



RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

Designed for WiMAX base station applications with frequencies up to 2700 MHz. Suitable for WiMAX, WiBro, BWA, and OFDM multicarrier Class AB and Class C amplifier applications.

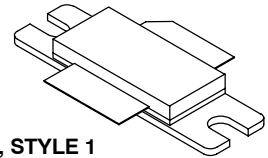
- Typical WiMAX Performance: $V_{DD} = 28$ Volts, $I_{DQ} = 1500$ mA, $P_{out} = 23$ Watts Avg., $f = 2500$ and 2700 MHz, 802.16d, 64 QAM $3/4$, 4 bursts, 7 MHz Channel Bandwidth, Input Signal PAR = 9.5 dB @ 0.01% Probability on CCDF.
Power Gain — 16.5 dB
Drain Efficiency — 20%
Device Output Signal PAR — 8.2 dB @ 0.01% Probability on CCDF
ACPR @ 5.25 MHz Offset — -49 dBc in 0.5 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 32 Vdc, 2600 MHz, 105 Watts CW Output Power

Features

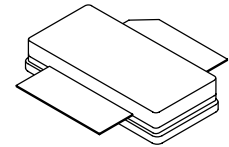
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

MRF7S27130HR3
MRF7S27130HSR3

2500-2700 MHz, 23 W AVG., 28 V
WiMAX
LATERAL N-CHANNEL
RF POWER MOSFETs



CASE 465-06, STYLE 1
NI-780
MRF7S27130HR3



CASE 465A-06, STYLE 1
NI-780S
MRF7S27130HSR3

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-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
CW Operation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	CW	150 0.83	W W/°C

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case Case Temperature 80°C , 104 W CW Case Temperature 69°C , 23 W CW	$R_{\theta JC}$	0.32 0.36	°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)	1B (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 ($V_{DS} = 28\text{ Vdc}$, $I_D = 1500\text{ mAdc}$)	$V_{GS(Q)}$	—	2.7	—	Vdc
Fixture Gate Quiescent Voltage ⁽¹⁾ ($V_{DD} = 28\text{ Vdc}$, $I_D = 1500\text{ mAdc}$, Measured in Functional Test)	$V_{GG(Q)}$	4	5.4	7	Vdc
Drain-Source On-Voltage ($V_{GS} = 10\text{ Vdc}$, $I_D = 3.4\text{ Adc}$)	$V_{DS(on)}$	0.1	0.24	0.3	Vdc

Dynamic Characteristics ⁽²⁾

Reverse Transfer Capacitance ($V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{rss}	—	10.4	—	pF
Output Capacitance ($V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{oss}	—	711	—	pF
Input Capacitance ($V_{DS} = 28\text{ Vdc}$, $V_{GS} = 0\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz)	C_{iss}	—	326	—	pF

Functional Tests (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$, $I_{DQ} = 1500\text{ mA}$, $P_{out} = 23\text{ W Avg.}$, $f = 2500\text{ MHz}$ and $f = 2700\text{ MHz}$, 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}	15	16.5	18.5	dB
Drain Efficiency	η_D	18	20	23	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	7.5	8.2	—	dB
Adjacent Channel Power Ratio	ACPR	—	-49	-46	dBc
Input Return Loss	IRL	—	-8	-5	dB

- $V_{GG} = 2 \times V_{GS(Q)}$. Parameter measured on Freescale Test Fixture, due to resistive divider network on the board. Refer to Test Circuit schematic.
- Part internally matched both on input and output.

(continued)

