RoHS

RF Power LDMOS Transistors

High Ruggedness N-Channel Enhancement-Mode Lateral MOSFETs

MMRF1320N
MMRF1320GN

These high ruggedness devices are designed for use in high VSWR defense and commercial radio communications and HF, VHF and UHF radar applications. The unmatched input and output designs allow wide frequency range utilization, from 1.8 to 600 MHz.

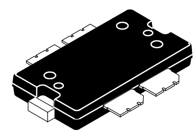
Typical Performance: V_{DD} = 50 Vdc

Frequency (MHz)	Signal Type	P_{out} (W)	G_{ps} (dB)	η_D (%)
230	CW	150	26.3	72.0
230	Pulse (100 μsec, 20% Duty Cycle)	150 Peak	26.1	70.3

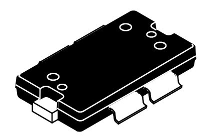
Load Mismatch/Ruggedness

Frequency (MHz)	Signal Type	VSWR	P_{in} (W)	Test Voltage	Result
230	Pulse (100 μsec, 20% Duty Cycle)	> 65:1 at all Phase Angles	0.62 Peak (3 dB Overdrive)	50	No Device Degradation

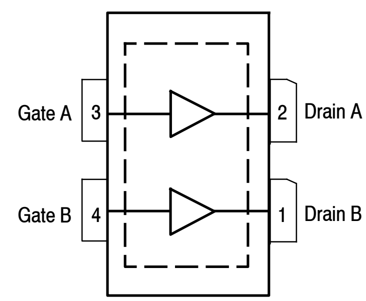
1.8–600 MHz, 150 W CW, 50 V WIDEBAND RF POWER LDMOS TRANSISTORS



TO-270WB-4 PLASTIC MMRF1320N



TO-270WBG-4 PLASTIC MMRF1320GN



(Top View)

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

Figure 1. Pin Connections

Features

- Wide operating frequency range
- Extreme ruggedness
- Unmatched input and output allowing wide frequency range utilization
- Integrated stability enhancements
- Low thermal resistance
- Integrated ESD protection circuitry

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	–0.5, +133	Vdc
Gate-Source Voltage	V_{GS}	–6.0, +10	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
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	952 4.76	W W/°C

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case CW: Case Temperature 80°C, 150 W CW, 50 Vdc, $I_{DQ(A+B)}$ = 100 mA, 230 MHz	$R_{\theta JC}$	0.21	°C/W
Thermal Impedance, Junction to Case Pulse: Case Temperature 66°C, 150 W Peak, 100 μsec Pulse Width, 20% Duty Cycle, 50 Vdc, $I_{DQ(A+B)}$ = 100 mA, 230 MHz	$Z_{\theta JC}$	0.04	°C/W

Table 3. ESD Protection Characteristics

Test Methodology	Class
Human Body Model (per JESD22-A114)	2, passes 2500 V
Machine Model (per EIA/JESD22-A115)	B, passes 250 V
Charge Device Model (per JESD22-C101)	IV, passes 1200 V

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°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Off Characteristics (4)					
Gate-Source Leakage Current (V_{GS} = 5 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	1	μAdc
Drain-Source Breakdown Voltage (V_{GS} = 0 Vdc, I_D = 50 mAdc)	$V_{(BR)DSS}$	133	139	—	Vdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 50 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	5	μAdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 100 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	10	μAdc
On Characteristics					
Gate Threshold Voltage (4) (V_{DS} = 10 Vdc, I_D = 480 μAdc)	$V_{GS(th)}$	1.8	2.4	2.8	Vdc
Gate Quiescent Voltage (V_{DD} = 50 Vdc, I_D = 100 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	2.3	2.8	3.3	Vdc
Drain-Source On-Voltage (4) (V_{GS} = 10 Vdc, I_D = 1 Adc)	$V_{DS(on)}$	—	0.26	—	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 5. Electrical Characteristics (T_A = 25°C unless otherwise noted) **(continued)**

Characteristic	Symbol	Min	Typ	Max	Unit
Dynamic Characteristics (1)					
Reverse Transfer Capacitance (V_{DS} = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	0.8	—	pF
Output Capacitance (V_{DS} = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	45.4	—	pF
Input Capacitance (V_{DS} = 50 Vdc, V_{GS} = 0 Vdc ± 30 mV(rms)ac @ 1 MHz)	C_{iss}	—	96.7	—	pF
Functional Tests (2) (In Freescale Test Fixture, 50 ohm system) V_{DD} = 50 Vdc, $I_{DQ(A+B)}$ = 100 mA, P_{out} = 150 W Peak (30 W Avg.), f = 230 MHz, 100 μsec Pulse Width, 20% Duty Cycle					
Power Gain	G_{ps}	25.0	26.1	27.5	dB
Drain Efficiency	η_D	68.0	70.3	—	%
Input Return Loss	IRL	—	–16	–9	dB

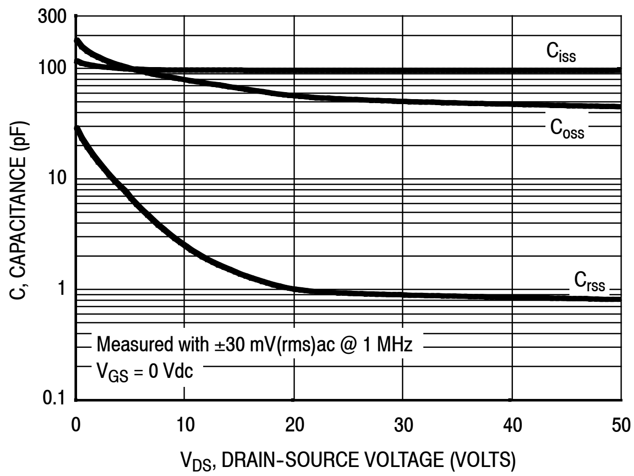
Load Mismatch/Ruggedness (In Freescale Test Fixture) 50 ohm system, $I_{DQ(A+B)}$ = 100 mA

