

MRF136



The RF MOSFET Line
15W, to 400MHz, 28V

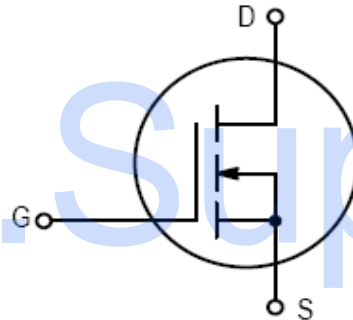
M/A-COM Products
Released - Rev. 05202009

Designed for wideband large signal amplifier and oscillator applications
Up to 400 MHz range, in single-ended configuration

N-Channel enhancement mode

- Guaranteed 28 volt, 150 MHz performance
Output power = 15 watts
Narrowband gain = 16 dB (Typ.)
Efficiency = 60% (Typ.)
- Small- and large-signal characterization
- 100% tested for load mismatch at all phase angles with 30:1 VSWR
- Excellent thermal stability, ideally suited for Cass A operation
- Facilitates manual gain control, ALC and modulation techniques

Product Image



MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|--|-----------|-------------|------------------------------|
| Drain-Source Voltage | V_{DSS} | 65 | Vdc |
| Drain-Gate Voltage ($R_{GS} = 1.0 \text{ M}\Omega$) | V_{DGR} | 65 | Vdc |
| Gate-Source Voltage | V_{GS} | ± 40 | Vdc |
| Drain Current — Continuous | I_D | 2.5 | Adc |
| Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C | P_D | 55 0.314 | Watts W/ $^\circ\text{C}$ |
| Storage Temperature Range | T_{stg} | -65 to +150 | $^\circ\text{C}$ |
| Operating Junction Temperature | T_J | 200 | $^\circ\text{C}$ |

THERMAL CHARACTERISTICS

| Characteristic | Symbol | Max | Unit |
|--------------------------------------|-----------------|-----|---------------------------|
| Thermal Resistance, Junction to Case | $R_{\theta JC}$ | 3.2 | $^\circ\text{C}/\text{W}$ |

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

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted.)

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

OFF CHARACTERISTICS (1)

| | | | | | |
|--|---------------|----|---|-----|-----------------|
| Drain-Source Breakdown Voltage ($V_{GS} = 0, I_D = 5.0 \text{ mA}$) | $V_{(BR)DSS}$ | 65 | — | — | Vdc |
| Zero-Gate Voltage Drain Current ($V_{DS} = 28 \text{ V}, V_{GS} = 0$) | I_{DSS} | — | — | 2.0 | mAdc |
| Gate-Source Leakage Current ($V_{GS} = 40 \text{ V}, V_{DS} = 0$) | I_{GSS} | — | — | 1.0 | μAdc |

ON CHARACTERISTICS (1)

| | | | | | |
|---|--------------|-----|-----|-----|-------|
| Gate Threshold Voltage ($V_{DS} = 10 \text{ V}, I_D = 25 \text{ mA}$) | $V_{GS(th)}$ | 1.0 | 3.0 | 6.0 | Vdc |
| Forward Transconductance ($V_{DS} = 10 \text{ V}, I_D = 250 \text{ mA}$) | gfs | 250 | 400 | — | mmhos |

DYNAMIC CHARACTERISTICS (1)

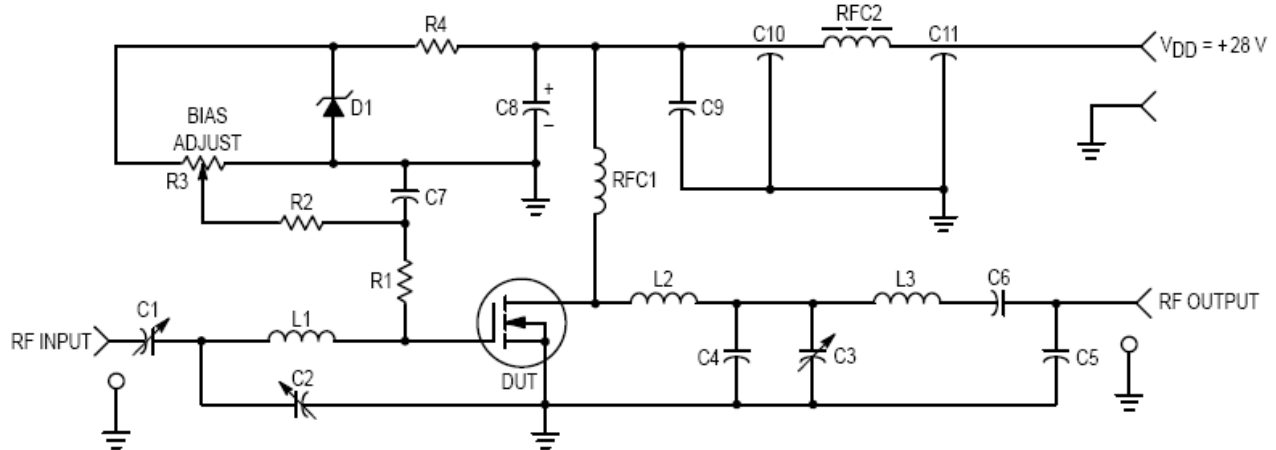
| | | | | | |
|--|-----------|---|-----|---|----|
| Input Capacitance ($V_{DS} = 28 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$) | C_{iss} | — | 24 | — | pF |
| Output Capacitance ($V_{DS} = 28 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$) | C_{oss} | — | 27 | — | pF |
| Reverse Transfer Capacitance ($V_{DS} = 28 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$) | C_{rss} | — | 5.5 | — | pF |

