



# RF Power LDMOS Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

These 50 watt RF power LDMOS transistors are designed for cellular base station applications covering the frequency range of 2110 to 2170 MHz.

- Typical Single-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 1500$  mA,  $P_{out} = 50$  Watts Avg., Input Signal PAR = 9.9 dB @ 0.01% Probability on CCDF.

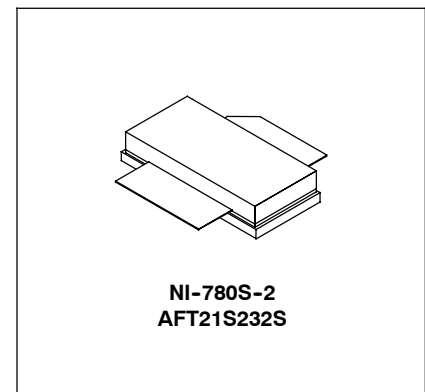
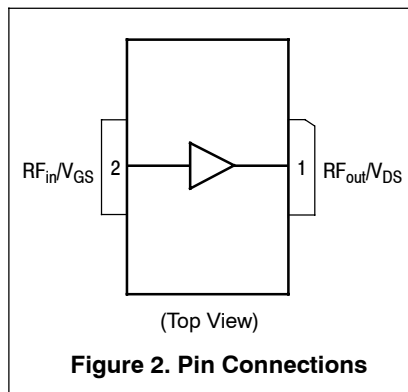
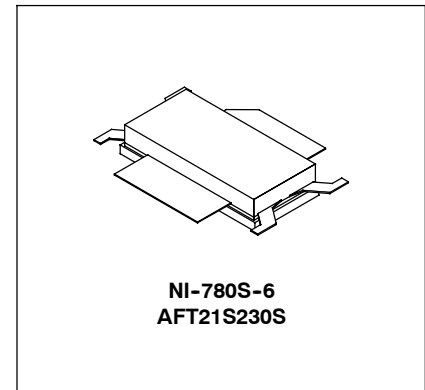
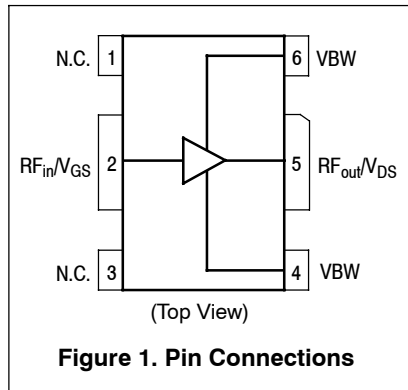
Frequency	$G_{ps}$ (dB)	$\eta_D$ (%)	Output PAR (dB)	ACPR (dBc)	IRL (dB)
2110 MHz	16.7	30.5	7.2	-35.7	-19
2140 MHz	17.0	31.0	7.1	-35.4	-20
2170 MHz	17.2	31.8	7.0	-34.8	-15

**AFT21S230SR3**  
**AFT21S232SR3**

**2110-2170 MHz, 50 W AVG., 28 V**

### Features

- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- Designed for Digital Predistortion Error Correction Systems
- Optimized for Doherty Applications
- NI-780S-6: R3 Suffix = 250 Units, 32 mm Tape Width, 13 inch Reel.
- NI-780S-2: R3 Suffix = 250 Units, 56 mm Tape Width, 13 inch Reel.  
 For R5 Tape and Reel options, see p. 18.



**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 Range	$T_C$	-40 to +150	°C
Operating Junction Temperature Range (1,2)	$T_J$	-40 to +225	°C
CW Operation @ $T_C = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	CW	163 0.79	W W/°C

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case Case Temperature $80^\circ\text{C}$ , 50 W CW, 28 Vdc, $I_{DQ} = 1500\text{ mA}$ , 2110 MHz Case Temperature $86^\circ\text{C}$ , 140 W CW(4), 28 Vdc, $I_{DQ} = 1500\text{ mA}$ , 2110 MHz	$R_{\theta JC}$	0.43 0.38	°C/W

**Table 3. ESD Protection Characteristics**

Test Methodology	Class
Human Body Model (per JESD22-A114)	2
Machine Model (per EIA/JESD22-A115)	B
Charge Device Model (per JESD22-C101)	IV

**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 ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 291\ \mu\text{Adc}$ )	$V_{GS(th)}$	1.5	2.0	2.5	Vdc
Gate Quiescent Voltage ( $V_{DD} = 28\text{ Vdc}$ , $I_D = 1500\text{ mAdc}$ , Measured in Functional Test)	$V_{GS(Q)}$	2.2	2.7	3.2	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 3.7\text{ Adc}$ )	$V_{DS(on)}$	0.1	0.2	0.3	Vdc

**Functional Tests** (5) (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1500\text{ mA}$ ,  $P_{out} = 50\text{ W Avg.}$ ,  $f = 2110\text{ MHz}$ , Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 9.9 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5\text{ MHz}$  Offset.