Frequency (MHz)	Signal Type	VSWR	P_{in} (W)	Test Voltage, V_{DD}	Result
230	Pulse (100 μsec, 20% Duty Cycle)	> 65:1 at all Phase Angles	0.62 Peak (3 dB Overdrive)	50	No Device Degradation

Table 6. Ordering Information

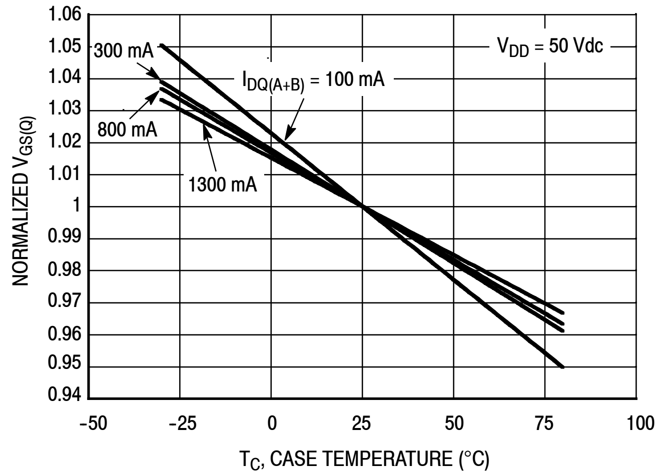
Device	Tape and Reel Information	Package
MMRF1320NR1	R1 Suffix = 500 Units, 44 mm Tape Width, 13-inch Reel	TO-270WB-4
MMRF1320GNR1		TO-270WBG-4

1. Each side of device measured separately.
2. Measurements made with device in straight lead configuration before any lead forming operation is applied. Lead forming is used for gull wing (GN) parts.



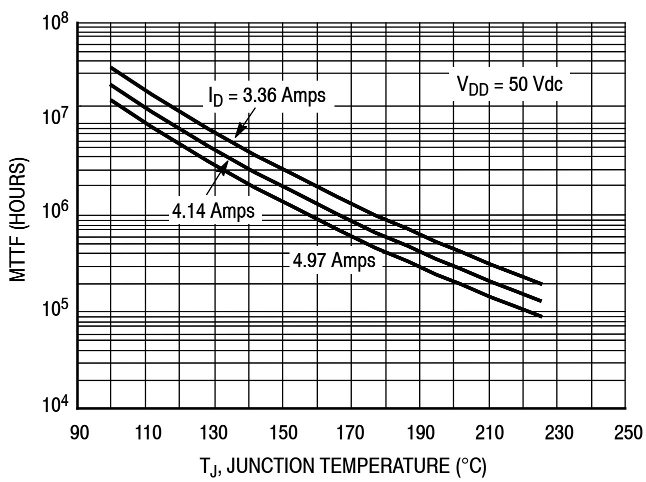
Note: Each side of device measured separately.

Figure 2. Capacitance versus Drain-Source Voltage



I_{DQ} (mA)	Slope (mV/°C)
100	–2.466
300	–2.058
800	–2.015
1300	–1.877

Figure 3. Normalized V_{GS} versus Quiescent Current and Case Temperature



Note: MTTF value represents the total cumulative operating time under indicated test conditions.

MTTF calculator available at http://www.freescale.com/rf/calculators.