FUNCTIONAL CHARACTERISTICS

| | | | | | |
|--|----------|--------------------------------|-----|---|----|
| Noise Figure ($V_{DS} = 28 \text{ Vdc}, I_D = 500 \text{ mA}, f = 150 \text{ MHz}$) | NF | — | 1.0 | — | dB |
| Common Source Power Gain (Figure 1) ($V_{DD} = 28 \text{ Vdc}, P_{out} = 15 \text{ W}, f = 150 \text{ MHz}, I_{DQ} = 25 \text{ mA}$) | G_{ps} | 13 | 16 | — | dB |
| Drain Efficiency (Figure 1) ($V_{DD} = 28 \text{ Vdc}, P_{out} = 15 \text{ W}, f = 150 \text{ MHz}, I_{DQ} = 25 \text{ mA}$) | η | 50 | 60 | — | % |
| Electrical Ruggedness (Figure 1) ($V_{DD} = 28 \text{ Vdc}, P_{out} = 15 \text{ W}, f = 150 \text{ MHz}, I_{DQ} = 25 \text{ mA},$ $V_{SWR} 30:1$ at all Phase Angles) | ψ | No Degradation in Output Power | | | |

NOTES:

1. Each side measured separately.



- C1, C2 — Arco 406, 15–115 pF or Equivalent
- C3 — Arco 404, 8–60 pF or Equivalent
- C4 — 43 pF Mini-Unelco or Equivalent
- C5 — 24 pF Mini-Unelco or Equivalent
- C6 — 680 pF, 100 Mils Chip
- C7 — 0.01 μ F Ceramic
- C8 — 100 μ F, 40 V
- C9 — 0.1 μ F Ceramic
- C10, C11 — 680 pF Feedthru
- D1 — 1N5925A Motorola Zener

- L1 — 2 Turns, 0.29" ID, #18 AWG, 0.10" Long
- L2 — 2 Turns, 0.23" ID, #18 AWG, 0.10" Long
- L3 — 2–1/4 Turns, 0.29" ID, #18 AWG, 0.125" Long
- RFC1 — 20 Turns, 0.30" ID, #20 AWG Enamel Closewound
- RFC2 — Ferroxcube VK-200 — 19/4B
- R1 — 27 Ω , 1 W Thin Film
- R2 — 10 k Ω , 1/4 W
- R3 — 10 Turns, 10 k Ω
- R4 — 1.8 k Ω , 1/2 W
- Board Material — 0.062" G10, 1 oz. Cu Clad, Double Sided

