Document Number: MRF6S9045
Rev. 1, 6/2005

RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

Designed for broadband commercial and industrial applications with frequencies up to 1000 MHz. The high gain and broadband performance of these devices make them 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} = 350 mA, P_{out} = 10 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 — 22.7 dB
  - Drain Efficiency — 32%
  - ACPR @ 750 kHz Offset — -47 dBc @ 30 kHz Bandwidth

GSM EDGE Application

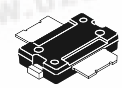
- Typical GSM EDGE Performance: V_{DD} = 28 Volts, I_{DQ} = 350 mA, P_{out} = 16 Watts Avg., Full Frequency Band (921-960 MHz)
  - Power Gain — 20 dB
  - Drain Efficiency — 46%
  - Spectral Regrowth @ 400 kHz Offset = -62 dBc
  - Spectral Regrowth @ 600 kHz Offset = -78 dBc
  - EVM — 1.5% rms

GSM Application

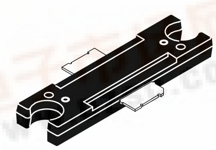
- Typical GSM Performance: V_{DD} = 28 Volts, I_{DQ} = 350 mA, P_{out} = 45 Watts, Full Frequency Band (921-960 MHz)
  - Power Gain — 20 dB
  - Drain Efficiency — 68%
- Capable of Handling 5:1 VSWR, @ 28 Vdc, 880 MHz, 45 Watts CW Output Power
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Integrated ESD Protection
- N Suffix Indicates Lead-Free Terminations
- 200°C Capable Plastic Package
- TO-270-2 in Tape and Reel. R1 Suffix = 500 Units per 24 mm, 13 inch Reel.
- TO-272-2 in Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.

MRF6S9045NR1
MRF6S9045NBR1
MRF6S9045MR1
MRF6S9045MBR1

880 MHz, 10 W AVG., 28 V
SINGLE N-CDMA
LATERAL N-CHANNEL
BROADBAND RF POWER MOSFETs



CASE 1265-08, STYLE 1
TO-270-2
PLASTIC
MRF6S9045NR1(MR1)



CASE 1337-03, STYLE 1
TO-272-2
PLASTIC
MRF6S9045NBR1(MBR1)

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	-0.5, +68	Vdc
Gate-Source Voltage	V_{GS}	-0.5, +12	Vdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	175 1.0	W W/°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Operating Junction Temperature	T_J	200	°C

NOTE - **CAUTION** - MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

Table 2. Thermal Characteristics

Characteristic	Symbol	Value [1,2]	Unit
Thermal Resistance, Junction to Case Case Temperature 81°C, 45 W CW Case Temperature 79°C, 10 W CW	$R_{\theta JC}$	 1.0 1.1	°C/W

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)	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_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Off Characteristics					
Zero Gate Voltage Drain Leakage Current (V_{DS} = 68 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 = 200 μA)	$V_{GS(th)}$	1	2	3	Vdc
Gate Quiescent Voltage (V_{DS} = 28 Vdc, I_D = 350 mAdc)	$V_{GS(Q)}$	2	2.9	4	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 1.0 Adc)	$V_{DS(on)}$	—	0.22	0.3	Vdc
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 3 Adc)	g_{fs}	—	4	—	S
Dynamic Characteristics					
Input Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{iss}	—	77	—	pF
Output Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	27	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	0.78	—	pF

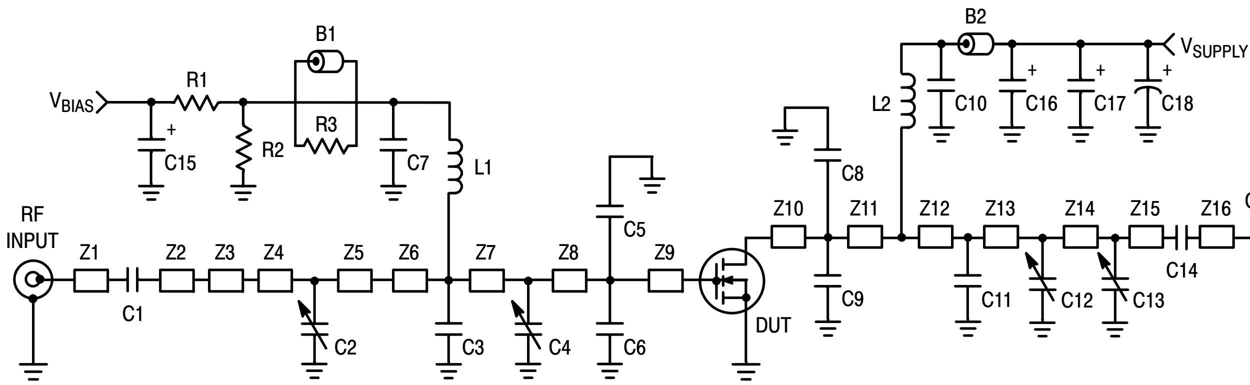
Functional Tests (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 350 mA, P_{out} = 10 W Avg., f = 880 MHz, Single-Carrier N-CDMA, 1.2288 MHz Channel Bandwidth Carrier. ACPR measured in 30 kHz Channel Bandwidth @ ±750 kHz Offset. PAR = 9.8 dB @ 0.01% Probability on CCDF

