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# 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.

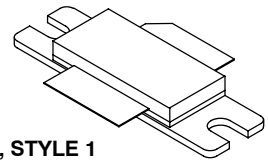
- Typical WiMAX Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 1500$  mA,  $P_{out} = 23$  Watts Avg.,  $f = 2700$  MHz, 802.16d, 64 QAM  $3/4$ , 4 bursts, 7 MHz Channel Bandwidth, Input Signal PAR = 9.5 dB @ 0.01% Probability on CCDF.
  - Power Gain — 16.5 dB
  - Drain Efficiency — 20%
  - Device Output 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

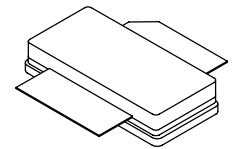
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units, 56 mm Tape Width, 13 inch Reel. For R5 Tape and Reel option, see p. 14.

**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** ( $T_A = 25^\circ\text{C}$  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	$\mu\text{Adc}$
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	$\mu\text{Adc}$

**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)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1500\text{ mA}$ ,  $P_{out} = 23\text{ W Avg.}$ ,  $f = 2700\text{ MHz}$ , 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	$\eta_D$	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)

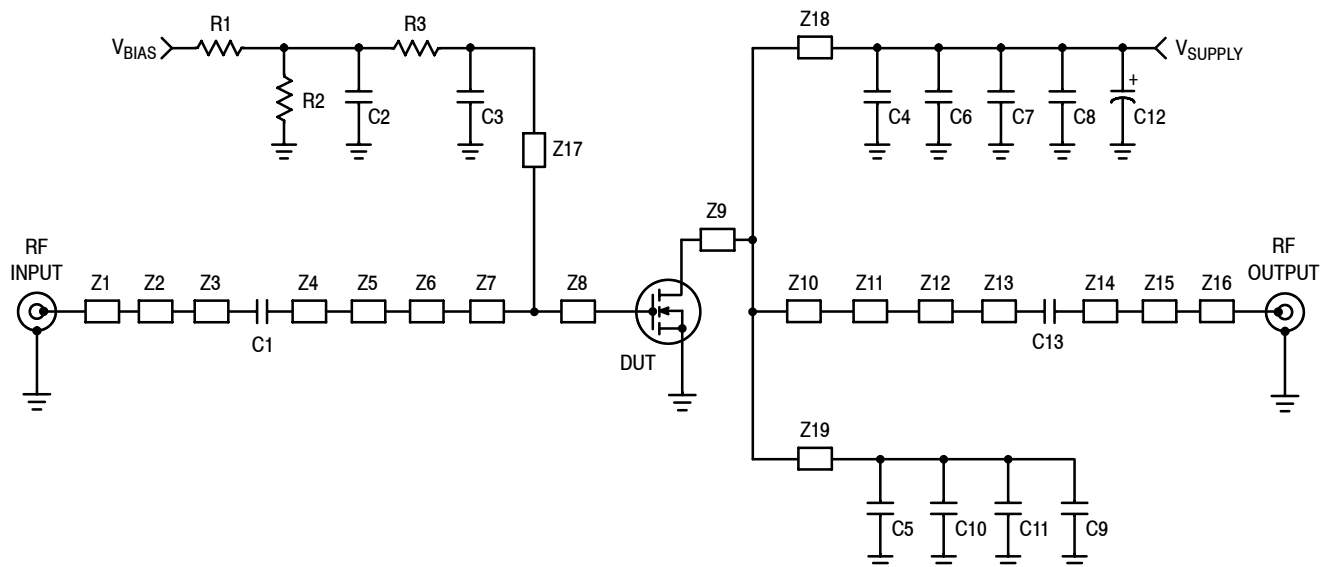
**Table 4. Electrical Characteristics** ( $T_A = 25^\circ\text{C}$  unless otherwise noted) (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Typical Performances OFDM Signal</b> (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 @ $P_{out} = 105\text{ W CW}$	$\Phi$	—	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 ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta G$	—	0.013	—	dB/°C
Output Power Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta P_{1dB}$	—	0.01	—	dB/°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 $\mu$ 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 $\mu$ F, 63 V Electrolytic Capacitor, Radial	EKME630ELL471MK255	Multicomp
C13	5.6 pF Chip Capacitor	ATC100B5R6BT500XT	ATC
R1, R2	2 K $\Omega$ , 1/4 W Chip Resistors	CRCW12062001FKEA	Vishay
R3	10 $\Omega$ , 1/4 W Chip Resistor	CRCW120610R1FKEA	Vishay

