

# 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
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

**MRF6S24140HR3**  
**MRF6S24140HSR3**

**2450 MHz, 140 W, 28 V  
CW  
LATERAL N-CHANNEL  
RF POWER MOSFETs**

**CASE 465B-04  
NI-880  
MRF6S24140HR3**

**CASE 465C-03  
NI-880S  
MRF6S24140HSR3**

**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 Case Temperature 82°C, 140 W CW Case Temperature 75°C, 28 W CW	$R_{\theta JC}$	0.29 0.33	°C/W

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
Machine Model (per EIA/JESD22-A115)	A
Charge Device Model (per JESD22-C101)	IV

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

Characteristic	Symbol	Min	Typ	Max	Unit
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**Off Characteristics**

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	$\text{nAdc}$

**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

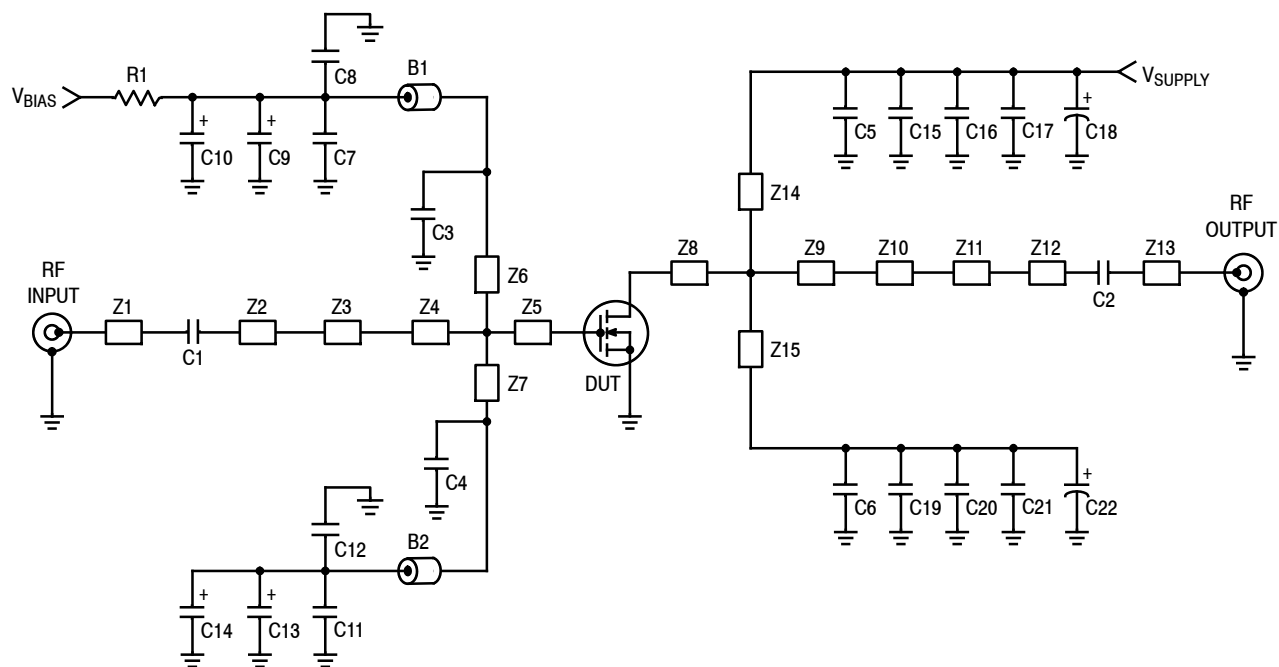
**Dynamic Characteristics** <sup>(1)</sup>

Reverse Transfer Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\ \text{mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{rss}$	—	2	—	$\text{pF}$
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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.

