

## The RF MOSFET Line 30W, to 400MHz, 28V

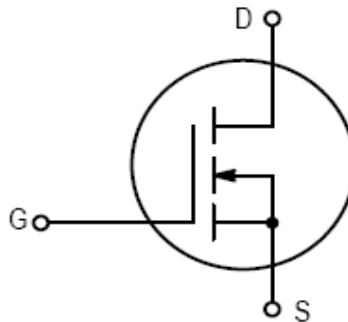
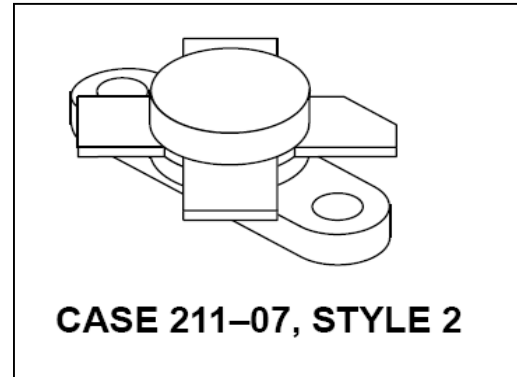
M/A-COM Products  
Released - Rev. 01302012

Designed for wideband large signal output and drive stages up to 400 MHz range.

N-Channel enhancement mode

- Guaranteed 28 V, 150 MHz performance  
Output power = 30 W  
Minimum gain = 13 dB  
Efficiency — 60% (Typical)
- Small- and large-signal characterization
- Typical performance at 400 MHz, 28 Vdc, 30 W output = 7.7 dB gain
- 100% tested for load mismatch at all phase angles with 30:1 VSWR
- Low noise figure — 1.5 dB (typ.) at 1.0 A, 150 MHz
- Excellent thermal stability, ideally suited for Class 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<br>( $R_{GS} = 1.0 \text{ M}\Omega$ )                               | $V_{DGR}$ | 65           | Vdc                          |
| Gate-Source Voltage                                                                    | $V_{GS}$  | $\pm 40$     | Vdc                          |
| Drain Current — Continuous                                                             | $I_D$     | 5.0          | Adc                          |
| Total Device Dissipation @ $T_C = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$ | $P_D$     | 100<br>0.571 | Watts<br>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 | $R_{\theta JC}$ | 1.75 | $^\circ\text{C/W}$ |

**Handling and Packaging** — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

## The RF MOSFET Line 30W, to 400MHz, 28V

M/A-COM Products  
Released - Rev. 01302012

### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted.)

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

#### OFF CHARACTERISTICS

|                                                                               |                      |    |   |     |      |
|-------------------------------------------------------------------------------|----------------------|----|---|-----|------|
| Drain–Source Breakdown Voltage (V <sub>GS</sub> = 0, I <sub>D</sub> = 10 mA)  | V <sub>(BR)DSS</sub> | 65 | — | —   | Vdc  |
| Zero Gate Voltage Drain Current (V <sub>DS</sub> = 28 V, V <sub>GS</sub> = 0) | I <sub>DSS</sub>     | —  | — | 4.0 | mAdc |
| Gate–Source Leakage Current (V <sub>GS</sub> = 20 V, V <sub>DS</sub> = 0)     | I <sub>GSS</sub>     | —  | — | 1.0 | μAdc |

#### ON CHARACTERISTICS

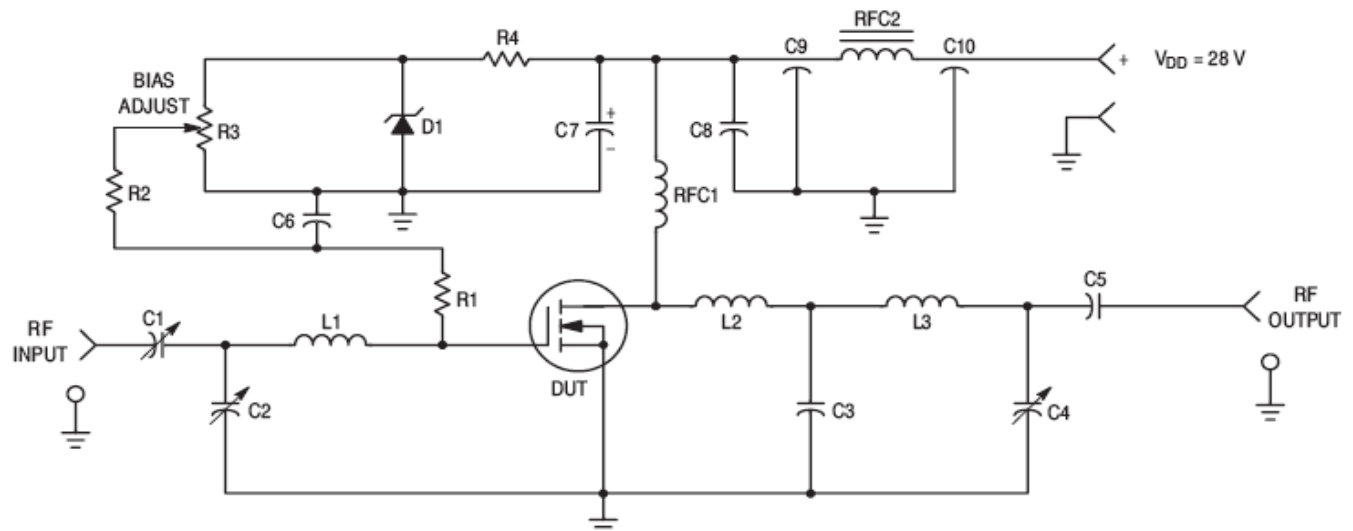
|                                                                            |                     |     |     |     |       |
|----------------------------------------------------------------------------|---------------------|-----|-----|-----|-------|
| Gate Threshold Voltage (V <sub>DS</sub> = 10 V, I <sub>D</sub> = 25 mA)    | V <sub>GS(th)</sub> | 1.0 | 3.0 | 6.0 | Vdc   |
| Forward Transconductance (V <sub>DS</sub> = 10 V, I <sub>D</sub> = 500 mA) | g <sub>fs</sub>     | 500 | 750 | —   | mmhos |

