Document Number: MRFE6S9060N
Rev. 1, 10/2007

RoHS

RF Power Field Effect Transistor

N-Channel Enhancement-Mode Lateral MOSFET

MRFE6S9060NR1

**880 MHz, 14 W AVG., 28 V
SINGLE N-CDMA
LATERAL N-CHANNEL
BROADBAND
RF POWER MOSFET**

Designed for broadband commercial and industrial applications with frequencies up to 1000 MHz. The high gain and broadband performance of this device makes it ideal for large-signal, common-source amplifier applications in 28 volt base station equipment.

- Typical Single-Carrier N-CDMA Performance @ 880 MHz, V_{DD} = 28 Volts, I_{DQ} = 450 mA, P_{out} = 14 Watts Avg., IS-95 CDMA (Pilot, Sync, Paging, Traffic Codes 8 Through 13) Channel Bandwidth = 1.2288 MHz. PAR = 9.8 dB @ 0.01% Probability on CCDF.
  Power Gain — 21.1 dB
  Drain Efficiency — 33%
  ACPR @ 750 kHz Offset — -45.7 dBc in 30 kHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 32 Vdc, 880 MHz, 3 dB Overdrive, Designed for Enhanced Ruggedness

GSM EDGE Application

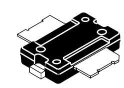
- Typical GSM EDGE Performance: V_{DD} = 28 Volts, I_{DQ} = 500 mA, P_{out} = 21 Watts Avg., Full Frequency Band (920-960 MHz)
  Power Gain — 20 dB
  Drain Efficiency — 46%
  Spectral Regrowth @ 400 kHz Offset = -62 dBc
  Spectral Regrowth @ 600 kHz Offset = -78 dBc
  EVM — 1.5% rms

GSM Application

- Typical GSM Performance: V_{DD} = 28 Volts, I_{DQ} = 500 mA, P_{out} = 60 Watts, Full Frequency Band (920-960 MHz)
  Power Gain — 20 dB
  Drain Efficiency — 63%

Features

- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Integrated ESD Protection
- 225°C Capable Plastic Package
- RoHS Compliant
- In Tape and Reel. R1 Suffix = 500 Units per 24 mm, 13 inch Reel.



**CASE 1265-09, STYLE 1
TO-270-2
PLASTIC**

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	-0.5, +66	Vdc
Gate-Source Voltage	V_{GS}	-0.5, +12	Vdc
Maximum Operation 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

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case Case Temperature 80°C, 60 W CW Case Temperature 78°C, 14 W CW	$R_{\theta JC}$	 0.77 0.88	°C/W

1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at http://www.freescale.com/rf. Select Tools (Software & 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.

Table 3. ESD Protection Characteristics

Test Methodology	Class
Human Body Model (per JESD22-A114)	2 (Minimum)
Machine Model (per EIA/JESD22-A115)	B (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_C = 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}	—	—	10	μAdc
On Characteristics					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 200 μA)	$V_{GS(th)}$	1	2.2	3	Vdc
Gate Quiescent Voltage (V_{DD} = 28 Vdc, I_D = 450 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	2	3	4	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 1.5 Adc)	$V_{DS(on)}$	0.05	0.27	0.4	Vdc
Dynamic Characteristics					
Reverse Transfer Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	1.1	—	pF
Output Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	33	—	pF
Input Capacitance (V_{DS} = 28 Vdc, V_{GS} = 0 Vdc ± 30 mV(rms)ac @ 1 MHz)	C_{iss}	—	109	—	pF

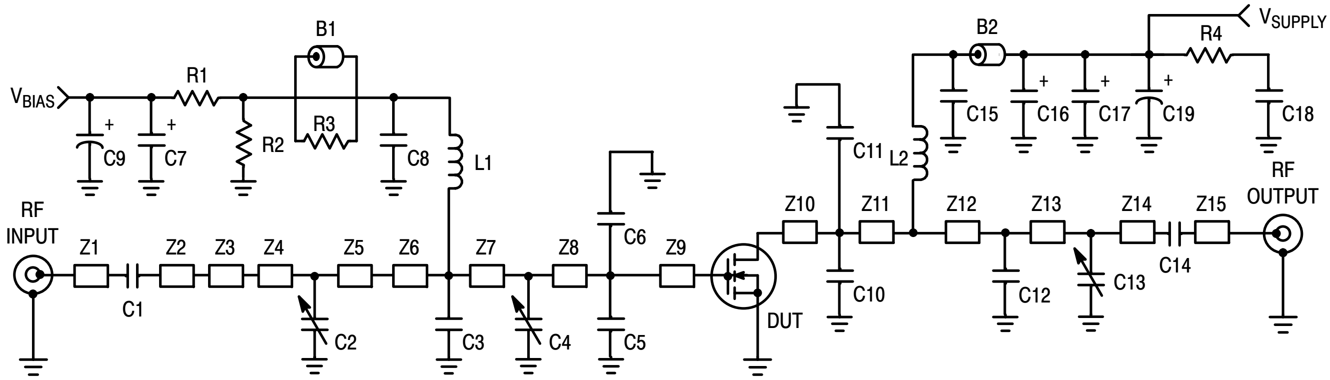
Functional Tests (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 450 mA, P_{out} = 14 W Avg., f = 880 MHz, Single-Carrier N-CDMA, 1.2288 MHz Channel Bandwidth Carrier. ACPR measured in 30 kHz Channel Bandwidth @ ±750 kHz Offset. PAR = 9.8 dB @ 0.01% Probability on CCDF