Figure 1. 150 MHz Test Circuit

TYPICAL CHARACTERISTICS

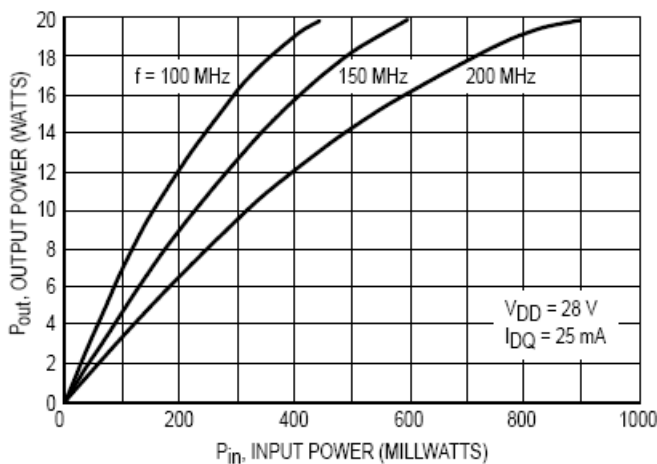


Figure 2. Output Power versus Input Power

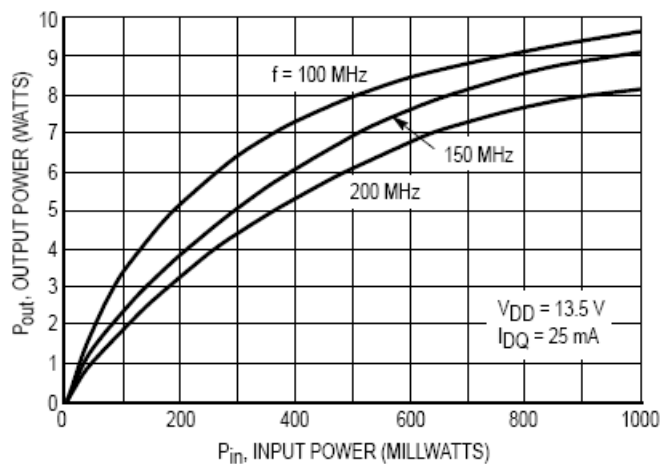


Figure 3. Output Power versus Input Power

TYPICAL CHARACTERISTICS

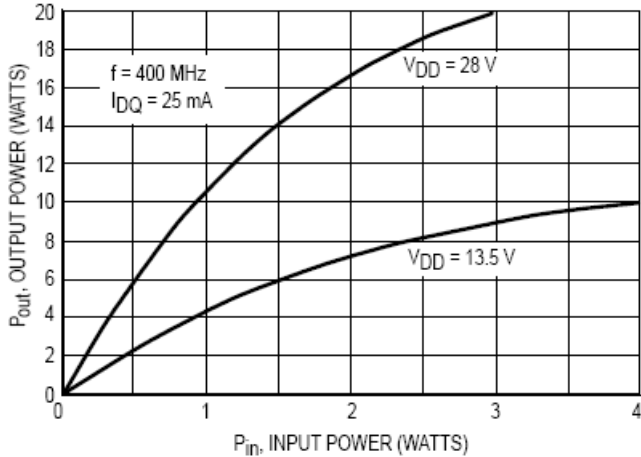


Figure 4. Output Power versus Input Power

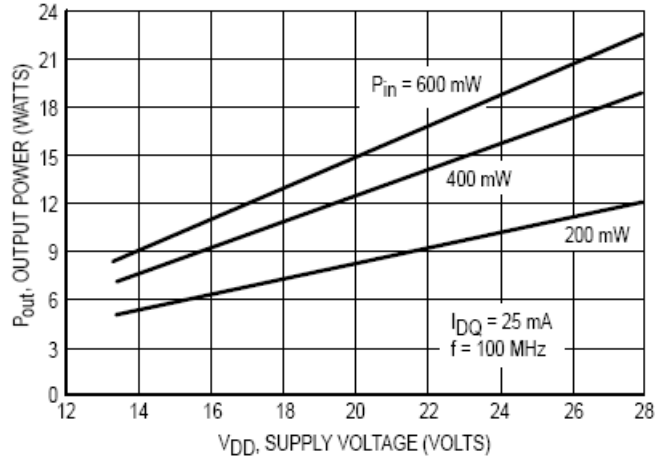


Figure 5. Output Power versus Supply Voltage

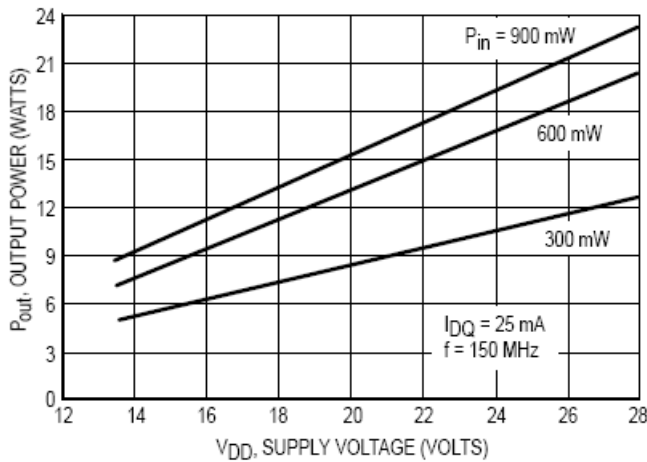


Figure 6. Output Power versus Supply Voltage

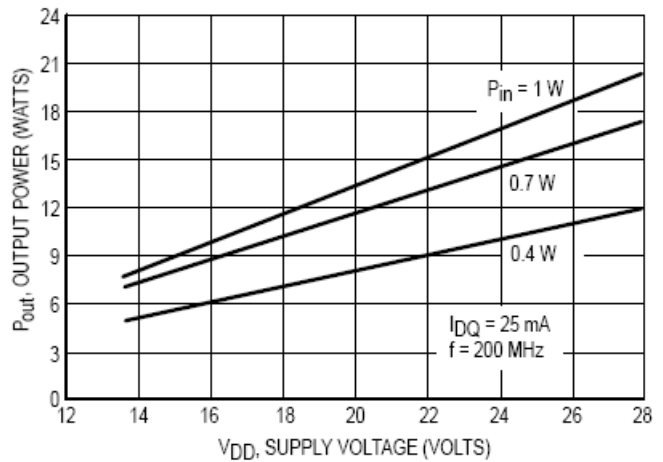


Figure 7. Output Power versus Supply Voltage

TYPICAL CHARACTERISTICS

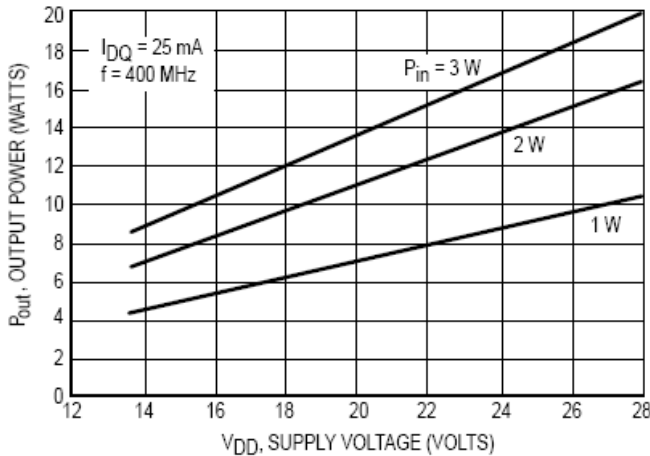


Figure 8. Output Power versus Supply Voltage

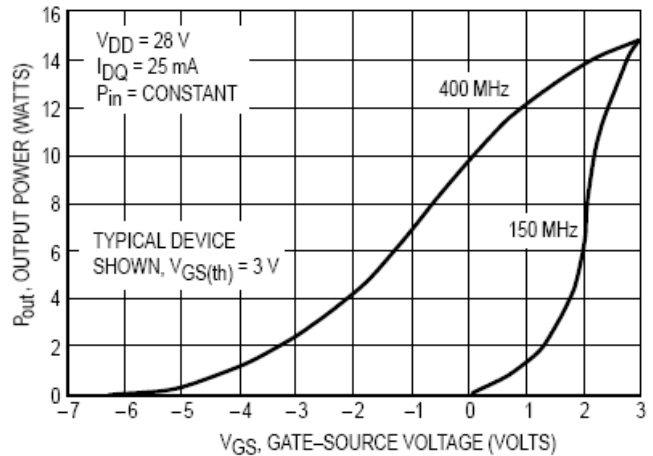


Figure 9. Output Power versus Gate Voltage

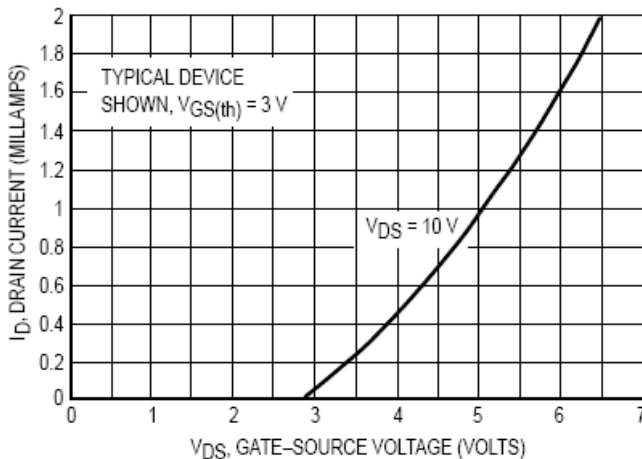


Figure 10. Drain Current versus Gate Voltage (Transfer Characteristics)