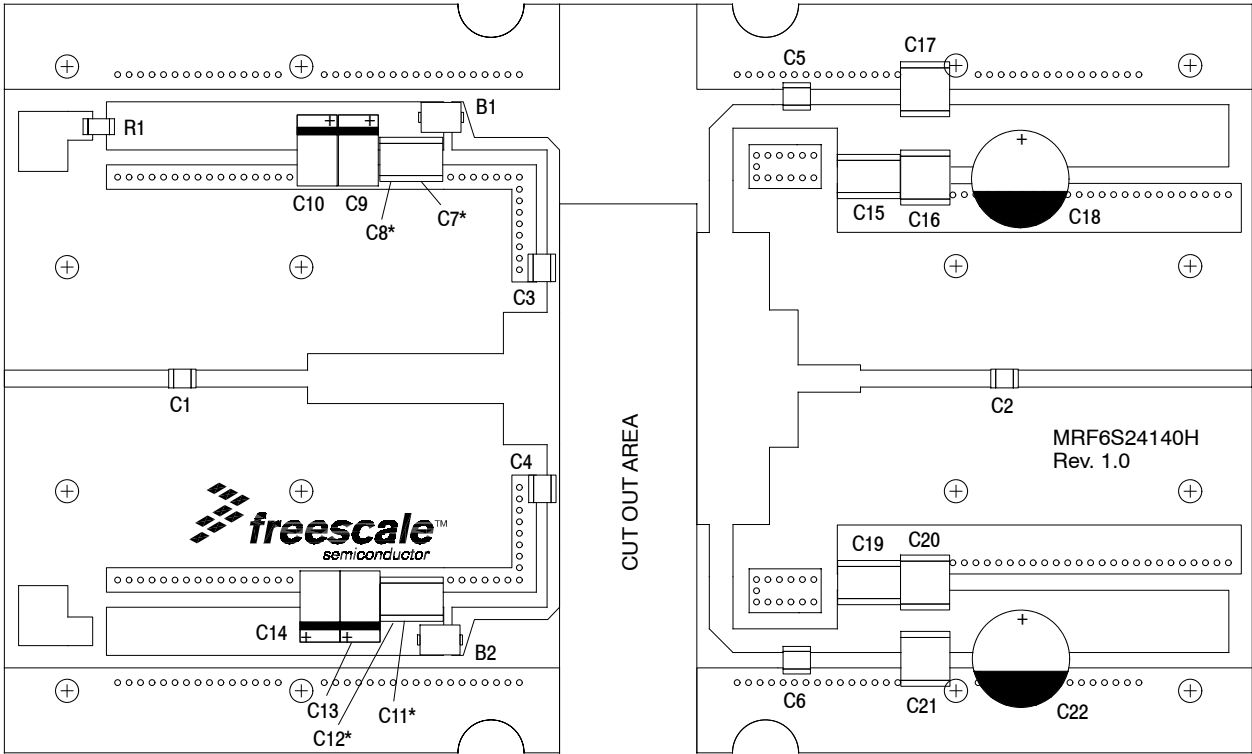


Z1	0.678" x 0.068" Microstrip	Z9	0.193" x 1.170" Microstrip
Z2	0.466" x 0.068" Microstrip	Z10	0.115" x 0.550" Microstrip
Z3	0.785" x 0.200" Microstrip	Z11	0.250" x 0.110" Microstrip
Z4	0.200" x 0.530" Microstrip	Z12	0.538" x 0.068" Microstrip
Z5	0.025" x 0.530" Microstrip	Z13	0.957" x 0.068" Microstrip
Z6, Z7	0.178" x 0.050" Microstrip	Z14, Z15	0.673" x 0.095" Microstrip
Z8	0.097" x 1.170" Microstrip	PCB	Taconic RF-35, 0.030", $\epsilon_r = 3.5$

