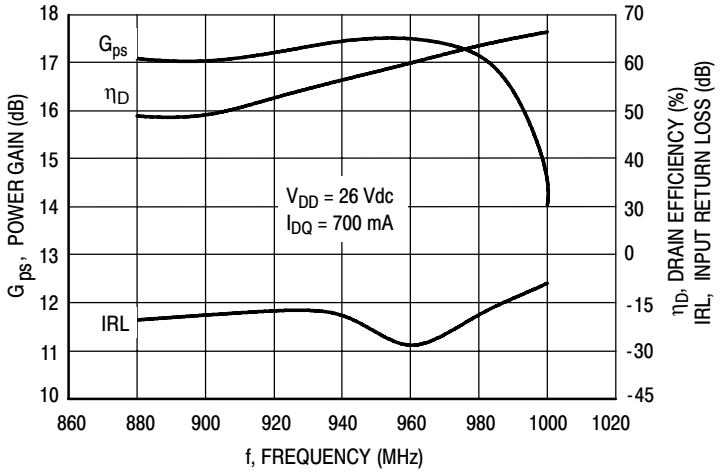



**Figure 3. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @ $P_{out}$ = 100 Watts CW**

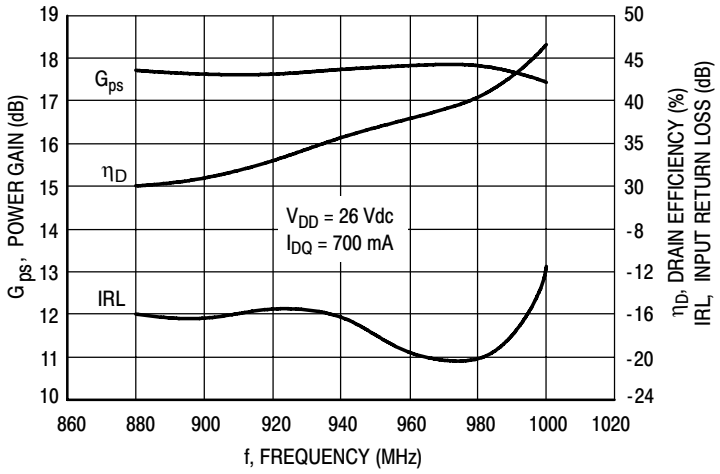



**Figure 4. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @ $P_{out}$ = 40 Watts CW**

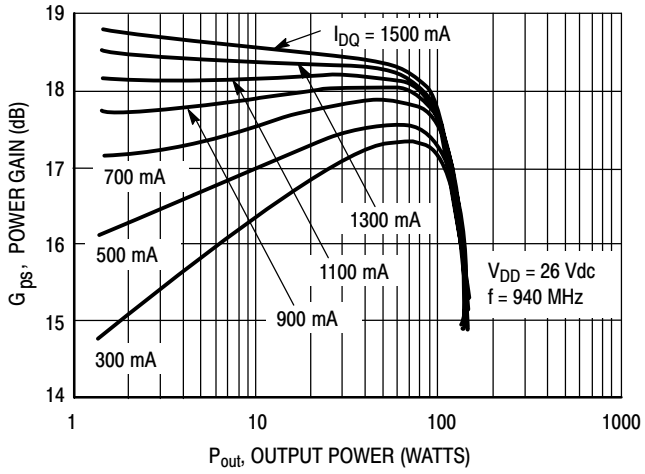



**Figure 5. Power Gain versus Output Power**

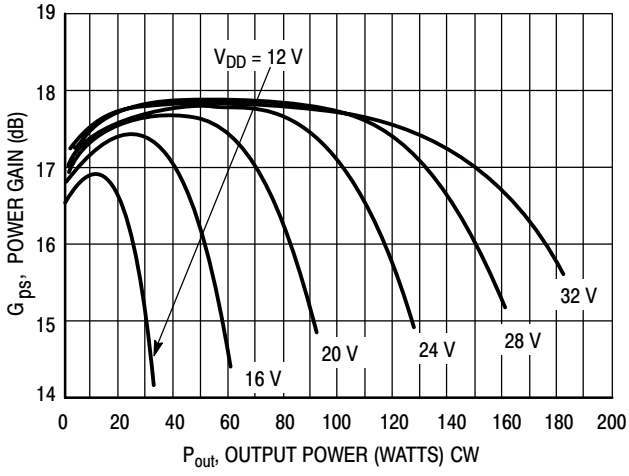



**Figure 6. Power Gain versus Output Power**

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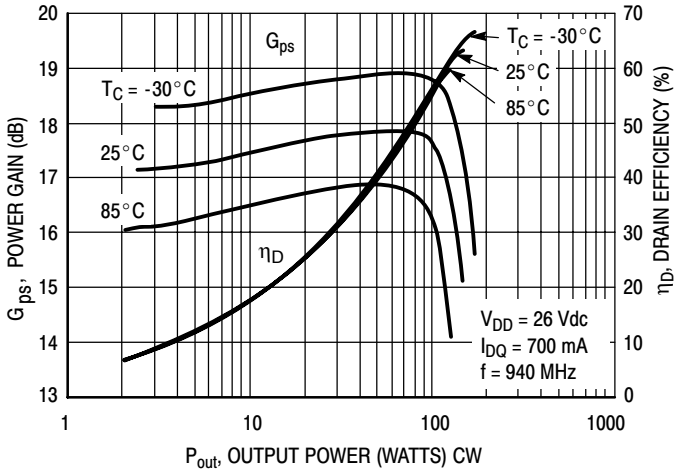