#### DYNAMIC CHARACTERISTICS

|                                                                                         |                  |   |    |   |    |
|-----------------------------------------------------------------------------------------|------------------|---|----|---|----|
| Input Capacitance (V <sub>DS</sub> = 28 V, V <sub>GS</sub> = 0, f = 1.0 MHz)            | C <sub>iss</sub> | — | 48 | — | pF |
| Output Capacitance (V <sub>DS</sub> = 28 V, V <sub>GS</sub> = 0, f = 1.0 MHz)           | C <sub>oss</sub> | — | 54 | — | pF |
| Reverse Transfer Capacitance (V <sub>DS</sub> = 28 V, V <sub>GS</sub> = 0, f = 1.0 MHz) | C <sub>rss</sub> | — | 11 | — | pF |

#### FUNCTIONAL CHARACTERISTICS

|                                                                                                                                                               |                 |                                |           |        |    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|--------------------------------|-----------|--------|----|
| Noise Figure<br>(V <sub>DS</sub> = 28 Vdc, I <sub>D</sub> = 1.0 A, f = 150 MHz)                                                                               | NF              | —                              | 1.5       | —      | dB |
| Common Source Power Gain<br>(V <sub>DD</sub> = 28 Vdc, P <sub>out</sub> = 30 W, I <sub>DQ</sub> = 25 mA)<br>f = 150 MHz (Figure 1)<br>f = 400 MHz (Figure 14) | G <sub>ps</sub> | 13<br>—                        | 16<br>7.7 | —<br>— | dB |
| Drain Efficiency (Figure 1)<br>(V <sub>DD</sub> = 28 Vdc, P <sub>out</sub> = 30 W, f = 150 MHz, I <sub>DQ</sub> = 25 mA)                                      | η               | 50                             | 60        | —      | %  |
| Electrical Ruggedness (Figure 1)<br>(V <sub>DD</sub> = 28 Vdc, P <sub>out</sub> = 30 W, f = 150 MHz, I <sub>DQ</sub> = 25 mA, VSWR 30:1 at All Phase Angles)  | ψ               | No Degradation in Output Power |           |        |    |



C1 — Arco 403, 3.0–35 pF, or equivalent  
C2 — Arco 406, 15–115 pF, or equivalent  
C3 — 56 pF Mini-Unelco, or equivalent  
C4 — Arco 404, 8.0–60 pF, or equivalent  
C5 — 680 pF, 100 Mils Chip  
C6 — 0.01  $\mu$ F, 100 V, Disc Ceramic  
C7 — 100  $\mu$ F, 40 V  
C8 — 0.1  $\mu$ F, 50 V, Disc Ceramic  
C9, C10 — 680 pF Feedthru  
D1 — 1N5925A Motorola Zener

L1 — 2 Turns, 0.29" ID, #18 AWG Enamel, Closewound  
L2 — 1-1/4 Turns, 0.2" ID, #18 AWG Enamel, Closewound  
L3 — 2 Turns, 0.2" ID, #18 AWG Enamel, Closewound  
RFC1 — 20 Turns, 0.30" ID, #20 AWG Enamel, Closewound  
RFC2 — Ferroxcube VK-200 — 19/4B  
R1 — 10 k $\Omega$ , 1/2 W Thin Film  
R2 — 10 k $\Omega$ , 1/4 W  
R3 — 10 Turns, 10 k $\Omega$   
R4 — 1.8 k $\Omega$ , 1/2 W  
Board — G10, 62 Mils

