

# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed for W-CDMA base station applications with frequencies from 2110 to 2170 MHz. Suitable for TDMA, CDMA and multicarrier amplifier applications. To be used in Class AB for PCN - PCS/cellular radio and WLL applications.

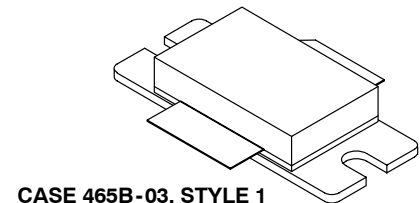
- Typical 2-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 1300$  mA,  $P_{out} = 33$  Watts Avg., Full Frequency Band, Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.  
Power Gain — 12.5 dB  
Efficiency — 25%  
IM3 @ 10 MHz Offset — -37 dBc in 3.84 MHz Channel Bandwidth  
ACPR @ 5 MHz Offset — -39 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 28 Vdc, 2140 MHz, 125 Watts CW Output Power

### Features

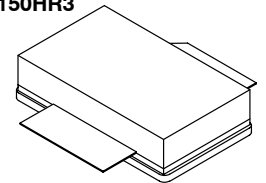
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 32  $V_{DD}$  Operation
- Integrated ESD Protection
- Lower Thermal Resistance Package
- Low Gold Plating Thickness on Leads, 40 $\mu$ m Nominal.
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

**MRF5S21150HR3**  
**MRF5S21150HSR3**

**2110-2170 MHz, 33 W AVG., 28 V**  
**2 x W-CDMA**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**



**CASE 465B-03, STYLE 1**  
**NI-880**  
**MRF5S21150HR3**



**CASE 465C-02, STYLE 1**  
**NI-880S**  
**MRF5S21150HSR3**

**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5, +65	Vdc
Gate-Source Voltage	$V_{GS}$	-0.5, +15	Vdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25 $^\circ\text{C}$	$P_D$	380 2.2	W W/ $^\circ\text{C}$
Storage Temperature Range	$T_{stg}$	- 65 to +150	$^\circ\text{C}$
Case Operating Temperature	$T_C$	150	$^\circ\text{C}$
Operating Junction Temperature	$T_J$	200	$^\circ\text{C}$
CW Operation @ $T_C = 25^\circ\text{C}$ Derate above 25 $^\circ\text{C}$	CW	150 0.84	W W/ $^\circ\text{C}$

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (1,2)	Unit
Thermal Resistance, Junction to Case Case Temperature 80 $^\circ\text{C}$ , 100 W CW Case Temperature 75 $^\circ\text{C}$ , 33 W CW	$R_{\theta JC}$	0.46 0.47	$^\circ\text{C}/\text{W}$

1. MTTF calculator available at <http://www.freescale.com/rtf>. 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/rtf>. Select Documentation/Application Notes - AN1955.

**Table 3. ESD Protection Characteristics**

Test Conditions	Class
Human Body Model	1 (Minimum)
Machine Model	M3 (Minimum)
Charge Device Model	C7 (Minimum)