**Figure 7. Power Gain and Drain Efficiency versus CW Output Power**

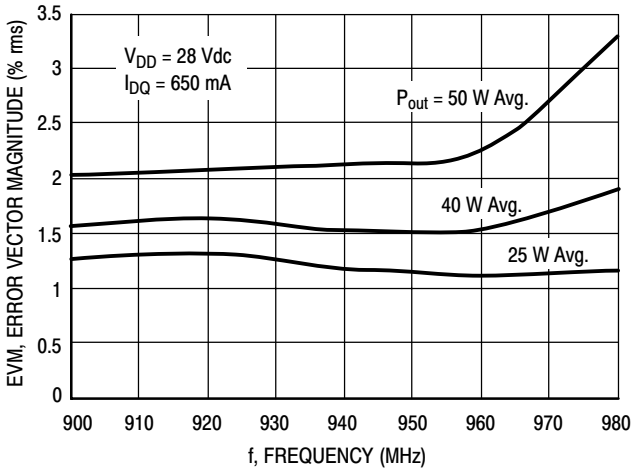



**Figure 8. Error Vector Magnitude versus Frequency**

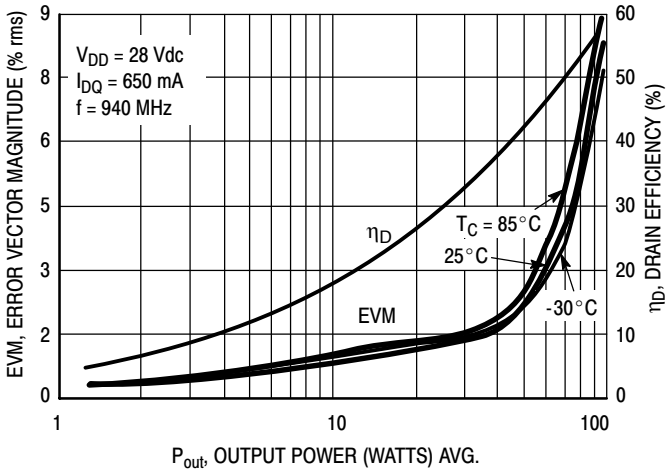



**Figure 9. Error Vector Magnitude and Drain Efficiency versus Output Power**

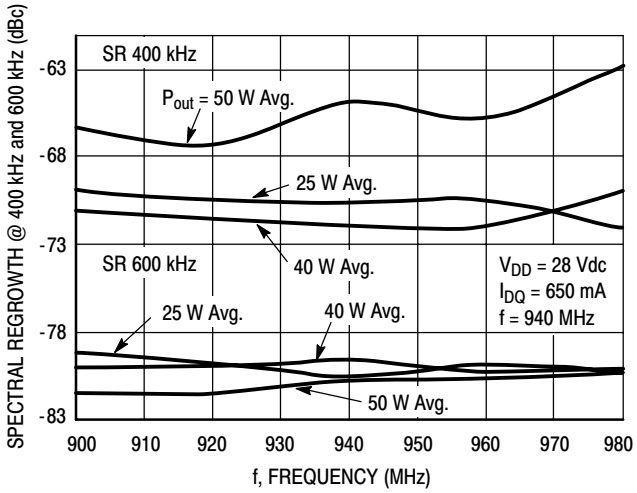



**Figure 10. Spectral Regrowth at 400 kHz and 600 kHz versus Frequency**

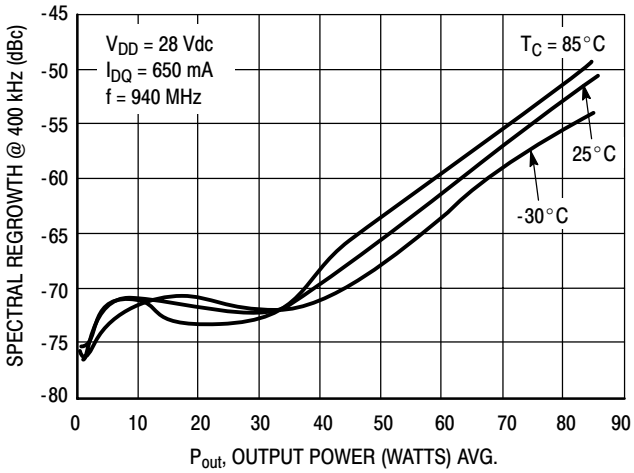



**Figure 11. Spectral Regrowth at 400 kHz versus Output Power**

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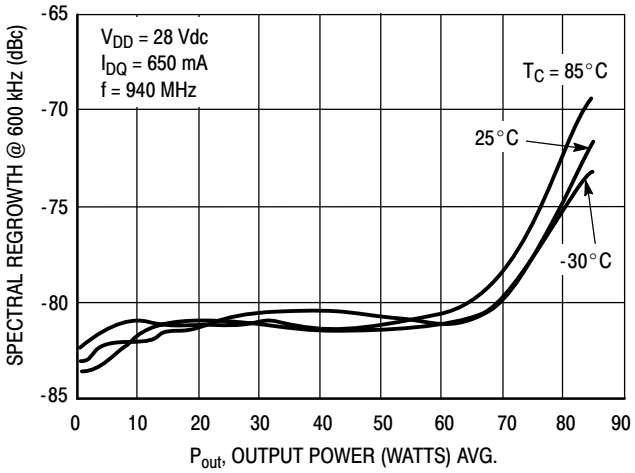
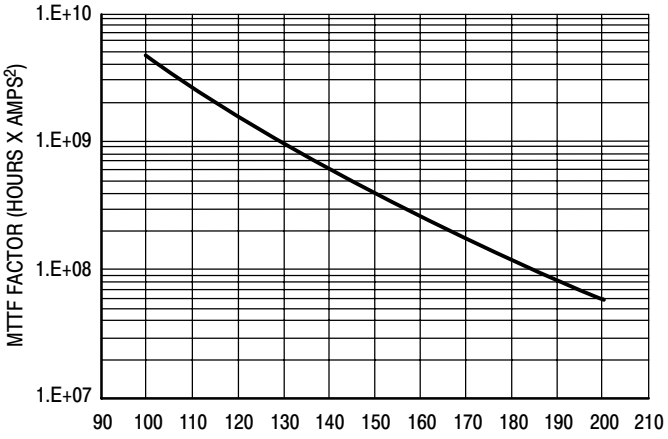