Figure 1. 150 MHz Test Circuit

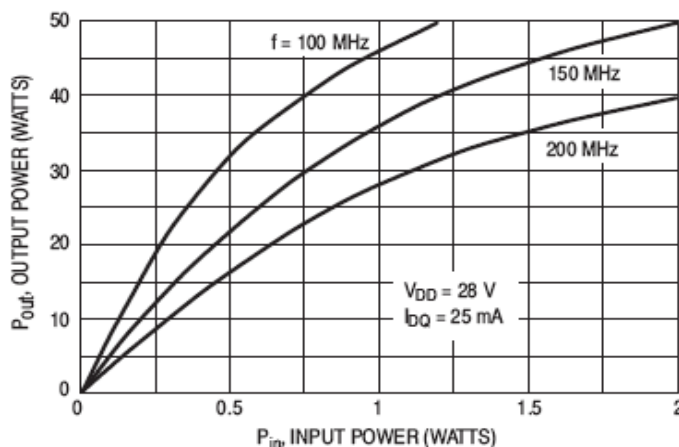


Figure 2. Output Power versus Input Power

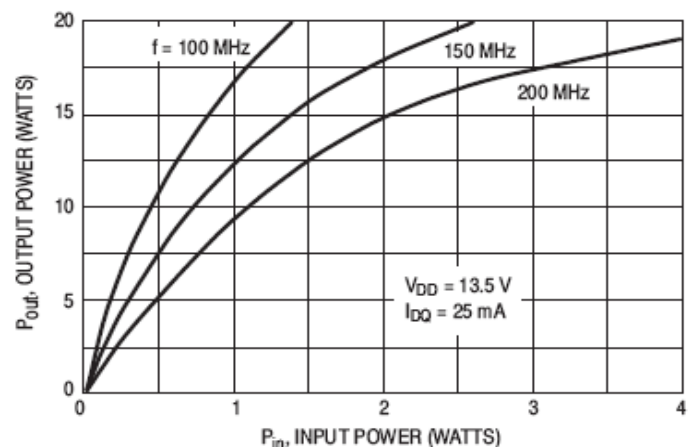


Figure 3. Output Power versus Input Power

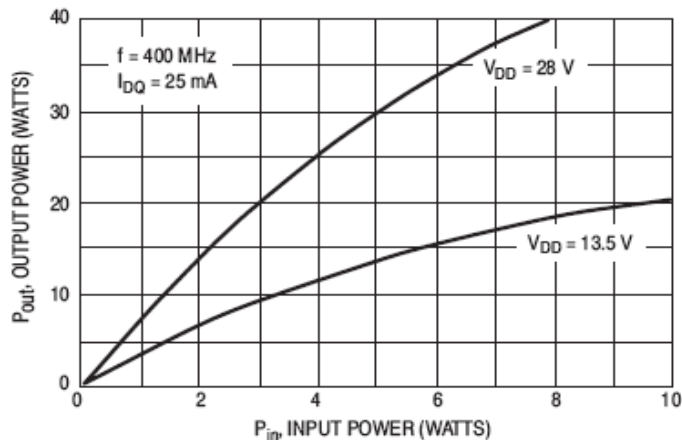


Figure 4. Output Power versus Input Power

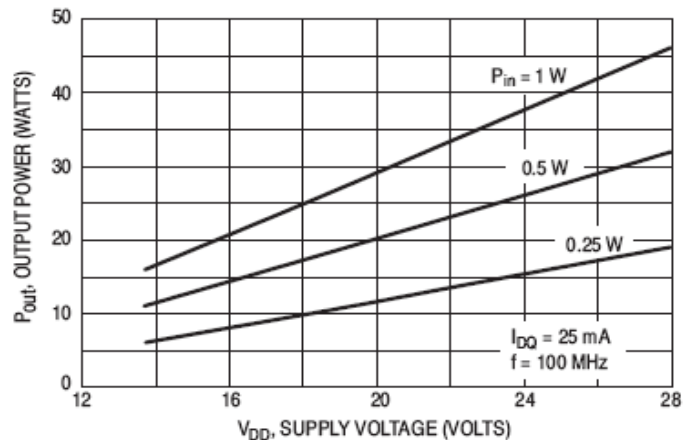


Figure 5. Output Power versus Supply Voltage

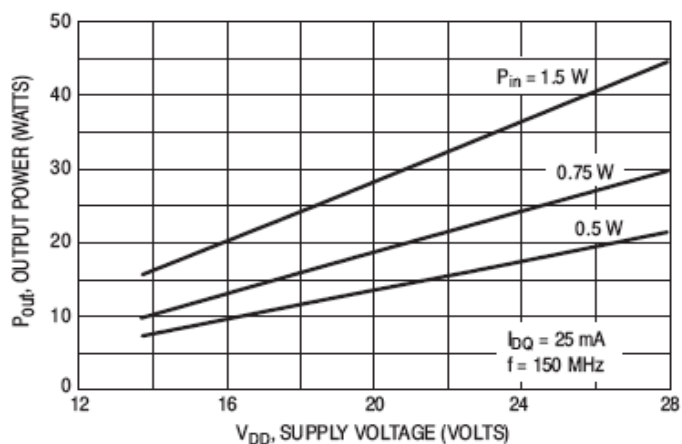


