

# RF LDMOS Integrated Power Amplifier

The MW6IC2420NB integrated circuit is designed with on-chip matching that makes it usable at 2450 MHz. This multi-stage structure is rated for 26 to 32 Volt operation and covers all typical industrial, scientific and medical modulation formats.

### Driver Applications

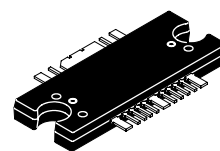
- Typical CW Performance at 2450 MHz:  $V_{DD} = 28$  Volts,  $I_{DQ1} = 210$  mA,  $I_{DQ2} = 370$  mA,  $P_{out} = 20$  Watts  
 Power Gain — 19.5 dB  
 Power Added Efficiency — 27%
- Capable of Handling 3:1 VSWR, @ 28 Vdc, 2170 MHz, 20 Watts CW Output Power
- Stable into a 3:1 VSWR. All Spurs Below -60 dBc @ 100 mW to 10 Watts CW  $P_{out}$ .

### Features

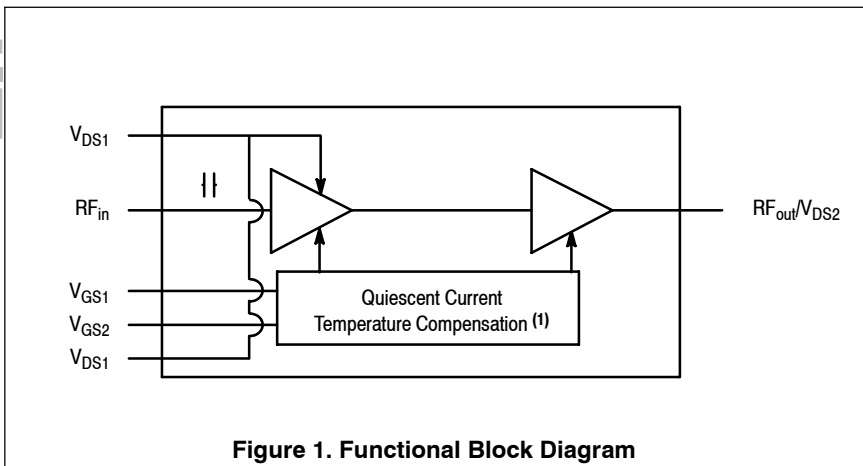
- Characterized with Series Equivalent Large-Signal Impedance Parameters and Common Source Scattering Parameters
- On-Chip Matching (50 Ohm Input, DC Blocked, >3 Ohm Output)
- Integrated Quiescent Current Temperature Compensation with Enable/Disable Function (1)
- Integrated ESD Protection
- 225°C Capable Plastic Package
- RoHS Compliant
- In Tape and Reel. R1 Suffix = 500 Units, 44 mm Tape Width, 13 inch Reel

**MW6IC2420NBR1**

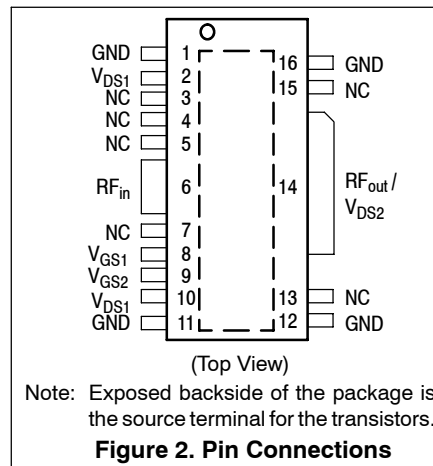
**2450 MHz, 20 W, 28 V  
 CW  
 RF LDMOS INTEGRATED POWER  
 AMPLIFIER**



**CASE 1329-09  
 TO-272 WB-16  
 PLASTIC**



**Figure 1. Functional Block Diagram**



**Figure 2. Pin Connections**

1. Refer to AN1977, *Quiescent Current Thermal Tracking Circuit in the RF Integrated Circuit Family* and to AN1987, *Quiescent Current Control for the RF Integrated Circuit Device Family*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1977 or AN1987.