Characteristic	Symbol	Min	Typ	Max	Unit
Power Gain	G_{ps}	21	22.7	25	dB
Drain Efficiency	η_D	30.5	32	—	%
Adjacent Channel Power Ratio	ACPR	—	-47	-45	dBc
Input Return Loss MRF6S9045NR1(MR1) MRF6S9045NBR1(MBR1)	IRL	—	 -20 -20	 -9 -7	dB

1. MTTF calculator available at http://www.freescale.com/rf. Select Tools/Software/Application Software/Calculators to access the 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 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 921-960 MHz, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 350 mA, P_{out} = 16 W Avg., f = 921-960 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 921-960 MHz, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 350 mA, P_{out} = 45 W, f = 921-960 MHz					
Power Gain	G_{ps}	—	20	—	dB
Drain Efficiency	η_D	—	68	—	%
Input Return Loss	IRL	—	-12	—	dB
P_{out} @ 1 dB Compression Point (f = 940 MHz)	P1dB	—	52	—	W



Z1	0.215″ x 0.065″ Microstrip	Z10	0.360″ x 0.270″ Microstrip
Z2	0.221″ x 0.065″ Microstrip	Z11	0.063″ x 0.270″ Microstrip
Z3	0.500″ x 0.100″ Microstrip	Z12	0.360″ x 0.065″ Microstrip
Z4	0.460″ x 0.270″ Microstrip	Z13	0.095″ x 0.065″ Microstrip
Z5	0.040″ x 0.270″ Microstrip	Z14	0.800″ x 0.065″ Microstrip
Z6	0.280″ x 0.270″ x 0.530″ Taper	Z15	0.260″ x 0.065″ Microstrip
Z7	0.087″ x 0.525″ Microstrip	Z16	0.325″ x 0.065″ Microstrip
Z8	0.435″ x 0.525″ Microstrip	PCB	Taconic RF-35 0.030″, ε_r = 3.5
Z9	0.057″ x 0.525″ Microstrip		

Figure 1. MRF6S9045NR1(MR1)/NBR1(MBR1) Test Circuit Schematic

Table 6. MRF6S9045NR1(MR1)/NBR1(MBR1) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
B1	Ferrite Bead	2743019447	Fair Rite
B2	Ferrite Bead	2743021447	Fair Rite
C1, C7, C10, C14	47 pF Chip Capacitors	100B470JP500X	ATC
C2, C4, C12	0.8-8.0 pF Variable Capacitors, Gigatrim	27291SL	Johanson
C3	15 pF Chip Capacitor	100B150JP500X	ATC
C5, C6	12 pF Chip Capacitors	100B120JP500X	ATC
C8, C9	13 pF Chip Capacitors	100B130JP500X	ATC
C11	7.5 pF Chip Capacitor	100B7R5JP500X	ATC
C13	0.6-4.5 pF Variable Capacitor, Gigatrim	27271SL	Johanson
C15, C16, C17	10 μF, 35 V Tantalum Capacitors	T491D106K035AS	Kemet
C18	220 μF, 50 V Electrolytic Capacitor	678D227M025CG3D	Vishay
L1, L2	12.5 nH Inductor	A04T-5	Coilcraft
R1	1 kΩ Chip Resistor	CRCW12061001F100	Vishay Dale
R2	560 kΩ Chip Resistor	CRCW12065603F100	Vishay Dale
R3	12 Ω Chip Resistor	CRC120612R0F100	Vishay Dale

