Freescale Semiconductor
Technical Data

Document Number: MRFE6S8046N
Rev. 0, 5/2009

RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

MRFE6S8046NR1
MRFE6S8046GNR1

864-894 MHz, 35.5 W CW, 28 V
GSM, GSM EDGE
LATERAL N-CHANNEL
RF POWER MOSFETs

Designed for GSM and GSM EDGE base station applications with frequencies from 864 to 894 MHz. Suitable for CDMA and multicarrier amplifier applications.

- Typical GSM Performance: V_{DD} = 28 Volts, I_{DQ} = 300 mA, P_{out} = 35.5 Watts CW

Frequency	G_{ps} (dB)	η_D (%)
864 MHz	19.9	58.7
880 MHz	20	58.5
894 MHz	19.8	57.7

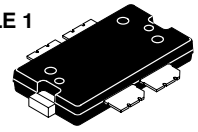
- Capable of Handling 5:1 VSWR, @ 32 Vdc, 880 MHz, 70 Watts CW Output Power (3 dB Input Overdrive from Rated P_{out}), Designed for Enhanced Ruggedness
- Typical P_{out} @ 1 dB Compression Point ≃ 47 Watts CW
- Typical GSM EDGE Performance: V_{DD} = 28 Volts, I_{DQ} = 285 mA, P_{out} = 17.8 Watts Avg.

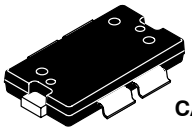
Frequency	G_{ps} (dB)	η_D (%)	Spectral Regrowth @ 400 kHz (dBc)	Spectral Regrowth @ 600 kHz (dBc)	EVM (% rms)
864 MHz	19.8	43.8	61.2	70.9	2.1
880 MHz	19.9	43.6	63.4	72.5	2
894 MHz	19.8	43.1	63.7	73	2

Features

- Class F Output Matched for Higher Impedances and Greater Efficiency
- Designed for High Efficiency. Typical Drain Efficiency @ P1dB ≃ 66%
- Characterized with Series Equivalent Large-Signal Impedance Parameters and Common Source S-Parameters
- Internally Matched for Ease of Use
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- 225°C Capable Plastic Package
- RoHS Compliant
- In Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.

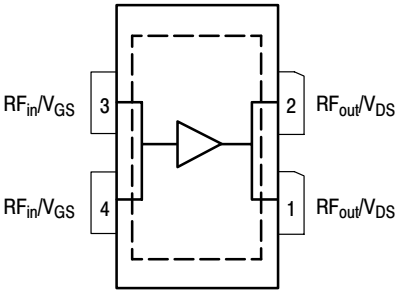
CASE 1486-03, STYLE 1
TO-270 WB-4
PLASTIC
MRFE6S8046NR1





CASE 1487-05, STYLE 1
TO-270 WB-4 GULL
PLASTIC
MRFE6S8046GNR1

PARTS ARE SINGLE-ENDED



(Top View)

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

Figure 1. Pin Connections

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	-0.5, +66	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	T_C	150	°C
Operating Junction Temperature (1,2)	T_J	225	°C

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.

freescale semiconductor

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (1,2)	Unit
Thermal Resistance, Junction to Case Case Temperature 80°C, 35.5 W CW, 28 Vdc, I_{DQ} = 300 mA Case Temperature 82°C, 18 W CW, 28 Vdc, I_{DQ} = 285 mA	$R_{\theta JC}$	 1.7 1.9	°C/W

Table 3. ESD Protection Characteristics

Test Methodology	Class
Human Body Model (per JESD22-A114)	1C (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 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					
Zero Gate Voltage Drain Leakage Current (V_{DS} = 66 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	10	μAdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 28 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	1	μAdc
Gate-Source Leakage Current (V_{GS} = 5 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	1	μAdc
On Characteristics					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 100 μAdc)	$V_{GS(th)}$	1	2.3	3	Vdc
Gate Quiescent Voltage (V_{DD} = 28 Vdc, I_D = 300 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	2	3	4	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 1 Adc)	$V_{DS(on)}$	0.1	0.3	0.4	Vdc

Functional Tests (3,4) (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, P_{out} = 35.5 W CW, I_{DQ} = 300 mA, f = 894 MHz

Characteristic	Symbol	Min	Typ	Max	Unit
Power Gain	G_{ps}	17.5	19.8	21.5	dB
Drain Efficiency	η_D	54	57.7	—	%
Input Return Loss	IRL	—	-17	-7	dB

1. MTTF calculator available at http://www.freescale.com/rf. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
2. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers.* Go to http://www.freescale.com/rf. Select Documentation/Application Notes - AN1955.
3. Part internally matched both on input and output.
4. Measurement made with device in straight lead configuration before any lead forming operation is applied.

(continued)

Table 5. Electrical Characteristics (T_A = 25°C unless otherwise noted) **(continued)**

Typical Broadband Performance (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 300 mA, P_{out} = 35.5 W CW

