



# RF Power Field Effect Transistors

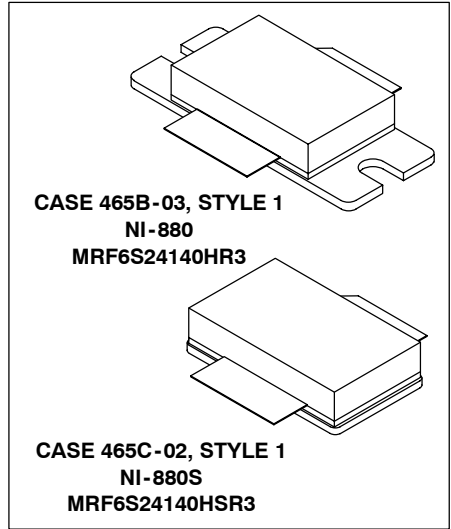
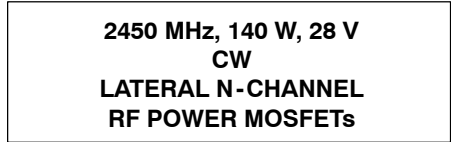
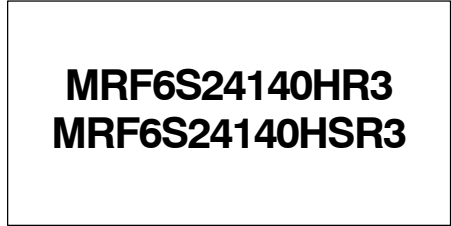
## N-Channel Enhancement-Mode Lateral MOSFETs

Designed primarily for large-signal output applications at 2450 MHz. Devices are suitable for use in industrial, medical and scientific applications.

- Typical CW Performance at 2450 MHz,  $V_{DD} = 28$  Volts,  $I_{DQ} = 1200$  mA,  $P_{out} = 140$  Watts  
 Power Gain — 13.2 dB  
 Drain Efficiency — 45%
- Capable of Handling 10:1 VSWR, @ 28 Vdc, 2390 MHz, 140 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
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.



**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5, +68	Vdc
Gate-Source Voltage	$V_{GS}$	-0.5, +12	Vdc
Storage Temperature Range	$T_{stg}$	-65 to +150	°C
Case Operating Temperature	$T_C$	150	°C
Operating Junction Temperature (1,2)	$T_J$	225	°C

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$		°C/W
Case Temperature 82°C, 140 W CW		0.29	
Case Temperature 75°C, 28 W CW		0.33	

1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
3. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1955.

**Table 3. ESD Protection Characteristics**

Test Methodology	Class
Human Body Model (per JESD22-A114)	2 (Minimum)
Machine Model (per EIA/JESD22-A115)	A (Minimum)
Charge Device Model (per JESD22-C101)	IV (Minimum)

**Table 4. Electrical Characteristics** ( $T_C = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Off Characteristics</b>					
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 68 \text{ Vdc}$ , $V_{GS} = 0 \text{ Vdc}$ )	$I_{DSS}$	—	—	10	$\mu\text{Adc}$
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 28 \text{ Vdc}$ , $V_{GS} = 0 \text{ Vdc}$ )	$I_{DSS}$	—	—	1	$\mu\text{Adc}$
Gate-Source Leakage Current ( $V_{GS} = 5 \text{ Vdc}$ , $V_{DS} = 0 \text{ Vdc}$ )	$I_{GSS}$	—	—	500	nAdc

**On Characteristics**

Gate Threshold Voltage ( $V_{DS} = 10 \text{ Vdc}$ , $I_D = 300 \mu\text{Adc}$ )	$V_{GS(th)}$	1	2	3	Vdc
Gate Quiescent Voltage ( $V_{DD} = 28 \text{ Vdc}$ , $I_D = 1300 \text{ mAdc}$ , Measured in Functional Test)	$V_{GS(Q)}$	2	2.8	4	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10 \text{ Vdc}$ , $I_D = 3 \text{ Adc}$ )	$V_{DS(on)}$	0.1	0.21	0.3	Vdc

