Document Number: MRF7S16150H
Rev. 1, 12/2008

RoHS

RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

MRF7S16150HR3
MRF7S16150HSR3

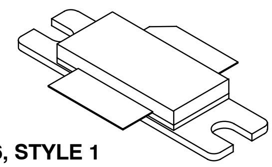
Designed for WiMAX base station applications with frequencies up to 1700 MHz. Suitable for WiMAX, WiBro, BWA, and OFDM multicarrier Class AB and Class C amplifier applications.

- Typical WiMAX Performance: V_{DD} = 28 Volts, I_{DQ} = 1500 mA, P_{out} = 32 Watts Avg., f = 1600 and 1660 MHz, 802.16d, 64 QAM $^3/_4$, 4 bursts, 7 MHz Channel Bandwidth, Input Signal PAR = 9.5 dB @ 0.01% Probability on CCDF.
  - Power Gain — 19.7 dB
  - Drain Efficiency — 25.4%
  - Device Output Signal PAR — 8.2 dB @ 0.01% Probability on CCDF
  - ACPR @ 5.25 MHz Offset — -47.5 dBc in 0.5 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 32 Vdc, 1630 MHz, 150 Watts CW Output Power
- P_{out} @ 1 dB Compression Point ≥ 150 Watts CW

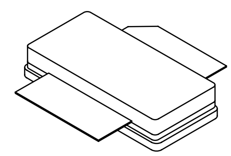
Features

- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

**1600-1660 MHz, 32 W AVG., 28 V
WiMAX
LATERAL N-CHANNEL
RF POWER MOSFETs**



**CASE 465-06, STYLE 1
NI-780
MRF7S16150HR3**



**CASE 465A-06, STYLE 1
NI-780S
MRF7S16150HSR3**

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	-0.5, +65	Vdc
Gate-Source Voltage	V_{GS}	-6.0, +10	Vdc
Operating Voltage	V_{DD}	32, +0	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 80°C, 149 W CW Case Temperature 75°C, 32 W CW	$R_{\theta JC}$	 0.34 0.37	°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.

freescale™ semiconductor

Table 3. ESD Protection Characteristics

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

Table 4. 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 = 348 μAdc)	$V_{GS(th)}$	1.2	2	2.7	Vdc
Gate Quiescent Voltage (V_{DD} = 28 Vdc, I_D = 1500 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	2	2.7	3.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 3.48 Adc)	$V_{DS(on)}$	0.1	0.2	0.3	Vdc
Dynamic Characteristics (1)					
Reverse Transfer Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	1.09	—	pF
Output Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	585	—	pF
Input Capacitance (V_{DS} = 28 Vdc, V_{GS} = 0 Vdc ± 30 mV(rms)ac @ 1 MHz)	C_{iss}	—	363	—	pF

Functional Tests (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1500 mA, P_{out} = 32 W Avg., f = 1600 MHz and f = 1660 MHz, WiMAX Signal, 802.16d, 7 MHz Channel Bandwidth, 64 QAM $^3/_4$, 4 bursts, PAR = 9.5 dB @ 0.01% Probability on CCDF. ACPR measured in 0.5 MHz Channel Bandwidth @ ±5.25 MHz Offset.

Characteristic	Symbol	Min	Typ	Max	Unit
Power Gain	G_{ps}	18.5	19.7	21.5	dB
Drain Efficiency	η_D	24	25.4	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	7.7	8.2	—	dB
Adjacent Channel Power Ratio	ACPR	-58	-47.5	-45	dBc
Input Return Loss	IRL	—	-12.1	-7	dB

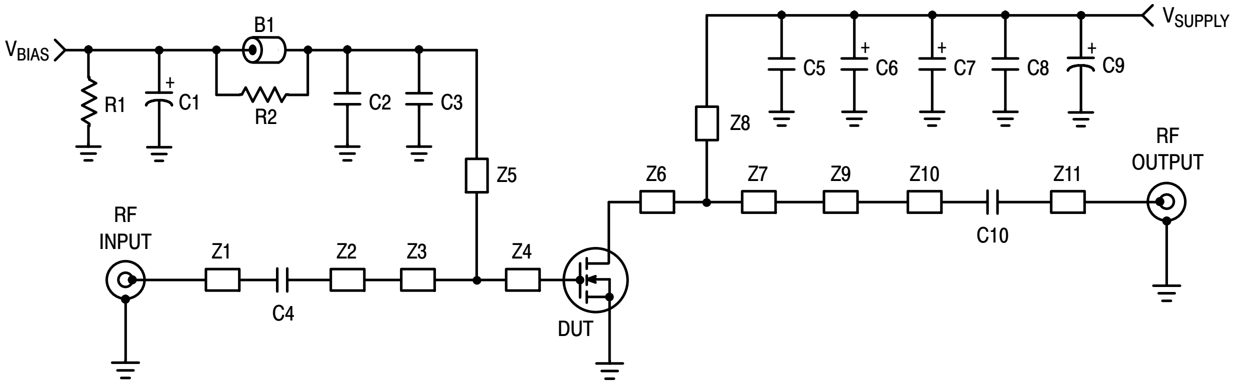
1. Part internally matched both on input and output.