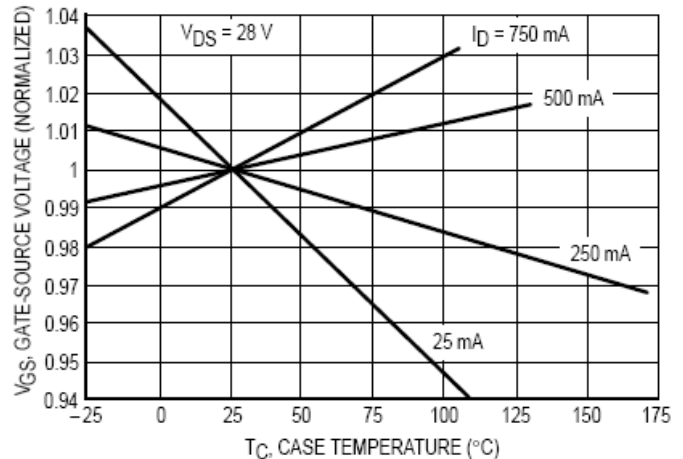


Figure 11. Gate-Source Voltage versus Case Temperature

TYPICAL CHARACTERISTICS

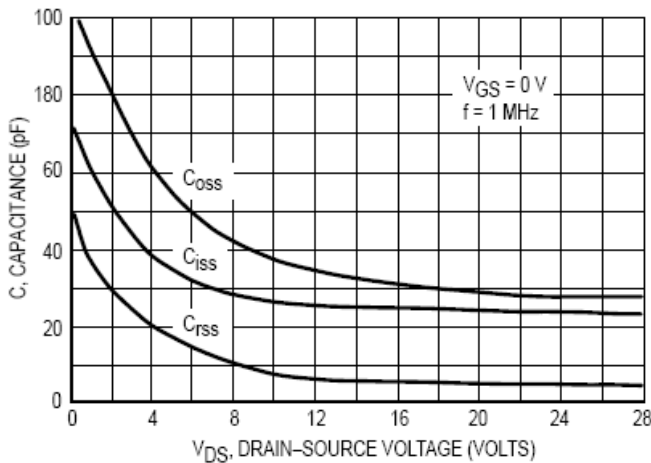


Figure 12. Capacitance versus Drain-Source Voltage

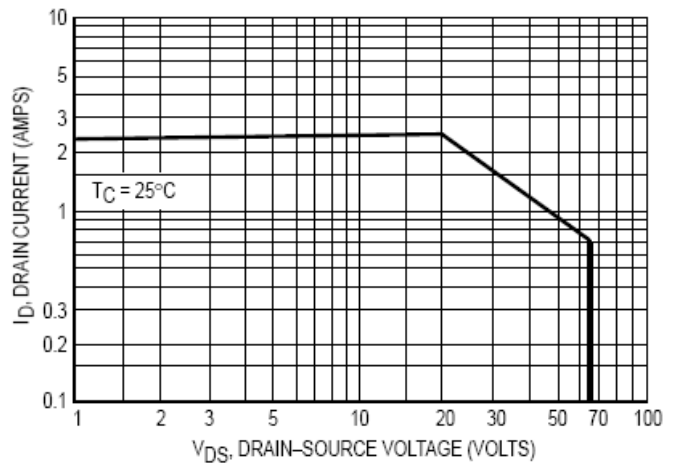


Figure 13. DC Safe Operating Area

TYPICAL 400 MHz PERFORMANCE

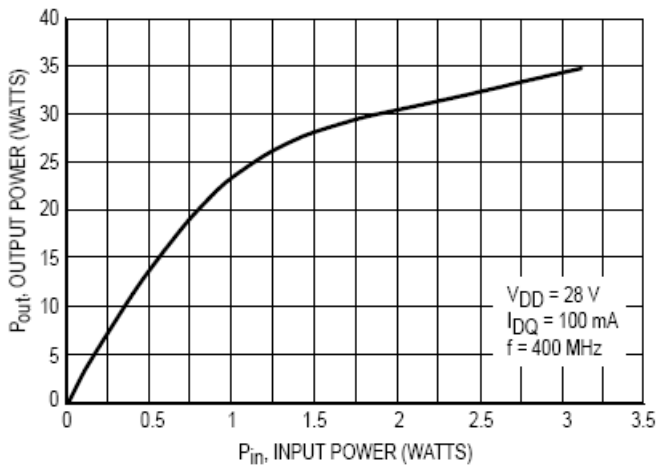


Figure 14. Output Power versus Input Power

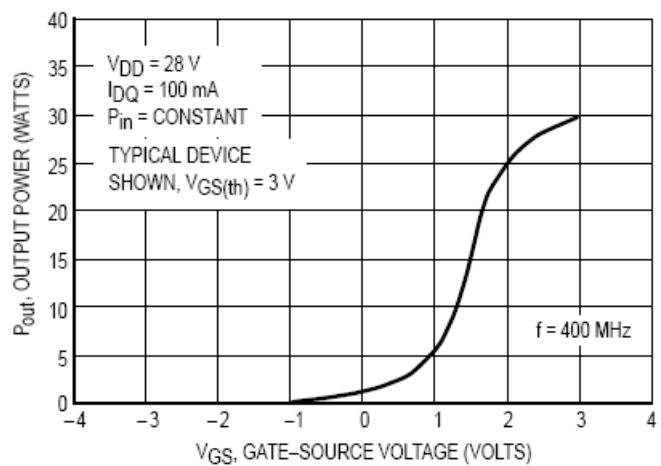


Figure 15. Output Power versus Gate Voltage

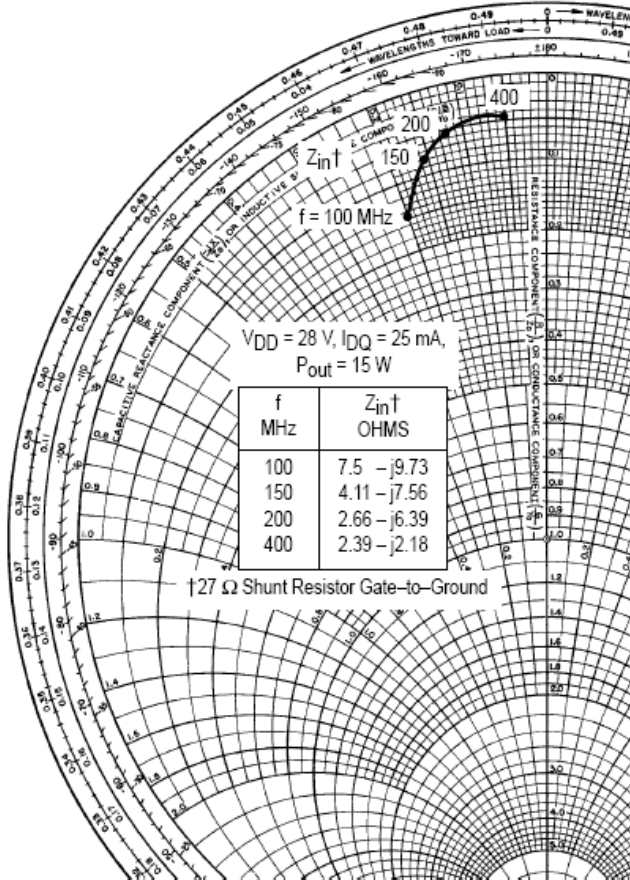


Figure 16. Large-Signal Series Equivalent Input Impedance, Z_{in}^\dagger

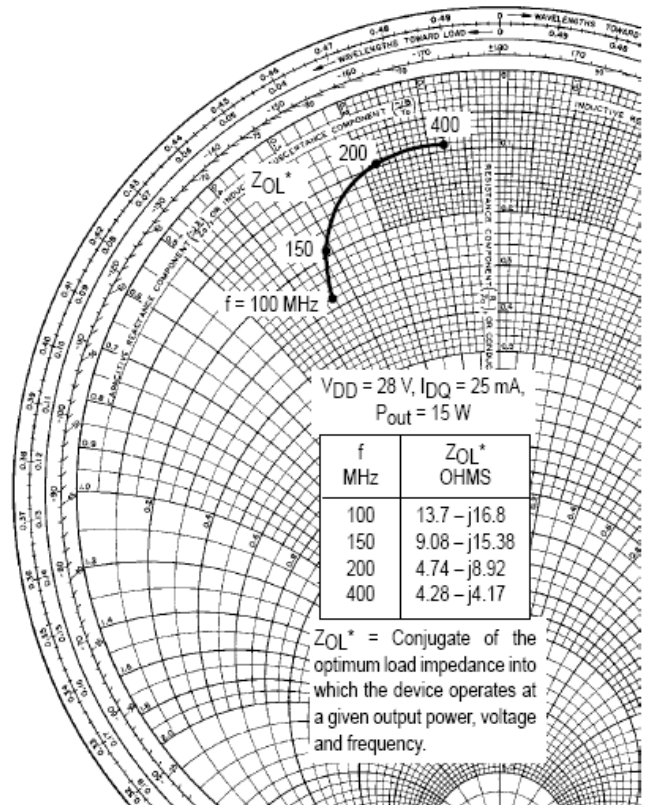


Figure 17. Large-Signal Series Equivalent Output Impedance, Z_{OL}^*

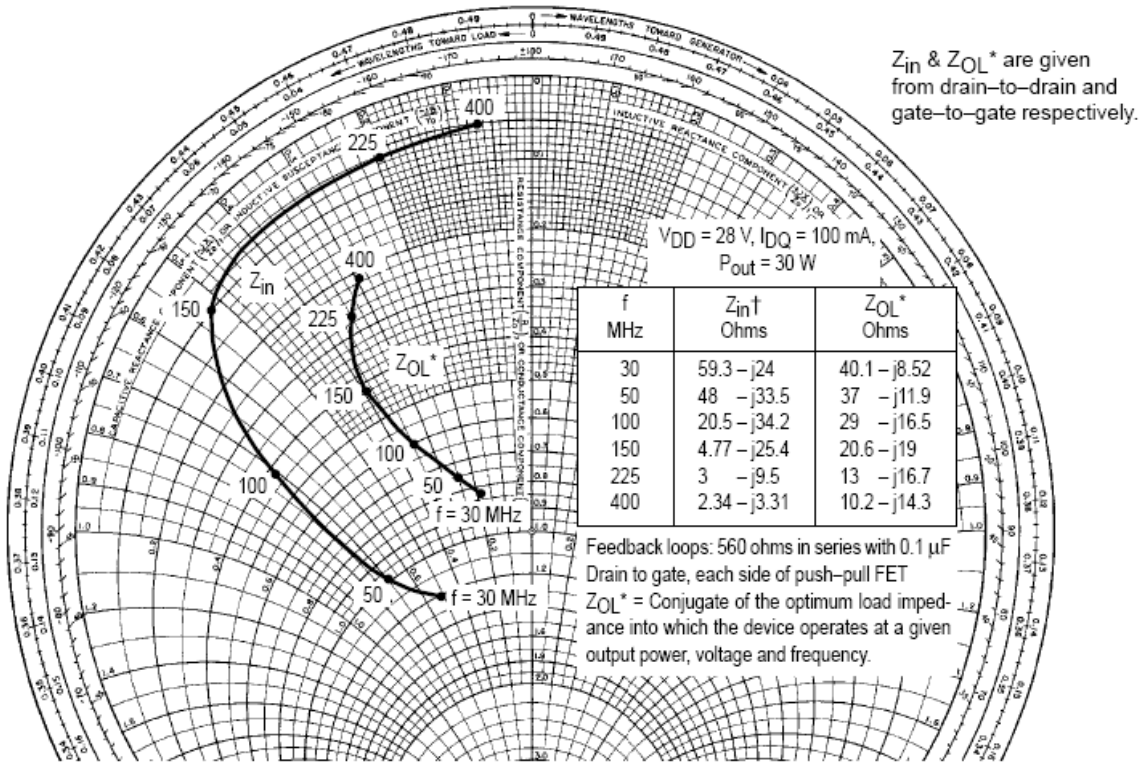


Figure 18. Input and Outut Impedance

| f (MHz) | S ₁₁ | | S ₂₁ | | S ₁₂ | | S ₂₂ | |
|------------|-----------------|------|-----------------|-----|-----------------|----|-----------------|------|
| | S ₁₁ | φ | S ₂₁ | φ | S ₁₂ | φ | S ₂₂ | φ |
| 2.0 | 0.988 | -11 | 41.19 | 173 | 0.006 | 67 | 0.729 | -12 |
| 5.0 | 0.970 | -27 | 40.07 | 164 | 0.014 | 62 | 0.720 | -31 |
| 10 | 0.923 | -52 | 35.94 | 149 | 0.026 | 54 | 0.714 | -58 |
| 20 | 0.837 | -88 | 27.23 | 129 | 0.040 | 36 | 0.690 | -96 |
| 30 | 0.784 | -111 | 20.75 | 117 | 0.046 | 27 | 0.684 | -118 |