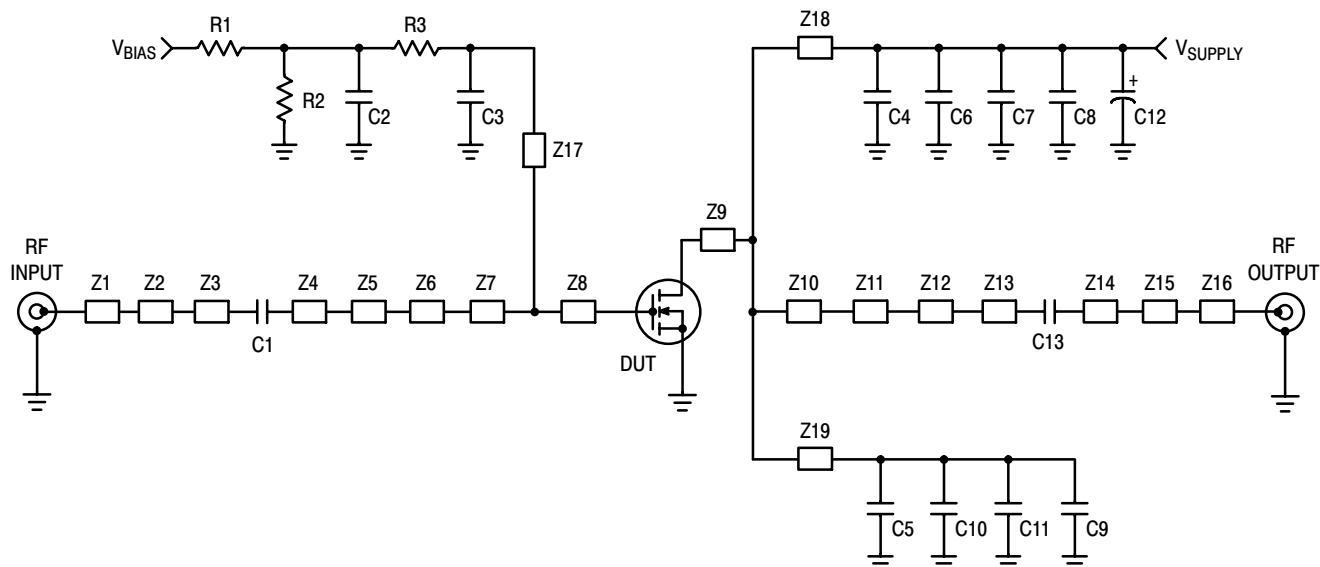
Table 4. Electrical Characteristics ($T_C = 25^\circ\text{C}$ unless otherwise noted) (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
Typical Performances OFDM Signal (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$, $I_{DQ} = 1500\text{ mA}$, $P_{out} = 23\text{ W Avg.}$, $f = 2500\text{ MHz}$ and $f = 2700\text{ MHz}$, 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 @ $P_{out} = 23\text{ W Avg.}$ 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 -40 -44 -60 -60	—	dBc
Relative Constellation Error @ $P_{out} = 23\text{ W Avg.}$ (1)	RCE	—	-33	—	dB
Error Vector Magnitude (1) (Typical EVM Performance @ $P_{out} = 23\text{ W Avg.}$ with OFDM 802.16d Signal Call)	EVM	—	2.2	—	% rms

Typical Performances (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$, $I_{DQ} = 1500\text{ mA}$, 2500-2700 MHz Bandwidth

Video Bandwidth @ 105 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	—	40	—	MHz
Gain Flatness in 200 MHz Bandwidth @ $P_{out} = 23\text{ W Avg.}$	G_F	—	1.2	—	dB
Average Deviation from Linear Phase in 200 MHz Bandwidth @ $P_{out} = 105\text{ W CW}$	Φ	—	135	—	°
Average Group Delay @ $P_{out} = 105\text{ W CW}$, $f = 2600\text{ MHz}$	Delay	—	1.5	—	ns
Part-to-Part Insertion Phase Variation @ $P_{out} = 105\text{ W CW}$, $f = 2600\text{ MHz}$, Six Sigma Window	$\Delta\Phi$	—	81.3	—	°
Gain Variation over Temperature (-30°C to $+85^\circ\text{C}$)	ΔG	—	0.013	—	dB/°C
Output Power Variation over Temperature (-30°C to $+85^\circ\text{C}$)	ΔP_{1dB}	—	0.01	—	dBm/°C

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



Z1	0.320" x 0.084" Microstrip	Z11	0.251" x 0.084" Microstrip
Z2	0.380" x 0.240" Microstrip	Z12	0.160" x 0.162" Microstrip
Z3	0.046" x 0.084" Microstrip	Z13	0.566" x 0.084" Microstrip
Z4	0.273" x 0.084" Microstrip	Z14	0.059" x 0.084" Microstrip
Z5	0.360" x 0.600" Microstrip	Z15	0.080" x 0.123" Microstrip
Z6	0.260" x 0.394" Microstrip	Z16	0.583" x 0.084" Microstrip
Z7	0.145" x 0.922" Microstrip	Z17*	0.950" x 0.100" Microstrip
Z8	0.455" x 0.922" Microstrip	Z18, Z19*	0.560" x 0.100" Microstrip
Z9	0.106" x 0.716" Microstrip	PCB	Taconic TLX8-0300, 0.030", $\epsilon_r = 2.55$
Z10	0.413" x 0.716" Microstrip		