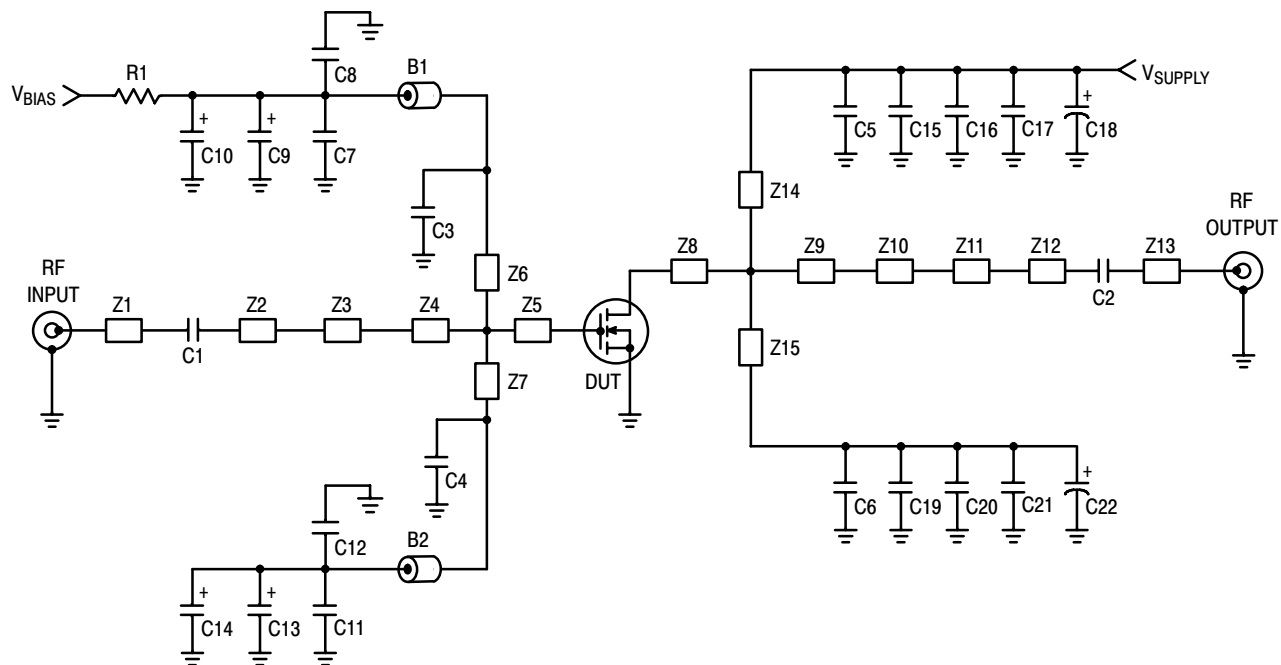
**Dynamic Characteristics** <sup>(1)</sup>

Reverse Transfer Capacitance ( $V_{DS} = 28 \text{ Vdc} \pm 30 \text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0 \text{ Vdc}$ )	$C_{rss}$	—	2	—	pF
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**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1300 \text{ mA}$ ,  $P_{out} = 28 \text{ W Avg.}$ ,  $f = 2390 \text{ MHz}$ , 2-Carrier W-CDMA, 3.84 MHz Channel Bandwidth Carriers. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5 \text{ MHz}$  Offset. IM3 measured in 3.84 MHz Bandwidth @  $\pm 10 \text{ MHz}$  Offset. Input Signal PAR = 8.5 dB @ 0.01% Probability on CCDF.

Power Gain	$G_{ps}$	13	15.2	17	dB
Drain Efficiency	$\eta_D$	23	25	—	%
Intermodulation Distortion	IM3	—	-37	-35	dBc
Adjacent Channel Power Ratio	ACPR	—	-40	-38	dBc
Input Return Loss	IRL	—	-15	—	dB