**Figure 12. Spectral Regrowth @ 600 kHz versus Output Power**

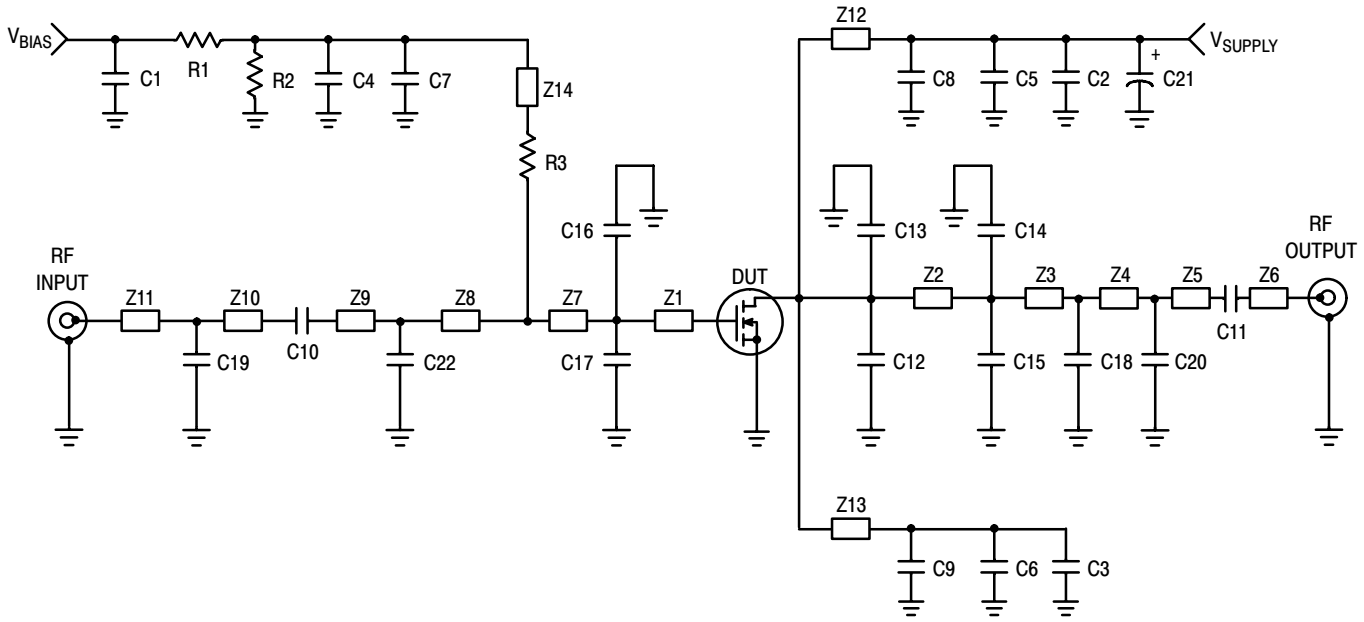



This above graph displays calculated MTTF in hours x ampere$^2$ drain current. Life tests at elevated temperatures have correlated to better than ±10% of the theoretical prediction for metal failure. Divide MTTF factor by $I_D^2$ for MTTF in a particular application.

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

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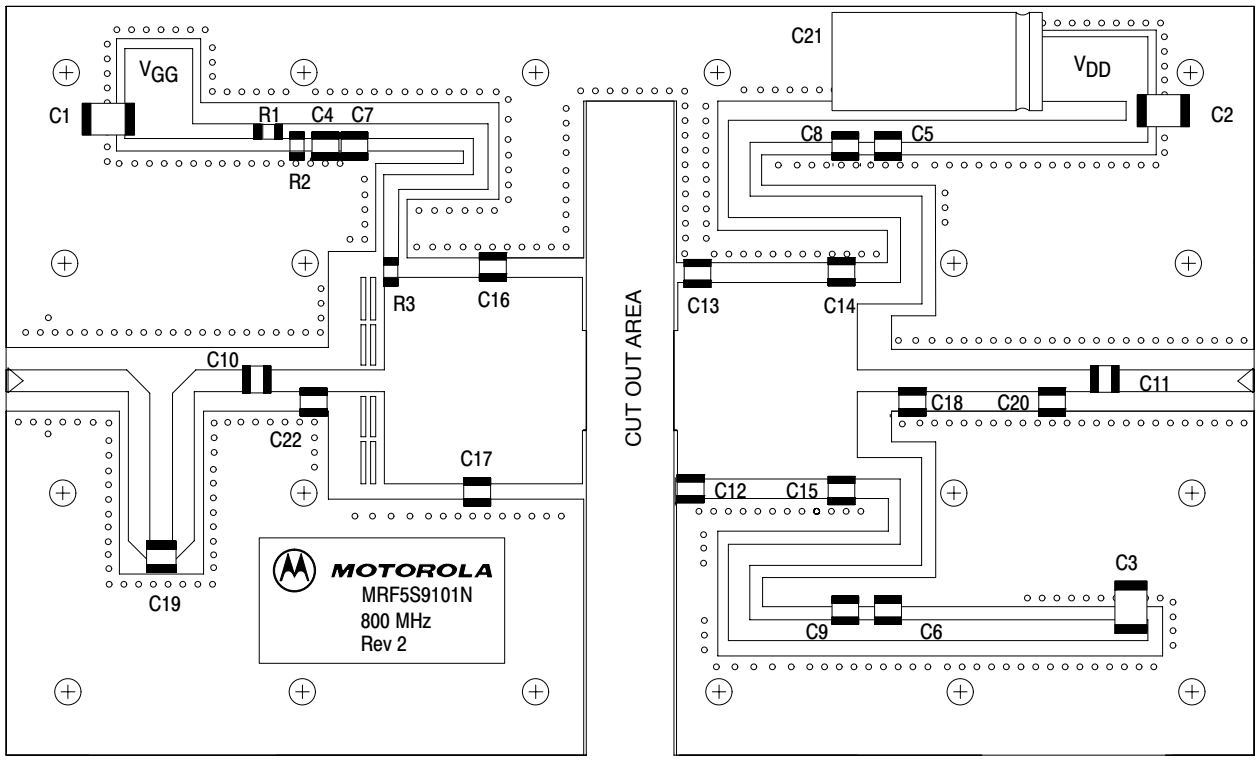

