

# RF Power LDMOS Transistor

## N-Channel Enhancement-Mode Lateral MOSFET

This 38 W RF power LDMOS transistor is designed for cellular base station applications covering the frequency range of 2110 to 2170 MHz.

### 2100 MHz

- Typical Single-Carrier W-CDMA Performance:  $V_{DD} = 28$  Vdc,  $I_{DQ} = 600$  mA,  $P_{out} = 38$  W Avg., Input Signal PAR = 9.9 dB @ 0.01% Probability on CCDF.

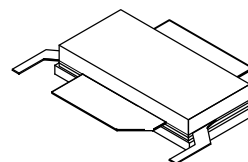
Frequency	$G_{ps}$ (dB)	$\eta_D$ (%)	Output PAR (dB)	ACPR (dBc)	IRL (dB)
2110 MHz	18.2	33.6	6.8	-33.4	-18
2140 MHz	18.3	33.0	6.7	-33.3	-15
2170 MHz	18.4	32.9	6.7	-33.0	-13

### Features

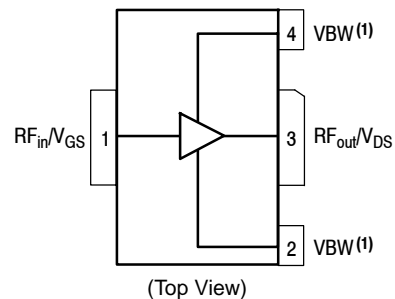
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- Designed for Digital Predistortion Error Correction Systems
- Optimized for Doherty Applications

**A2T21S160-12SR3**

**2110-2170 MHz, 38 W AVG., 28 V  
AIRFAST RF POWER LDMOS  
TRANSISTOR**



**NI-780S-2L2L**



**Figure 1. Pin Connections**

- Device cannot operate with  $V_{DD}$  current supplied through pin 2 and pin 4.

**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

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value(2,3)	Unit
Thermal Resistance, Junction to Case Case Temperature 73°C, 38 W CW, 28 Vdc, $I_{DQ} = 600$ mA, 2140 MHz	$R_{\theta JC}$	0.30	°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 ( $V_{DS} = 65$ Vdc, $V_{GS} = 0$ Vdc)	$I_{DSS}$	—	—	10	$\mu\text{Adc}$
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 32$ Vdc, $V_{GS} = 0$ Vdc)	$I_{DSS}$	—	—	1	$\mu\text{Adc}$
Gate-Source Leakage Current ( $V_{GS} = 5$ Vdc, $V_{DS} = 0$ Vdc)	$I_{GSS}$	—	—	1	$\mu\text{Adc}$

**On Characteristics**

Gate Threshold Voltage ( $V_{DS} = 10$ Vdc, $I_D = 151$ $\mu\text{Adc}$ )	$V_{GS(th)}$	1.4	1.8	2.2	Vdc
Gate Quiescent Voltage ( $V_{DD} = 28$ Vdc, $I_D = 600$ mAdc, Measured in Functional Test)	$V_{GS(Q)}$	2.2	2.6	3.0	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10$ Vdc, $I_D = 1.5$ Adc)	$V_{DS(on)}$	0.1	0.2	0.3	Vdc

**Functional Tests** (4) (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28$  Vdc,  $I_{DQ} = 600$  mA,  $P_{out} = 38$  W Avg.,  $f = 2170$  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 @  $\pm 5$  MHz Offset.

Power Gain	$G_{ps}$	17.7	18.4	20.7	dB
Drain Efficiency	$\eta_D$	31.1	32.9	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	6.3	6.7	—	dB
Adjacent Channel Power Ratio	ACPR	—	-33.0	-30.9	dBc
Input Return Loss	IRL	—	-13	-7	dB