1. Part internally matched both on input and output.

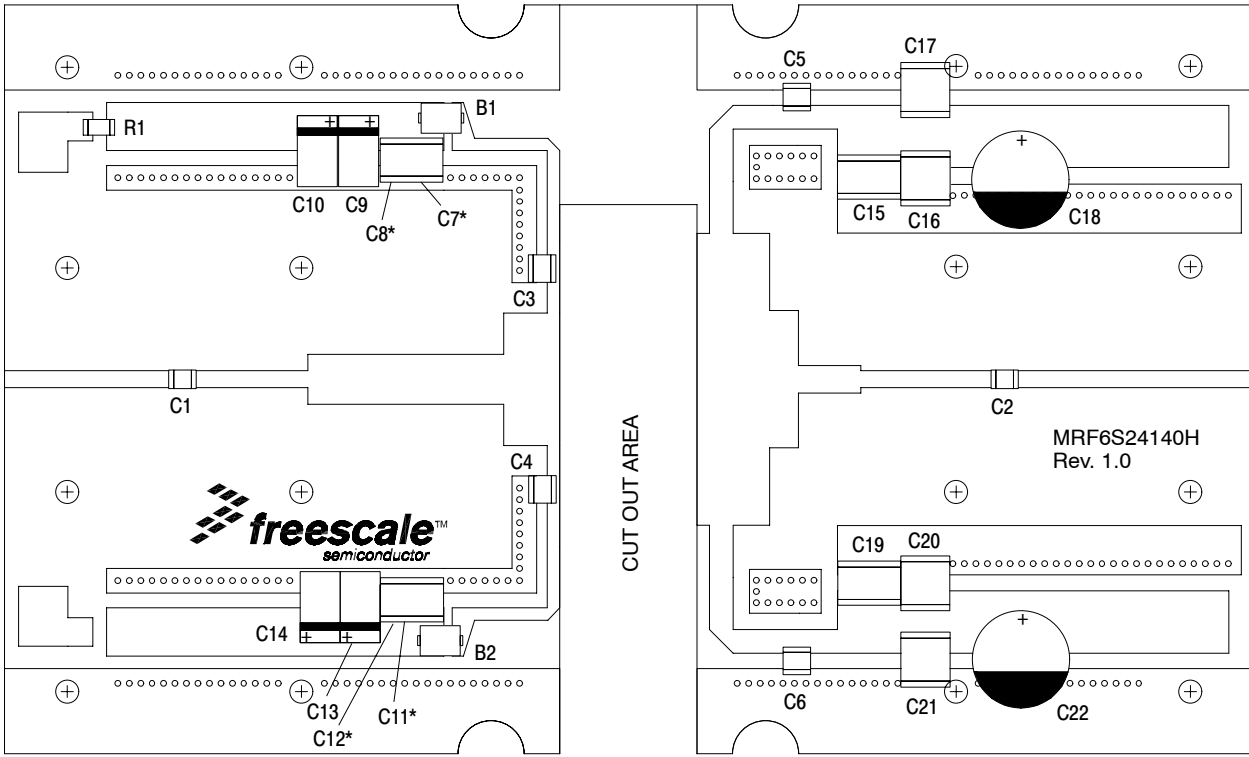


Z1	0.678" x 0.068" Microstrip	Z9	0.193" x 1.170" Microstrip
Z2	0.466" x 0.068" Microstrip	Z10	0.115" x 0.550" Microstrip
Z3	0.785" x 0.200" Microstrip	Z11	0.250" x 0.110" Microstrip
Z4	0.200" x 0.530" Microstrip	Z12	0.538" x 0.068" Microstrip
Z5	0.025" x 0.530" Microstrip	Z13	0.957" x 0.068" Microstrip
Z6, Z7	0.178" x 0.050" Microstrip	Z14, Z15	0.673" x 0.095" Microstrip
Z8	0.097" x 1.170" Microstrip	PCB	Arlon CuClad 250GX-0300-55-22, 0.030", $\epsilon_r = 2.55$