(continued)

Table 4. Electrical Characteristics (T_C = 25°C unless otherwise noted) **(continued)**

Characteristic	Symbol	Min	Typ	Max	Unit
Typical Performances OFDM Signal (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1500 mA, P_{out} = 32 W Avg., f = 1600 MHz and f = 1660 MHz, WiMAX Signal, OFDM Single-Carrier, 7 MHz Channel Bandwidth, 64 QAM 3/4, 4 Bursts, PAR = 9.5 dB @ 0.01% Probability on CCDF.					
Mask System Type G @ P_{out} = 32 W Avg.	Mask				dBc
Point B at 3.5 MHz Offset		—	-27	—	
Point C at 5 MHz Offset		—	-36	—	
Point D at 7.4 MHz Offset		—	-41	—	
Point E at 14 MHz Offset		—	-59	—	
Point F at 17.5 MHz Offset		—	-62	—	
Relative Constellation Error @ P_{out} = 32 W Avg. (1)	RCE	—	-29.6	—	dB
Error Vector Magnitude (1) (Typical EVM Performance @ P_{out} = 32 W Avg. with OFDM 802.16d Signal Call)	EVM	—	3.3	—	% rms
Typical Performances (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1500 mA, 1600-1660 MHz Bandwidth					
Video Bandwidth @ 180 W PEP P_{out} where IM3 = -30 dBc (Tone Spacing from 100 kHz to VBW) ΔIMD3 = IMD3 @ VBW frequency - IMD3 @ 100 kHz <1 dBc (both sidebands)	VBW	—	20	—	MHz
Gain Flatness in 60 MHz Bandwidth @ P_{out} = 32 W Avg.	G_F	—	0.292	—	dB
Average Deviation from Linear Phase in 60 MHz Bandwidth @ P_{out} = 150 W CW	Φ	—	82.71	—	°
Average Group Delay @ P_{out} = 150 W CW, f = 1630 MHz	Delay	—	7.19	—	ns
Part-to-Part Insertion Phase Variation @ P_{out} = 150 W CW, f = 1630 MHz, Six Sigma Window	ΔΦ	—	22.38	—	°
Gain Variation over Temperature (-30°C to +85°C)	ΔG	—	0.01387	—	dB/°C
Output Power Variation over Temperature (-30°C to +85°C)	ΔP1dB	—	0.409	—	dBm/°C

1. RCE = 20Log(EVM/100)



Z1, Z5, Z11	0.744″ x 0.084″ Microstrip	Z7	0.619″ x 1.330″ Microstrip
Z2	0.822″ x 0.084″ Microstrip	Z8	0.284″ x 0.190″ Microstrip
Z3	0.252″ x 1.240″ Microstrip	Z9	0.220″ x 0.250″ Microstrip
Z4	0.402″ x 1.240″ Microstrip	Z10	0.531″ x 0.084″ Microstrip
Z6	0.111″ x 1.330″ Microstrip	PCB	Arlon CuClad 250GX-0300-55-22, 0.030″, ε_r = 2.55

Figure 1. MRF7S16150HR3(HSR3) Test Circuit Schematic

Table 5. MRF7S16150HR3(HSR3) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
B1	Small Ferrite Bead	2743019447	Fair Rite
C1	10 μF, 35 V Electrolytic Capacitor	EMVY350ADA100ME55G	Nippon Chemi-Con
C2, C8	0.01 μF, 50 V Chip Capacitors	C1825C103J5RAC	Kemit
C3, C5	10 pF Chip Capacitors	ATC100B100BT500XT	ATC
C4, C10	47 pF Chip Capacitors	ATC100B470BT500XT	ATC
C6, C7	22 μF, 35 V Tantalum Capacitors	T491X226K035AT	Kemet
C9	220 μF, 50 V Electrolytic Capacitor	EMVY500ADA221MJ0G	Nippon Chemi-Con
R1	1 KΩ, 1/4 W Chip Resistor	CRCW12061001FKEA	Vishay
R2	10 Ω, 1/4 W Chip Resistor	CRCW120610R1FKEA	Vishay