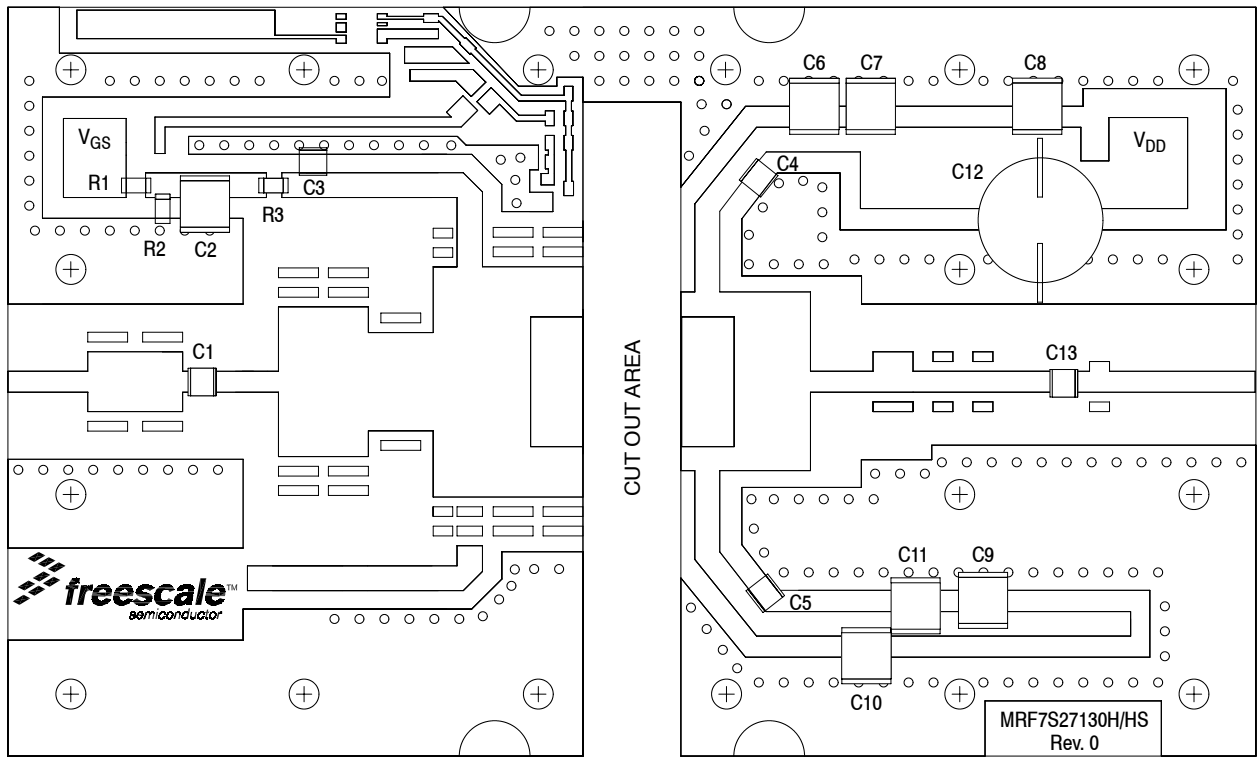


Figure 2. MRF7S27130HR3(HSR3) Test Circuit Component Layout

### TYPICAL CHARACTERISTICS

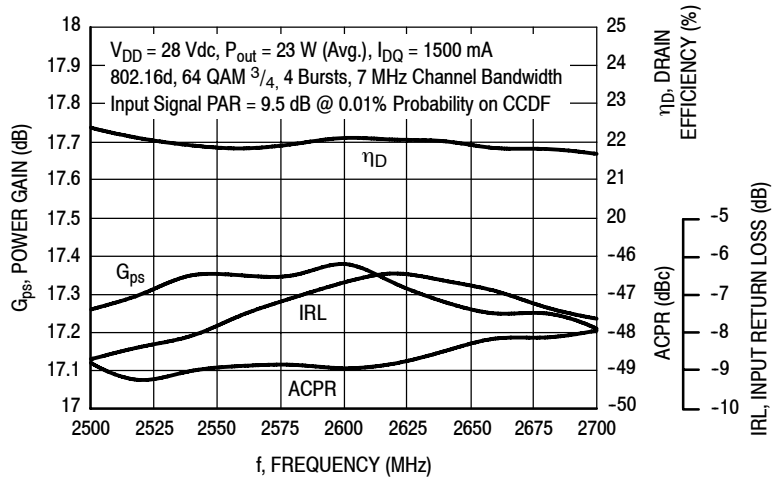


Figure 3. WiMAX Broadband Performance @  $P_{out} = 23 \text{ Watts Avg.}$

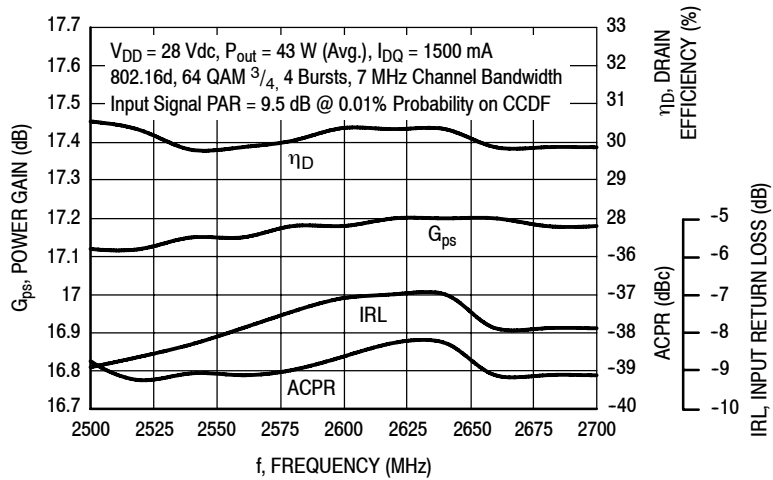


