Freescale Semiconductor, Inc.

The RF MOSFET Line
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 for V_{DD} = 28 Volts, I_{DQ} = 1300 mA, f1 = 2135 MHz, f2 = 2145 MHz, Channel Bandwidth = 3.84 MHz, Adjacent Channels Measured over 3.84 MHz BW @ f1 -5 MHz and f2 +5 MHz, Distortion Products Measured over a 3.84 MHz BW @ f1 -10 MHz and f2 +10 MHz, Peak/Avg. = 8.5 dB @ 0.01% Probability on CCDF.

     Output Power — 33 Watts Avg.
   Power Gain — 12.5 dB
     Efficiency — 25%
   IM3 — -37 dBc
     ACPR — -39 dBc
- Internally Matched, Controlled Q, for Ease of Use
- High Gain, High Efficiency and High Linearity
- Integrated ESD Protection
- Designed for Maximum Gain and Insertion Phase Flatness
- Capable of Handling 10:1 VSWR, @ 28 Vdc, 2140 MHz, 125 Watts CW Output Power
- Excellent Thermal Stability
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Qualified Up to a Maximum of 32 V_{DD} Operation
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

MRF5S21150R3
MRF5S21150SR3

**2170 MHz, 33 W AVG.,
2 x W-CDMA, 28 V
LATERAL N-CHANNEL
RF POWER MOSFETs**
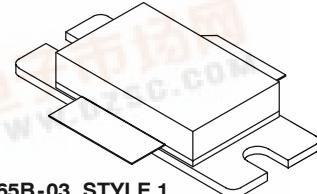
**CASE 465B-03, STYLE 1
NI-880
MRF5S21150R3**
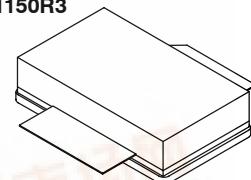
**CASE 465C-02, STYLE 1
NI-880S
MRF5S21150SR3**

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	65	Vdc
Gate-Source Voltage	V_{GS}	-0.5, +15	Vdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	367 2.1	Watts W/°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Operating Junction Temperature	T_J	200	°C
CW Operation	CW	125	Watts

THERMAL CHARACTERISTICS

Characteristic	Symbol	Value (1)(2)	Unit

Thermal Resistance, Junction to Case
  Case Temperature 80°C, 125 W CW
  Case Temperature 80°C, 33 W CW
	$R_{\theta JC}$	
		0.47
		0.53
			°C/W

(1) MTTF calculator available at http://www.motorola.com/semiconductors/rf. Select Tools/Software/Application Software/Calculators to access the MTTF calculators by product.

(2) Refer to AN1955/D, *Thermal Measurement Methodology of RF Power Amplifiers.* Go to http://www.motorola.com/semiconductors/rf. Select Documentation/Application Notes - AN1955.

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

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ESD PROTECTION CHARACTERISTICS

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

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Zero Gate Voltage Drain Leakage Current (V_{DS} = 65 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	10	µAdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 28 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	1	µAdc
Gate-Source Leakage Current (V_{GS} = 5 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	1	µAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 360 µAdc)	$V_{GS(th)}$	2.5	—	3.5	Vdc
Gate Quiescent Voltage (V_{DS} = 28 Vdc, I_D = 1300 mAdc)	$V_{GS(Q)}$	—	3.7	—	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 3.6 Adc)	$V_{DS(on)}$	—	0.26	0.3	Vdc
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 3.6 Adc)	g_{fs}	—	9	—	S
DYNAMIC CHARACTERISTICS (1)					
Reverse Transfer Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	3.2	—	pF

FUNCTIONAL TESTS (In Motorola Test Fixture, 50 ohm system) 2-carrier W-CDMA, 3.84 MHz Channel Bandwidth Carriers, ACPR and IM3 measured in 3.84 MHz Bandwidth. Peak/Avg. = 8.5 dB @ 0.01% Probability on CCDF.