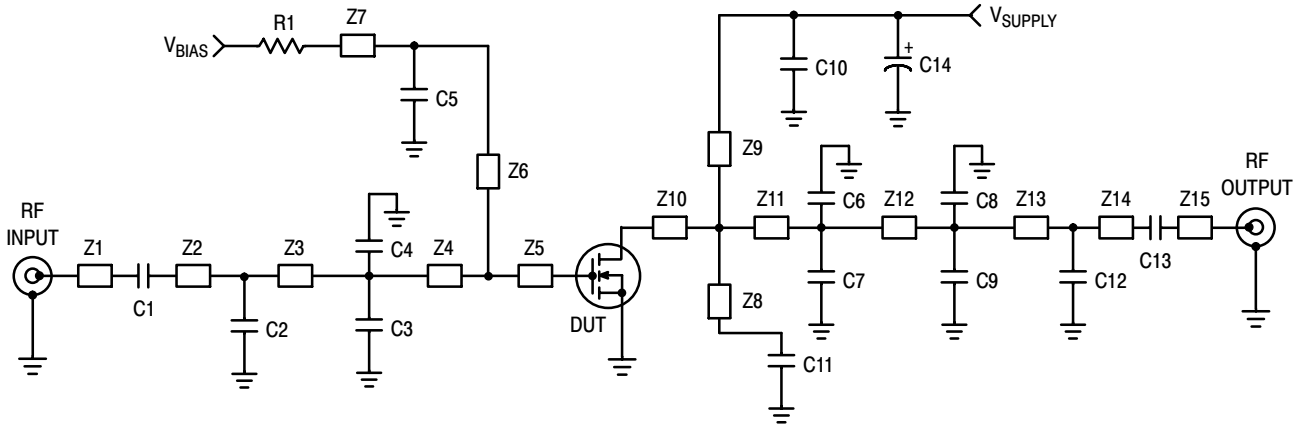
Frequency	G_{ps} (dB)	η_D (%)	IRL (dB)
864 MHz	19.9	58.7	-12
880 MHz	20	58.5	-17
894 MHz	19.8	57.7	-17

Typical Performances (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 300 mA, 864-894 MHz Bandwidth

Characteristic	Symbol	Min	Typ	Max	Unit
P_{out} @ 1 dB Compression Point	P1dB	—	47	—	W
IMD Symmetry @ 41 W PEP, P_{out} where IMD Third Order Intermodulation ≅ 30 dBc (Delta IMD Third Order Intermodulation between Upper and Lower Sidebands > 2 dB)	IMD_{sym}	—	22	—	MHz
VBW Resonance Point (IMD Third Order Intermodulation Inflection Point)	VBW_{res}	—	25	—	MHz
Gain Flatness in 30 MHz Bandwidth @ P_{out} = 35.5 W CW	G_F	—	0.2	—	dB
Gain Variation over Temperature (-30°C to +85°C)	ΔG	—	0.017	—	dB/°C
Output Power Variation over Temperature (-30°C to +85°C)	ΔP1dB	—	0.004	—	dBm/°C

Typical GSM EDGE Performances (In Freescale GSM EDGE Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 285 mA, P_{out} = 17.8 W Avg., 864-894 MHz EDGE Modulation

Frequency	G_{ps} (dB)	η_D (%)	Spectral Regrowth @ 400 kHz (dBc)	Spectral Regrowth @ 600 kHz (dBc)	EVM (% rms)
864 MHz	19.8	43.8	61.2	70.9	2.1
880 MHz	19.9	43.6	63.4	72.5	2
894 MHz	19.8	43.1	63.7	73	2



Z1	1.320″ x 0.044″ Microstrip	Z10	0.040″ x 0.450″ Microstrip
Z2	0.212″ x 0.044″ Microstrip	Z11	0.321″ x 0.450″ Microstrip
Z3	0.362″ x 0.044″ Microstrip	Z12	0.080″ x 0.280″ Microstrip
Z4	0.321″ x 0.450″ Microstrip	Z13	0.263″ x 0.044″ Microstrip
Z5	0.039″ x 0.450″ Microstrip	Z14	0.233″ x 0.044″ Microstrip
Z6*	0.306″ x 0.040″ Microstrip	Z15	1.332″ x 0.044″ Microstrip
Z7	0.708″ x 0.051″ Microstrip	PCB	Rogers R04350, 0.020″, ε_r = 3.50
Z8* Z9*	0.738″ x 0.040″ Microstrip		

* Line length includes microstrip bends

Figure 2. MRFE6S8046NR1(GNR1) Reference Design Test Circuit Schematic

Table 6. MRFE6S8046NR1(GNR1) Reference Design Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1, C13	56 pF Chip Capacitors	ATC600F560BT500XT	ATC
C2	3.9 pf Chip Capacitor	ATC600F3R0BT250XT	ATC
C3, C4	8.2 pF Chip Capacitors	ATC600F8R2BT500XT	ATC
C5	0.01 μF Chip Capacitor	C1825C103K1GAC	Kemet
C6, C7	1.5 pF Chip Capacitors	ATC600F1R5BT250XT	ATC
C8, C9	1.2 pF Chip Capacitors	ATC600F1R2BT250XT	ATC
C10, C11	39 pF Chip Capacitors	ATC600F390BT500XT	ATC
C12	6.8 pF Chip Capacitor	ATC600F6R8BT500XT	ATC
C14	470 μF 63V Electrolytic Capacitor	MCGPR63V477M13X26-RH	MultiComp
R1	4.7 KΩ, 1/4 W Chip Resistor	CRCW12064K70FKEA	Vishay