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

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

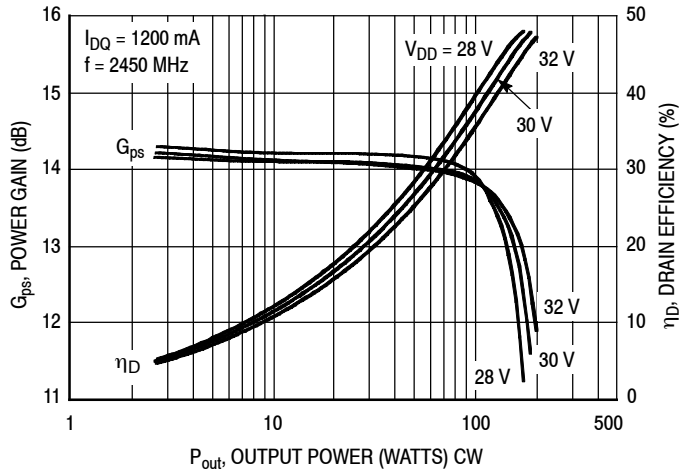
Part	Description	Part Number	Manufacturer
B1, B2	47 $\Omega$ , 100 MHz Short Ferrite Beads, Surface Mount	2743019447	Fair-Rite
C1, C2, C3, C4, C5, C6	5.6 pF Chip Capacitors	ATC600B5R6BT500XT	ATC
C7, C11	0.01 $\mu$ F, 100 V Chip Capacitors	C1825C103J1RAC	Kemet
C8, C12, C15, C19	2.2 $\mu$ F, 50 V Chip 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