Characteristic	Symbol	Min	Typ	Max	Unit
Common-Source Amplifier Power Gain (V_{DD} = 28 Vdc, P_{out} = 33 W Avg., I_{DQ} = 1300 mA, f1 = 2112.5 MHz, f2 = 2122.5 MHz and f1 = 2157.5 MHz, f2 = 2167.5 MHz)	G_{ps}	11	12.5	—	dB
Drain Efficiency (V_{DD} = 28 Vdc, P_{out} = 33 W Avg., I_{DQ} = 1300 mA, f1 = 2112.5 MHz, f2 = 2122.5 MHz and f1 = 2157.5 MHz, f2 = 2167.5 MHz)	η	23	25	—	%
Third Order Intermodulation Distortion (V_{DD} = 28 Vdc, P_{out} = 33 W Avg., I_{DQ} = 1300 mA, f1 = 2112.5 MHz, f2 = 2122.5 MHz and f1 = 2157.5 MHz, f2 = 2167.5 MHz; IM3 measured over 3.84 MHz BW at f1 -10 MHz and f2 +10 MHz referenced to carrier channel power.)	IM3	—	-37	-35	dBc
Adjacent Channel Power Ratio (V_{DD} = 28 Vdc, P_{out} = 33 W Avg., I_{DQ} = 1300 mA, f1 = 2112.5 MHz, f2 = 2122.5 MHz and f1 = 2157.5 MHz, f2 = 2167.5 MHz; ACPR measured over 3.84 MHz at f1 -5 MHz and f2 +5 MHz.)	ACPR	—	-39	-37	dBc
Input Return Loss (V_{DD} = 28 Vdc, P_{out} = 33 W Avg., I_{DQ} = 1300 mA, f1 = 2112.5 MHz, f2 = 2122.5 MHz and f1 = 2157.5 MHz, f2 = 2167.5 MHz)	IRL	—	-12	-9	dB

(1) Part is internally matched both on input and output.

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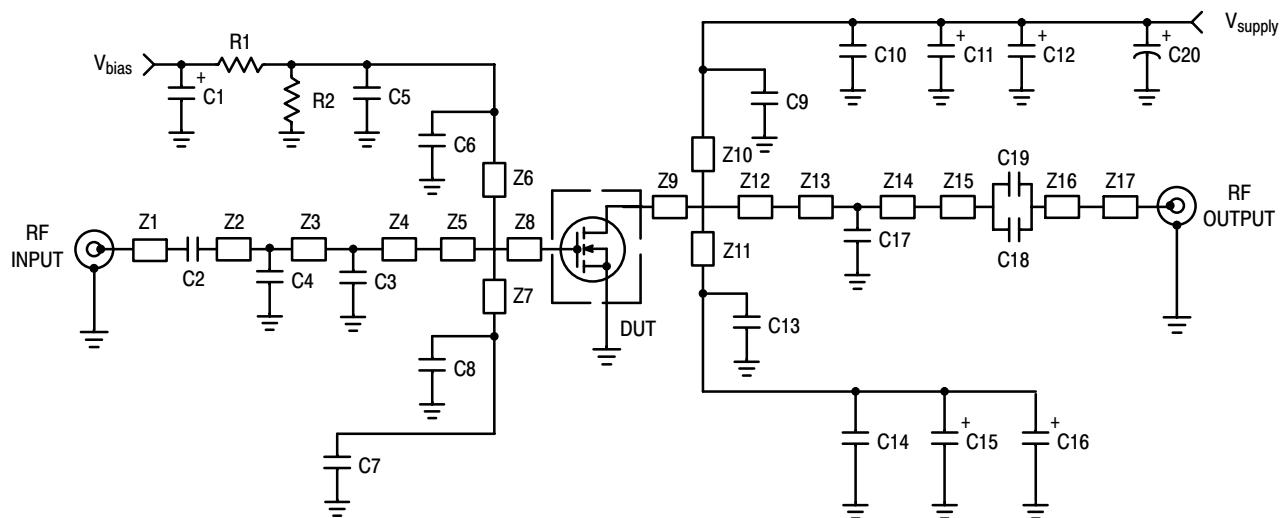
Z1	0.500″ x 0.083″ Microstrip	Z10, Z11	0.709″ x 0.083″ Microstrip
Z2	0.505″ x 0.083″ Microstrip	Z12	0.415″ x 1.100″ Microstrip
Z3	0.536″ x 0.083″ Microstrip	Z13	0.874″ x 0.083″ Microstrip
Z4	0.776″ x 0.083″ Microstrip	Z14	1.182″ x 0.083″ Microstrip
Z5	0.119″ x 1.024″ Microstrip	Z15, Z16	0.070″ x 0.220″ 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″, ε_r = 2.55
Z9	0.117″ x 1.100″ Microstrip		