Figure 4. MTTF versus Junction Temperature - CW

230 MHz NARROWBAND PRODUCTION TEST FIXTURE

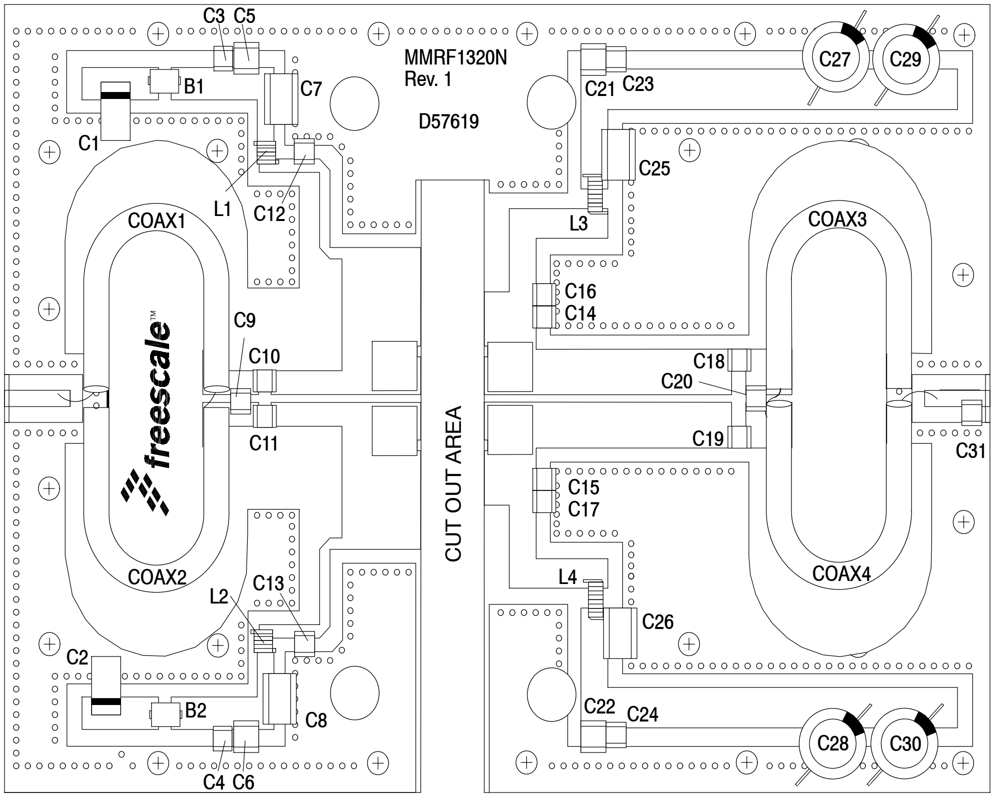


Figure 5. MMRF1320N Narrowband Test Circuit Component Layout — 230 MHz

Table 7. MMRF1320N Narrowband Test Circuit Component Designations and Values — 230 MHz

Part	Description	Part Number	Manufacturer
B1, B2	Small Ferrite Beads, Surface Mount	2743019447	Fair-Rite
C1, C2	22 μF, 35 V Tantalum Capacitors	T491X226K035AT	Kemet
C3, C4, C23, C24	0.1 μF Chip Capacitors	CDR33BX104AKWS	AVX
C5, C6	220 nF Chip Capacitors	C1812C224K5RACTU	Kemet
C7, C8	2.2 μF Chip Capacitors	C1825C225J5RACTU	Kemet
C9	2.2 pF Chip Capacitor	ATC100B2R2JT500XT	ATC
C10, C11	18 pF Chip Capacitors	ATC100B180JT500XT	ATC
C12, C13	330 pF Chip Capacitors	ATC100B331JT200XT	ATC
C14, C15	39 pF Chip Capacitors	ATC100B390JT500XT	ATC
C16, C17	15 pF Chip Capacitors	ATC100B150JT500XT	ATC
C18, C19	1000 pF Chip Capacitors	ATC100B102JT50XT	ATC
C20	82 pF Chip Capacitor	ATC100B820JT500XT	ATC
C21, C22	0.10 μF Chip Capacitors	C1812F104K1RACTU	Kemet
C25, C26	2.2 μF Chip Capacitors	2225X7R225KT3AB	ATC
C27, C28, C29, C30	470 μF, 63 V Electrolytic Capacitors	MCGPR63V477M13X26-RH	Multicomp
C31	36 pF Chip Capacitor	ATC100B360JT500XT	ATC
Coax1, 2, 3, 4	25 Ω SemiRigid Coax, 2.4″ Shield Length	UT-141C-25	Micro-Coax
L1, L2	3 Turns, 12 nH Inductors	GA3094-ALC	Coilcraft
L3, L4	4 Turns, 17.5 nH Inductors	GA3095-ALC	Coilcraft
PCB	Arlon AD255A, 0.030″, ε_r = 2.55	D57619	MTL