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**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5, +68	Vdc
Gate-Source Voltage	$V_{GS}$	-0.5, +6	Vdc
Storage Temperature Range	$T_{stg}$	-65 to +150	°C
Case Operating Temperature	$T_C$	150	°C
Operating Junction Temperature (1,2)	$T_J$	225	°C
Input Power	$P_{in}$	23	dBm

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$		°C/W
W-CDMA Application ( $P_{out} = 4.5$ W Avg.)	Stage 1, 28 Vdc, $I_{DQ} = 210$ mA Stage 2, 28 Vdc, $I_{DQ} = 370$ mA	1.8 1	

**Table 3. ESD Protection Characteristics**

Test Methodology	Class
Human Body Model (per JESD22-A114)	1A (Minimum)
Machine Model (per EIA/JESD22-A115)	A (Minimum)
Charge Device Model (per JESD22-C101)	III (Minimum)

**Table 4. Moisture Sensitivity Level**

Test Methodology	Rating	Package Peak Temperature	Unit
Per JESD 22-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
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**Functional Tests** (In Freescale Wideband 2110–2170 MHz Test Fixture, 50 ohm system)  $V_{DD} = 28$  Vdc,  $I_{DQ1} = 210$  mA,  $I_{DQ2} = 370$  mA,  $P_{out} = 4.5$  W Avg.,  $f_1 = 2157.5$  MHz,  $f_2 = 2167.5$  MHz, 2-Carrier W-CDMA, 3.84 MHz Channel Bandwidth Carriers. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5$  MHz Offset. IM3 measured in 3.84 MHz Channel Bandwidth @  $\pm 10$  MHz Offset. Input Signal PAR = 8.5 dB @ 0.01% Probability on CCDF.

Power Gain	$G_{ps}$	25.5	28	30	dB
Power Added Efficiency	PAE	13.7	15	—	%
Intermodulation Distortion	IM3	—	-43	-40	dBc
Adjacent Channel Power Ratio	ACPR	—	-46	-43	dBc
Input Return Loss	IRL	—	-15	-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.

(continued)

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

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Typical Performances</b> (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$ , $I_{DQ1} = 210\text{ mA}$ , $I_{DQ2} = 370\text{ mA}$ , 2110-2170 MHz					
Video Bandwidth @ 20 W PEP $P_{out}$ where $IM3 = -30\text{ dBc}$ (Tone Spacing from 100 kHz to VBW) $\Delta IMD3 = IMD3 @ \text{VBW frequency} - IMD3 @ 100\text{ kHz} < 1\text{ dBc}$ (both sidebands)	VBW	—	30	—	MHz
Quiescent Current Accuracy over Temperature with 18 k $\Omega$ Gate Feed Resistors (-10 to 85°C) (1)	$\Delta I_{QT}$	—	$\pm 5$	—	%
Gain Flatness in 30 MHz Bandwidth @ $P_{out} = 1\text{ W CW}$	$G_F$	—	0.2	—	dB
Average Deviation from Linear Phase in 30 MHz Bandwidth @ $P_{out} = 1\text{ W CW}$	$\Phi$	—	2	—	°
Average Group Delay @ $P_{out} = 1\text{ W CW}$ Including Output Matching	Delay	—	2.8	—	ns
Part-to-Part Insertion Phase Variation @ $P_{out} = 1\text{ W CW}$ , Six Sigma Window	$\Delta\Phi$	—	18	—	°