| | | | |
|---|---|---|---|
| Z1 | 0.432″ x 0.827″ Microstrip | Z10 | 0.897″ x 0.087″ Microstrip |
| Z2 | 0.720″ x 0.788″ Microstrip | Z11 | 1.161″ x 0.087″ Microstrip |
| Z3 | 0.195″ x 0.087″ Microstrip | Z12, Z13* | 1.6″ x 0.089″ Microstrip (quarter wave length for supply purpose) |
| Z4 | 0.584″ x 0.087″ Microstrip | | |
| Z5 | 0.173″ x 0.087″ Microstrip | Z14* | 1.2″ x 0.059″ Microstrip (quarter wave length for bias purpose) |
| Z6 | 0.560″ x 0.087″ Microstrip | | |
| Z7 | 0.378″ x 0.827″ Microstrip | PCB | Taconic TLX8-0300, 0.030″, $\varepsilon_r$ = 2.55 |
| Z8 | 0.279″ x 0.087″ Microstrip | | |
| Z9 | 0.193″ x 0.087″ Microstrip | *Variable for tuning | |

**Figure 14. MRF5S9101MR1(MBR1) 800 MHz Test Circuit Schematic**

**Table 7. MRF5S9101MR1(MBR1) 800 MHz Test Circuit Component Designations and Values**

| Part | Description | Part Number | Manufacturer |
|---|---|---|---|
| C1, C2, C3 | 4.7 μF Chip Capacitors (2220) | GRM55ER7H475KA01 | Murata |
| C4, C5, C6 | 10 nF 200B Chip Capacitors | 200B103MW | ATC |
| C7, C8, C9 | 33 pF 100B Chip Capacitors | 100B330JW | ATC |
| C10, C11 | 22 pF 100B Chip Capacitors | 100B220GW | ATC |
| C12, C13, C17 | 10 pF 100B Chip Capacitors | 100B100GW | ATC |
| C14, C15 | 8.2 pF 100B Chip Capacitors | 100B8R2CW | ATC |
| C16, C22 | 6.8 pF 100B Chip Capacitors | 100B6R8CW | ATC |
| C18 | 5.6 pF 100B Chip Capacitor | 100B5R6CW | ATC |
| C19, C20 | 2.7 pF 100B Chip Capacitors | 100B2R7BW | ATC |
| C21 | 220 μF, 50 V Electrolytic Capacitor, Axial | 516D227M050NP7B | Sprague |
| R1, R2 | 10 kΩ, 1/4 W Chip Resistors (1206) | | |
| R3 | 10 Ω, 1/4 W Chip Resistor (1206) | | |

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**Figure 15. MRF5S9101MR1(MBR1) 800 MHz Test Circuit Component Layout**

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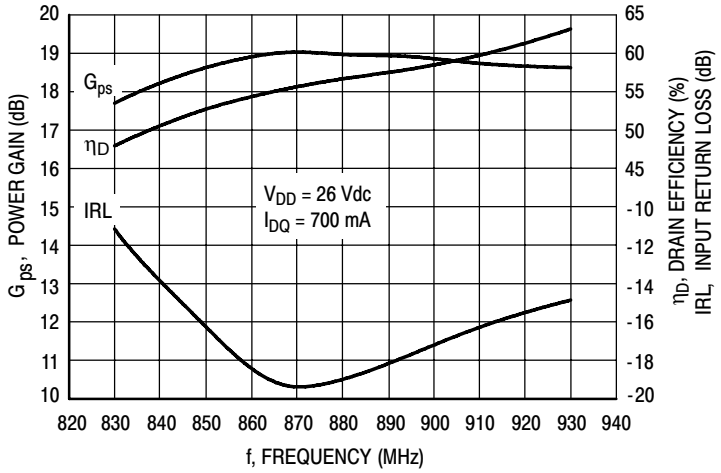



