



# RF Power LDMOS Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

These 24 W symmetrical Doherty RF power LDMOS transistors are designed for cellular base station applications requiring very wide instantaneous bandwidth capability covering the frequency range of 1880 to 2025 MHz.

- Typical Doherty Single-Carrier W-CDMA Performance:  $V_{DD} = 28$  Vdc,  $I_{DQA} = 500$  mA,  $V_{GSB} = 0.6$  Vdc,  $P_{out} = 24$  W Avg., Input Signal PAR = 9.9 dB @ 0.01% Probability on CCDF.

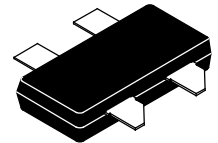
Frequency	$G_{ps}$ (dB)	$\eta_D$ (%)	Output PAR (dB)	ACPR (dBc)
1880 MHz	17.8	41.7	7.7	-31.0
1960 MHz	17.8	41.7	7.7	-33.7
2025 MHz	17.6	41.2	7.8	-34.0

### Features

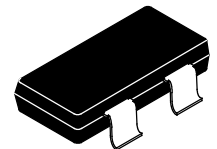
- Designed for wide instantaneous bandwidth applications
- Greater negative gate-source voltage range for improved Class C operation
- Able to withstand extremely high output VSWR and broadband operating conditions
- Designed for digital predistortion error correction systems
- In tape and reel. R3 suffix = 250 units, 32 mm tape width, 13-inch reel.

**AFT20P140-4WNR3**  
**AFT20P140-4WGNR3**

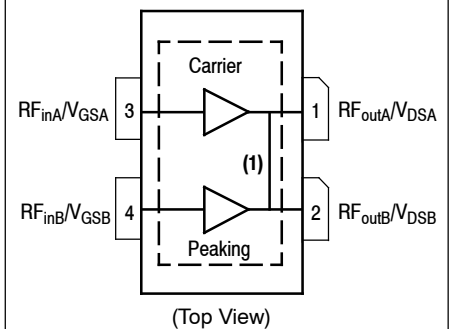
**1880-2025 MHz, 24 W AVG., 28 V**  
**AIRFAST RF POWER LDMOS**  
**TRANSISTORS**



**OM-780-4L**  
**PLASTIC**  
**AFT20P140-4WNR3**



**OM-780G-4L**  
**PLASTIC**  
**AFT20P140-4WGNR3**



Note: Exposed backside of the package is the source terminal for the transistor.

**Figure 1. Pin Connections**

1. Pin connections 1 and 2 are DC coupled and RF independent.

**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 +125	°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 74°C, 24 W 2-Carrier W-CDMA, 28 Vdc, $I_{DQA} = 500$ mA, $V_{GSB} = 0.6$ Vdc, f1 = 1880 MHz, f2 = 1910 MHz	$R_{\theta JC}$	0.60	°C/W
Case Temperature 88°C, 118 W 2-Carrier W-CDMA, 28 Vdc, $I_{DQA} = 500$ mA, $V_{GSB} = 0.6$ Vdc, f1 = 1880 MHz, f2 = 1910 MHz		0.42	

**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. Moisture Sensitivity Level**

Test Methodology	Rating	Package Peak Temperature	Unit
Per JESD22-A113, IPC/JEDEC J-STD-020	3	260	°C

**Table 5. Electrical Characteristics** ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Off Characteristics (4)</b>					
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 ( $V_{DS} = 28$ Vdc, $V_{GS} = 0$ Vdc)	$I_{DSS}$	—	—	5	$\mu\text{Adc}$
Gate-Source Leakage Current ( $V_{GS} = 5$ Vdc, $V_{DS} = 0$ Vdc)	$I_{GSS}$	—	—	1	$\mu\text{Adc}$
<b>On Characteristics (5)</b>					
Gate Threshold Voltage (6) ( $V_{DS} = 10$ Vdc, $I_D = 150$ $\mu\text{Adc}$ )	$V_{GS(th)}$	0.8	1.2	1.6	Vdc
Gate Quiescent Voltage ( $V_{DD} = 28$ Vdc, $I_{DA} = 500$ mAdc, Measured in Functional Test)	$V_{GSA(Q)}$	1.3	1.9	2.3	Vdc
Drain-Source On-Voltage (4) ( $V_{GS} = 10$ Vdc, $I_D = 2.0$ 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.nxp.com/RF/calculators>.
3. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.nxp.com/RF> and search for AN1955.
4. Side A and Side B are tied together for these measurements.
5.  $V_{DDA}$  and  $V_{ddb}$  must be tied together and powered by a single DC power supply.
6. Each side of device measured separately.

(continued)

**Table 5. Electrical Characteristics** ( $T_A = 25^\circ\text{C}$  unless otherwise noted) (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Functional Tests — 1900 MHz</b> <sup>(1,2,3,4)</sup> (In NXP Doherty Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$ , $I_{DQA} = 500\text{ mA}$ , $V_{GSB} = 0.6\text{ Vdc}$ , $P_{out} = 24\text{ W Avg.}$ , $f_1 = 1880\text{ MHz}$ , $f_2 = 1910\text{ MHz}$ , 2-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 @ $\pm 20\text{ MHz}$ Offset.					
Power Gain	$G_{ps}$	17.0	17.8	20.0	dB
Drain Efficiency	$\eta_D$	38.0	41.4	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	7.1	7.7	—	dB
Adjacent Channel Power Ratio	ACPR	—	-33.1	-31.0	dBc
$P_{out}$ @ 3 dB Compression Point @ 1880 MHz, CW	P3dB	120	—	—	W

**Functional Tests — 2025 MHz** <sup>(1,2,3,4)</sup> (In NXP Doherty Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQA} = 500\text{ mA}$ ,  $V_{GSB} = 0.6\text{ Vdc}$ ,  $P_{out} = 24\text{ W Avg.}$ ,  $f_1 = 1995\text{ MHz}$ ,  $f_2 = 2025\text{ MHz}$ , 2-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 @  $\pm 20\text{ MHz}$  Offset.