| 40 | 0.751 | -125 | 16.49 | 108 | 0.048 | 22 | 0.680 | -131 |
| 50 | 0.733 | -135 | 13.41 | 103 | 0.050 | 19 | 0.679 | -139 |
| 60 | 0.720 | -142 | 11.43 | 99 | 0.050 | 16 | 0.678 | -145 |
| 70 | 0.709 | -147 | 9.871 | 96 | 0.050 | 14 | 0.679 | -149 |
| 80 | 0.707 | -152 | 8.663 | 93 | 0.051 | 13 | 0.683 | -153 |
| 90 | 0.706 | -155 | 7.784 | 91 | 0.051 | 13 | 0.682 | -155 |
| 100 | 0.708 | -157 | 7.008 | 88 | 0.051 | 13 | 0.680 | -157 |
| 110 | 0.711 | -159 | 6.435 | 86 | 0.051 | 14 | 0.681 | -158 |
| 120 | 0.714 | -161 | 5.899 | 85 | 0.051 | 15 | 0.682 | -159 |
| 130 | 0.717 | -163 | 5.439 | 82 | 0.052 | 16 | 0.684 | -160 |
| 140 | 0.720 | -164 | 5.068 | 80 | 0.052 | 17 | 0.684 | -161 |
| 150 | 0.723 | -165 | 4.709 | 80 | 0.052 | 18 | 0.686 | -161 |
| 160 | 0.727 | -166 | 4.455 | 78 | 0.052 | 18 | 0.690 | -161 |
| 170 | 0.732 | -167 | 4.200 | 77 | 0.052 | 18 | 0.694 | -162 |
| 180 | 0.735 | -168 | 3.967 | 75 | 0.052 | 19 | 0.699 | -162 |
| 190 | 0.738 | -169 | 3.756 | 74 | 0.052 | 19 | 0.703 | -163 |
| 200 | 0.740 | -170 | 3.545 | 73 | 0.052 | 20 | 0.706 | -163 |
| 225 | 0.746 | -171 | 3.140 | 69 | 0.053 | 22 | 0.717 | -163 |
| 250 | 0.742 | -172 | 2.783 | 67 | 0.053 | 25 | 0.724 | -163 |
| 275 | 0.744 | -173 | 2.540 | 64 | 0.054 | 27 | 0.724 | -163 |