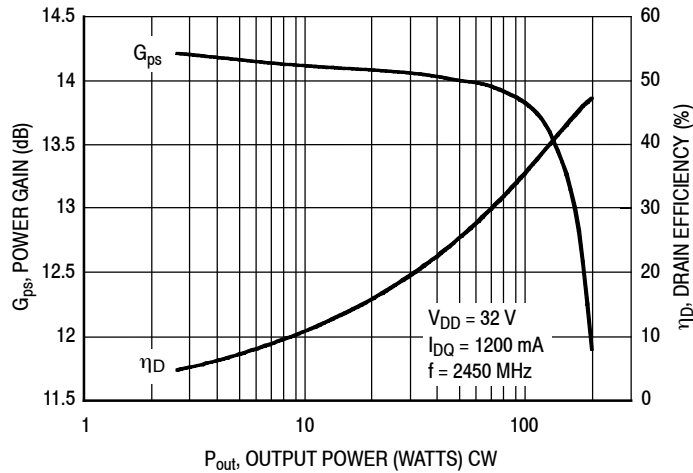
\* Stacked

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

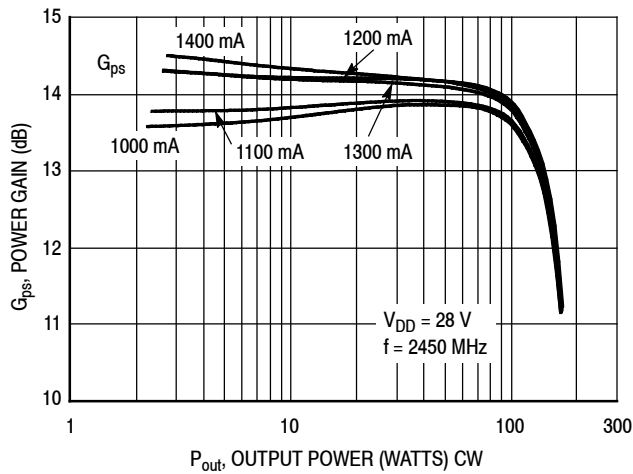
### TYPICAL CHARACTERISTICS — 2450 MHz



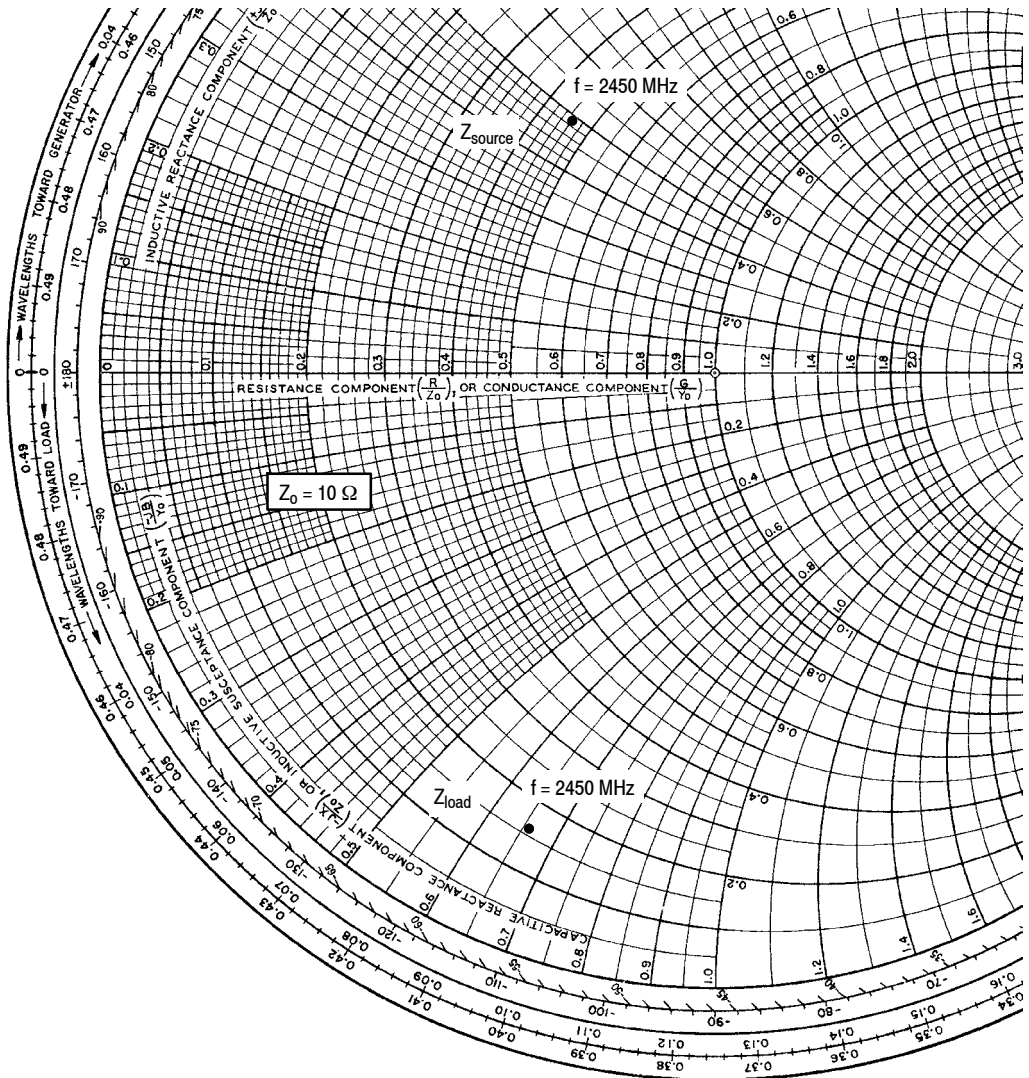
**Figure 3. Power Gain and Drain Efficiency versus CW Output Power as a Function of  $V_{DD}$**



**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  $I_{DQ}$**



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

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
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.

