



# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed for W-CDMA base station applications with frequencies from 2110 to 2170 MHz. Suitable for TDMA, CDMA and multicarrier amplifier applications. To be used in Class AB for PCN-PCS/cellular radio and WLL applications.

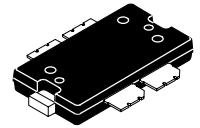
- Typical 2-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 500$  mA,  $P_{out} = 10$  Watts Avg.,  $f = 2112.5$  MHz, Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.  
 Power Gain — 14.5 dB  
 Drain Efficiency — 25.5%  
 IM3 @ 10 MHz Offset — -37 dBc in 3.84 MHz Channel Bandwidth  
 ACPR @ 5 MHz Offset — -39 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 5:1 VSWR, @ 28 Vdc, 2140 MHz, 45 Watts CW Output Power

### Features

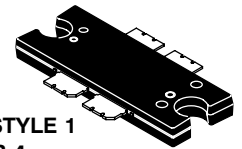
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 32  $V_{DD}$  Operation
- Integrated ESD Protection
- 200°C Capable Plastic Package
- N Suffix Indicates Lead-Free Terminations. RoHS Compliant.
- In Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.

**MRF5S21045NR1**  
**MRF5S21045NBR1**

**2110-2170 MHz, 10 W AVG., 28 V**  
**2 x W-CDMA**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**



**CASE 1486-03, STYLE 1**  
**TO-270 WB-4**  
**PLASTIC**  
**MRF5S21045NR1**



**CASE 1484-04, STYLE 1**  
**TO-272 WB-4**  
**PLASTIC**  
**MRF5S21045NBR1**

**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5, +68	Vdc
Gate-Source Voltage	$V_{GS}$	-0.5, +15	Vdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	$P_D$	130 0.74	W W/°C
Storage Temperature Range	$T_{stg}$	-65 to +150	°C
Operating Junction Temperature	$T_J$	200	°C

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (1,2)	Unit
Thermal Resistance, Junction to Case Case Temperature 80°C, 45 W CW Case Temperature 79°C, 10 W CW	$R_{\theta JC}$	1.35 1.48	°C/W

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.

**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)	IV (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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**Off Characteristics**

Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 68\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	10	$\mu\text{Adc}$
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	1	$\mu\text{Adc}$
Gate-Source Leakage Current ( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )	$I_{GSS}$	—	—	1	$\mu\text{Adc}$

**On Characteristics**

Gate Threshold Voltage ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 120\ \mu\text{Adc}$ )	$V_{GS(th)}$	2	—	3.5	Vdc
Gate Quiescent Voltage ( $V_{DS} = 28\text{ Vdc}$ , $I_D = 500\text{ mAdc}$ )	$V_{GS(Q)}$	2	3.8	5	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 1.2\text{ Adc}$ )	$V_{DS(on)}$	0.2	—	0.35	Vdc
Forward Transconductance ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 1.2\text{ Adc}$ )	$g_{fs}$	—	3.2	—	S

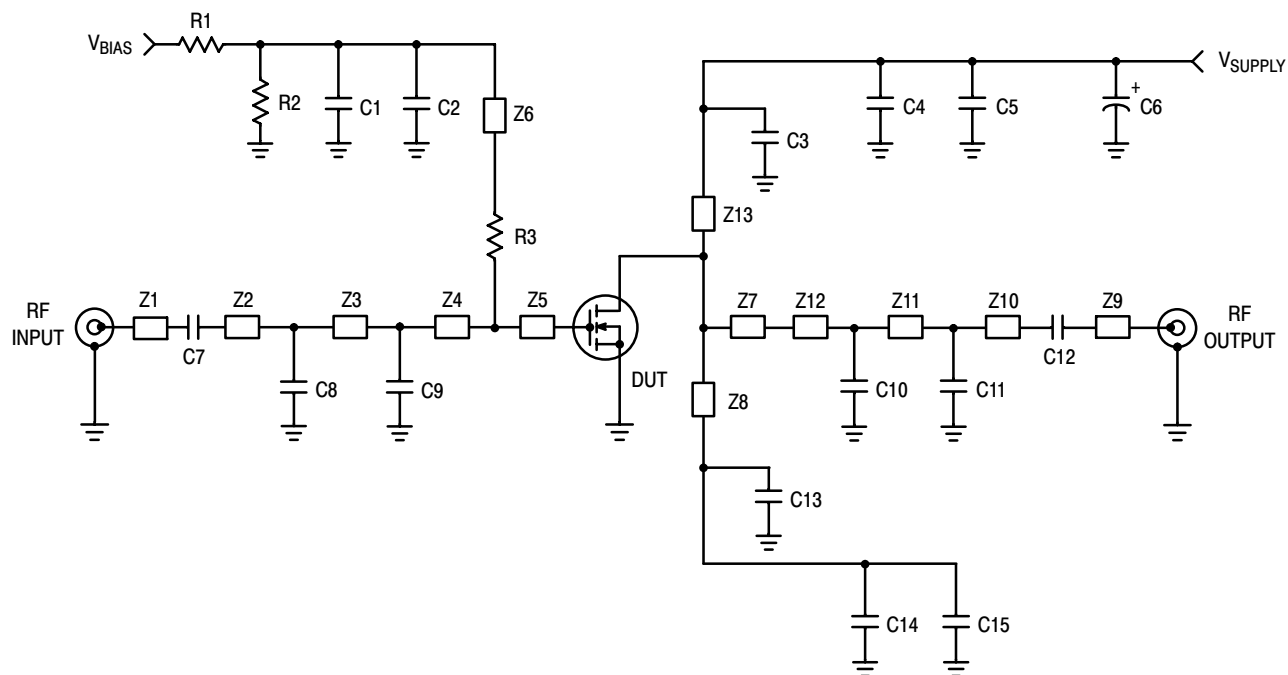
**Dynamic Characteristics** <sup>(1)</sup>

Reverse Transfer Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{rss}$	—	0.9	—	pF
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**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 500\text{ mA}$ ,  $P_{out} = 10\text{ W Avg.}$ ,  $f_1 = 2112.5\text{ MHz}$ ,  $f_2 = 2122.5\text{ MHz}$ , 2-carrier W-CDMA, 3.84 MHz Channel Bandwidth Carriers. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5\text{ MHz}$  Offset. IM3 measured in 3.84 MHz Bandwidth @  $\pm 10\text{ MHz}$  Offset. PAR = 8.5 dB @ 0.01% Probability on CCDF.