Figure 1. MRF5S21150 Test Circuit Schematic

Table 1. MRF5S21150 Test Circuit Component Designations and Values

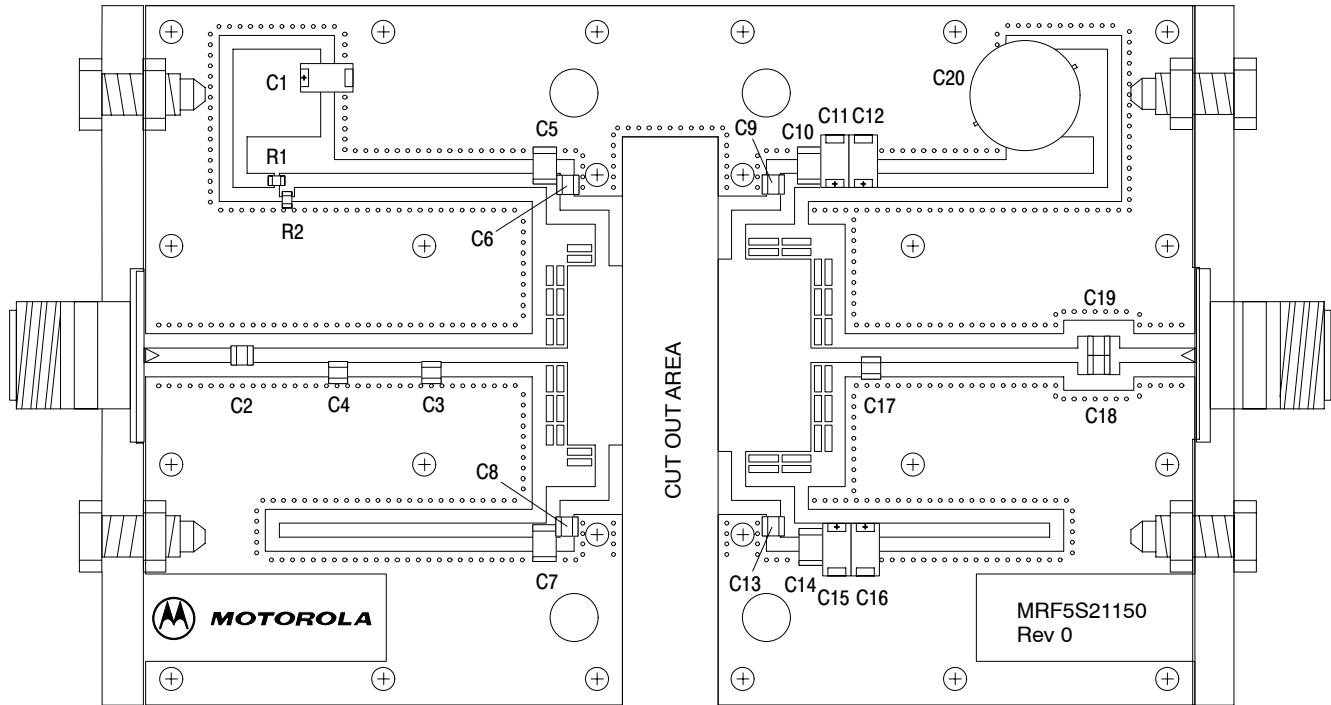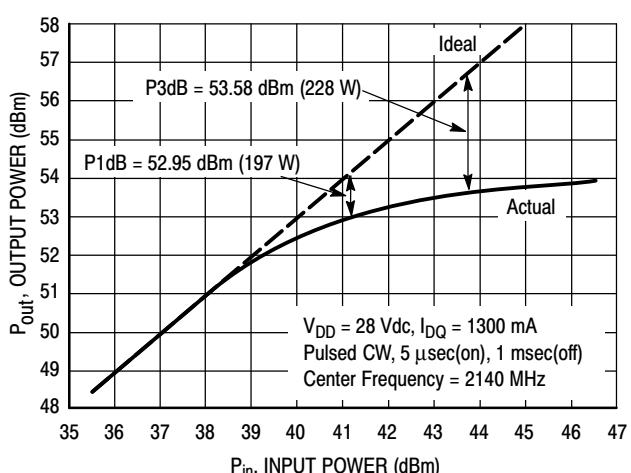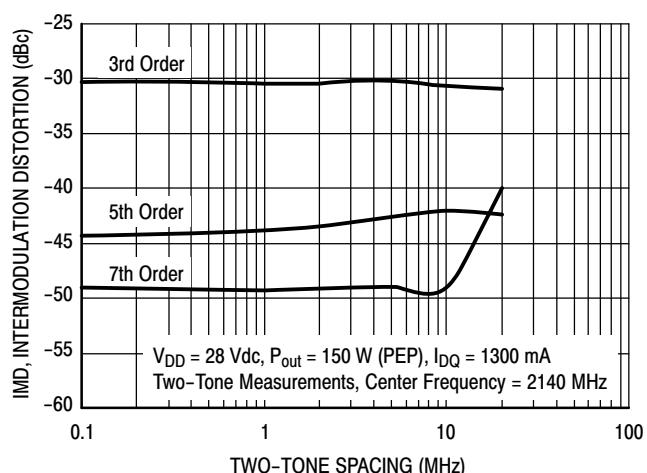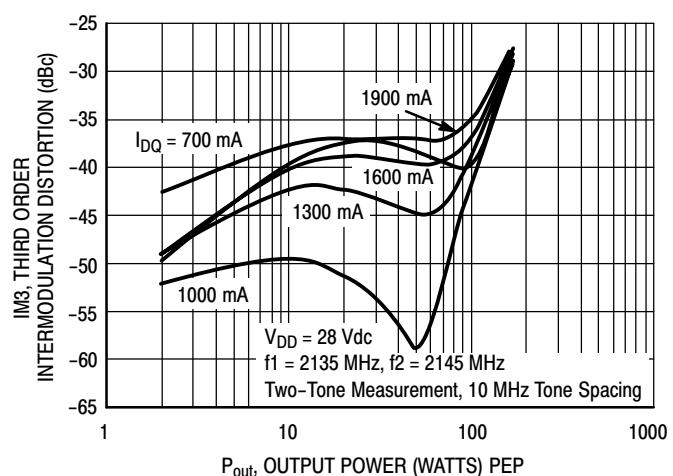| Part	Description	Value, P/N or DWG	Manufacturer
C1	22 µF, 35 V Tantalum Capacitor	TAJE226M035R	AVX
C2, C6, C8, C9, C13, C18, C19	6.8 pF 100B Chip Capacitors	100B6R8CW	ATC
C3,C4	1.8 pF 100B Chip Capacitors	100B1R8BW	ATC
C5, C7, C10, C14	220 nF Chip Capacitors (1812)	1812Y224KXA	Vishay - Vitramon
C11,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