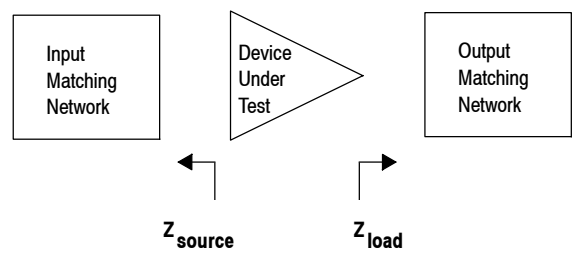
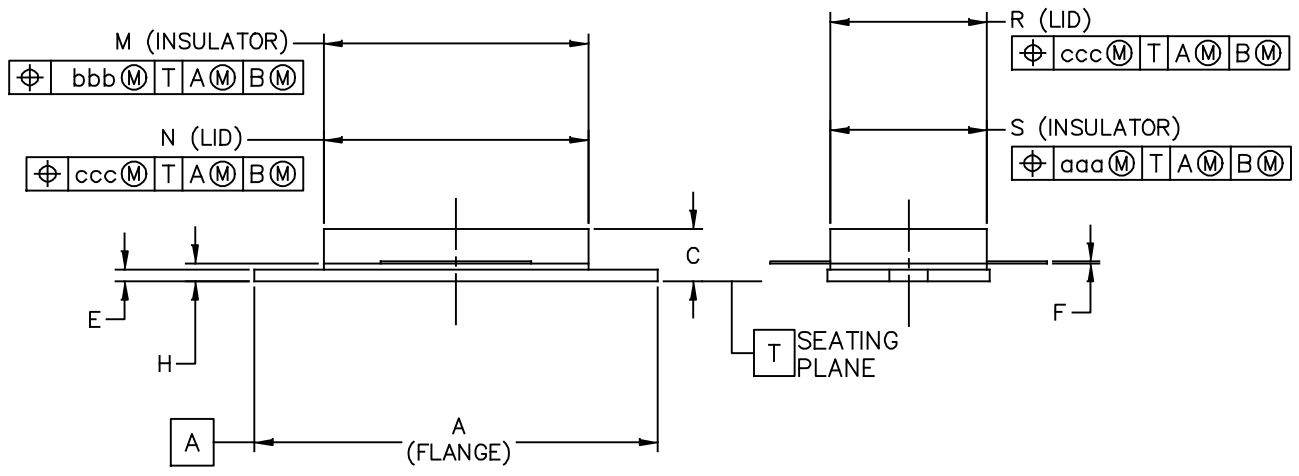
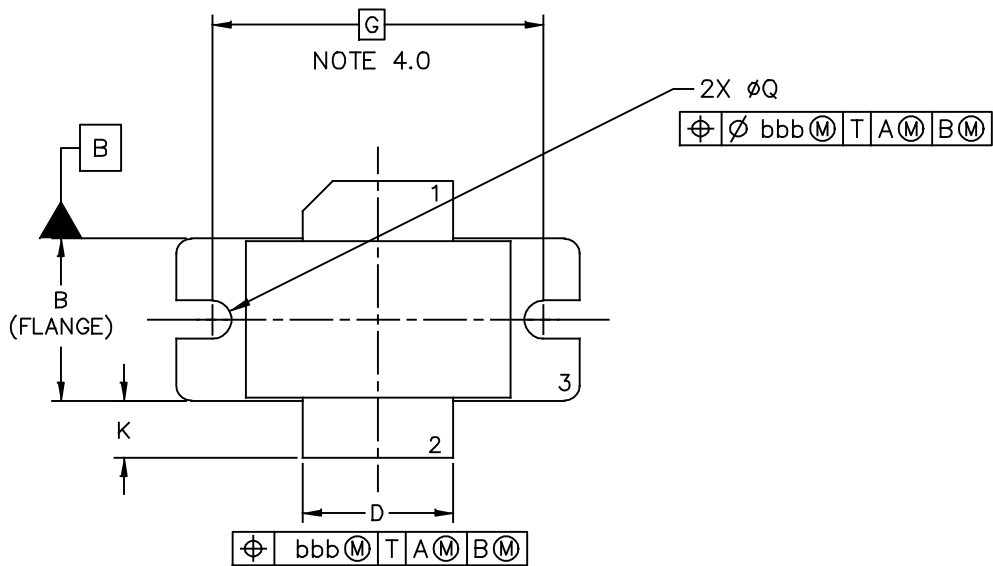