Power Gain	$G_{ps}$	13.5	14.5	16.5	dB
Drain Efficiency	$\eta_D$	24	25.5	—	%
Intermodulation Distortion	IM3	—	-37	-35	dBc
Adjacent Channel Power Ratio	ACPR	—	-39	-37	dBc
Input Return Loss	IRL	—	-12	-9	dB

1. Part is internally matched both on input and output.



Z1, Z9	0.250" x 0.080" Microstrip	Z7	0.500" x 1.000" Microstrip
Z2	0.987" x 0.080" Microstrip	Z8, Z13	0.270" x 0.080" Microstrip
Z3	0.157" x 0.080" Microstrip	Z10	0.789" x 0.080" Microstrip
Z4	0.375" x 0.080" Microstrip	Z11	0.527" x 0.080" Microstrip
Z5	0.480" x 1.000" Microstrip	Z12	0.179" x 0.080" Microstrip
Z6	0.510" x 0.080" Microstrip	PCB	Taconic TLX8-0300, 0.030", $\epsilon_r = 2.55$

Figure 1. MRF5S21045NR1(NBR1) Test Circuit Schematic

Table 6. MRF5S21045NR1(NBR1) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1	220 nF Chip Capacitor (1812)	1812Y224KAT	AVX
C2, C3, C7, C12, C13	6.8 pF 100B Chip Capacitors	ATC100B6R8CT500XT	ATC
C4, C5, C14, C15	6.8 $\mu$ F Chip Capacitors (1812)	C4532X5R1H685MT	TDK
C6	220 $\mu$ F, 63 V Electrolytic Capacitor, Radial	2222-136-68221	Vishay
C8, C10	1 pF 100B Chip Capacitors	ATC100B1R0BT500XT	ATC
C9	1.5 pF 100B Chip Capacitor	ATC100B1R5BT500XT	ATC
C11	0.5 pF 100B Chip Capacitor	ATC100B0R5BT500XT	ATC
R1, R2	10 k $\Omega$ , 1/4 W Chip Resistors	CRCW12061002FKEA	Vishay
R3	10 $\Omega$ , 1/4 W Chip Resistor	CRCW120610R0FKEA	Vishay

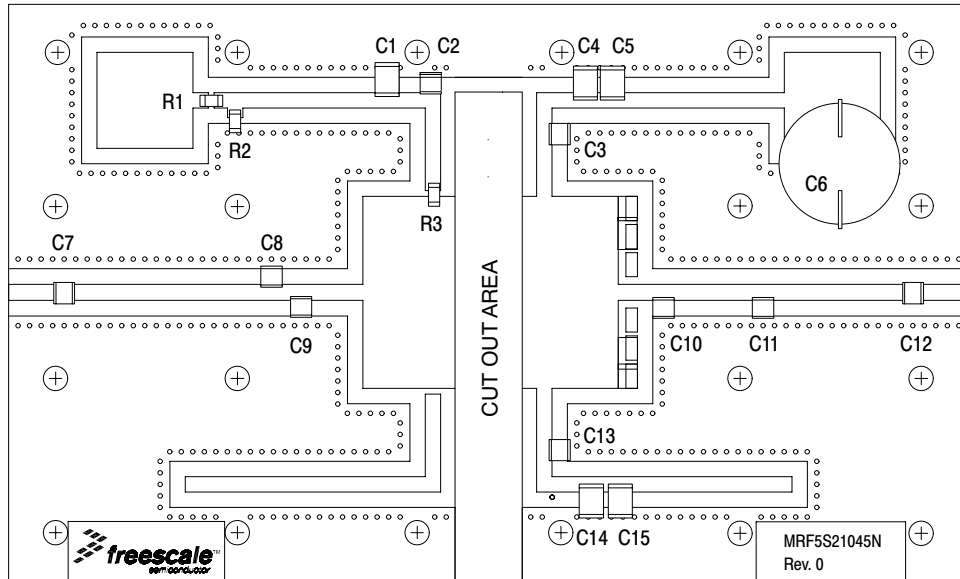
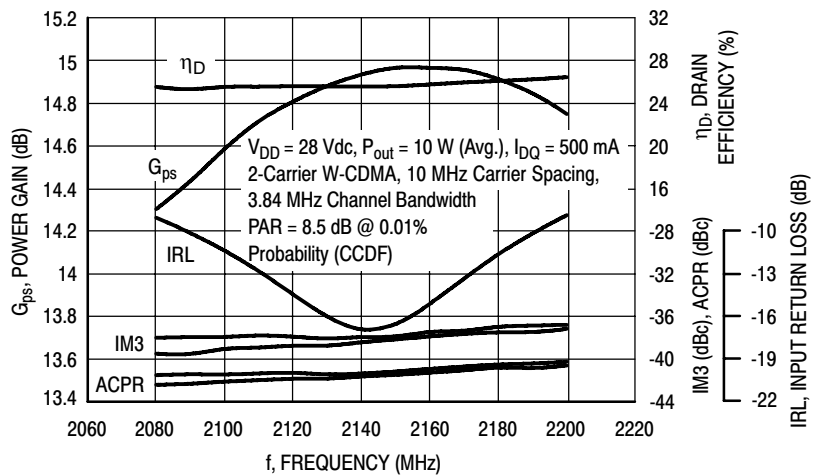
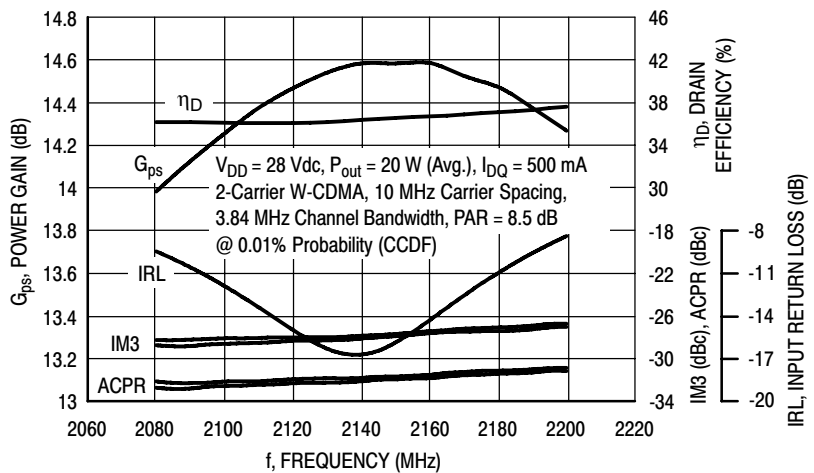