Power Gain	$G_{ps}$	16.0	16.7	19.0	dB
Drain Efficiency	$\eta_D$	29.0	30.5	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	6.7	7.2	—	dB
Adjacent Channel Power Ratio	ACPR	—	-35.7	-34.0	dBc
Input Return Loss	IRL	—	-19	-10	dB

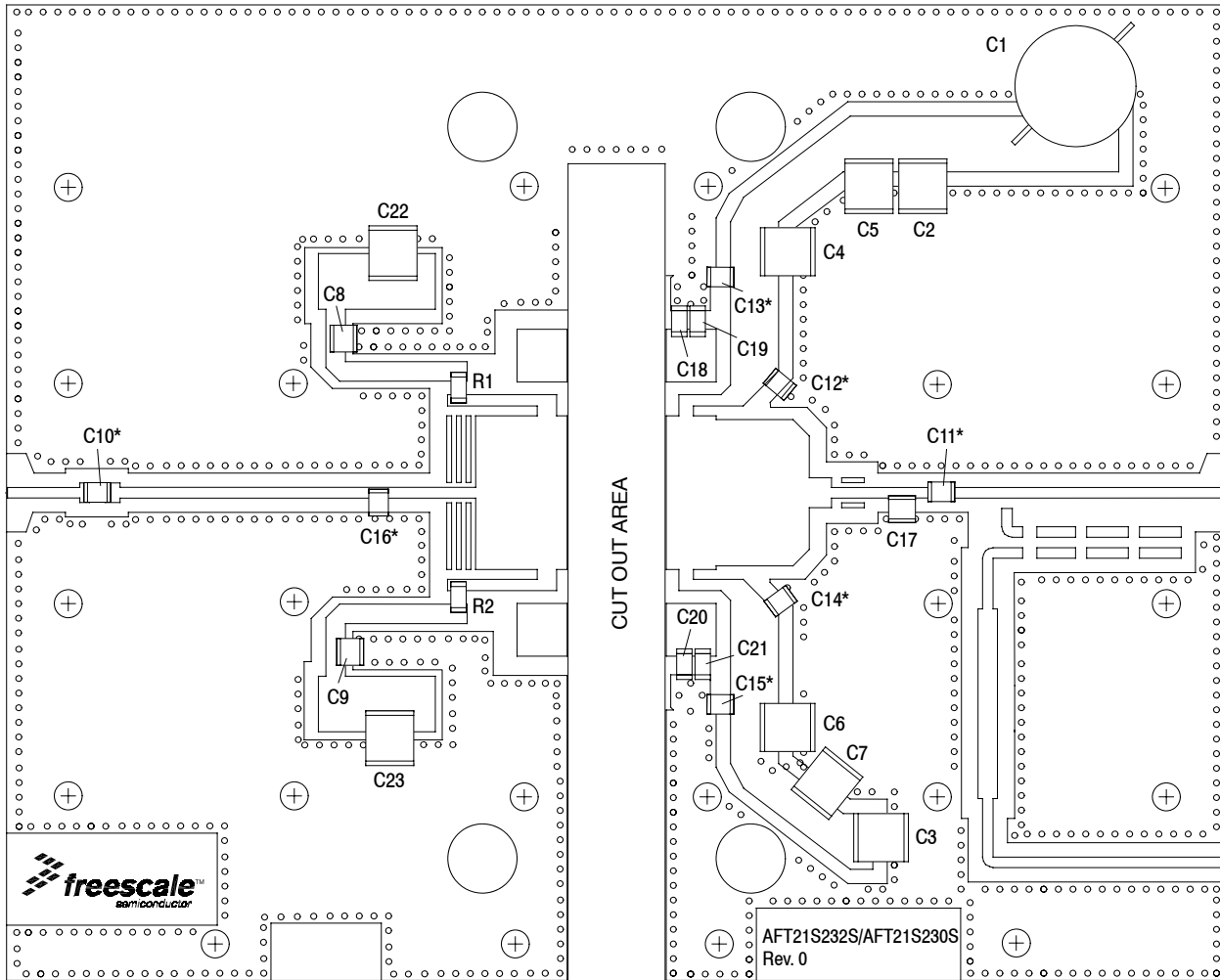
1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
3. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1955.
4. Exceeds recommended operating conditions. See CW operation data in Maximum Ratings table.
5. 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>Load Mismatch</b> (In Freescale Test Fixture, 50 ohm system) $I_{DQ} = 1500\text{ mA}$ , $f = 2140\text{ MHz}$					
VSWR 10:1 at 32 Vdc, 269 W CW Output Power (3 dB Input Overdrive from 182 W CW Rated Power)	No Device Degradation				
<b>Typical Performance</b> (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$ , $I_{DQ} = 1500\text{ mA}$ , 2110–2170 MHz Bandwidth					
$P_{out}$ @ 1 dB Compression Point, CW	P1dB	—	182 (1)	—	W
AM/PM (Maximum value measured at the P3dB compression point across the 2110–2170 MHz bandwidth)	$\Phi$	—	-19.3	—	°
VBW Resonance Point (IMD Third Order Intermodulation Inflection Point)	VBW <sub>res</sub>	—		—	MHz
			95 60		
Gain Flatness in 60 MHz Bandwidth @ $P_{out} = 50\text{ W Avg.}$	$G_F$	—	0.5	—	dB
Gain Variation over Temperature (-30°C to +85°C)	$\Delta G$	—	0.016	—	dB/°C
Output Power Variation over Temperature (-30°C to +85°C) (1)	$\Delta P1dB$	—	0.007	—	dB/°C