Figure 6. Output Power versus Supply Voltage

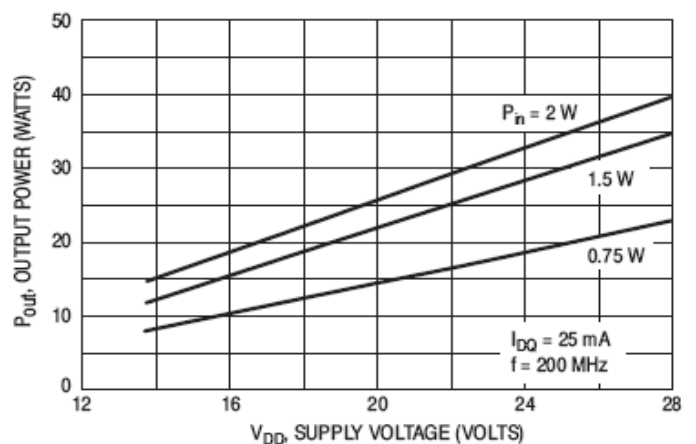


Figure 7. Output Power versus Supply Voltage

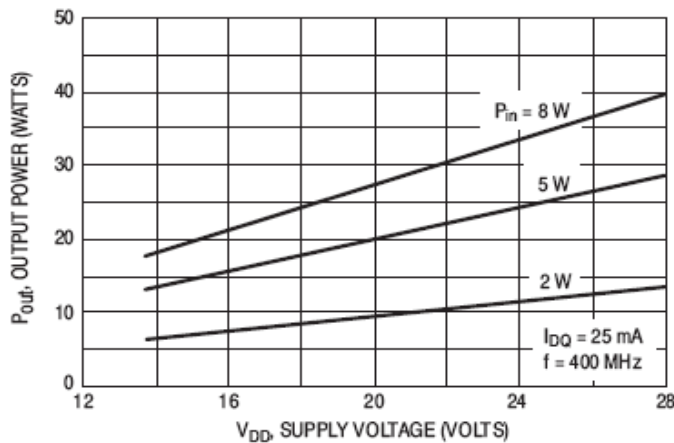


Figure 8. Output Power versus Supply Voltage

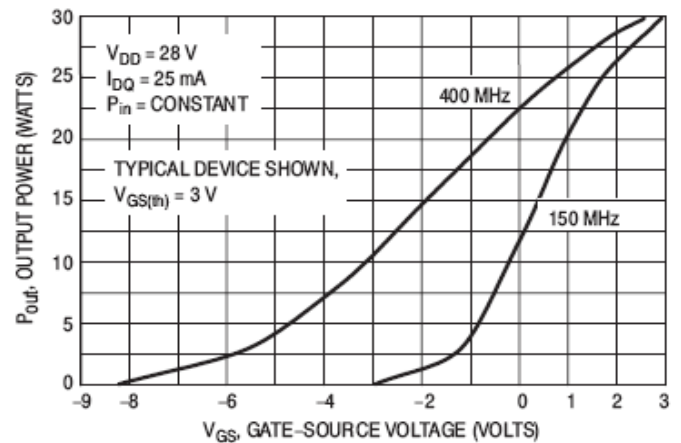


Figure 9. Output Power versus Gate Voltage

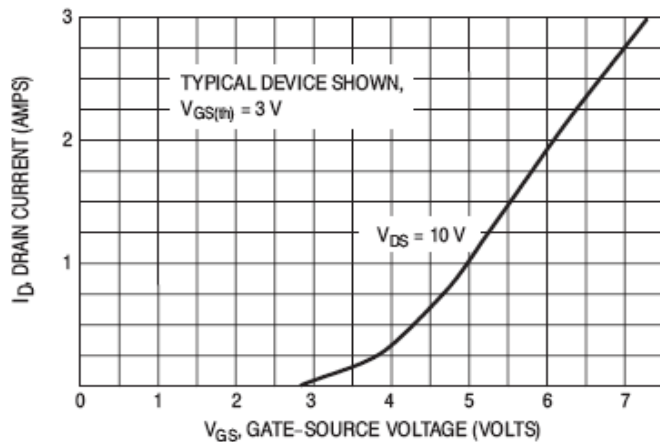


Figure 10. Drain Current versus Gate Voltage  
(Transfer Characteristics)