Figure 2. MRF5S21045NR1(NBR1) Test Circuit Component Layout

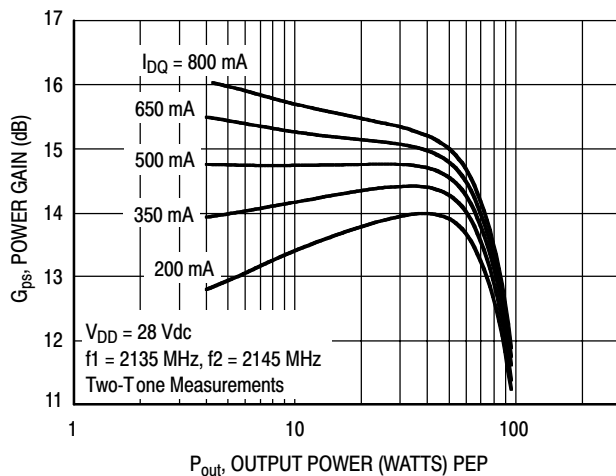
## TYPICAL CHARACTERISTICS



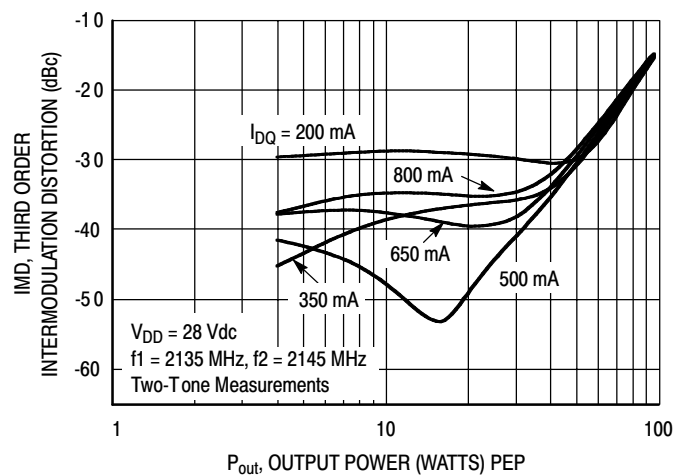
**Figure 3. 2-Carrier W-CDMA Broadband Performance @  $P_{out} = 10$  Watts**