Power Gain	$G_{ps}$	16.6	17.8	19.6	dB
Drain Efficiency	$\eta_D$	38.0	40.7	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	7.1	7.8	—	dB
Adjacent Channel Power Ratio	ACPR	—	-33.5	-31.0	dBc
$P_{out}$ @ 3 dB Compression Point @ 2025 MHz, CW	P3dB	120	—	—	W

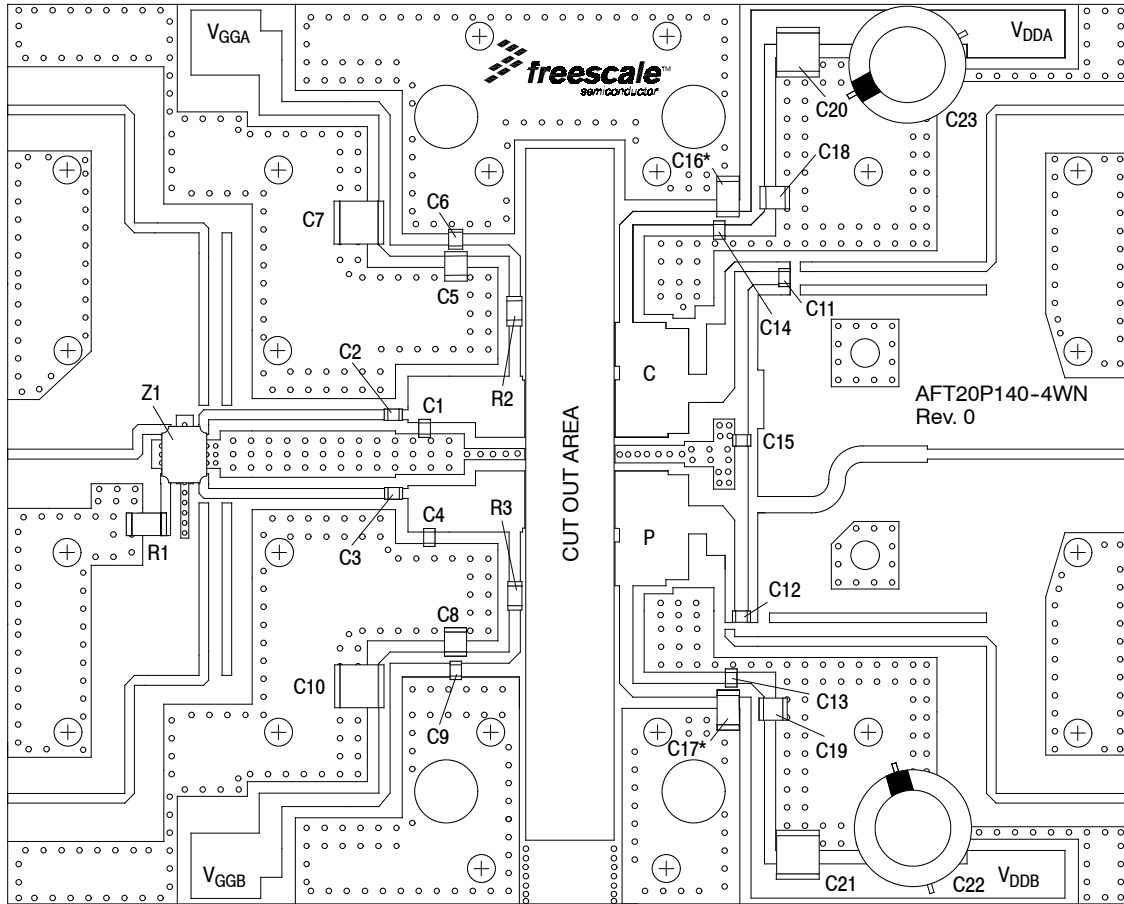
**Load Mismatch** (In NXP Test Fixture, 50 ohm system)  $I_{DQA} = 500\text{ mA}$ ,  $f = 1960\text{ MHz}$

VSWR 10:1 at 32 Vdc, 170 W CW Output Power (3 dB Input Overdrive from 130 W CW Rated Power)	No Device Degradation				
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**Typical Performance** <sup>(3)</sup> (In NXP Doherty Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQA} = 500\text{ mA}$ ,  $V_{GSB} = 0.6\text{ Vdc}$ , 1880–2025 MHz Bandwidth

$P_{out}$ @ 1 dB Compression Point, CW	P1dB	—	130	—	W
$P_{out}$ @ 3 dB Compression Point <sup>(5)</sup>	P3dB	—	170	—	W
AM/PM (Maximum value measured at the P3dB compression point across the 1880–2025 MHz bandwidth)	$\Phi$	—	-22.7	—	$^\circ$
VBW Resonance Point (IMD Third Order Intermodulation Inflection Point)	$VBW_{res}$	—	160	—	MHz
Gain Flatness in 145 MHz Bandwidth @ $P_{out} = 24\text{ W Avg.}$	$G_F$	—	0.25	—	dB
Gain Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta G$	—	0.001	—	dB/ $^\circ\text{C}$
Output Power Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta P1dB$	—	0.003	—	dB/ $^\circ\text{C}$

- $V_{DDA}$  and  $V_{ddb}$  must be tied together and powered by a single DC power supply.
- Part internally matched both on input and output.
- Measurement made with device in a symmetrical Doherty configuration.
- Measurements made with device in straight lead configuration before any lead forming operation is applied. Lead forming is used for gull wing (GN) parts.
- 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.



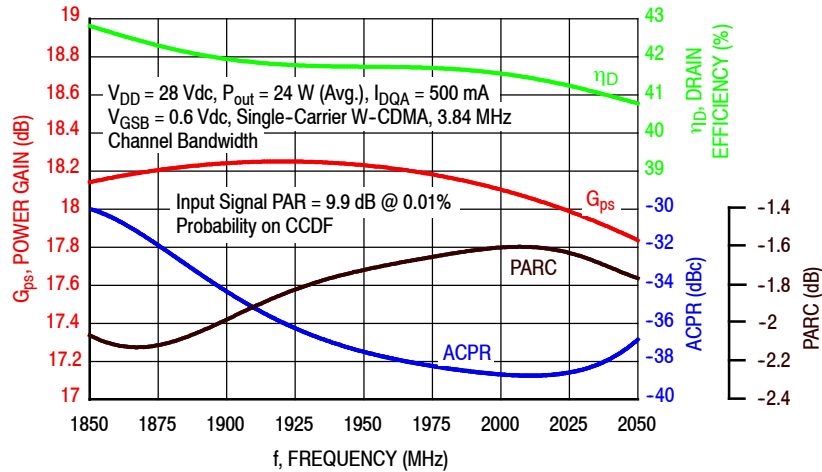
\*C16 and C17 are mounted vertically.