Figure 4. WiMAX Broadband Performance @  $P_{out} = 43 \text{ Watts Avg.}$

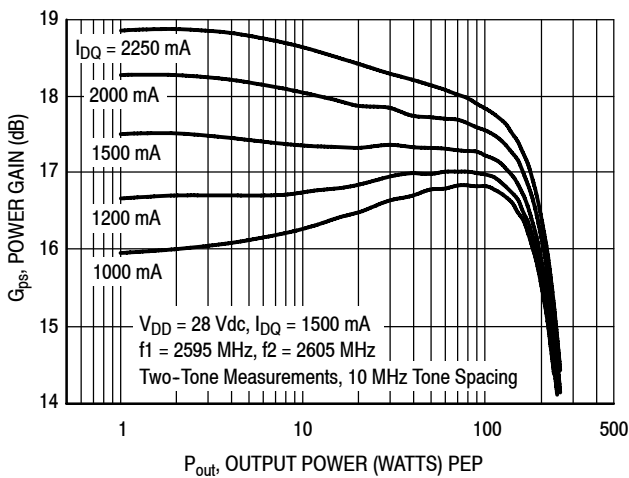


Figure 5. Two-Tone Power Gain versus Output Power

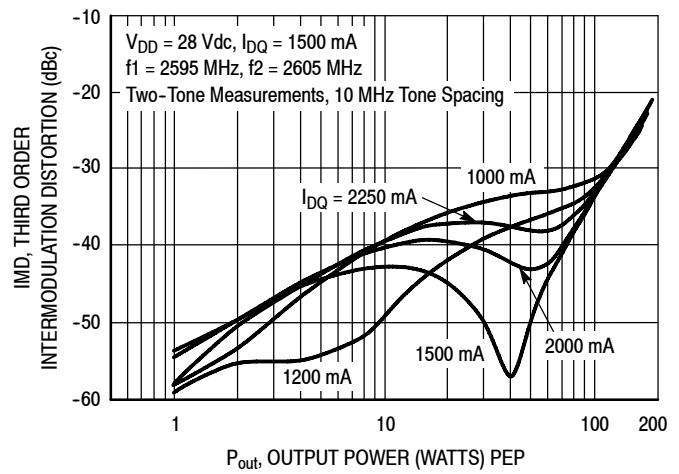
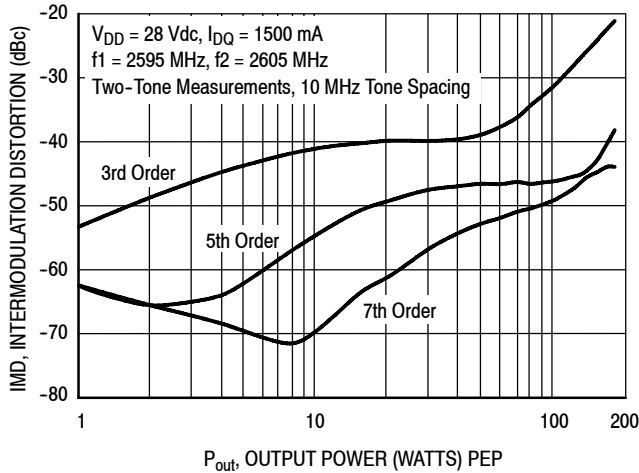