**Figure 4. 2-Carrier W-CDMA Broadband Performance @  $P_{out} = 20$  Watts**

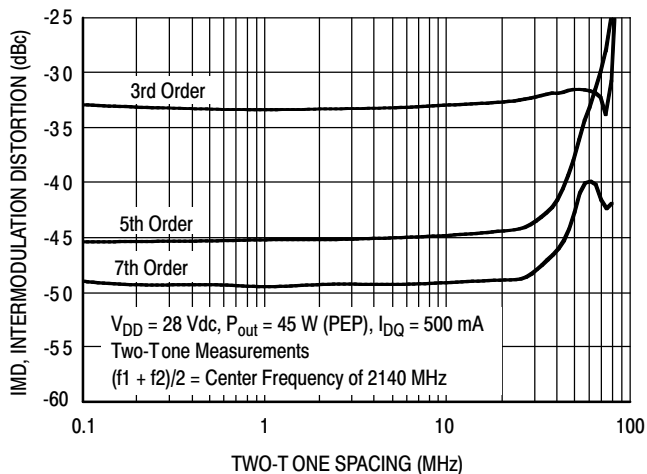


**Figure 5. Two-Tone Power Gain versus Output Power**

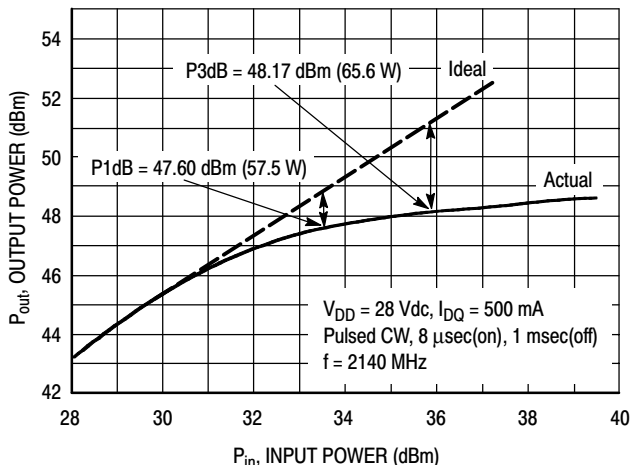


**Figure 6. Third Order Intermodulation Distortion versus Output Power**

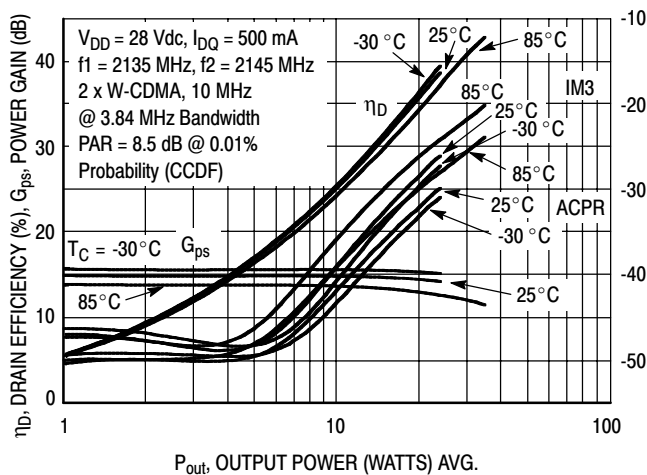
## TYPICAL CHARACTERISTICS



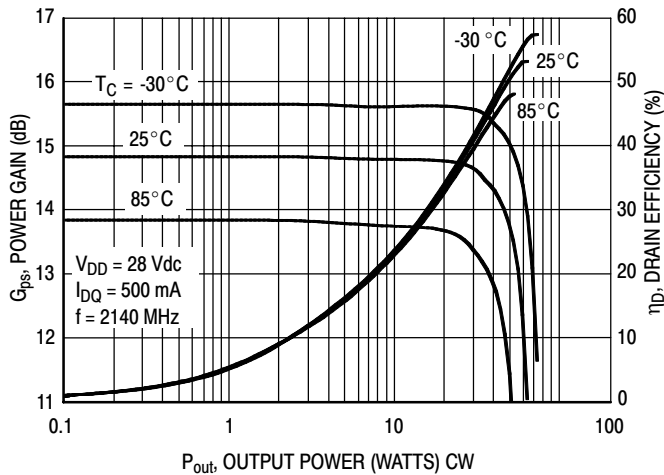
**Figure 7. Intermodulation Distortion Products versus Tone Spacing**



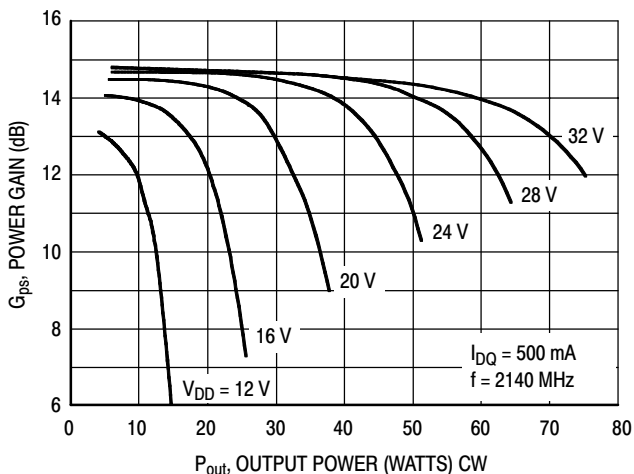
**Figure 8. Pulse CW Output Power versus Input Power**



