

RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

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.

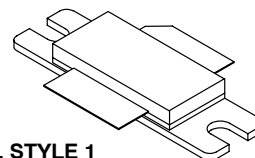
- Typical WiMAX Performance: $V_{DD} = 28$ Volts, $I_{DQ} = 1500$ mA, $P_{out} = 32$ Watts Avg., $f = 1600$ and 1660 MHz, 802.16d, 64 QAM $3/4$, 4 bursts, 7 MHz Channel Bandwidth, Input Signal PAR = 9.5 dB @ 0.01% Probability on CCDF.
Power Gain — 19.7 dB
Drain Efficiency — 25.4%
Device Output Signal 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

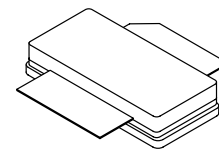
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

MRF7S16150HR3
MRF7S16150HSR3

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.

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 ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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Off Characteristics

Zero Gate Voltage Drain Leakage Current ($V_{DS} = 65\text{ Vdc}$, $V_{GS} = 0\text{ Vdc}$)	I_{DSS}	—	—	10	μAdc
Zero Gate Voltage Drain Leakage Current ($V_{DS} = 28\text{ Vdc}$, $V_{GS} = 0\text{ Vdc}$)	I_{DSS}	—	—	1	μAdc
Gate-Source Leakage Current ($V_{GS} = 5\text{ Vdc}$, $V_{DS} = 0\text{ Vdc}$)	I_{GSS}	—	—	1	μAdc

On Characteristics

Gate Threshold Voltage ($V_{DS} = 10\text{ Vdc}$, $I_D = 348\ \mu\text{Adc}$)	$V_{GS(th)}$	1.2	2	2.7	Vdc
Gate Quiescent Voltage ($V_{DD} = 28\text{ Vdc}$, $I_D = 1500\text{ mAdc}$, Measured in Functional Test)	$V_{GS(Q)}$	2	2.7	3.5	Vdc
Drain-Source On-Voltage ($V_{GS} = 10\text{ Vdc}$, $I_D = 3.48\text{ Adc}$)	$V_{DS(on)}$	0.1	0.2	0.3	Vdc

Dynamic Characteristics (1)

Reverse Transfer Capacitance ($V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{rss}	—	1.09	—	pF
Output Capacitance ($V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{oss}	—	585	—	pF
Input Capacitance ($V_{DS} = 28\text{ Vdc}$, $V_{GS} = 0\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz)	C_{iss}	—	363	—	pF

Functional Tests (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$, $I_{DQ} = 1500\text{ mA}$, $P_{out} = 32\text{ W Avg.}$, $f = 1600\text{ MHz}$ and $f = 1660\text{ MHz}$, 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 @ $\pm 5.25\text{ MHz}$ Offset.

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)