**Figure 16. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @ $P_{out}$ = 100 W CW**

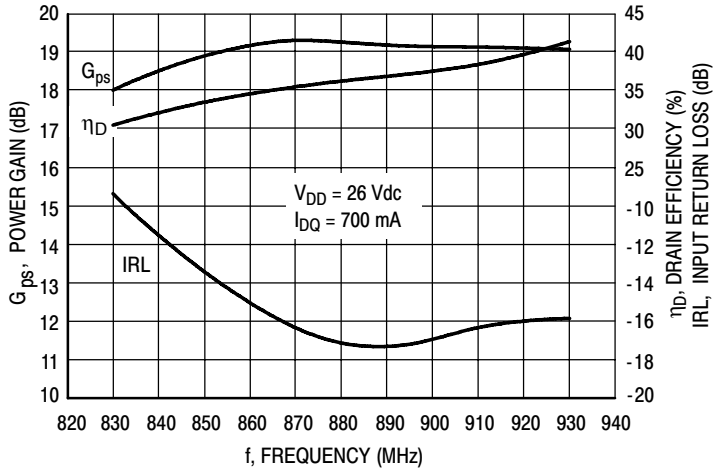



**Figure 17. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @ $P_{out}$ = 40 W CW**

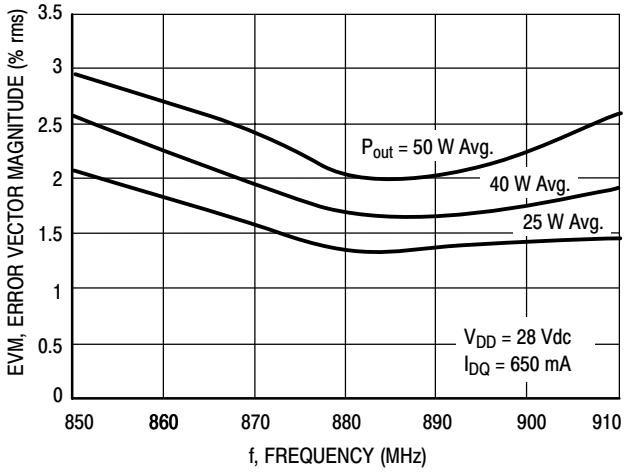



**Figure 18. Error Vector Magnitude versus Frequency**

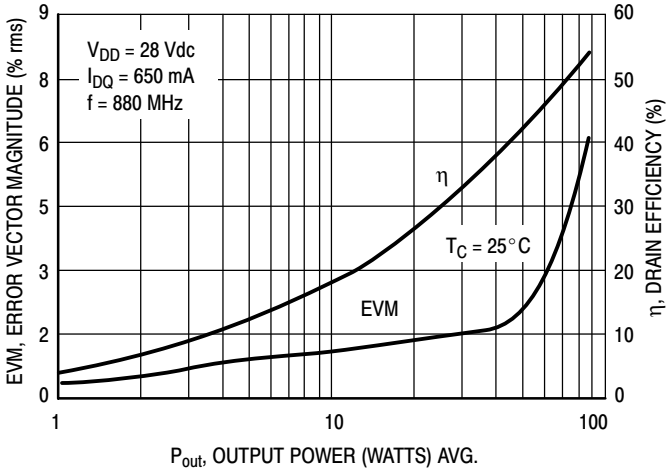



**Figure 19. Error Vector Magnitude and Drain Efficiency versus Output Power**

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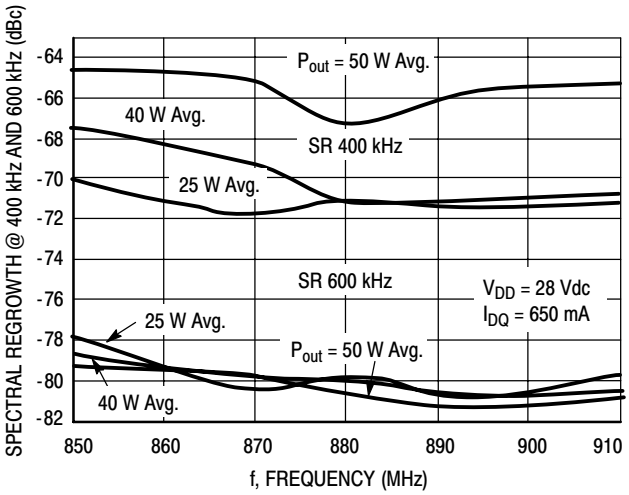



