

# RF Power LDMOS Transistor

## N-Channel Enhancement-Mode Lateral MOSFET

This 32 W asymmetrical Doherty RF power LDMOS transistor is designed for cellular base station applications covering the frequency range of 2300 to 2400 MHz.

### 2300 MHz

- Typical Doherty Single-Carrier W-CDMA Performance:  $V_{DD} = 28$  Vdc,  $I_{DQA} = 450$  mA,  $V_{GSB} = 0.6$  Vdc,  $P_{out} = 32$  W Avg., Input Signal PAR = 9.9 dB @ 0.01% Probability on CCDF.

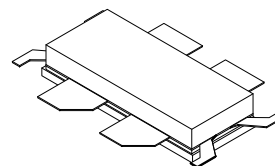
Frequency	$G_{ps}$ (dB)	$\eta_D$ (%)	Output PAR (dB)	ACPR (dBc)
2300 MHz	16.7	46.6	8.0	-31.7
2350 MHz	16.9	46.4	7.7	-32.8
2400 MHz	16.8	46.3	7.6	-34.1

### Features

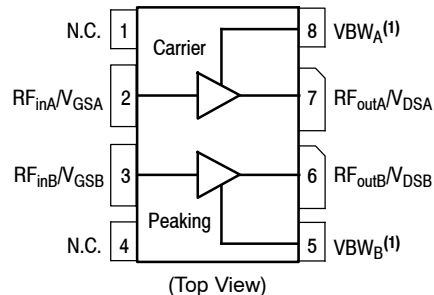
- Advanced High Performance In-Package Doherty
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- Designed for Digital Predistortion Error Correction Systems

## AFT23H160-25SR3

**2300-2400 MHz, 32 W AVG., 28 V AIRFAST RF POWER LDMOS TRANSISTOR**



**NI-880XS-4L4S**



**Figure 1. Pin Connections**

- Device cannot operate with  $V_{DD}$  current supplied through pin 5 and pin 8.

**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 72°C, 32 W Avg., W-CDMA, 28 Vdc, $I_{DQA} = 450$ mA, $V_{GSB} = 0.6$ Vdc, 2350 MHz	$R_{\theta JC}$	0.40	°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 (4)**

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 - Side A, Carrier**

Gate Threshold Voltage ( $V_{DS} = 10$ Vdc, $I_D = 80$ $\mu\text{Adc}$ )	$V_{GS(th)}$	0.8	1.2	1.6	Vdc
Gate Quiescent Voltage ( $V_{DD} = 28$ Vdc, $I_D = 450$ mAdc, Measured in Functional Test)	$V_{GSA(Q)}$	1.4	1.8	2.2	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10$ Vdc, $I_D = 0.8$ Adc)	$V_{DS(on)}$	0.1	0.15	0.3	Vdc

**On Characteristics - Side B, Peaking**

Gate Threshold Voltage ( $V_{DS} = 10$ Vdc, $I_D = 120$ $\mu\text{Adc}$ )	$V_{GS(th)}$	0.8	1.2	1.6	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10$ Vdc, $I_D = 1.2$ Adc)	$V_{DS(on)}$	0.1	0.15	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. Each side of device measured separately.

(continued)

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

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Functional Tests</b> <sup>(1,2)</sup> (In Freescale Doherty Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$ , $I_{DQA} = 450\text{ mA}$ , $V_{GSB} = 0.6\text{ Vdc}$ , $P_{out} = 32\text{ W Avg.}$ , $f = 2300\text{ MHz}$ , 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	$G_{ps}$	15.3	16.7	18.3	dB
Drain Efficiency	$\eta_D$	43.0	46.6	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	7.4	8.0	—	dB
Adjacent Channel Power Ratio	ACPR	—	-31.7	-28.0	dBc

**Load Mismatch** <sup>(2)</sup> (In Freescale Doherty Test Fixture, 50 ohm system)  $I_{DQA} = 450\text{ mA}$ ,  $V_{GSB} = 0.6\text{ Vdc}$ ,  $f = 2300\text{ MHz}$ 