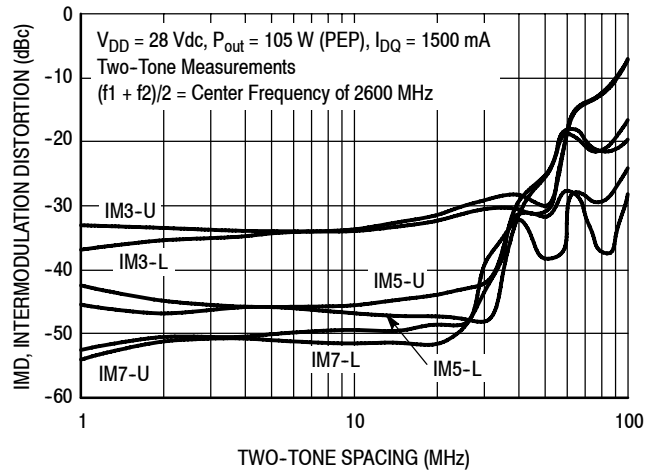


Figure 6. Third Order Intermodulation Distortion versus Output Power

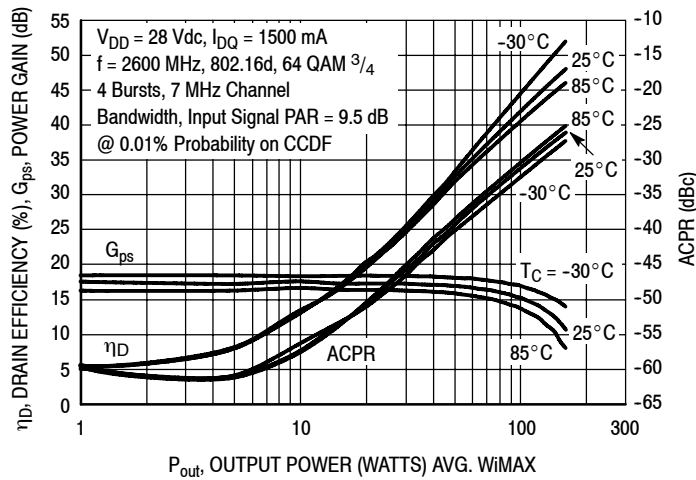
## TYPICAL CHARACTERISTICS



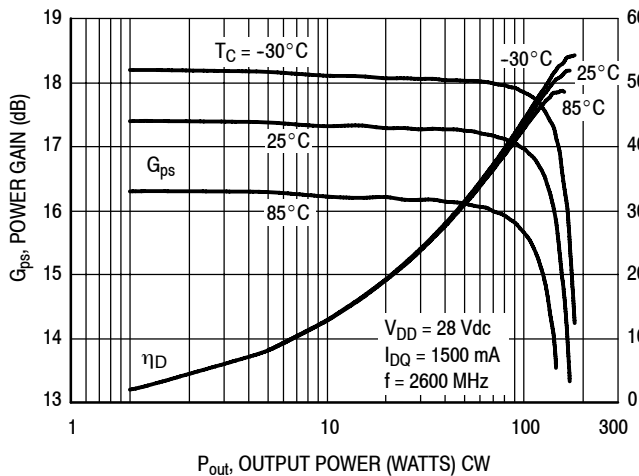
**Figure 7. Intermodulation Distortion Products versus Output Power**