Characteristic	Symbol	Min	Typ	Max	Unit
Power Gain	G_{ps}	20	21.1	23	dB
Drain Efficiency	η_D	30.5	33	—	%
Adjacent Channel Power Ratio	ACPR	—	-45.7	-44	dBc
Input Return Loss	IRL	—	-18	-9	dB

(continued)

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

Characteristic	Symbol	Min	Typ	Max	Unit
Typical GSM EDGE Performances (In Freescale GSM EDGE Test Fixture Optimized for 920-960 MHz, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 500 mA, P_{out} = 21 W Avg., f = 920-960 MHz, GSM EDGE Signal					
Power Gain	G_{ps}	—	20	—	dB
Drain Efficiency	η_D	—	46	—	%
Error Vector Magnitude	EVM	—	1.5	—	%
Spectral Regrowth at 400 kHz Offset	SR1	—	-62	—	dBc
Spectral Regrowth at 600 kHz Offset	SR2	—	-78	—	dBc
Typical CW Performances (In Freescale GSM Test Fixture Optimized for 920-960 MHz, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 500 mA, P_{out} = 60 W, f = 920-960 MHz					
Power Gain	G_{ps}	—	20	—	dB
Drain Efficiency	η_D	—	63	—	%
Input Return Loss	IRL	—	-12	—	dB
P_{out} @ 1 dB Compression Point (f = 940 MHz)	P1dB	—	67	—	W
Typical Performances (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 450 mA, 865-900 MHz Bandwidth					
Video Bandwidth @ 60 W PEP P_{out} where IM3 = -30 dBc (Tone Spacing from 100 kHz to VBW) ΔIMD3 = IMD3 @ VBW frequency - IMD3 @ 100 kHz <1 dBc (both sidebands)	VBW	—	3	—	MHz
Gain Flatness in 35 MHz Bandwidth @ P_{out} = 14 W Avg.	G_F	—	0.27	—	dB
Gain Variation over Temperature (-30°C to +85°C)	ΔG	—	0.011	—	dB/°C
Output Power Variation over Temperature (-30°C to +85°C)	ΔP1dB	—	0.088	—	dBm/°C



Z1	0.215″ x 0.065″ Microstrip	Z9	0.057″ x 0.525″ Microstrip
Z2	0.221″ x 0.065″ Microstrip	Z10	0.360″ x 0.270″ Microstrip
Z3	0.500″ x 0.100″ Microstrip	Z11	0.063″ x 0.270″ Microstrip
Z4	0.460″ x 0.270″ Microstrip	Z12	0.360″ x 0.065″ Microstrip
Z5	0.040″ x 0.270″ Microstrip	Z13	0.170″ x 0.065″ Microstrip
Z6	0.280″ x 0.270″ x 0.530″ Taper	Z14	0.880″ x 0.065″ Microstrip
Z7	0.087″ x 0.525″ Microstrip	Z15	0.260″ x 0.065″ Microstrip
Z8	0.435″ x 0.525″ Microstrip	PCB	Taconic RF-35 0.030″, ε_r = 3.5

Figure 1. MRFE6S9060NR1 Test Circuit Schematic

Table 6. MRFE6S9060NR1 Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
B1	Ferrite Bead	2743019447	Fair Rite
B2	Ferrite Bead	274021447	Fair Rite
C1, C8, C14, C15	47 pF Chip Capacitors	ATC100B470JT500XT	ATC
C2, C4, C13	0.8-8.0 pF Variable Capacitors, Gigatrim	2729152	Johanson
C3	3.0 pF Chip Capacitor	ATC100B3R0JT500XT	ATC
C5, C6	15 pF Chip Capacitors	ATC100B150JT500XT	ATC
C7, C16, C17	10 μF, 35 V Tantalum Capacitors	T491D106K035AT	Kemet
C9	100 μF, 50 V Electrolytic Capacitor	MCHT101M1HB-1017-RH	Multicomp
C10, C11	12 pF Chip Capacitors	ATC100B120JT500XT	ATC
C12	4.3 pF Chip Capacitor	ATC100B4R3JT500XT	ATC
C18	0.56 μF Chip Capacitor	ATC700A561MT150XT	ATC
C19	470 μF, 63 V Electrolytic Capacitor	EKME630ELL471MK255	Multicomp
L1, L2	12.5 nH Inductor	A04T-5	Coilcraft
R1	1 kΩ, 1/4 W Chip Resistor	CRCW12061001FKEA	Vishay
R2	560 kΩ, 1/4 W Chip Resistor	CRCW12065600FKEA	Vishay
R3	12 Ω, 1/4 W Chip Resistor	CRCW120612R0FKEA	Vishay
R4	27 Ω, 1/4 W Chip Resistor	CRCW120627R0FKEA	Vishay