VSWR 10:1 at 32 Wdc, 224 W CW Output Power (3 dB Input Overdrive from 114 W Rated Power)	No Device Degradation
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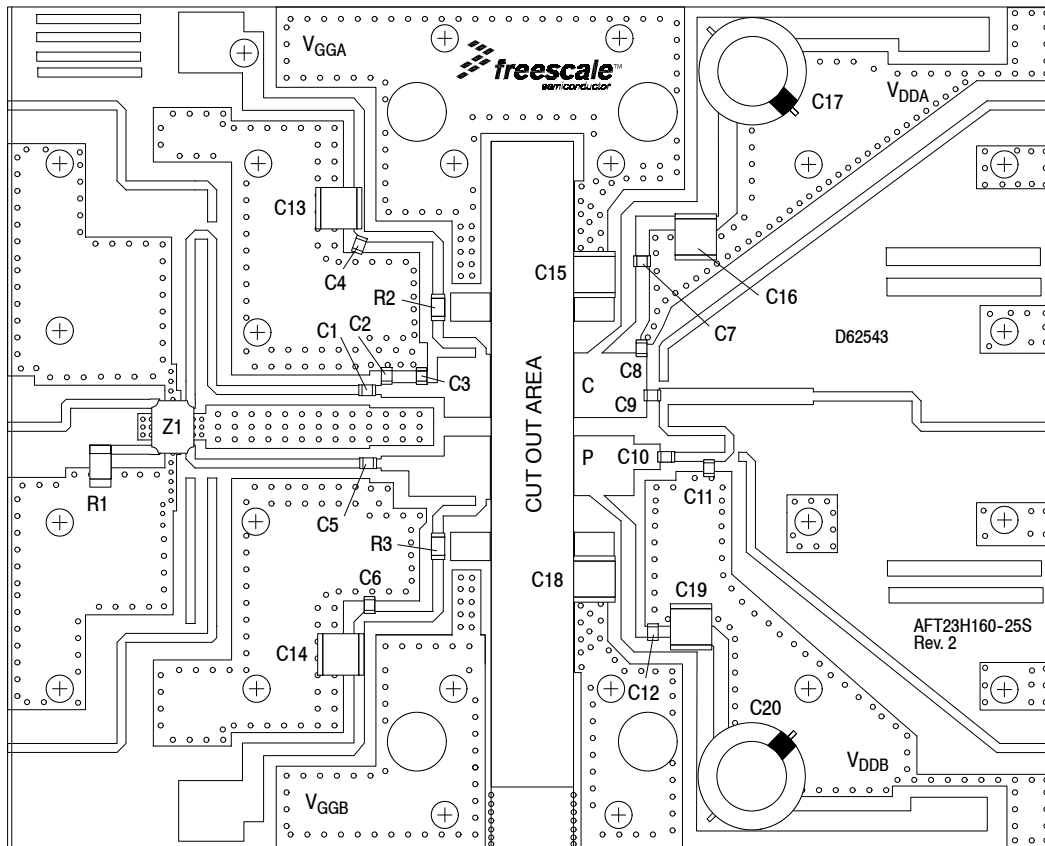
**Typical Performance** (In Freescale Doherty Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQA} = 450\text{ mA}$ ,  $V_{GSB} = 0.6\text{ Vdc}$ , 2300–2400 MHz Bandwidth

$P_{out}$ @ 1 dB Compression Point, CW	P1dB	—	114	—	W
$P_{out}$ @ 3 dB Compression Point <sup>(3)</sup>	P3dB	—	203	—	W
AM/PM (Maximum value measured at the P3dB compression point across the 2300–2400 MHz frequency range)	$\Phi$	—	-14	—	°
VBW Resonance Point (IMD Third Order Intermodulation Inflection Point)	$VBW_{res}$	—	95	—	MHz
Gain Flatness in 100 MHz Bandwidth @ $P_{out} = 32\text{ W Avg.}$	$G_F$	—	1.3	—	dB
Gain Variation over Temperature (-30°C to +85°C)	$\Delta G$	—	0.008	—	dB/°C
Output Power Variation over Temperature (-30°C to +85°C)	$\Delta P1dB$	—	0.008	—	dB/°C

**Table 5. Ordering Information**

Device	Tape and Reel Information	Package
AFT23H160-25SR3	R3 Suffix = 250 Units, 56 mm Tape Width, 13-inch Reel	NI-880XS-4L4S

- Part internally matched both on input and output.
- Measurements made with device in an asymmetrical Doherty configuration.
- $P3dB = P_{avg} + 7.0\text{ dB}$  where  $P_{avg}$  is the average output power measured using an unclipped W-CDMA single-carrier input signal where output PAR is compressed to 7.0 dB @ 0.01% probability on CCDF.

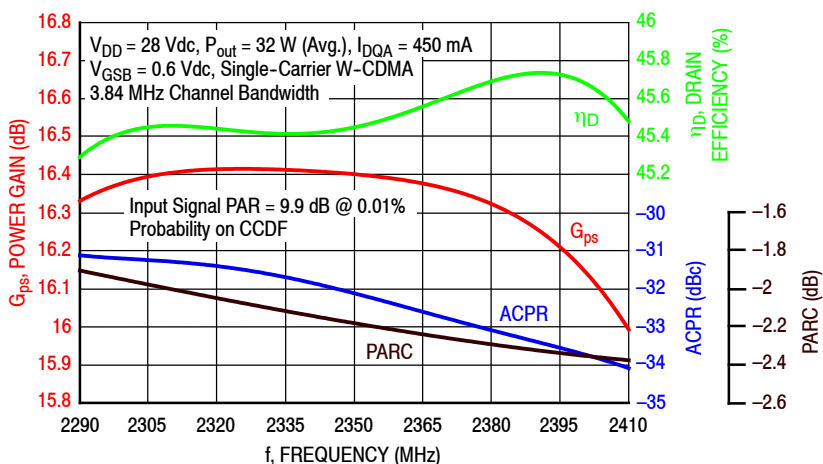


**Figure 2. AFT23H160-25SR3 Test Circuit Component Layout**

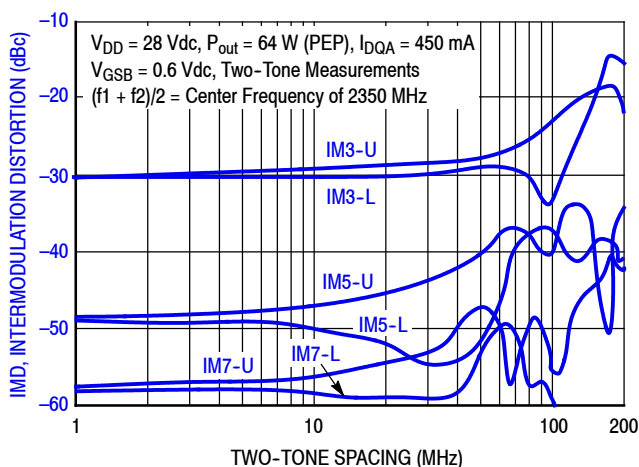
**Table 6. AFT23H160-25SR3 Test Circuit Component Designations and Values**