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. 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) $I_{DQ} = 600\text{ mA}$ , $f = 2140\text{ MHz}$					
VSWR 10:1 at 32 Vdc, 190 W CW Output Power (3 dB Input Overdrive from 140 W CW Rated Power)	No Device Degradation				
<b>Typical Performance</b> (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$ , $I_{DQ} = 600\text{ mA}$ , 2110–2170 MHz Bandwidth					
$P_{out}$ @ 1 dB Compression Point, CW	P1dB	—	140	—	W
AM/PM (Maximum value measured at the P3dB compression point across the 2110–2170 MHz bandwidth)	$\Phi$	—	-16.4	—	°
VBW Resonance Point (IMD Third Order Intermodulation Inflection Point)	VBW <sub>res</sub>	—	90	—	MHz
Gain Flatness in 60 MHz Bandwidth @ $P_{out} = 38\text{ W Avg.}$	$G_F$	—	0.3	—	dB
Gain Variation over Temperature (-30°C to +85°C)	$\Delta G$	—	0.011	—	dB/°C
Output Power Variation over Temperature (-30°C to +85°C)	$\Delta P1dB$	—	0.009	—	dB/°C

**Table 5. Ordering Information**

Device	Tape and Reel Information	Package
A2T21S160-12SR3	R3 Suffix = 250 Units, 44 mm Tape Width, 13-inch Reel	NI-780S-2L2L

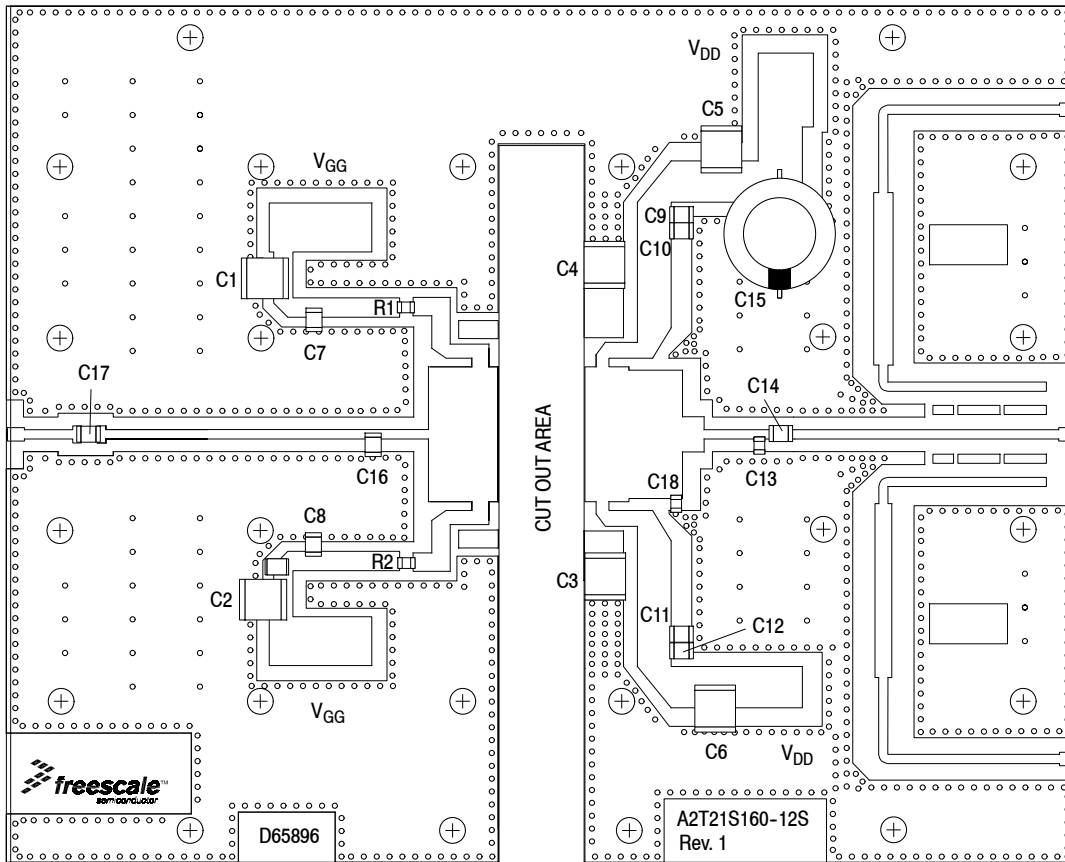
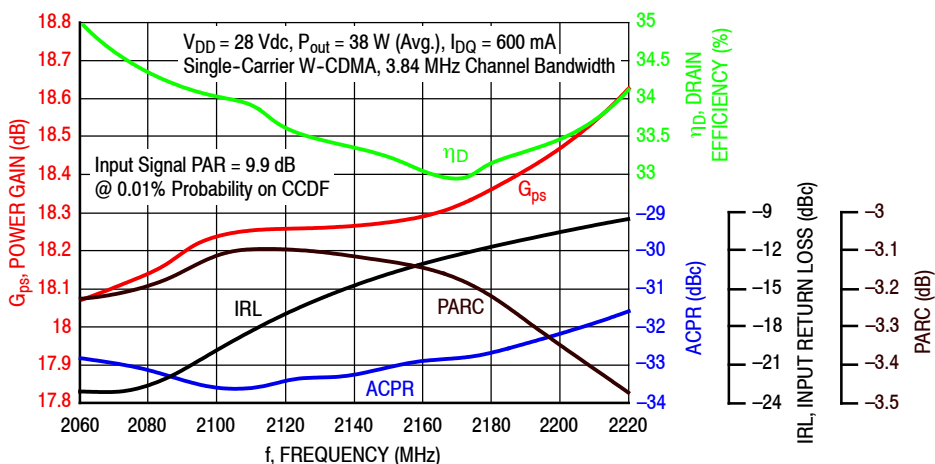