**Figure 20. Spectral Regrowth at 400 kHz and 600 kHz versus Frequency**

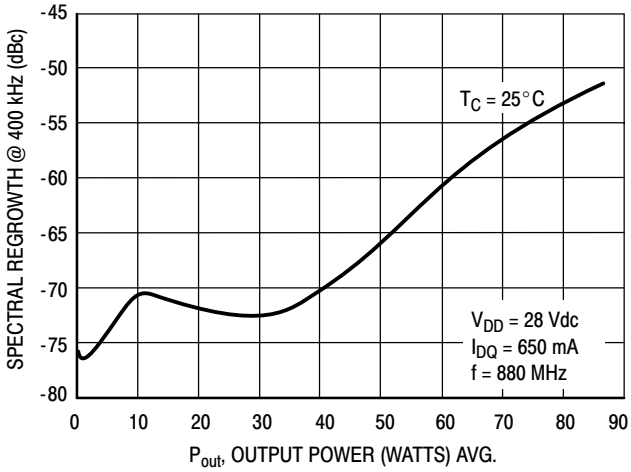



**Figure 21. Spectral Regrowth at 400 kHz versus Output Power**

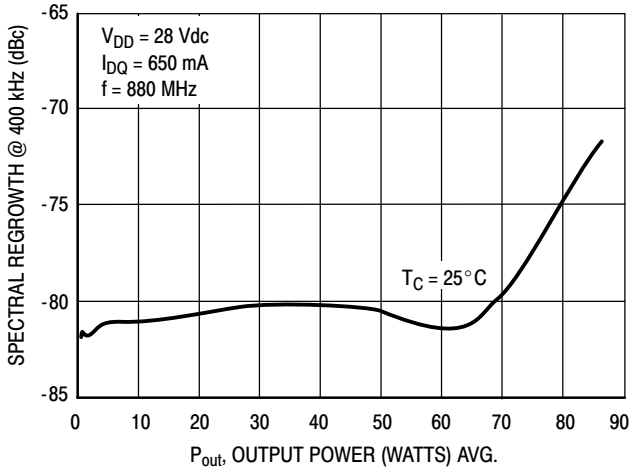


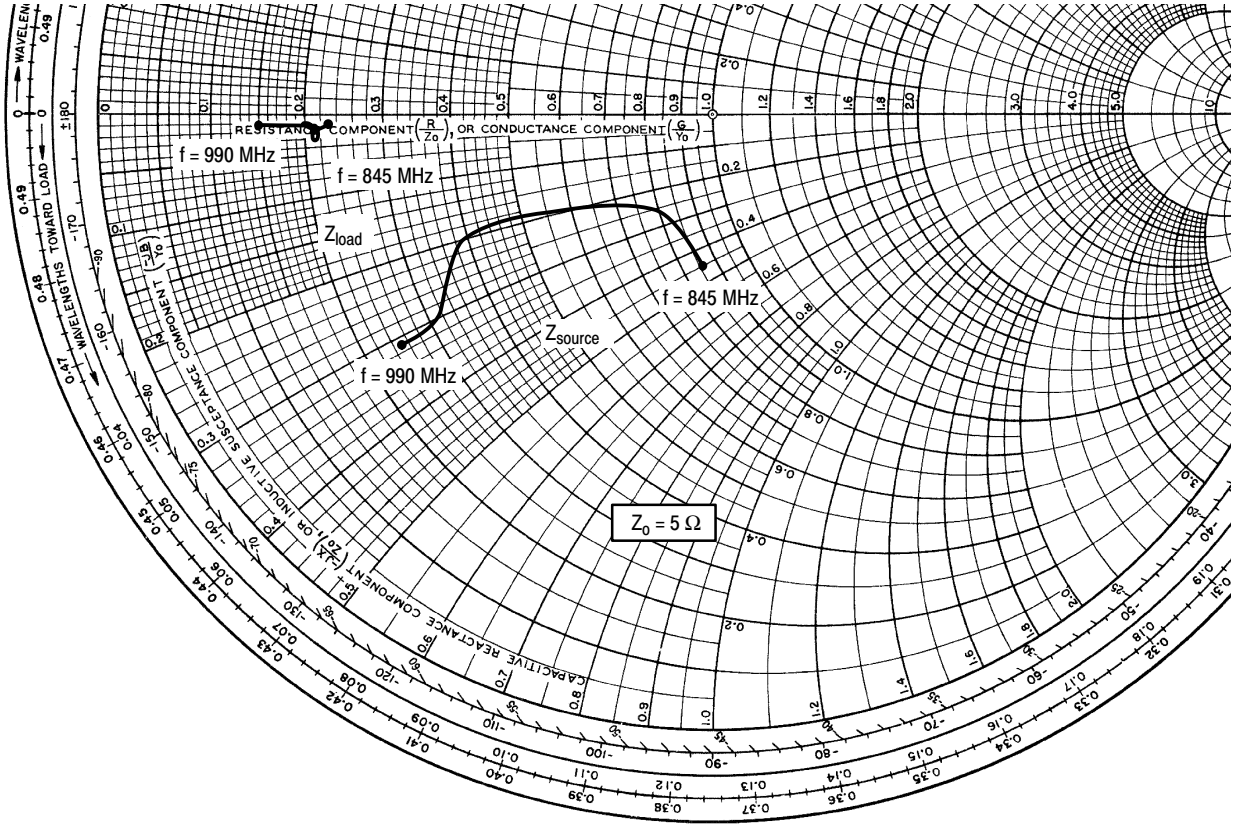

**Figure 22. Spectral Regrowth at 600 kHz versus Output Power**

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$V_{DD}$ = 26 Vdc, $I_{DQ}$ = 700 mA, $P_{out}$ = 100 W CW

| f MHz | $Z_{source}$ Ω | $Z_{load}$ Ω |
|---|---|---|
| 845 | 4.29 - j2.23 | 1.15 - j0.04 |
| 865 | 3.94 - j1.24 | 1.05 - j0.10 |
| 890 | 2.72 - j0.96 | 1.02 - j0.07 |
| 920 | 1.96 - j1.02 | 1.03 - j0.15 |
| 960 | 1.58 - j1.43 | 1.03 - j0.05 |
| 990 | 1.27 - j1.54 | 0.73 - j0.07 |