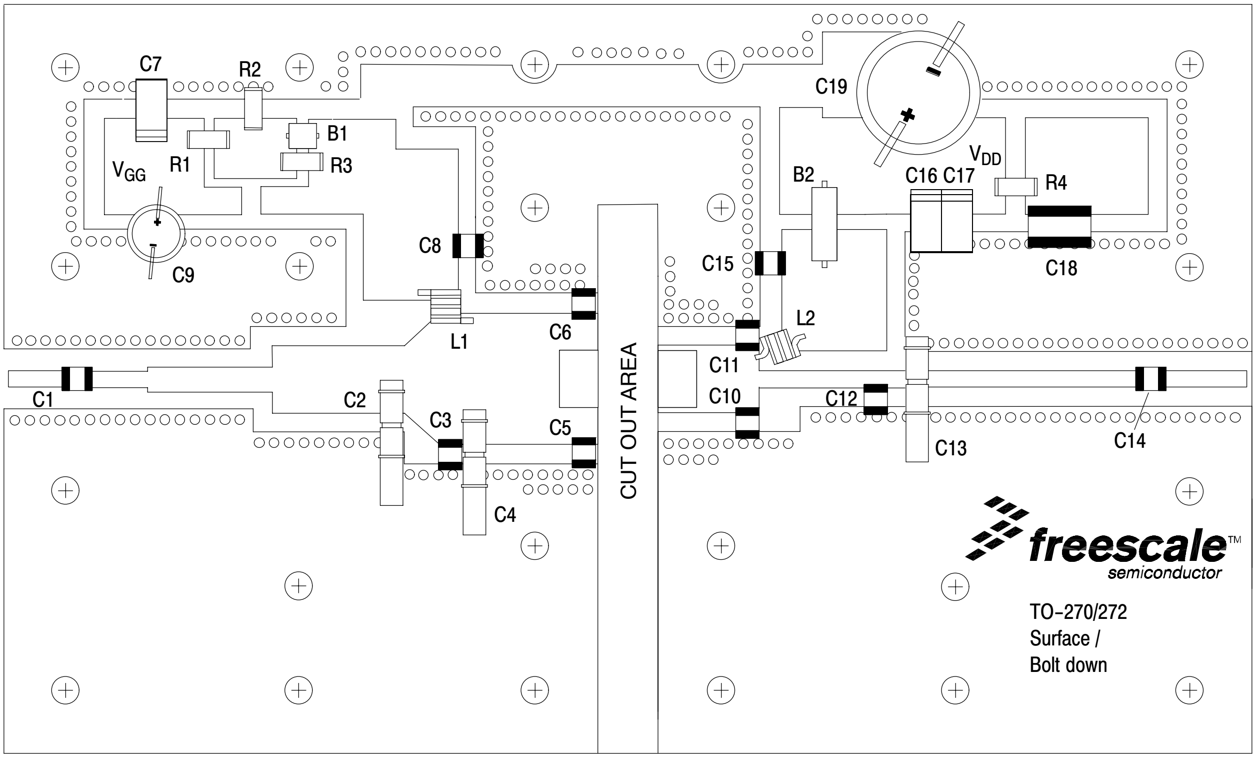


Figure 2. MRFE6S9060NR1 Test Circuit Component Layout

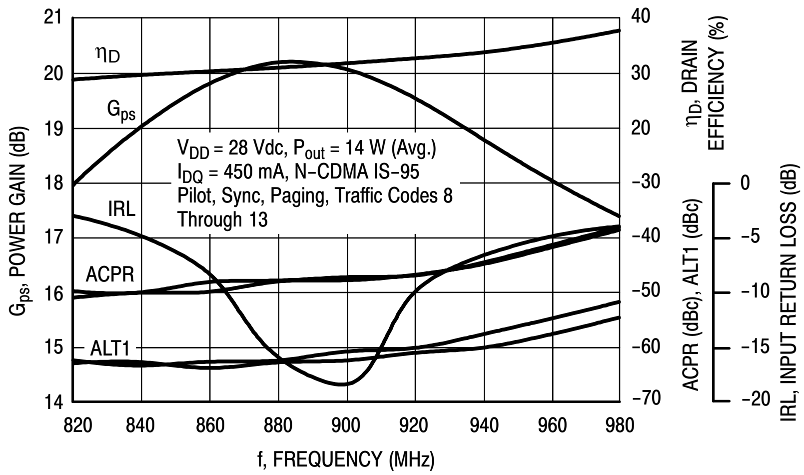


Figure 3. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 14 Watts Avg.

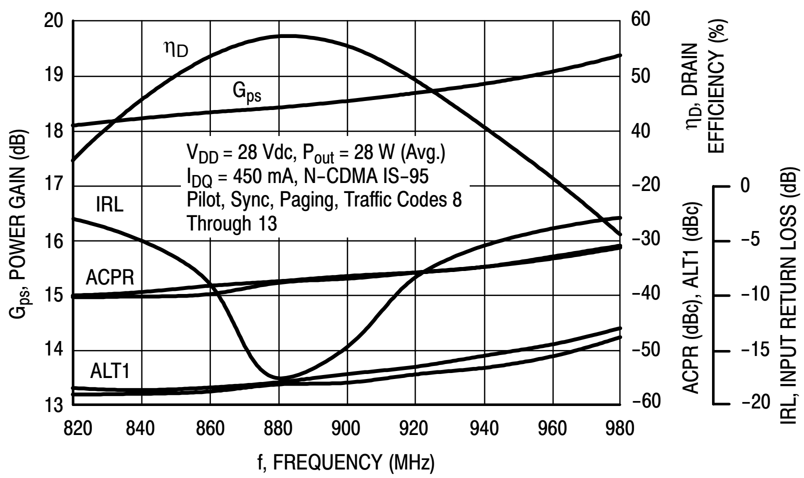


Figure 4. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 28 Watts Avg.

