Document Number: AFT09S200W02S
Rev. 0, 4/2015

RoHS

RF Power LDMOS Transistor

N–Channel Enhancement–Mode Lateral MOSFET

This 56 W RF power LDMOS transistor is designed for cellular base station applications requiring very wide instantaneous bandwidth capability covering the frequency range of 920 to 960 MHz.

- Typical Single–Carrier W–CDMA Performance: V_{DD} = 28 Vdc, I_{DQ} = 1400 mA, P_{out} = 56 W Avg., Input Signal PAR = 9.9 dB @ 0.01% Probability on CCDF.

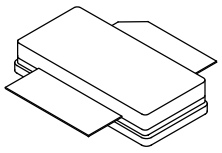
Frequency	G_{ps} (dB)	η_D (%)	Output PAR (dB)	ACPR (dBc)	IRL (dB)
920 MHz	19.6	34.1	6.9	–35.2	–28
940 MHz	19.6	34.7	7.0	–35.4	–18
960 MHz	19.4	35.6	6.8	–34.7	–12

Features

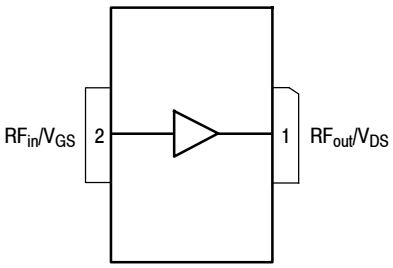
- Designed for Wide Instantaneous Bandwidth Applications
- Greater Negative Gate–Source Voltage Range for Improved Class C Operation
- Designed for Digital Predistortion Error Correction Systems
- Able to Withstand Extremely High Output VSWR and Broadband Operating Conditions
- Optimized for Doherty Applications

AFT09S200W02SR3

920–960 MHz, 56 W AVG., 28 V AIRFAST RF POWER LDMOS TRANSISTOR



NI–780S–2L



(Top View)

Figure 1. Pin Connections

freescale Airfast

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	–0.5, +70	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 +125	°C
Operating Junction Temperature Range (1,2)	T_J	–40 to +225	°C
CW Operation @ T_C = 25°C Derate above 25°C	CW	226 1.1	W W/°C

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case Case Temperature 81°C, 56 W CW, 28 Vdc, I_{DQ} = 1400 mA, 940 MHz	$R_{\theta JC}$	0.34	°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°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Off Characteristics					
Zero Gate Voltage Drain Leakage Current (V_{DS} = 70 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	10	μAdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 32 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	5	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 = 270 μAdc)	$V_{GS(th)}$	1.0	1.5	2.0	Vdc
Gate Quiescent Voltage (V_{DS} = 28 Vdc, I_D = 1400 mAdc)	$V_{GS(Q)}$	—	2.15	—	Vdc
Fixture Gate Quiescent Voltage (4) (V_{DD} = 28 Vdc, I_D = 1400 mAdc, Measured in Functional Test)	$V_{GG(Q)}$	3.2	4.3	5.2	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 2.7 Adc)	$V_{DS(on)}$	0.1	0.26	0.3	Vdc

1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at http://www.freescale.com/rf/calculators.
3. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers.* Go to http://www.freescale.com/rf and search for AN1955.
4. $V_{GG} = 2 \times V_{GS(Q)}$. Parameter measured on Freescale Text Fixture, due to resistor divider network on the board. Refer to Test Fixture Layout.

(continued)