Figure 2. A2T21S160-12SR3 Test Circuit Component Layout

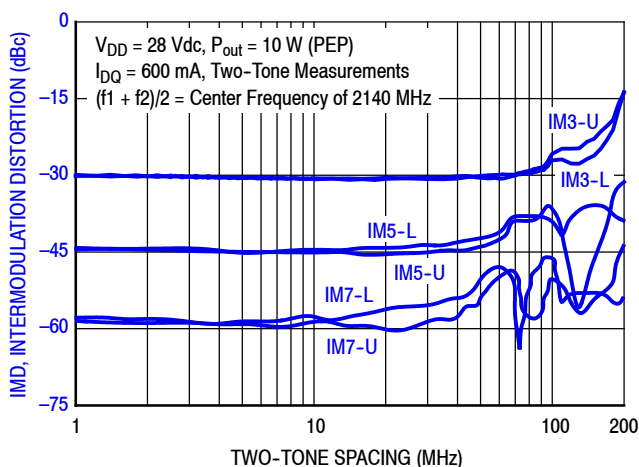
Table 6. A2T21S160-12SR3 Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1, C2, C3, C4, C5, C6	10 $\mu$ F Chip Capacitors	C5750X7S2A106M230KB	TDK
C7, C8, C10, C11, C14, C17	9.1 pF Chip Capacitors	ATC100B9R1CT500XT	ATC
C9	0.8 pF Chip Capacitor	ATC100B0R8BT500XT	ATC
C12	0.9 pF Chip Capacitor	ATC100B0R9BT500XT	ATC
C13, C18	0.1 pF Chip Capacitors	ATC600F0R1BT250XT	ATC
C15	470 $\mu$ F, 63 V Electrolytic Capacitor	MCGPR63V477M13X26-RH	Multicomp
C16	1.1 pF Chip Capacitor	ATC100B1R1BT500XT	ATC
R1, R2	3 $\Omega$ , 1/4 W Chip Resistors	RC1206FR-073RL	Yageo
PCB	Rogers RO4350B, 0.020", $\epsilon_r = 3.66$	D65896	MTL