* Variable for tuning

Figure 1. MRF7S27130HR3(HSR3) Test Circuit Schematic

Table 5. MRF7S27130HR3(HSR3) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1	2 pF Chip Capacitor	ATC100B2R0BT500XT	ATC
C2, C6, C7, C8, C9, C10, C11	10 μ F, 50 V Chip Capacitors	C5750X5R1H106M	TDK
C3	3 pF Chip Capacitor	ATC100B3R0BT500XT	ATC
C4, C5	3.6 pF Chip Capacitors	ATC100B3R6BT500XT	ATC
C12	470 μ F, 63 V Electrolytic Capacitor, Radial	EKME630ELL471MK25S	Nippon Chemi-Con
C13	5.6 pF Chip Capacitor	ATC100B5R6BT500XT	ATC
R1, R2	2 K Ω , 1/4 W Chip Resistors	CRCW12062001FKEA	Vishay
R3	10 Ω , 1/4 W Chip Resistor	CRCW120610R1FKEA	Vishay

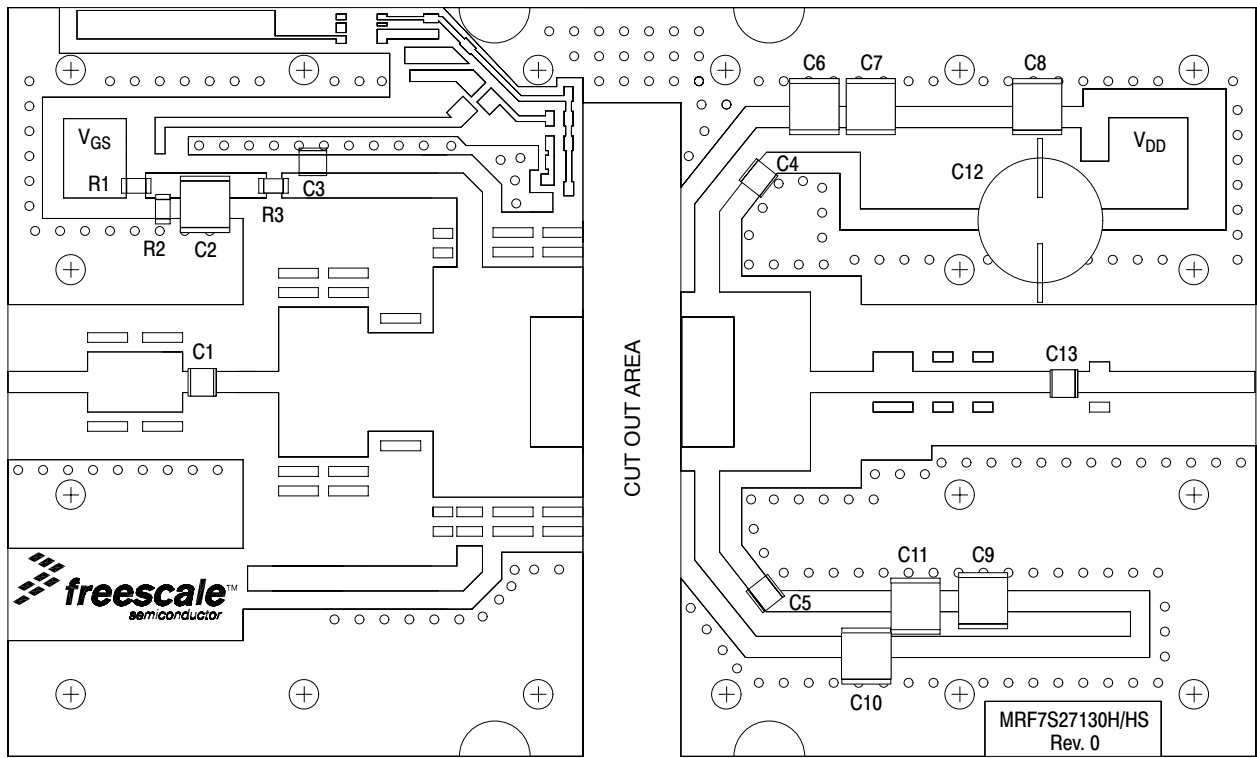


Figure 2. MRF7S27130HR3(HSR3) Test Circuit Component Layout

TYPICAL CHARACTERISTICS

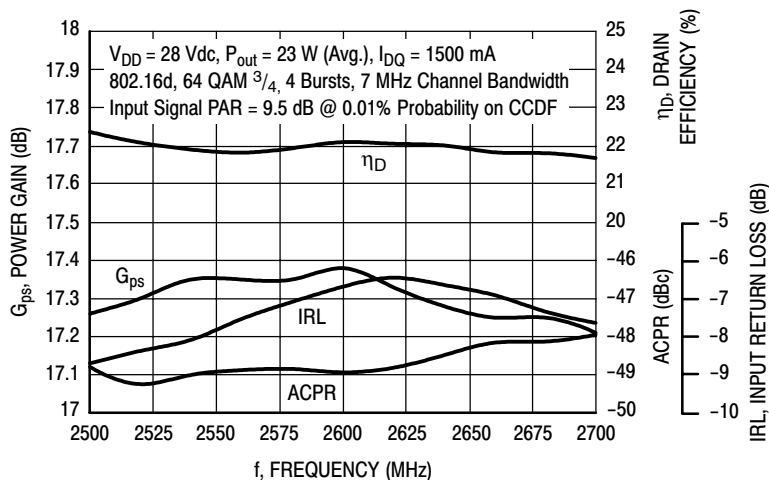


Figure 3. WiMAX Broadband Performance @ $P_{out} = 23$ Watts Avg.

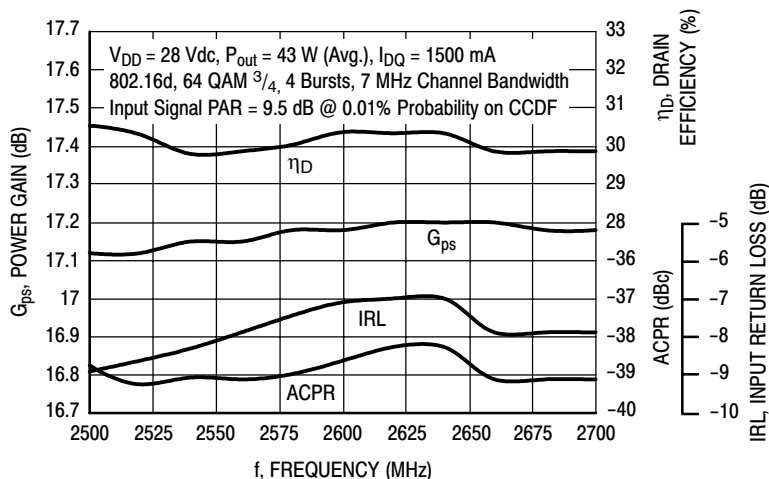


Figure 4. WiMAX Broadband Performance @ $P_{out} = 43$ Watts Avg.