1. Exceeds recommended operating conditions. See CW operation data in Maximum Ratings table.



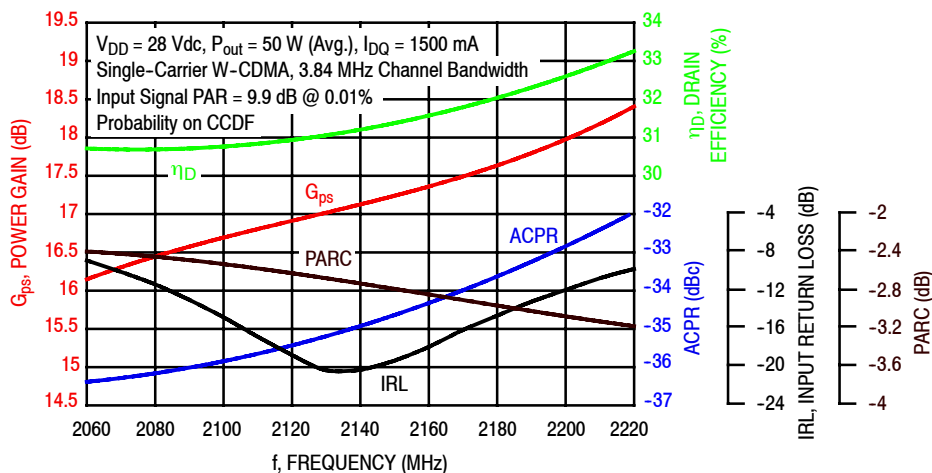
\*C10, C11, C12, C13, C14, C15 and C16 are mounted vertically.

Figure 3. AFT21S230SR3(232SR3) Test Circuit Component Layout

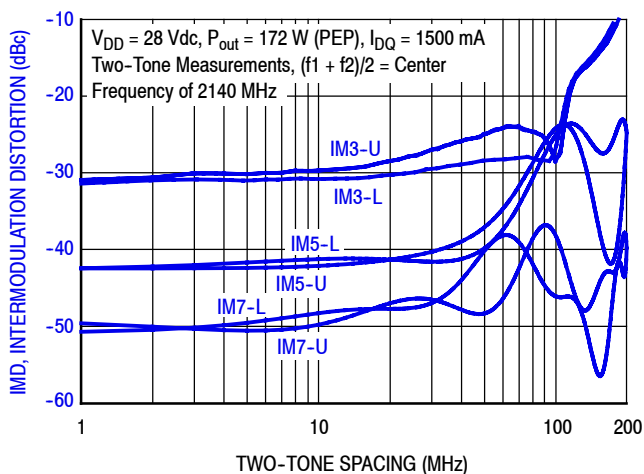
Table 5. AFT21S230SR3(232SR3) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1	470 $\mu$ F, 63 V Electrolytic Capacitor	B41694A5477Q7	EPCOS
C2, C3, C4, C5, C6, C7, C22, C23	10 $\mu$ F, 100 V Chip Capacitors	C5750X7S2A106M	TDK
C8, C9, C10, C11, C12, C13, C14, C15	6.8 pF Chip Capacitors	ATC100B6R8BT500XT	ATC
C16	0.6 pF Chip Capacitor	ATC100B0R6BT500XT	ATC
C17	0.3 pF Chip Capacitor	ATC100B0R3BT500XT	ATC
C18, C19, C20, C21	1 $\mu$ F, 50 V Chip Capacitors	CDR34BX104AKWS	AVX
R1, R2	8.2 $\Omega$ , 1/4 W Chip Resistors	RC1206FR-108R2L	Yageo
PCB	0.020", $\epsilon_r = 3.5$	RO4350B	Rogers