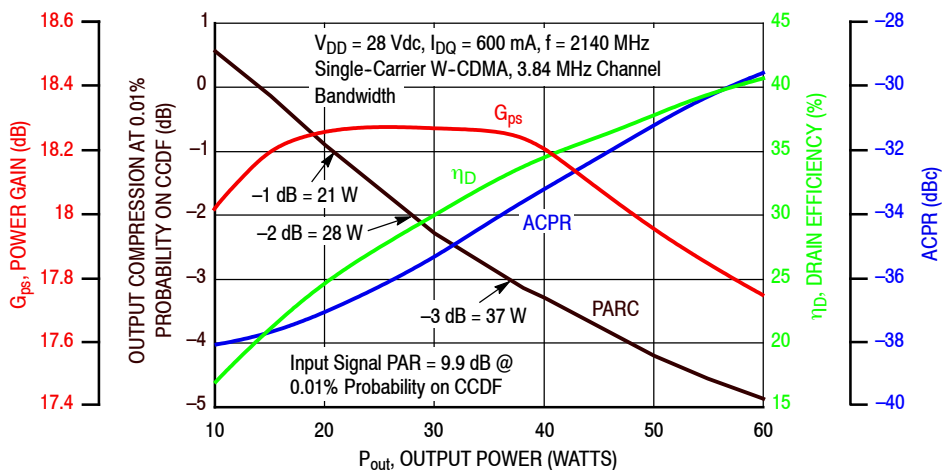
### TYPICAL CHARACTERISTICS



**Figure 3. Single-Carrier Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 38$  Watts Avg.**

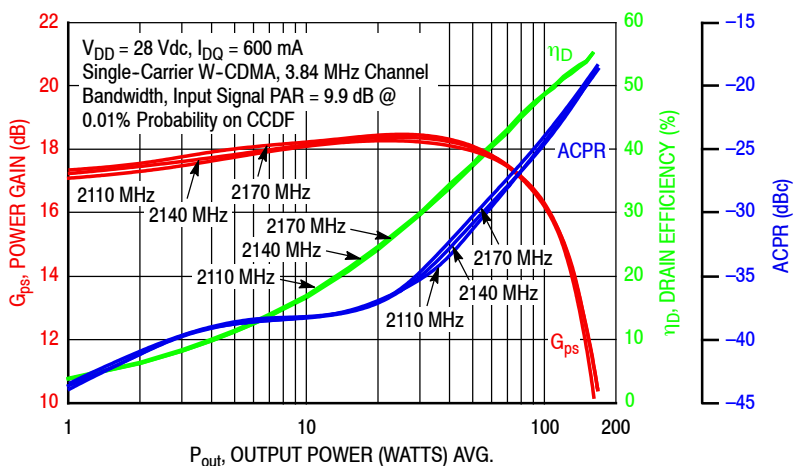


**Figure 4. Intermodulation Distortion Products versus Two-Tone Spacing**

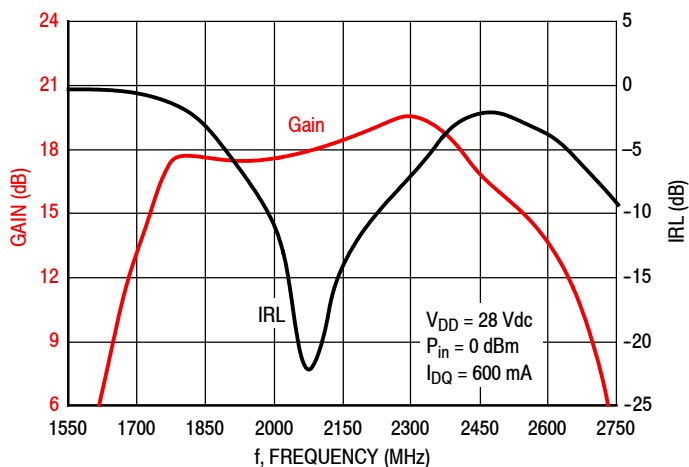


**Figure 5. Output Peak-to-Average Ratio Compression (PARC) versus Output Power**

### 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**
 $V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 793 \text{ mA}$ , Pulsed CW, 10  $\mu\text{sec}(\text{on})$ , 10% Duty Cycle

f (MHz)	$Z_{\text{source}} (\Omega)$	$Z_{\text{in}} (\Omega)$	Max Output Power					
			P1dB					
			$Z_{\text{load}}^{(1)} (\Omega)$	Gain (dB)	(dBm)	(W)	$\eta_D$ (%)	AM/PM (°)
2110	2.40 – j5.03	2.40 + j4.74	1.71 – j4.45	18.6	52.5	178	54.8	–14
2140	2.86 – j5.52	2.96 + j5.22	1.70 – j4.29	18.8	52.6	181	55.4	–15
2170	4.27 – j6.11	4.03 + j5.56	1.71 – j4.44	18.8	52.6	182	54.8	–15