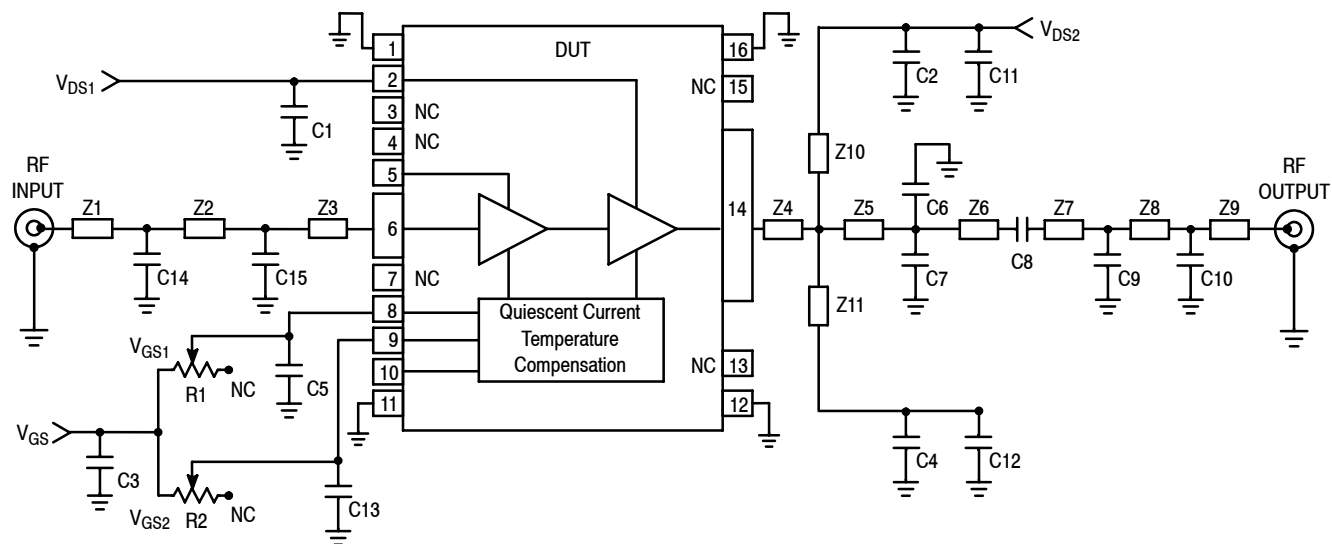
**Table 6. Electrical Characteristics** ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Typical Performances</b> (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$ , $I_{DQ1} = 110\text{ mA}$ , $I_{DQ2} = 370\text{ mA}$ , 2110-2170 MHz					
Saturated Pulsed Output Power (8 $\mu\text{sec}(\text{on})$ , 1 $\text{msec}(\text{off})$ )	$P_{sat}$	—	60	—	W

1. Refer to AN1977, *Quiescent Current Thermal Tracking Circuit in the RF Integrated Circuit Family* and to AN1987, *Quiescent Current Control for the RF Integrated Circuit Device Family*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1977 or AN1987.

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Z1	0.510" x 0.054" Microstrip	Z6	0.189" x 0.237" Microstrip
Z2	0.300" x 0.054" Microstrip	Z7	0.127" x 0.054" Microstrip
Z3, Z8	0.410" x 0.054" Microstrip	Z9	0.182" x 0.054" Microstrip
Z4	0.138" x 0.237" Microstrip	Z10, Z11	1.073" x 0.054" Microstrip
Z5	0.086" x 0.237" Microstrip	PCB	Taconic RF35, 0.020", $\epsilon_r = 3.5$

Figure 3. MW6IC2420NBR1 Test Circuit Schematic — 2450 MHz

Table 7. MW6IC2420NBR1 Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1, C2, C3, C4	2.2 $\mu$ F Chip Capacitors	C32225X5R1H225MT	TDK
C5, C13	100 nF Chip Capacitors	C1206C104K1KAC	Kemet
C6, C7	0.5 pF Chip Capacitors	08051J0R5BS	AVX
C8	6.8 pF Chip Capacitor	08051J6R8BS	AVX
C9	2.2 pF Chip Capacitor	08051J2R2BS	AVX
C10	1 pF Chip Capacitor	08051J1R0BS	AVX
C11, C12	5.6 pF Chip Capacitors	08051J5R6BS	AVX
C14	0.3 pF Chip Capacitor	ATC100B0R3BT500XT	ATC
C15	0.5 pF Chip Capacitor	ATC100B0R5BT500XT	ATC
R1, R2	5 k $\Omega$ Potentiometer CMS Cermet Multi-turn	3224W-1-502E	Bourns