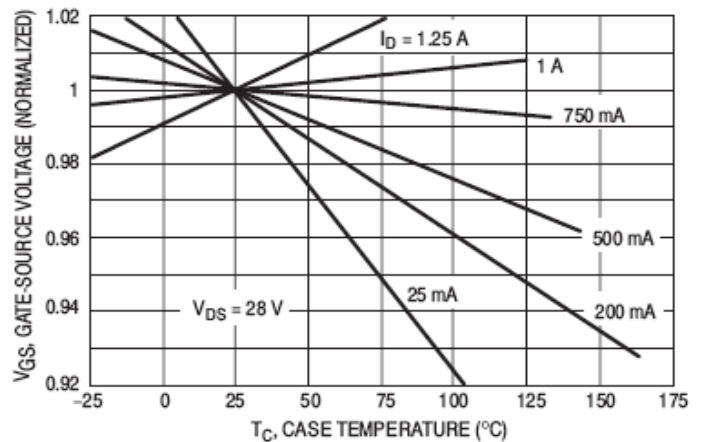


Figure 11. Gate Source Voltage versus  
Case Temperature

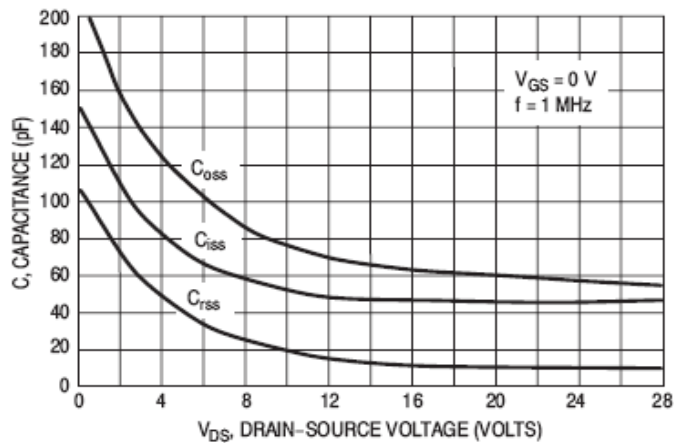


Figure 12. Capacitance versus Drain-Source Voltage

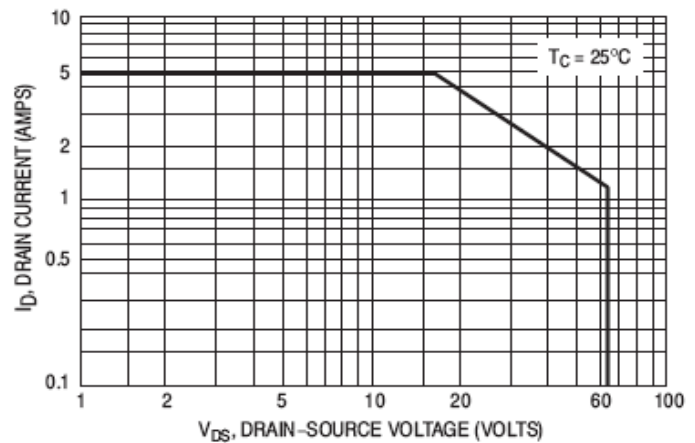
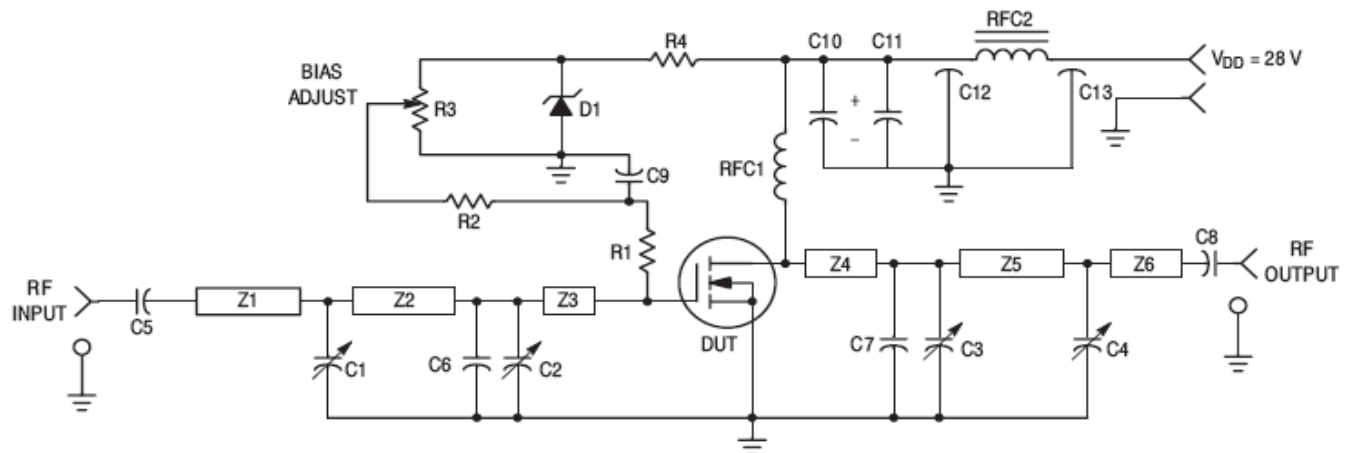


Figure 13. DC Safe Operating Area



C1, C2, C3, C4 — 0–20 pF Johanson, or equivalent  
C5, C8 — 270 pF, 100 Mil Chip  
C6, C7 — 24 pF Mini-Unelco, or equivalent  
C9 — 0.01  $\mu\text{F}$ , 100 V, Disc Ceramic  
C10 — 100  $\mu\text{F}$ , 40 V  
C11 — 0.1  $\mu\text{F}$ , 50 V, Disc Ceramic  
C12, C13 — 680 pF Feedthru  
D1 — 1N5925A Motorola Zener  
R1, R2 — 10 k $\Omega$ , 1/4 W  
R3 — 10 Turns, 10 k $\Omega$

R4 — 1.8 k $\Omega$ , 1/2 W  
Z1 — 2.9"  $\times$  0.166" Microstrip  
Z2, Z4 — 0.35"  $\times$  0.166" Microstrip  
Z3 — 0.40"  $\times$  0.166" Microstrip  
Z5 — 1.05"  $\times$  0.166" Microstrip  
Z6 — 1.9"  $\times$  0.166" Microstrip  
RFC1 — 6 Turns, 0.300" ID, #20 AWG Enamel, Closewound  
RFC2 — Ferroxcube VK-200 — 19/4B  
Board — Glass Teflon, 62 Mils