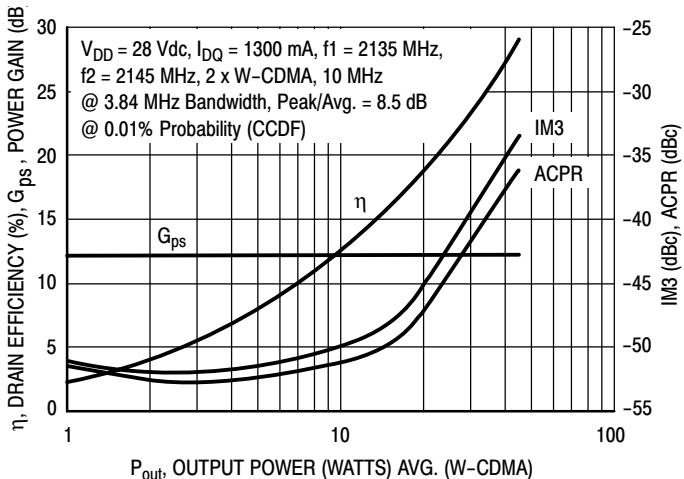# Freescale Semiconductor, Inc.

Figure 2. MRF5S21150 Test Circuit Component Layout

TYPICAL CHARACTERISTICS

V_{DD} = 28 Vdc, P_{out} = 33 W (Avg.), I_{DQ} = 1300 mA
2-Carrier W-CDMA, 10 MHz Carrier Spacing,
3.84 MHz Channel Bandwidth, Peak/Avg. = 8.5 dB
@ 0.01% Probability (CCDF)

Figure 3. 2-Carrier W-CDMA Broadband Performance

V_{DD} = 28 Vdc
$f1$ = 2135 MHz, $f2$ = 2145 MHz
Two-Tone Measurement, 10 MHz Tone Spacing

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

V_{DD} = 28 Vdc
$f1$ = 2135 MHz, $f2$ = 2145 MHz
Two-Tone Measurement, 10 MHz Tone Spacing

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

3rd Order

5th Order

7th Order

V_{DD} = 28 Vdc, P_{out} = 150 W (PEP), I_{DQ} = 1300 mA
Two-Tone Measurements, Center Frequency = 2140 MHz

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

Ideal

P3dB = 53.58 dBm (228 W)

P1dB = 52.95 dBm (197 W)

Actual

V_{DD} = 28 Vdc, I_{DQ} = 1300 mA
Pulsed CW, 5 μsec(on), 1 msec(off)
Center Frequency = 2140 MHz

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

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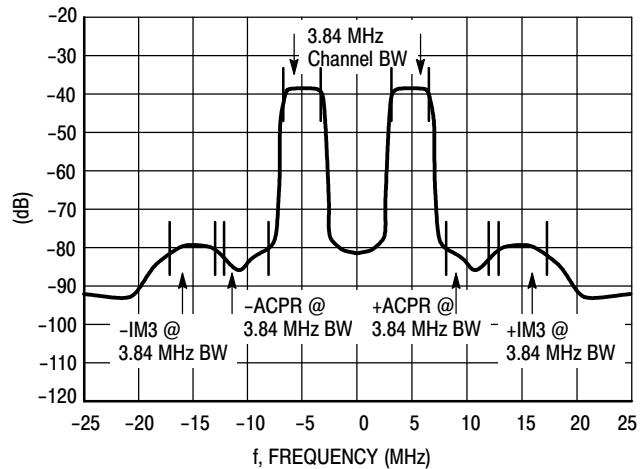**Power Gain and Drain Efficiency**
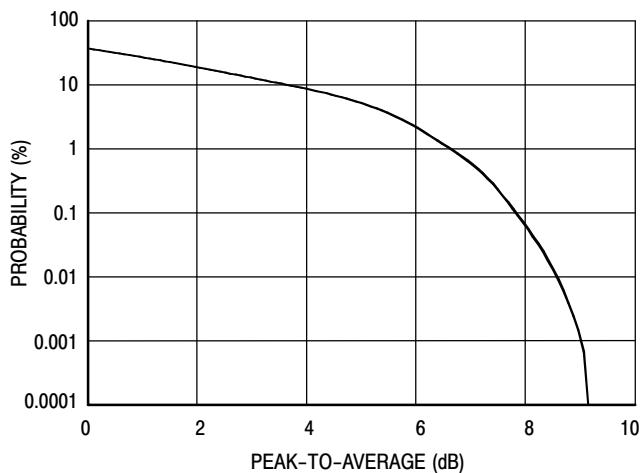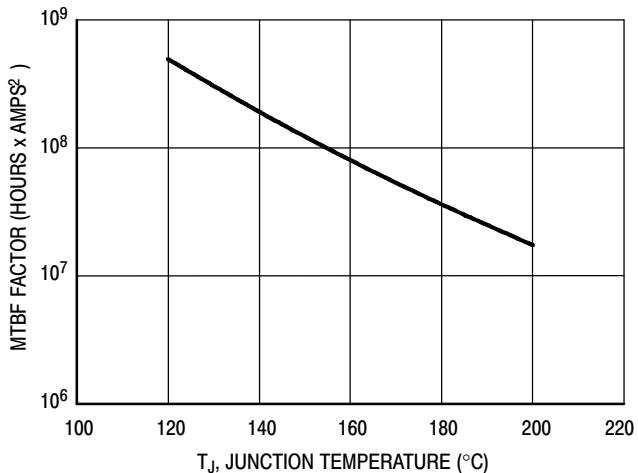**versus Output Power**