**Figure 1. MRF6S24140HR3(SR3) Test Circuit Schematic — 2450 MHz**

**Table 5. MRF6S24140HR3(SR3) Test Circuit Component Designations and Values**

Part	Description	Part Number	Manufacturer
B1, B2	47 $\Omega$ , 100 MHz Short Ferrite Beads, Surface Mount	2743019447	Fair-Rite
C1, C2, C3, C4, C5, C6	5.6 pF Chip Capacitors	ATC600B5R6BT500XT	ATC
C7, C11	0.01 $\mu$ F, 100 V Chip Capacitors	C1825C103J1RAC	Kemet
C8, C12, C15, C19	2.2 $\mu$ F, 50 V Chip Capacitors	C1825C225J5RAC	Kemet
C9, C13	22 $\mu$ F, 25 V Tantalum Capacitors	T491D226M025AT	Kemet
C10, C14	47 $\mu$ F, 16 V Tantalum Capacitors	T491D476K016AT	Kemet
C16, C17, C20, C21	10 $\mu$ F, 50 V Chip Capacitors	GRM55DR61H106KA88B	Murata
C18, C22	220 $\mu$ F, 50 V Electrolytic Capacitors	2222-150-95102	Vishay
R1	240 $\Omega$ , 1/4 W Chip Resistor	CRC12062400FKEA	Vishay



\* Stacked

Figure 2. MRF6S24140HR3(SR3) Test Circuit Component Layout — 2450 MHz

TYPICAL CHARACTERISTICS — 2450 MHz

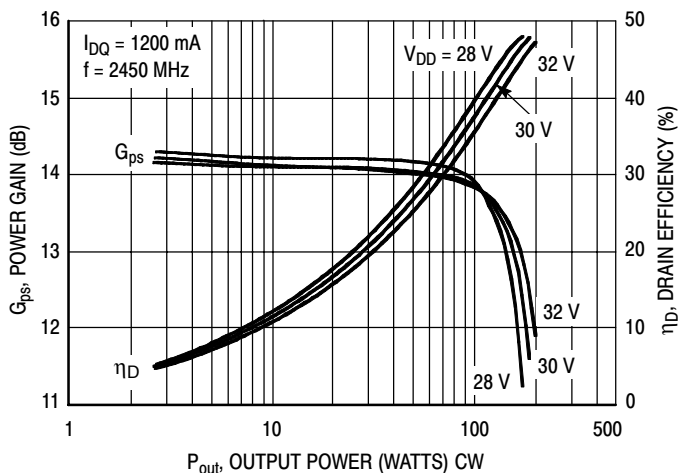


Figure 3. Power Gain and Drain Efficiency versus CW Output Power as a Function of  $V_{DD}$