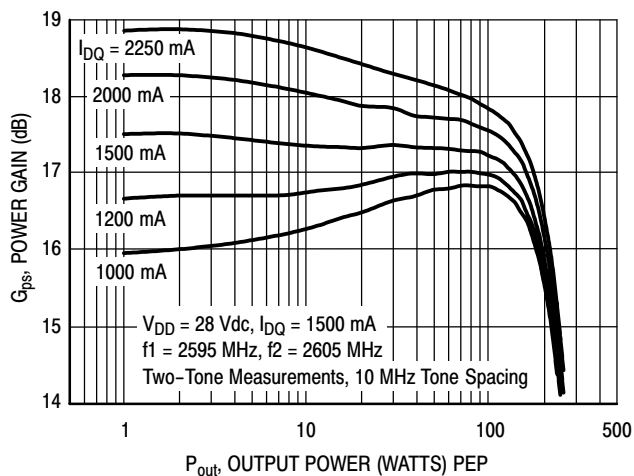


Figure 5. Two-Tone Power Gain versus Output Power

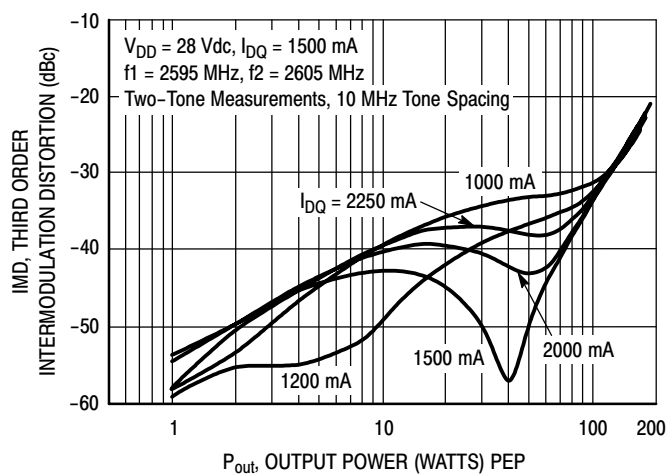


Figure 6. Third Order Intermodulation Distortion versus Output Power

TYPICAL CHARACTERISTICS

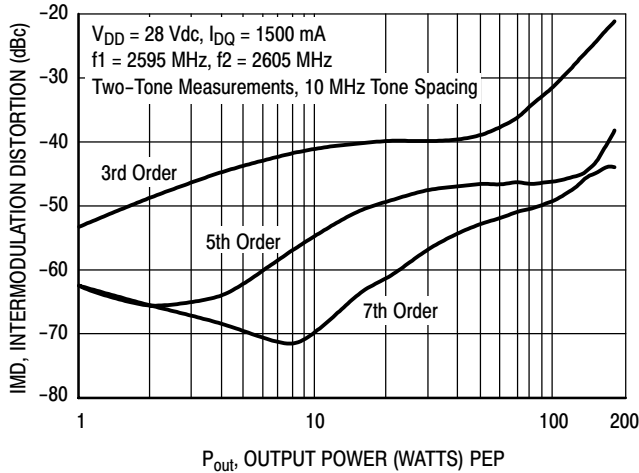


Figure 7. Intermodulation Distortion Products versus Output Power

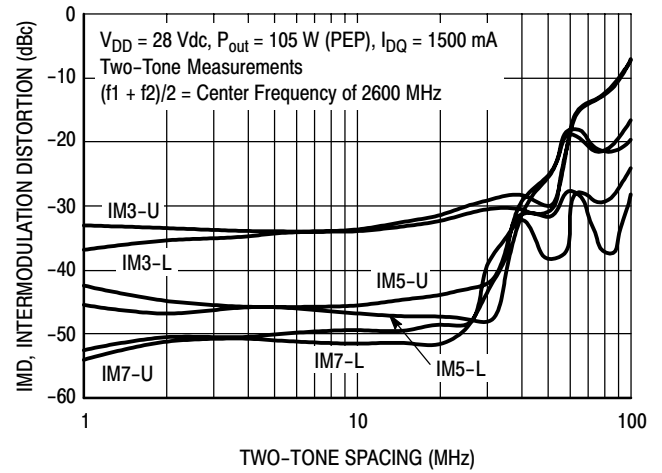


Figure 8. Intermodulation Distortion Products versus Tone Spacing

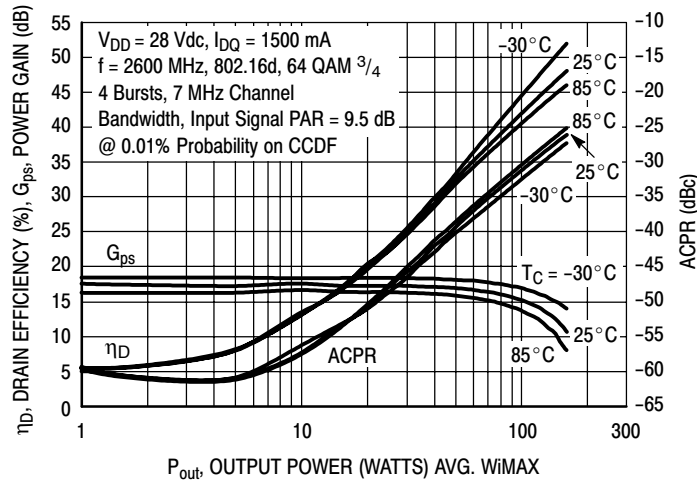