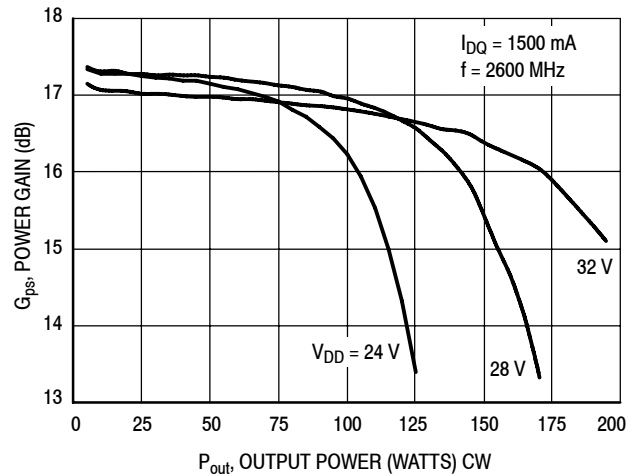
**Figure 8. Intermodulation Distortion Products versus Tone Spacing**



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



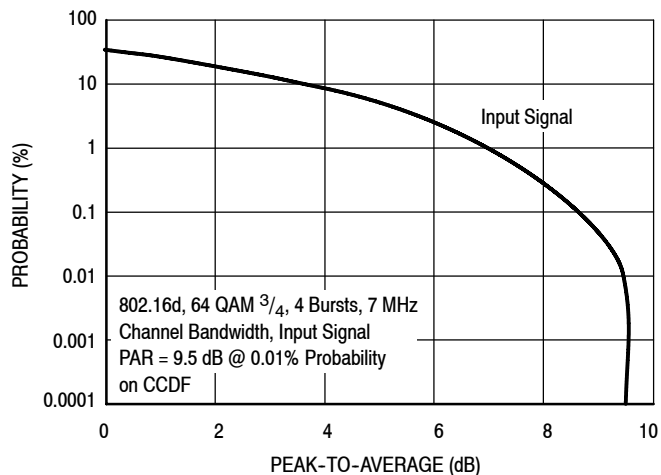
**Figure 10. Power Gain and Drain Efficiency versus CW Output Power**



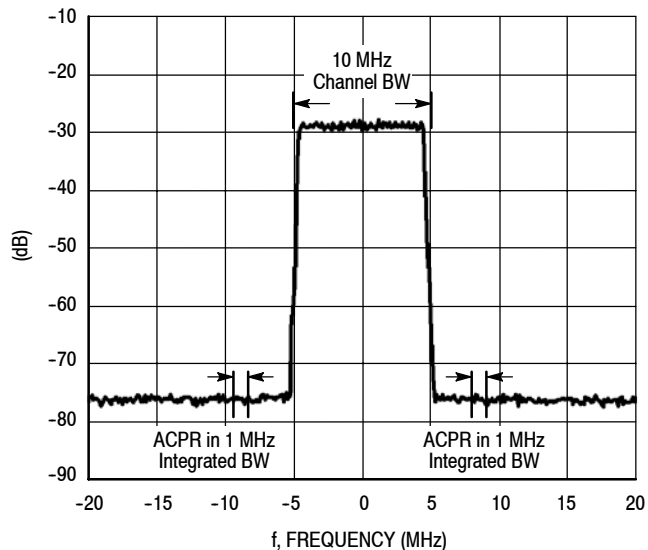
**Figure 11. Power Gain versus Output Power**