f (MHz)	$Z_{\text{source}} (\Omega)$	$Z_{\text{in}} (\Omega)$	Max Output Power					
			P3dB					
			$Z_{\text{load}}^{(2)} (\Omega)$	Gain (dB)	(dBm)	(W)	$\eta_D$ (%)	AM/PM (°)
2110	2.40 – j5.03	2.33 + j5.03	1.72 – j4.68	16.3	53.3	214	56.3	–18
2140	2.86 – j5.52	2.96 + j5.56	1.71 – j4.64	16.4	53.3	216	56.1	–19
2170	4.27 – j6.11	4.13 + j6.04	1.72 – j4.67	16.5	53.3	215	55.9	–19

(1) Load impedance for optimum P1dB power.

(2) Load impedance for optimum P3dB 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.

**Table 8. Load Pull Performance — Maximum Drain Efficiency Tuning**
 $V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 793 \text{ mA}$ , Pulsed CW, 10  $\mu\text{sec}(\text{on})$ , 10% Duty Cycle

f (MHz)	$Z_{\text{source}} (\Omega)$	$Z_{\text{in}} (\Omega)$	Max Drain Efficiency					
			P1dB					
			$Z_{\text{load}}^{(1)} (\Omega)$	Gain (dB)	(dBm)	(W)	$\eta_D$ (%)	AM/PM (°)
2110	2.40 – j5.03	2.71 + j5.02	3.37 – j2.33	21.8	50.1	102	66.7	–21
2140	2.86 – j5.52	3.42 + j5.53	2.99 – j2.05	22.1	49.9	98	66.6	–22
2170	4.27 – j6.11	4.77 + j5.85	2.70 – j2.14	22.1	50.0	100	66.0	–23

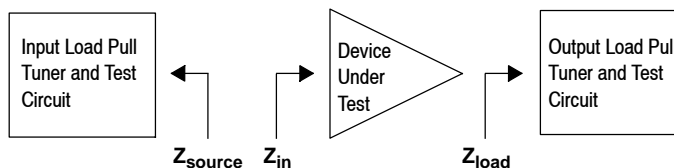
f (MHz)	$Z_{\text{source}} (\Omega)$	$Z_{\text{in}} (\Omega)$	Max Drain Efficiency					
			P3dB					
			$Z_{\text{load}}^{(2)} (\Omega)$	Gain (dB)	(dBm)	(W)	$\eta_D$ (%)	AM/PM (°)
2110	2.40 – j5.03	2.65 + j5.25	3.37 – j2.33	19.8	50.8	120	68.0	–28
2140	2.86 – j5.52	3.40 + j5.87	2.78 – j2.07	20.1	50.6	115	67.9	–31
2170	4.27 – j6.11	4.90 + j6.17	2.70 – j2.14	20.1	50.7	116	67.4	–31

(1) Load impedance for optimum P1dB efficiency.

(2) Load impedance for optimum P3dB 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.


### P1dB – TYPICAL LOAD PULL CONTOURS — 2140 MHz

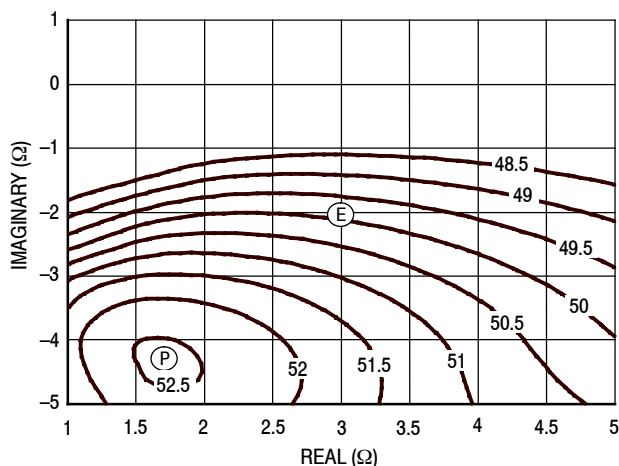


Figure 8. P1dB Load Pull Output Power Contours (dBm)