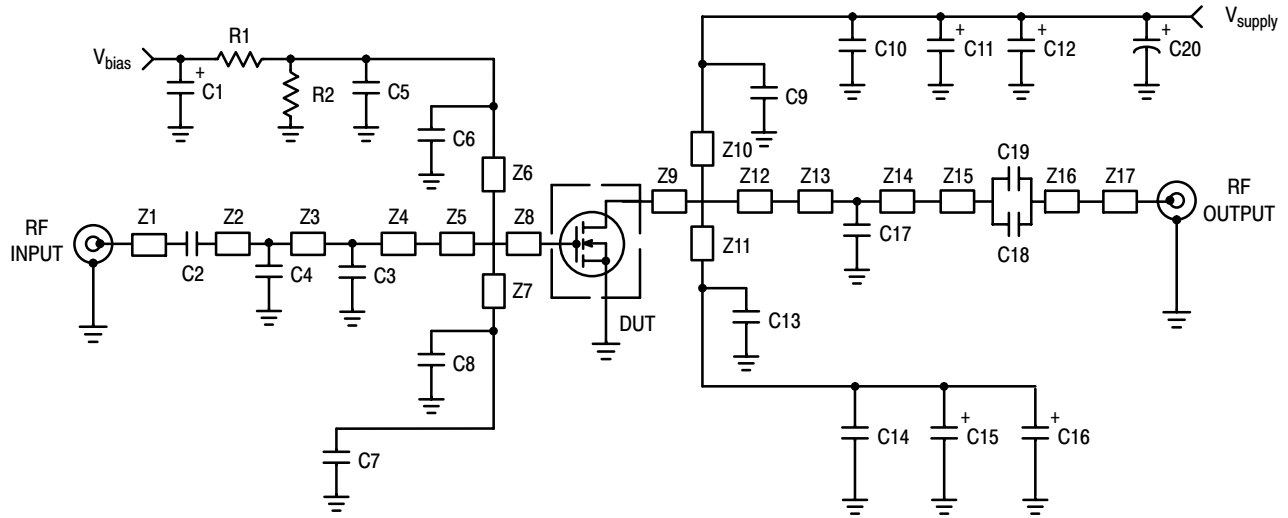
**Table 4. Electrical Characteristics** ( $T_C = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Off Characteristics</b>					
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 65\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	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 ( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )	$I_{GSS}$	—	—	1	$\mu\text{Adc}$
<b>On Characteristics</b>					
Gate Threshold Voltage ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 360\ \mu\text{Adc}$ )	$V_{GS(th)}$	2.5	—	3.5	Vdc
Gate Quiescent Voltage ( $V_{DS} = 28\text{ Vdc}$ , $I_D = 1300\ \text{mAdc}$ )	$V_{GS(Q)}$	—	3.7	—	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 3.6\ \text{Adc}$ )	$V_{DS(on)}$	—	0.26	0.3	Vdc
Forward Transconductance ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 3.6\ \text{Adc}$ )	$g_{fs}$	—	9	—	S
<b>Dynamic Characteristics</b> <sup>(1)</sup>					
Reverse Transfer Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\ \text{mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{rSS}$	—	3.2	—	pF

**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1300\ \text{mA}$ ,  $P_{out} = 33\ \text{W Avg.}$ ,  $f_1 = 2112.5\ \text{MHz}$ ,  $f_2 = 2122.5\ \text{MHz}$  and  $f_1 = 2157.5\ \text{MHz}$ ,  $f_2 = 2167.5\ \text{MHz}$ , 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. PAR = 8.5 dB @ 0.01% Probability on CCDF.

Power Gain	$G_{ps}$	11	12.5	—	dB
Drain Efficiency	$\eta_D$	23	25	—	%
Intermodulation Distortion	IM3	—	-37	-35	dBc
Adjacent Channel Power Ratio	ACPR	—	-39	-37	dBc
Input Return Loss	IRL	—	-12	-9	dB