Figure 9. WiMAX, ACPR, Power Gain and Drain Efficiency versus Output Power

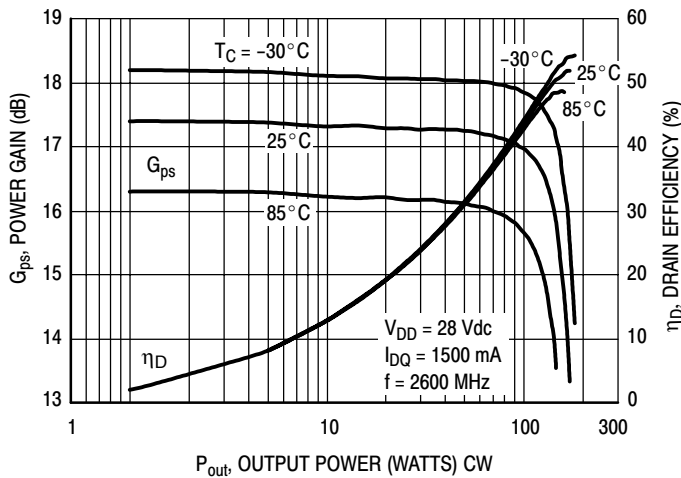


Figure 10. Power Gain and Drain Efficiency versus CW Output Power

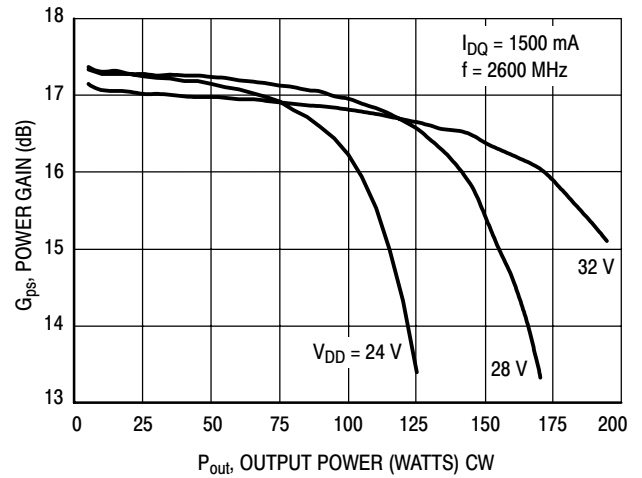
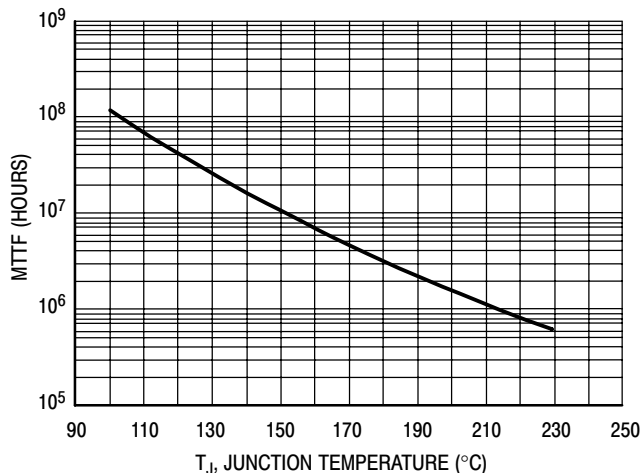


Figure 11. Power Gain versus Output Power

TYPICAL CHARACTERISTICS



This above graph displays calculated MTTF in hours when the device is operated at $V_{DD} = 28$ Vdc, $P_{out} = 23$ W Avg., and $\eta_D = 20\%$.