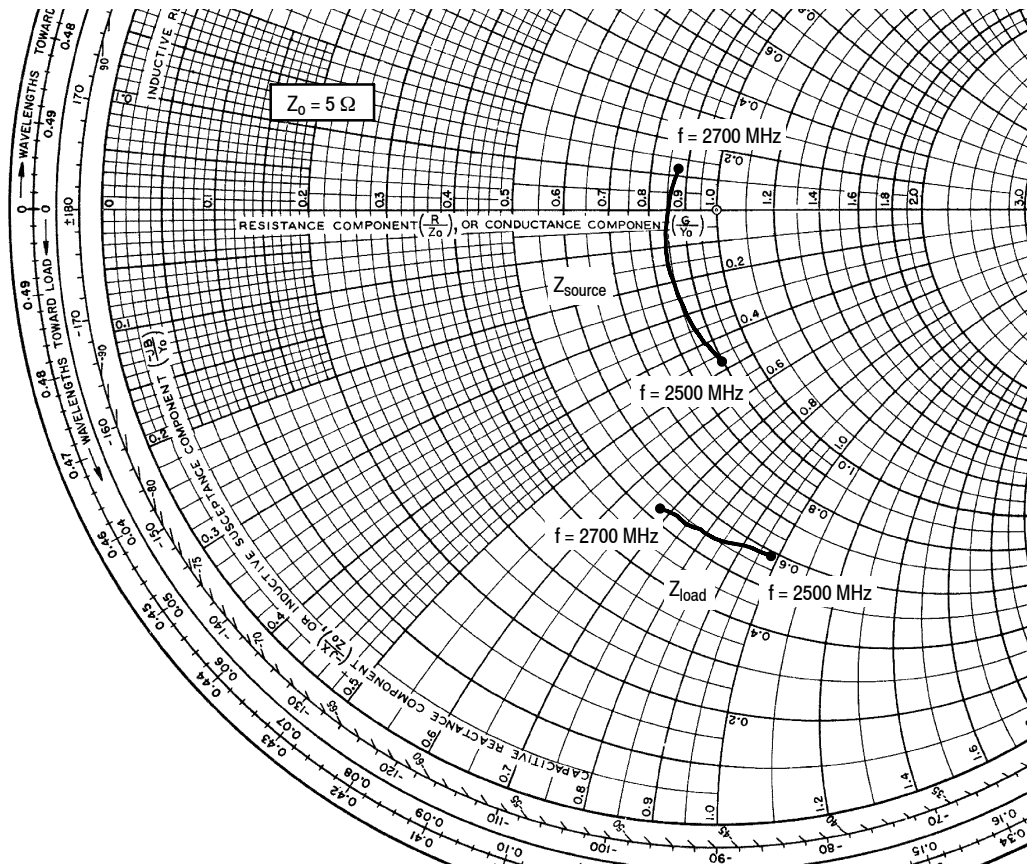
### WiMAX TEST SIGNAL



**Figure 12. OFDM 802.16d Test Signal**



**Figure 13. WiMAX Spectrum Mask Specifications**



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

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
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.

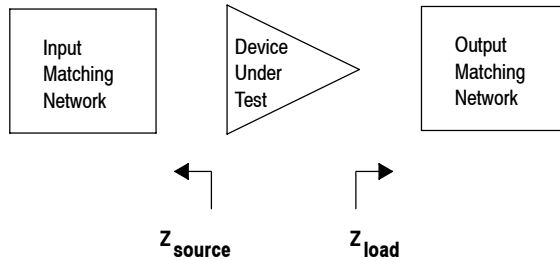
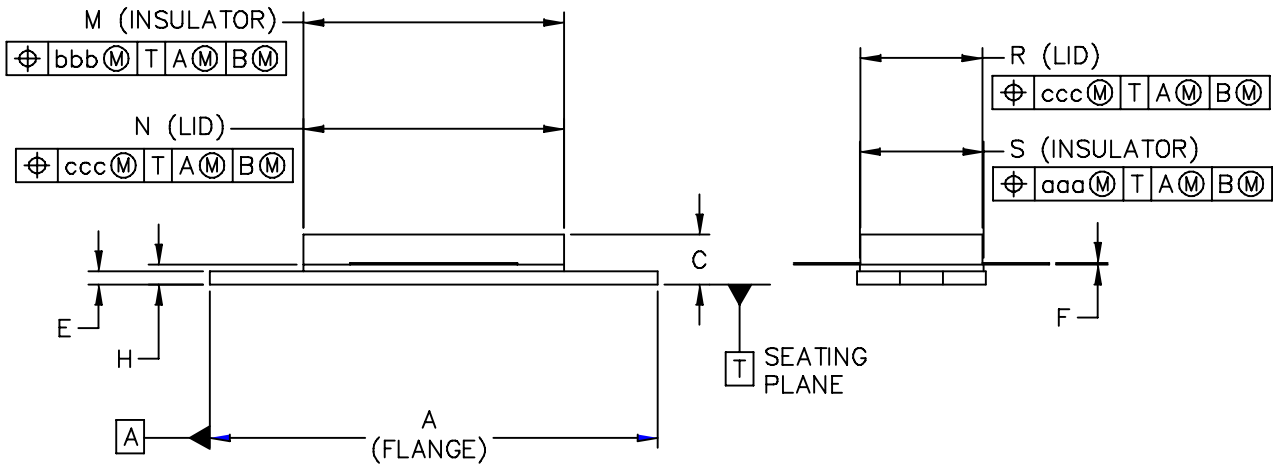
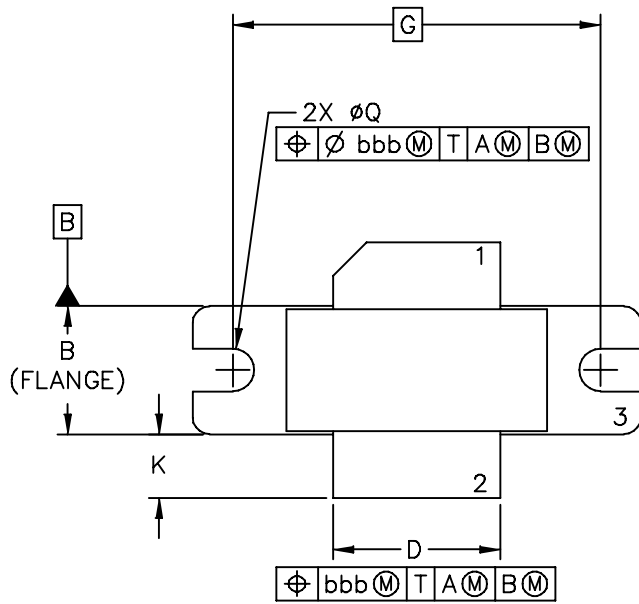