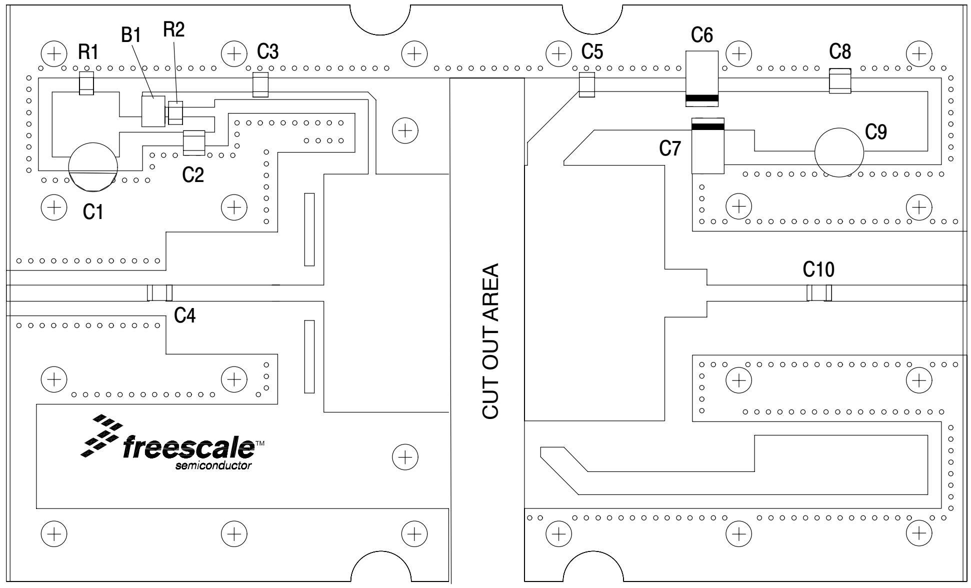


Figure 2. MRF7S16150HR3(HSR3) Test Circuit Component Layout

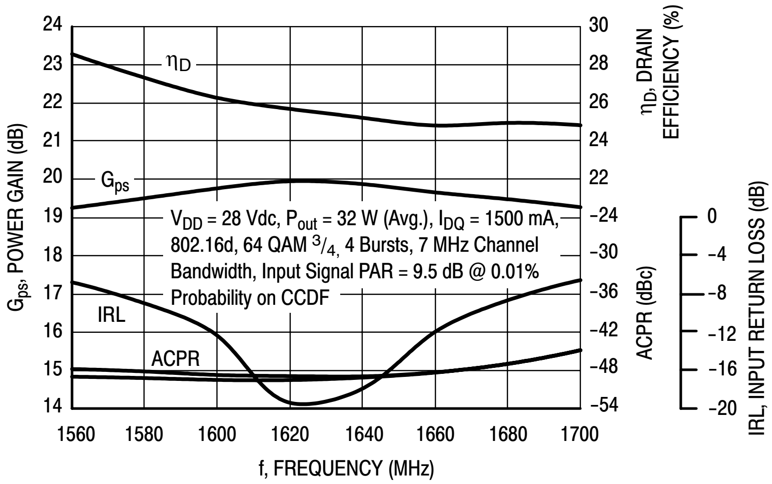


Figure 3. WiMAX Broadband Performance @ P_{out} = 32 Watts Avg.

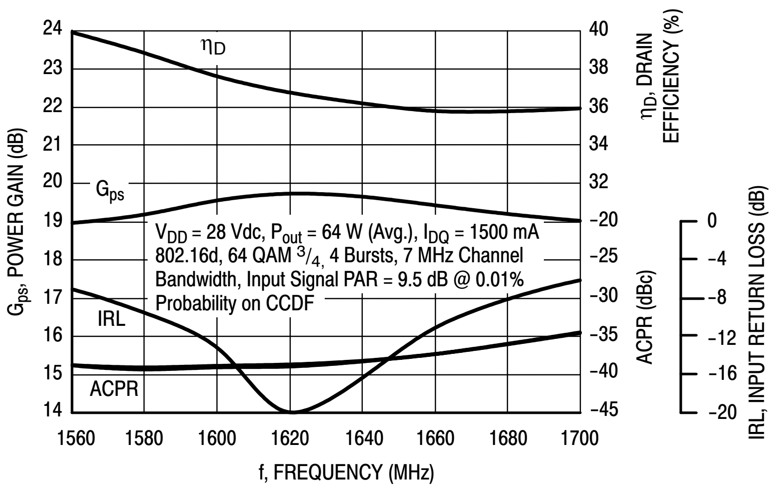


Figure 4. WiMAX Broadband Performance @ P_{out} = 64 Watts Avg.