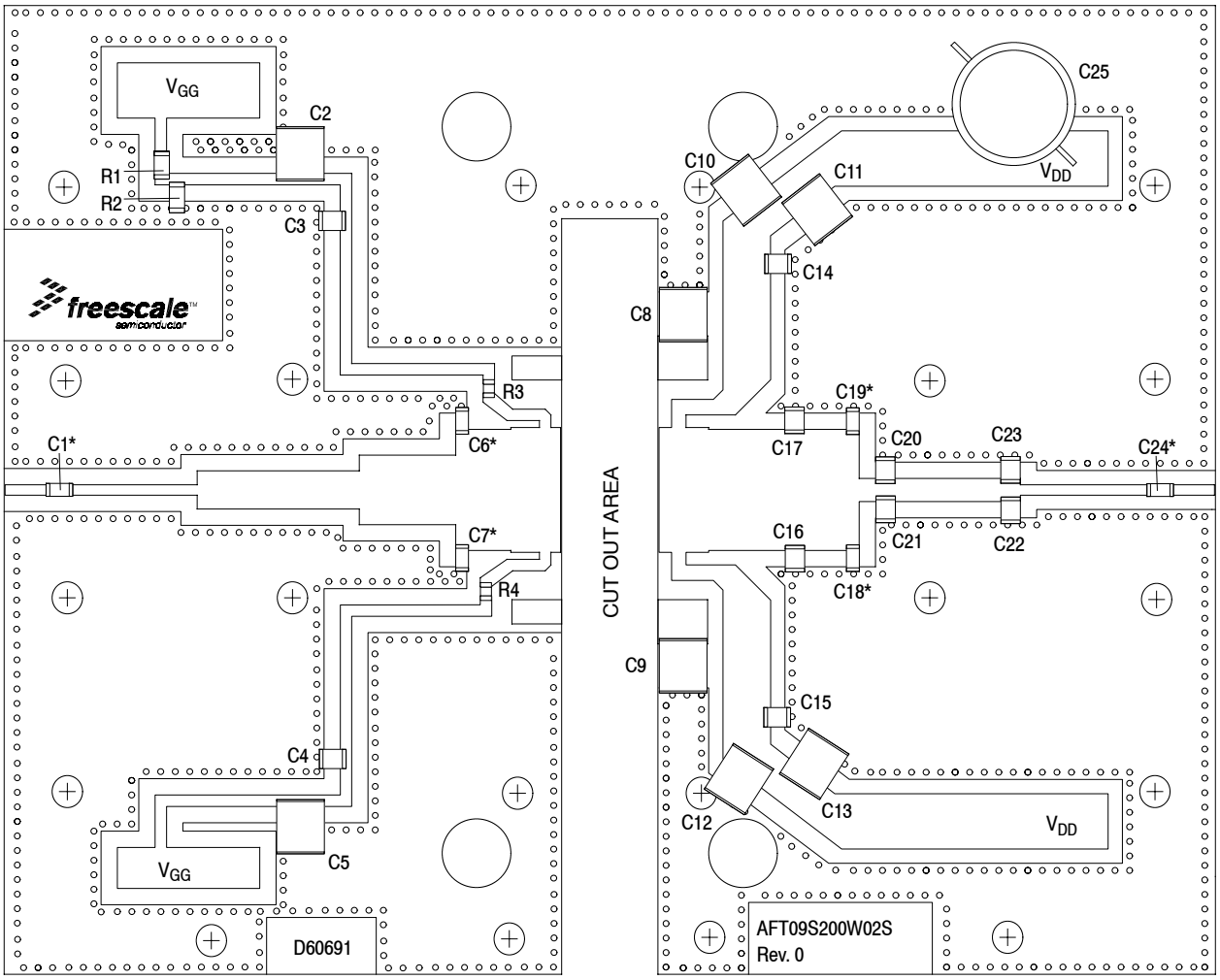
Table 4. Electrical Characteristics (T_A = 25°C unless otherwise noted) **(continued)**

Characteristic	Symbol	Min	Typ	Max	Unit
Functional Tests (1) (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1400 mA, P_{out} = 56 W Avg., f = 960 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 @ ±5 MHz Offset.					
Power Gain	G_{ps}	18.5	19.4	21.5	dB
Drain Efficiency	η_D	32.5	35.6	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	6.3	6.8	—	dB
Adjacent Channel Power Ratio	ACPR	—	–34.7	-33.0	dBc
Input Return Loss	IRL	—	–12	-9	dB
Load Mismatch (In Freescale Test Fixture, 50 ohm system) I_{DQ} = 1400 mA, f = 940 MHz					
VSWR 10:1 at 32 Vdc, 148 W CW Output Power (0 dB Input Overdrive from 148 W CW Rated Power)		No Device Degradation			
Typical Performance (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1400 mA, 920–960 MHz Bandwidth					
P_{out} @ 1 dB Compression Point, CW	P1dB	—	148	—	W
AM/PM (Maximum value measured at the P3dB compression point across the 920–960 MHz frequency range)	Φ	—	-12	—	°
VBW Resonance Point (IMD Third Order Intermodulation Inflection Point)	VBW_{res}	—	230	—	MHz
Gain Flatness in 40 MHz Bandwidth @ P_{out} = 56 W Avg.	G_F	—	0.3	—	dB
Gain Variation over Temperature (–30°C to +85°C)	ΔG	—	0.018	—	dB/°C
Output Power Variation over Temperature (–30°C to +85°C)	ΔP1dB	—	0.004	—	dB/°C