1. Part internally matched both on input and output.

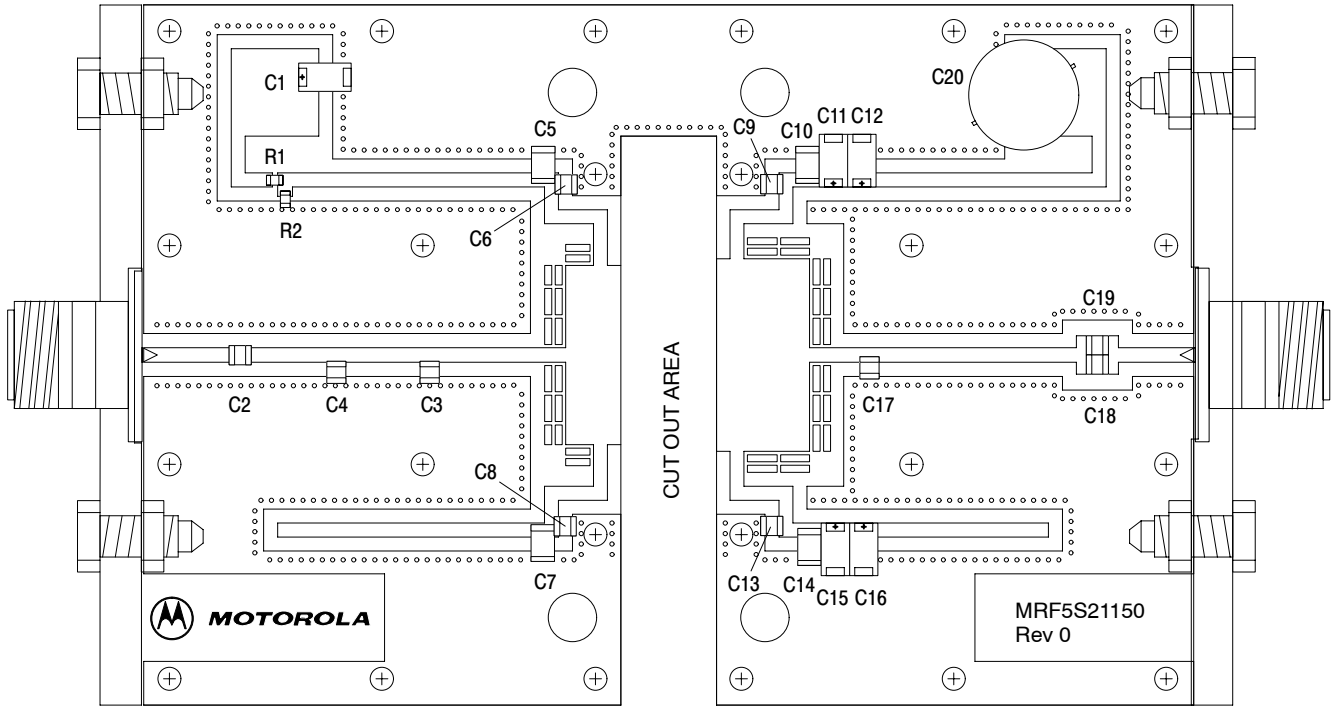


Z1	0.500" x 0.083" Microstrip	Z10, Z11	0.709" x 0.083" Microstrip
Z2	0.505" x 0.083" Microstrip	Z12	0.415" x 1.100" Microstrip
Z3	0.536" x 0.083" Microstrip	Z13	0.874" x 0.083" Microstrip
Z4	0.776" x 0.083" Microstrip	Z14	1.182" x 0.083" Microstrip
Z5	0.119" x 1.024" Microstrip	Z15, Z16	0.070" x 0.220" Microstrip
Z6, Z7	0.749" x 0.083" Microstrip	Z17	0.430" x 0.083" Microstrip
Z8	0.117" x 1.024" Microstrip	PCB	Taconic TLX8, 0.030", $\epsilon_r = 2.55$
Z9	0.117" x 1.100" Microstrip		