Part	Description	Part Number	Manufacturer
C1, C4, C5, C6, C7, C12	8.2 pF Chip Capacitors	ATC600F8R2BT250XT	ATC
C2, C3	0.2 pF Chip Capacitors	ATC600F0R2BT250XT	ATC
C8, C11	0.9 pF Chip Capacitors	ATC600F0R9BT250XT	ATC
C9	12 pF Chip Capacitor	ATC600F12R0BT250XT	ATC
C10	5.6 pF Chip Capacitor	ATC600F5R6BT250XT	ATC
C13, C14, C15, C16, C18, C19	10 $\mu$ F Chip Capacitors	C5750X7S2A106M230KB	TDK
C17, C20	470 $\mu$ F, 63 V Electrolytic Capacitors	MCGPR63V477M13X26	Multicomp
R1	50 $\Omega$ , 10 W Termination	CW12010T0050GBK	ATC
R2, R3	5.9 $\Omega$ , 1/4 W Chip Resistors	CRCW12065R9FKEA	Vishay
Z1	2300–2700 MHz Band, 90°, 5 dB Directional Coupler	X3C25P1-05S	Anaren
PCB	Rogers RO4350B, 0.020", $\epsilon_r = 3.66$	D62543	MTL

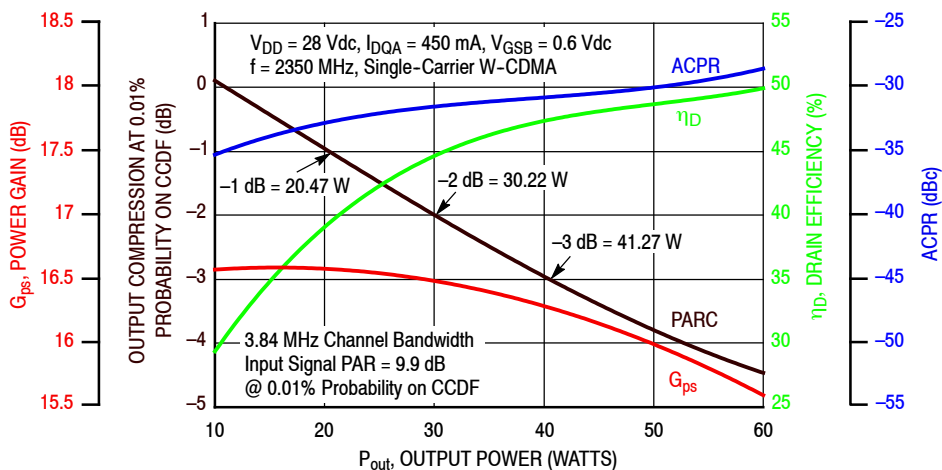
### TYPICAL CHARACTERISTICS



**Figure 3. Single-Carrier Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 32$  Watts Avg.**

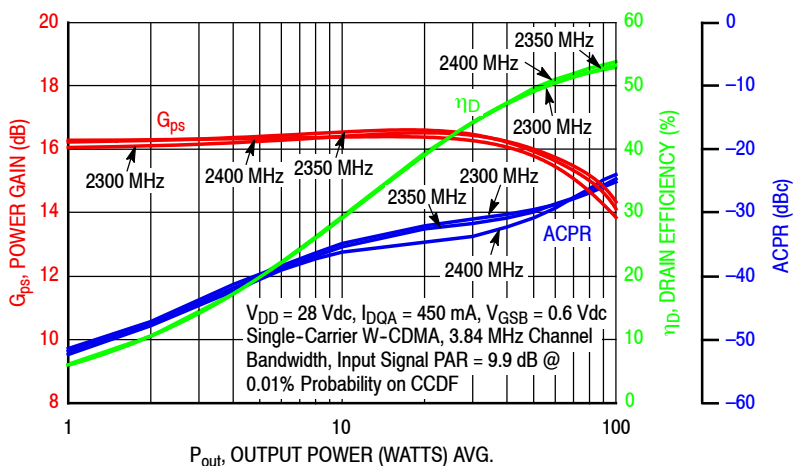


**Figure 4. Intermodulation Distortion Products versus Two-Tone Spacing**

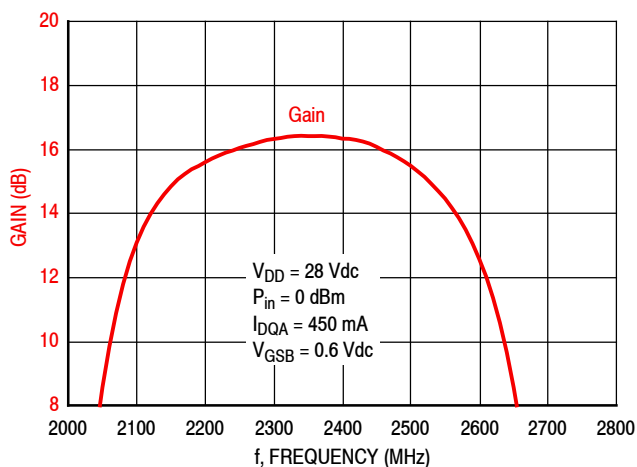


**Figure 5. Output Peak-to-Average Ratio Compression (PARC) versus Output Power**

### TYPICAL CHARACTERISTICS



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



**Figure 7. Broadband Frequency Response**

**Table 7. Carrier Side Load Pull Performance — Maximum Power Tuning**
 $V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQA} = 493 \text{ mA}$ , Pulsed CW,  $10 \mu\text{sec(ON)}$ , 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 (°)
2300	$7.70 - j15.4$	$7.58 + j14.9$	$5.12 - j7.00$	18.5	49.4	87	53.6	-12
2350	$11.0 - j16.4$	$10.9 + j15.6$	$5.00 - j7.12$	18.5	49.4	87	52.7	-12
2400	$17.1 - j18.0$	$16.9 + j15.7$	$4.90 - j7.21$	18.5	49.4	87	53.6	-13