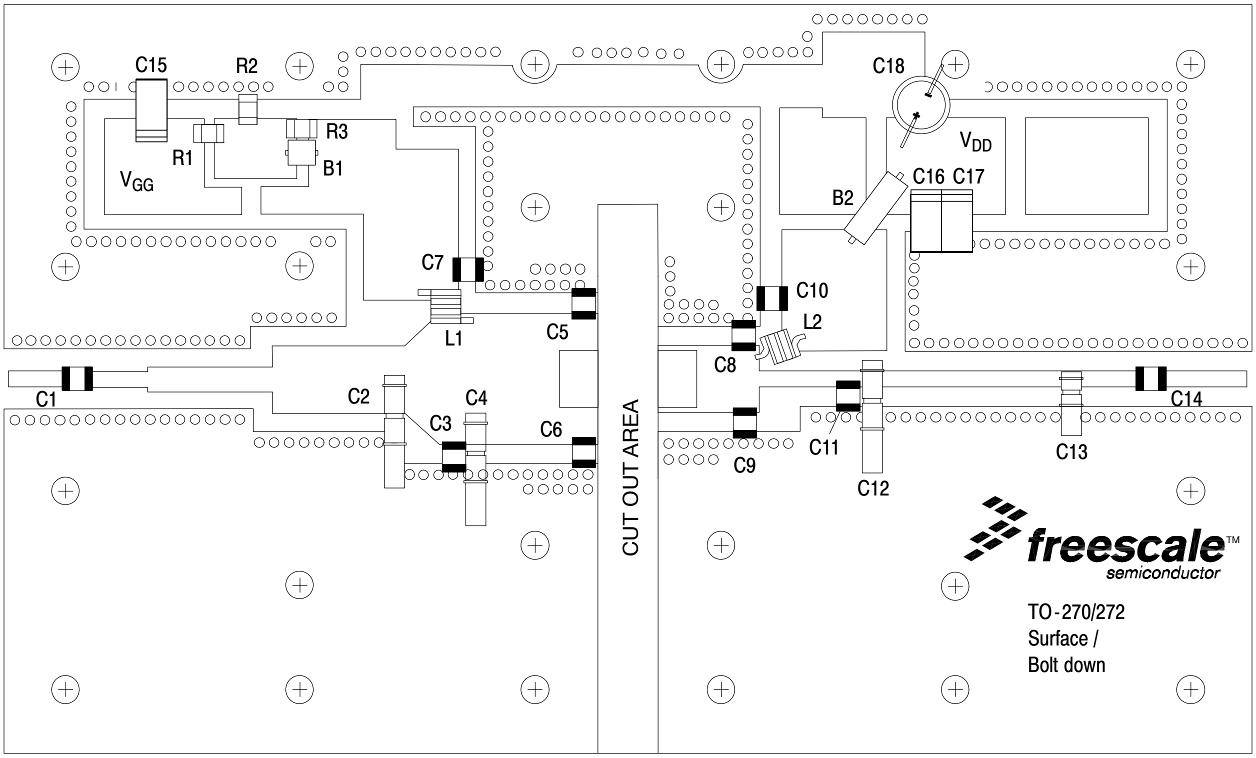


Figure 2. MRF6S9045NR1(MR1)/NBR1(MBR1) Test Circuit Component Layout

TYPICAL CHARACTERISTICS

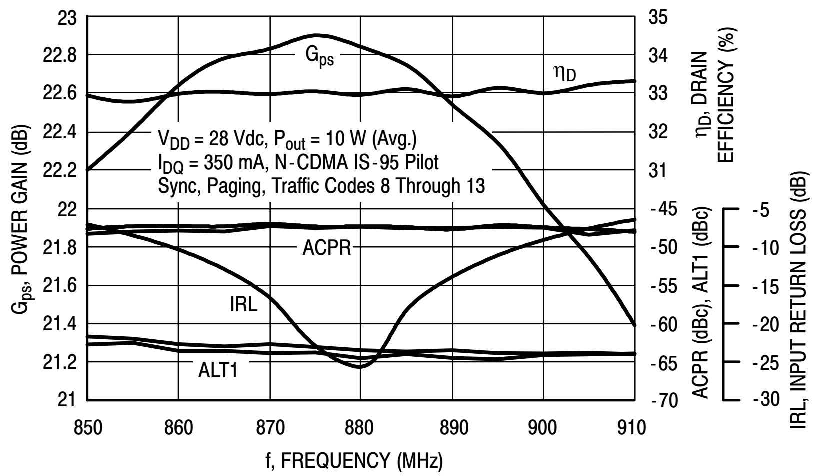


Figure 3. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 10 Watts Avg.

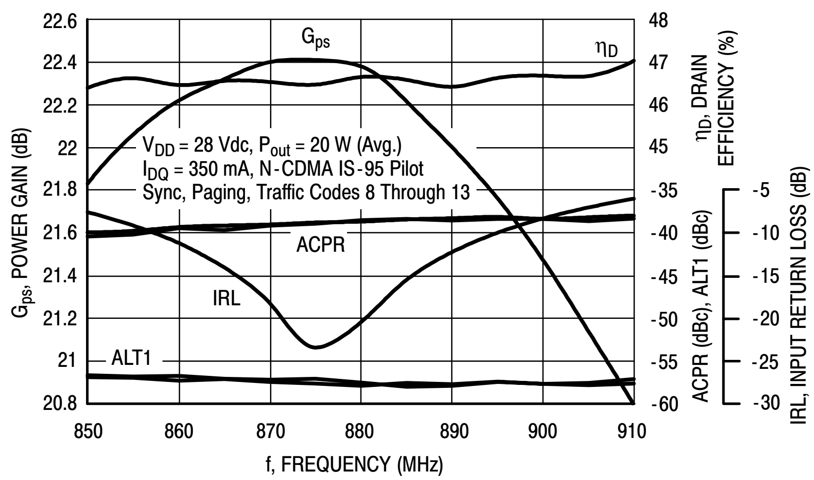


Figure 4. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 20 Watts Avg.