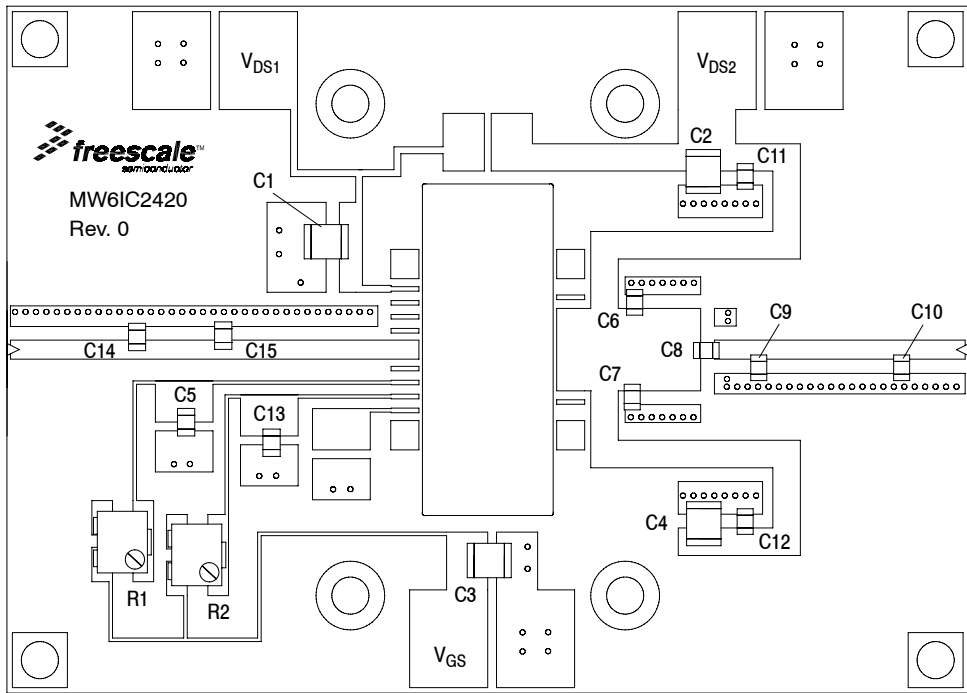
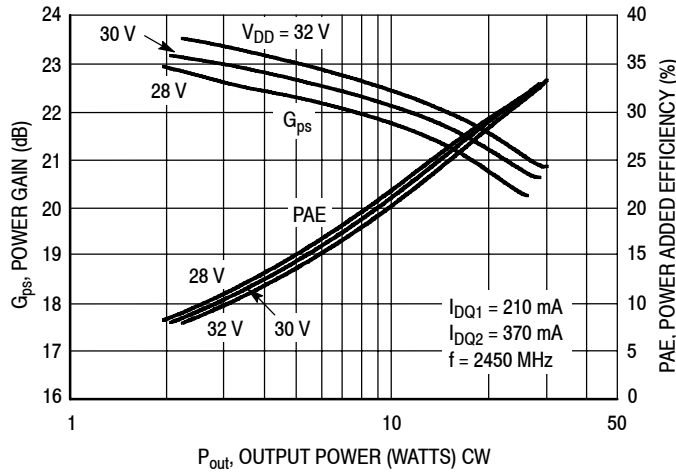
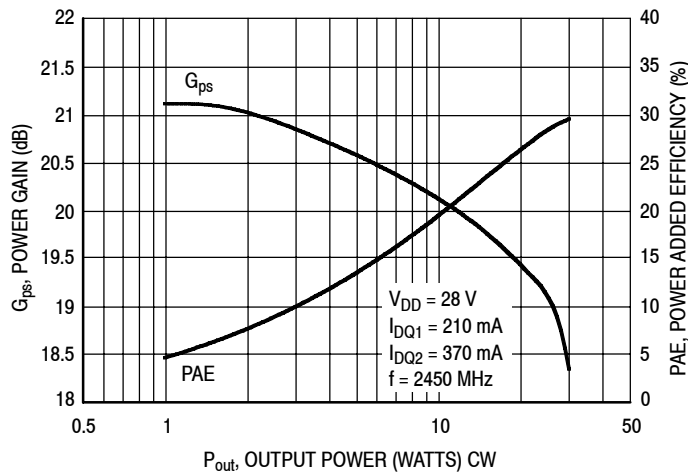