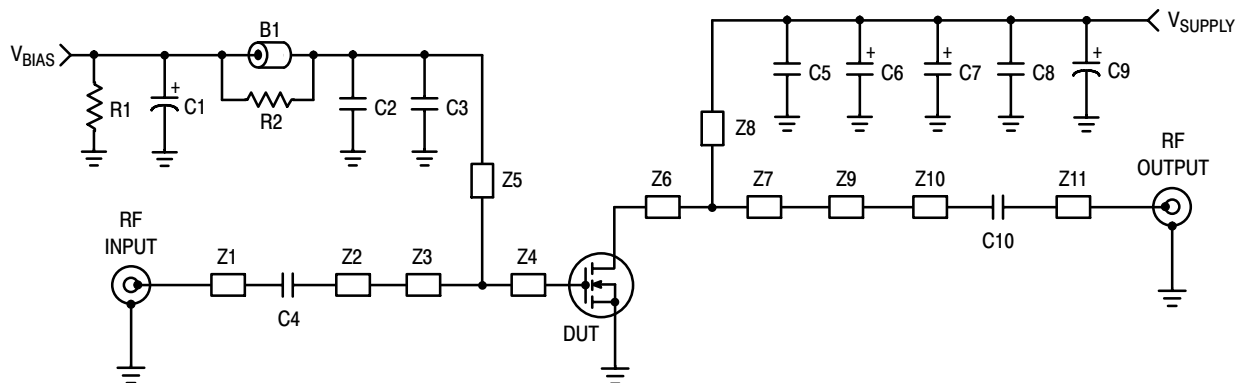
Table 4. Electrical Characteristics ($T_C = 25^\circ\text{C}$ unless otherwise noted) (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
Typical Performances OFDM Signal (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$, $I_{DQ} = 1500\text{ mA}$, $P_{out} = 32\text{ W Avg.}$, $f = 1600\text{ MHz}$ and $f = 1660\text{ MHz}$, 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 @ $P_{out} = 32\text{ W Avg.}$ Point B at 3.5 MHz Offset Point C at 5 MHz Offset Point D at 7.4 MHz Offset Point E at 14 MHz Offset Point F at 17.5 MHz Offset	Mask	—	-27 -36 -41 -59 -62	—	dBc
Relative Constellation Error @ $P_{out} = 32\text{ W Avg.}$ (1)	RCE	—	-29.6	—	dB
Error Vector Magnitude (1) (Typical EVM Performance @ $P_{out} = 32\text{ W Avg.}$ with OFDM 802.16d Signal Call)	EVM	—	3.3	—	% rms

Typical Performances (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$, $I_{DQ} = 1500\text{ mA}$, 1600-1660 MHz Bandwidth

Video Bandwidth @ 180 W PEP P_{out} where $IM3 = -30\text{ dBc}$ (Tone Spacing from 100 kHz to VBW) $\Delta IMD3 = IMD3 @ \text{VBW frequency} - IMD3 @ 100\text{ kHz} < 1\text{ dBc}$ (both sidebands)	VBW	—	20	—	MHz
Gain Flatness in 60 MHz Bandwidth @ $P_{out} = 32\text{ W Avg.}$	G_F	—	0.292	—	dB
Average Deviation from Linear Phase in 60 MHz Bandwidth @ $P_{out} = 150\text{ W CW}$	Φ	—	82.71	—	$^\circ$
Average Group Delay @ $P_{out} = 150\text{ W CW}$, $f = 1630\text{ MHz}$	Delay	—	7.19	—	ns
Part-to-Part Insertion Phase Variation @ $P_{out} = 150\text{ W CW}$, $f = 1630\text{ MHz}$, Six Sigma Window	$\Delta\Phi$	—	22.38	—	$^\circ$
Gain Variation over Temperature (-30°C to $+85^\circ\text{C}$)	ΔG	—	0.01387	—	dB/ $^\circ\text{C}$
Output Power Variation over Temperature (-30°C to $+85^\circ\text{C}$)	ΔP_{1dB}	—	0.409	—	dBm/ $^\circ\text{C}$

1. $RCE = 20\text{Log}(EVM/100)$



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", $\epsilon_r = 2.55$

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 μ F, 35 V Electrolytic Capacitor	EMVY350ADA100ME55G	Nippon Chemi-Con
C2, C8	0.01 μ F, 50 V Chip Capacitors	C1825C103J5RAC	Kemet
C3, C5	10 pF Chip Capacitors	ATC100B100BT500XT	ATC
C4, C10	47 pF Chip Capacitors	ATC100B470BT500XT	ATC
C6, C7	22 μ F, 35 V Tantalum Capacitors	T491X226K035AT	Kemet
C9	220 μ F, 50 V Electrolytic Capacitor	EMVY500ADA221MJ0G	Nippon Chemi-Con
R1	1 K Ω , 1/4 W Chip Resistor	CRCW12061001FKEA	Vishay
R2	10 Ω , 1/4 W Chip Resistor	CRCW120610R1FKEA	Vishay