Figure 14. Series Equivalent Source and Load Impedance

PACKAGE DIMENSIONS



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	CASE NUMBER: 465-06		31 MAR 2005
	STANDARD: NON-JEDEC		

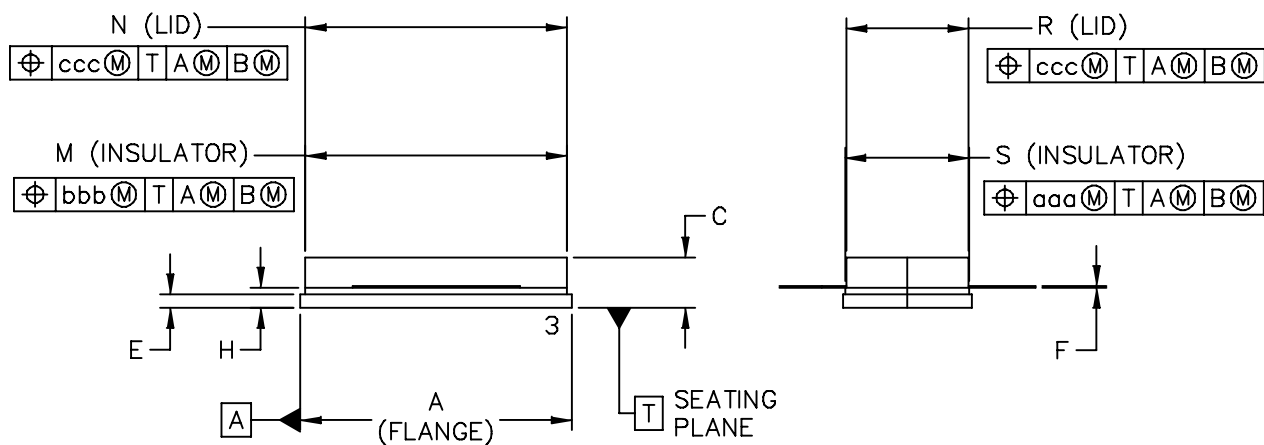
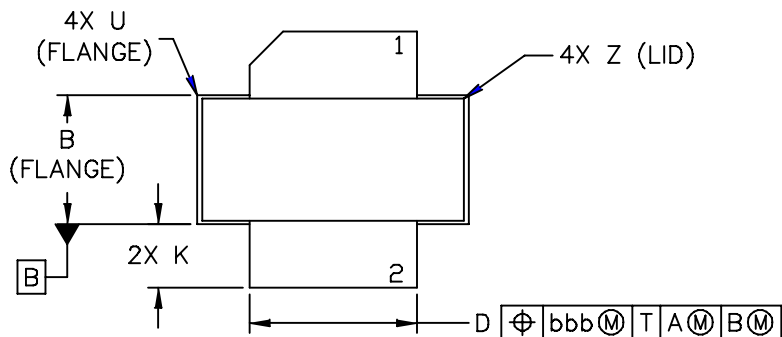
NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED .030 (.762) AWAY FROM PACKAGE BODY.