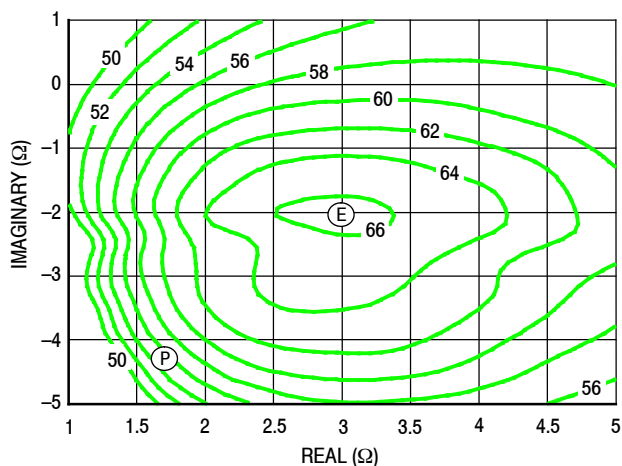


Figure 9. P1dB Load Pull Efficiency Contours (%)

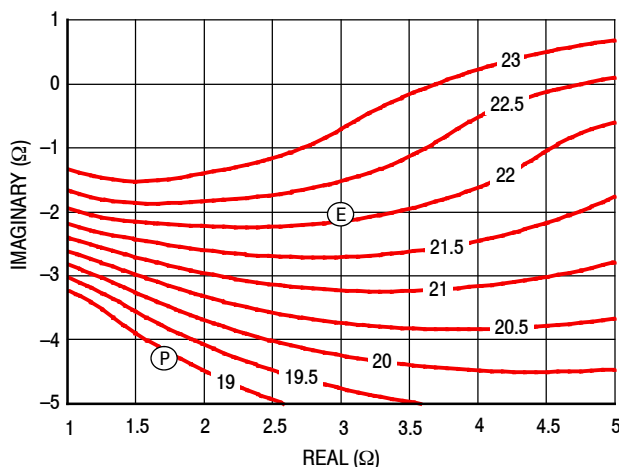


Figure 10. P1dB Load Pull Gain Contours (dB)

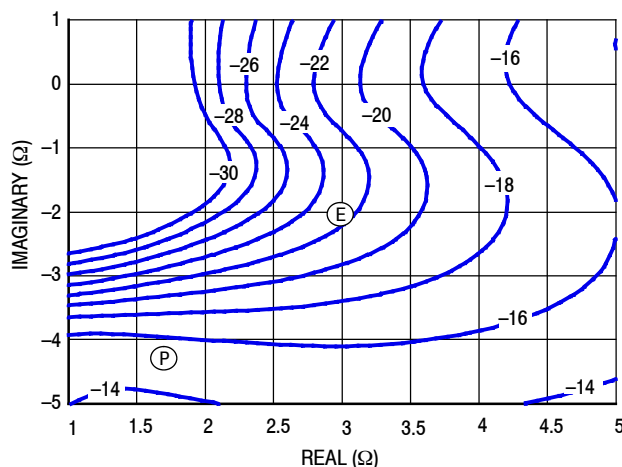


Figure 11. P1dB Load Pull AM/PM Contours (°)

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

- Gain
- Drain Efficiency
- Linearity
- Output Power



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

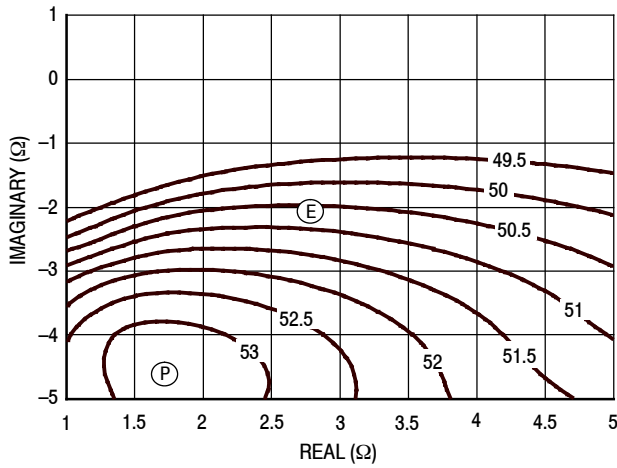


Figure 12. P3dB Load Pull Output Power Contours (dBm)