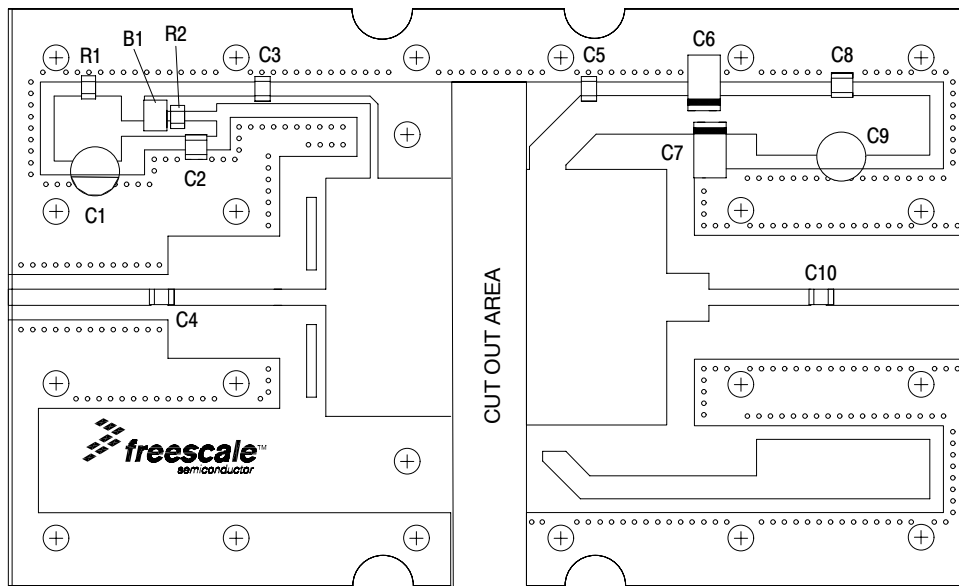


Figure 2. MRF7S16150HR3(HSR3) Test Circuit Component Layout

TYPICAL CHARACTERISTICS

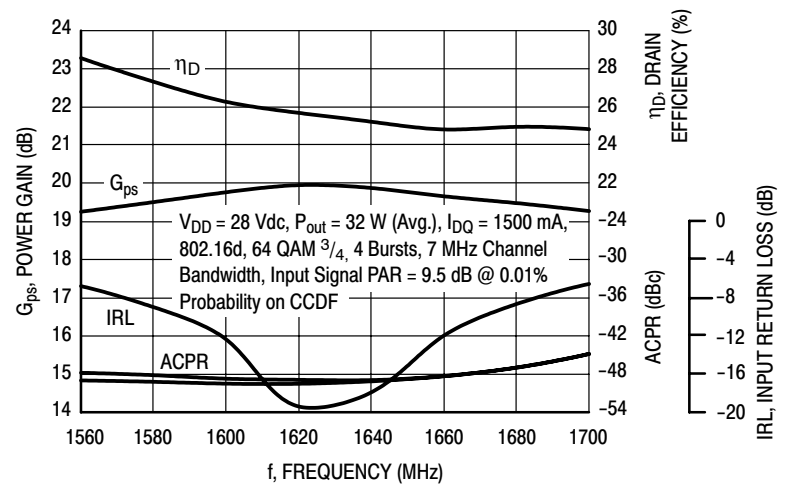


Figure 3. WiMAX Broadband Performance @ $P_{out} = 32$ Watts Avg.

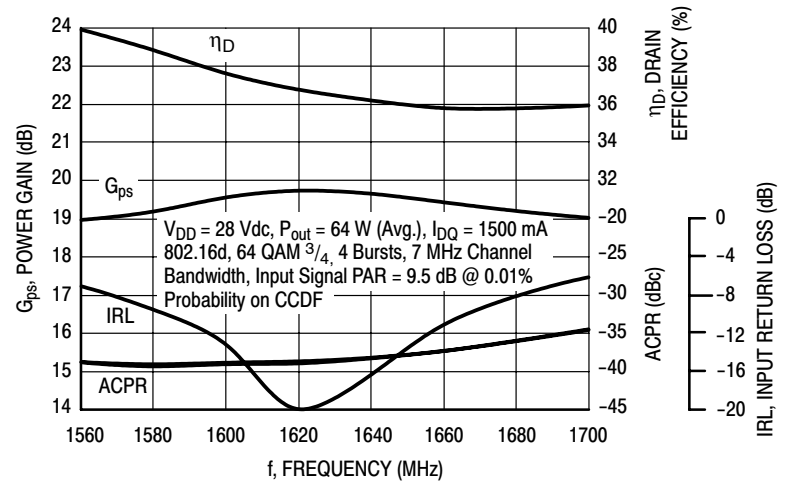


Figure 4. WiMAX Broadband Performance @ $P_{out} = 64$ Watts Avg.