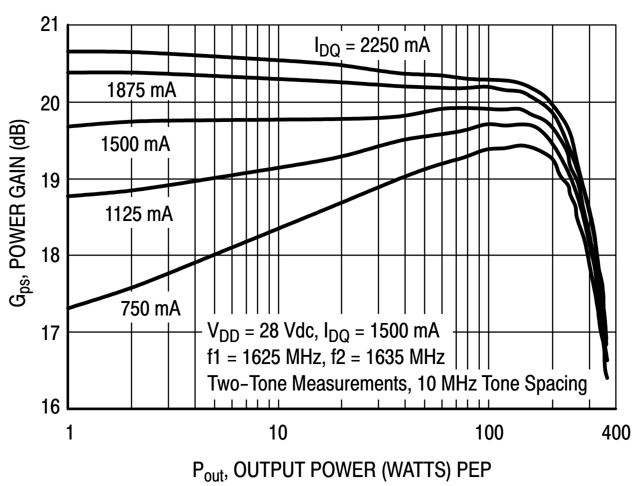


Figure 5. Two-Tone Power Gain versus Output Power

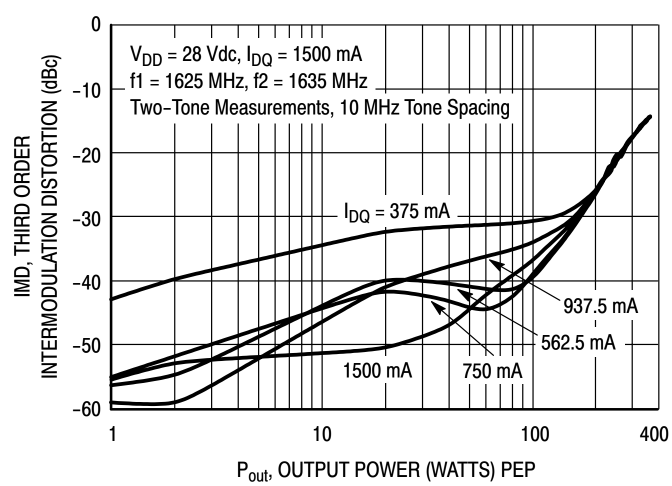


Figure 6. Third Order Intermodulation Distortion versus Output Power

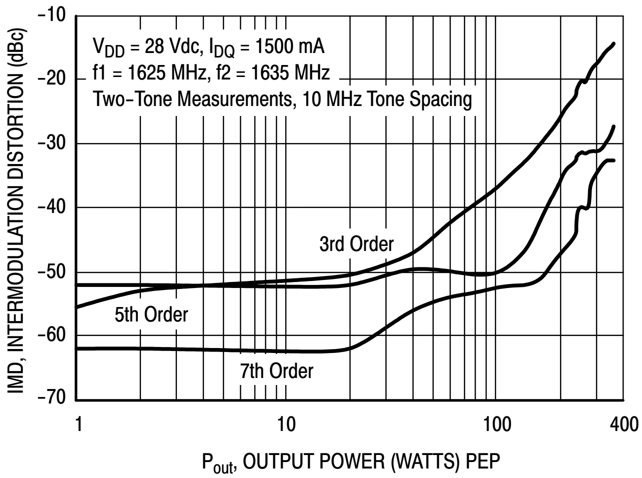


Figure 7. Intermodulation Distortion Products versus Output Power

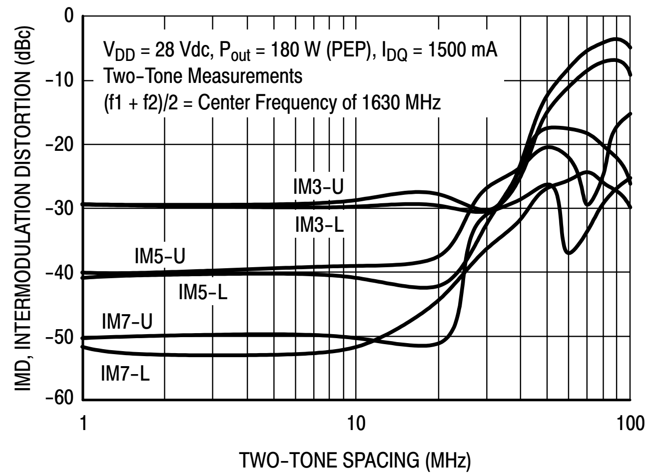


Figure 8. Intermodulation Distortion Products versus Tone Spacing

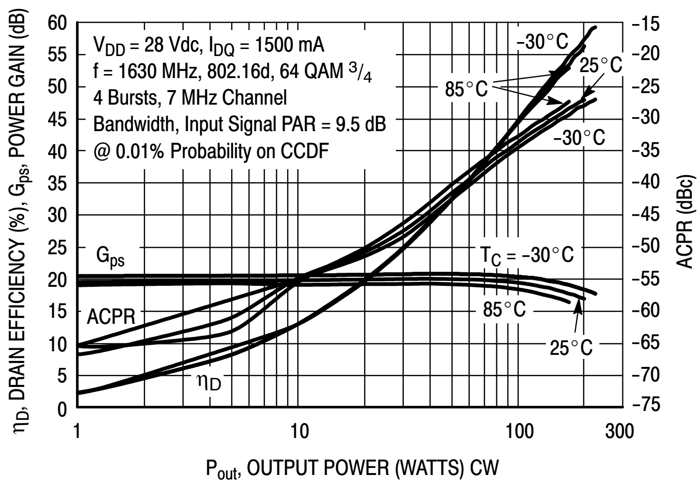