Figure 4. MW6IC2420NBR1 Test Circuit Component Layout — 2450 MHz

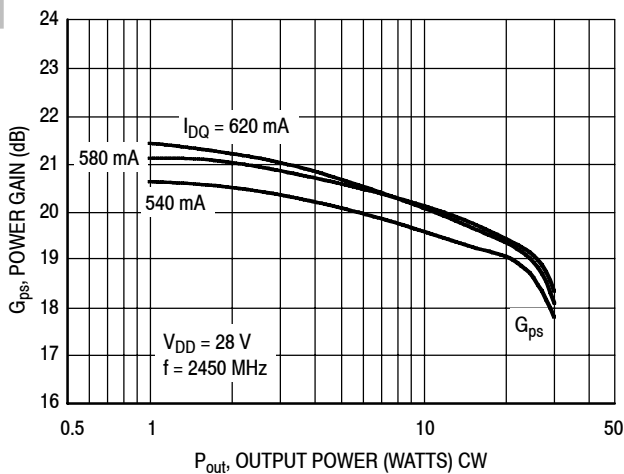
### TYPICAL CHARACTERISTICS — 2450 MHz



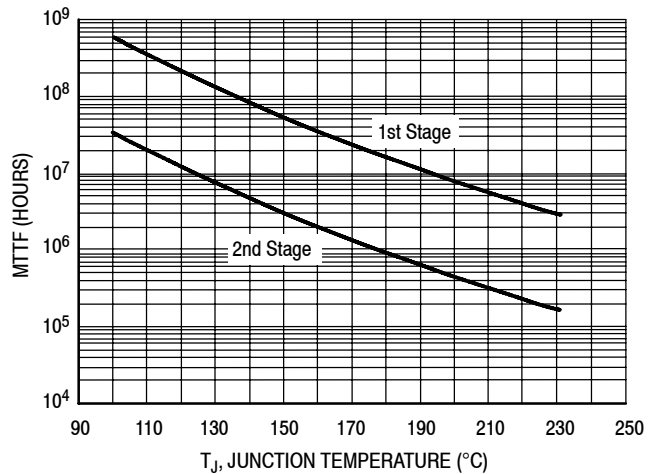
**Figure 5. Power Gain and Power Added Efficiency versus CW Output Power as a Function of  $V_{DD}$**



**Figure 6. Power Gain and Power Added Efficiency versus CW Output Power**



**Figure 7. Power Gain and Power Added Efficiency versus CW Output Power as a Function of Total  $I_{DQ}$**



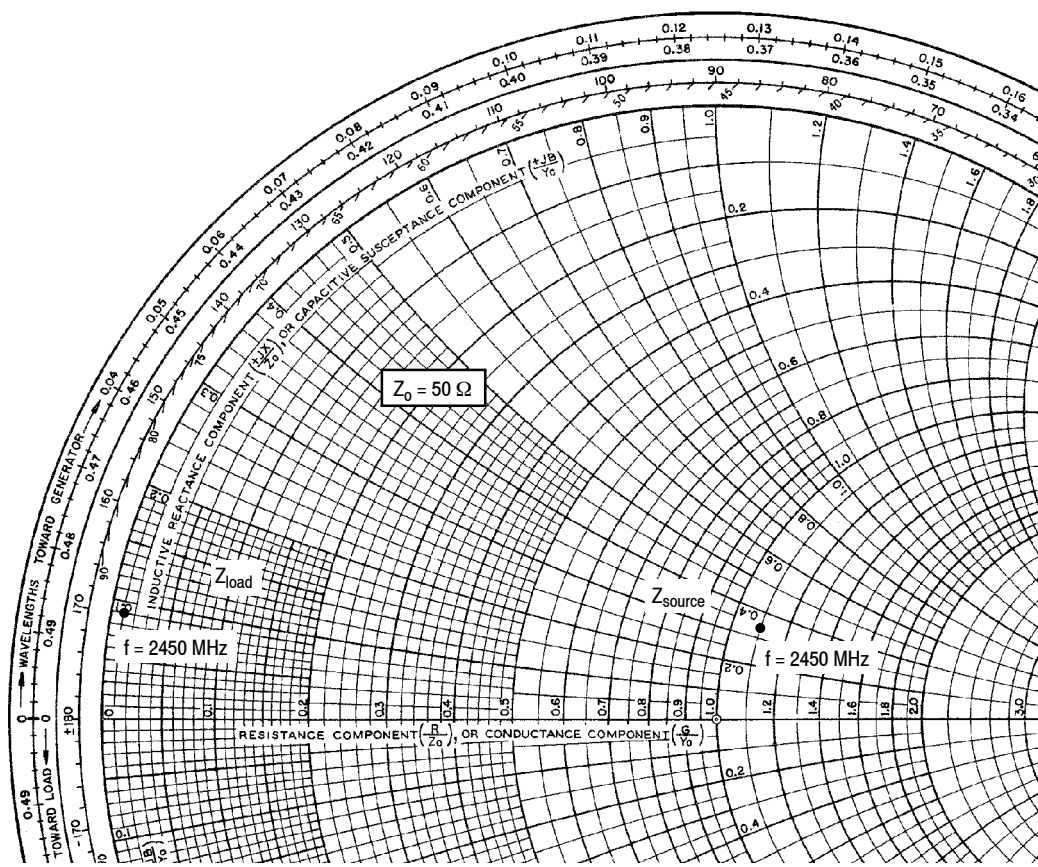
This above graph displays calculated MTTF in hours when the device is operated at  $V_{DD} = 28$  Vdc,  $P_{out} = 20$  W Avg., and  $PAE = 27\%$ .

MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.

**Figure 8. MTTF versus Junction Temperature**

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$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ1} = 210 \text{ mA}$ ,  $I_{DQ2} = 370 \text{ mA}$ ,  $P_{out} = 20 \text{ W CW}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
2450	$54.8 + j16.6$	$0.42 + j4.3$

$Z_{source}$  = Test circuit impedance as measured from gate to ground.

$Z_{load}$  = Test circuit impedance as measured from drain to ground.

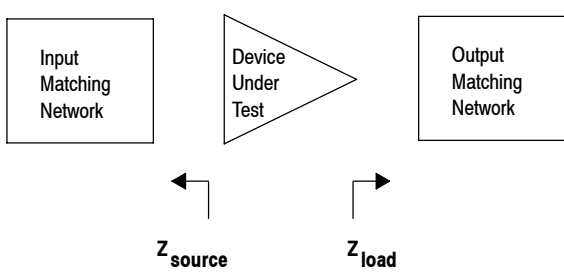
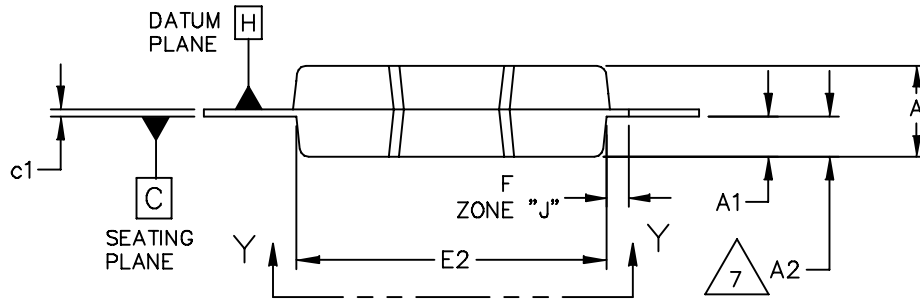
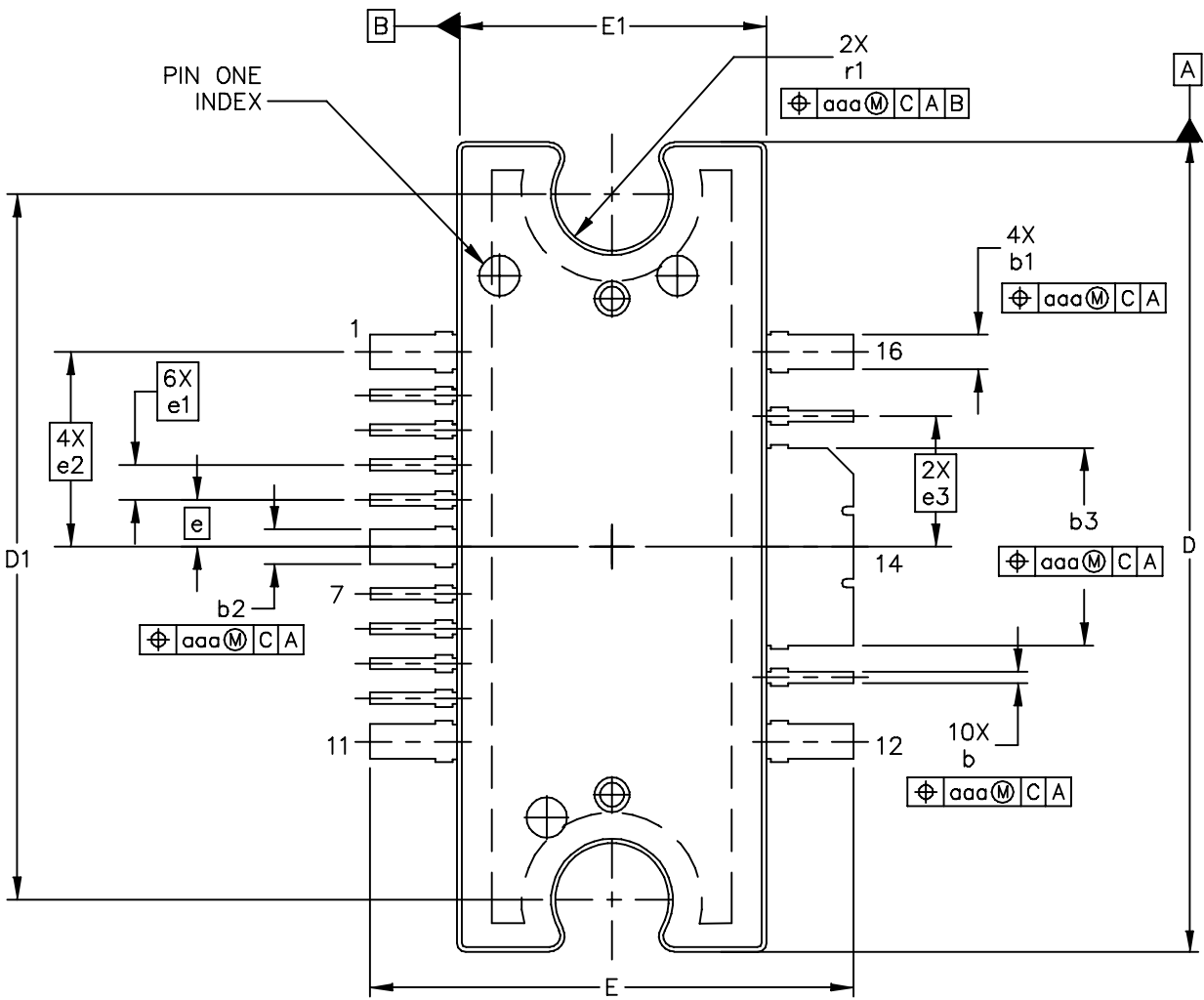