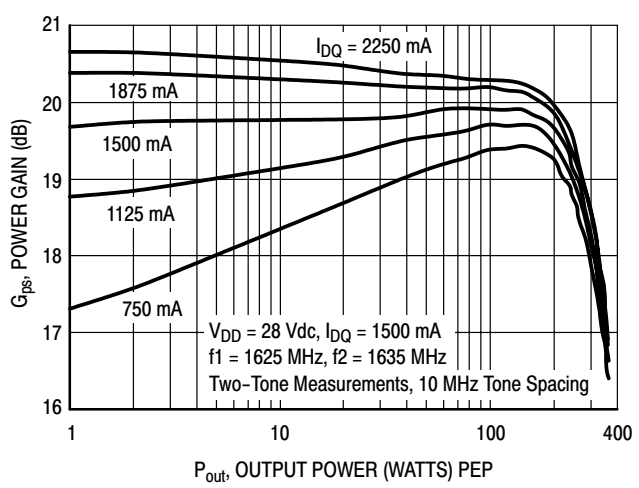


Figure 5. Two-Tone Power Gain versus Output Power

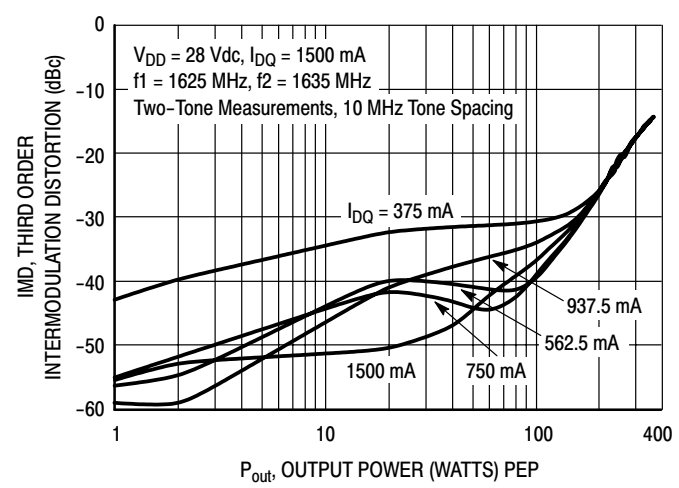


Figure 6. Third Order Intermodulation Distortion versus Output Power

TYPICAL CHARACTERISTICS

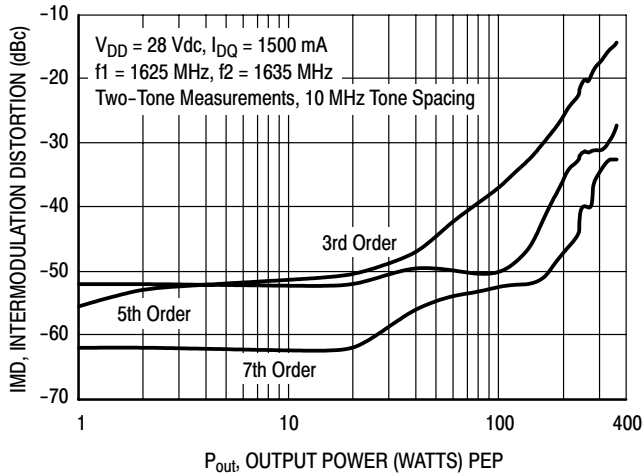


Figure 7. Intermodulation Distortion Products versus Output Power

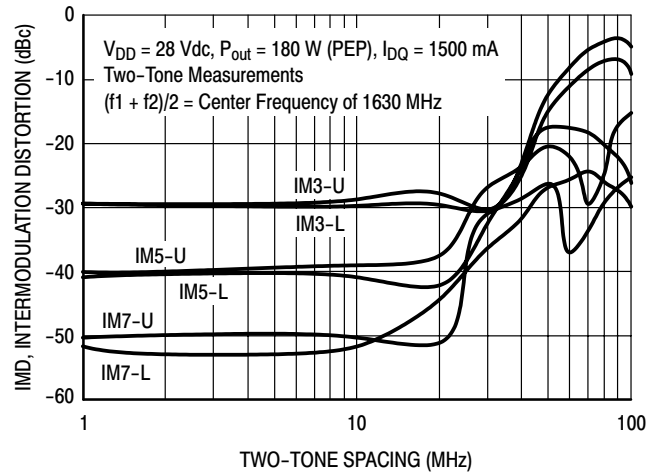


Figure 8. Intermodulation Distortion Products versus Tone Spacing