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

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

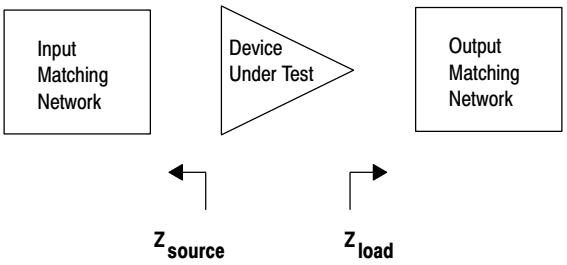
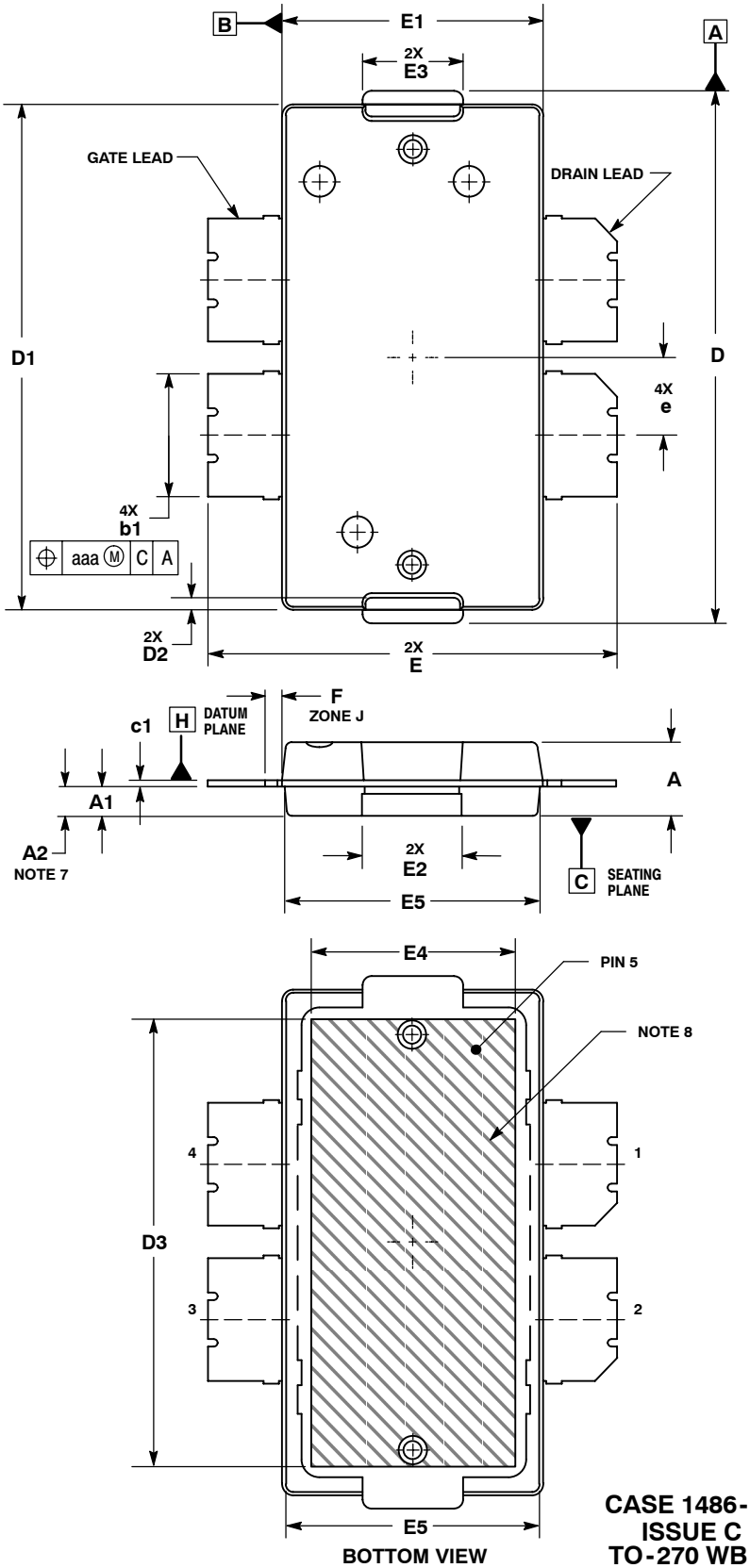