**Figure 9. 2-Carrier W-CDMA Spectrum**

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

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

Figure 11. MTBF Factor versus Junction Temperature
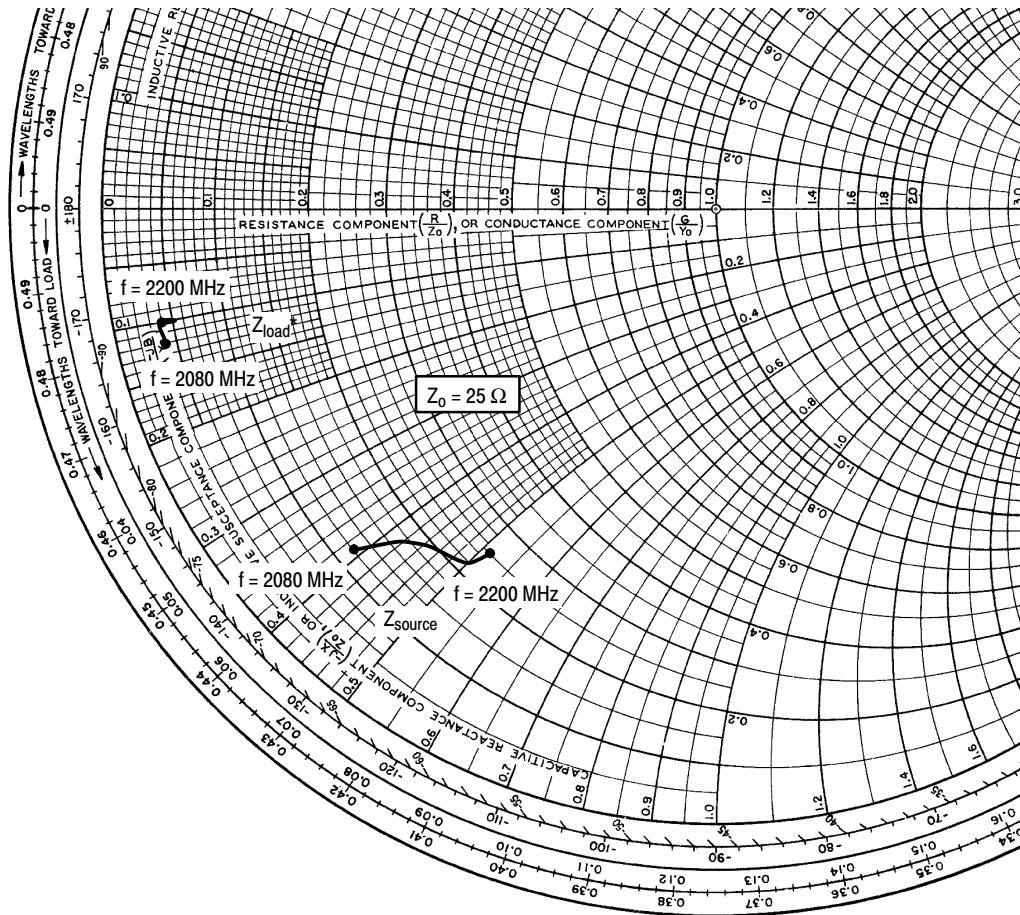
V_{DD} = 28 Vdc, I_{DQ} = 1300 mA, P_{out} = 33 W Avg.

f MHz	Z_{source} Ω	Z_{load} Ω
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.