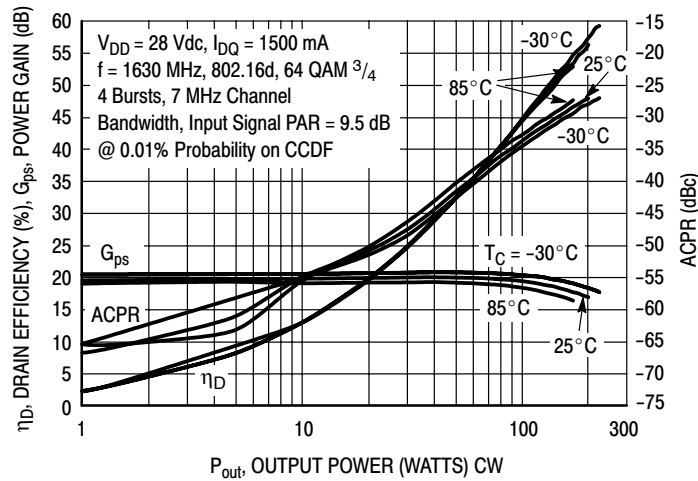


Figure 9. WiMAX, ACPR, Power Gain and Drain Efficiency versus Output Power

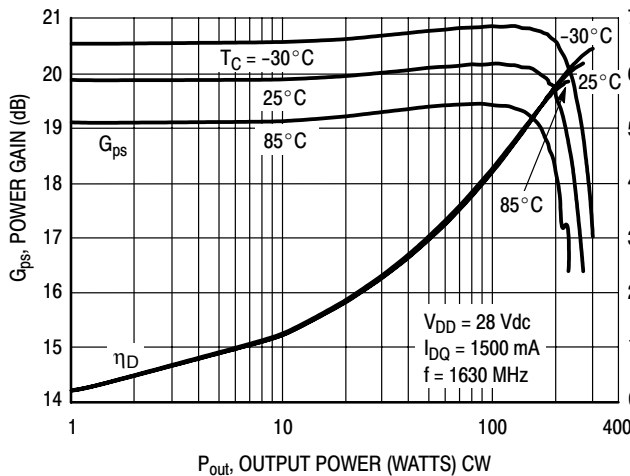


Figure 10. Power Gain and Drain Efficiency versus CW Output Power

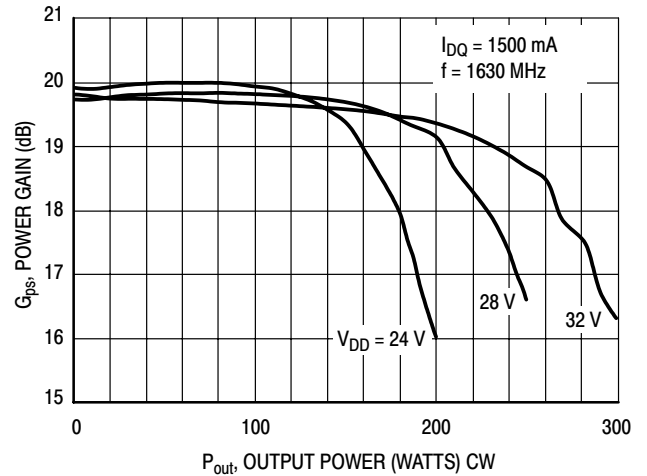
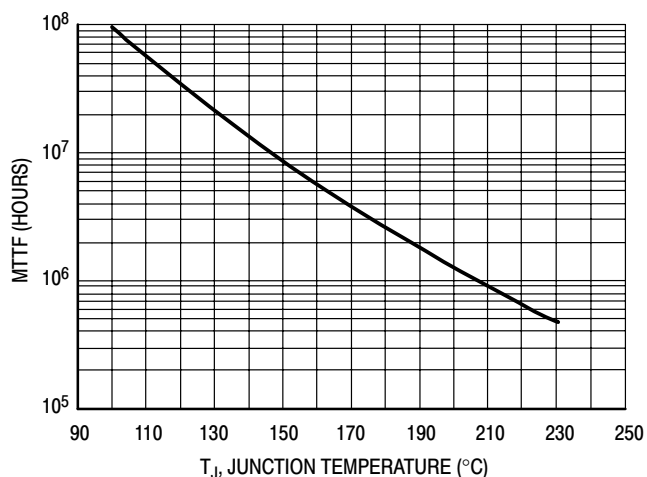


Figure 11. Power Gain versus Output Power

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 $\eta_D = 25.4\%$.