**Figure 23. Series Equivalent Source and Load Impedance**

# NOTES

# NOTES

## PACKAGE DIMENSIONS

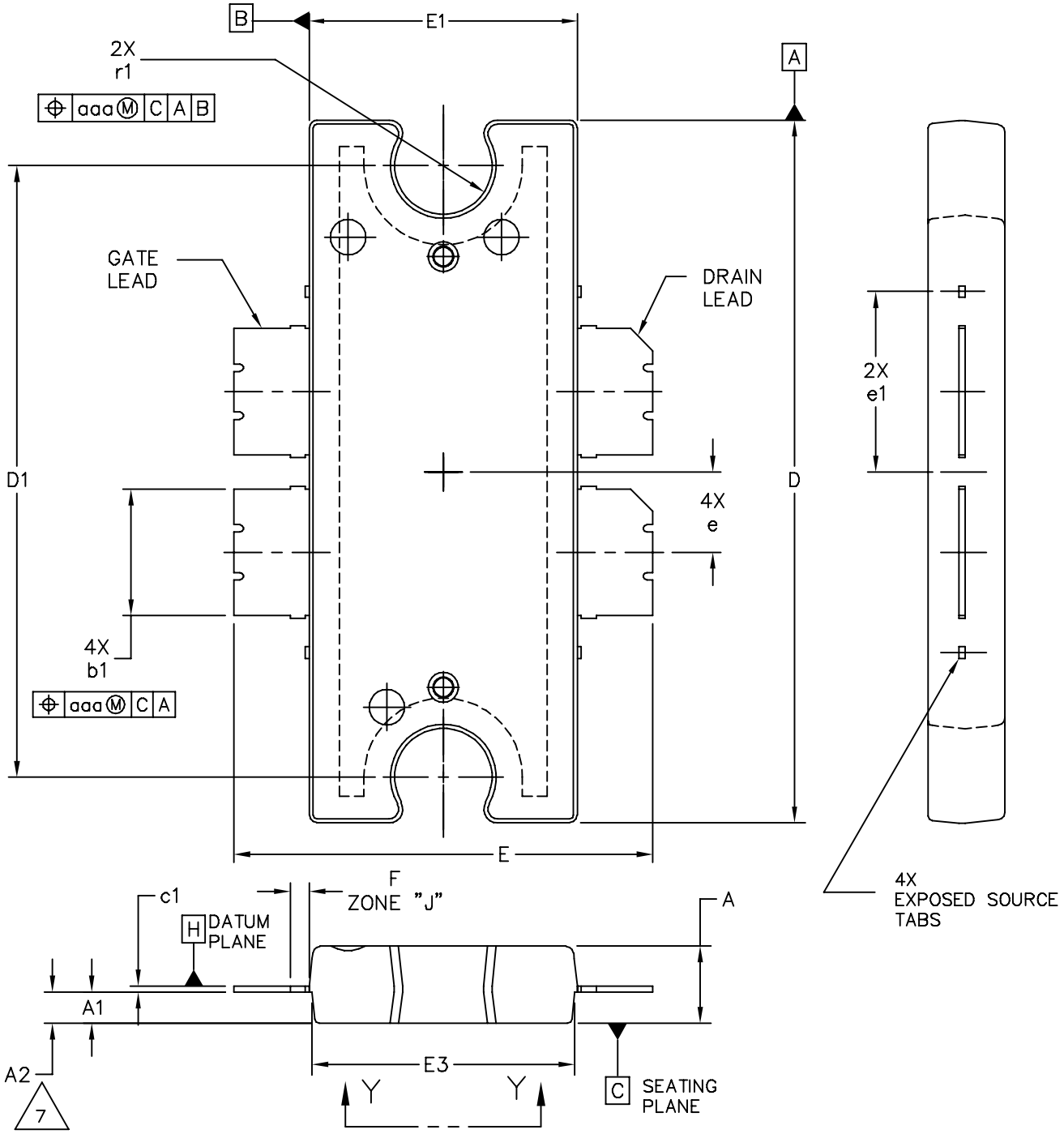



NOTES:
1. CONTROLLING DIMENSION: INCH.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
3. DATUM PLANE -H- IS LOCATED AT THE TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
4. DIMENSIONS "D" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. 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.

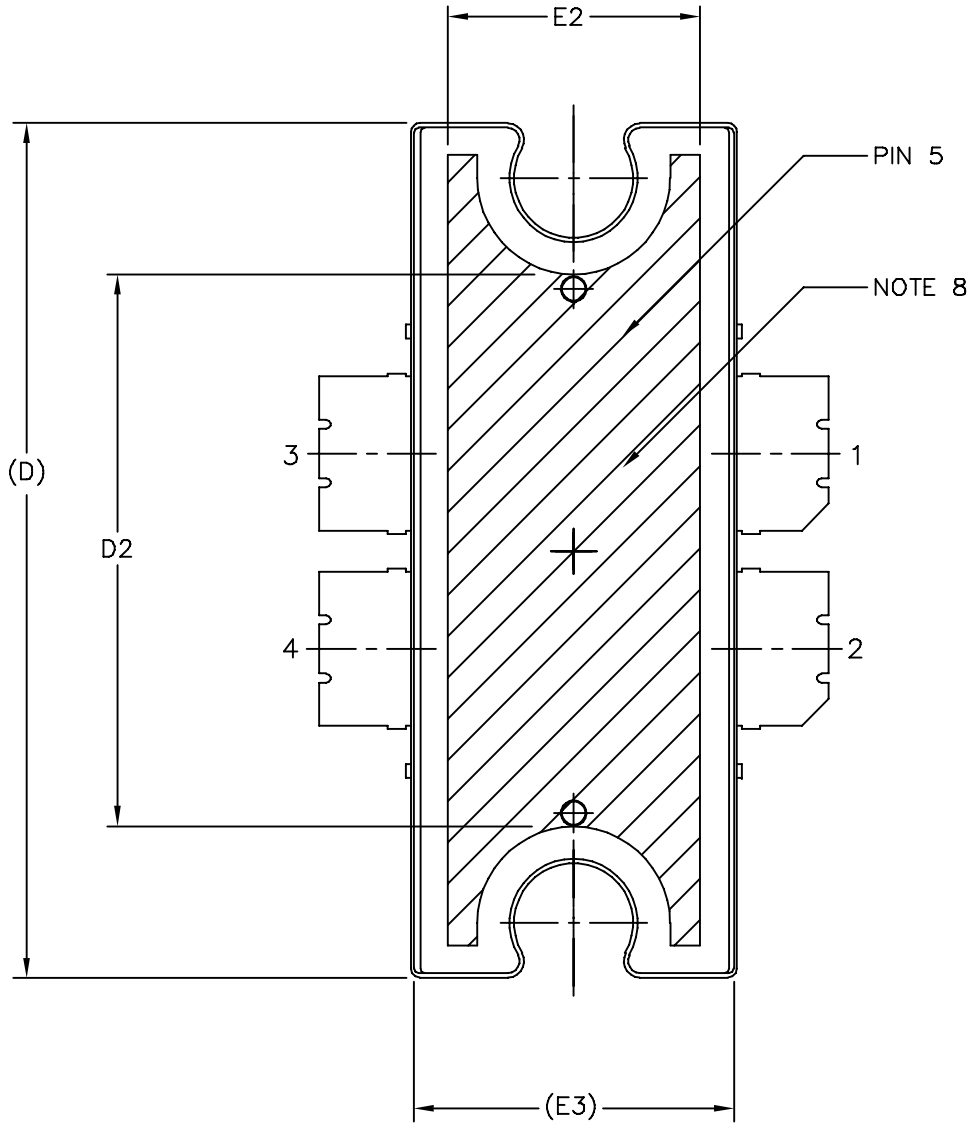
| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | .100 | .104 | 2.54 | 2.64 |
| A1 | .039 | .043 | 0.99 | 1.09 |
| A2 | .040 | .042 | 1.02 | 1.07 |
| D | .712 | .720 | 18.08 | 18.29 |
| D1 | .688 | .692 | 17.48 | 17.58 |
| D2 | .011 | .019 | 0.28 | 0.48 |
| D3 | .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:
PIN 1. DRAIN
2. DRAIN
3. GATE
4. GATE
5. SOURCE

**CASE 1486-03**
**ISSUE C**
**TO-270 WB-4**
**PLASTIC**
**MRF5S9101MR1**




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




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|---|---|---|
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NOTES:

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

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