Figure 9. WiMAX, ACPR, Power Gain and Drain Efficiency versus Output Power

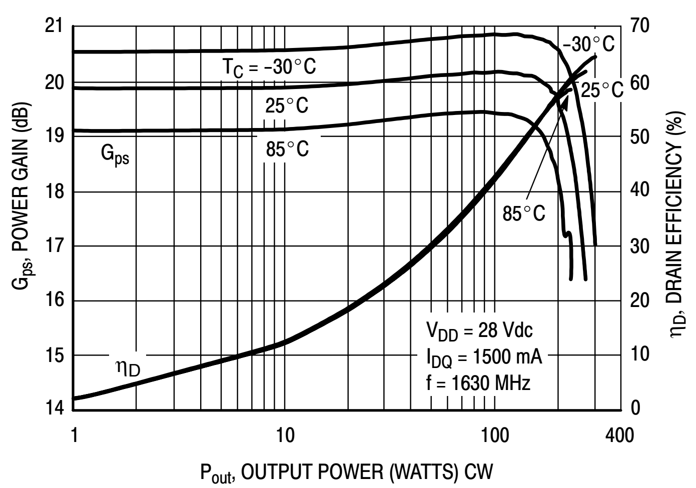


Figure 10. Power Gain and Drain Efficiency versus CW Output Power

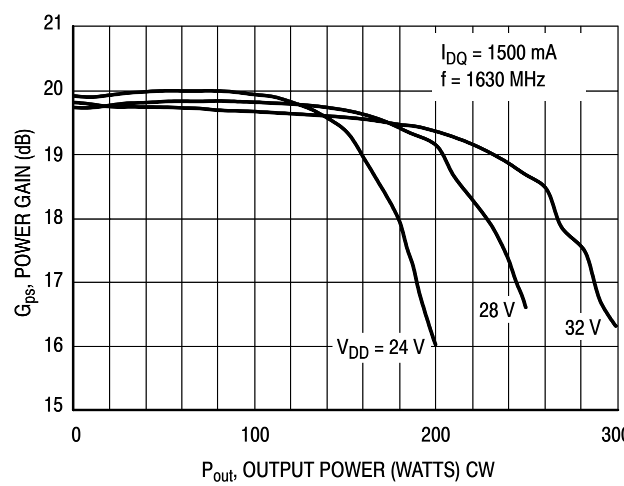
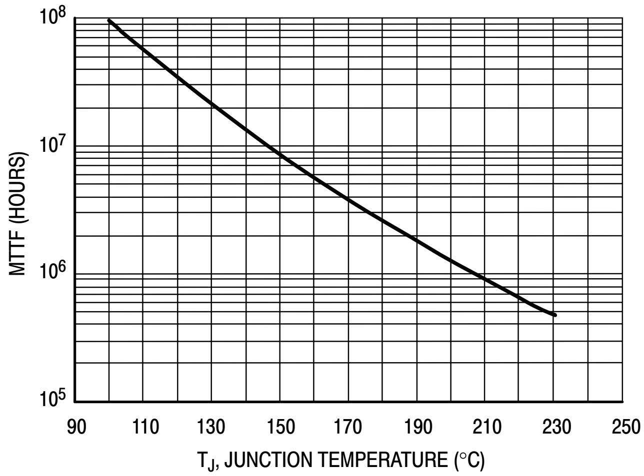


Figure 11. Power Gain versus Output Power

TYPICAL CHARACTERISTICS



This above graph displays calculated MTTF in hours when the device is operated at V_{DD} = 28 Vdc, P_{out} = 32 W Avg., and η_D = 25.4%.