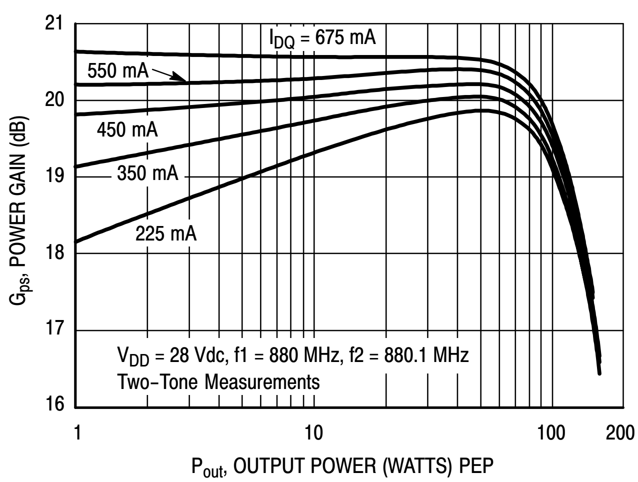


Figure 5. Two-Tone Power Gain versus Output Power

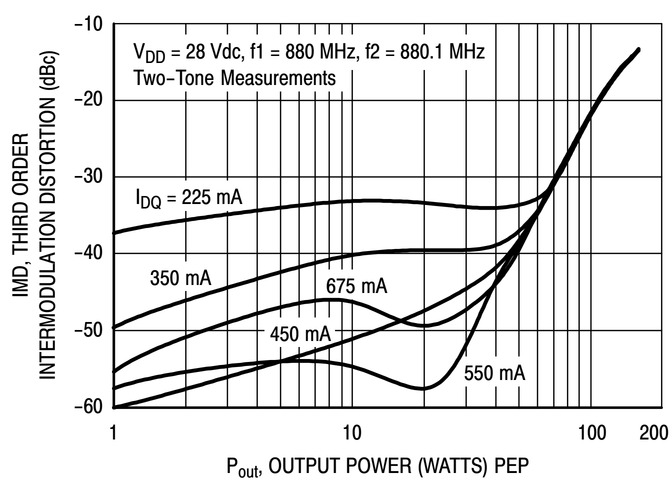


Figure 6. Third Order Intermodulation Distortion versus Output Power

TYPICAL CHARACTERISTICS

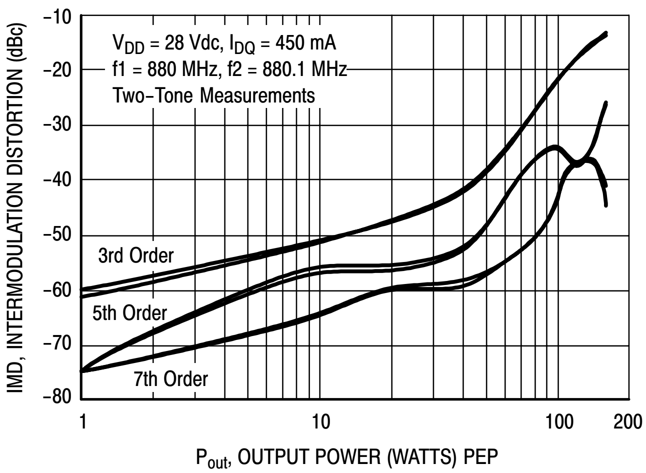


Figure 7. Intermodulation Distortion Products versus Output Power

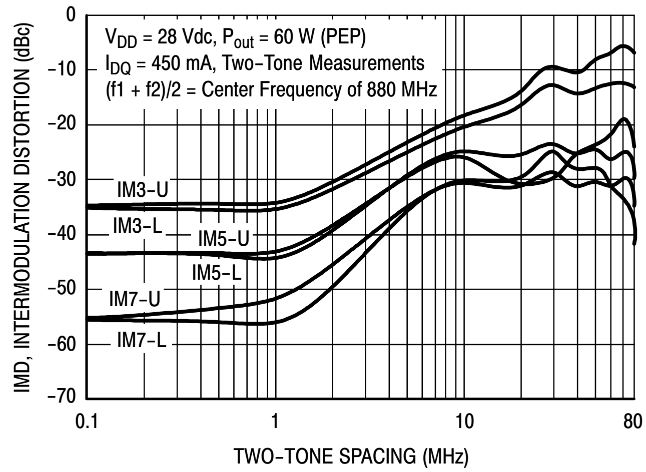


Figure 8. Intermodulation Distortion Products versus Tone Spacing

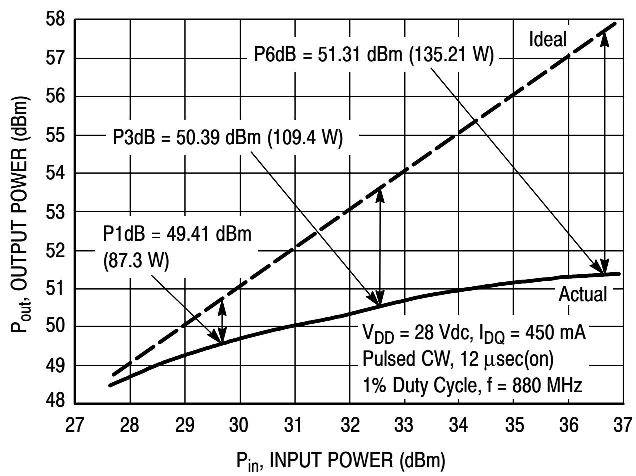


Figure 9. Pulsed CW Output Power versus Input Power