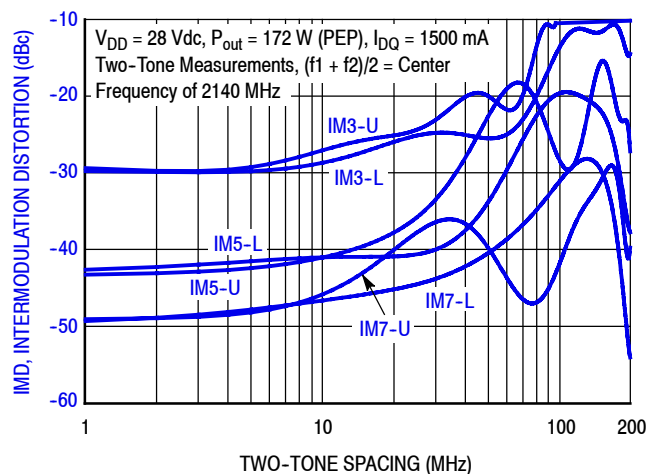
## TYPICAL CHARACTERISTICS



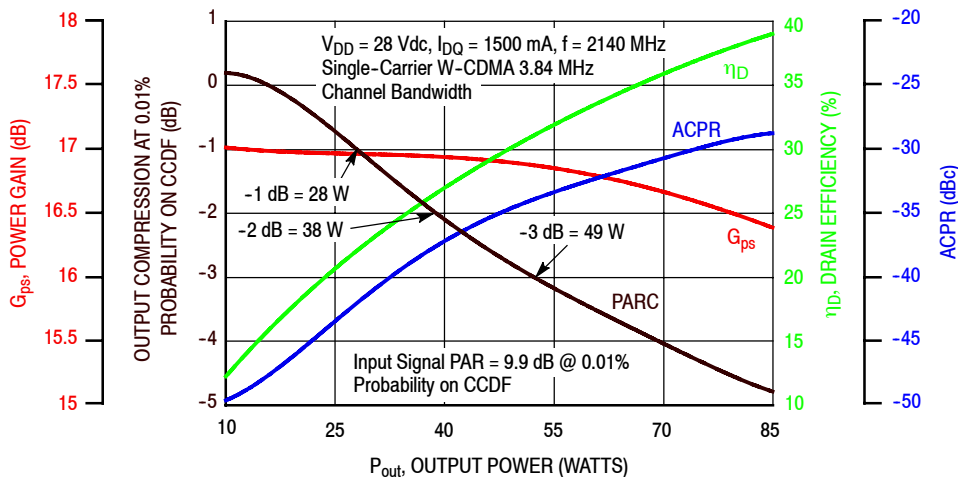
**Figure 4. Single-Carrier Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 50$  Watts Avg.**



**Figure 5a. Intermodulation Distortion Products versus Two-Tone Spacing — AFT21S230S**

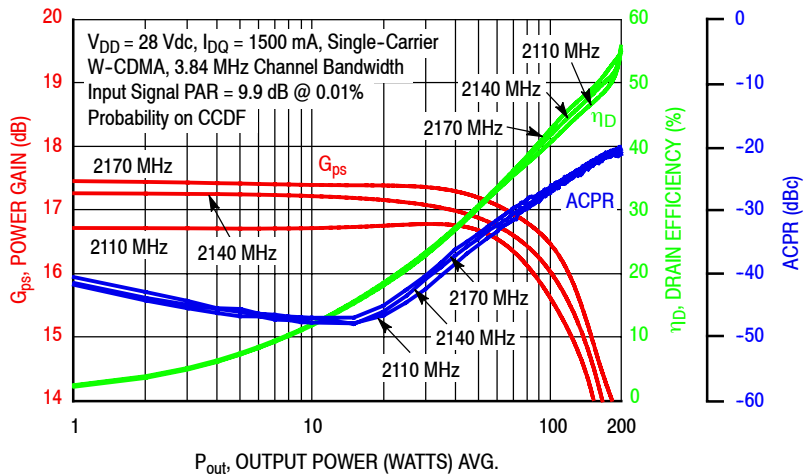


**Figure 5b. Intermodulation Distortion Products versus Two-Tone Spacing — AFT21S232S**

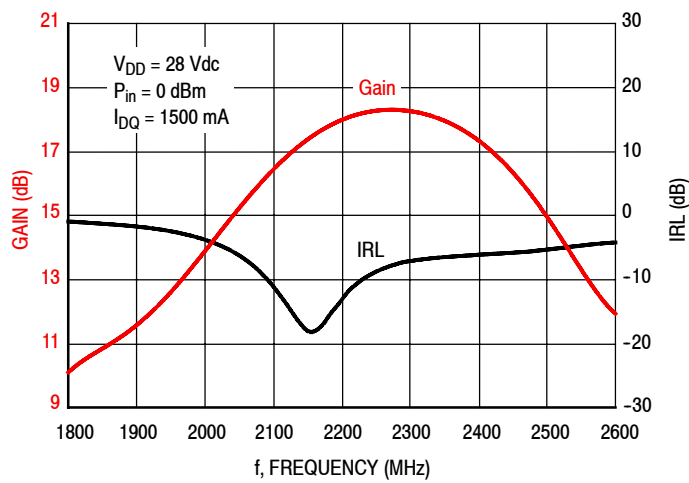


**Figure 6. Output Peak-to-Average Ratio Compression (PARC) versus Output Power**

## TYPICAL CHARACTERISTICS



**Figure 7. Single-Carrier W-CDMA Power Gain, Drain Efficiency and ACPR versus Output Power**



**Figure 8. Broadband Frequency Response**

$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1500 \text{ mA}$ , Pulsed CW, 10  $\mu\text{sec(on)}$ , 10% Duty Cycle

f (MHz)	$Z_{\text{source}} (\Omega)$	$Z_{\text{in}} (\Omega)$	$Z_{\text{load}}^{(1)} (\Omega)$	Max Linear Gain (dB)	Max Output Power							
					P1dB				P3dB			
					(dBm)	(W)	$\eta_D$ (%)	AM/PM (°)	(dBm)	(W)	$\eta_D$ (%)	AM/PM (°)
2110	1.20 - j6.00	1.20 + j5.90	1.50 - j3.90	17.7	54.3	269	55.4	11	55.2	331	57.0	16
2140	1.70 - j6.40	1.50 + j6.30	1.60 - j4.00	17.7	54.3	269	55.1	10	55.2	331	56.0	15
2170	1.70 - j6.80	1.75 + j6.70	1.50 - j4.00	17.8	54.3	269	54.7	11	55.2	331	56.0	16

(1) Load impedance for optimum P1dB power.

$Z_{\text{source}}$  = Measured impedance presented to the input of the device at the package reference plane.

$Z_{\text{in}}$  = Impedance as measured from gate contact to ground.

$Z_{\text{load}}$  = Measured impedance presented to the output of the device at the package reference plane.