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

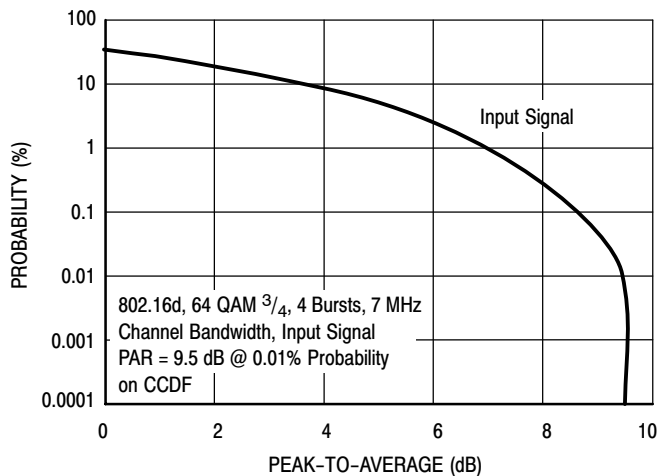


Figure 13. OFDM 802.16d Test Signal

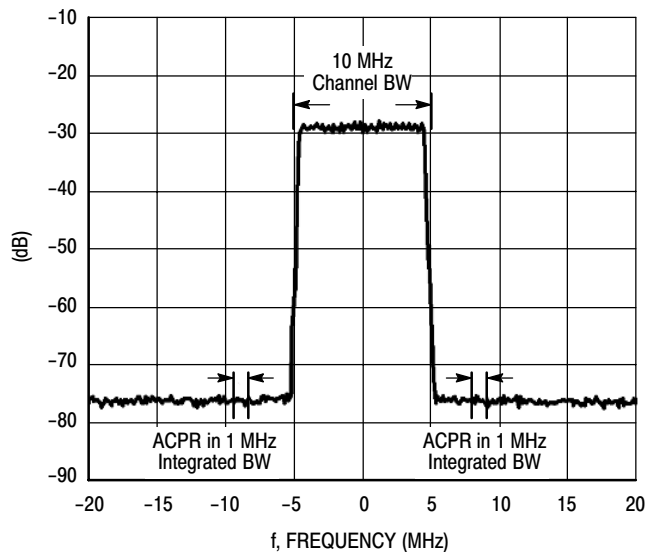
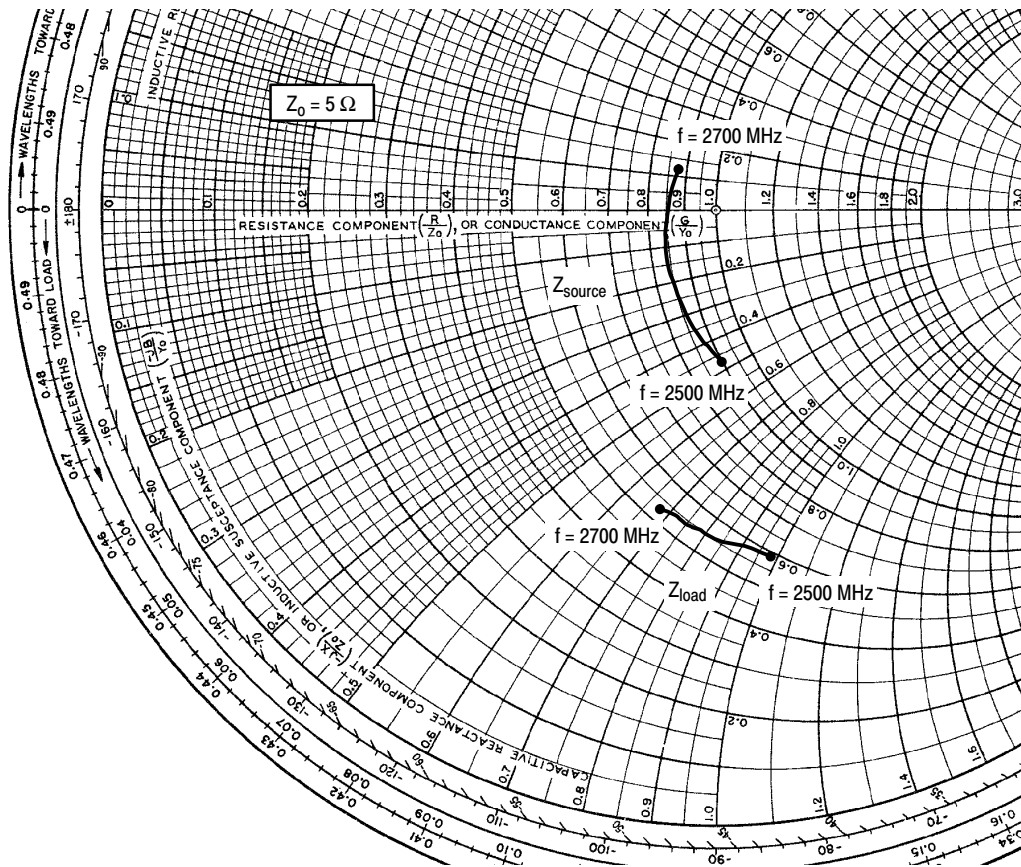


Figure 14. WiMAX Spectrum Mask Specifications



$V_{DD} = 28 \text{ Vdc}$, $I_{DQ} = 1500 \text{ mA}$, $P_{out} = 23 \text{ W Avg.}$

f MHz	Z_{source} Ω	Z_{load} Ω
2500	4.499 - j2.335	2.936 - j4.876
2525	4.382 - j1.944	2.885 - j4.666
2550	4.294 - j1.567	2.838 - j4.467
2575	4.234 - j1.194	2.797 - j4.273
2600	4.209 - j0.820	2.763 - j4.084
2625	4.219 - j0.447	2.733 - j3.903
2650	4.248 - j0.090	2.706 - j3.732
2675	4.304 + j0.261	2.678 - j3.570
2700	4.390 + j0.612	2.652 - j3.410