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

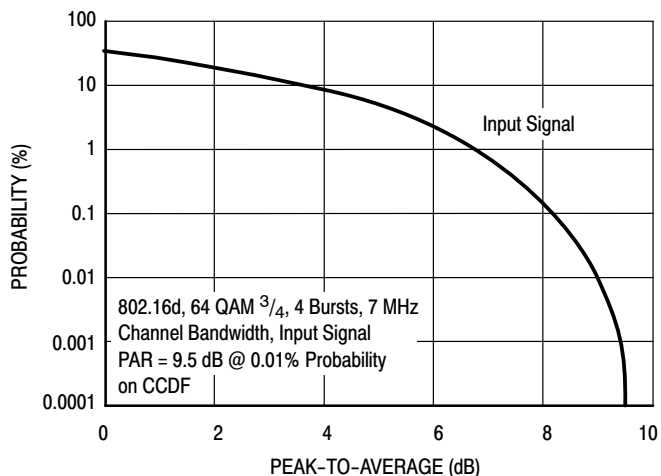


Figure 13. OFDM 802.16d Test Signal

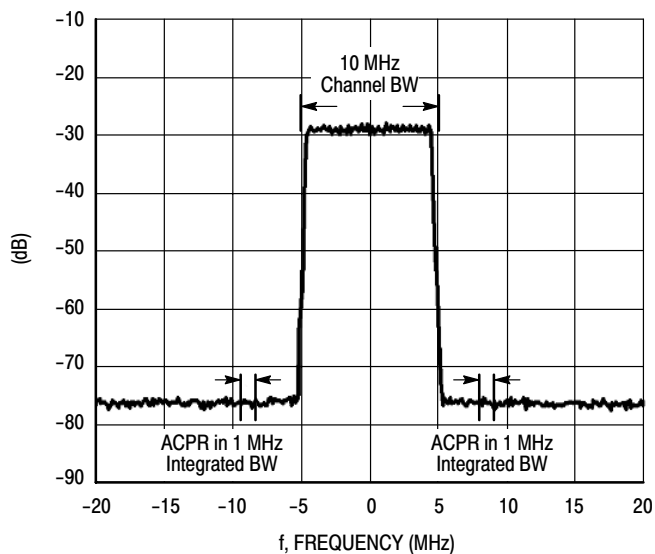