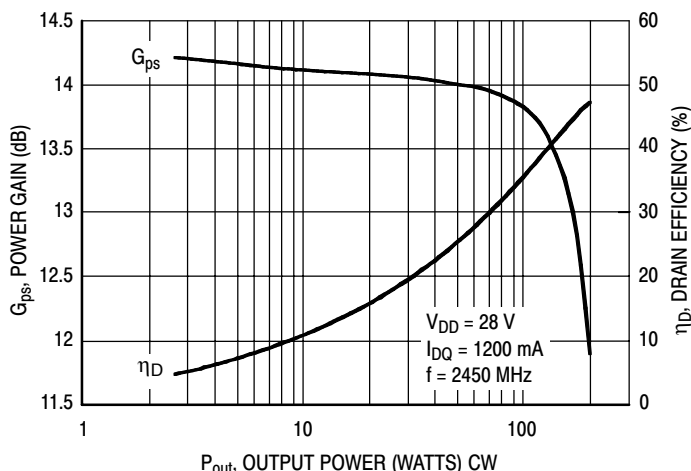


Figure 4. Power Gain and Drain Efficiency versus CW Output Power

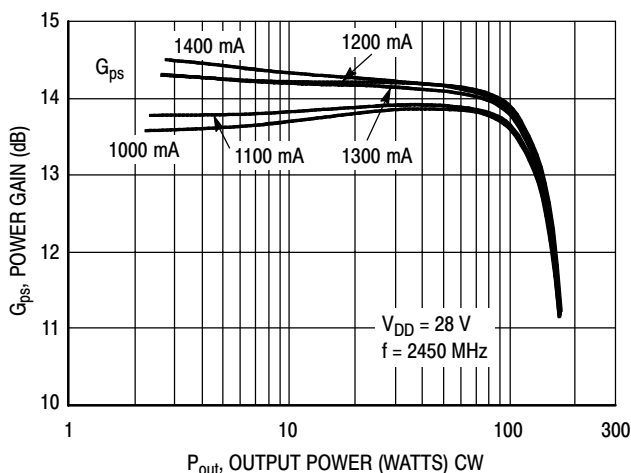
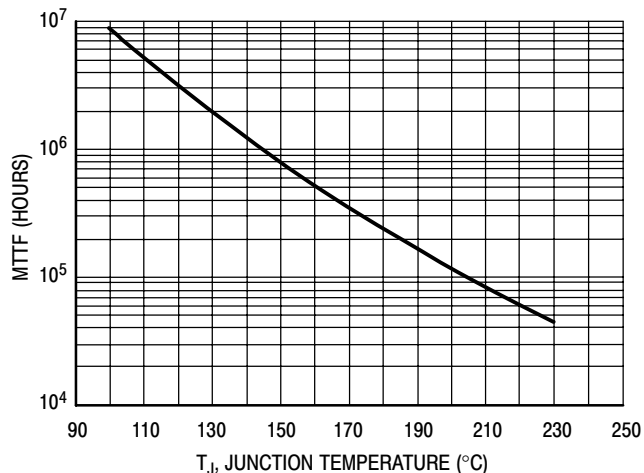


Figure 5. Power Gain and Drain Efficiency versus CW Output Power as a Function of Total  $I_{DQ}$