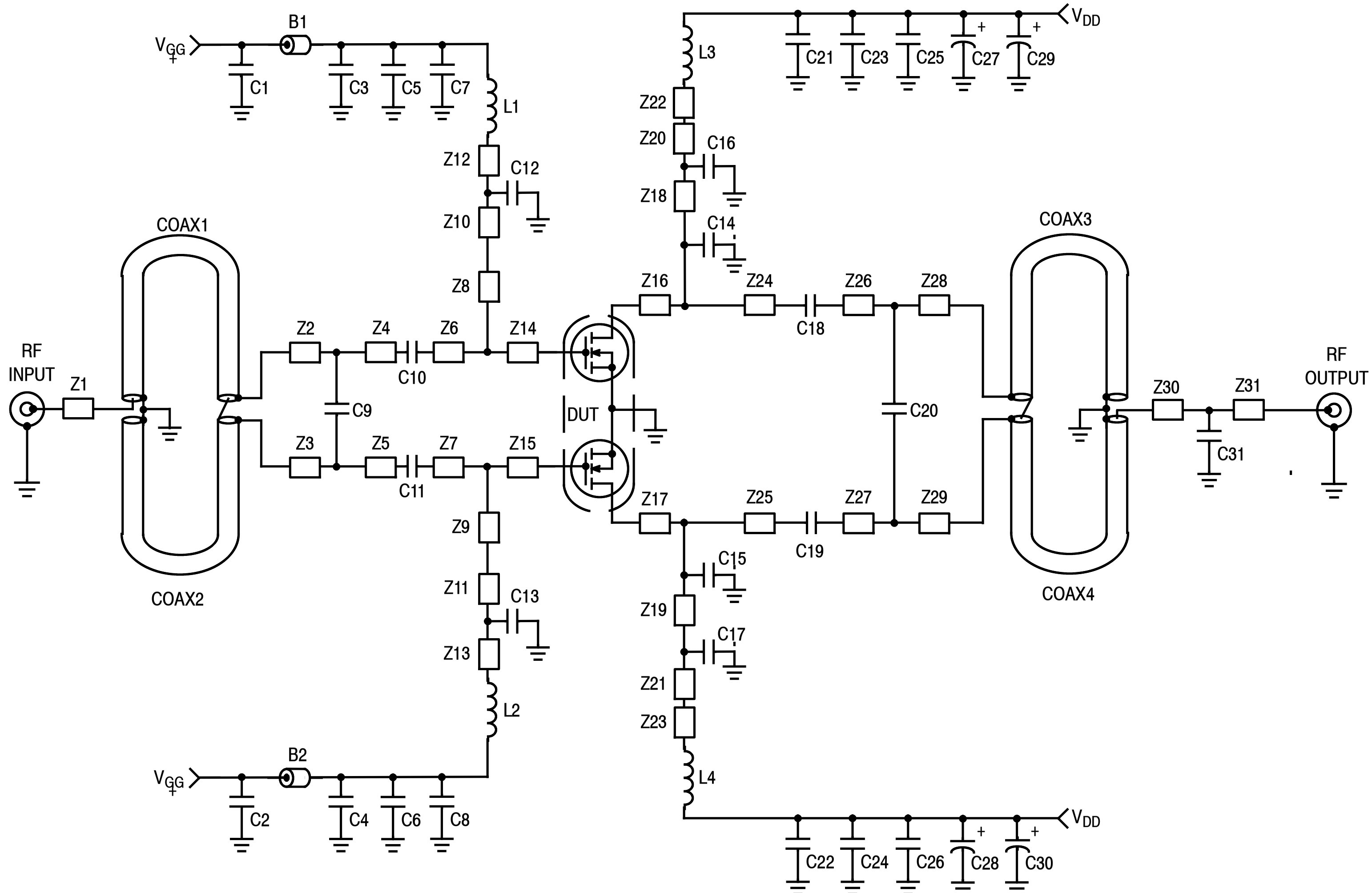


Figure 6. MMRF1320N Narrowband Test Circuit Schematic — 230 MHz

Table 8. MMRF1320N Narrowband Test Circuit Microstrips — 230 MHz

Microstrip	Description
Z1	0.366″ × 0.082″ Microstrip
Z2, Z3	0.690″ × 0.120″ Microstrip
Z4, Z5	0.134″ × 0.120″ Microstrip
Z6, Z7	0.395″ × 0.120″ Microstrip
Z8*, Z9*	0.125″ × 0.058″ Microstrip
Z10, Z11	0.450″ × 0.058″ Microstrip
Z12, Z13	0.210″ × 0.068″ Microstrip
Z14, Z15	0.439″ × 0.746″ Microstrip
Z16, Z17	0.289″ × 0.393″ Microstrip
Z18, Z19	0.112″ × 0.289″ Microstrip
Z20, Z21	0.422″ × 0.150″ Microstrip
Z22, Z23	0.400″ × 0.150″ Microstrip
Z24, Z25	1.090″ × 0.230″ Microstrip
Z26, Z27	0.093″ × 0.230″ Microstrip
Z28, Z29	0.144″ × 0.230″ Microstrip
Z30	0.262″ × 0.082″ Microstrip
Z31	0.102″ × 0.082″ Microstrip

* Line length include microstrip bends

TYPICAL CHARACTERISTICS — 230 MHz

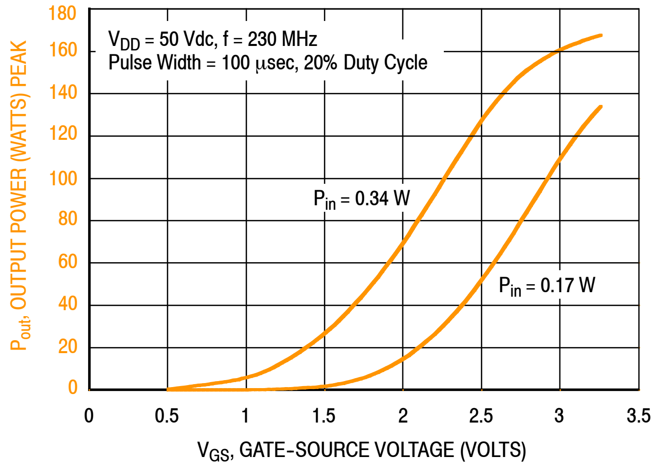
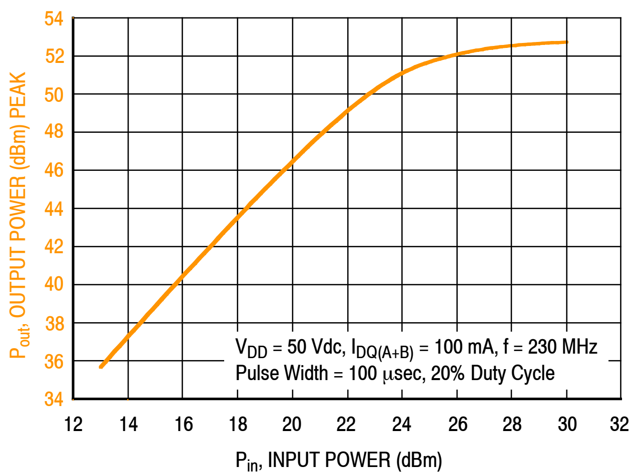


Figure 7. Output Power versus Gate-Source Voltage at a Constant Input Power



f (MHz)	P1dB (W)	P3dB (W)
230	159	182

Figure 8. Output Power versus Input Power

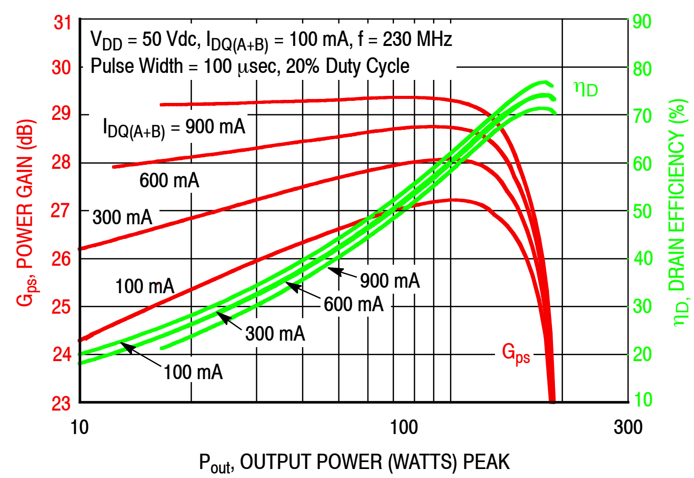


Figure 9. Power Gain and Drain Efficiency versus Output Power and Quiescent Current