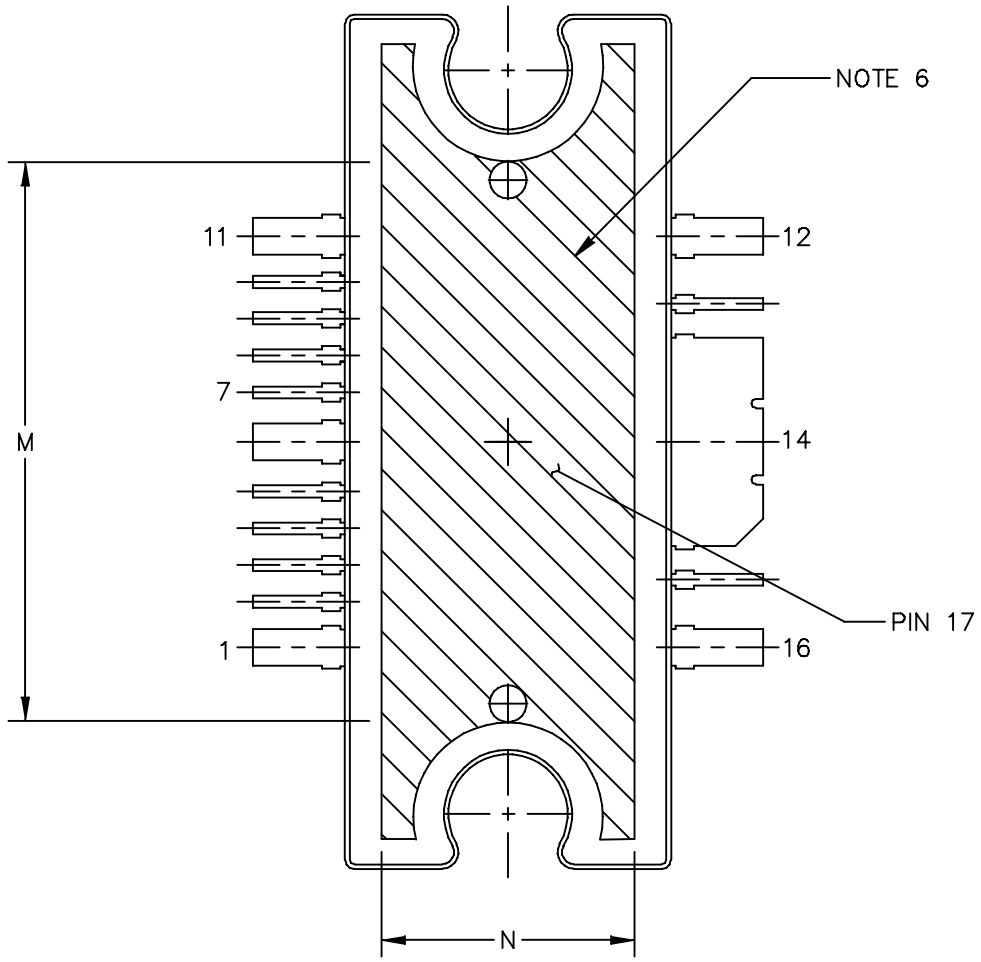
Figure 9. Series Equivalent Source and Load Impedance