Table 5. Ordering Information

Device	Tape and Reel Information	Package
AFT09S200W02SR3	R3 Suffix = 250 Units, 56 mm Tape Width, 13-inch Reel	NI-780S-2L

1. Part internally matched both on input and output.



*C1, C6, C7, C18, C19 and C24 are mounted vertically.

Figure 2. AFT09S200W02SR3 Test Circuit Component Layout — 920–960 MHz

Table 6. AFT09S200W02SR3 Test Circuit Component Designations and Values — 920–960 MHz

Part	Description	Part Number	Manufacturer
C1, C3, C4, C14, C15, C24	47 pF Chip Capacitors	ATC100B470JT500XT	ATC
C2, C5, C8, C9, C10, C11, C12, C13	10 μF Chip Capacitors	C5750X7S2A106M230KB	TDK
C6, C7	2.7 pF Chip Capacitors	ATC100B2R7BT500XT	ATC
C16, C17	5.6 pF Chip Capacitors	ATC100B5R6CT500XT	ATC
C18, C19	2.0 pF Chip Capacitors	ATC100B2R0BT500XT	ATC
C20, C21	1.0 pF Chip Capacitors	ATC100B1R0BT500XT	ATC
C22, C23	0.3 pF Chip Capacitors	ATC100B0R3BT500XT	ATC
C25	220 μF, 100 V Electrolytic Capacitor	EEV-FK2A221M	Panasonic-ECG
R1, R2	1000 Ω, 1/4 W Chip Resistors	CRCW12061K00FKEA	Vishay
R3, R4	10 Ω, 1/8 W Chip Resistors	RK73H2ATTD10R0F	KOA Speer
PCB	Rogers RO4350B, 0.020″, ε_r = 3.66	D60691	MTL

TYPICAL CHARACTERISTICS

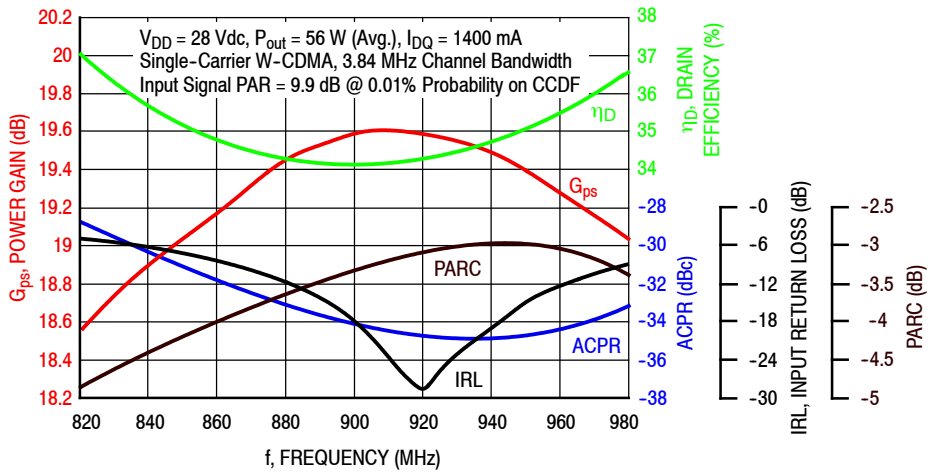


Figure 3. Single-Carrier Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @ P_{out} = 56 Watts Avg.