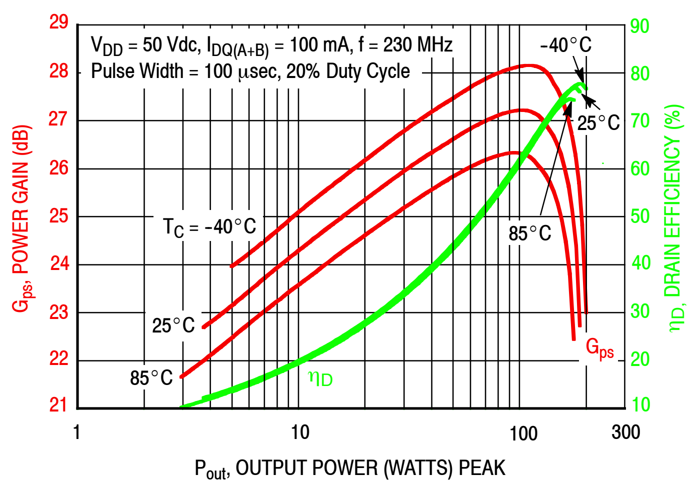


Figure 10. Power Gain and Drain Efficiency versus Output Power

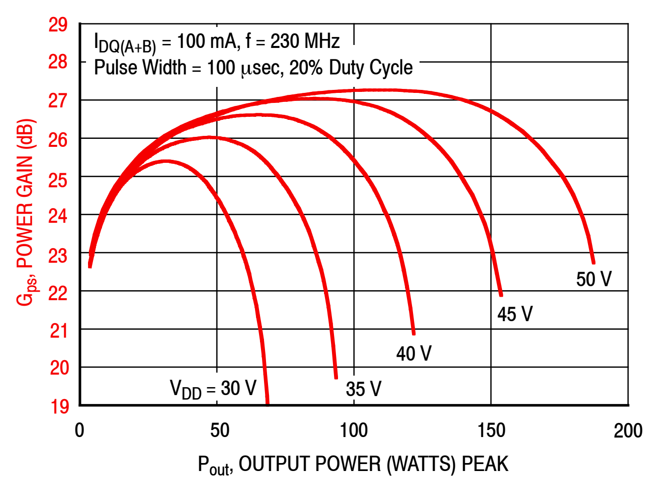


Figure 11. Power Gain versus Output Power and Drain-Source Voltage

f MHz	Z_{source} Ω	Z_{load} Ω
230	6.2 + j17.7	12.1 + j12.5

Z_{source} = Test circuit impedance as measured from gate to gate, balanced configuration.

Z_{load} = Test circuit impedance as measured from drain to drain, balanced configuration.

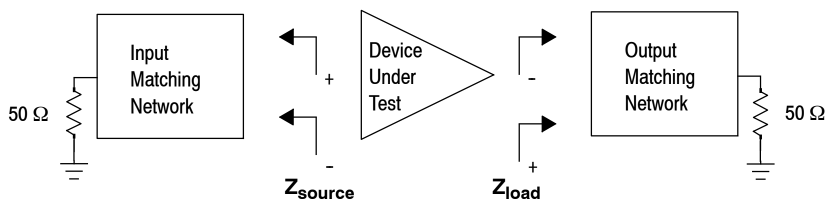
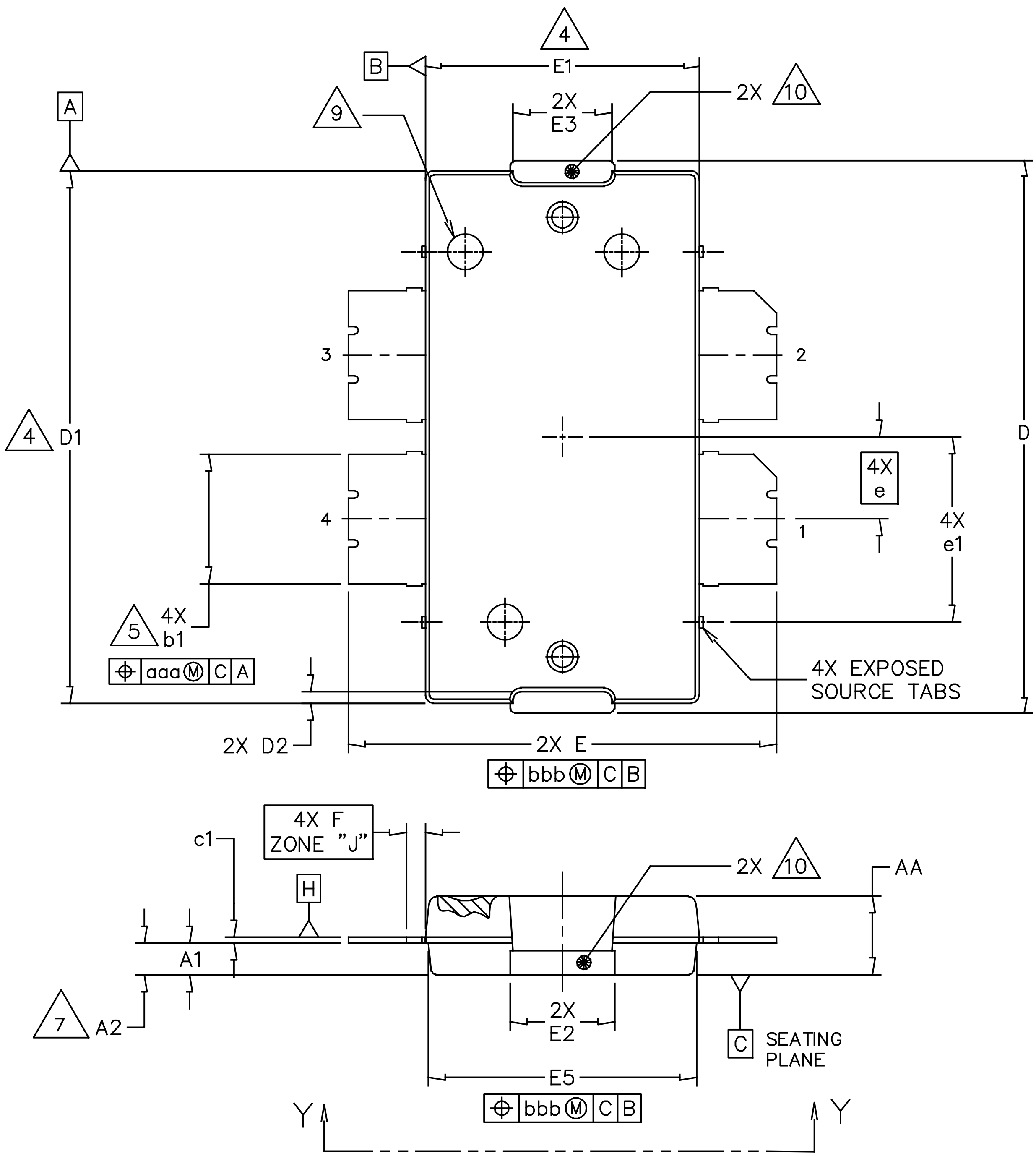