**Figure 9. 2-Carrier W-CDMA ACPR, IM3, Power Gain and Drain Efficiency versus Output Power**

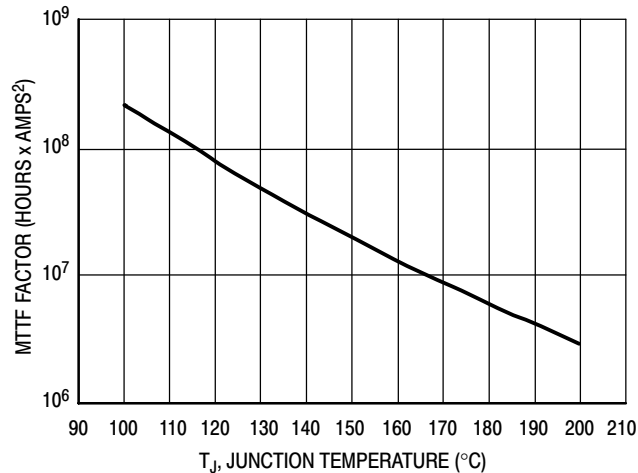


**Figure 10. Power Gain and Drain Efficiency versus CW Output Power**



**Figure 11. Power Gain versus Output Power**

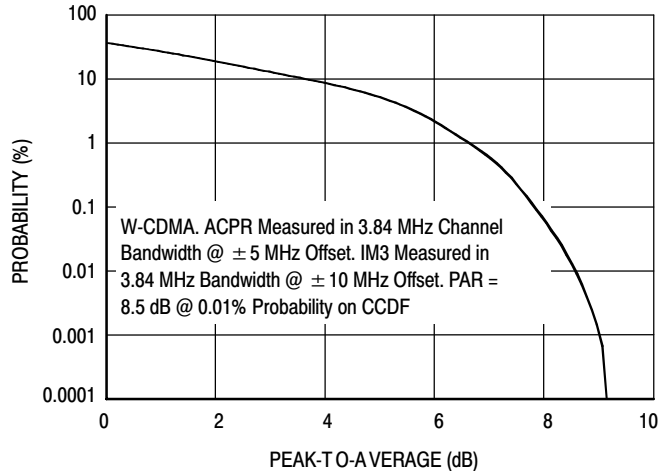
## TYPICAL CHARACTERISTICS



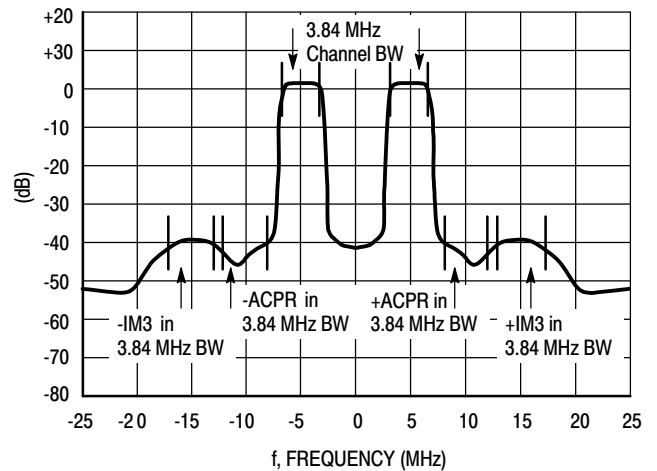
This above graph displays calculated MTTF in hours x ampere<sup>2</sup> drain current. Life tests at elevated temperatures have correlated to better than  $\pm 10\%$  of the theoretical prediction for metal failure. Divide MTTF factor by  $I_D^2$  for MTTF in a particular application.

**Figure 12. MTTF Factor versus Junction Temperature**

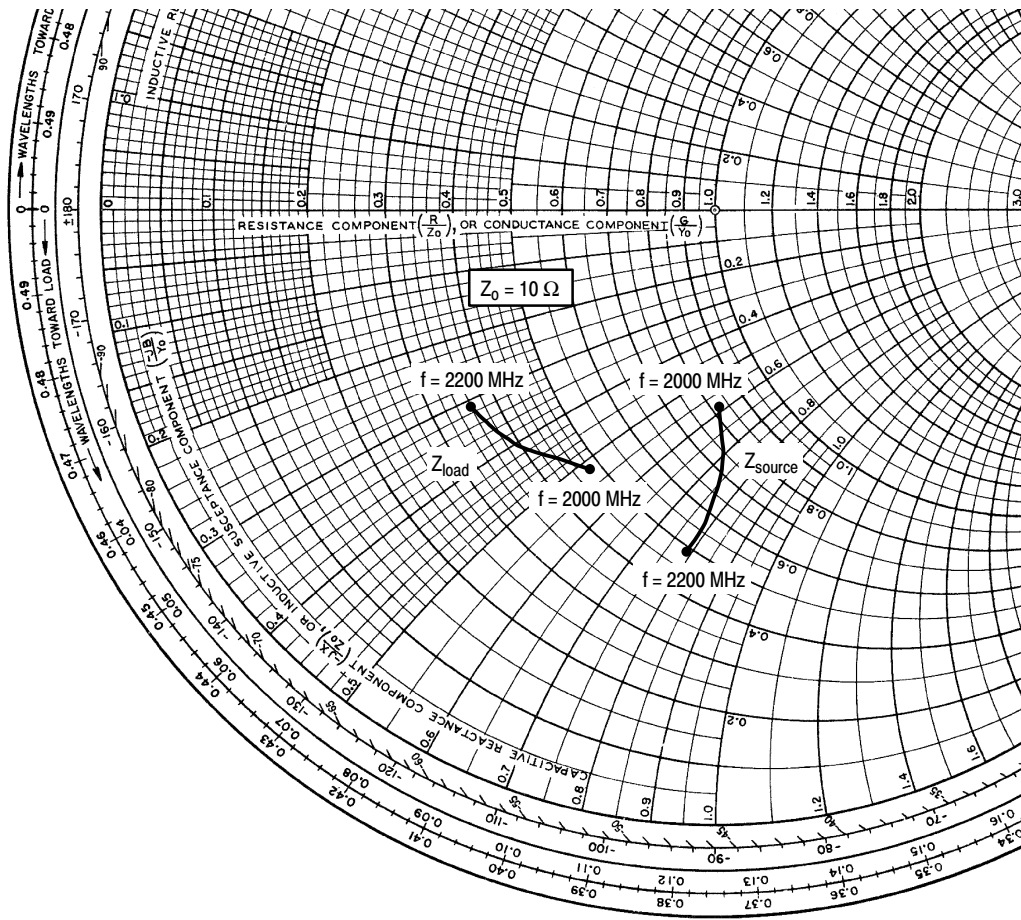
## W-CDMA TEST SIGNAL



**Figure 13. CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 67% Clipping, Single-Carrier Test Signal**



**Figure 14. 2-Carrier W-CDMA Spectrum**



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 500 \text{ mA}$ ,  $P_{out} = 10 \text{ W Avg.}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
2000	$8.15 - j5.91$	$4.78 - j5.19$
2110	$7.07 - j7.32$	$4.04 - j4.14$
2140	$6.28 - j7.71$	$3.81 - j3.69$
2170	$5.61 - j7.85$	$3.69 - j3.39$
2200	$4.92 - j7.85$	$3.57 - j3.11$