**Figure 1. MRF5S21150HR3(HSR3) Test Circuit Schematic**

**Table 5. MRF5S21150HR3(HSR3) Test Circuit Component Designations and Values**

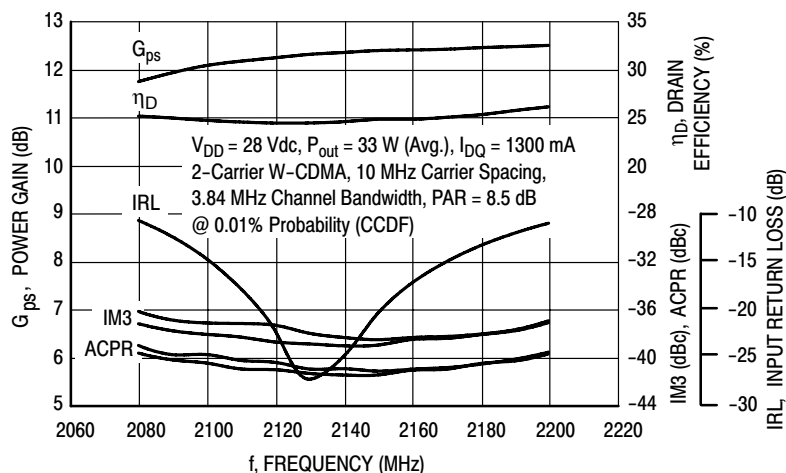
Part	Description	Part Number	Manufacturer
C1	22 $\mu$ F, 35 V Tantalum Capacitor	TAJE226M035R	AVX
C2, C6, C8, C9, C13, C18, C19	6.8 pF 100B Chip Capacitors	100B6R8CW	ATC
C3, C4	1.8 pF 100B Chip Capacitors	100B1R8BW	ATC
C5, C7, C10, C14	220 nF Chip Capacitors (1812)	1812Y224KXA	Vishay - Vitramon
C11, C12, C15, C16	10 $\mu$ F, 35 V Tantalum Capacitors	293D1106X9035D	Vishay - Sprague
C17	0.3 pF Chip Capacitor	100B0R3BW	ATC
C20	470 $\mu$ F, 63 V Electrolytic Capacitor, Radial	13661471	Philips
R1, R2	10 k $\Omega$ , 1/4 W Chip Resistors		



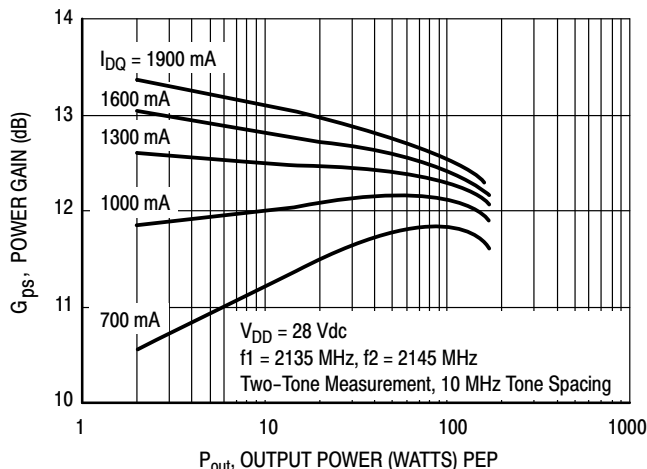
Freescale has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescale Semiconductor signature/logo. PCBs may have either Motorola or Freescale markings during the transition period. These changes will have no impact on form, fit or function of the current product.