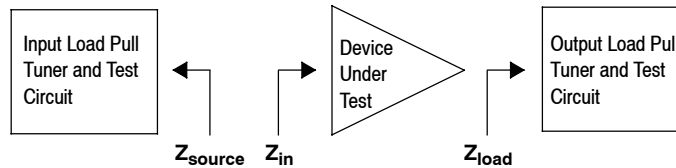


Figure 9. Load Pull Performance — Maximum P1dB Tuning

$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1500 \text{ mA}$ , Pulsed CW, 10  $\mu\text{sec(on)}$ , 10% Duty Cycle

f (MHz)	$Z_{\text{source}} (\Omega)$	$Z_{\text{in}} (\Omega)$	$Z_{\text{load}}^{(1)} (\Omega)$	Max Linear Gain (dB)	Max Drain Efficiency							
					P1dB				P3dB			
					(dBm)	(W)	$\eta_D$ (%)	AM/PM (°)	(dBm)	(W)	$\eta_D$ (%)	AM/PM (°)
2110	1.20 - j6.00	1.20 + j5.93	2.10 - j2.41	20.0	52.7	186	64.9	16	54.3	269	66.2	20
2140	1.70 - j6.40	1.40 + j6.30	1.80 - j2.60	19.8	52.8	191	64.2	16	53.4	219	65.4	24
2170	1.70 - j6.80	1.80 + j6.80	1.70 - j2.60	20.0	52.8	191	64.2	17	54.2	263	65.5	22

(1) Load impedance for optimum P1dB efficiency.

$Z_{\text{source}}$  = Measured impedance presented to the input of the device at the package reference plane.

$Z_{\text{in}}$  = Impedance as measured from gate contact to ground.

$Z_{\text{load}}$  = Measured impedance presented to the output of the device at the package reference plane.

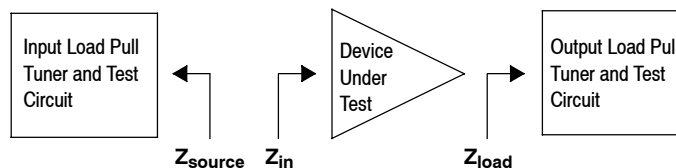


Figure 10. Load Pull Performance — Maximum Drain Efficiency Tuning

## P1dB - TYPICAL LOAD PULL CONTOURS — 2140 MHz

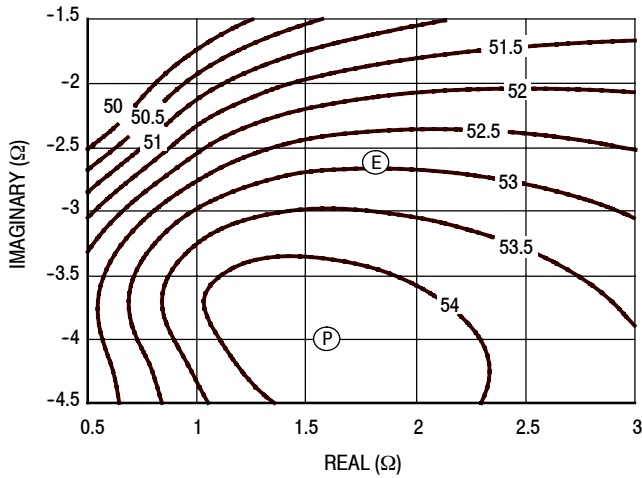


Figure 11. P1dB Load Pull Output Power Contours (dBm)

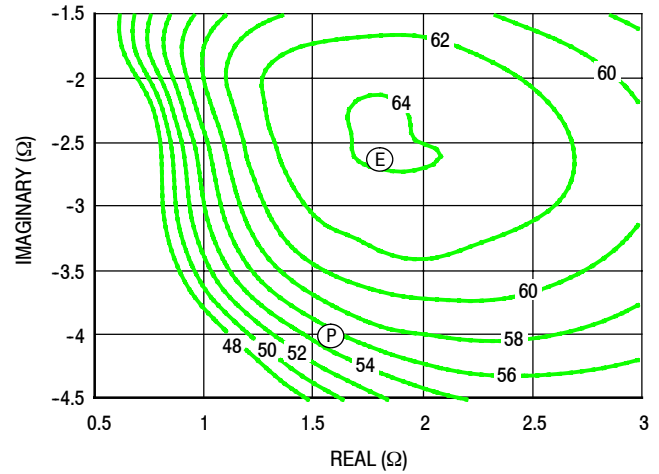


Figure 12. P1dB Load Pull Efficiency Contours (%)

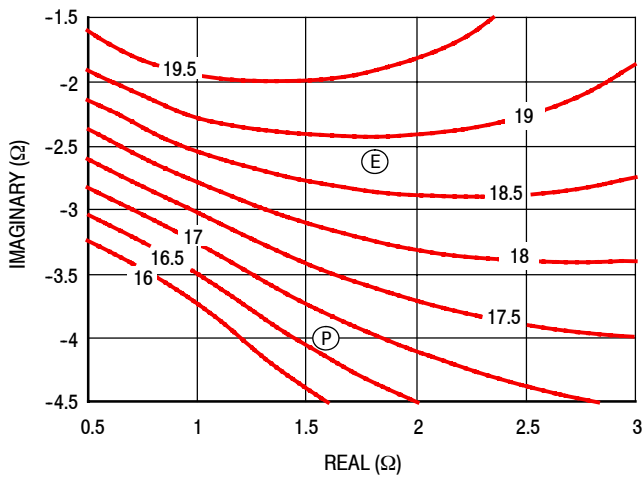


Figure 13. P1dB Load Pull Gain Contours (dB)