STYLE 1:

- PIN 1. DRAIN  
 2. GATE  
 3. SOURCE

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	1.335	1.345	33.91	34.16	R	.365	.375	9.27	9.53
B	.380	.390	9.65	9.91	S	.365	.375	9.27	9.52
C	.125	.170	3.18	4.32	aaa	—	.005	—	0.127
D	.495	.505	12.57	12.83	bbb	—	.010	—	0.254
E	.035	.045	0.89	1.14	ccc	—	.015	—	0.381
F	.003	.006	0.08	0.15	—	—	—	—	—
G	1.100 BSC		27.94 BSC		—	—	—	—	—
H	.057	.067	1.45	1.7	—	—	—	—	—
K	.170	.210	4.32	5.33	—	—	—	—	—
M	.774	.786	19.66	19.96	—	—	—	—	—
N	.772	.788	19.6	20	—	—	—	—	—
Q	∅.118	∅.138	∅3	∅3.51	—	—	—	—	—
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3. DELETED
4. DIMENSION H IS MEASURED .030 (0.762) AWAY FROM PACKAGE BODY.

STYLE 1:

- PIN 1. DRAIN
2. GATE
3. SOURCE

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.805	-.815	20.45	20.7	U	-	-.040	-	1.02
B	.380	-.390	9.65	9.91	Z	-	-.030	-	0.76
C	.125	-.170	3.18	4.32	aaa	-	.005	-	0.127
D	.495	-.505	12.57	12.83	bbb	-	.010	-	0.254
E	.035	-.045	0.89	1.14	ccc	-	.015	-	0.381
F	.003	-.006	0.08	0.15	-	-	-	-	-
H	.057	-.067	1.45	1.7	-	-	-	-	-
K	.170	-.210	4.32	5.33	-	-	-	-	-
M	.774	-.786	19.61	20.02	-	-	-	-	-
N	.772	-.788	19.61	20.02	-	-	-	-	-
R	.365	-.375	9.27	9.53	-	-	-	-	-
S	.365	-.375	9.27	9.52	-	-	-	-	-

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TITLE:  NI-780S		DOCUMENT NO: 98ASB16718C		REV: H	
		CASE NUMBER: 465A-06		31 MAR 2005	
		STANDARD: NON-JEDEC			

## PRODUCT DOCUMENTATION AND SOFTWARE

Refer to the following documents and software 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

### Software

- Electromigration MTTF Calculator
- RF High Power Model

For Software, do a Part Number search at <http://www.freescale.com>, and select the "Part Number" link. Go to the Software & Tools tab on the part's Product Summary page to download the respective tool.

## R5 TAPE AND REEL OPTION

R5 Suffix = 50 Units, 56 mm Tape Width, 13 inch Reel.

The R5 tape and reel option for MRF7S27130H and MRF7S27130HS parts will be available for 2 years after release of MRF7S27130H and MRF7S27130HS. Freescale Semiconductor, Inc. reserves the right to limit the quantities that will be delivered in the R5 tape and reel option. At the end of the 2 year period customers who have purchased these devices in the R5 tape and reel option will be offered MRF7S27130H and MRF7S27130HS in the R3 tape and reel option.

## REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	Sept. 2007	<ul style="list-style-type: none"> <li>• Initial Release of Data Sheet</li> </ul>
1	Dec. 2008	<ul style="list-style-type: none"> <li>• Modified Fig. 13 to display Input Signal only, p. 8</li> <li>• Updated Fig. 14, WiMAX Spectrum Mask Specification, to reflect the distortion free input test signal versus the distortion loaded output signal, p. 8</li> </ul>
2	Mar. 2011	<ul style="list-style-type: none"> <li>• Modified data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN13628, p. 1, 2</li> <li>• Fig. 12, MTTF versus Junction Temperature removed, p. 8. Refer to the device's MTTF Calculator available at <a href="http://freescale.com/RFpower">freescale.com/RFpower</a>. Go to Design Resources &gt; Software and Tools.</li> <li>• Added Electromigration MTTF Calculator and RF High Power Model availability to Product Software, p. 14</li> </ul>

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