Figure 6. Series Equivalent Source and Load Impedance

### PACKAGE DIMENSIONS



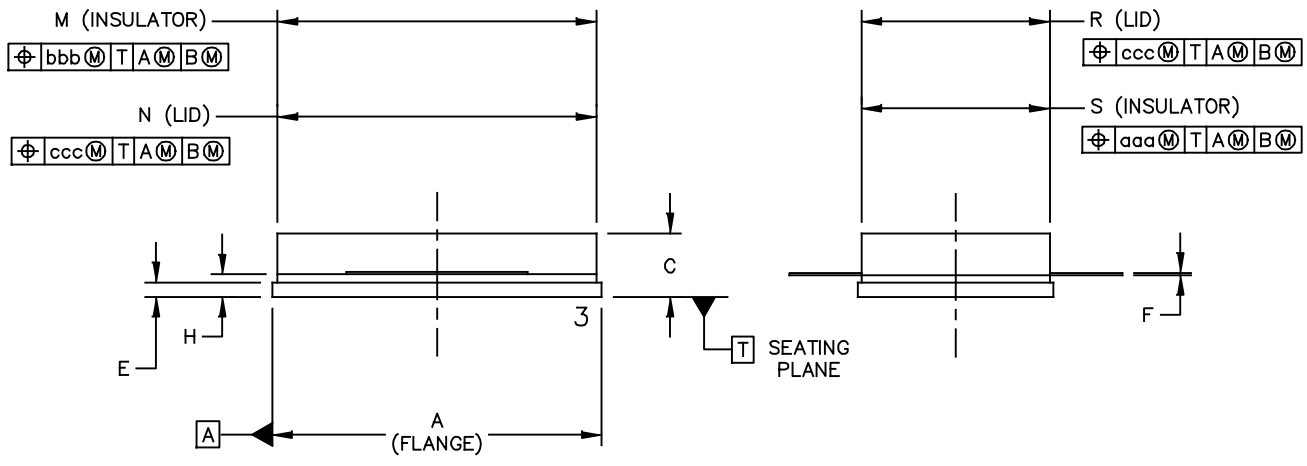
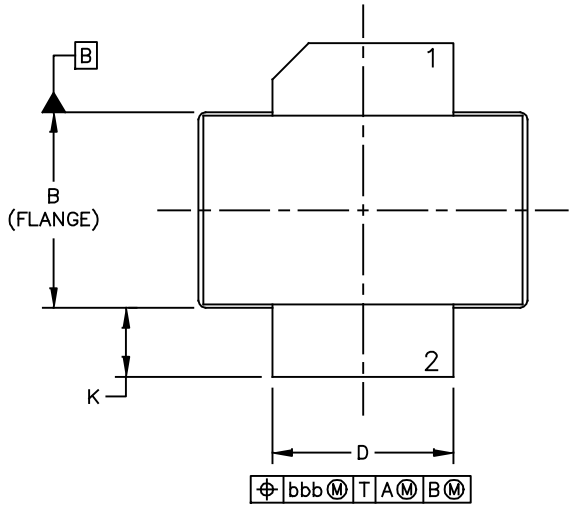
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NOTES:

- 1.0 DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
- 2.0 CONTROLLING DIMENSION: INCH.
- 3.0 DIMENSION H IS MEASURED .030 (0.762) AWAY FROM PACKAGE BODY.
- 4.0 RECOMMENDED BOLT CENTER DIMENSION OF 1.16 (29.57) BASED ON M3 SCREW.

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	1.335	1.345	33.91	34.16	R	.515	– .525	13.08	– 13.34
B	.535	.545	13.59	13.84	S	.515	– .525	13.08	– 13.34
C	.147	.200	3.73	5.08	aaa	–	.007 –	–	0.178 –
D	.495	.505	12.57	12.83	bbb	–	.010 –	–	0.254 –
E	.035	.045	0.89	1.14	ccc	–	.015 –	–	0.381 –
F	.003	.006	0.08	0.15	–	–	– –	–	– –
G	1.100 BSC		27.94 BSC		–	–	– –	–	– –
H	.057	.067	1.45	1.70	–	–	– –	–	– –
K	.175	.205	4.45	5.21	–	–	– –	–	– –
M	.872	.888	22.15	22.56	–	–	– –	–	– –
N	.871	.889	22.12	22.58	–	–	– –	–	– –
Q	∅.118	∅.138	∅3.00	∅3.51	–	–	– –	–	– –
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NOTES:

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2. CONTROLLING DIMENSION: INCH.
3. DIMENSION H IS MEASURED .030 (0.762) AWAY FROM PACKAGE BODY.