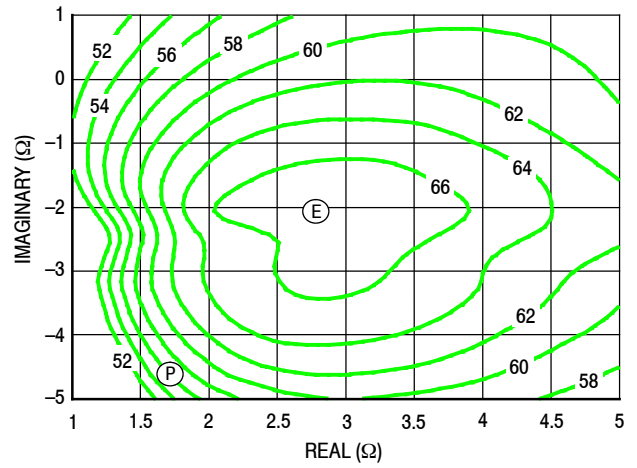


Figure 13. P3dB Load Pull Efficiency Contours (%)

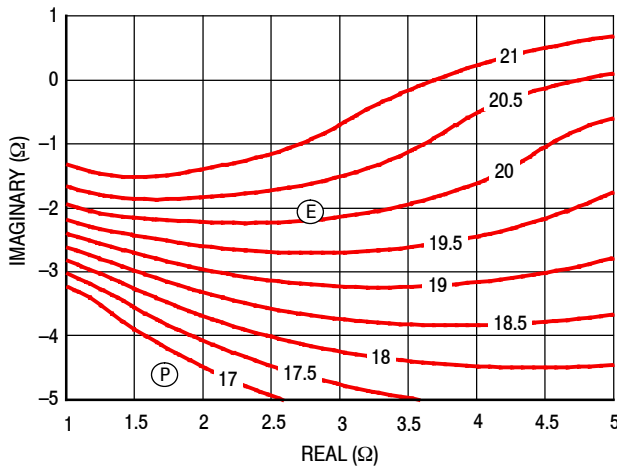


Figure 14. P3dB Load Pull Gain Contours (dB)