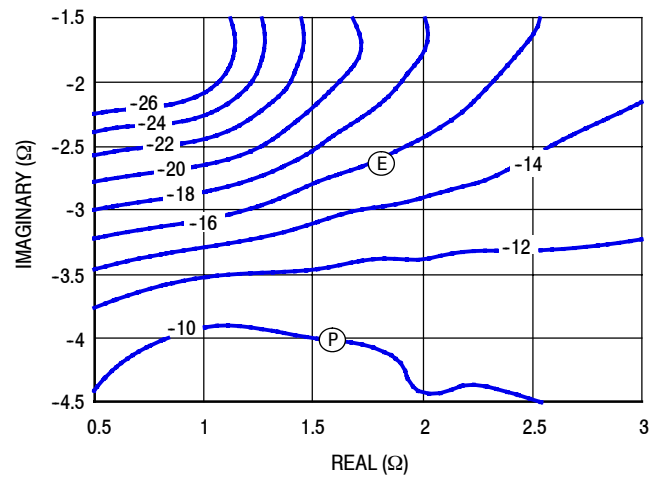


Figure 14. P1dB Load Pull AM/PM Contours (°)

**NOTE:** (P) = Maximum Output Power  
(E) = Maximum Drain Efficiency

- Power Gain
- Drain Efficiency
- Linearity
- Output Power



### P3dB - TYPICAL LOAD PULL CONTOURS — 2140 MHz

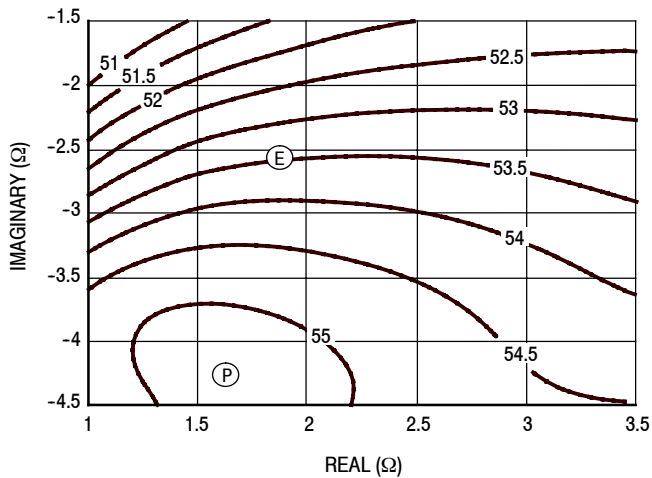


Figure 15. P3dB Load Pull Output Power Contours (dBm)

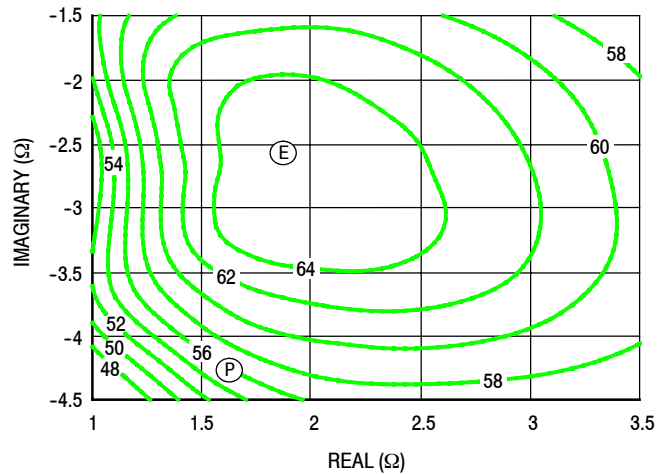


Figure 16. P3dB Load Pull Efficiency Contours (%)

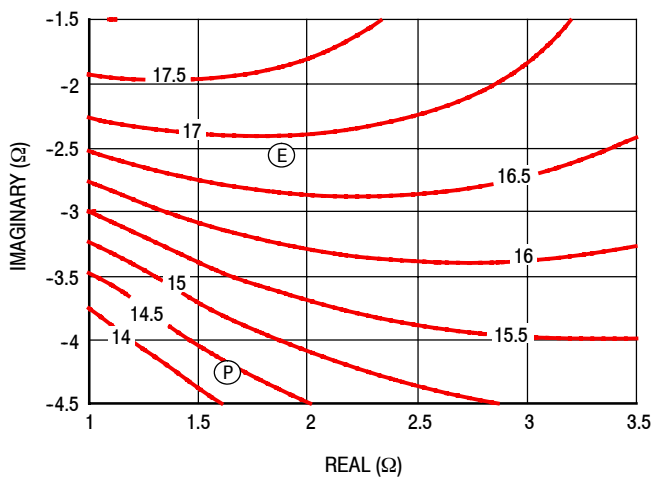


Figure 17. P3dB Load Pull Gain Contours (dB)