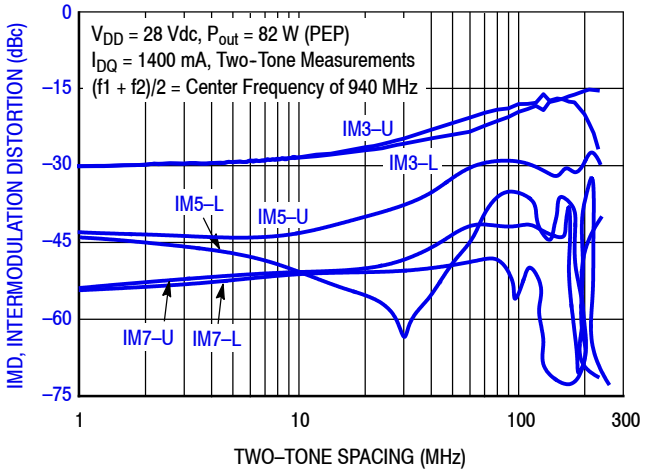


Figure 4. Intermodulation Distortion Products versus Two-Tone Spacing

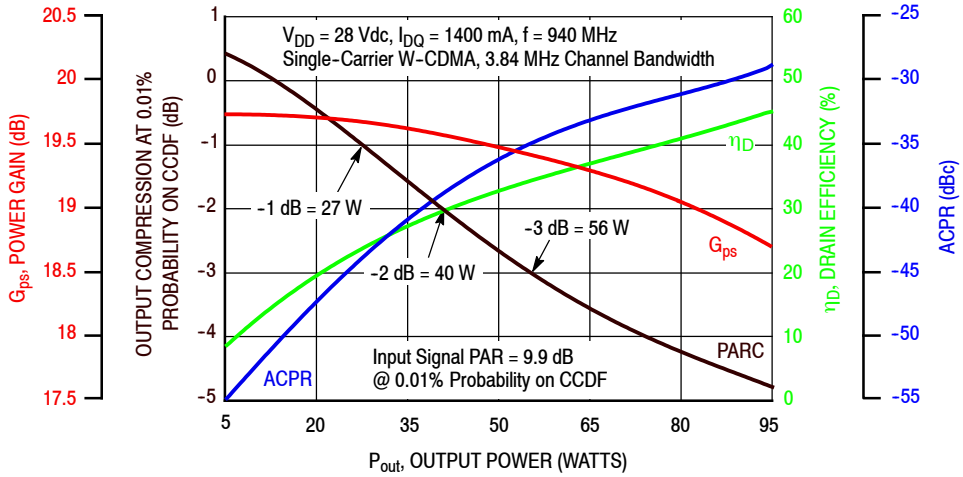


Figure 5. Output Peak-to-Average Ratio Compression (PARC) versus Output Power

TYPICAL CHARACTERISTICS

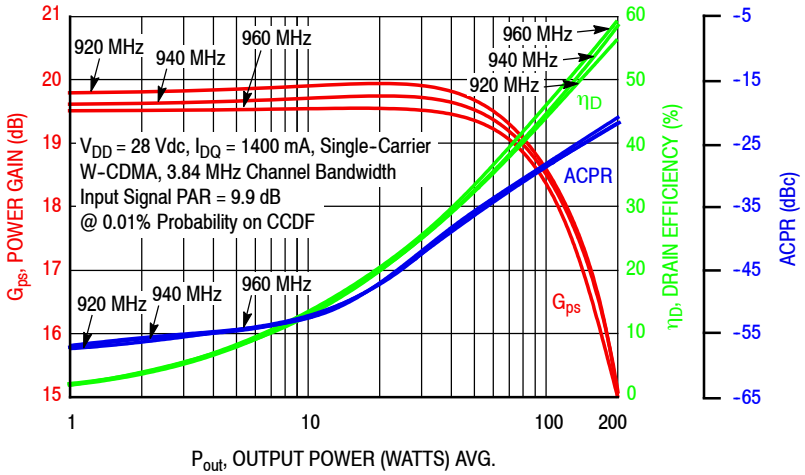


Figure 6. Single-Carrier W-CDMA Power Gain, Drain Efficiency and ACPR versus Output Power