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

Figure 12. MTTF versus Junction Temperature

WIMAX TEST SIGNAL

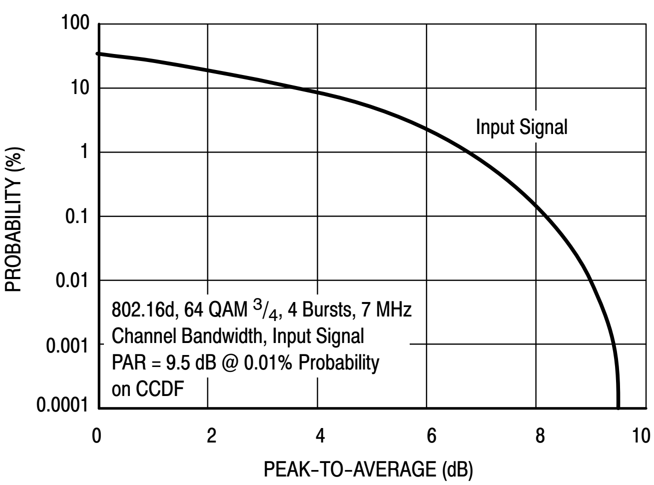


Figure 13. OFDM 802.16d Test Signal

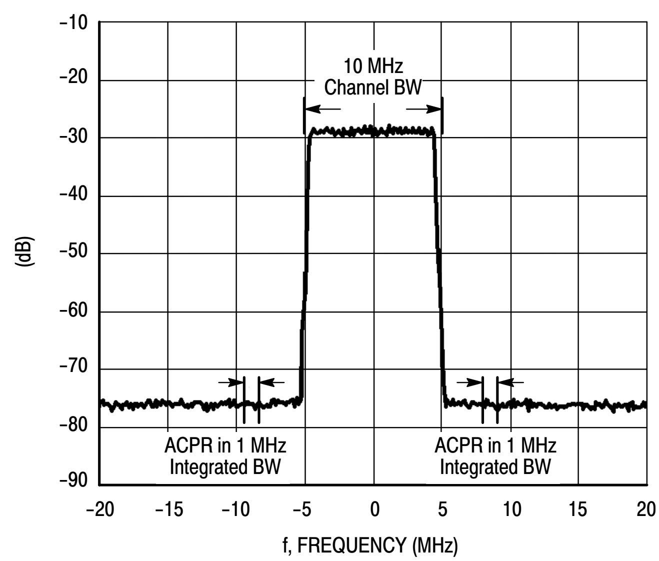
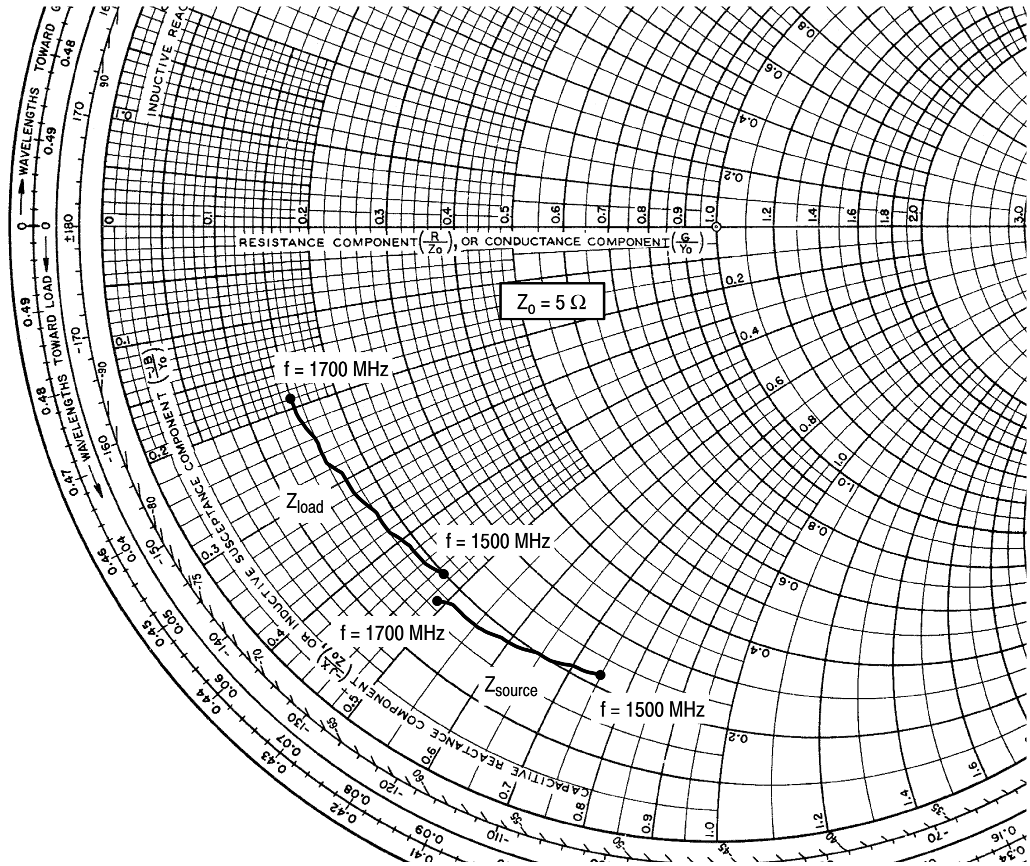