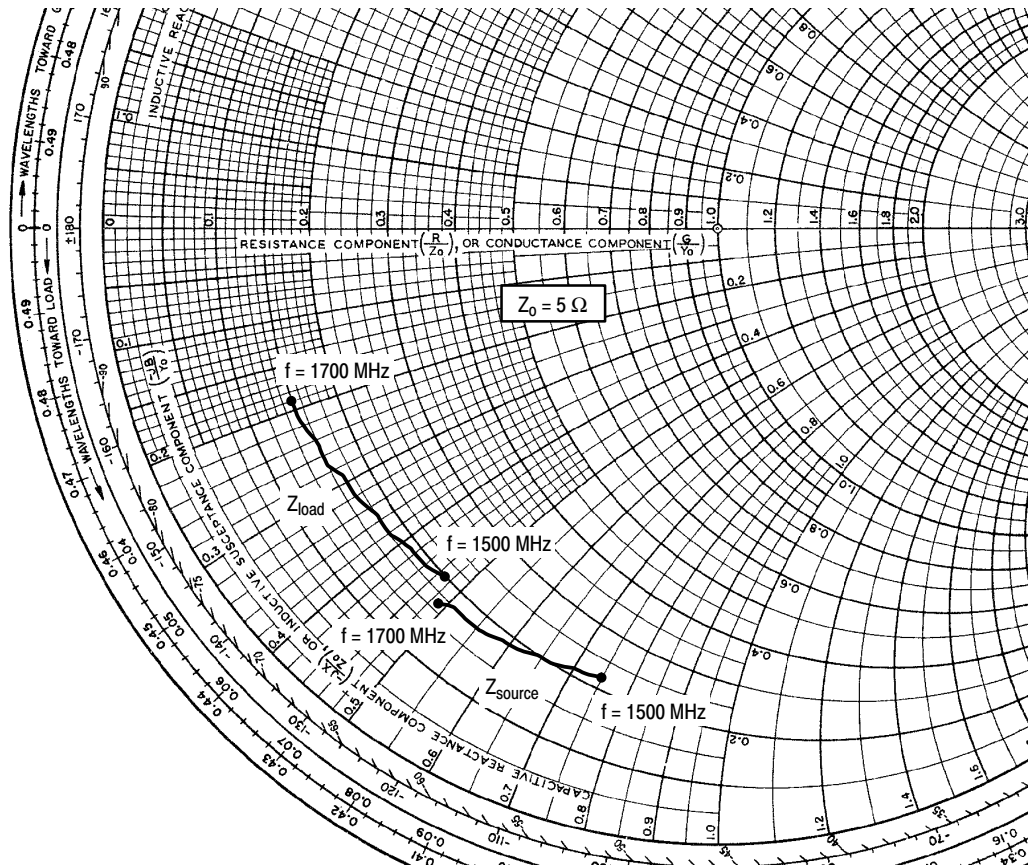


Figure 14. WiMAX Spectrum Mask Specifications



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

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.