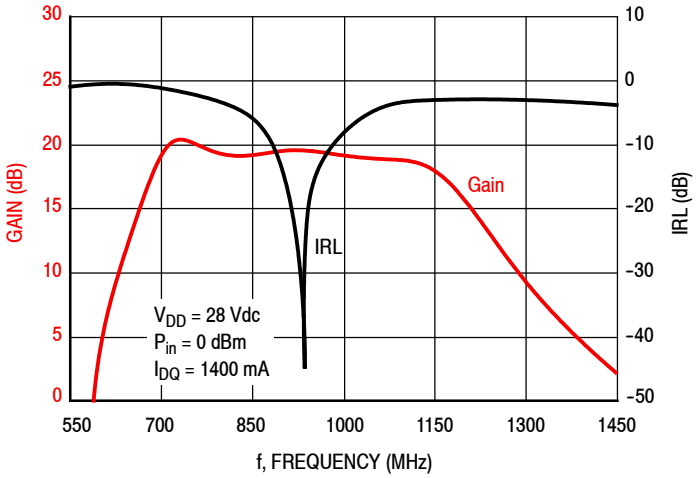


Figure 7. Broadband Frequency Response

Table 7. Load Pull Performance — Maximum Power Tuning

V_{DD} = 28 Vdc, I_{DQ} = 1389 mA, Pulsed CW, 10 μsec(on), 10% Duty Cycle

f (MHz)	Z_{source} (Ω)	Z_{in} (Ω)	Max Output Power P1dB Z_{load} (1) (Ω)	Gain (dB)	(dBm)	(W)	η_D (%)	AM/PM (°)
920	2.13 – j4.05	2.08 + j4.13	0.69 – j1.56	18.5	54.2	266	52.4	–6
940	2.50 – j4.42	2.43 + j4.41	0.69 – j1.61	18.2	54.2	266	52.4	–6
960	2.80 – j4.82	2.83 + j4.76	0.69 – j1.67	18.0	54.1	259	51.9	–6

f (MHz)	Z_{source} (Ω)	Z_{in} (Ω)	Max Output Power P3dB Z_{load} (2) (Ω)	Gain (dB)	(dBm)	(W)	η_D (%)	AM/PM (°)
920	2.13 – j4.05	2.09 + j4.23	0.65 – j1.63	16.2	55.5	351	56.4	–9
940	2.50 – j4.42	2.45 + j4.52	0.63 – j1.67	15.8	55.5	353	56.1	–9
960	2.80 – j4.82	2.86 + j4.89	0.63 – j1.68	15.6	55.4	348	56.1	–9

(1) Load impedance for optimum P1dB power.
(2) Load impedance for optimum P3dB power.
Z_{source} = Measured impedance presented to the input of the device at the package reference plane.
Z_{in} = Impedance as measured from gate contact to ground.
Z_{load} = Measured impedance presented to the output of the device at the package reference plane.

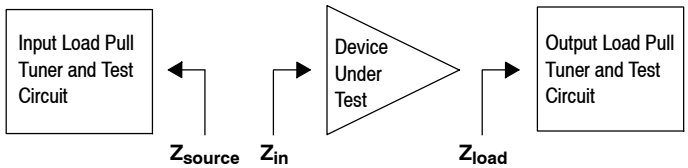
Table 8. Load Pull Performance — Maximum Drain Efficiency Tuning

V_{DD} = 28 Vdc, I_{DQ} = 1389 mA, Pulsed CW, 10 μsec(on), 10% Duty Cycle

f (MHz)	Z_{source} (Ω)	Z_{in} (Ω)	Max Drain Efficiency P1dB Z_{load} (1) (Ω)	Gain (dB)	(dBm)	(W)	η_D (%)	AM/PM (°)
920	2.13 – j4.05	2.09 + j4.20	1.84 – j0.62	22.1	51.6	143	66.4	–13
940	2.50 – j4.42	2.47 + j4.48	1.79 – j0.56	21.9	51.4	137	66.8	–14
960	2.80 – j4.82	2.88 + j4.81	1.69 – j0.72	21.5	51.5	142	65.7	–13

f (MHz)	Z_{source} (Ω)	Z_{in} (Ω)	Max Drain Efficiency P3dB Z_{load} (2) (Ω)	Gain (dB)	(dBm)	(W)	η_D (%)	AM/PM (°)
920	2.13 – j4.05	2.10 + j4.29	1.65 – j0.75	19.8	52.9	196	70.5	–18
940	2.50 – j4.42	2.47 + j4.56	1.56 – j0.87	19.4	53.1	203	70.4	–18
960	2.80 – j4.82	2.90 + j4.92	1.54 – j0.90	19.1	53.0	197	69.2	–17

(1) Load impedance for optimum P1dB efficiency.
(2) Load impedance for optimum P3dB efficiency.
Z_{source} = Measured impedance presented to the input of the device at the package reference plane.
Z_{in} = Impedance as measured from gate contact to ground.
Z_{load} = Measured impedance presented to the output of the device at the package reference plane.