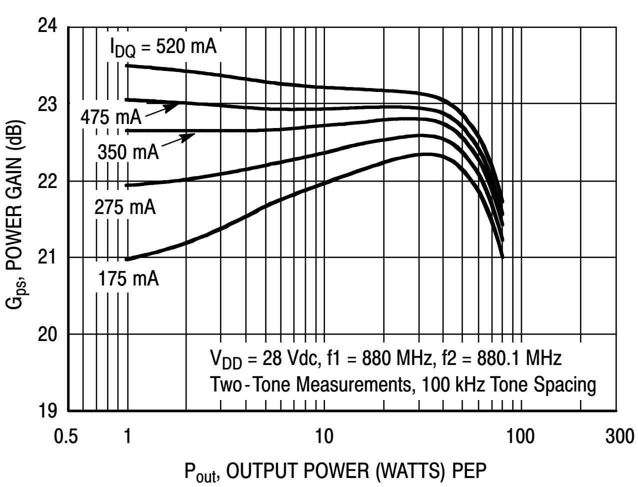


Figure 5. Two-Tone Power Gain versus Output Power

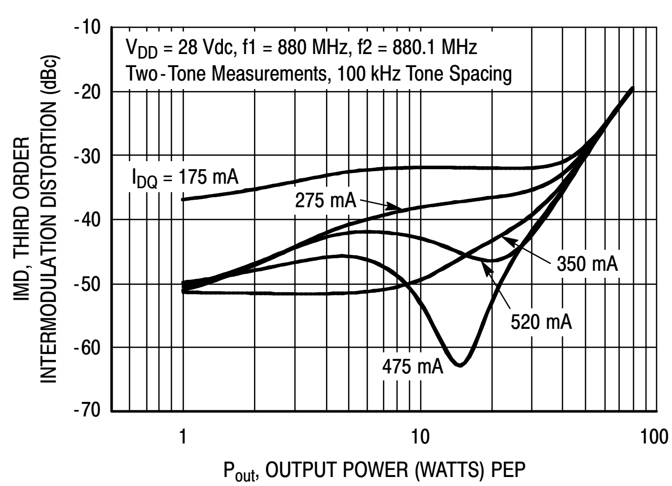


Figure 6. Third Order Intermodulation Distortion versus Output Power

TYPICAL CHARACTERISTICS

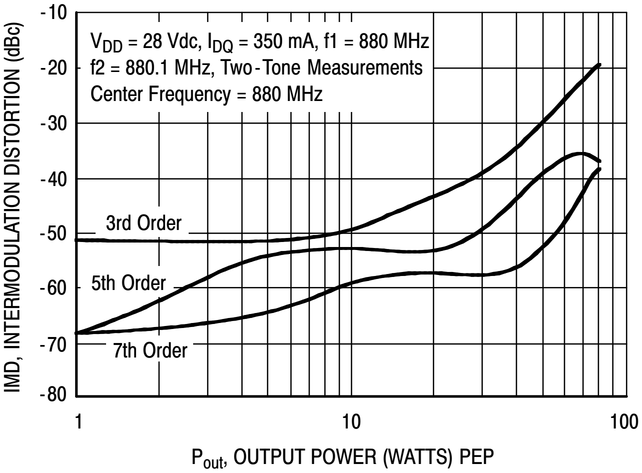


Figure 7. Intermodulation Distortion Products versus Output Power

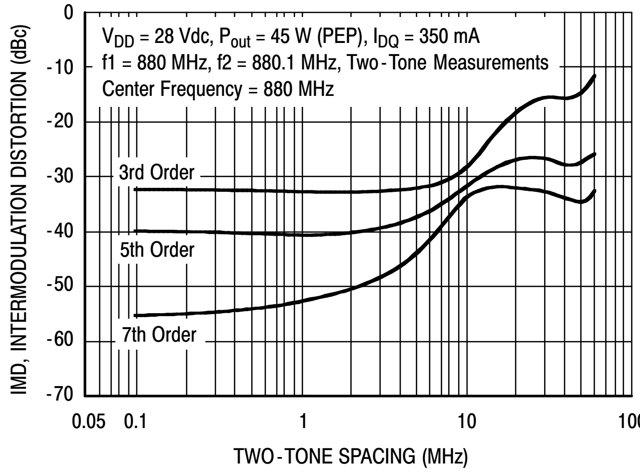


Figure 8. Intermodulation Distortion Products versus Tone Spacing