**Figure 2. AFT20P140-4WNR3 Test Circuit Component Layout**

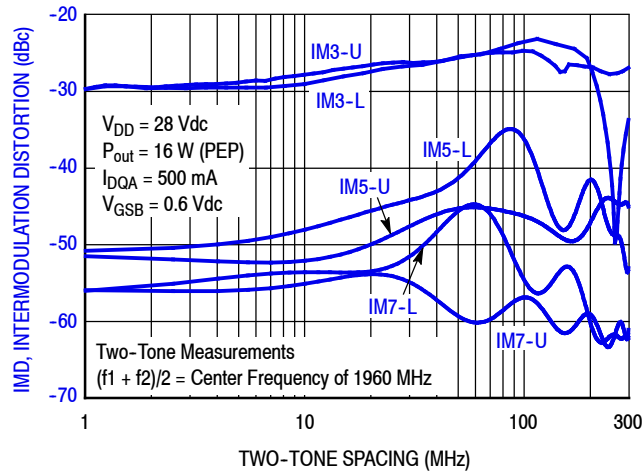
**Table 6. AFT20P140-4WNR3 Test Circuit Component Designations and Values**

Part	Description	Part Number	Manufacturer
C1	0.6 pF Chip Capacitor	ATC600F0R6BT250XT	ATC
C2, C3, C6, C9, C11, C12, C13, C14	12 pF Chip Capacitors	ATC600F120JT250XT	ATC
C4	0.3 pF Chip Capacitor	ATC600F0R3BT250XT	ATC
C5, C8, C18, C19	2.2 $\mu$ F, 100 V Chip Capacitors	C3225X7R2A225KT	TDK
C7, C10, C20, C21	10 $\mu$ F, 100 V Chip Capacitors	C5750X7S2A106KT	TDK
C15	0.5 pF Chip Capacitor	ATC600F0R5BT250XT	ATC
C16, C17	6.8 $\mu$ F, 50 V Chip Capacitors	C4532X7R1H685KT	TDK
C22, C23	100 $\mu$ F, 63 V Electrolytic Capacitors	SK063M0100B5S-1012	Yageo
R1	50 $\Omega$ , 10 W Chip Resistor	CW12010T0050GBK	ATC
R2, R3	3 $\Omega$ , 1/4 W Chip Resistors	CRCW12063R00FKEA	Vishay
Z1	1700–2000 MHz Band, 90°, 3 dB Hybrid Couplers	1P503S	Anaren
PCB	0.020", $\epsilon_r = 3.5$	RO4350B	Rogers