| 300 | 0.751 | -174 | 2.323 | 60 | 0.055 | 29 | 0.736 | -163 |
| 325 | 0.757 | -175 | 2.140 | 58 | 0.058 | 32 | 0.749 | -163 |
| 350 | 0.760 | -176 | 1.963 | 54 | 0.059 | 35 | 0.758 | -163 |
| 375 | 0.762 | -177 | 1.838 | 52 | 0.062 | 38 | 0.768 | -163 |
| 400 | 0.774 | -179 | 1.696 | 50 | 0.065 | 41 | 0.783 | -163 |
| 425 | 0.775 | -179 | 1.590 | 48 | 0.068 | 43 | 0.793 | -163 |
| 450 | 0.781 | +179 | 1.493 | 46 | 0.071 | 46 | 0.805 | -163 |
| 475 | 0.787 | +177 | 1.415 | 43 | 0.074 | 47 | 0.813 | -164 |
| 500 | 0.792 | +176 | 1.332 | 40 | 0.079 | 48 | 0.825 | -164 |
| 525 | 0.797 | +175 | 1.259 | 38 | 0.083 | 50 | 0.831 | -164 |
| 550 | 0.801 | +175 | 1.185 | 37 | 0.088 | 51 | 0.843 | -164 |
| 575 | 0.810 | +174 | 1.145 | 36 | 0.094 | 52 | 0.855 | -164 |
| 600 | 0.816 | +173 | 1.091 | 34 | 0.101 | 52 | 0.869 | -165 |
| 625 | 0.818 | +171 | 1.041 | 32 | 0.106 | 53 | 0.871 | -165 |
| 650 | 0.825 | +170 | 0.994 | 30 | 0.112 | 53 | 0.884 | -165 |
| 675 | 0.834 | +169 | 0.962 | 29 | 0.119 | 53 | 0.890 | -165 |
| 700 | 0.837 | +168 | 0.922 | 27 | 0.127 | 53 | 0.906 | -166 |
| 725 | 0.836 | +167 | 0.879 | 25 | 0.133 | 52 | 0.909 | -167 |
| 750 | 0.841 | +166 | 0.838 | 25 | 0.140 | 53 | 0.917 | -167 |
| 775 | 0.844 | +165 | 0.824 | 24 | 0.148 | 52 | 0.933 | -167 |
| 800 | 0.846 | +163 | 0.785 | 21 | 0.154 | 50 | 0.941 | -168 |