Figure 14. 400 MHz Test Circuit

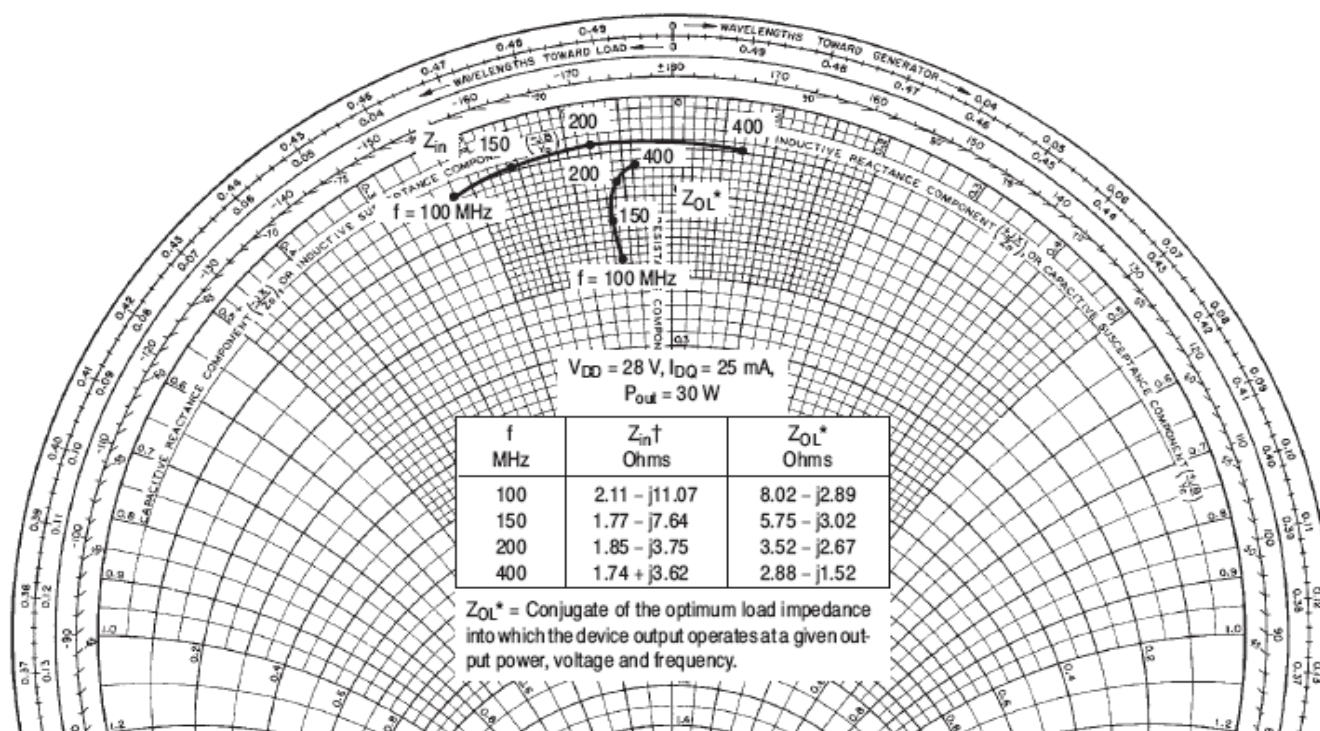


Figure 15. Large-Signal Series Equivalent Input and Output Impedance,  $Z_{in}$ ,  $Z_{OL}^*$

| f<br>(MHz) | S <sub>11</sub> |      | S <sub>21</sub> |     | S <sub>12</sub> |     | S <sub>22</sub> |      |
|------------|-----------------|------|-----------------|-----|-----------------|-----|-----------------|------|
|            | S <sub>11</sub> | ∠ φ  | S <sub>21</sub> | ∠ φ | S <sub>12</sub> | ∠ φ | S <sub>22</sub> | ∠ φ  |
| 2.0        | 0.977           | -32  | 59.48           | 163 | 0.011           | 67  | 0.661           | -36  |
| 5.0        | 0.919           | -70  | 48.67           | 142 | 0.024           | 44  | 0.692           | -78  |
| 10         | 0.852           | -109 | 33.50           | 122 | 0.032           | 29  | 0.747           | -117 |
| 20         | 0.817           | -140 | 19.05           | 106 | 0.037           | 16  | 0.768           | -146 |
| 30         | 0.814           | -153 | 13.11           | 99  | 0.038           | 14  | 0.774           | -157 |
| 40         | 0.811           | -159 | 9.88            | 95  | 0.038           | 13  | 0.782           | -162 |
| 50         | 0.812           | -164 | 7.98            | 92  | 0.038           | 12  | 0.787           | -165 |
| 60         | 0.813           | -166 | 6.66            | 89  | 0.038           | 12  | 0.787           | -168 |
| 70         | 0.815           | -168 | 5.708           | 86  | 0.038           | 11  | 0.787           | -169 |
| 80         | 0.816           | -170 | 5.003           | 84  | 0.038           | 11  | 0.787           | -170 |
| 90         | 0.817           | -171 | 4.560           | 83  | 0.038           | 12  | 0.787           | -171 |
| 100        | 0.817           | -172 | 4.170           | 81  | 0.039           | 13  | 0.787           | -172 |
| 110        | 0.818           | -173 | 3.670           | 80  | 0.039           | 13  | 0.788           | -172 |
| 120        | 0.820           | -173 | 3.420           | 79  | 0.039           | 13  | 0.788           | -173 |
| 130        | 0.821           | -173 | 3.170           | 79  | 0.039           | 13  | 0.788           | -173 |
| 140        | 0.822           | -174 | 2.980           | 78  | 0.039           | 13  | 0.788           | -173 |
| 150        | 0.823           | -175 | 2.826           | 77  | 0.039           | 14  | 0.788           | -173 |
| 160        | 0.824           | -175 | 2.650           | 76  | 0.039           | 14  | 0.790           | -174 |
| 170        | 0.825           | -176 | 2.438           | 75  | 0.039           | 14  | 0.792           | -174 |
| 180        | 0.827           | -176 | 2.325           | 73  | 0.039           | 15  | 0.793           | -174 |
| 190        | 0.829           | -177 | 2.175           | 72  | 0.039           | 16  | 0.796           | -174 |
| 200        | 0.831           | -177 | 2.084           | 71  | 0.039           | 16  | 0.799           | -174 |
| 225        | 0.836           | -178 | 1.824           | 69  | 0.039           | 18  | 0.805           | -174 |
| 250        | 0.846           | -178 | 1.621           | 66  | 0.039           | 21  | 0.816           | -174 |
| 275        | 0.853           | -179 | 1.462           | 64  | 0.039           | 23  | 0.822           | -174 |
| 300        | 0.853           | -179 | 1.319           | 61  | 0.040           | 25  | 0.833           | -174 |
| 325        | 0.856           | -179 | 1.194           | 59  | 0.040           | 27  | 0.828           | -174 |
| 350        | 0.857           | +179 | 1.089           | 56  | 0.040           | 30  | 0.842           | -174 |
| 375        | 0.861           | +179 | 1.014           | 54  | 0.042           | 32  | 0.849           | -174 |
| 400        | 0.865           | +178 | 0.927           | 51  | 0.043           | 35  | 0.856           | -174 |
| 425        | 0.875           | +178 | 0.876           | 49  | 0.045           | 37  | 0.866           | -174 |
| 450        | 0.881           | +178 | 0.810           | 46  | 0.046           | 40  | 0.870           | -174 |
| 475        | 0.886           | +177 | 0.755           | 44  | 0.046           | 43  | 0.875           | -174 |
| 500        | 0.887           | +177 | 0.694           | 41  | 0.051           | 43  | 0.888           | -174 |
| 525        | 0.888           | +176 | 0.677           | 39  | 0.052           | 43  | 0.890           | -174 |
| 550        | 0.896           | +176 | 0.625           | 36  | 0.055           | 45  | 0.898           | -174 |
| 575        | 0.907           | +175 | 0.603           | 34  | 0.058           | 45  | 0.913           | -174 |
| 600        | 0.910           | +175 | 0.585           | 32  | 0.061           | 45  | 0.918           | -174 |
| 625        | 0.910           | +174 | 0.563           | 30  | 0.065           | 45  | 0.945           | -174 |
| 650        | 0.920           | +174 | 0.543           | 28  | 0.069           | 46  | 0.952           | -174 |
| 675        | 0.938           | +173 | 0.533           | 26  | 0.074           | 47  | 0.974           | -174 |
| 700        | 0.943           | +171 | 0.515           | 24  | 0.078           | 47  | 0.958           | -176 |
| 725        | 0.934           | +170 | 0.491           | 22  | 0.079           | 46  | 0.953           | -177 |
| 750        | 0.940           | +170 | 0.475           | 22  | 0.084           | 48  | 0.943           | -177 |
| 775        | 0.953           | +169 | 0.477           | 21  | 0.090           | 48  | 0.957           | -177 |
| 800        | 0.959           | +168 | 0.467           | 17  | 0.093           | 48  | 0.957           | -179 |