**Figure 2. MRF5S21150HR3(HSR3) Test Circuit Component Layout**

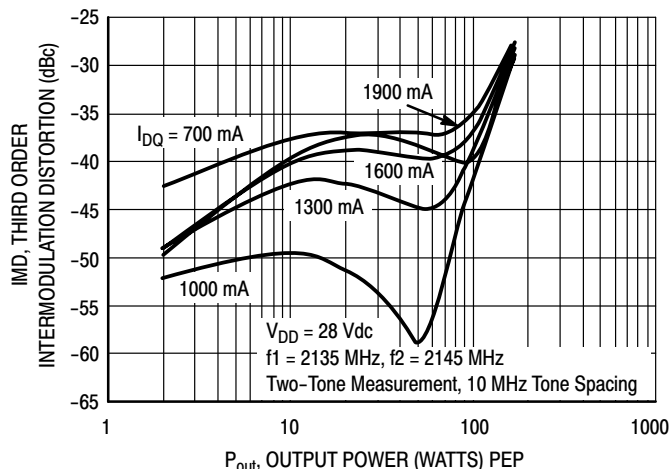
## TYPICAL CHARACTERISTICS



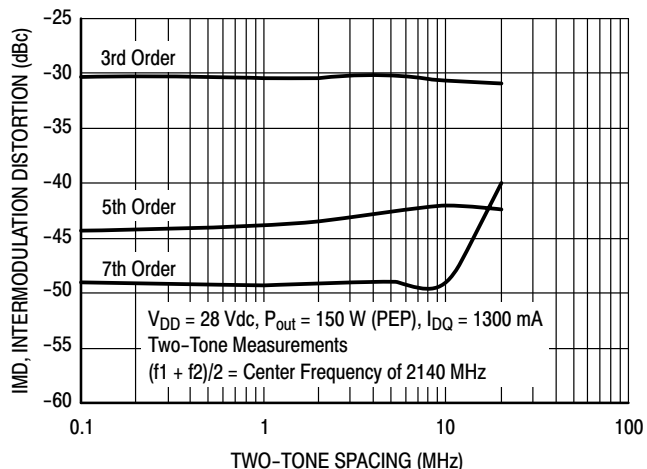
**Figure 3. 2-Carrier W-CDMA Broadband Performance @  $P_{out} = 33$  Watts Avg.**



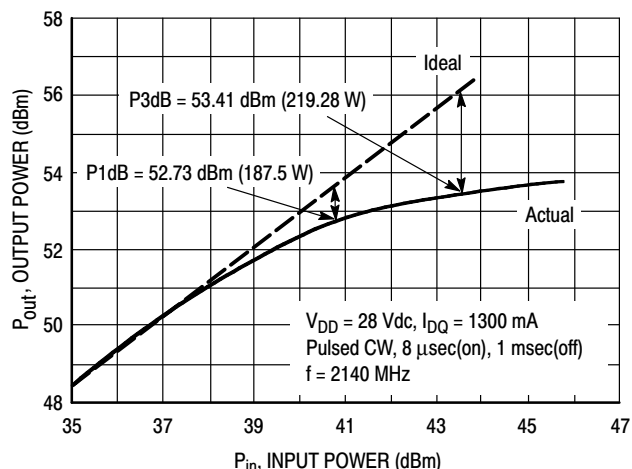
**Figure 4. Two-Tone Power Gain versus Output Power**



**Figure 5. Third Order Intermodulation Distortion versus Output Power**



**Figure 6. Intermodulation Distortion Products versus Tone Spacing**

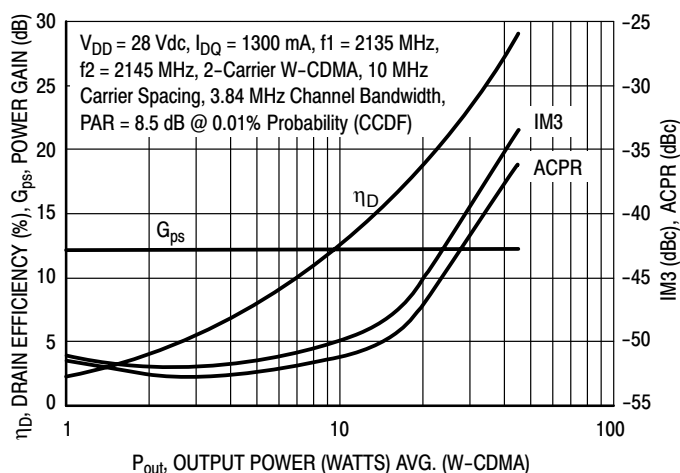


**Figure 7. Pulse CW Output Power versus Input Power**

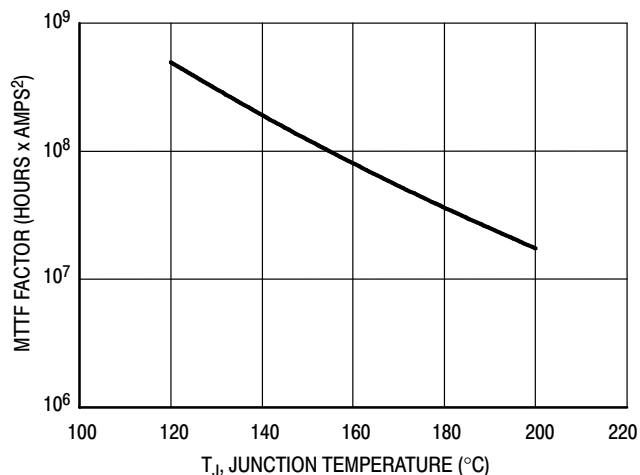
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## TYPICAL CHARACTERISTICS