P1dB - TYPICAL LOAD PULL CONTOURS — 940 MHz

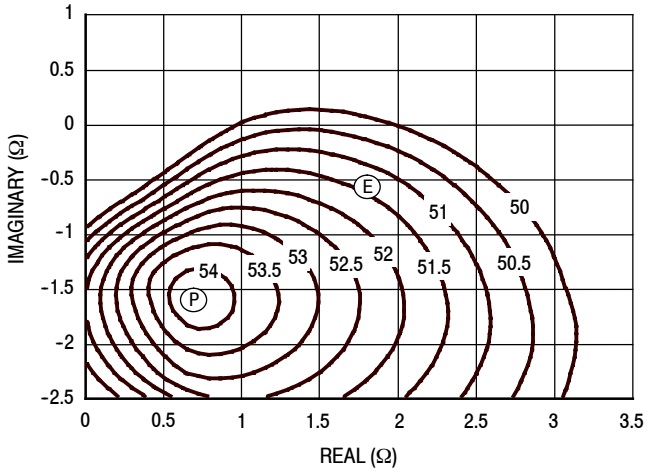


Figure 8. P1dB Load Pull Output Power Contours (dBm)

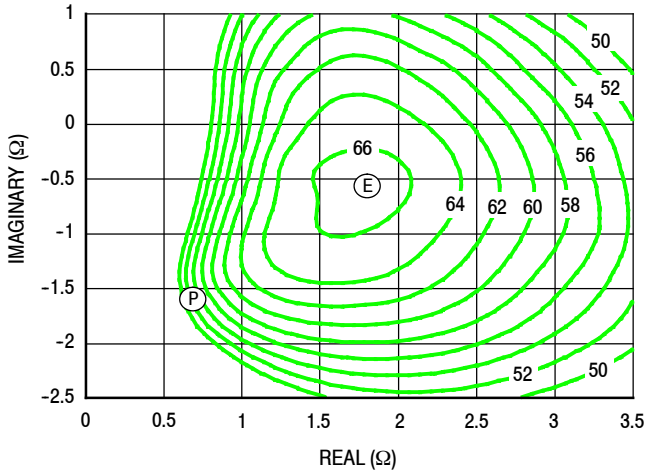


Figure 9. P1dB Load Pull Efficiency Contours (%)

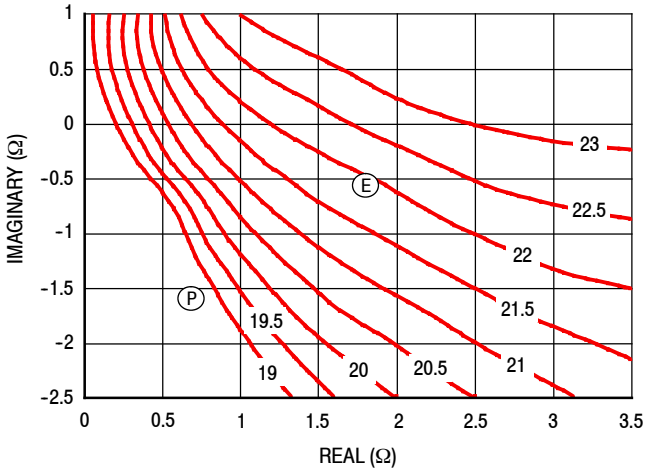


Figure 10. P1dB Load Pull Gain Contours (dB)

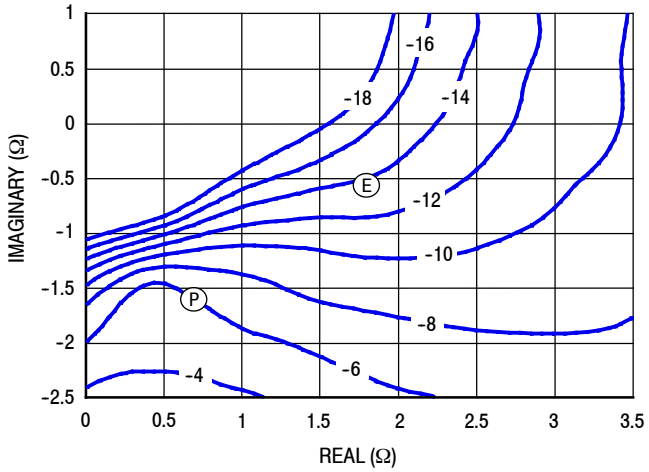


Figure 11. P1dB Load Pull AM/PM Contours (°)