Figure 12. Narrowband Series Equivalent Source and Load Impedance — 230 MHz

PACKAGE DIMENSIONS



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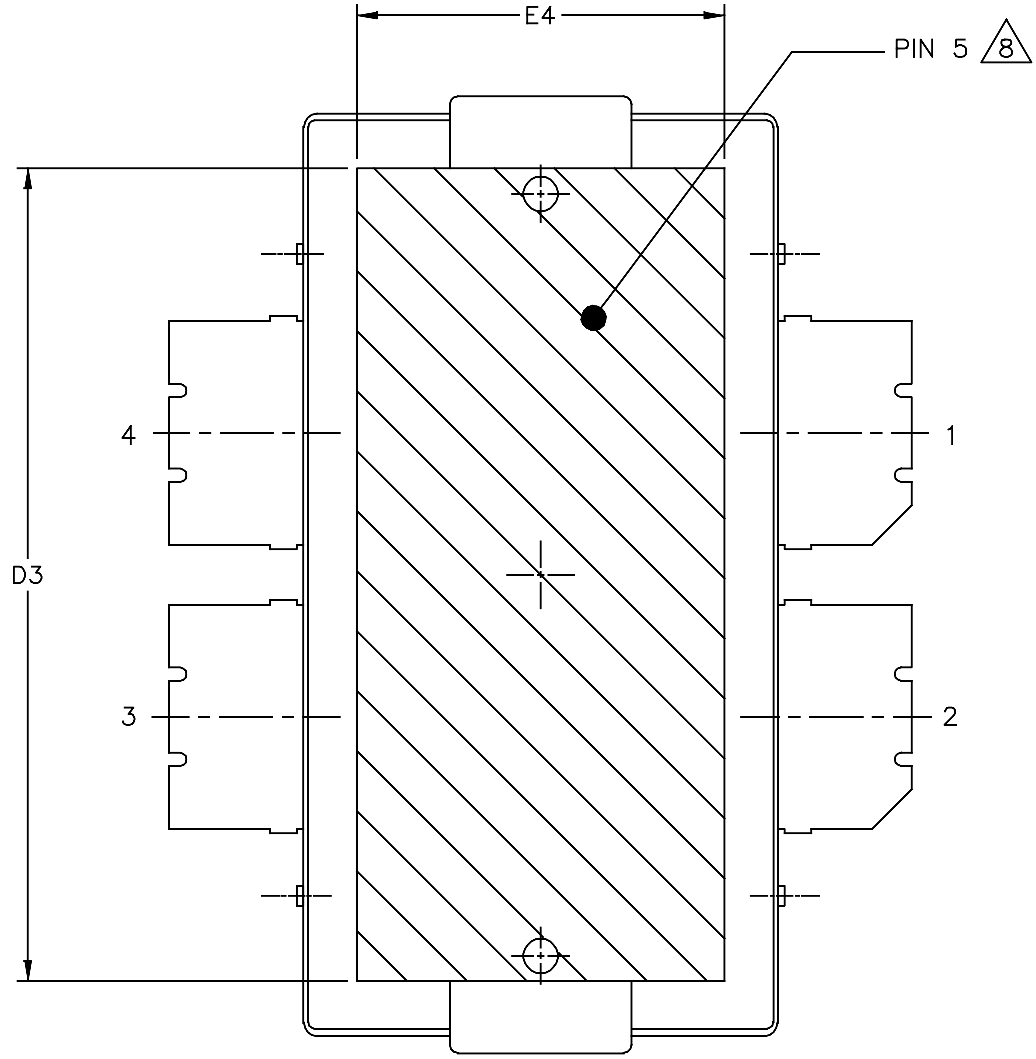
	STANDARD: NON–JEDEC	
	27 AUG 2013	



VIEW Y–Y

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	STANDARD: NON–JEDEC	
	27 AUG 2013	