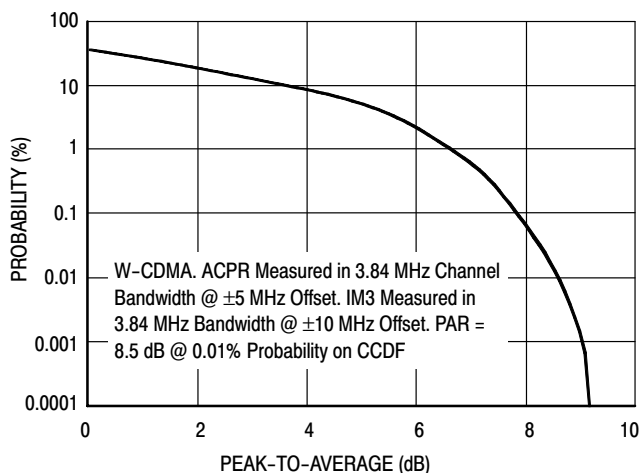
**Figure 8. 2-Carrier W-CDMA ACPR, IM3, Power Gain and Drain Efficiency versus Output Power**



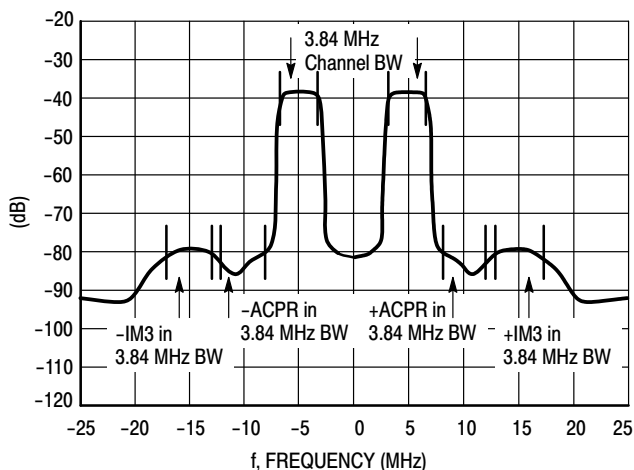
This above graph displays calculated MTTF in hours x ampere<sup>2</sup> drain current. Life tests at elevated temperatures have correlated to better than  $\pm 10\%$  of the theoretical prediction for metal failure. Divide MTTF factor by  $I_D^2$  for MTTF in a particular application.