**Table 1. Common Source Scattering Parameters**  
**50 Ω System**  
**V<sub>DS</sub> = 28 V, I<sub>D</sub> = 0.75 A**

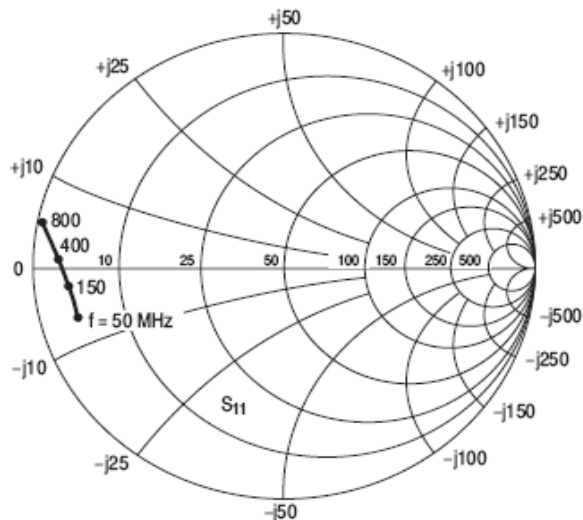


Figure 16.  $S_{11}$ , Input Reflection Coefficient  
versus Frequency  
 $V_{DS} = 28\text{ V}$   $I_D = 0.75\text{ A}$

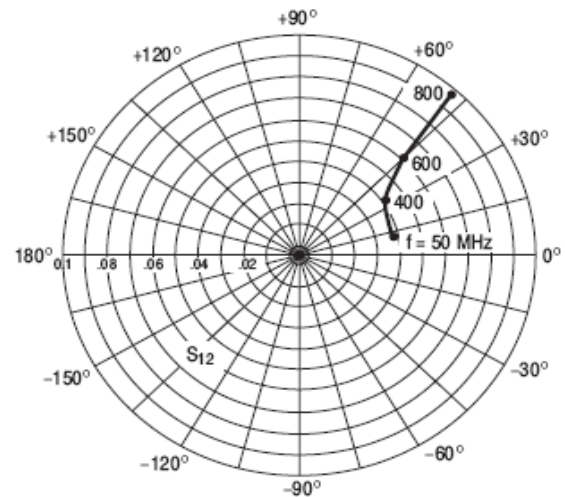


Figure 17.  $S_{12}$ , Reverse Transmission Coefficient  
versus Frequency  
 $V_{DS} = 28\text{ V}$   $I_D = 0.75\text{ A}$