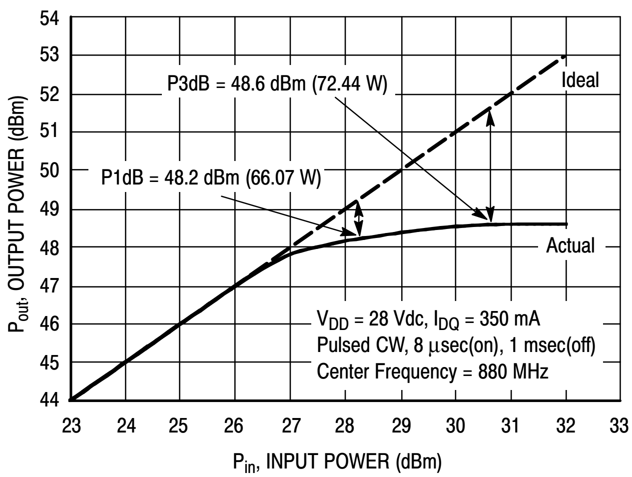


Figure 9. Pulse CW Output Power versus Input Power

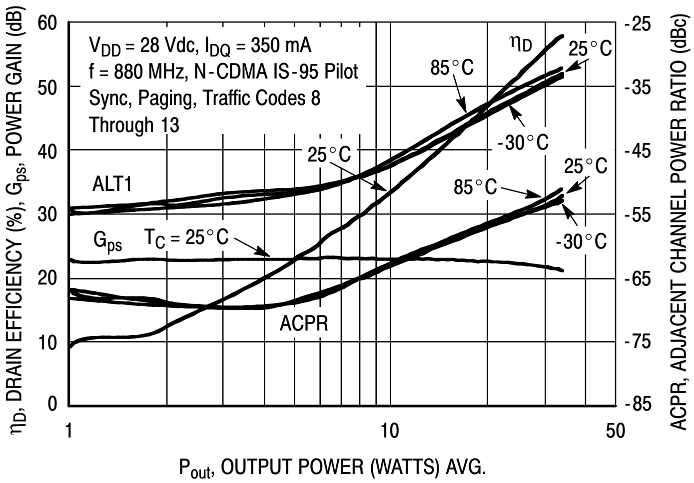


Figure 10. Single-Carrier N-CDMA ACPR, ALT1, Power Gain and Drain Efficiency versus Output Power

TYPICAL CHARACTERISTICS

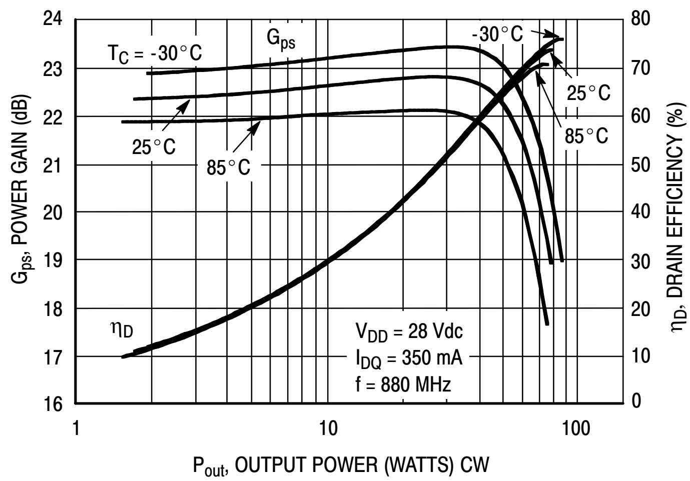


Figure 11. Power Gain and Drain Efficiency versus CW Output Power

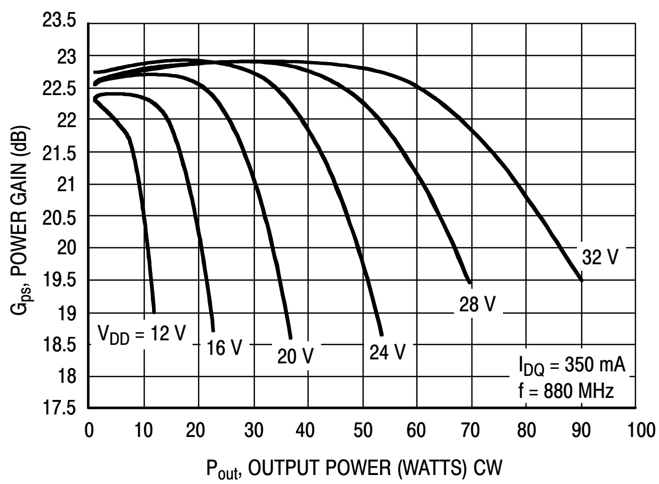
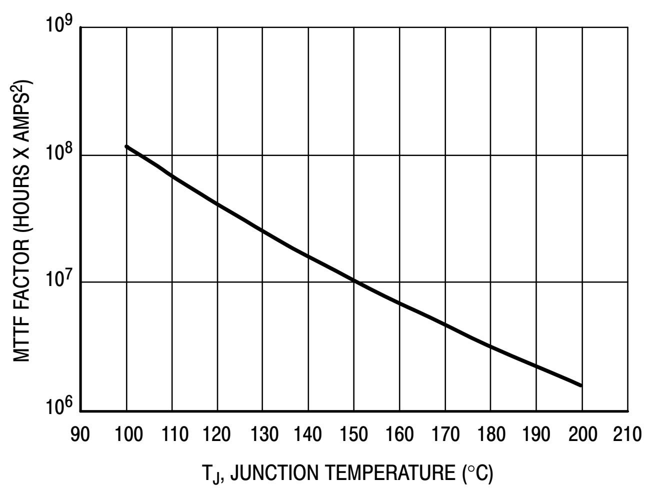