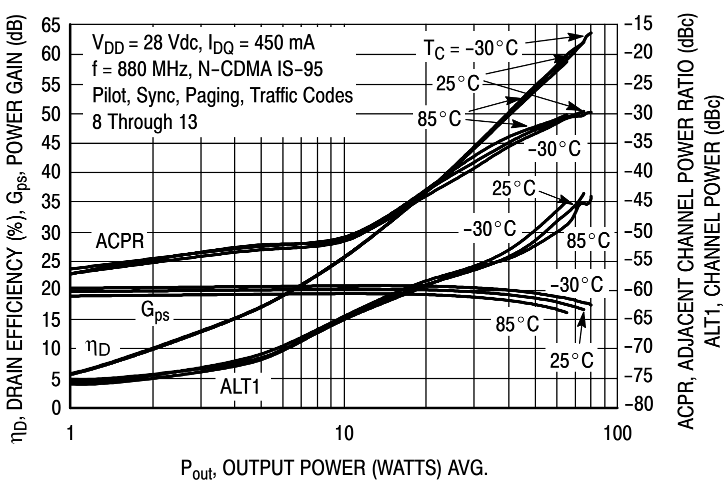


Figure 10. Single-Carrier N-CDMA ACPR, ALT1, Power Gain and Drain Efficiency versus Output Power

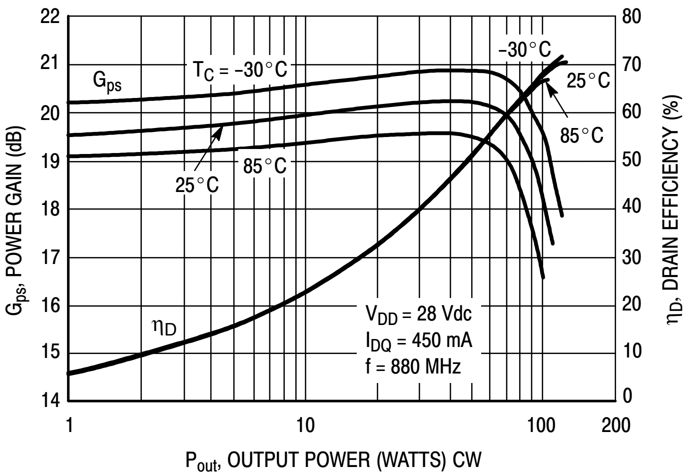


Figure 11. Power Gain and Drain Efficiency versus CW Output Power

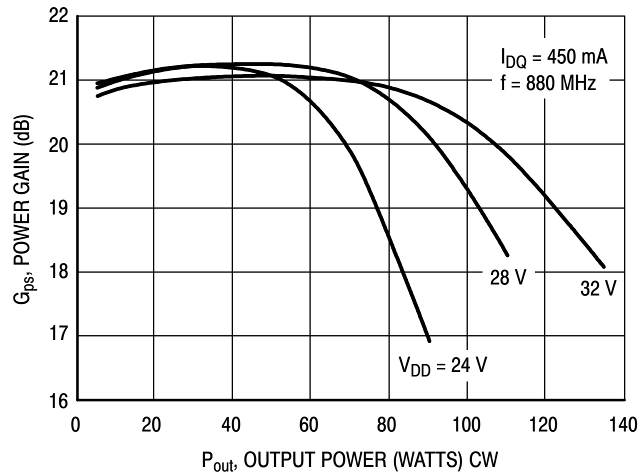
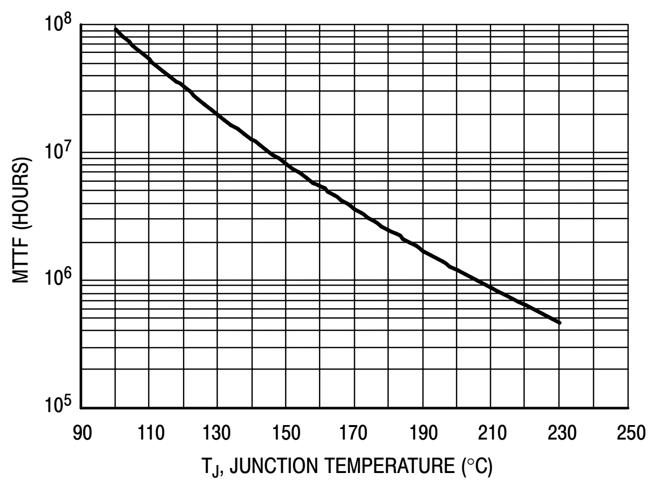


Figure 12. Power Gain versus Output Power



This above graph displays calculated MTTF in hours when the device is operated at V_{DD} = 28 Vdc, P_{out} = 14 W Avg., and η_D = 32.5%.