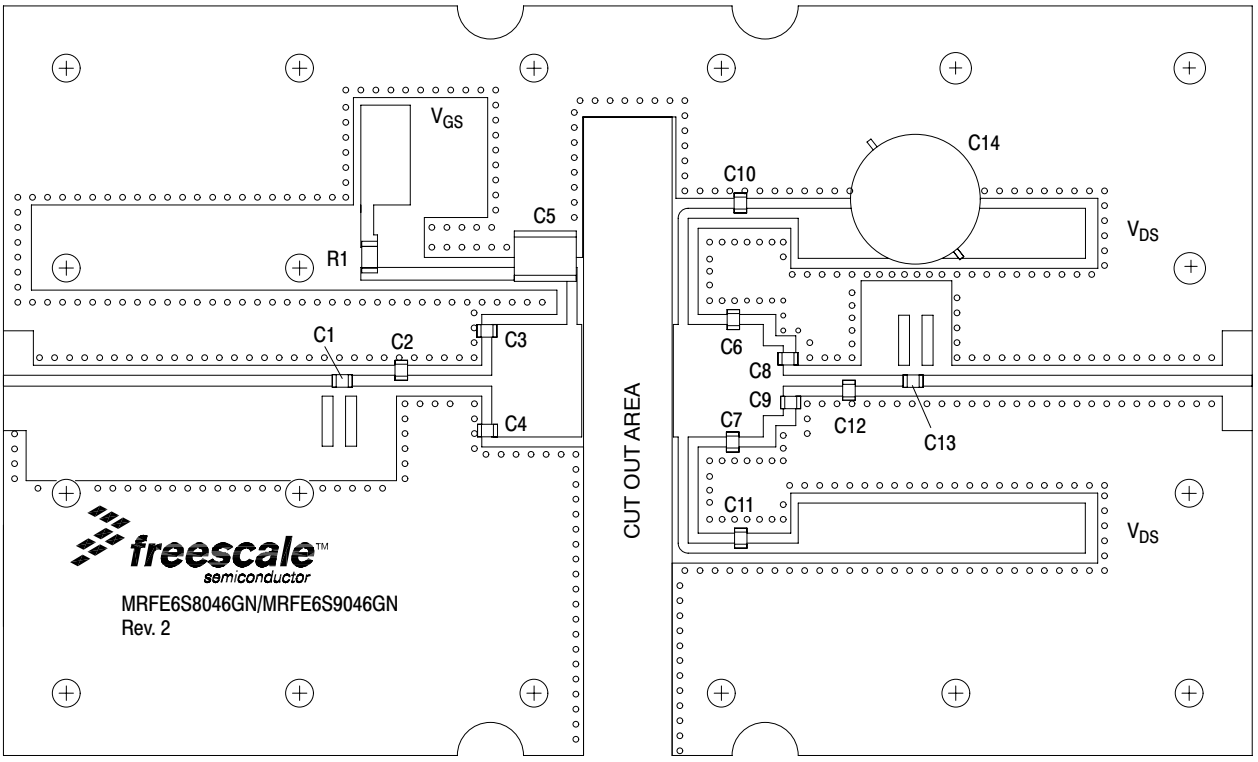


Figure 3. MRFE6S8046NR1(GNR1) Reference Design Test Circuit Component Layout

TYPICAL CHARACTERISTICS

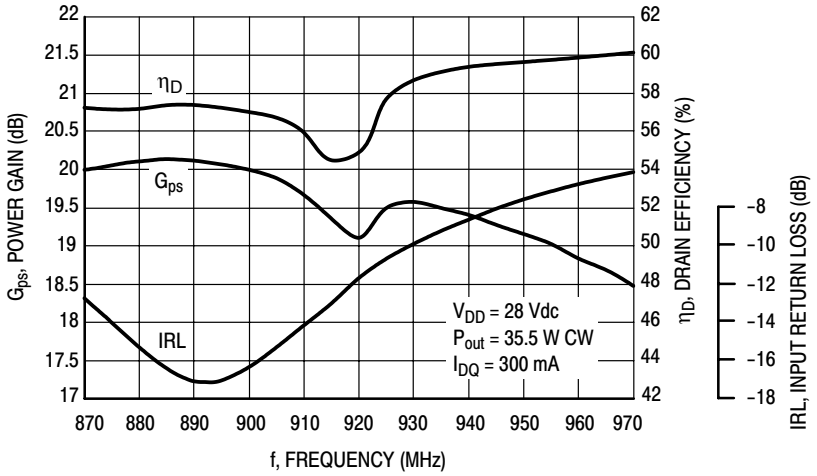


Figure 4. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @ P_{out} = 35.5 Watts CW

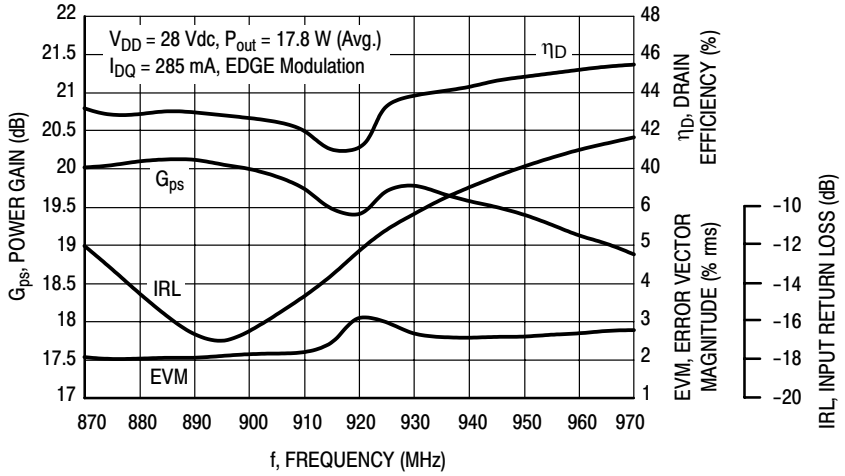


Figure 5. Power Gain, Input Return Loss, EVM and Drain Efficiency versus Frequency @ P_{out} = 17.8 Watts Avg.