**Figure 9. MTTF Factor versus Junction Temperature**

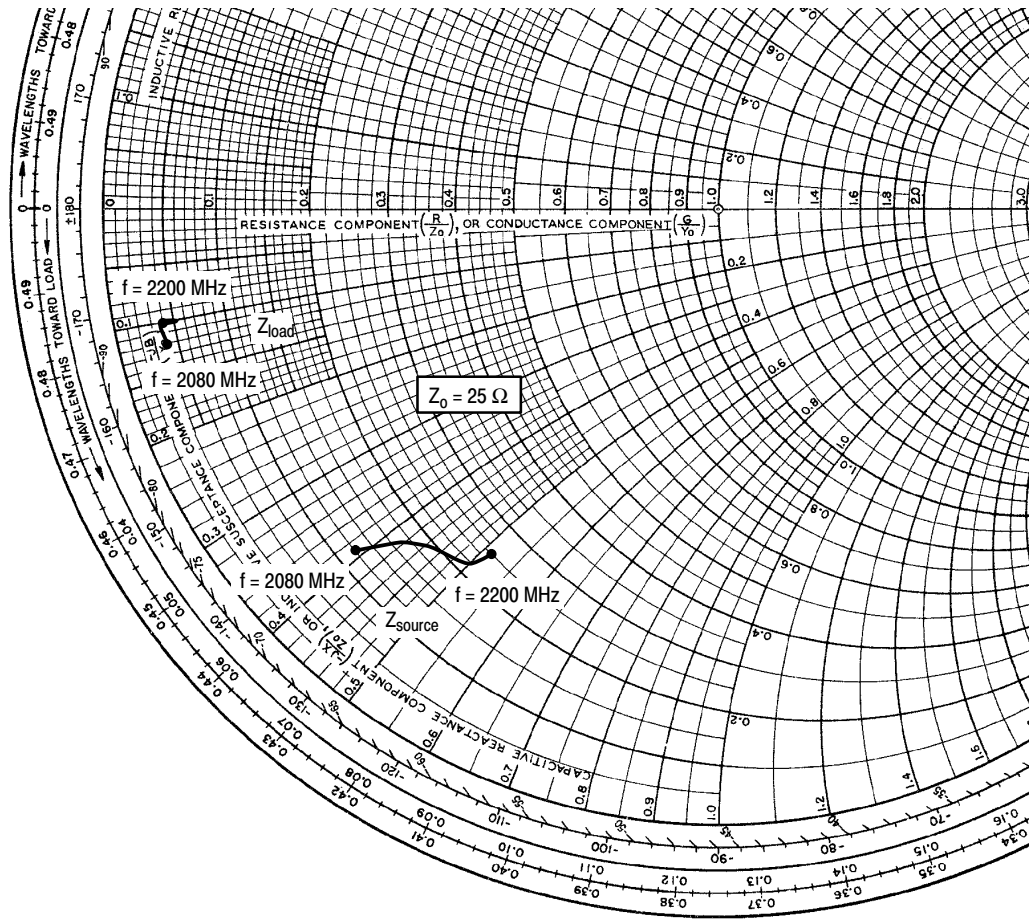
## W-CDMA TEST SIGNAL



**Figure 10. CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 67% Clipping, Single-Carrier Test Signal**



**Figure 11. 2-Carrier W-CDMA Spectrum**



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1300 \text{ mA}$ ,  $P_{out} = 33 \text{ W Avg.}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
2080	$3.05 - j9.66$	$1.02 - j2.94$
2110	$3.97 - j10.31$	$1.09 - j2.51$
2140	$4.70 - j11.03$	$1.16 - j2.46$
2170	$5.45 - j12.41$	$1.16 - j2.58$
2200	$6.18 - j13.04$	$1.02 - j2.55$