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 (°)
2300	$7.70 - j15.4$	$7.82 + j15.8$	$4.96 - j7.92$	16.2	50.2	105	54.1	-16
2350	$11.0 - j16.4$	$11.8 + j16.8$	$4.97 - j7.93$	16.3	50.2	105	54.2	-17
2400	$17.1 - j18.0$	$19.0 + j16.8$	$4.98 - j8.06$	16.3	50.2	104	53.8	-18

(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. Carrier Side Load Pull Performance — Maximum Drain Efficiency Tuning**
 $V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQA} = 493 \text{ mA}$ , Pulsed CW,  $10 \mu\text{sec(ON)}$ , 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 (°)
2300	$7.70 - j15.4$	$7.53 + j15.5$	$11.5 - j2.65$	21.0	47.3	54	63.3	-19
2350	$11.0 - j16.4$	$11.0 + j16.3$	$9.63 - j2.57$	20.9	47.5	56	63.1	-19
2400	$17.1 - j18.0$	$17.2 + j16.5$	$7.79 - j3.03$	20.6	47.9	61	63.3	-19

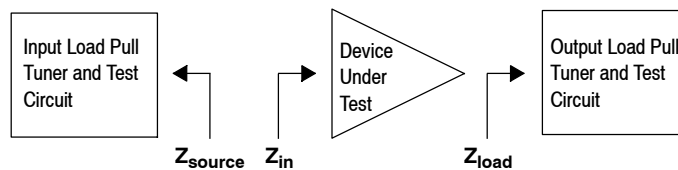
f (MHz)	$Z_{\text{source}} (\Omega)$	$Z_{\text{in}} (\Omega)$	Max Drain Efficiency					
			P3dB					
			$Z_{\text{load}}^{(2)} (\Omega)$	Gain (dB)	(dBm)	(W)	$\eta_D$ (%)	AM/PM (°)
2300	$7.70 - j15.4$	$7.57 + j16.1$	$9.19 - j4.55$	18.4	48.9	78	63.7	-23
2350	$11.0 - j16.4$	$11.6 + j17.4$	$8.35 - j3.56$	18.5	48.7	74	63.7	-25
2400	$17.1 - j18.0$	$19.0 + j17.7$	$7.42 - j3.66$	18.4	48.8	76	64.0	-26

(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.


**Table 9. Peaking Side Load Pull Performance — Maximum Power Tuning**
 $V_{DD} = 28 \text{ Vdc}$ ,  $V_{GSB} = 0.6 \text{ Vdc}$ , 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 ( $^\circ$ )
2300	7.70 – j15.4	6.47 + j15.8	4.76 – j6.72	13.4	51.0	125	53.0	–23
2350	11.0 – j16.4	9.78 + j17.0	4.63 – j6.66	13.5	51.0	126	53.5	–24
2400	16.7 – j15.9	15.4 + j17.5	4.47 – j6.69	13.6	51.0	126	54.2	–25

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 ( $^\circ$ )
2300	7.70 – j15.4	6.99 + j16.7	4.85 – j7.29	11.2	51.8	150	54.6	–29
2350	11.0 – j16.4	11.1 + j18.0	4.82 – j7.32	11.3	51.7	149	54.5	–31
2400	16.7 – j15.9	18.2 + j17.9	4.82 – j7.44	11.5	51.7	149	54.8	–31

(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 10. Peaking Side Load Pull Performance — Maximum Drain Efficiency Tuning**
 $V_{DD} = 28 \text{ Vdc}$ ,  $V_{GSB} = 0.6 \text{ Vdc}$ , 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 ( $^\circ$ )
2300	7.70 – j15.4	5.61 + j15.7	8.65 – j1.94	14.4	49.4	88	64.4	–27
2350	11.0 – j16.4	8.68 + j17.3	7.79 – j2.72	14.5	49.7	92	64.5	–28
2400	16.7 – j15.9	13.9 + j18.5	6.48 – j3.10	14.6	49.8	96	64.5	–28

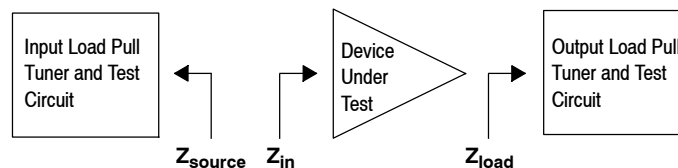
f (MHz)	$Z_{\text{source}}$ ( $\Omega$ )	$Z_{\text{in}}$ ( $\Omega$ )	Max Drain Efficiency					
			P3dB					
			$Z_{\text{load}}^{(2)}$ ( $\Omega$ )	Gain (dB)	(dBm)	(W)	$\eta_D$ (%)	AM/PM ( $^\circ$ )
2300	7.70 – j15.4	6.34 + j16.7	9.88 – j3.77	12.3	50.4	109	64.2	–33
2350	11.0 – j16.4	10.0 + j18.4	8.16 – j2.83	12.4	50.2	106	64.2	–36
2400	16.7 – j15.9	16.8 + j19.2	6.75 – j3.16	12.6	50.4	110	64.2	–37

(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 CARRIER LOAD PULL CONTOURS — 2350 MHz