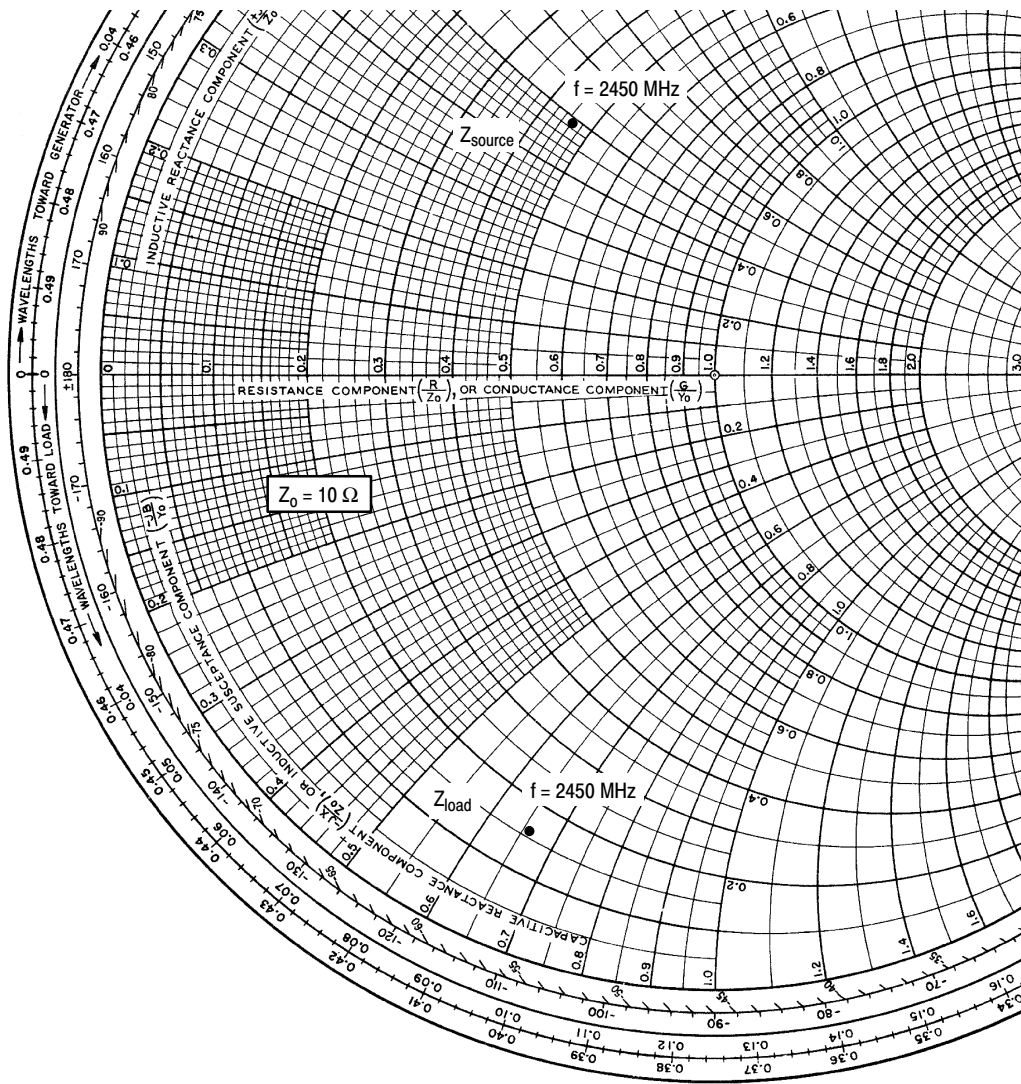


This above graph displays calculated MTTF in hours when the device is operated at  $V_{DD} = 28\text{ Vdc}$ ,  $P_{out} = 140\text{ W CW}$ , and  $\eta_D = 45\%$ .

MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.

Figure 6. MTTF versus Junction Temperature

MRF6S24140HR3 MRF6S24140HSR3



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1200 \text{ mA}$ ,  $P_{out} = 140 \text{ W CW}$

f MHz	$Z_{source}$ Ω	$Z_{load}$ Ω
2450	$4.55 + j4.9$	$1.64 - j6.57$

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

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

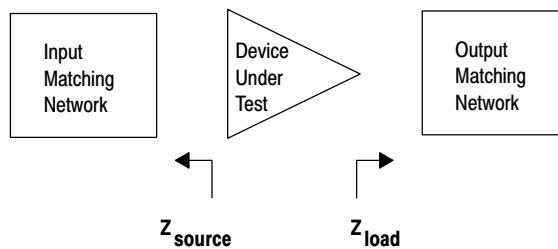
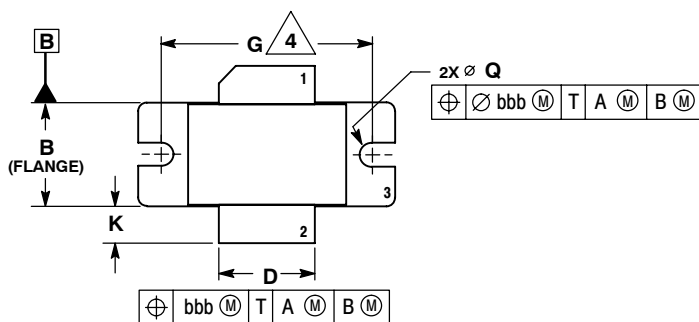


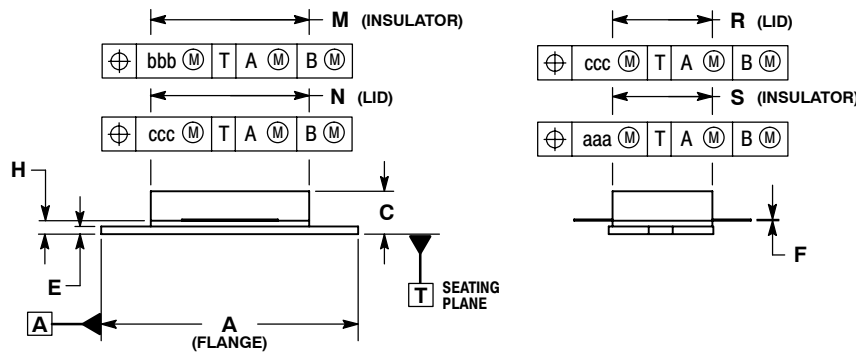
Figure 7. Series Equivalent Source and Load Impedance