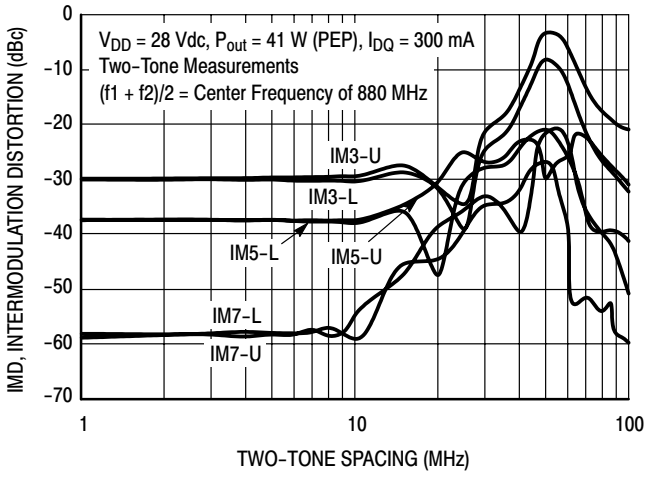


Figure 6. Intermodulation Distortion Products versus Two-Tone Spacing

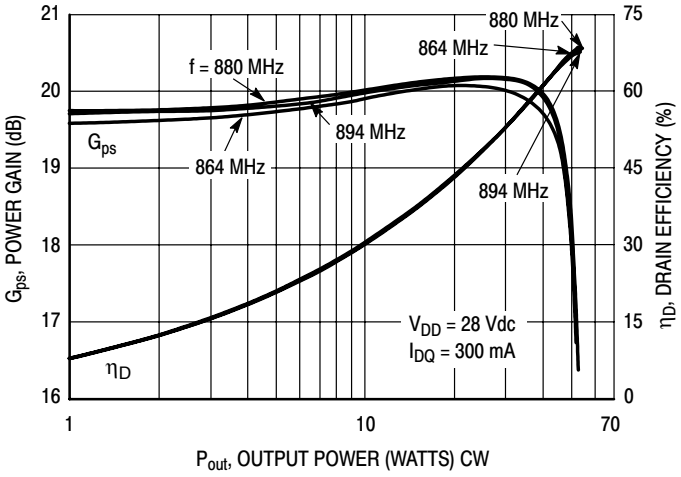


Figure 7. Power Gain and Drain Efficiency versus Output Power

TYPICAL CHARACTERISTICS

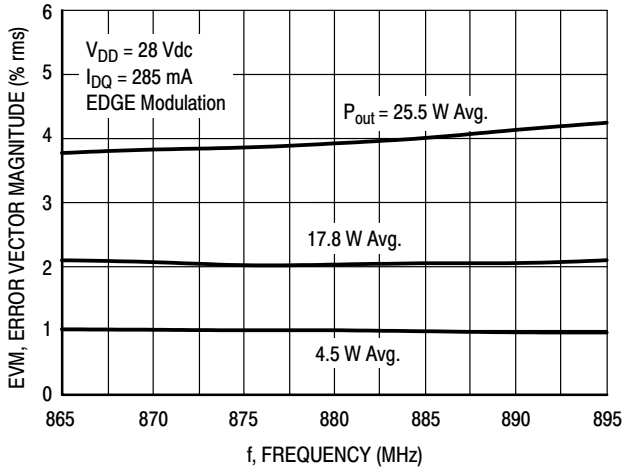


Figure 8. EVM versus Frequency

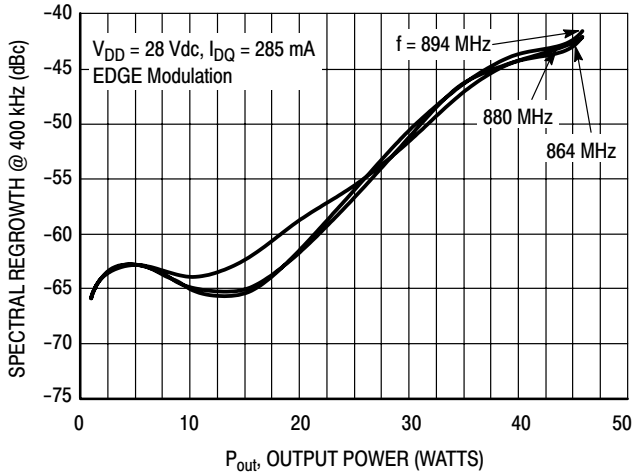


Figure 9. Spectral Regrowth at 400 kHz versus Output Power

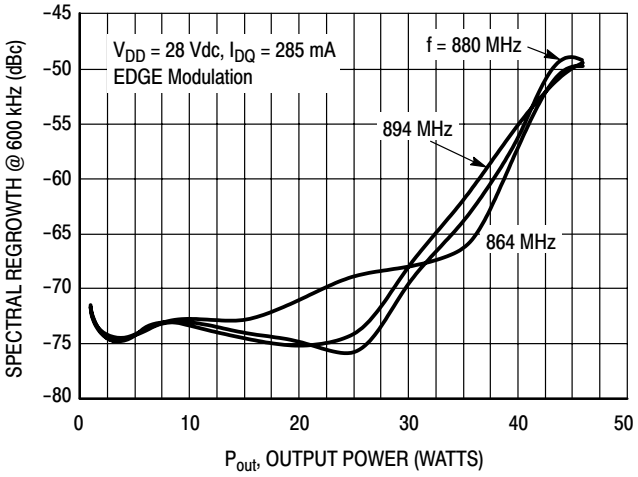


Figure 10. Spectral Regrowth at 600 kHz versus Output Power

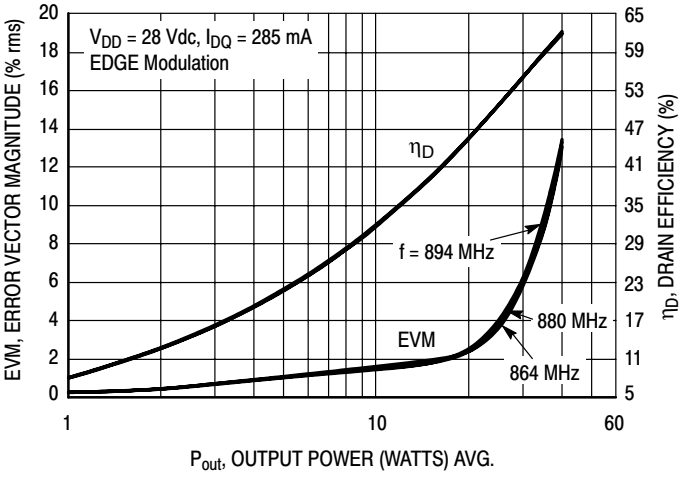


Figure 11. EVM and Drain Efficiency versus Output Power

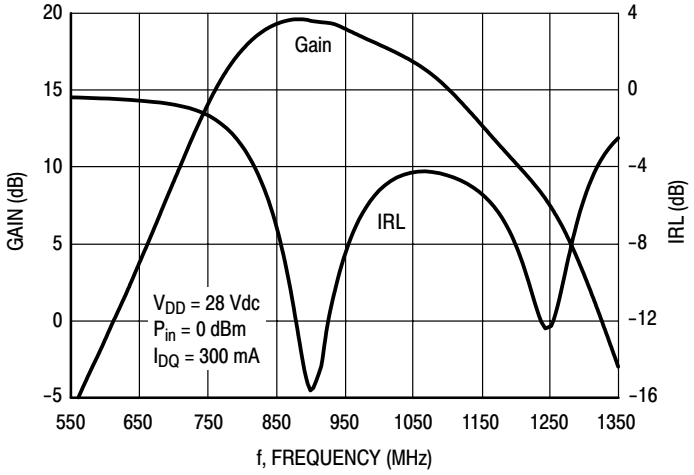