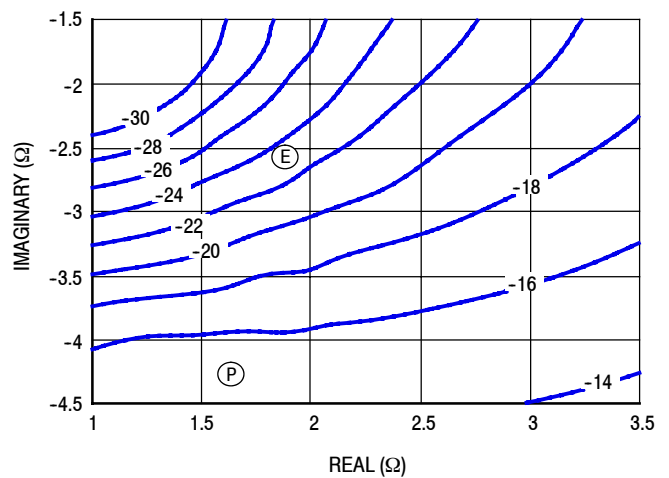
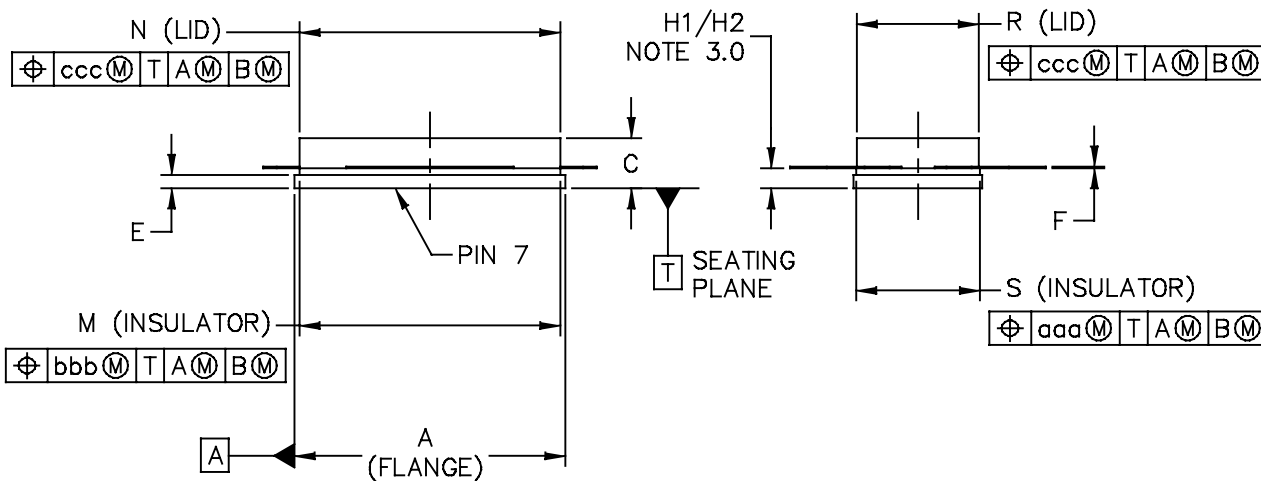
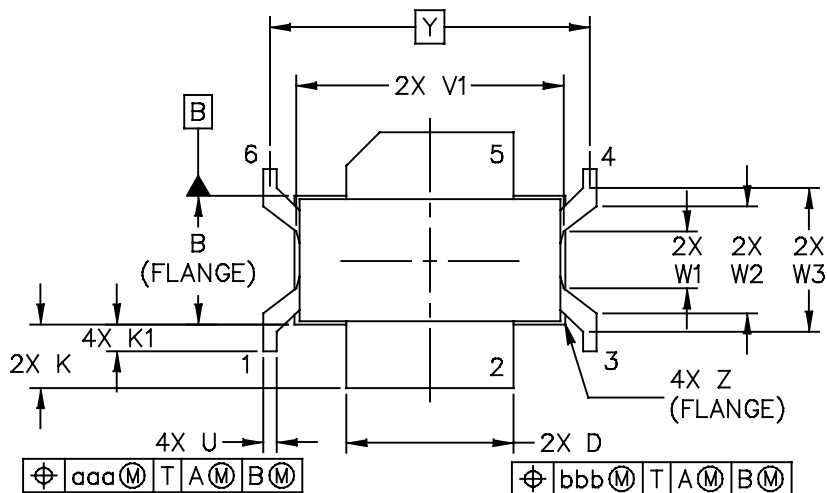


Figure 18. P3dB Load Pull AM/PM Contours (°)

**NOTE:** (P) = Maximum Output Power  
(E) = Maximum Drain Efficiency

- Power Gain
- Drain Efficiency
- Linearity
- Output Power

PACKAGE DIMENSIONS



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TITLE:  NI-780S-6	DOCUMENT NO: 98ASA00443D	REV: A	
	CASE NUMBER: 2268-02	24 MAY 2012	
	STANDARD: NON-JEDEC		

NOTES:

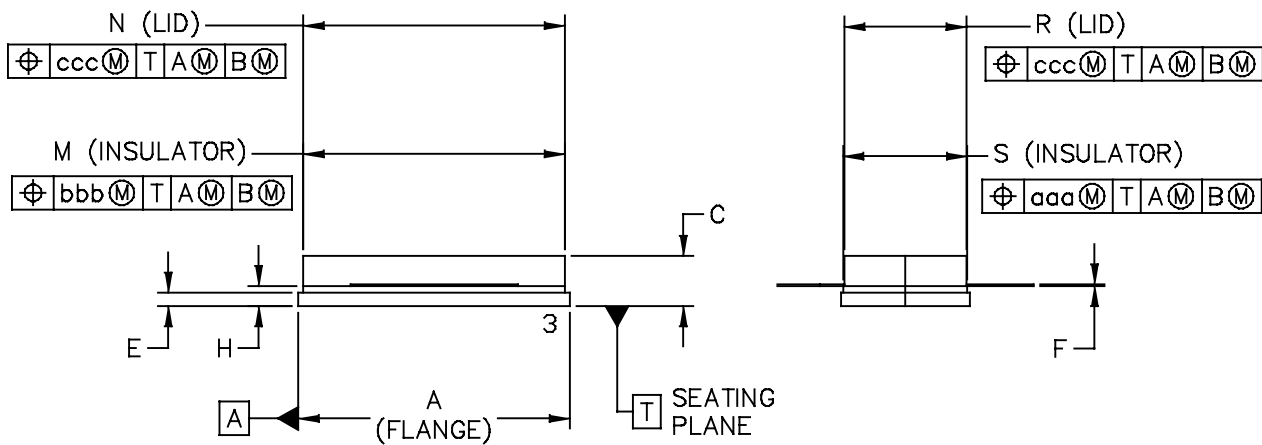
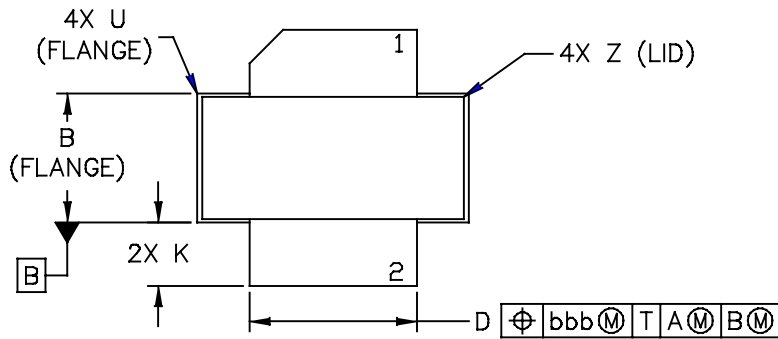
1.0 CONTROLLING DIMENSION: INCH.

2.0 INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.

3.0 DIMENSIONS H1 AND H2 ARE MEASURED .030 INCH (0.762 MM) AWAY FROM FLANGE PARALLEL TO DATUM B. H1 APPLIES TO PINS 2 & 5. H2 APPLIES TO PINS 1, 3, 4 & 6.

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.805	– .815	20.45	– 20.70	R	.365	– .375	9.27	– 9.53
B	.380	– .390	9.65	– 9.91	S	.365	– .375	9.27	– 9.53
C	.125	– .170	3.18	– 4.32	U	.035	– .045	0.89	– 1.14
D	.495	– .505	12.57	– 12.83	V1	.795	– .805	20.19	– 20.45
E	.035	– .045	0.89	– 1.14	W1	.165	– .175	4.19	– 4.45
F	.004	– .007	0.10	– 0.18	W2	.315	– .325	8.00	– 8.26
H1	.057	– .067	1.45	– 1.70	W3	.425	– .435	10.80	– 11.05
H2	.054	– .070	1.37	– 1.78	Y	.956 BSC		24.28 BSC	
K	.170	– .210	4.32	– 5.33	Z	R.000 – R.040		R.00 – R1.02	
K1	.070	– .090	1.78	– 2.29	aaa	– .005	–	–	0.127 –
M	.774	– .786	19.66	– 19.96	bbb	– .010	–	–	0.254 –
N	.772	– .788	19.61	– 20.02	ccc	– .015	–	–	0.381 –

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TITLE:  NI-780S-6			DOCUMENT NO: 98ASA00443D		REV: A
			CASE NUMBER: 2268-02		24 MAY 2012
			STANDARD: NON-JEDEC		



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TITLE:  NI-780S	DOCUMENT NO: 98ASB16718C	REV: H
	CASE NUMBER: 465A-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 (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	-				
© FREESCALE SEMICONDUCTOR, INC. ALL RIGHTS RESERVED.			MECHANICAL OUTLINE			PRINT VERSION NOT TO SCALE			
TITLE:  NI-780S					DOCUMENT NO: 98ASB16718C			REV: H	
					CASE NUMBER: 465A-06			31 MAR 2005	
					STANDARD: NON-JEDEC				

## PRODUCT DOCUMENTATION, SOFTWARE AND TOOLS

Refer to the following documents, software and tools 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
- .s2p File

### Development Tools

- Printed Circuit Boards

For Software and Tools, 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

NI-780S-6: R5 Suffix = 50 Units, 32 mm Tape Width, 13 inch Reel.

NI-780S-2: R5 Suffix = 50 Units, 56 mm Tape Width, 13 inch Reel.

The R5 tape and reel option for AFT21S230S and AFT21S232S parts will be available for 2 years after release of AFT21S230S and AFT21S232S. 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 this device in the R5 tape and reel option will be offered AFT21S230S and AFT21S232S in the R3 tape and reel option.

## REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	Oct. 2012	• Initial Release of Data Sheet

## ***How to Reach Us:***

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