**PACKAGE DIMENSIONS**



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		STANDARD: NON-JEDEC	

NOTES:

1. CONTROLLING DIMENSION: INCH
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
3. DATUM PLANE -H- IS LOCATED AT THE 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 (0.15) PER SIDE. DIMENSIONS "D" AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -H-.
5. DIMENSIONS "b", "b1", "b2" AND "b3" DO NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 (0.13) TOTAL IN EXCESS OF THE "b", "b1", "b2" AND "b3" DIMENSIONS AT MAXIMUM MATERIAL CONDITION.
6. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG. HATCHED AREA SHOWN IS ON THE SAME PLANE.
7. DIM A2 APPLIES WITHIN ZONE "J" ONLY.

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.100	.104	2.54	2.64	b	.011	.017	0.28	0.43
A1	.038	.044	0.96	1.12	b1	.037	.043	0.94	1.09
A2	.040	.042	1.02	1.07	b2	.037	.043	0.94	1.09
D	.928	.932	23.57	23.67	b3	.225	.231	5.72	5.87
D1	.810 BSC		20.57 BSC		c1	.007	.011	.18	.28
E	.551	.559	14.00	14.20	e	.054 BSC		1.37 BSC	
E1	.353	.357	8.97	9.07	e1	.040 BSC		1.02 BSC	
E2	.346	.350	8.79	8.89	e2	.224 BSC		5.69 BSC	
F	.025 BSC		0.64 BSC		e3	.150 BSC		3.81 BSC	
M	.600	----	15.24	----	r1	.063	.068	1.6	1.73
N	.270	----	6.86	----	aaa	.004		.10	
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## PRODUCT DOCUMENTATION

Refer to the following documents 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
- AN1977: Quiescent Current Thermal Tracking Circuit in the RF Integrated Circuit Family
- AN1987: Quiescent Current Control for the RF Integrated Circuit Device Family
- AN3263: Bolt Down Mounting Method for High Power RF Transistors and RFICs in Over-Molded Plastic Packages

### Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

## REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	Mar. 2007	<ul style="list-style-type: none"> <li>• Initial Release of Data Sheet</li> </ul>
1	Apr. 2008	<ul style="list-style-type: none"> <li>• Changed 220°C to 225°C in Capable Plastic Package bullet, p. 1</li> <li>• Added Footnote 1 to Quiescent Current Temperature bullet under Features section and to callout in Fig. 1, Functional Block Diagram, p. 1</li> <li>• Added Case Operating Temperature limit to the Maximum Ratings table and set limit to 150°C, p. 2</li> <li>• Operating Junction Temperature increased from 200°C to 225°C in Maximum Ratings table and related "Continuous use at maximum temperature will affect MTTF" footnote added, p. 2</li> <li>• Replaced Case Outline 1329-09, Issue L, with 1329-09, Issue M, p. 8-10. Added pin numbers 1 through 17.</li> </ul>
2	Feb. 2009	<ul style="list-style-type: none"> <li>• Changed Storage Temperature Range in Max Ratings table from -65 to +200 to -65 to +150 for standardization across products, p. 2</li> <li>• Modified data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN13232, p. 2</li> </ul>
3	Dec. 2010	<ul style="list-style-type: none"> <li>• Corrected data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN13232, and Product Discontinuance Notification number, PCN14260, adding applicable overlay, p. 1, 2</li> </ul>

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