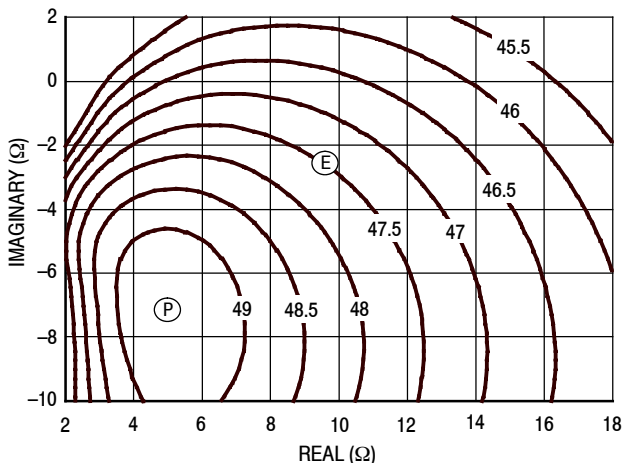


Figure 8. P1dB Load Pull Output Power Contours (dBm)

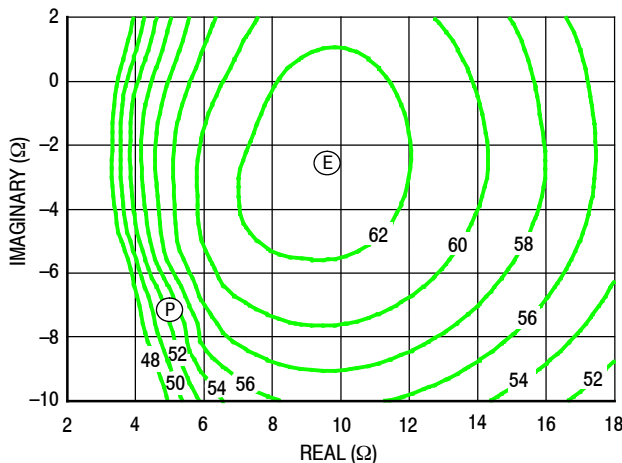


Figure 9. P1dB Load Pull Efficiency Contours (%)

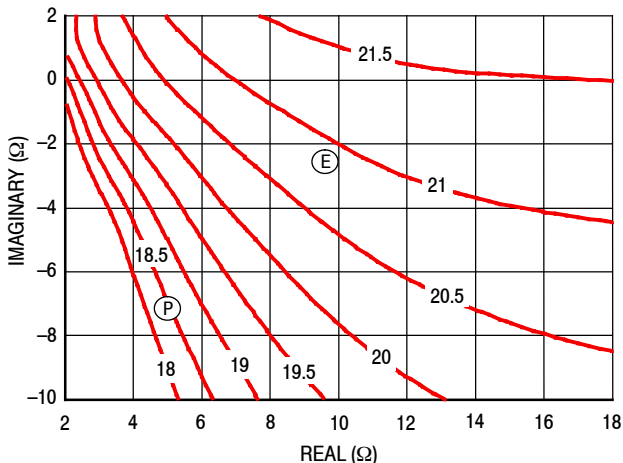


Figure 10. P1dB Load Pull Gain Contours (dB)

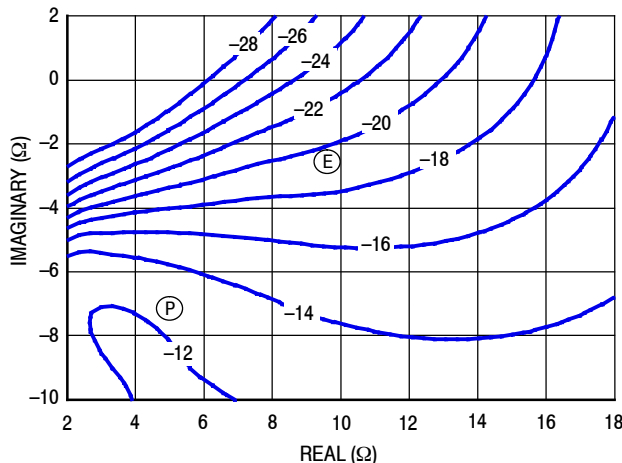


Figure 11. P1dB Load Pull AM/PM Contours (°)

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

- Gain
- Drain Efficiency
- Linearity
- Output Power

P3dB – TYPICAL CARRIER LOAD PULL CONTOURS — 2350 MHz

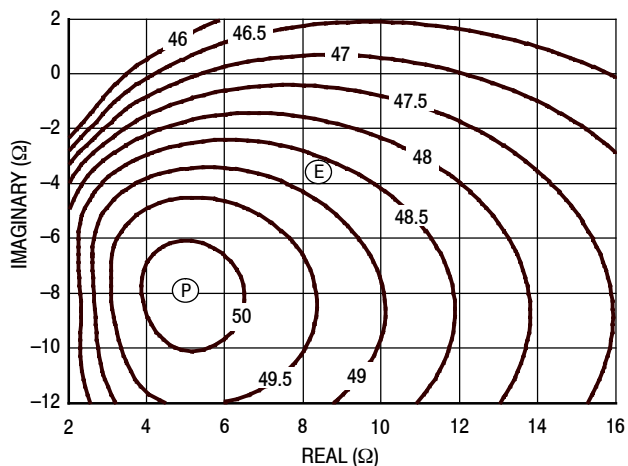


Figure 12. P3dB Load Pull Output Power Contours (dBm)