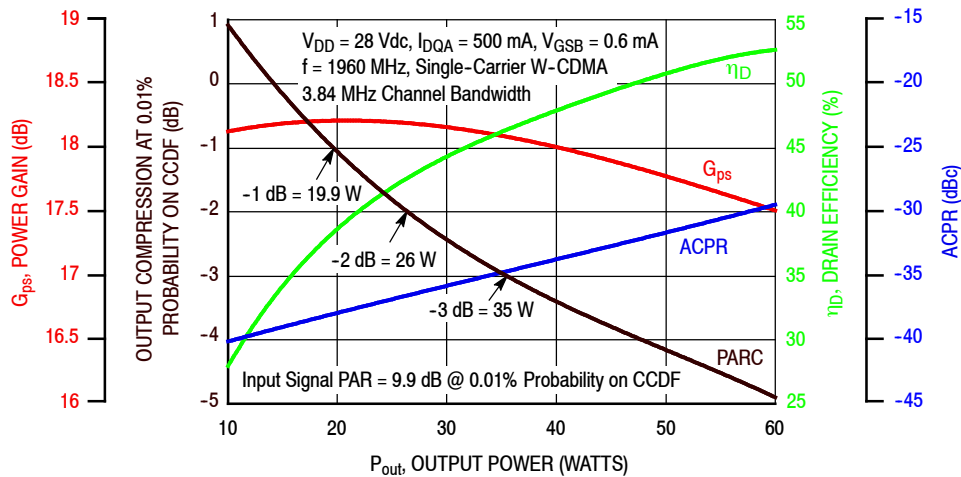
### TYPICAL CHARACTERISTICS



**Figure 3. Single-Carrier Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 24$  Watts Avg.**

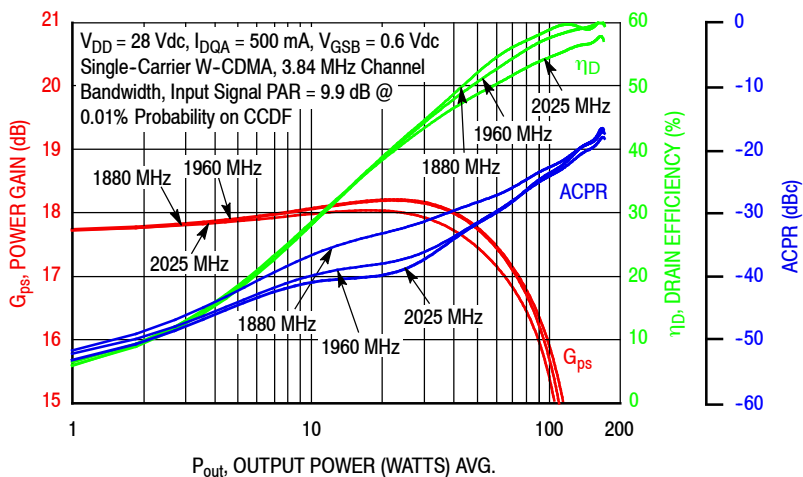


**Figure 4. Intermodulation Distortion Products versus Two-Tone Spacing**

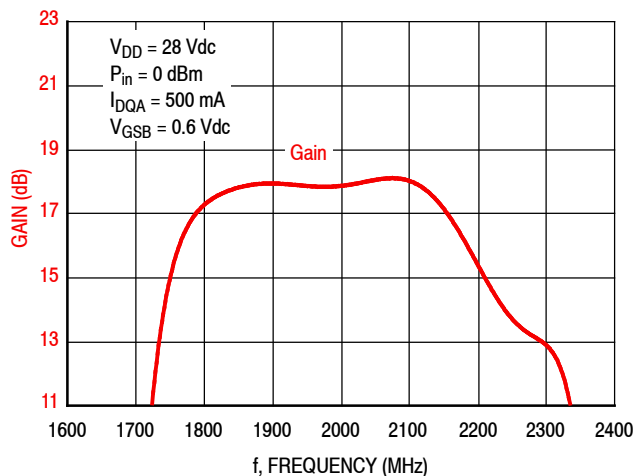


**Figure 5. Output Peak-to-Average Ratio Compression (PARC) versus Output Power**

### TYPICAL CHARACTERISTICS



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



**Figure 7. Broadband Frequency Response**

$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQA} = 511 \text{ mA}$ , 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 (°)
1880	6.86 - j8.74	6.24 + j8.58	2.15 - j5.34	19.2	50.0	101	54.0	-13
1960	10.2 - j5.77	8.98 + j6.06	2.20 - j5.78	19.1	49.9	98	53.3	-14
2025	8.51 - j1.35	8.23 + j2.78	2.14 - j6.19	18.9	50.1	102	52.6	-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 (°)
1880	6.86 - j8.74	6.77 + j9.00	2.02 - j5.66	16.9	50.8	121	55.1	-17
1960	10.2 - j5.77	10.0 + j5.72	2.08 - j6.06	16.7	50.7	118	53.6	-18
2025	8.51 - j1.35	8.44 + j1.79	2.08 - j6.50	16.5	50.8	121	53.0	-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.

**Figure 8. Single Side Load Pull Performance — Maximum Power Tuning**

$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQA} = 511 \text{ mA}$ , 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 (°)
1880	6.86 - j8.74	6.66 + j8.74	4.65 - j4.23	21.6	48.4	69	64.6	-21
1960	10.2 - j5.77	9.17 + j5.67	4.26 - j3.66	21.6	48.0	63	64.1	-22
2025	8.51 - j1.35	7.90 + j2.75	3.73 - j4.44	21.2	48.5	70	62.7	-21

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 (°)
1880	6.86 - j8.74	7.01 + j9.10	4.65 - j4.32	19.5	49.0	79	65.6	-27
1960	10.2 - j5.77	9.95 + j5.36	4.09 - j3.61	19.6	48.6	73	65.0	-30
2025	8.51 - j1.35	8.11 + j2.05	3.50 - j4.62	19.0	49.3	86	63.7	-28

(1) Load impedance for optimum P1dB efficiency.

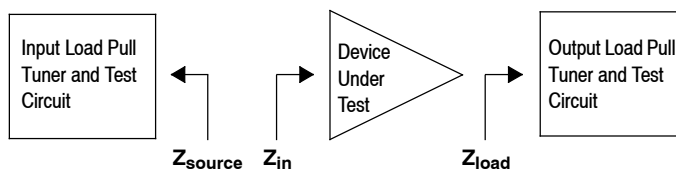
(2) Load impedance for optimum P3dB efficiency.

$Z_{\text{source}}$  = 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.

**Figure 9. Single Side Load Pull Performance — Maximum Drain Efficiency Tuning**



AFT20P140-4WNR3 AFT20P140-4WGNR3

## P1dB - TYPICAL LOAD PULL CONTOURS — 1960 MHz

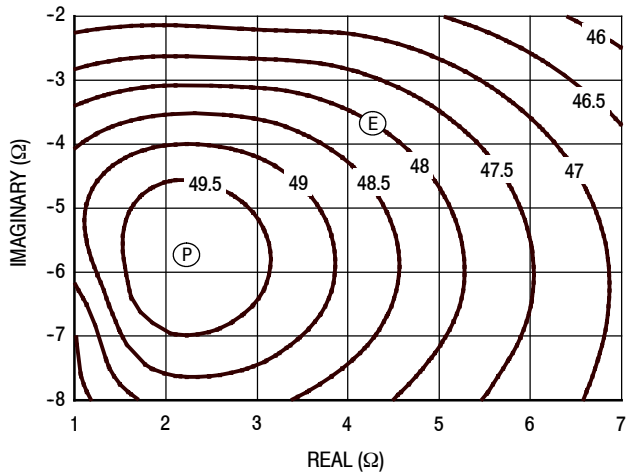


Figure 10. P1dB Load Pull Output Power Contours (dBm)

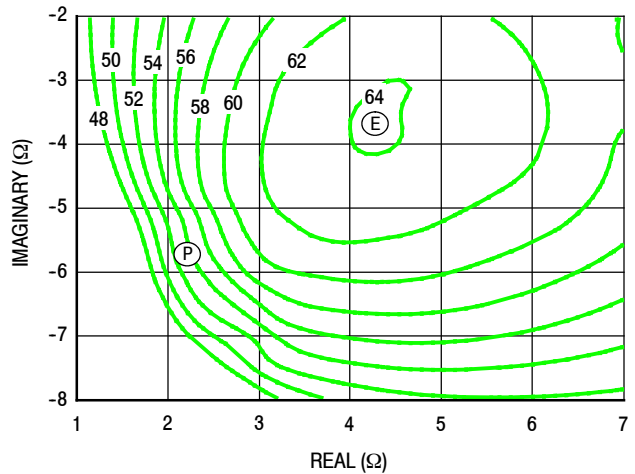


Figure 11. P1dB Load Pull Efficiency Contours (%)

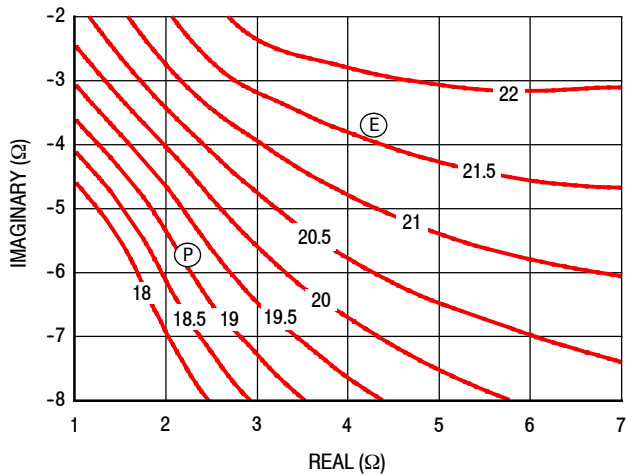


Figure 12. P1dB Load Pull Gain Contours (dB)