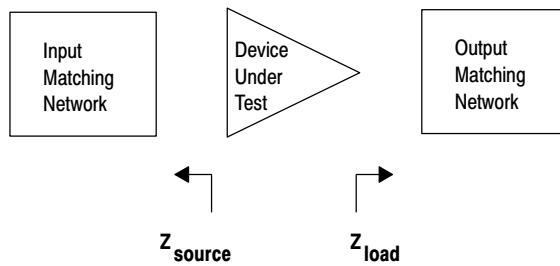Z_{load} = Test circuit impedance as measured from drain to ground.

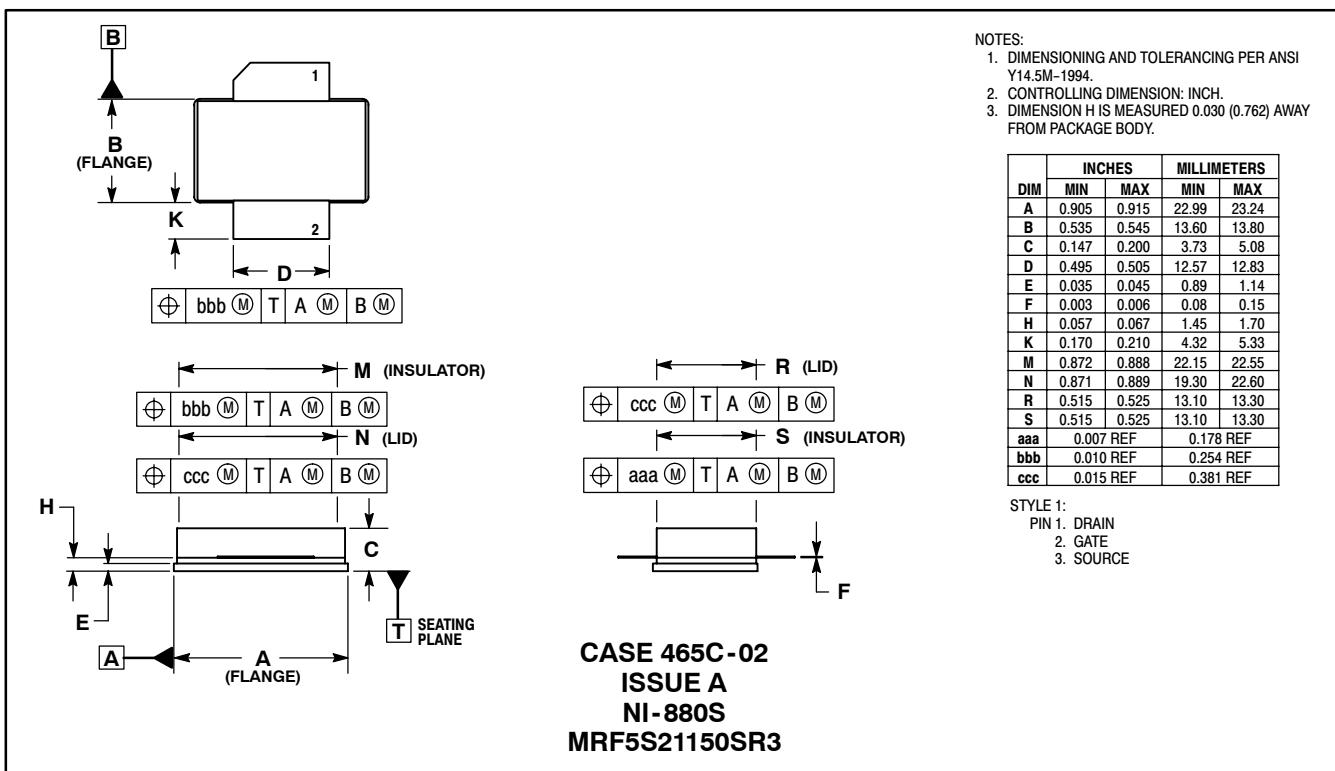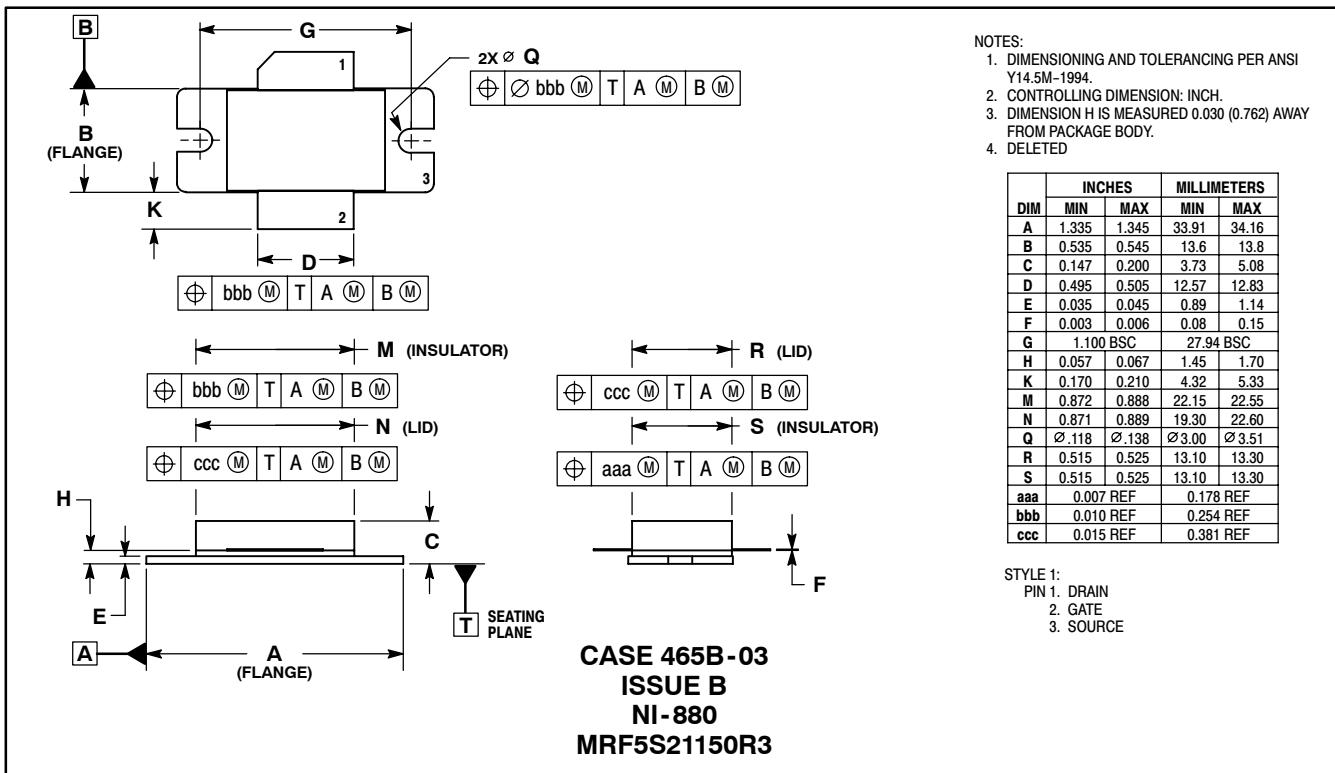Figure 12. Series Equivalent Input and Output Impedance

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NOTES

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NOTES

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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. DELETED

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS 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	∅.118	∅.138	∅3.00	∅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 465B-03
ISSUE B
NI-880
MRF5S21150R3

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 MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS 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

CASE 465C-02
ISSUE A
NI-880S
MRF5S21150SR3

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