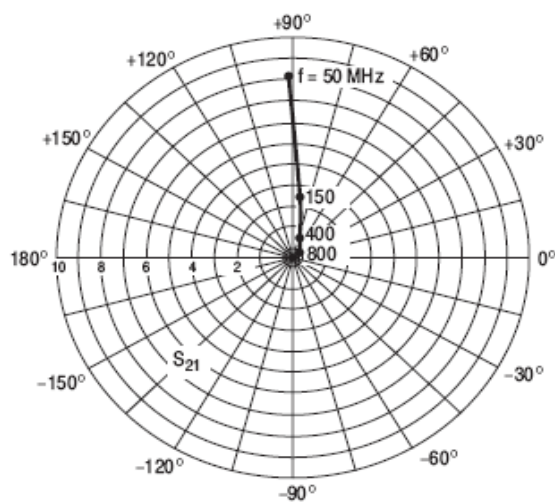


Figure 18.  $S_{21}$ , Forward Transmission Coefficient  
versus Frequency  
 $V_{DS} = 28\text{ V}$   $I_D = 0.75\text{ A}$

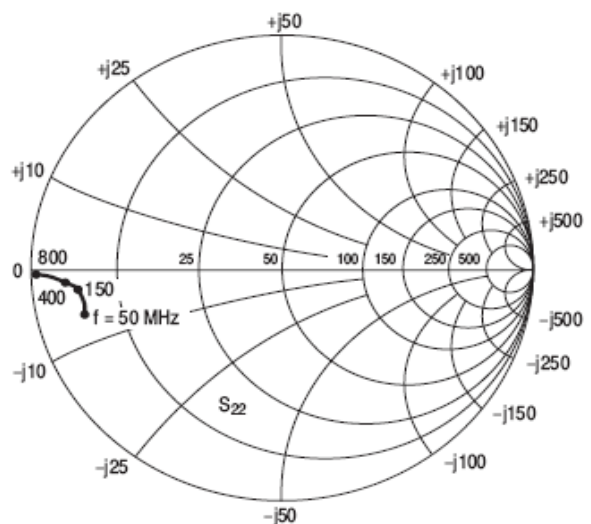


Figure 19.  $S_{22}$ , Output Reflection Coefficient  
versus Frequency  
 $V_{DS} = 28\text{ V}$   $I_D = 0.75\text{ A}$

## 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.

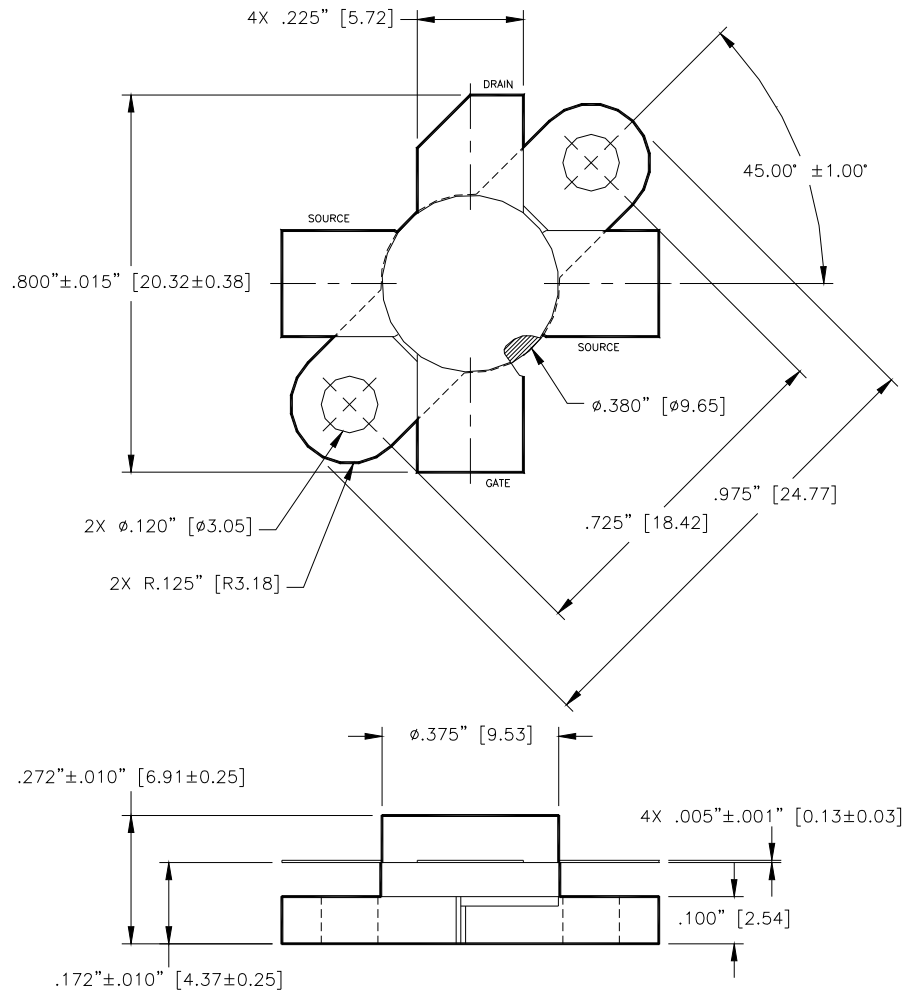
### GAIN CONTROL

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.



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