Figure 12. Power Gain versus Output Power



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

Figure 13. MTTF Factor versus Junction Temperature

N-CDMA TEST SIGNAL

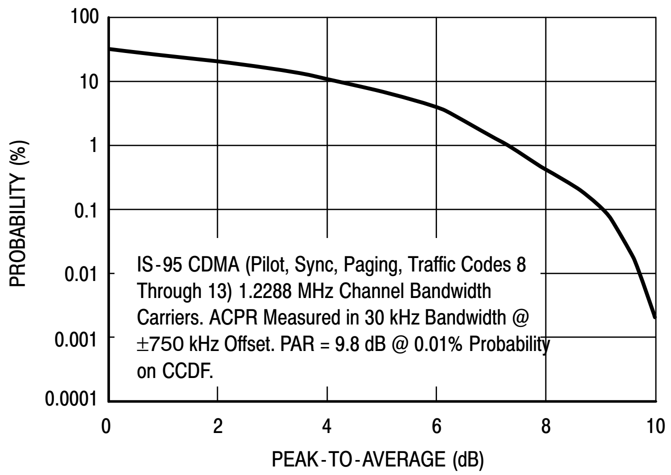


Figure 14. Single-Carrier CCDF N-CDMA

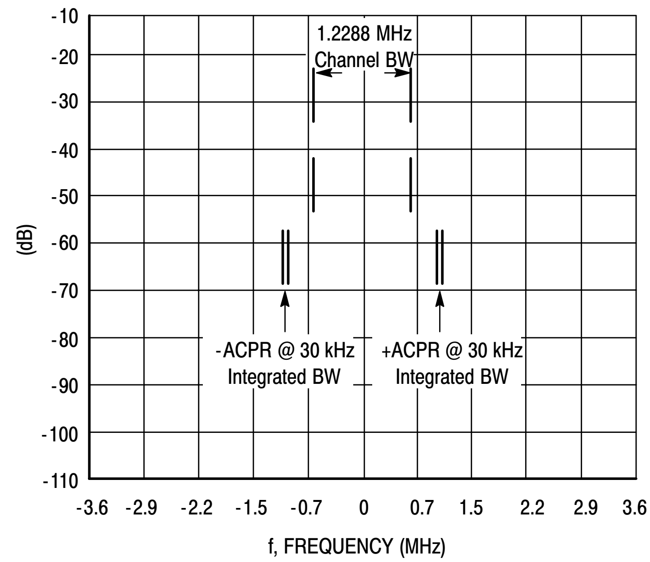
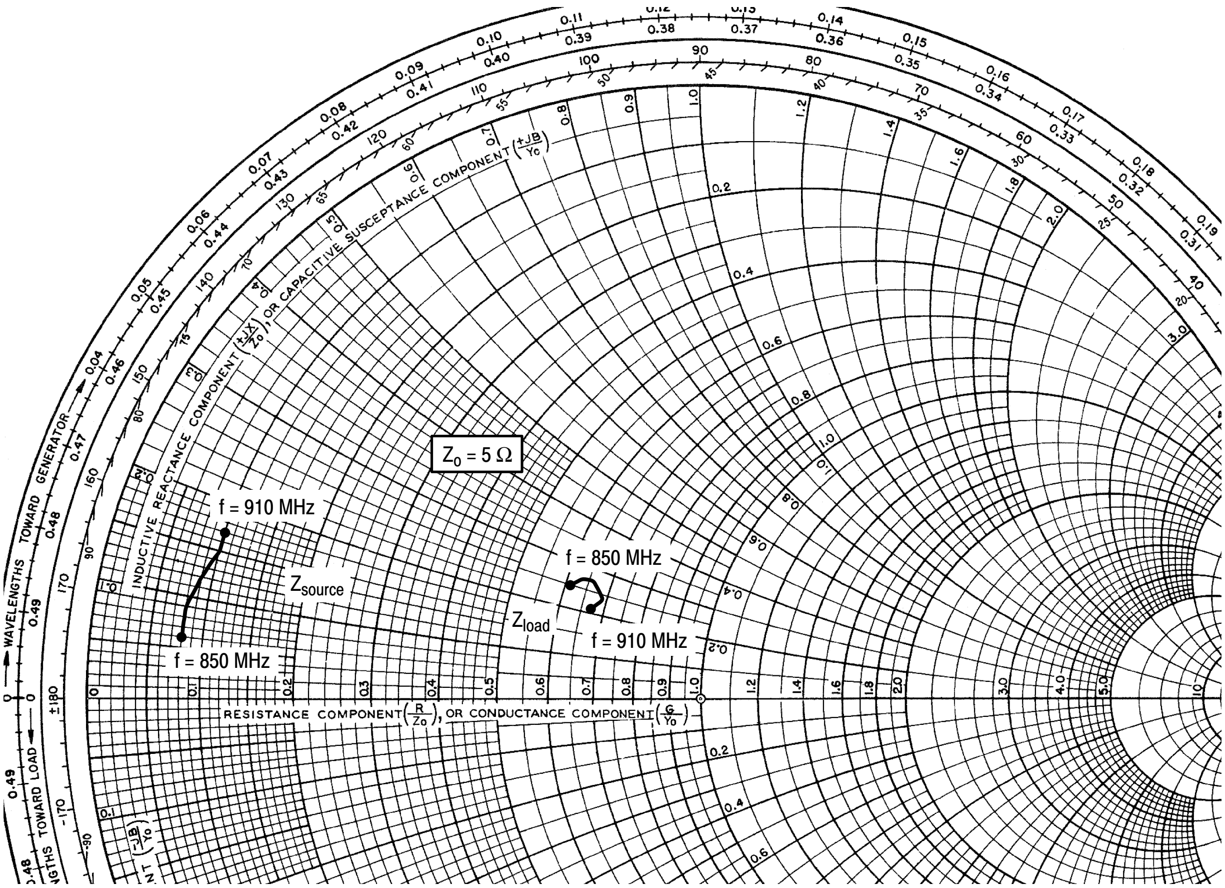