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

Figure 13. MTTF versus Junction Temperature

N-CDMA TEST SIGNAL

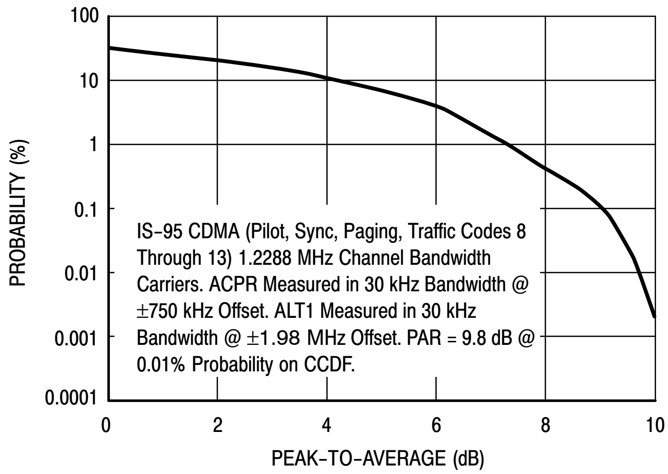


Figure 14. Single-Carrier CCDF N-CDMA

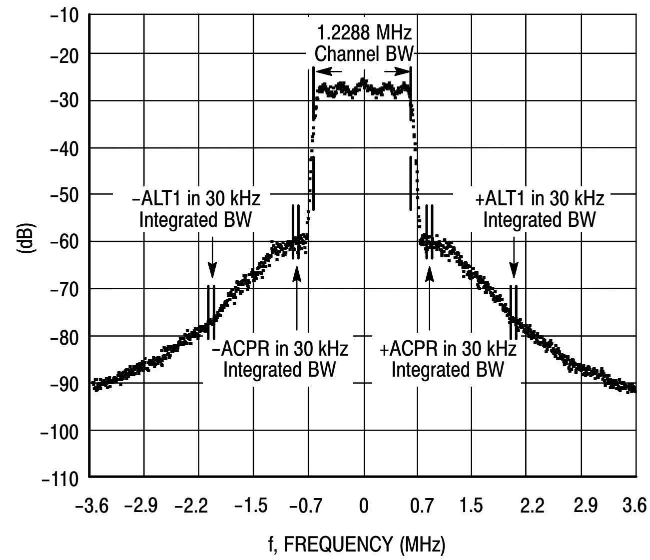
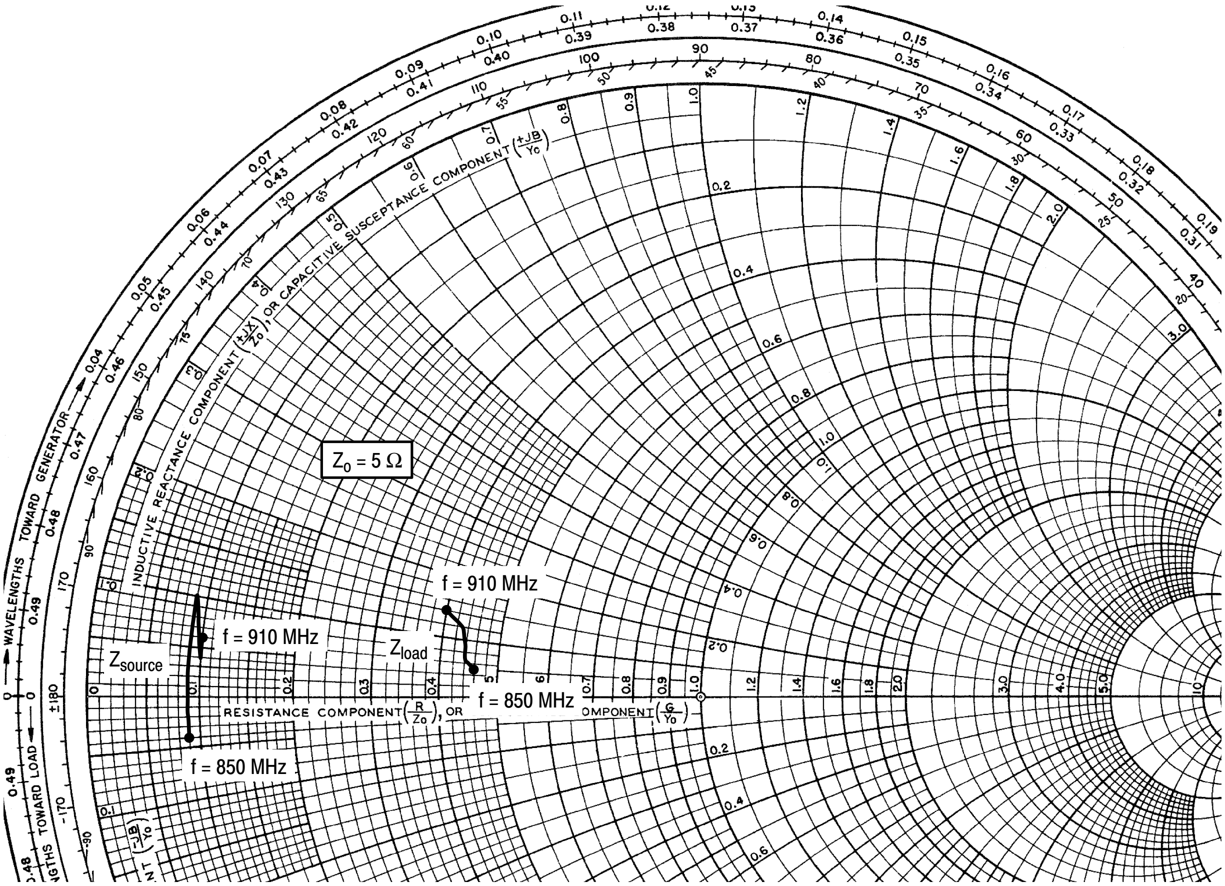