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

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

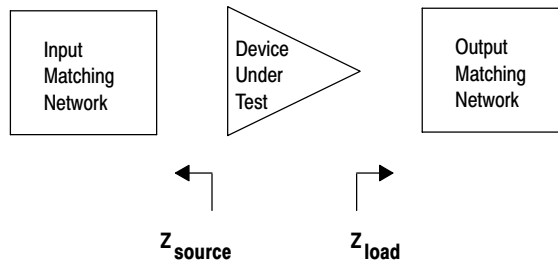
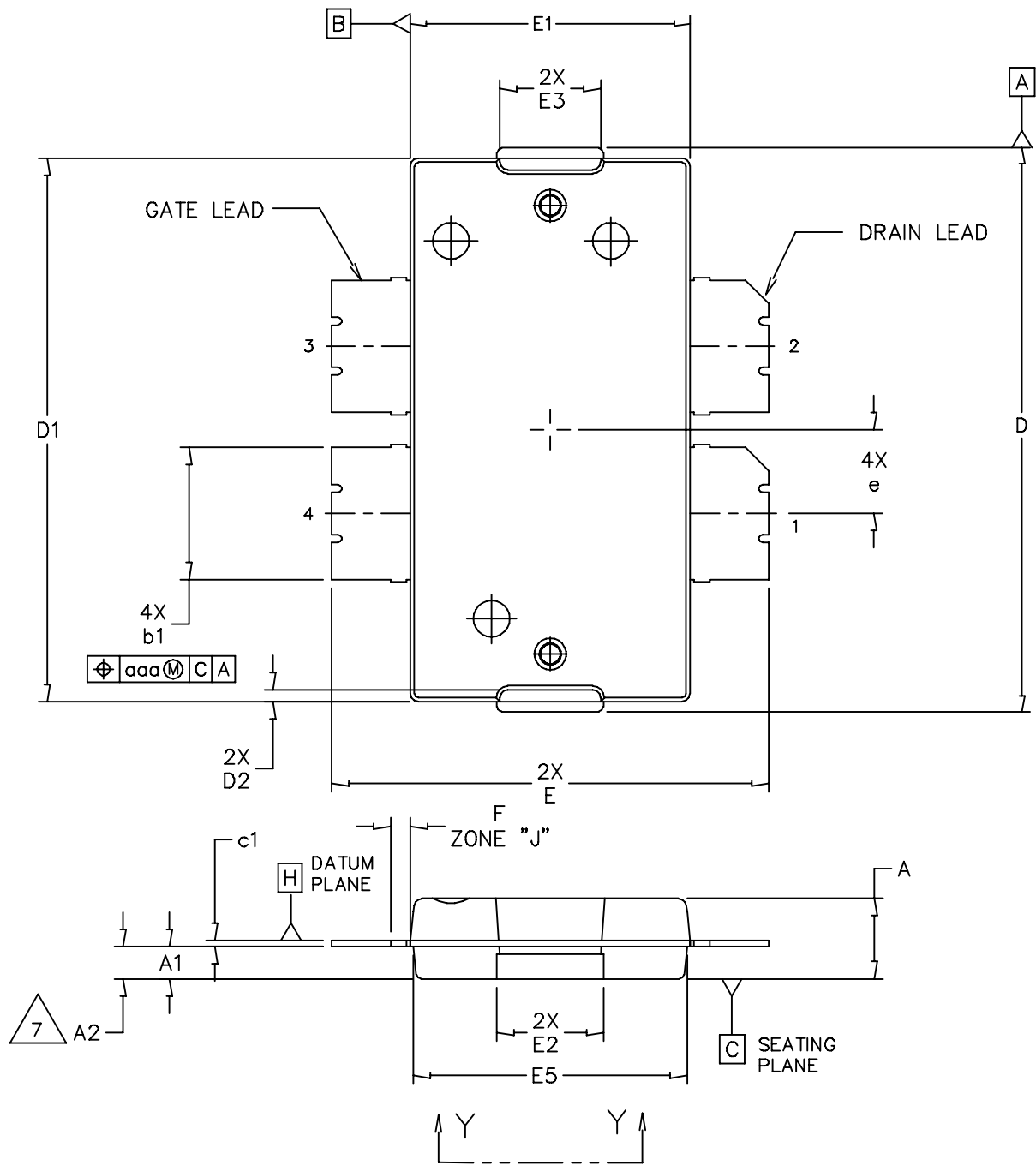