Figure 12. Broadband Frequency Response

GSM TEST SIGNAL

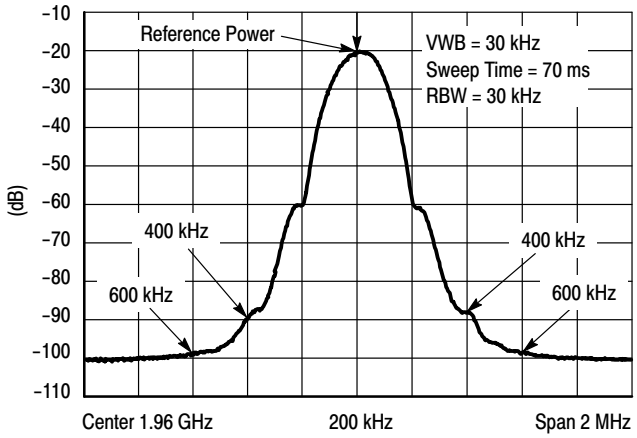


Figure 13. EDGE Spectrum

V_{DD} = 28 Vdc, I_{DQ} = 300 mA, P_{out} = 35.5 W CW

f (MHz)	Z_{source} Ω	Z_{load} Ω
820	4.11 - j6.76	7.93 - j3.90
840	3.74 - j6.21	7.23 - j3.60
860	3.42 - j5.75	6.71 - j3.29
880	3.17 - j5.29	6.27 - j2.95
900	2.94 - j4.86	5.87 - j2.61
920	2.78 - j4.47	5.33 - j2.29
940	2.65 - j4.14	5.32 - j1.62
960	2.51 - j3.82	5.15 - j1.35
980	2.38 - j3.57	4.98 - j1.00

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

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

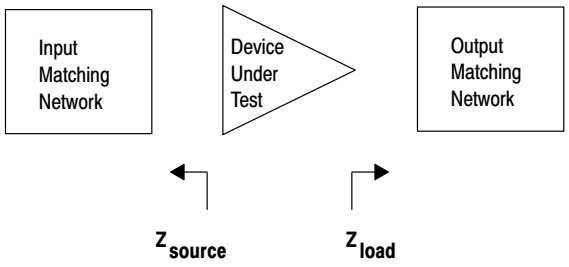
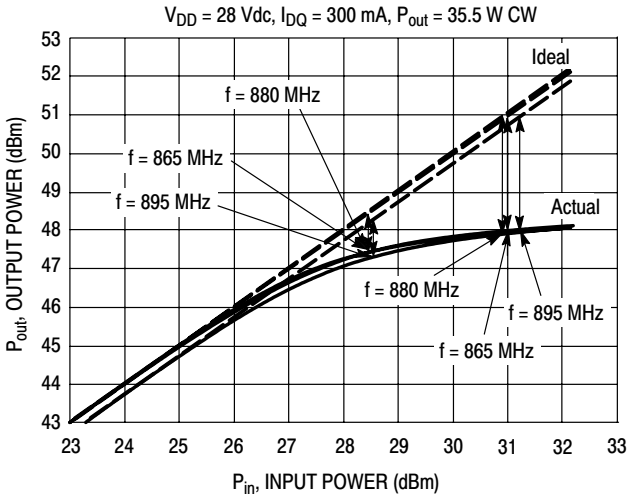