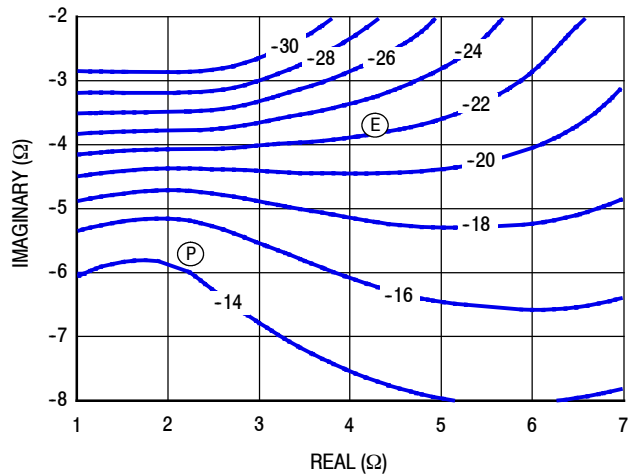


Figure 13. P1dB Load Pull AM/PM Contours (°)

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

- Gain
- Drain Efficiency
- Linearity
- Output Power



### P3dB - TYPICAL LOAD PULL CONTOURS — 1960 MHz

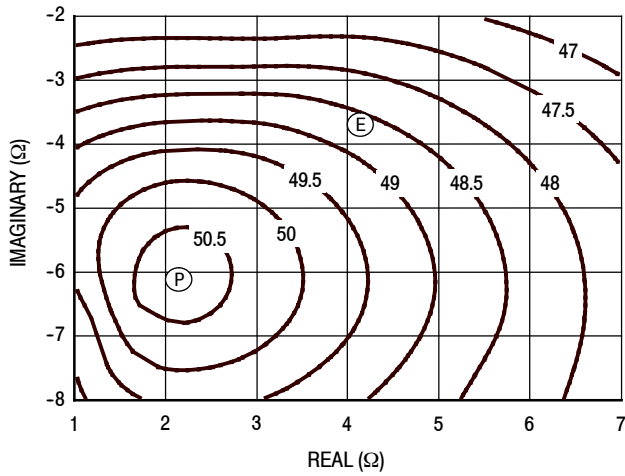


Figure 14. P3dB Load Pull Output Power Contours (dBm)

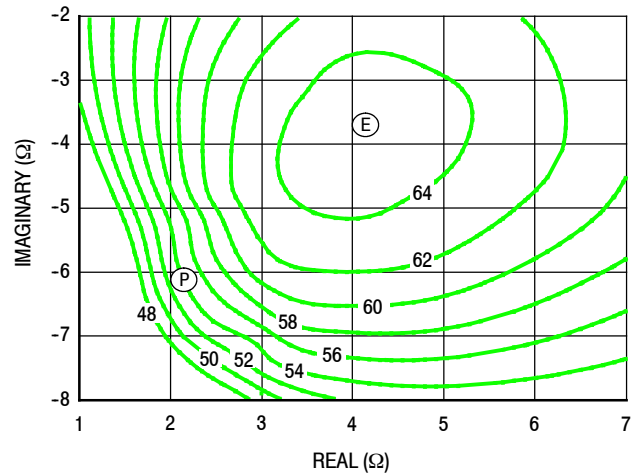


Figure 15. P3dB Load Pull Efficiency Contours (%)

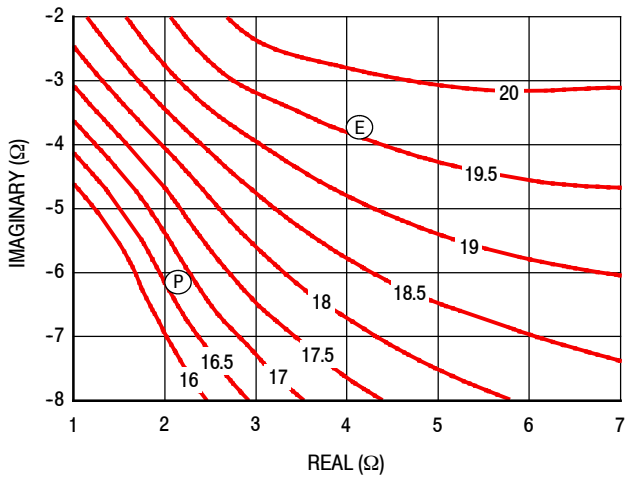


Figure 16. P3dB Load Pull Gain Contours (dB)