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 D1 AND E1 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 INCH (0.15MM) PER SIDE. DIMENSIONS D1 AND E1 DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H.
5. DIMENSIONS b1 DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 INCH (0.13MM) TOTAL IN EXCESS OF THE b1 DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUMS A AND B TO BE DETERMINED AT DATUM PLANE H.
7. DIMENSION A2 APPLIES WITHIN ZONE J ONLY.
8. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG. DIMENSIONS D3 AND D4 REPRESENT THE VALUES BETWEEN THE TWO OPPOSITE POINTS ALONG THE EDGES OF EXPOSED AREA OF HEAT SLUG.
9. DIMPLED HOLE REPRESENTS INPUT SIDE.
10. THESE SURFACES OF THE HEAT SLUG ARE NOT PART OF THE SOLDERABLE SURFACES AND MAY REMAIN UNPLATED.

	INCH		MILLIMETER			INCH		MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
AA	.100	.104	2.54	2.64	F	.025 BSC		0.64 BSC	
A1	.039	.043	0.99	1.09	b1	.164	.170	4.17	4.32
A2	.040	.042	1.02	1.07	c1	.007	.011	0.18	0.28
D	.712	.720	18.08	18.29	e	.106 BSC		2.69 BSC	
D1	.688	.692	17.48	17.58	e1	.239 INFO ONLY		6.07 INFO ONLY	
D2	.011	.019	0.28	0.48	aaa	.004		0.10	
D3	.600	---	15.24	---	bbb	.008		0.20	
E	.551	.559	14.00	14.20					
E1	.353	.357	8.97	9.07					
E2	.132	.140	3.35	3.56					
E3	.124	.132	3.15	3.35					
E4	.270	---	6.86	---					
E5	.346	.350	8.79	8.89					

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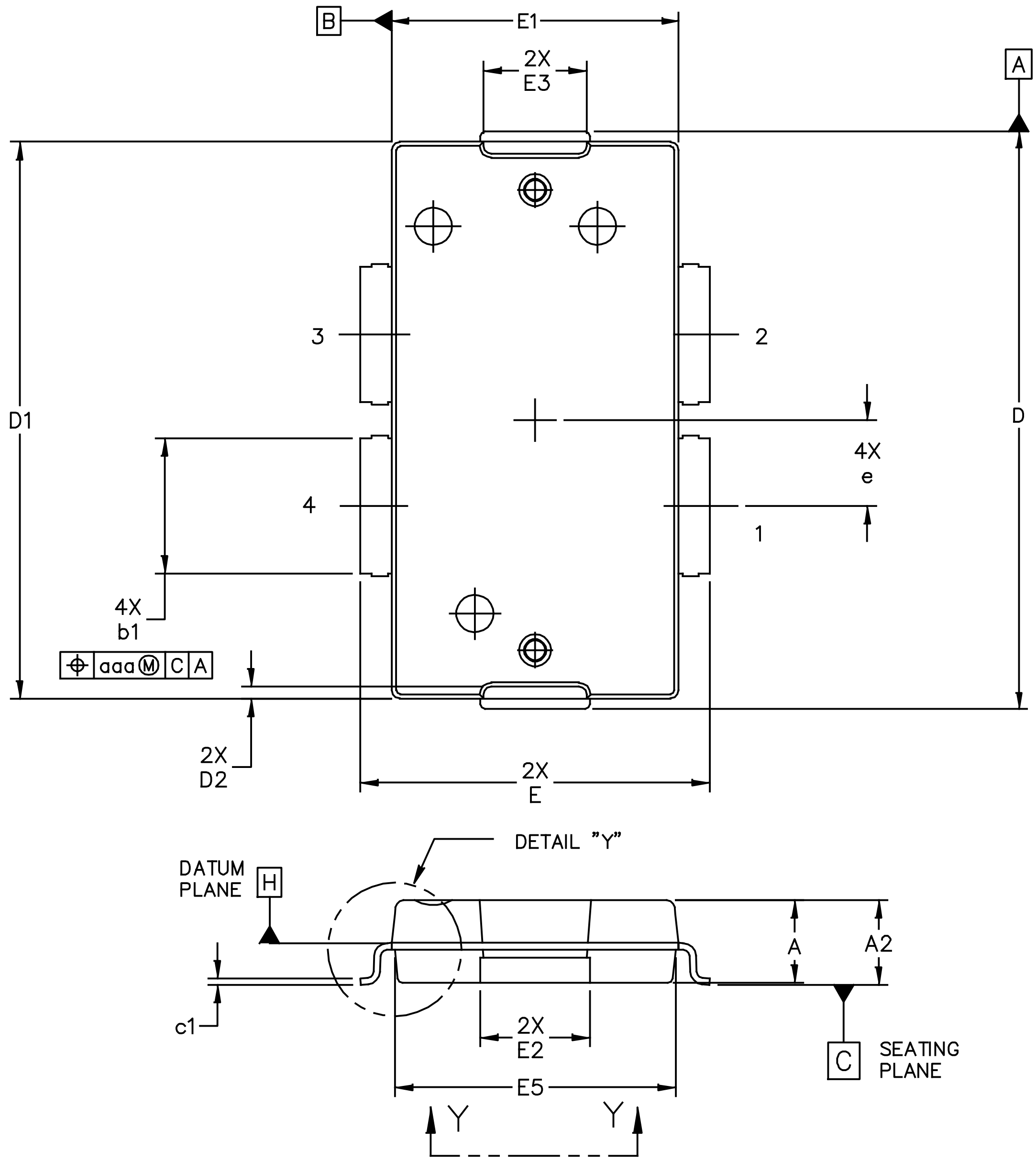