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

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

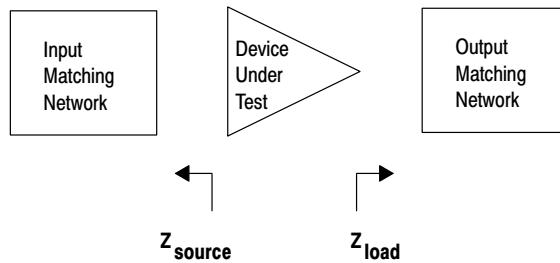


Figure 12. Series Equivalent Source and Load Impedance

# NOTES

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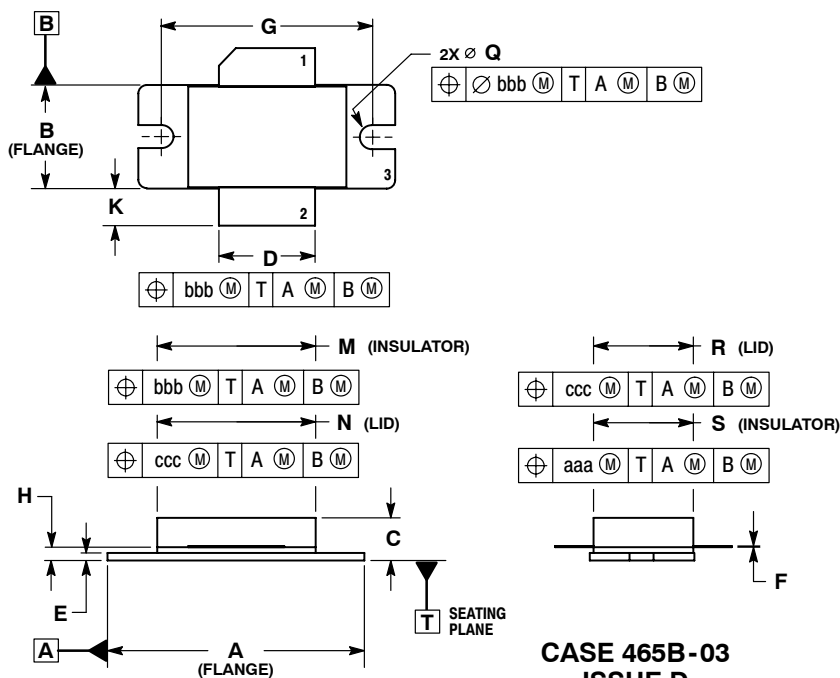
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## PACKAGE DIMENSIONS

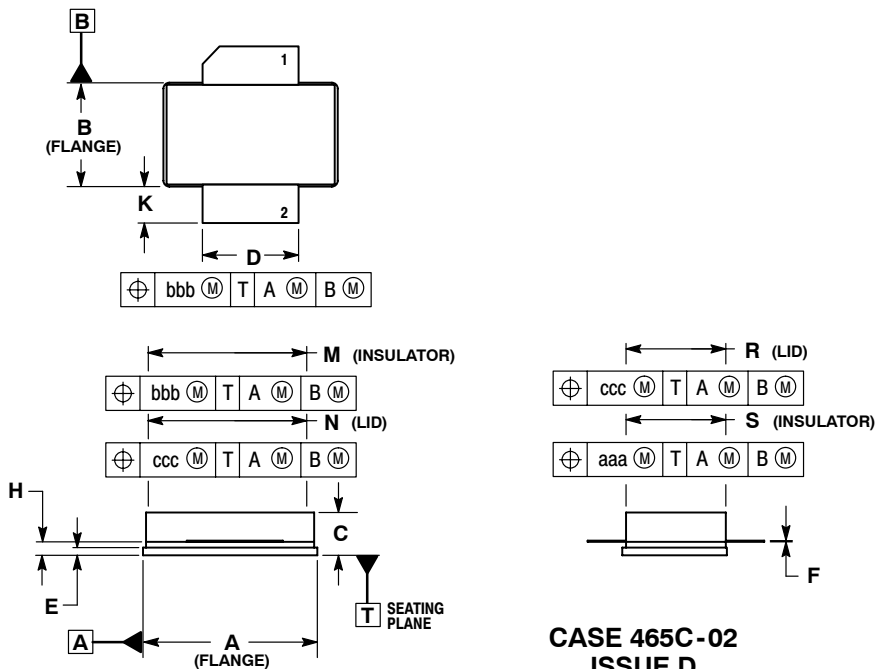


**CASE 465B-03  
ISSUE D  
NI-880  
MRF5S21150HR3**

- 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. DELETED

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	0.170	0.210	4.32	5.33
M	0.872	0.888	22.15	22.55
N	0.871	0.889	19.30	22.60
Q	$\varnothing$ 0.118	$\varnothing$ 0.138	$\varnothing$ 3.00	$\varnothing$ 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	

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



**CASE 465C-02  
ISSUE D  
NI-880S  
MRF5S21150HSR3**

- 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	

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

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**Japan:**  
Freescale Semiconductor Japan Ltd.  
Headquarters  
ARCO Tower 15F  
1-8-1, Shimo-Meguro, Meguro-ku,  
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Japan  
0120 191014 or +81 3 5437 9125  
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