Figure 15. Single-Carrier N-CDMA Spectrum



V_{DD} = 28 Vdc, I_{DQ} = 450 mA, P_{out} = 14 W Avg.

f MHz	Z_{source} Ω	Z_{load} Ω
850	0.44 - j0.20	2.28 + j0.23
865	0.44 - j0.07	2.18 + j0.33
880	0.45 + j0.50	2.20 + j0.47
895	0.48 + j0.18	2.15 + j0.61
910	0.52 + j0.29	2.00 + j0.68

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

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

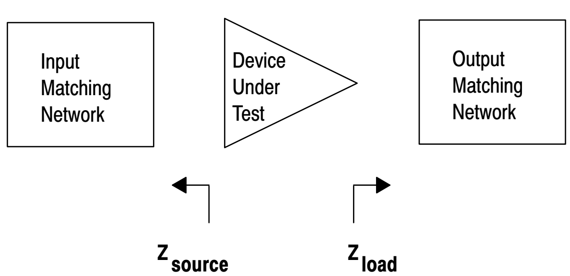
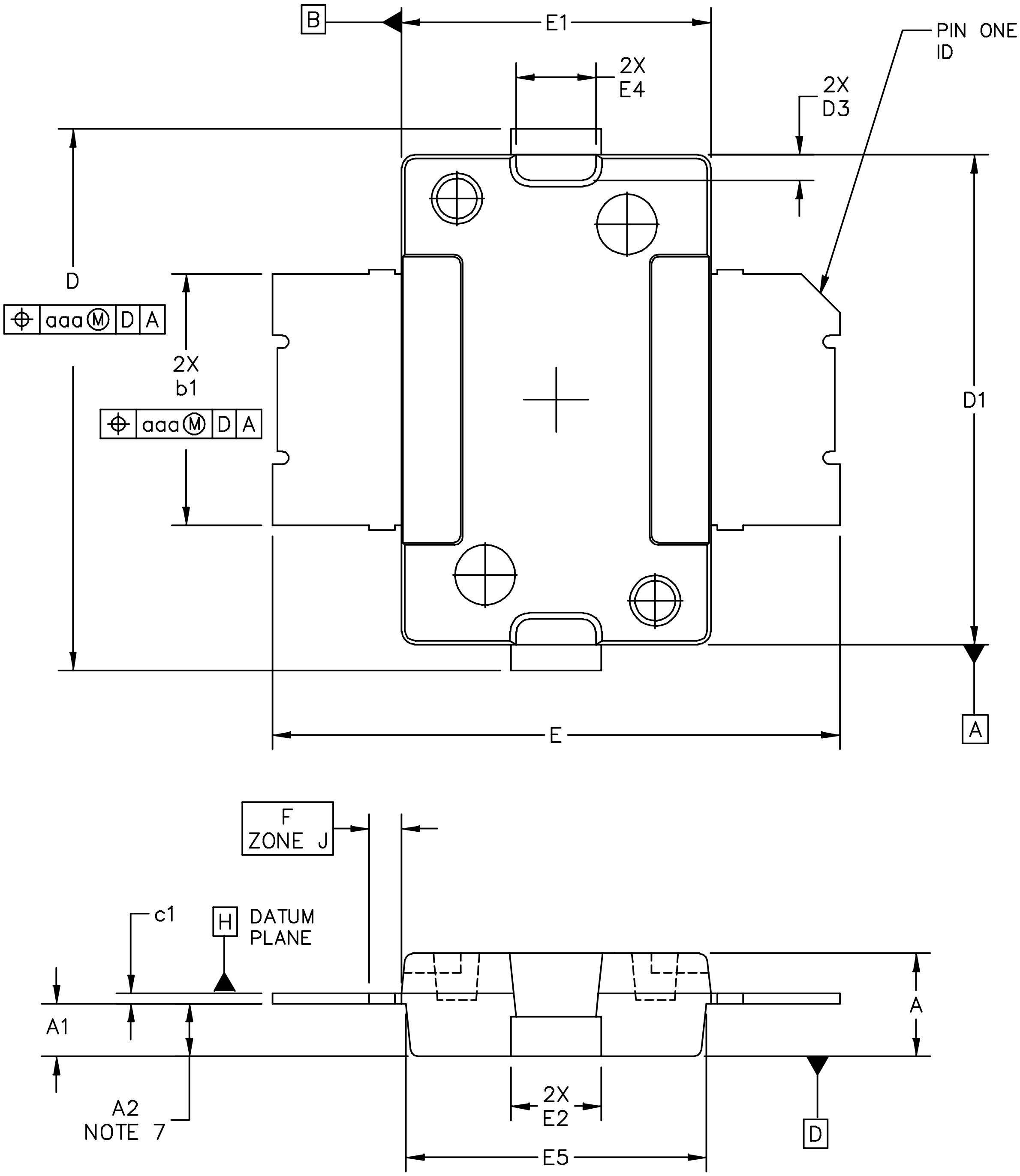