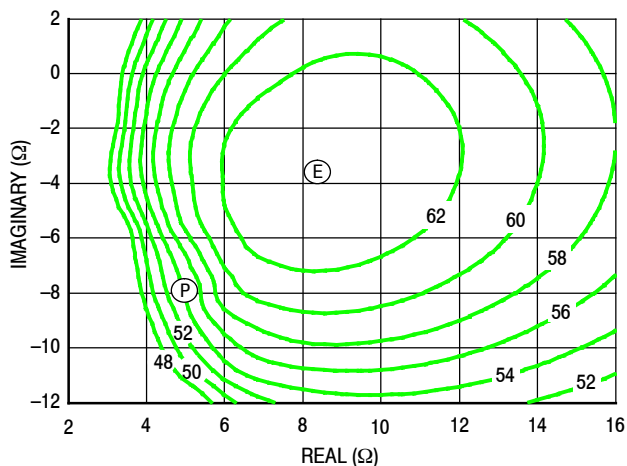


Figure 13. P3dB Load Pull Efficiency Contours (%)

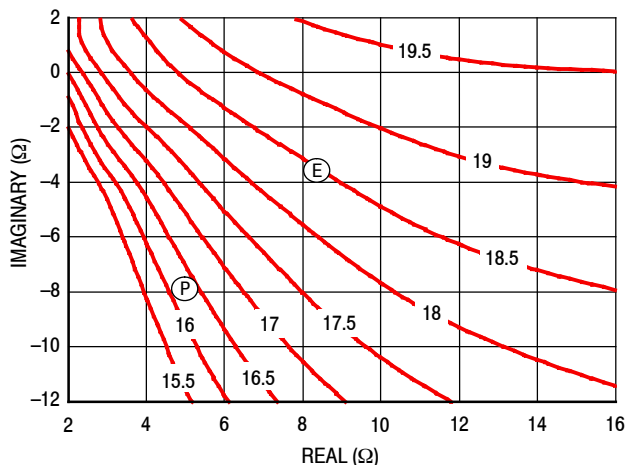


Figure 14. P3dB Load Pull Gain Contours (dB)

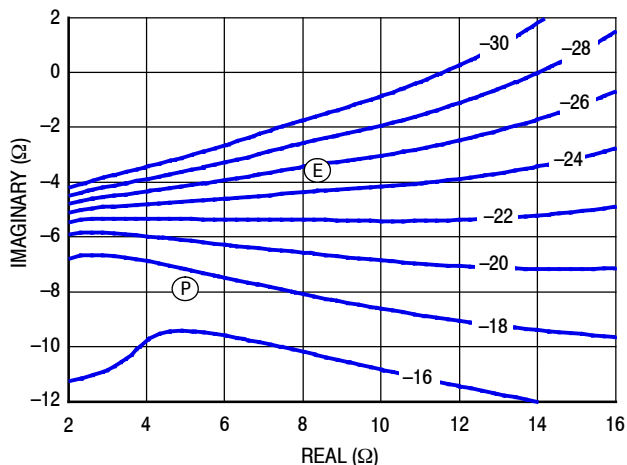
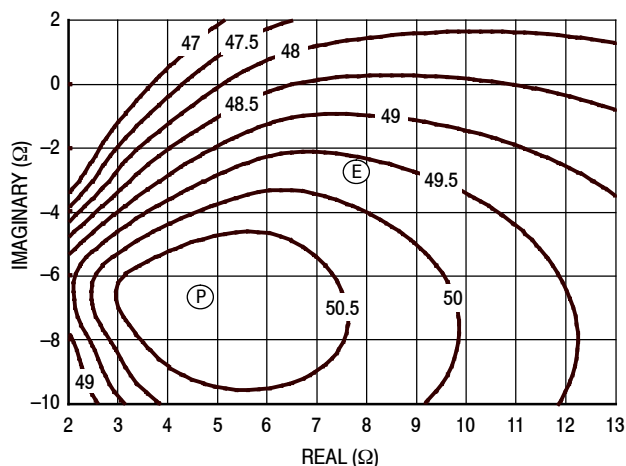


Figure 15. P3dB Load Pull AM/PM Contours (°)

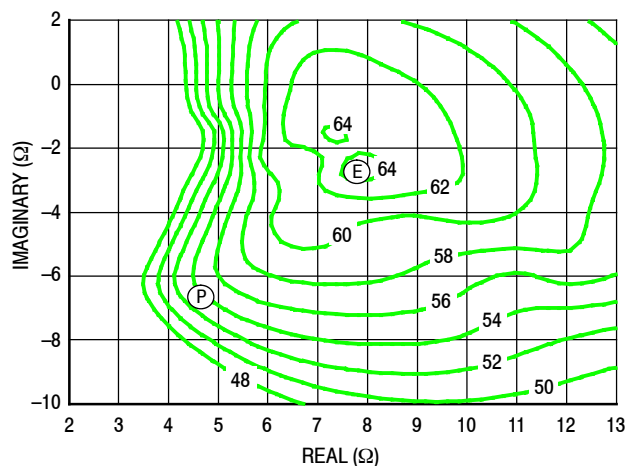
NOTE: (P) = Maximum Output Power  
(E) = Maximum Drain Efficiency

- Gain
- Drain Efficiency
- Linearity
- Output Power

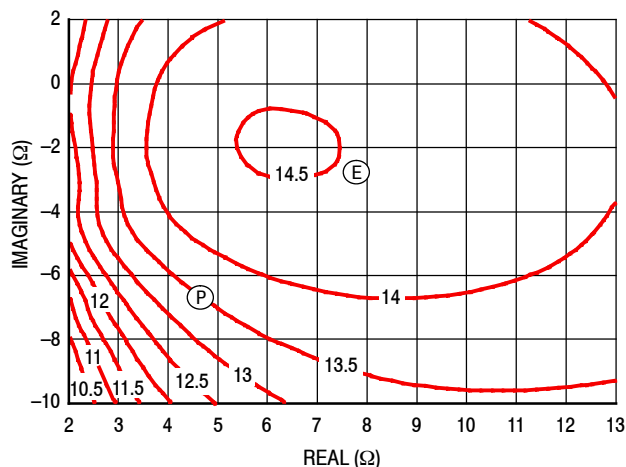
**P1dB – TYPICAL PEAKING LOAD PULL CONTOURS — 2350 MHz**