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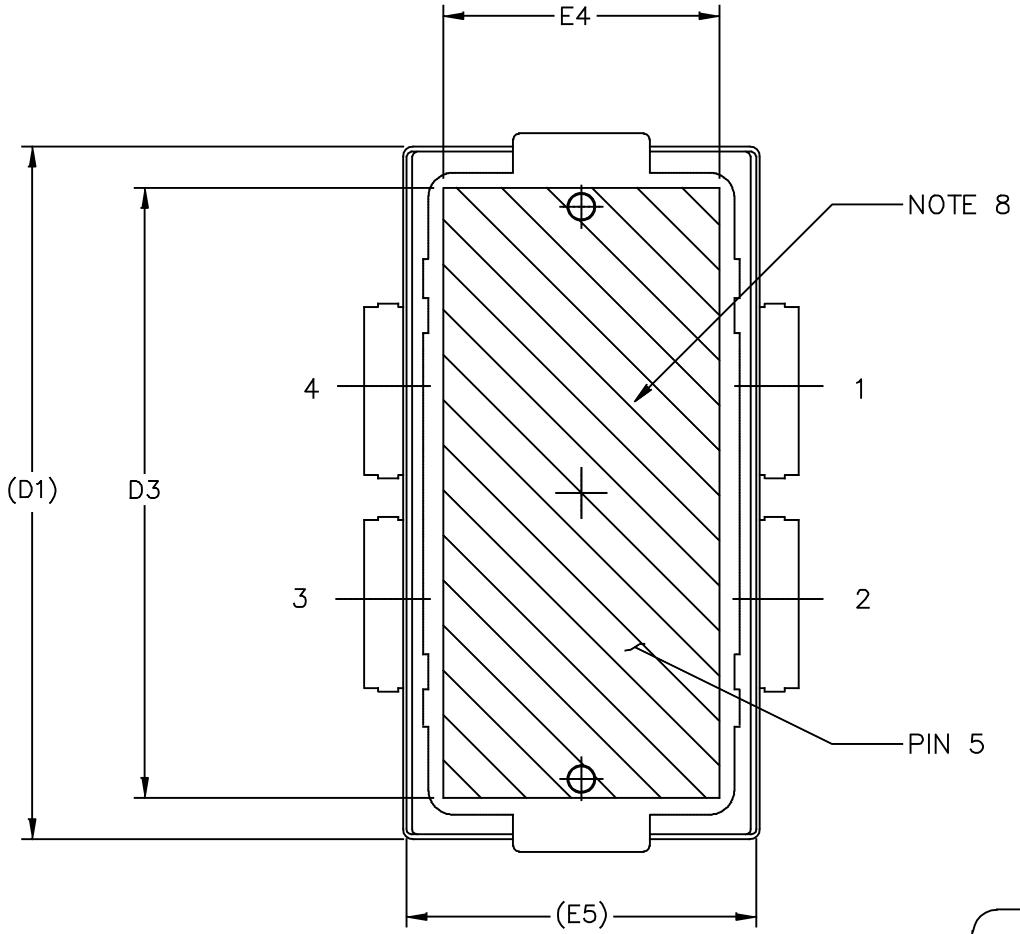
	CASE NUMBER: 1487–05	03 AUG 2007
	STANDARD: JEDEC TO–270 BB	



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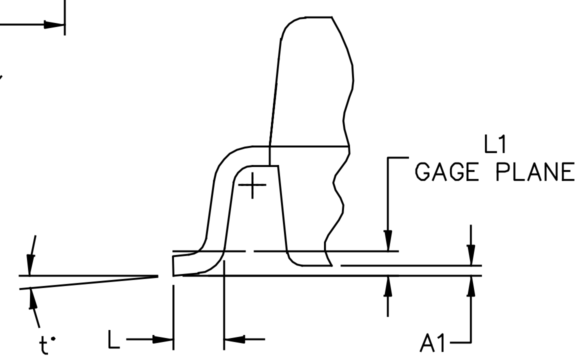

DETAIL "Y"

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	CASE NUMBER: 1487–05		03 AUG 2007
	STANDARD: JEDEC TO–270 BB		

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. DIMENSION "b1" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 (0.13) TOTAL IN EXCESS OF THE "b1" DIMENSION AT MAXIMUM MATERIAL CONDITION.

6. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG.

STYLE 1:
PIN 1 – DRAIN
PIN 2 – DRAIN
PIN 3 – GATE
PIN 4 – GATE
PIN 5 – SOURCE

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.100	.104	2.54	2.64	L	.018	.024	0.46	0.61
A1	.001	.004	0.02	0.10	L1	.01 BSC		0.25 BSC	
A2	.101	.108	2.56	2.74	b1	.164	.170	4.17	4.32
D	.712	.720	18.08	18.29	c1	.007	.011	.18	.28
D1	.688	.692	17.48	17.58	e	.106 BSC		2.69 BSC	
D2	.011	.019	0.28	0.48	t	2°	8°	2°	8°
D3	.600	----	15.24	----	aaa	.004		0.1	
E	.429	.437	10.90	11.10					
E1	.353	.357	8.97	9.07					
E2	.132	.140	3.35	3.56					
E3	.124	.132	3.15	3.35					
E4	.270	----	6.86	----					
E5	.346	.350	8.79	8.89					

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TITLE: TO–270 4 LEAD, WIDE BODY GULL WING	DOCUMENT NO: 98ASA10578D	REV: D
	CASE NUMBER: 1487–05	03 AUG 2007
	STANDARD: JEDEC TO–270 BB	

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

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	July 2015	• Initial Release of Data Sheet