Table 1. Common Source Scattering Parameters
V_{DS} = 28 V, I_D = 0.5 A

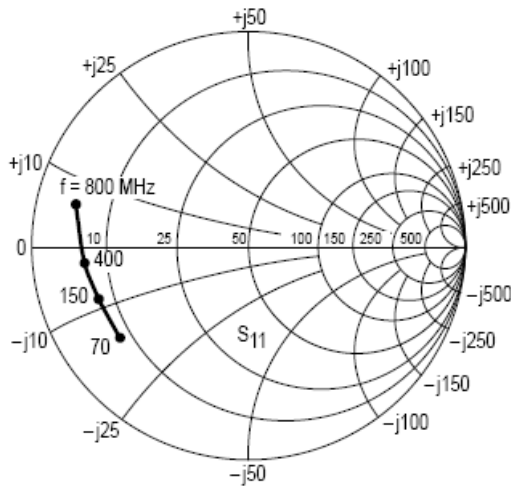


Figure 19. S₁₁, Input Reflection Coefficient versus Frequency
V_{DS} = 28 V I_D = 0.5 A

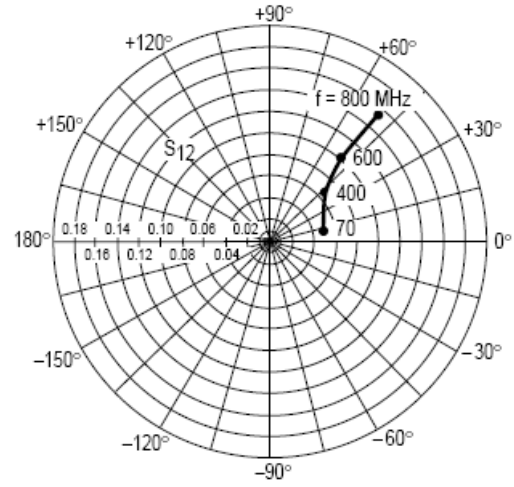


Figure 20. S₁₂, Reverse Transmission Coefficient versus Frequency
V_{DS} = 28 V I_D = 0.5 A

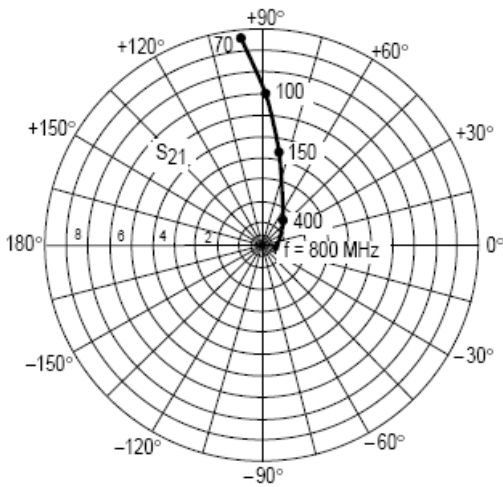


Figure 21. S₂₁, Forward Transmission Coefficient versus Frequency
V_{DS} = 28 V I_D = 0.5 A

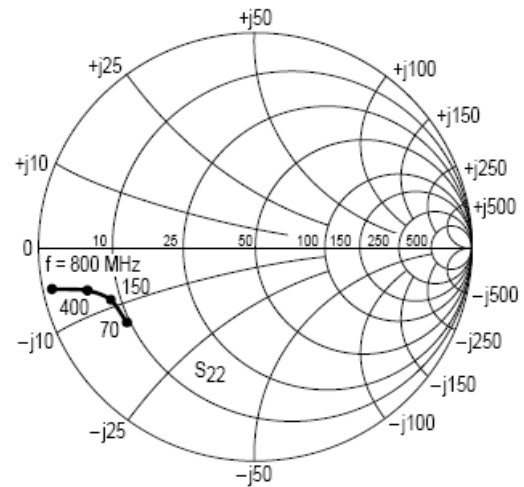


Figure 22. S₂₂, Output Reflection Coefficient versus Frequency
V_{DS} = 28 V I_D = 0.5 A

RF POWER MOSFET CONSIDERATIONS

DESIGN CONSIDERATIONS

The MRF137 is a RF power N-Channel enhancement-mode field-effect transistor (FET) designed especially for VHF power amplifier applications. M/A-COM RF MOS FETs feature a vertical structure with a planar design, thus avoiding the processing difficulties associated with V-groove vertical power FETs.