Figure 15. Single-Carrier N-CDMA Spectrum



V_{DD} = 28 Vdc, I_{DQ} = 350 mA, P_{out} = 10 W Avg.

f MHz	Z_{source} Ω	Z_{load} Ω
850	0.42 + j0.30	3.05 + j1.27
865	0.42 + j0.44	3.16 + j1.33
880	0.45 + j0.60	3.31 + j1.33
895	0.48 + j0.74	3.43 + j1.20
910	0.50 + j0.85	3.35 + j1.05

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

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

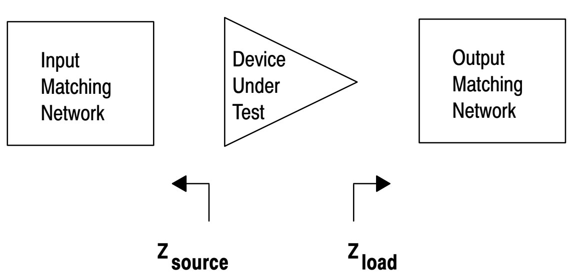


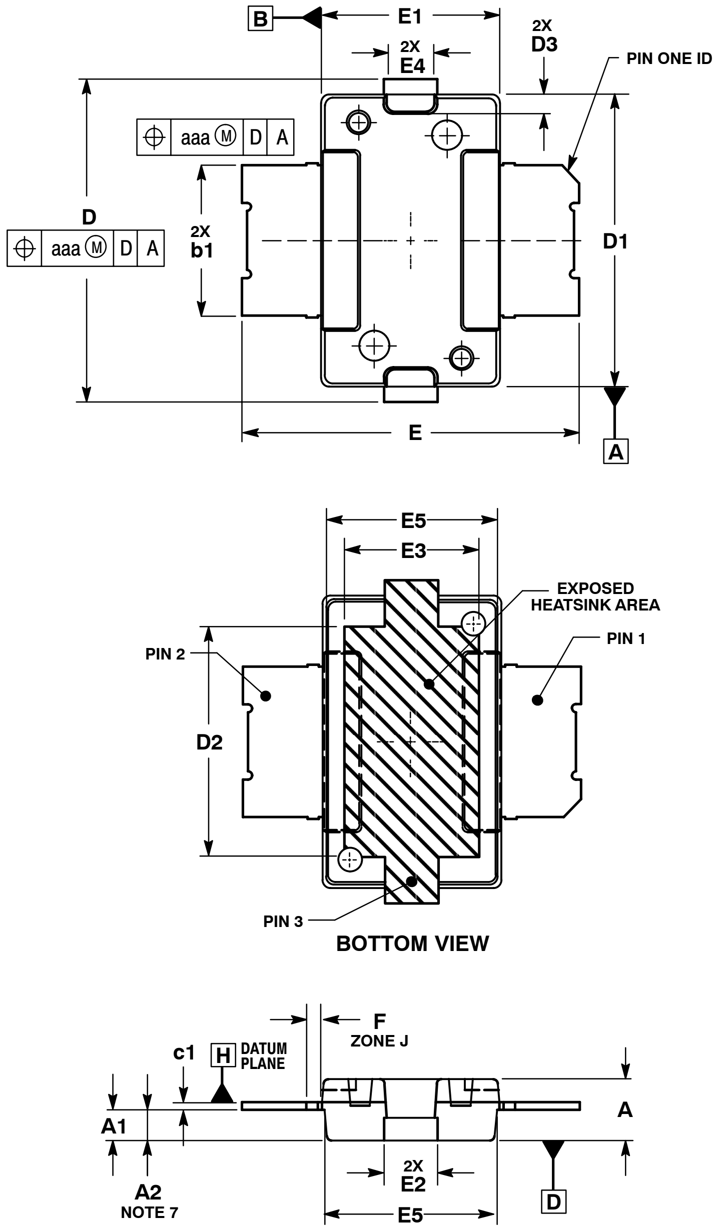
Figure 16. Series Equivalent Source and Load Impedance