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

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

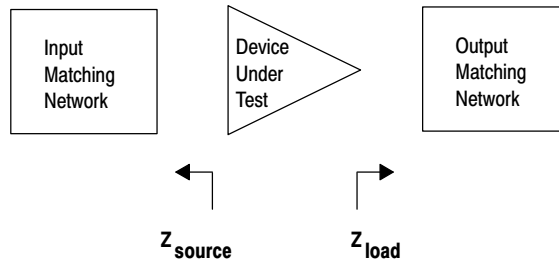
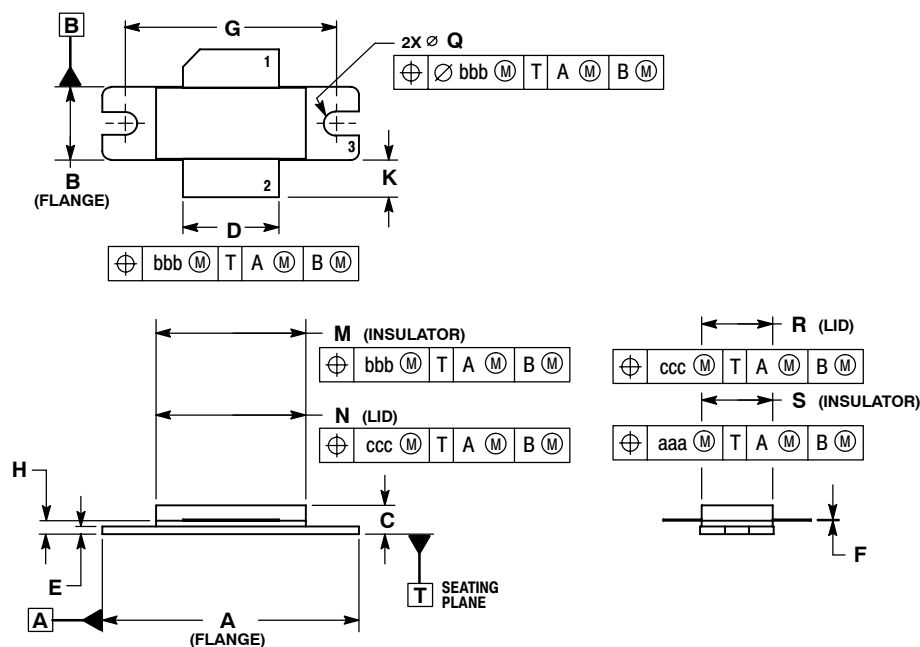


Figure 15. Series Equivalent Source and Load Impedance

PACKAGE DIMENSIONS

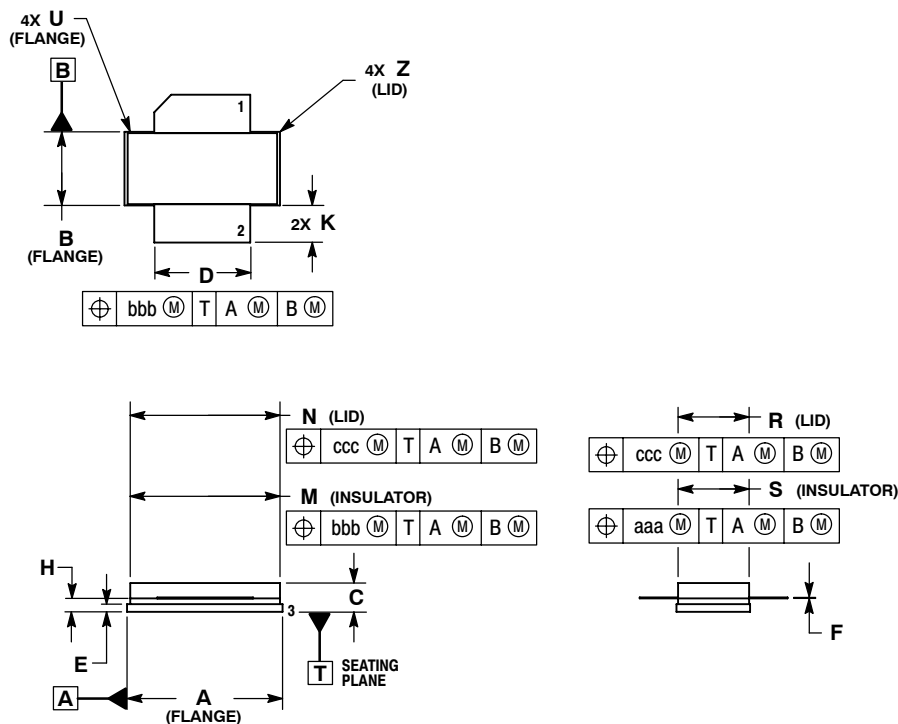


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
 2. CONTROLLING DIMENSION: INCH.
 3. DELETED
 4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

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	Ø.118	Ø.138	Ø3.00	Ø3.51
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
 MRF7S27130HR3**



- NOTES:
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 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
 MRF7S27130HSR3**

MRF7S27130HR3 MRF7S27130HSR3

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	Sept. 2007	<ul style="list-style-type: none">• Initial Release of Data Sheet
1	Dec. 2008	<ul style="list-style-type: none">• Modified Fig. 13 to display Input Signal only, p. 8• Updated Fig. 14, WiMAX Spectrum Mask Specification, to reflect the distortion free input test signal versus the distortion loaded output signal, p. 8

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