Figure 15. Series Equivalent Source and Load Impedance

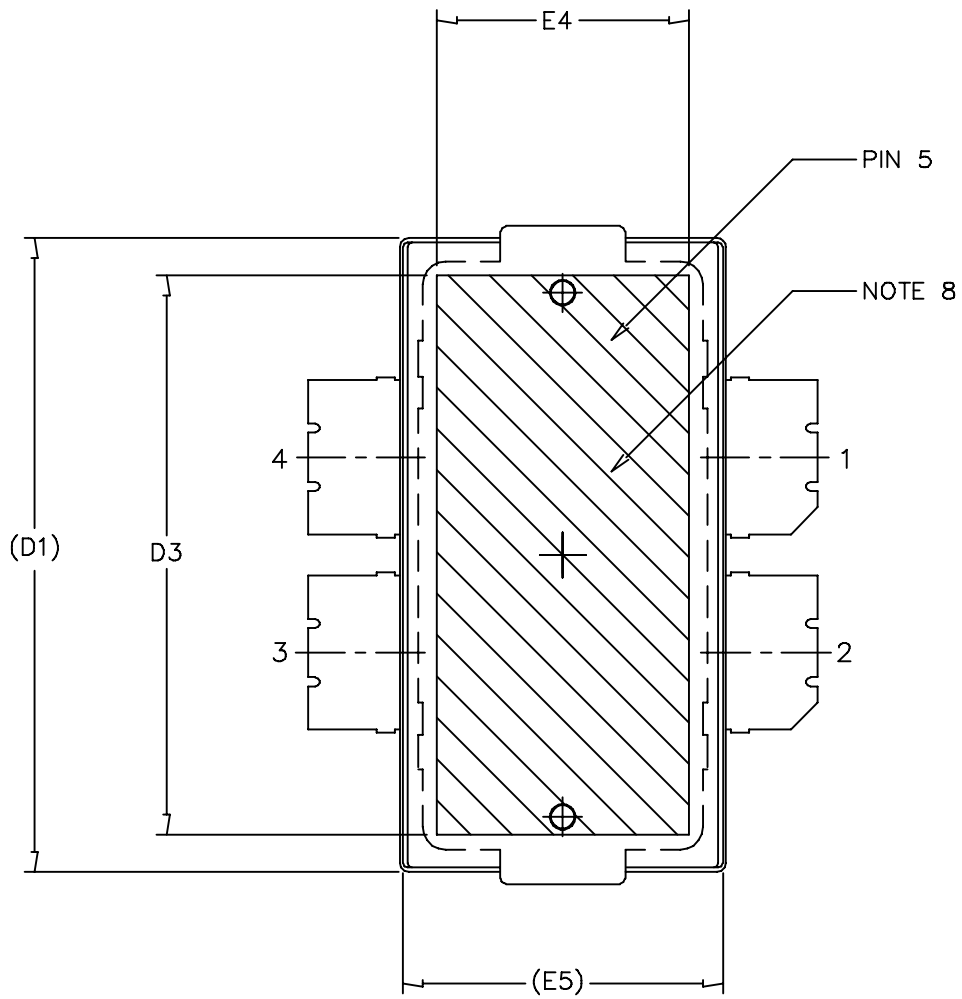


### PACKAGE DIMENSIONS



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**MRF5S21045NR1 MRF5S21045NBR1**



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	STANDARD: NON-JEDEC		

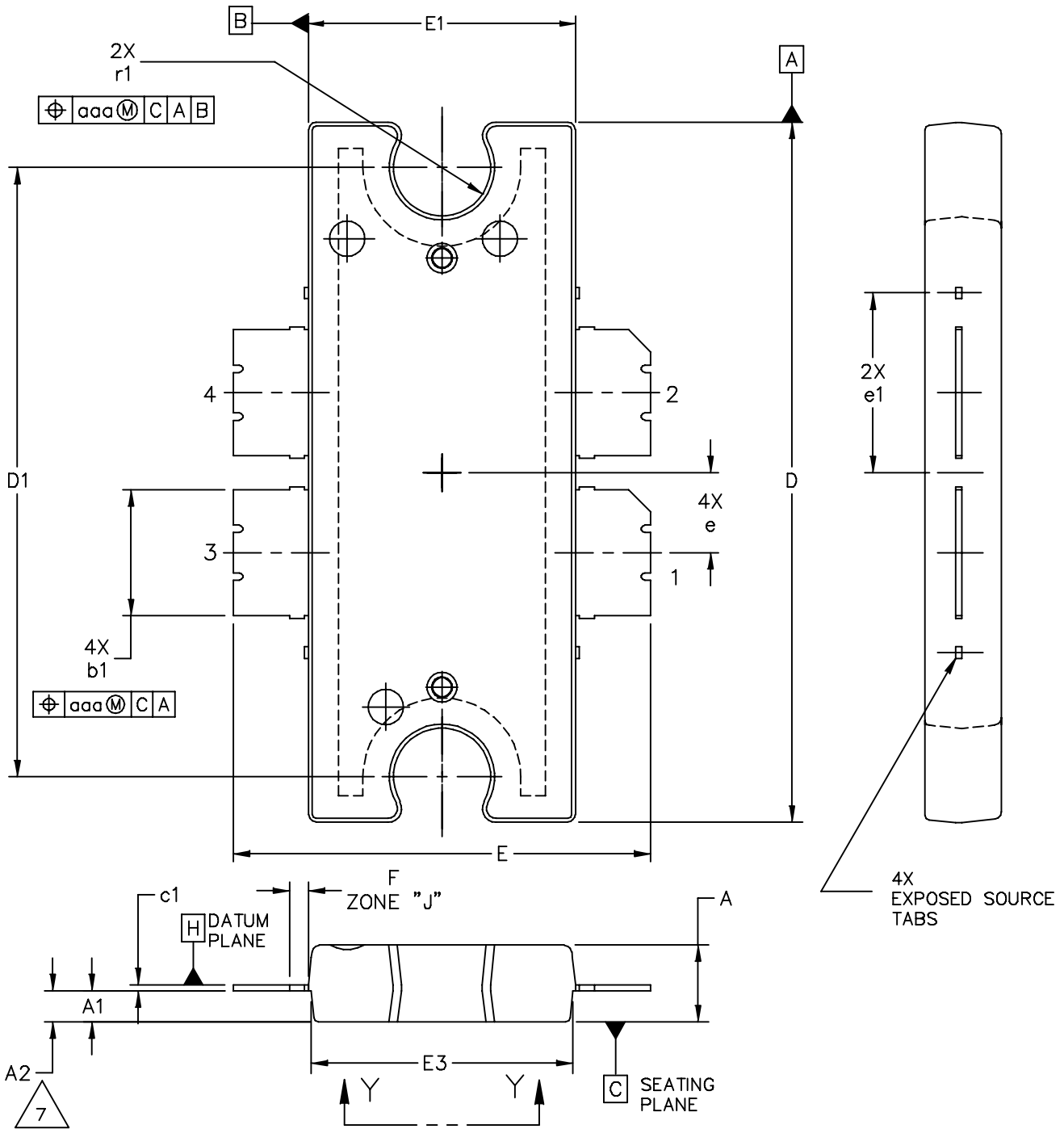
NOTES:

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 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.