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.905	– .915	22.99	– 23.24	aaa	– .007	–	– 0.178	–
B	.535	– .545	13.59	– 13.84	bbb	– .010	–	– 0.254	–
C	.147	– .200	3.73	– 5.08	ccc	– .015	–	– 0.381	–
D	.495	– .505	12.57	– 12.83	–	–	–	–	–
E	.035	– .045	0.89	– 1.14	–	–	–	–	–
F	.003	– .006	0.08	– 0.15	–	–	–	–	–
H	.057	.067	1.45	1.70	–	–	–	–	–
K	.170	– .210	4.32	– 5.33	–	–	–	–	–
M	.872	– .888	22.15	– 22.56	–	–	–	–	–
N	.871	– .889	22.12	– 22.58	–	–	–	–	–
R	.515	– .525	13.08	– 13.34	–	–	–	–	–
S	.515	– .525	13.08	– 13.34	–	–	–	–	–

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		CASE NUMBER: 465C-03		26 MAY 2011	
		STANDARD: NON-JEDEC			

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

**Software**

- Electromigration MTTF Calculator
- RF High Power Model

For Software and Tools, do a Part Number search at <http://www.freescale.com>, and select the “Part Number” link. Go to the Software & Tools tab on the part’s Product Summary page to download the respective tool.

**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>
3	Mar. 2010	<ul style="list-style-type: none"> <li>• Fig. 1, Test Circuit Schematic, Z-list, corrected PCB information to reflect Taconic as manufacturer, p. 3</li> <li>• Fig. 4, Power Gain and Drain Efficiency versus CW Output Power, corrected 28 V to read 32 V, p. 5</li> <li>• Added Electromigration MTTF Calculator and RF High Power Model availability to Product Software, p. 8</li> </ul>
4	Feb. 2012	<ul style="list-style-type: none"> <li>• Table 3, ESD Protection Characteristics, removed the word “Minimum” after the ESD class rating. ESD ratings are characterized during new product development but are not 100% tested during production. ESD ratings provided in the data sheet are intended to be used as a guideline when handling ESD sensitive devices, p. 2.</li> <li>• Fig. 6, MTTF versus Junction Temperature removed, p. 5. Refer to the device’s MTTF Calculator available at <a href="http://www.freescale.com/RFpower">freescale.com/RFpower</a>. Go to Design Resources &gt; Software and Tools.</li> <li>• Replaced Case Outline 465B-03, Issue D, with 465B-04, Issue F, p. 1, 7-8. Deleted Style 1 pin note on Sheet 2. On Sheet 2, changed dimension B in mm from 13.6-13.8 to 13.59-13.84, changed dimension H in mm from 1.45-1.7 to 1.45-1.70, changed dimension K in mm from 4.44-5.21 to 4.45-5.21, changed dimension M in mm from 22.15-22.55 to 22.15-22.56, changed dimension N in mm from 19.3-22.6 to 22.12-22.58, changed dimension Q in mm from 3-3.51 to 3.00-3.51, changed dimension R and S in mm from 13.1-13.3 to 13.08-13.34.</li> <li>• Replaced Case Outline 465C-02, Issue D, with 465C-03, Issue E, p. 1, 9-10. Deleted Style 1 pin note on Sheet 2. On Sheet 2, changed dimension B in mm from 13.6-13.8 to 13.59-13.84, changed dimension H in mm from 1.45-1.7 to 1.45-1.70, changed dimension M in mm from 22.15-22.55 to 22.15-22.56, changed dimension N in mm from 19.3-22.6 to 22.12-22.58, changed dimension R and S in mm from 13.1-13.3 to 13.08-13.34.</li> </ul>

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