Figure 16. Series Equivalent Source and Load Impedance

PACKAGE DIMENSIONS



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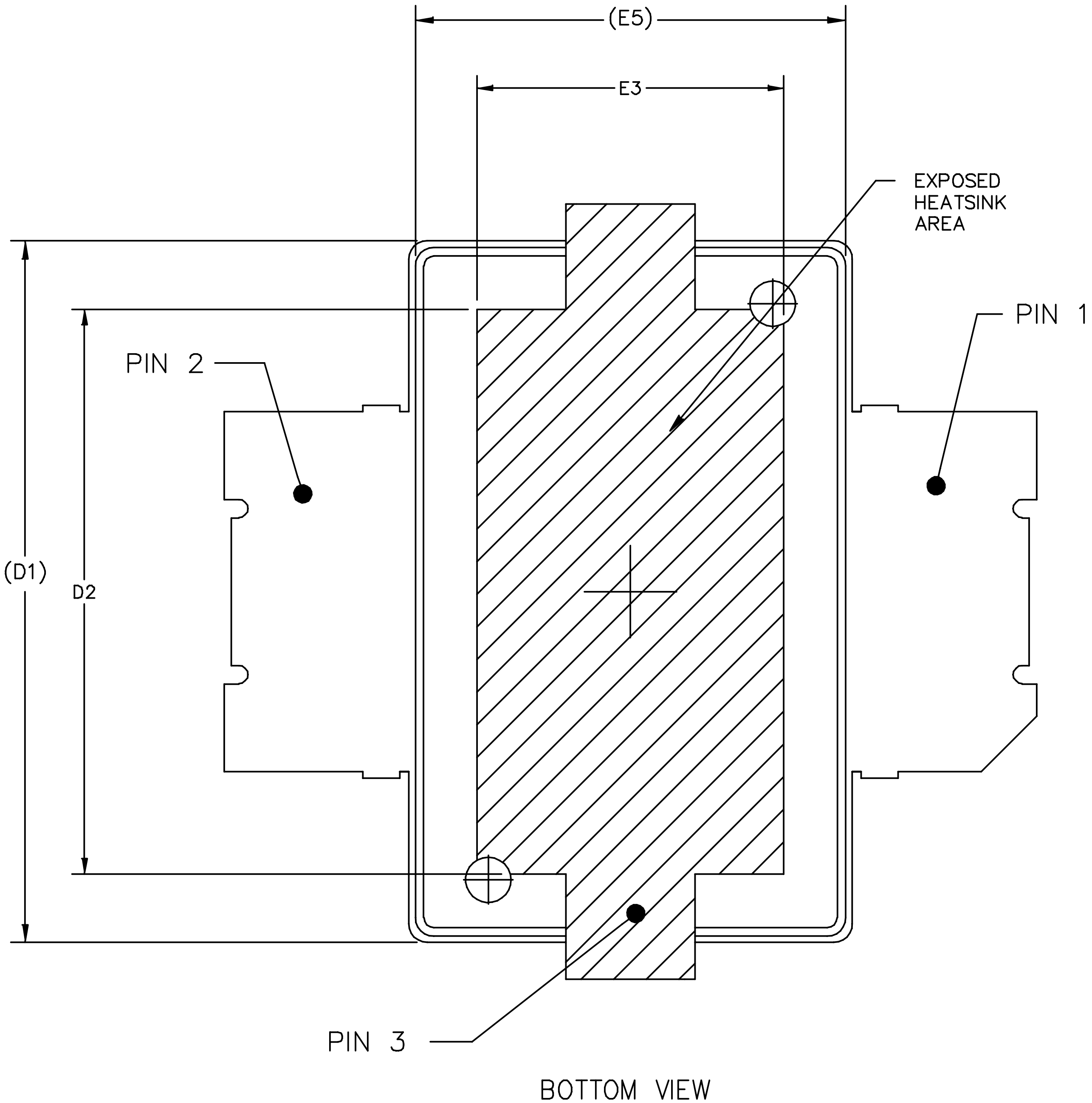
		CASE NUMBER: 1265–09	29 JUN 2007
		STANDARD: JEDEC TO–270 AA	



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TITLE: TO−270 SURFACE MOUNT	DOCUMENT NO: 98ASH98117A	REV: K	
	CASE NUMBER: 1265−09	29 JUN 2007	
	STANDARD: JEDEC TO−270 AA		

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 "D1" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 PER SIDE. DIMENSIONS "D1 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 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. DIMENSIONS "D" AND "E2" DO NOT INCLUDE MOLD PROTRUSION. OVERALL LENGTH INCLUDING MOLD PROTRUSION SHOULD NOT EXCEED 0.430 INCH FOR DIMENSION "D" AND 0.080 INCH FOR DIMENSION "E2". DIMENSIONS "D" AND "E2" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -D-.

STYLE 1:
PIN 1 - DRAIN
PIN 2 - GATE
PIN 3 - SOURCE

DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX
A	.078	.082	1.98	2.08	F	.025 BSC		0.64 BSC	
A1	.039	.043	0.99	1.09	b1	.193	.199	4.90	5.06
A2	.040	.042	1.02	1.07	c1	.007	.011	0.18	0.28
D	.416	.424	10.57	10.77	aaa	.004		0.10	
D1	.378	.382	9.60	9.70					
D2	.290	----	7.37	----					
D3	.016	.024	0.41	0.61					
E	.436	.444	11.07	11.28					
E1	.238	.242	6.04	6.15					
E2	.066	.074	1.68	1.88					
E3	.150	----	3.81	----					
E4	.058	.066	1.47	1.68					
E5	.231	.235	5.87	5.97					

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	CASE NUMBER: 1265-09	29 JUN 2007
	STANDARD: JEDEC TO-270 AA	

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
- 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	Oct. 2007	• Initial Release of Data Sheet
1	Oct. 2007	• Added Min value to $V_{DS(on)}$, On Characteristics table, p. 2

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