Figure 14. WiMAX Spectrum Mask Specifications



V_{DD} = 28 Vdc, I_{DQ} = 1500 mA, P_{out} = 32 W Avg.

f MHz	Z_{source} Ω	Z_{load} Ω
1500	1.09 - j3.76	1.00 - j2.35
1520	1.06 - j3.62	0.96 - j2.19
1540	1.04 - j3.48	0.93 - j2.03
1560	1.01 - j3.34	0.91 - j1.88
1580	0.99 - j3.21	0.88 - j1.74
1600	0.96 - j3.07	0.86 - j1.60
1620	0.94 - j2.94	0.83 - j1.46
1640	0.92 - j2.81	0.81 - j1.33
1660	0.90 - j2.69	0.79 - j1.20
1680	0.88 - j2.56	0.77 - j1.07
1700	0.86 - j2.44	0.76 - j0.95

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

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

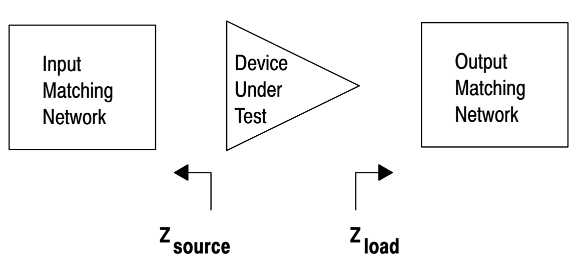
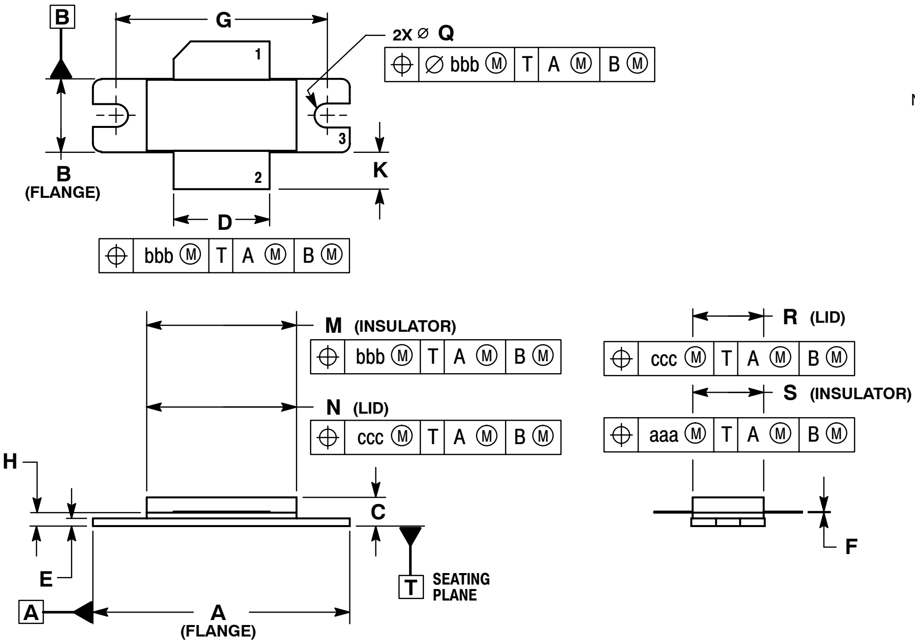