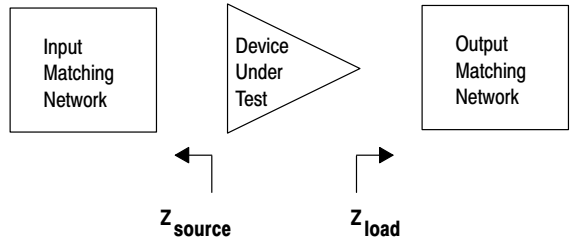
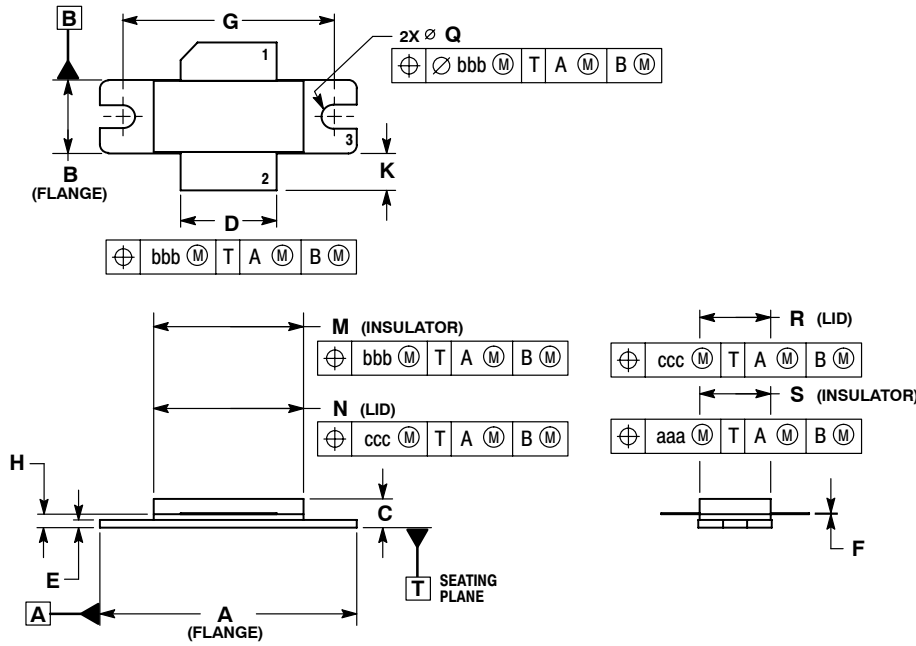


Figure 15. Series Equivalent Source and Load Impedance

PACKAGE DIMENSIONS

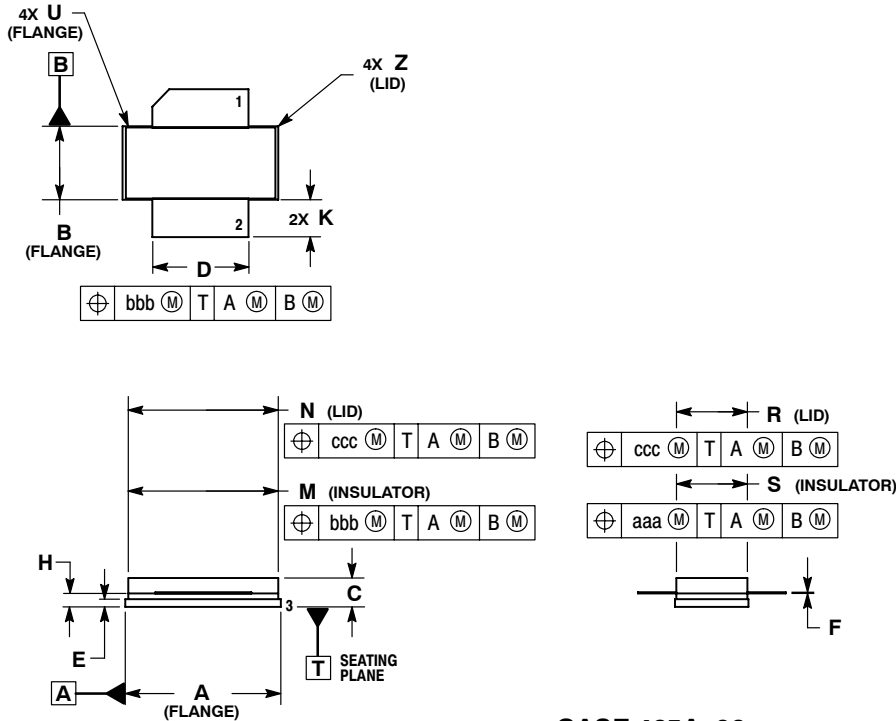


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
 2. CONTROLLING DIMENSION: INCH.
 3. DELETED
 4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

DIM	INCHES		MILLIMETERS	
	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	$\varnothing 0.118$	$\varnothing 0.138$	$\varnothing 3.00$	$\varnothing 3.51$
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:
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 2. CONTROLLING DIMENSION: INCH.
 3. DELETED
 4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

DIM	INCHES		MILLIMETERS	
	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	<ul style="list-style-type: none"> • Initial Release of Data Sheet
1	Dec. 2008	<ul style="list-style-type: none"> • 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

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