## PACKAGE DIMENSIONS



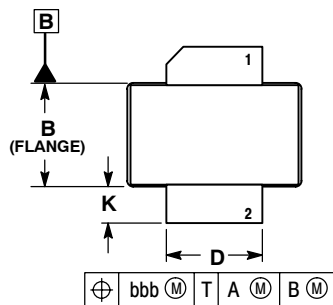
- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
  2. CONTROLLING DIMENSION: INCH.
  3. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.
  4. RECOMMENDED BOLT CENTER DIMENSION OF 1.16 (29.57) BASED ON M3 SCREW.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.335	1.345	33.91	34.16
B	0.535	0.545	13.6	13.8
C	0.147	0.200	3.73	5.08
D	0.495	0.505	12.57	12.83
E	0.035	0.045	0.89	1.14
F	0.003	0.006	0.08	0.15
G	1.100 BSC		27.94 BSC	
H	0.057	0.067	1.45	1.70
K	0.175	0.205	4.44	5.21
M	0.872	0.888	22.15	22.55
N	0.871	0.889	19.30	22.60
Q	Ø 0.118	Ø 0.138	Ø 3.00	Ø 3.51
R	0.515	0.525	13.10	13.30
S	0.515	0.525	13.10	13.30
aaa	0.007 REF		0.178 REF	
bbb	0.010 REF		0.254 REF	
ccc	0.015 REF		0.381 REF	



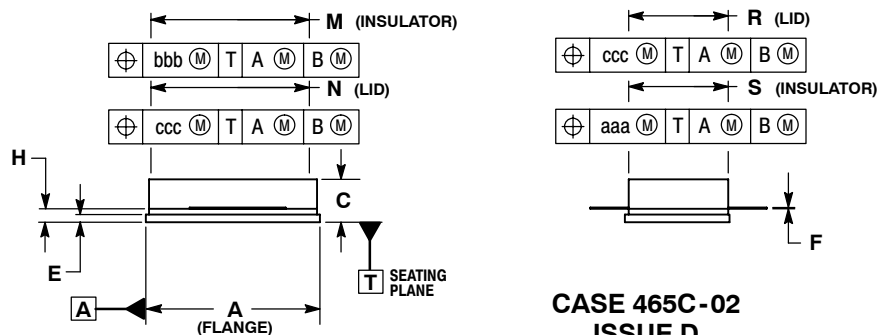
**CASE 465B-03  
ISSUE D  
NI-880  
MRF6S24140HR3**

- STYLE 1:  
PIN 1. DRAIN  
2. GATE  
3. SOURCE



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
  2. CONTROLLING DIMENSION: INCH.
  3. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.905	0.915	22.99	23.24
B	0.535	0.545	13.60	13.80
C	0.147	0.200	3.73	5.08
D	0.495	0.505	12.57	12.83
E	0.035	0.045	0.89	1.14
F	0.003	0.006	0.08	0.15
H	0.057	0.067	1.45	1.70
K	0.170	0.210	4.32	5.33
M	0.872	0.888	22.15	22.55
N	0.871	0.889	19.30	22.60
R	0.515	0.525	13.10	13.30
S	0.515	0.525	13.10	13.30
aaa	0.007 REF		0.178 REF	
bbb	0.010 REF		0.254 REF	
ccc	0.015 REF		0.381 REF	



**CASE 465C-02  
ISSUE D  
NI-880S  
MRF6S24140HSR3**

- STYLE 1:  
PIN 1. DRAIN  
2. GATE  
3. SOURCE

## PRODUCT DOCUMENTATION

Refer to the following documents to aid your design process.

### Application Notes

- AN1955: Thermal Measurement Methodology of RF Power Amplifiers

### Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

## REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	Mar. 2007	<ul style="list-style-type: none"><li>• Initial Release of Data Sheet</li></ul>
1	Apr. 2008	<ul style="list-style-type: none"><li>• Operating Junction Temperature increased from 200°C to 225°C in Maximum Ratings table and related "Continuous use at maximum temperature will affect MTTF" footnote added, p. 1</li><li>• Corrected <math>V_{DS}</math> to <math>V_{DD}</math> in the RF test condition voltage callout for <math>V_{GS(Q)}</math>, and added "Measured in Functional Test", On Characteristics table, p. 2</li><li>• Updated PCB information to show more specific material details, Fig. 1, Test Circuit Schematic, p. 3</li></ul>
2	Feb. 2009	<ul style="list-style-type: none"><li>• Modified data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN13232, p. 2</li></ul>



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