M/A-COM Application Note AN211A, FETs in Theory and Practice, is suggested reading for those not familiar with the construction and characteristics of FETs.

The major advantages of RF power FETs include high gain, low noise, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage. Power output can be varied over a wide range with a low power dc control signal, thus facilitating manual gain control, ALC and modulation.

DC BIAS

The MRF137 is an enhancement mode FET and, therefore, does not conduct when drain voltage is applied. Drain current flows when a positive voltage is applied to the gate. See Figure 10 for a typical plot of drain current versus gate voltage. RF power FETs require forward bias for optimum performance.

The value of quiescent drain current (I_{DQ}) is not critical for many applications. The MRF137 was characterized at $I_{DQ} = 25$ mA, which is the suggested minimum value of I_{DQ} . For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws no current. Therefore, the gate bias circuit may generally be just a simple

resistive divider network. Some special applications may require a more elaborate bias system.

GAIN CONTROL

Power output of the MRF137 may be controlled from its rated value down to zero (negative gain) by varying the dc gate voltage. This feature facilitates the design of manual gain control, AGC/ALC and modulation systems. (See Figure 9.)

AMPLIFIER DESIGN

Impedance matching networks similar to those used with bipolar VHF transistors are suitable for MRF137. See M/A-COM Application Note AN721, Impedance Matching Networks Applied to RF Power Transistors. The higher input impedance of RF MOS FETs helps ease the task of broadband network design. Both small signal scattering parameters and large signal impedances are provided. While the s-parameters will not produce an exact design solution for high power operation, they do yield a good first approximation. This is an additional advantage of RF MOS power FETs.

RF power FETs are triode devices and, therefore, not unilateral. This, coupled with the very high gain of the MRF137, yields a device capable of self oscillation. Stability may be achieved by techniques such as drain loading, input shunt resistive loading, or output to input feedback. Two port parameter stability analysis with the MRF137 s-parameters provides a useful tool for selection of loading or feedback circuitry to assure stable operation. See M/A-COM Application Note AN215A for a discussion of two port network theory and stability.

LOW NOISE OPERATION

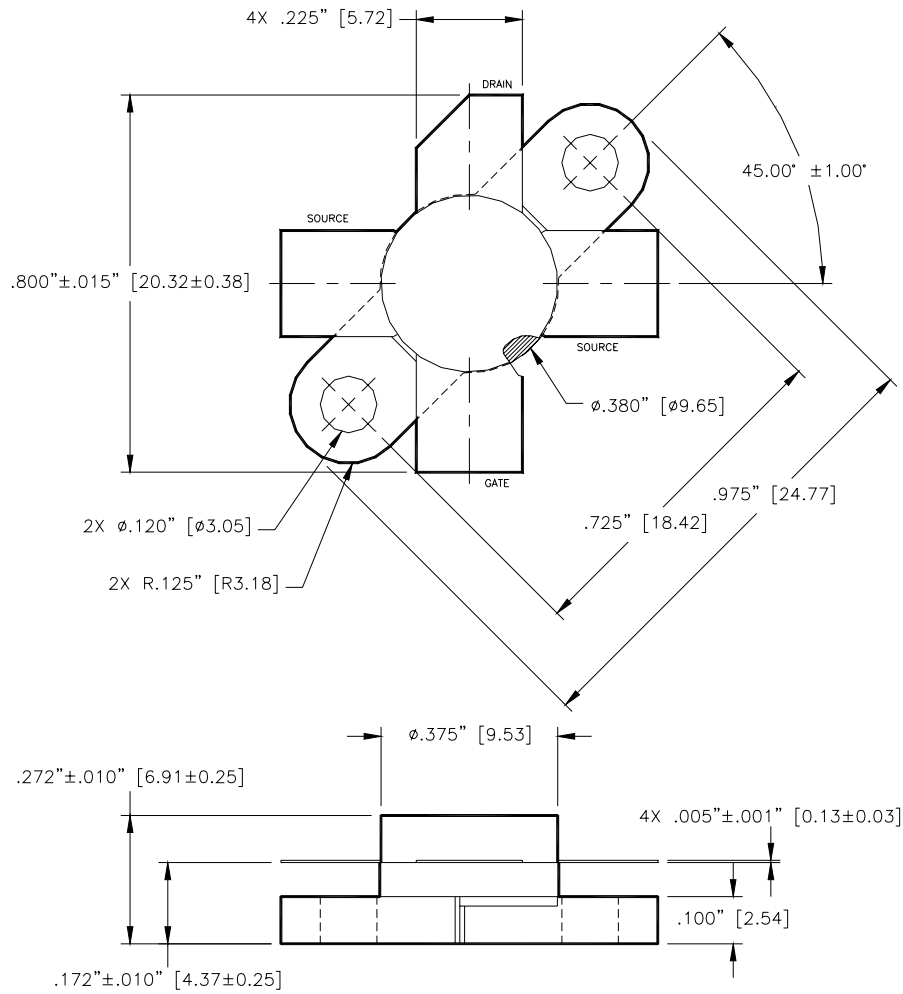
Input resistive loading will degrade noise performance, and noise figure may vary significantly with gate driving impedance. A low loss input matching network with its gate impedance optimized for lowest noise is recommended.

MRF136



The RF MOSFET Line
15W, to 400MHz, 28V

M/A-COM Products
Released - Rev. 05202009



Unless otherwise noted, tolerances are inches ±.005" [millimeters ±0.13mm]

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