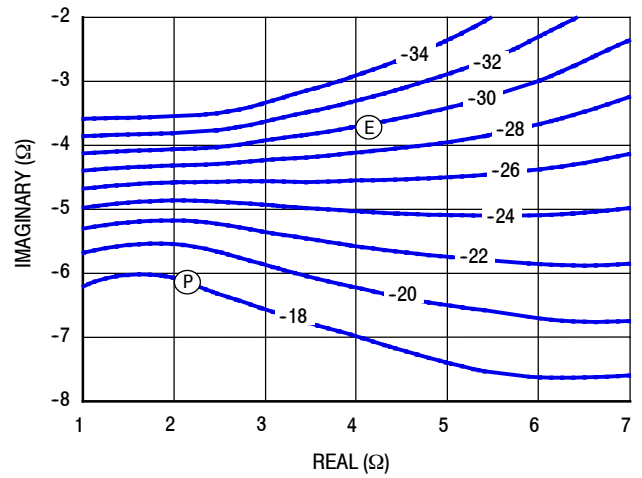
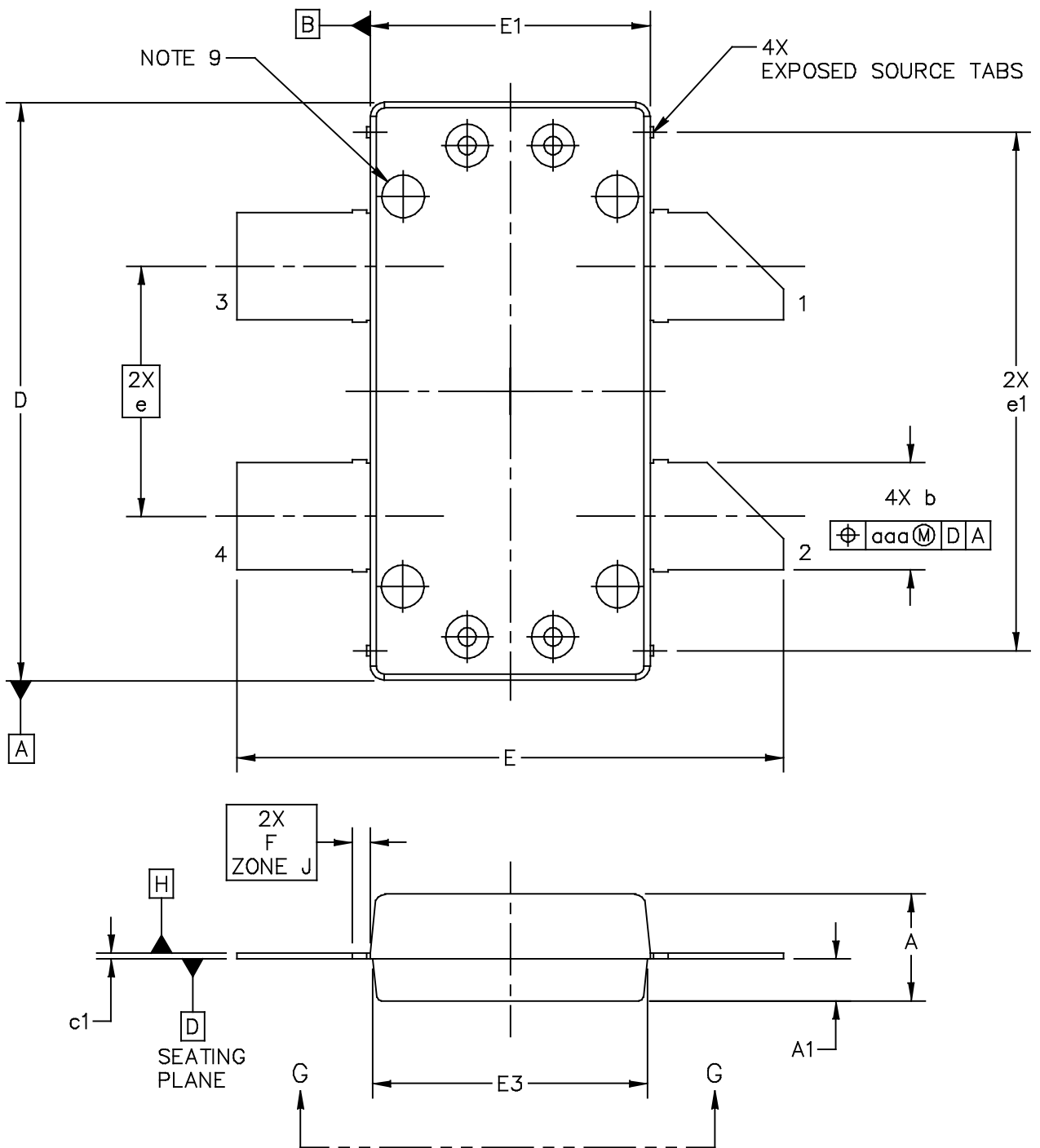


Figure 17. P3dB Load Pull AM/PM Contours (°)

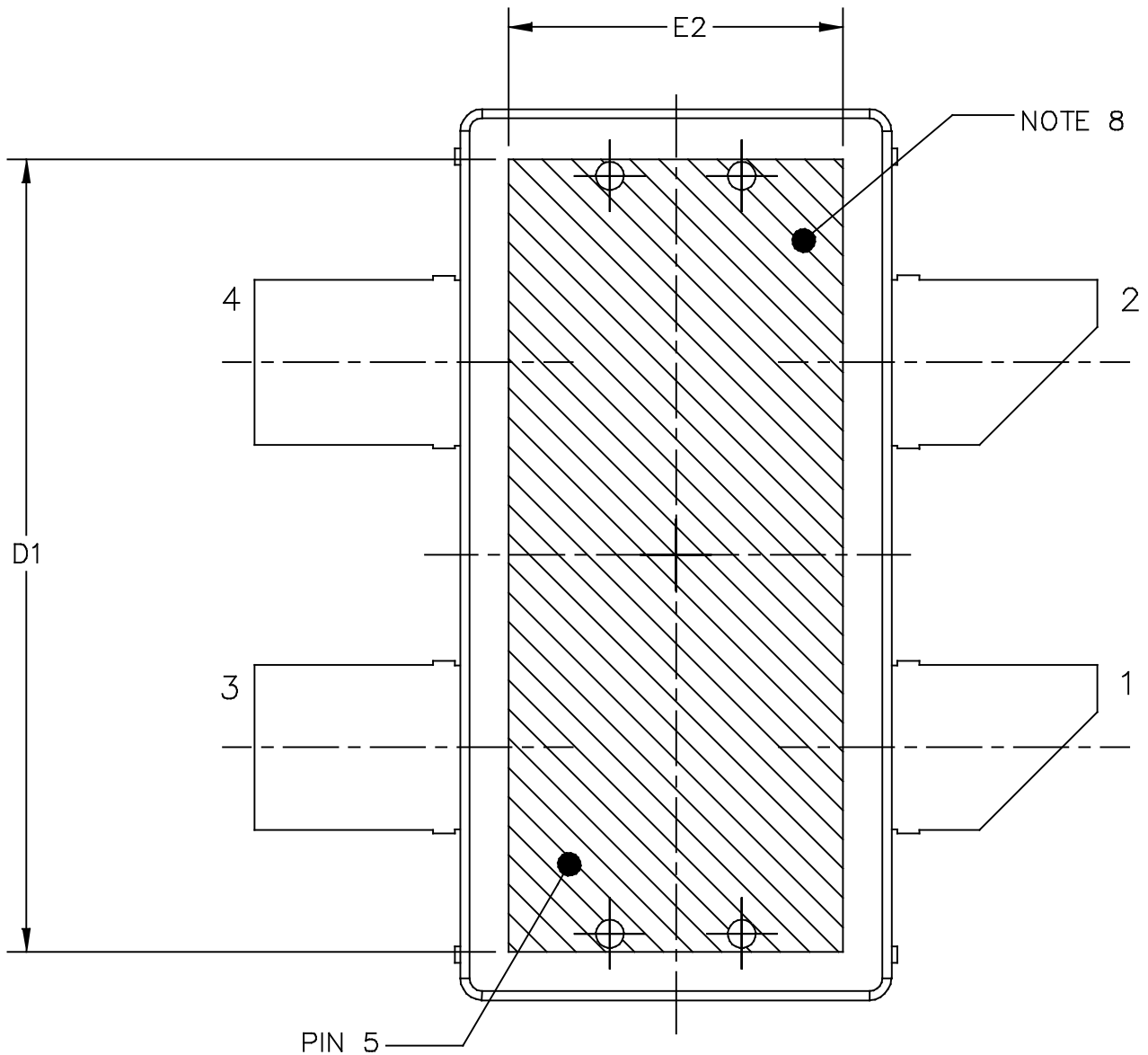
**NOTE:** (P) = Maximum Output Power  
(E) = Maximum Drain Efficiency