NOTE: Ⓟ = Maximum Output Power

Ⓔ = Maximum Drain Efficiency

Gain

Drain Efficiency

Linearity

Output Power

P3dB - TYPICAL LOAD PULL CONTOURS — 940 MHz

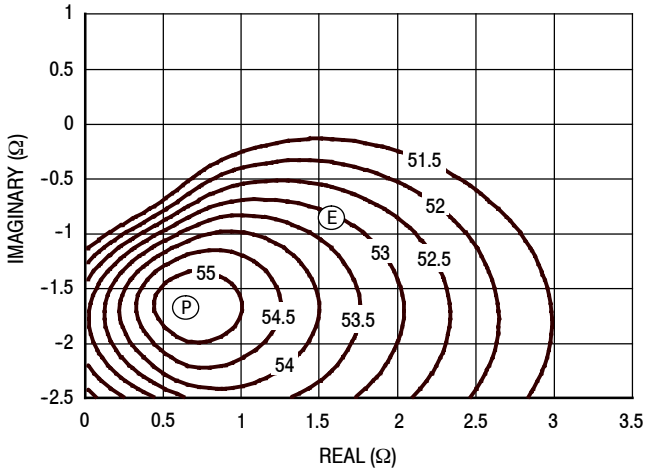


Figure 12. P3dB Load Pull Output Power Contours (dBm)

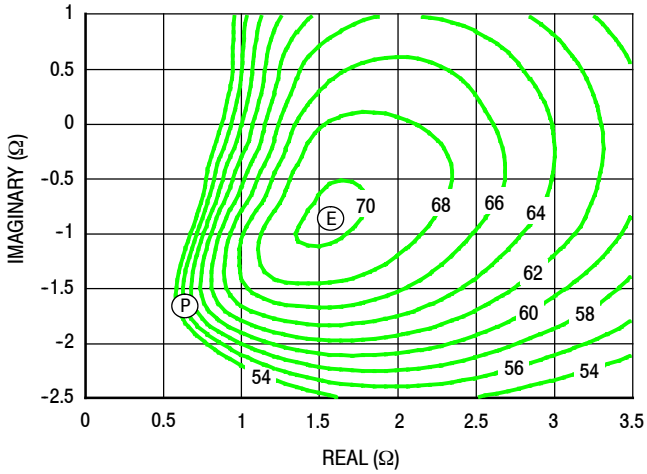


Figure 13. P3dB Load Pull Efficiency Contours (%)

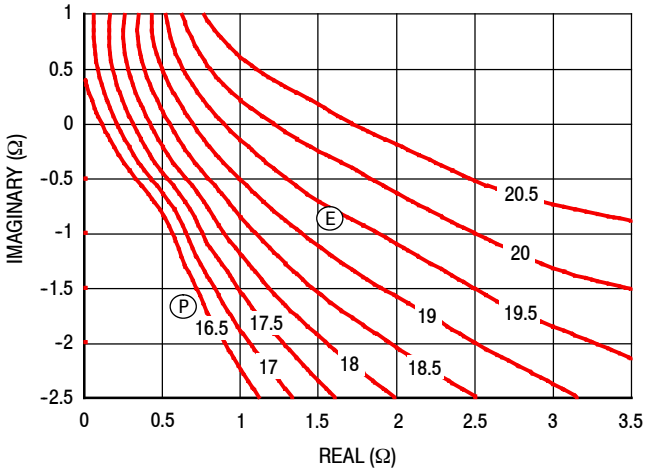


Figure 14. P3dB Load Pull Gain Contours (dB)