Figure 15. Series Equivalent Source and Load Impedance

PACKAGE DIMENSIONS

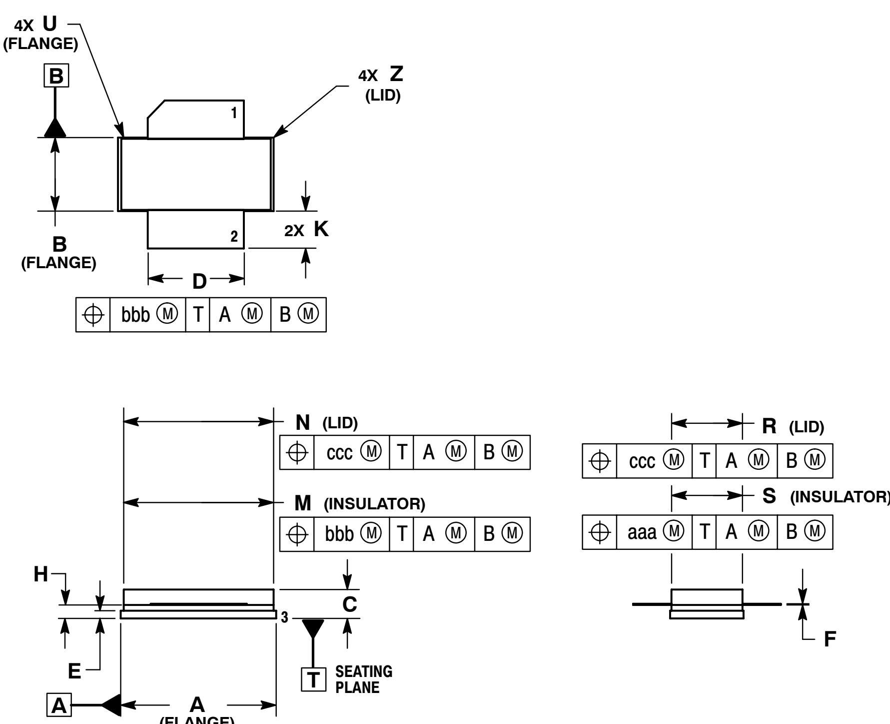


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	1.335	1.345	33.91	34.16
B	0.380	0.390	9.65	9.91
C	0.125	0.170	3.18	4.32
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	0.774	0.786	19.66	19.96
N	0.772	0.788	19.60	20.00
Q	∅.118	∅.138	∅3.00	∅3.51
R	0.365	0.375	9.27	9.53
S	0.365	0.375	9.27	9.52
aaa	0.005 REF		0.127 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 465-06
ISSUE G
NI-780
MRF7S16150HR3



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

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.805	0.815	20.45	20.70
B	0.380	0.390	9.65	9.91
C	0.125	0.170	3.18	4.32
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	0.774	0.786	19.61	20.02
N	0.772	0.788	19.61	20.02
R	0.365	0.375	9.27	9.53
S	0.365	0.375	9.27	9.52
U	---	0.040	---	1.02
Z	---	0.030	---	0.76
aaa	0.005 REF		0.127 REF	
bbb	0.010 REF		0.254 REF	
ccc	0.015 REF		0.381 REF	

STYLE 1:
PIN 1. DRAIN
2. GATE
5. SOURCE

CASE 465A-06
ISSUE H
NI-780S
MRF7S16150HSR3

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	June 2007	• Initial Release of Data Sheet
1	Dec. 2008	• Table 4, On Characteristics, tightened $V_{GS(Q)}$ max value from 3.8 to 3.5 to match production test value, p. 2 • Updated PCB information to show more specific material details, Fig. 1, Test Circuit Schematic, p. 4 • Updated Part Numbers in Table 5, Component Designations and Values, to latest RoHS compliant part numbers, p. 4 • Updated Fig. 13, OFDM 802.16d Test Signal, to show input signal only, p. 8 • Updated Fig. 14, WiMAX Spectrum Mask Specifications, to more accurately represent the WiMAX spectrum, p. 8

How to Reach Us:

Home Page:
www.freescale.com

Web Support:
http://www.freescale.com/support

USA/Europe or Locations Not Listed:
Freescale Semiconductor, Inc.
Technical Information Center, EL516
2100 East Elliot Road
Tempe, Arizona 85284
1-800-521-6274 or +1-480-768-2130
www.freescale.com/support

Europe, Middle East, and Africa:
Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
www.freescale.com/support

Japan:
Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064
Japan
0120 191014 or +81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:
Freescale Semiconductor China Ltd.
Exchange Building 23F
No. 118 Jianguo Road
Chaoyang District
Beijing 100022
China
+86 10 5879 8000
support.asia@freescale.com

For Literature Requests Only:
Freescale Semiconductor Literature Distribution Center
P.O. Box 5405
Denver, Colorado 80217
1-800-441-2447 or +1-303-675-2140
Fax: +1-303-675-2150
LDCForFreescaleSemiconductor@hibbertgroup.com

freescale™
semiconductor

Document Number: MRF7S16150H
Rev. 1, 12/2008