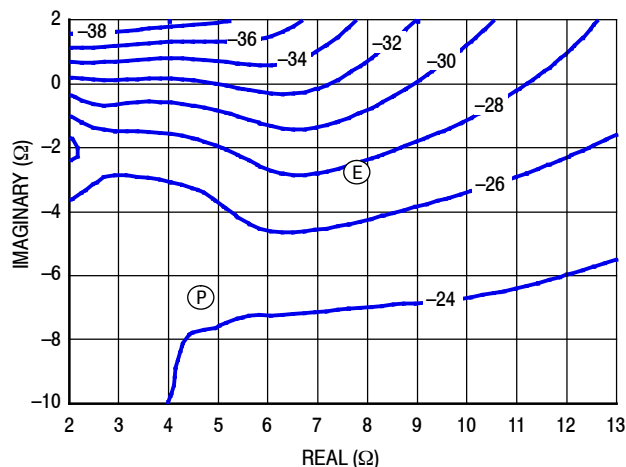
**Figure 16. P1dB Load Pull Output Power Contours (dBm)**



**Figure 17. P1dB Load Pull Efficiency Contours (%)**



**Figure 18. P1dB Load Pull Gain Contours (dB)**

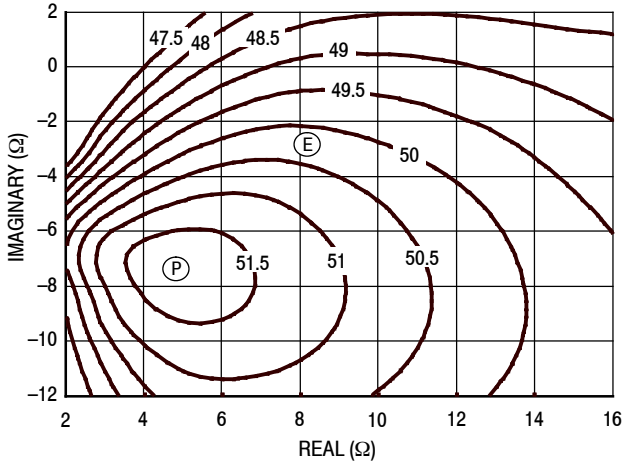


**Figure 19. P1dB Load Pull AM/PM Contours (°)**

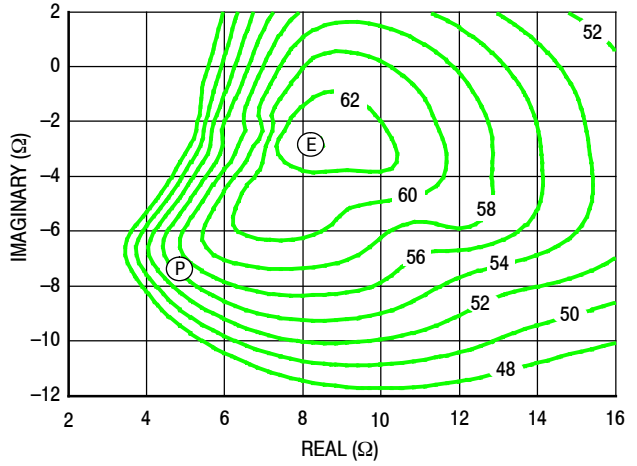
**NOTE:** (P) = Maximum Output Power  
(E) = Maximum Drain Efficiency

- Gain
- Drain Efficiency
- Linearity
- Output Power

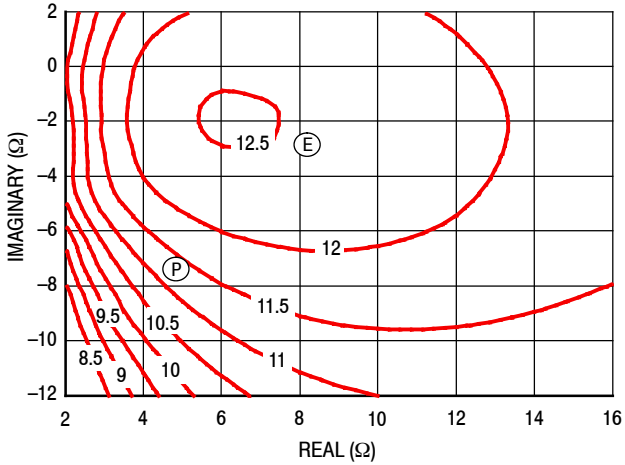
**P3dB – TYPICAL PEAKING LOAD PULL CONTOURS — 2350 MHz**



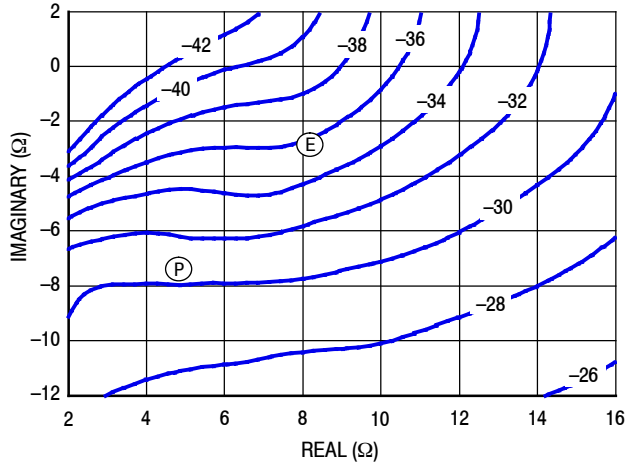
**Figure 20. P3dB Load Pull Output Power Contours (dBm)**