Figure 14. Series Equivalent Source and Load Impedance

ALTERNATIVE PEAK TUNE LOAD PULL CHARACTERISTICS



NOTE: Load Pull Test Fixture Tuned for Peak P1dB Output Power @ 28 V

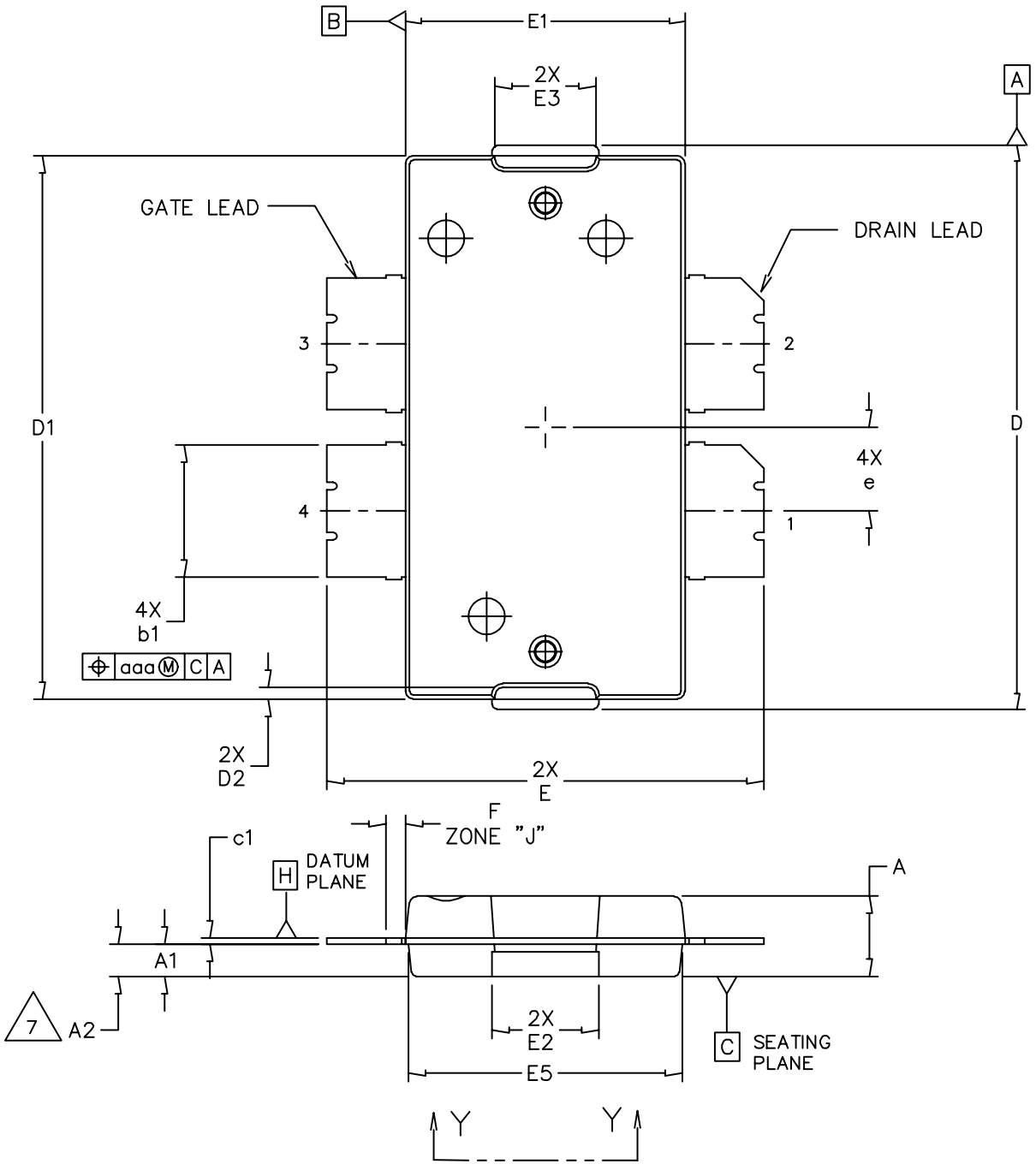
f (MHz)	P1dB		P3dB	
	Watts	dBm	Watts	dBm
865	55	47.4	63	48.0
880	55	47.4	62	47.9
895	54	47.3	62	47.9

Test Impedances per Compression Level

f (MHz)		Z_{source} Ω	Z_{load} Ω
865	P1dB	2.08 - j5.40	4.39 - j2.89
880	P1dB	2.54 - j5.63	4.63 - j2.96
895	P1dB	3.31 - j6.08	4.42 - j3.30