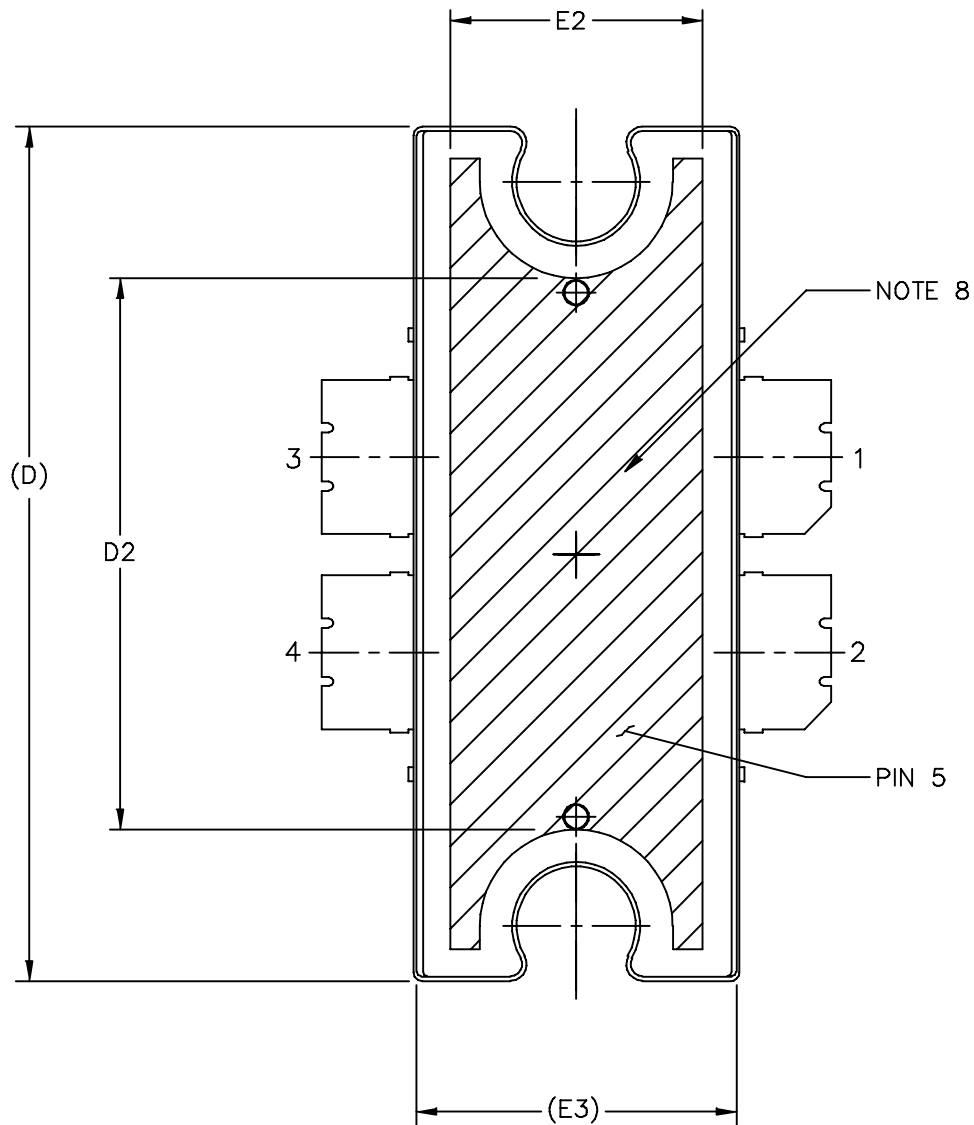
STYLE 1:

PIN 1 - DRAIN      PIN 2 - DRAIN  
 PIN 3 - GATE      PIN 4 - GATE  
 PIN 5 - SOURCE

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	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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MRF5S21045NR1 MRF5S21045NBR1

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. DATUM A AND B TO BE DETERMINED AT DATUM PLANE H.
7. DIMENSION A2 APPLIES WITHIN ZONE "J" ONLY.
8. HATCHING REPRESENTS EXPOSED AREA OF THE HEAT SLUG. HATCHED AREA SHOWN IS ON THE SAME PLANE.

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	b1	.164	.170	4.17	4.32
A1	.039	.043	0.99	1.09	c1	.007	.011	.18	.28
A2	.040	.042	1.02	1.07	r1	.063	.068	1.60	1.73
D	.928	.932	23.57	23.67	e	.106 BSC		2.69 BSC	
D1	.810 BSC		20.57 BSC		e1	.239 INFO ONLY		6.07 INFO ONLY	
D2	.600	---	15.24	---	aaa	.004		.10	
E	.551	.559	14	14.2					
E1	.353	.357	8.97	9.07					
E2	.270	---	6.86	---					
E3	.346	.350	8.79	8.89					
F	.025 BSC		0.64 BSC						

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	STANDARD: NON-JEDEC		

## 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
4	Oct. 2008	<ul style="list-style-type: none"><li>• Modified data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN12779, p. 1, 2</li><li>• Updated Part Numbers in Table 6, Component Designations and Values, to latest RoHS compliant part numbers, p. 3</li><li>• Replaced Case Outline 1486-03, Issue C, with 1486-03, Issue D, p. 9-11. Added pin numbers 1 through 4 on Sheet 1.</li><li>• Replaced Case Outline 1484-04, Issue D, with 1484-04, Issue E, p. 12-14. Added pin numbers 1 through 4 on Sheet 1, replacing Gate and Drain notations with Pin 1 and Pin 2 designations.</li><li>• Added Product Documentation and Revision History, p. 15</li></ul>
4.1	Dec. 2009	<ul style="list-style-type: none"><li>• Corrected data sheet to reflect RF Test Reduction frequency described in Product and Process Change Notification number, PCN12779, p. 2</li></ul>

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