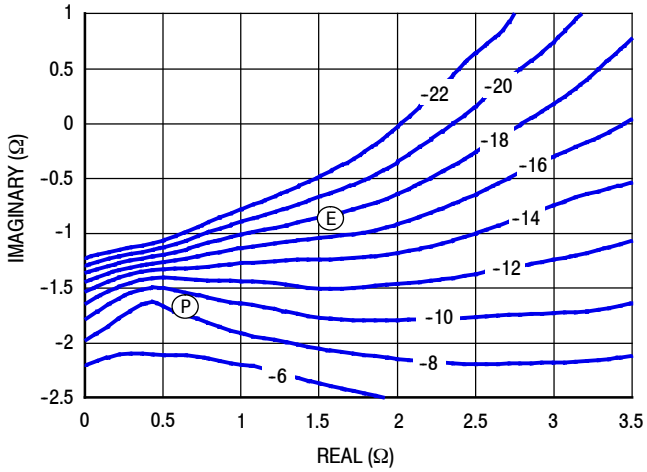


Figure 15. P3dB Load Pull AM/PM Contours (°)

NOTE: Ⓟ = Maximum Output Power

Ⓔ = Maximum Drain Efficiency

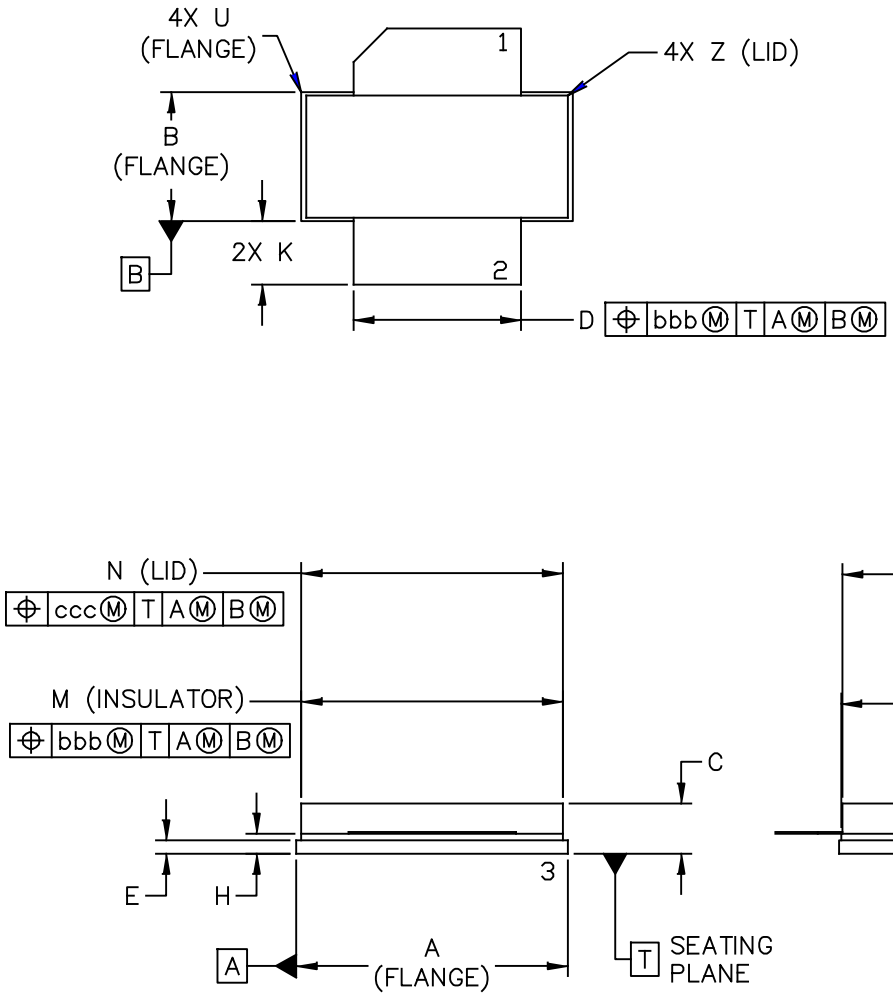
Gain

Drain Efficiency

Linearity

Output Power

PACKAGE DIMENSIONS



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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 MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER 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	–	–	–	–	–

MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE

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NI–780S	CASE NUMBER: 465A–06	31 MAR 2005
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PRODUCT DOCUMENTATION, SOFTWARE AND TOOLS

Refer to the following resources 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

To Download Resources Specific to a Given Part Number:

1. Go to http://www.freescale.com/rf
2. Search by part number
3. Click part number link
4. Choose the desired resource from the drop down menu

REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	Apr. 2015	• Initial Release of Data Sheet

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freescale.com/support

Document Number: AFT09S200W02S
Rev. 0, 4/2015