Figure 15. Pulsed CW Output Power versus Input Power @ 28 V

PACKAGE DIMENSIONS



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TITLE: TO-270 4 LEAD, WIDE BODY	DOCUMENT NO: 98ASA10577D	REV: D	
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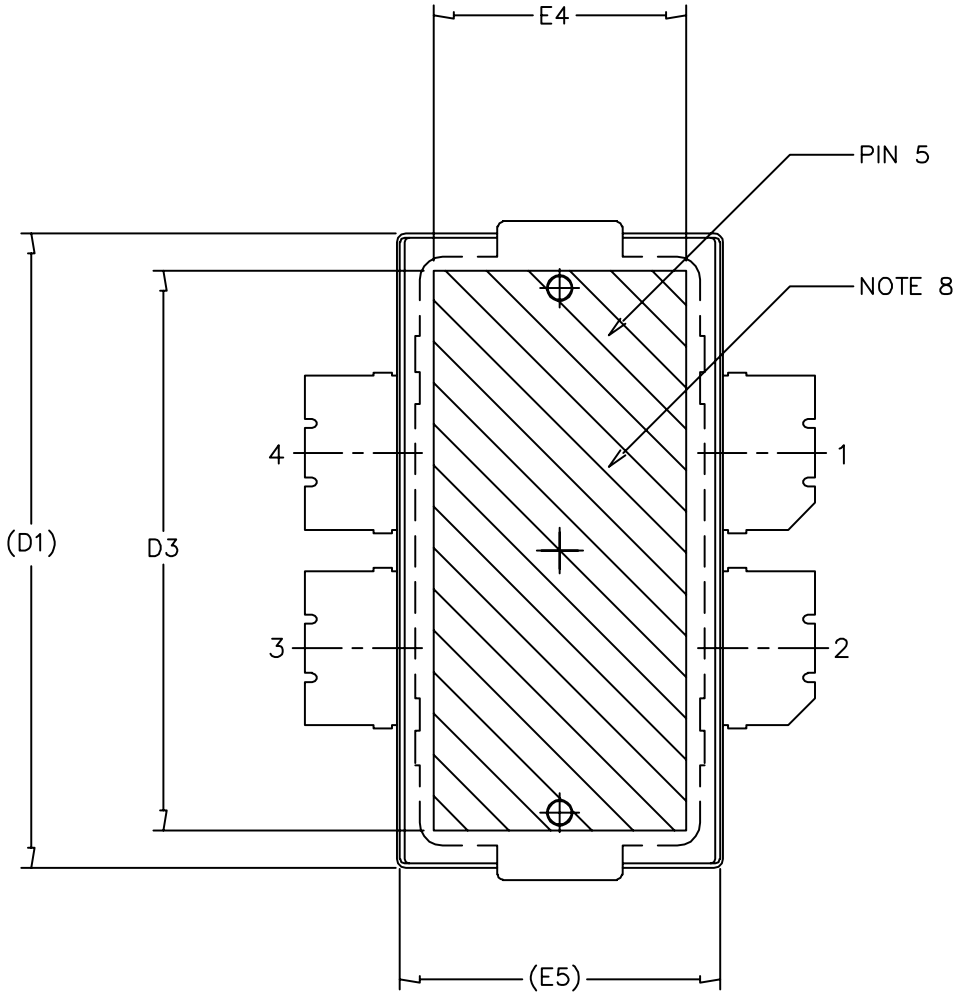
	STANDARD: NON-JEDEC		



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TITLE: TO−270 4 LEAD, WIDE BODY	DOCUMENT NO: 98ASA10577D	REV: D
	CASE NUMBER: 1486−03	13 AUG 2007
	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 PER SIDE. DIMENSIONS "D" 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 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.

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

DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX
A	.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	.18	.28
D	.712	.720	18.08	18.29	e	.106 BSC		2.69 BSC	
D1	.688	.692	17.48	17.58	aaa	.004		.10	
D2	.011	.019	0.28	0.48					
D3	.600	---	15.24	---					
E	.551	.559	14	14.2					
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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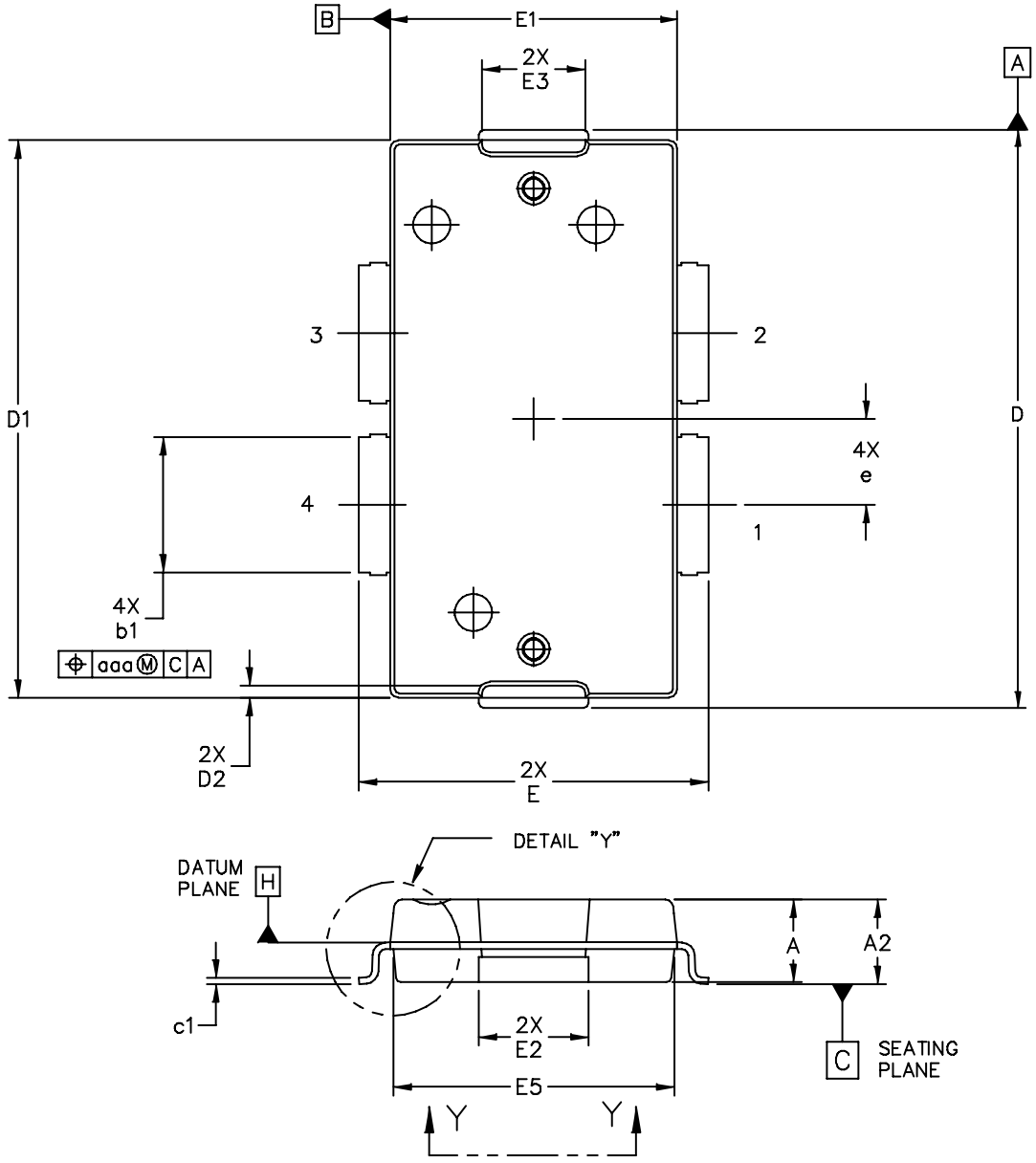