**Figure 21. P3dB Load Pull Efficiency Contours (%)**



**Figure 22. P3dB Load Pull Gain Contours (dB)**

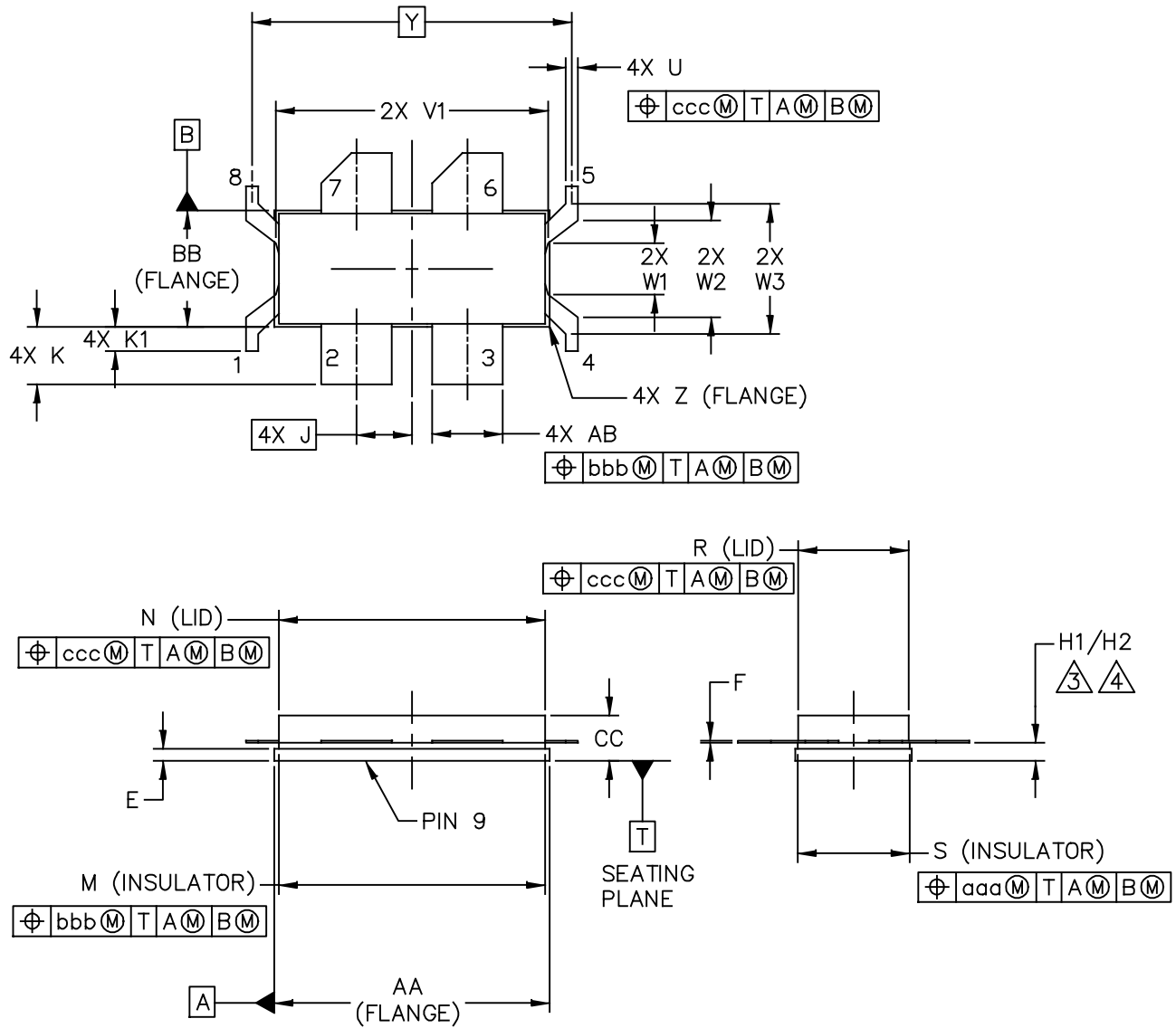


**Figure 23. P3dB Load Pull AM/PM Contours (°)**

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

- Gain
- Drain Efficiency
- Linearity
- Output Power

PACKAGE DIMENSIONS



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NOTES:

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

③ DIMENSIONS H1 AND H2 ARE MEASURED .030 INCH (0.762 MM) AWAY FROM FLANGE PARALLEL TO DATUM B. H1 APPLIES TO PINS 2, 3, 6 & 7. H2 APPLIES TO PINS 1, 4, 5 & 8.

④ TOLERANCE OF DIMENSION H2 IS TENTATIVE.

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
AA	.905	.915	22.99	23.24	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
E	.035	.045	0.89	1.14	V1	.895	.905	22.73	22.99
F	.004	.007	0.10	0.18	W1	.165	.175	4.19	4.45
H1	.057	.067	1.45	1.70	W2	.315	.325	8.00	8.26
H2	.054	.070	1.37	1.78	W3	.425	.435	10.80	11.05
J	.184 BSC		4.66 BSC		Y	1.056 BSC		26.82 BSC	
K	.170	.210	4.32	5.33	Z	R.000	R.040	R0.00	R1.02
K1	.070	.090	1.78	2.29	AB	.228	.238	5.79	6.05
M	.874	.886	22.20	22.50	aaa	.005		0.13	
N	.872	.888	22.15	22.56	bbb	.010		0.25	
					ccc	.015		0.38	
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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	Nov. 2015	• Initial Release of Data Sheet

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