- Gain
- Drain Efficiency
- Linearity
- Output Power

PACKAGE DIMENSIONS



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	STANDARD: NON-JEDEC	
	SOT1818-4	16 MAR 2016



BOTTOM VIEW  
VIEW G-G

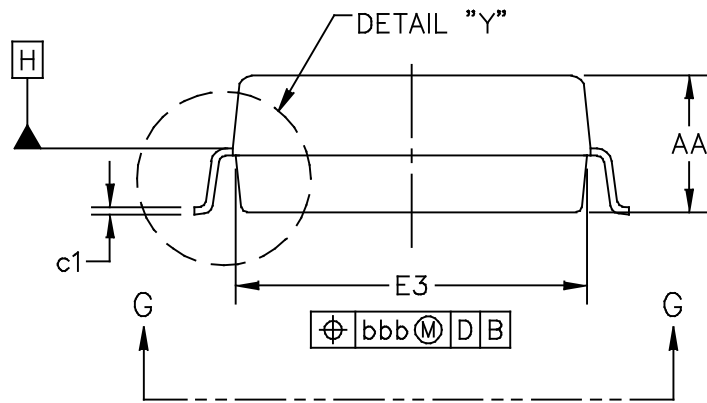
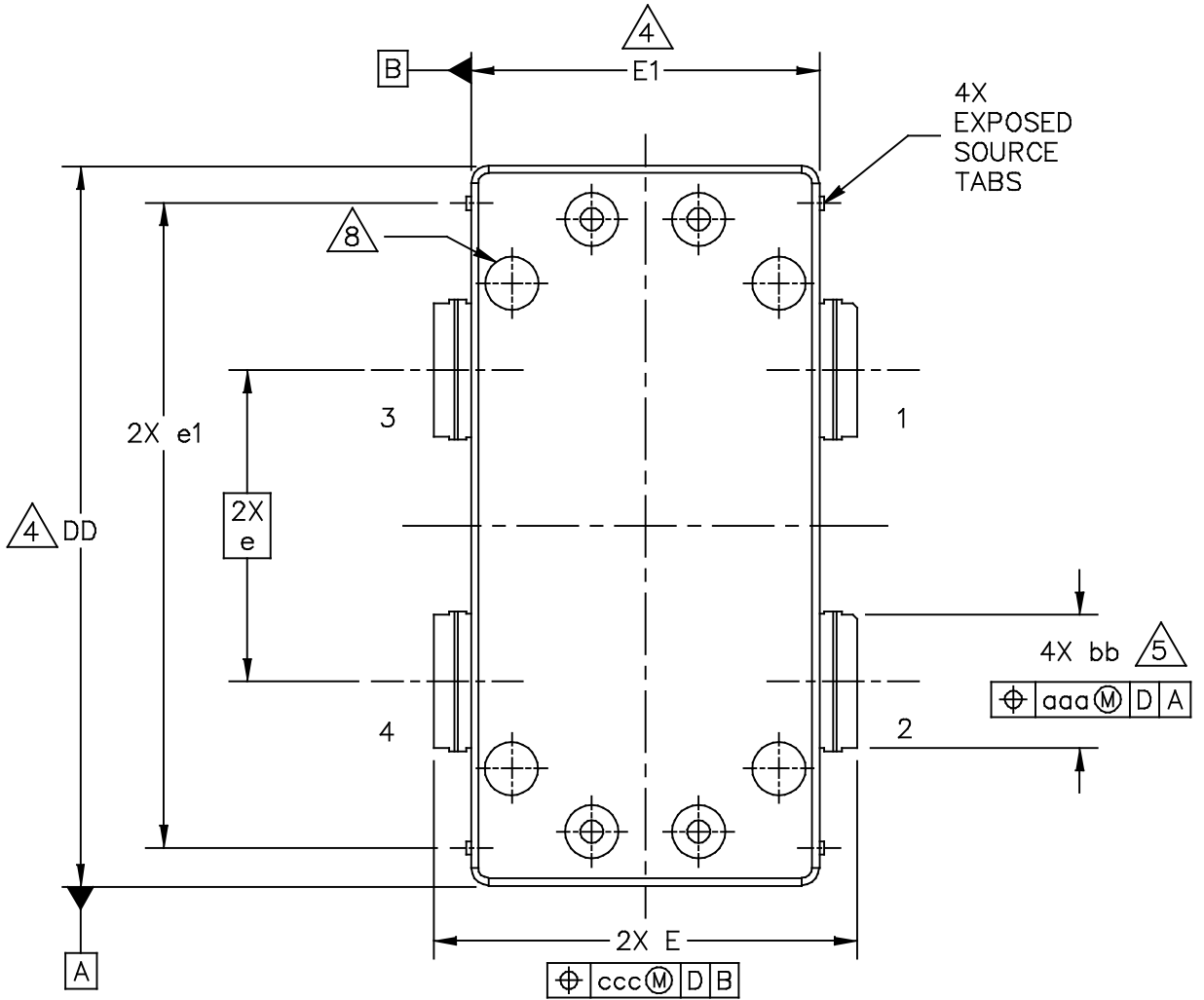
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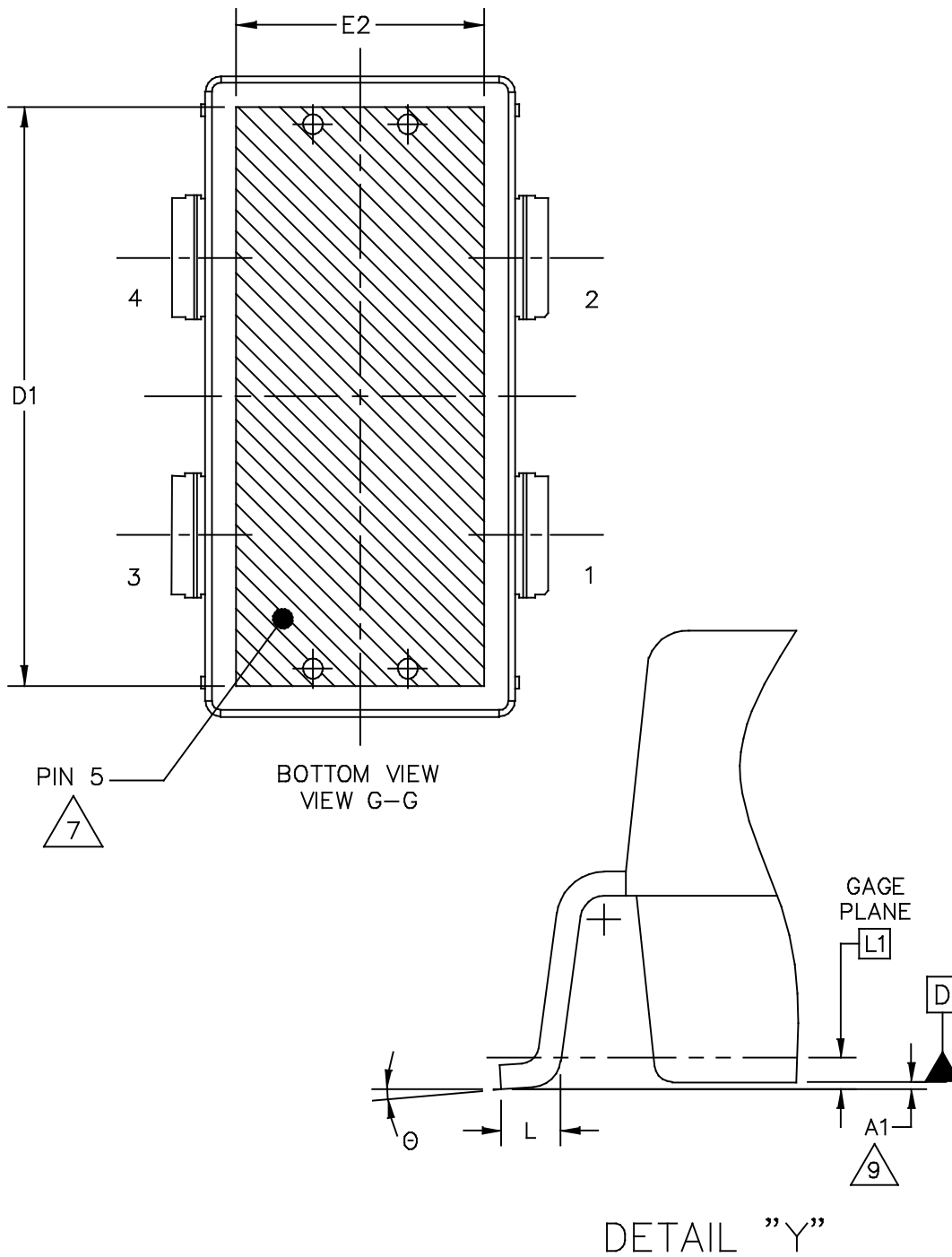
NOTES:

1. CONTROLLING DIMENSION: INCH
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
3. DATUM PLANE -H- IS LOCATED AT TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
4. DIMENSIONS "D" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 PER SIDE. DIMENSIONS "D AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -H-.
5. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE b DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUMS -A- AND -B- TO BE DETERMINED AT DATUM PLANE -H-.
7. DIMENSION A1 APPLIES WITHIN ZONE "J" ONLY.
8. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG. THE DIMENSIONS D1 AND E2 REPRESENT THE VALUES BETWEEN THE TWO OPPOSITE POINTS ALONG THE EDGES OF EXPOSED AREA OF HEAT SLUG.
9. DIMPLED HOLE REPRESENTS INPUT SIDE.

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	0.148	.152	3.76	3.86	b	.147	.153	3.73	3.89
A1	.059	.065	1.50	1.65	c1	.007	.011	0.18	0.28
D	.808	.812	20.52	20.62	e	.350 BSC		8.89 BSC	
D1	.720	----	18.29	----	e1	.721	.729	18.31	18.52
E	.762	.770	19.36	19.56					
E1	.390	.394	9.91	10.01	aaa	.004		0.10	
E2	.306	----	7.77	----					
E3	.383	.387	9.72	9.83					
F	.025 BSC		0.635 BSC						
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NOTES:

1. CONTROLLING DIMENSION: INCH
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
3. DATUM PLANE H IS LOCATED AT TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
4. DIMENSIONS DD AND E1 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 INCH (0.15 MM) PER SIDE. DIMENSIONS DD AND E1 DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H.
5. DIMENSION bb DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 INCH (0.13 MM) TOTAL IN EXCESS OF THE bb DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUMS A AND B TO BE DETERMINED AT DATUM PLANE H.
7. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG. THE DIMENSIONS D1 AND E2 REPRESENT THE VALUES BETWEEN THE TWO OPPOSITE POINTS ALONG THE EDGES OF EXPOSED AREA OF HEAT SLUG.
8. DIMPLED HOLE REPRESENTS INPUT SIDE.
9. DIMENSION A1 IS MEASURED WITH REFERENCE TO DATUM D. THE POSITIVE VALUE IMPLIES THAT THE BOTTOM OF PACKAGE IS HIGHER THAN THE BOTTOM OF THE LEAD.

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
AA	.148	.152	3.76	3.86	bb	.147	.153	3.73	3.89
A1	-.002	.002	-0.05	0.05	c1	.007	.011	0.18	0.28
DD	.808	.812	20.52	20.62	e	0.350 BSC		8.89 BSC	
D1	.720	----	18.29	----	e1	.721	.729	18.31	18.52
E	.470	.482	11.94	12.24	θ	0°	8°	0°	8°
E1	.390	.394	9.91	10.01	aaa	.004		0.10	
E2	.306	----	7.77	----	bbb	.006		0.15	
E3	.383	.387	9.73	9.83	ccc	.010		0.25	
L	.018	.024	0.46	0.61					
L1	.010 BSC		0.25 BSC						

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## PRODUCT DOCUMENTATION, SOFTWARE AND TOOLS

Refer to the following resources to aid your design process.

### Application Notes

- AN1907: Solder Reflow Attach Method for High Power RF Devices in Plastic Packages
- 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.nxp.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. 2013	• Initial Release of Data Sheet
1	Jan. 2014	• Added part number AFT20P140-4WGNR3, p. 1 • Added OM780G-4L isometric, p. 1, and Mechanical Outline, pp. 13-15
2	Oct. 2016	• Functional test table: added P3dB minimum performance value, p. 3



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