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	CASE NUMBER: 1487−05	03 AUG 2007
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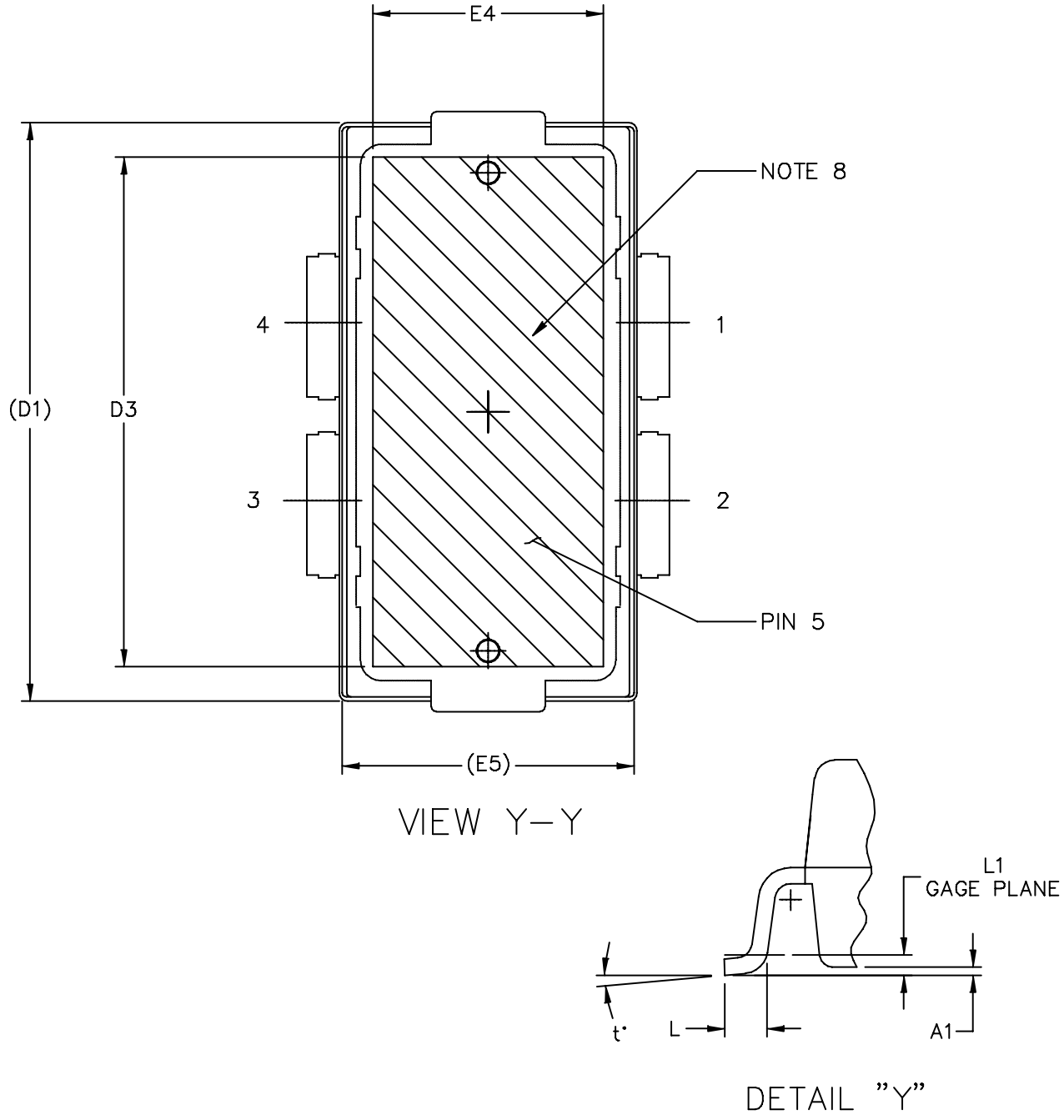

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	CASE NUMBER: 1487–05	03 AUG 2007
	STANDARD: JEDEC TO–270 BB	

NOTES:

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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 MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER 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					

MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE

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

PRODUCT DOCUMENTATION

Refer to the following documents, tools and software 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
- AN3263: Bolt Down Mounting Method for High Power RF Transistors and RFICs in Over-Molded Plastic Packages
- AN3789: Clamping of High Power RF Transistors and RFICs in Over-Molded Plastic Packages

Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

Software

- Electromigration MTTF Calculator
- .s2p File

For Software and Tools, do a Part Number search at http://www.freescale.com, and select the “Part Number” link. Go to the Software & Tools tab on the part’s Product Summary page to download the respective tool.

REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	May 2009	• Initial Release of Data Sheet

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