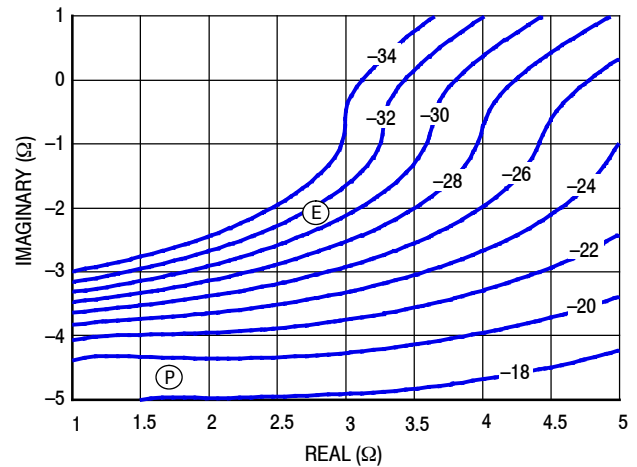
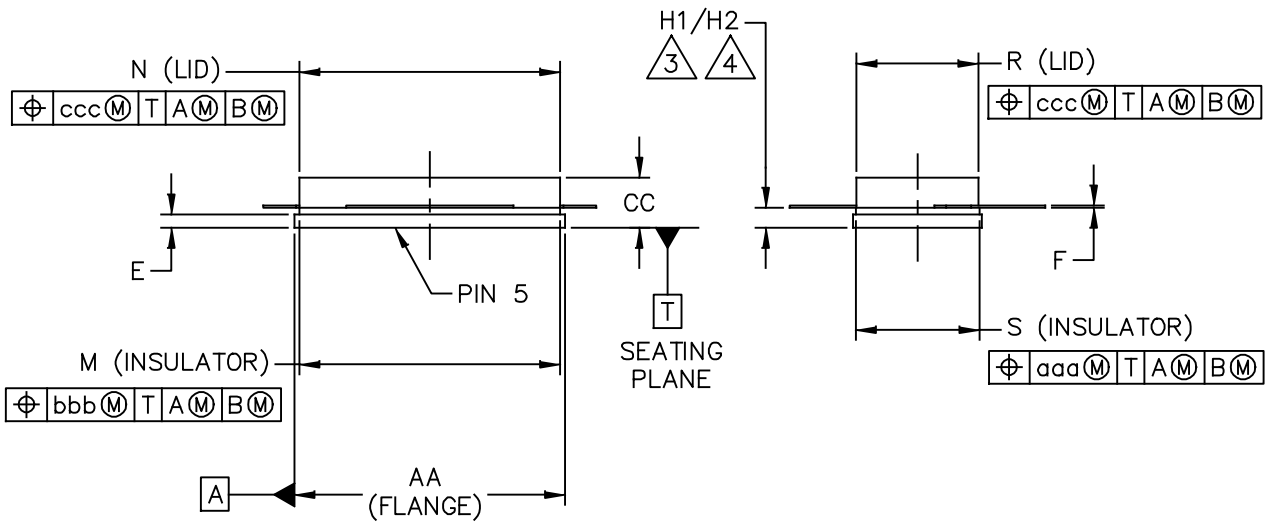
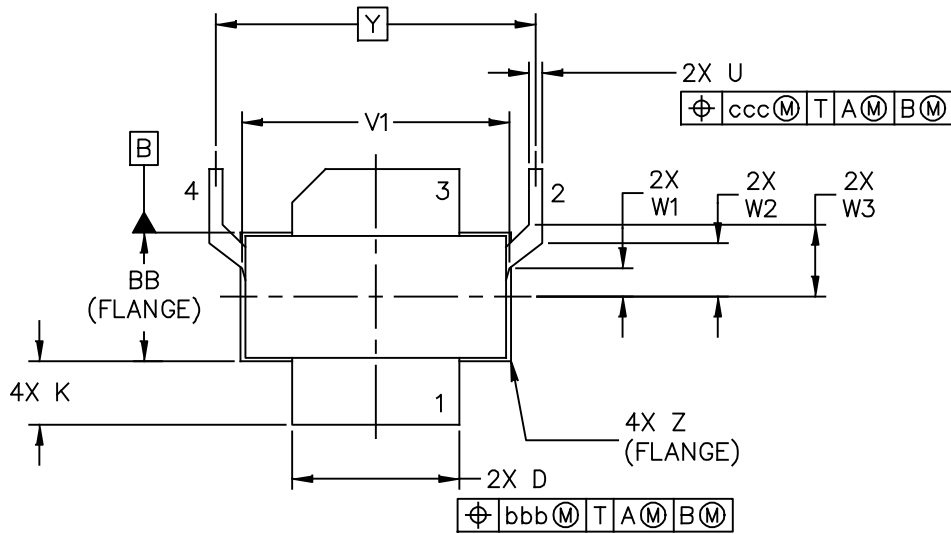


Figure 15. P3dB Load Pull AM/PM Contours (°)

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

- Gain
- Drain Efficiency
- Linearity
- Output Power

### PACKAGE DIMENSIONS



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	08 MAR 2013	

NOTES:

1. CONTROLLING DIMENSION: INCH.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.

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

4. TOLERANCE OF DIMENSION H2 IS TENTATIVE AND COULD CHANGE ONCE SUFFICIENT MANUFACTURING DATA IS AVAILABLE.

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
AA	.805	– .815	20.45	– 20.70	R	.365	– .375	9.27	– 9.53
BB	.380	– .390	9.65	– 9.91	S	.365	– .375	9.27	– 9.53
CC	.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	.080	– .090	2.03	– 2.29
F	.004	– .007	0.10	– 0.18	W2	.155	– .165	3.94	– 4.19
H1	.057	– .067	1.45	– 1.70	W3	.210	– .220	5.33	– 5.59
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		R0.00 – R1.02	
M	.774	– .786	19.66	– 19.96	aaa	– .005	–	– 0.13	–
N	.772	– .788	19.61	– 20.02	bbb	– .010	–	– 0.25	–
					ccc	– .015	–	– 0.38	–
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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	Aug. 2015	• Initial Release of Data Sheet

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