NOTES

NOTES

NOTES

PACKAGE DIMENSIONS

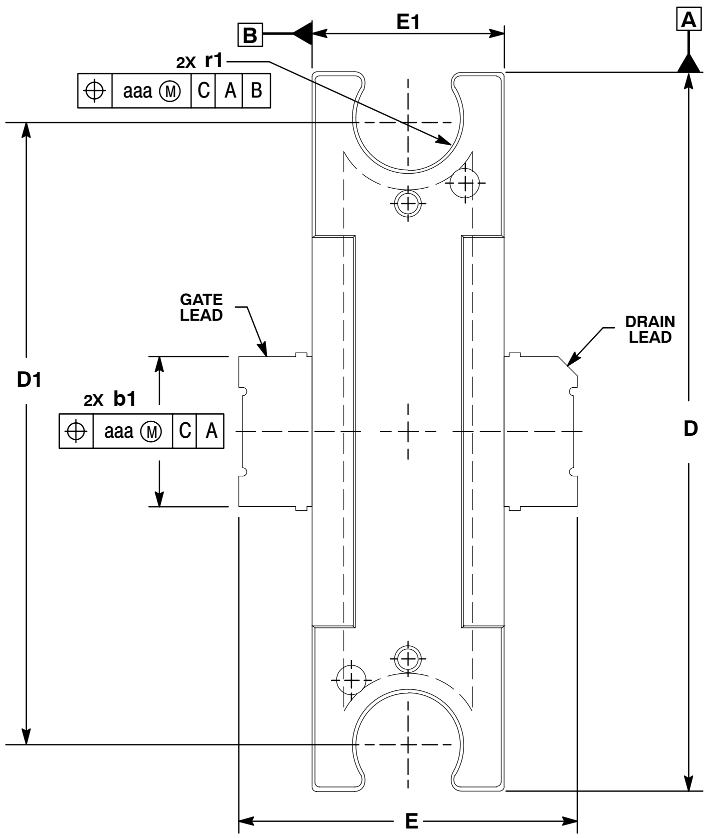


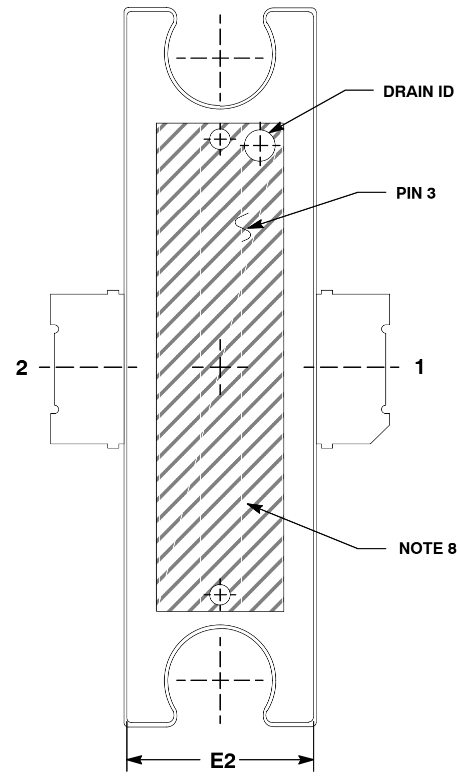
NOTES:
1. CONTROLLING DIMENSION: INCH.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
3. DATUM PLANE -H- IS LOCATED AT TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
4. DIMENSIONS "D1" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. 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. ALLOWABLE PROTRUSION IS .003 PER SIDE. DIMENSIONS "D" AND "E2" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -D-.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	.078	.082	1.98	2.08
A1	.039	.043	0.99	1.09
A2	.040	.042	1.02	1.07
D	.416	.424	10.57	10.77
D1	.378	.382	9.60	9.70
D2	.290	.320	7.37	8.13
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	.180	3.81	4.57
E4	.058	.066	1.47	1.68
E5	.231	.235	5.87	5.97
F	.025 BSC		0.64 BSC	
b1	.193	.199	4.90	5.06
c1	.007	.011	0.18	0.28
aaa	.004		0.10	

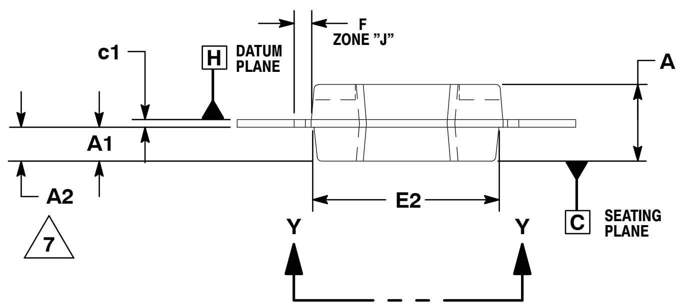
STYLE 1:
PIN 1. DRAIN
2. GATE
3. SOURCE

CASE 1265-08
ISSUE H
TO-270-2
PLASTIC
MRF6S9045NR1(MR1)





VIEW Y-Y



NOTES:
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6. DATUMS -A- AND -B- TO BE DETERMINED AT DATUM PLANE -H-.
7. DIMENSION A2 APPLIES WITHIN ZONE "J" ONLY.
8. CROSSHATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	.100	.104	2.54	2.64
A1	.039	.043	0.99	1.09
A2	.040	.042	1.02	1.07
D	.928	.932	23.57	23.67
D1	.810 BSC		20.57 BSC	
E	.438	.442	11.12	11.23
E1	.248	.252	6.30	6.40
E2	.241	.245	6.12	6.22
F	.025 BSC		0.64 BSC	
b1	.193	.199	4.90	5.05
c1	.007	.011	.18	.28
r1	.063	.068	1.60	1.73
aaa	.004		.10	

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

CASE 1337-03
ISSUE C
TO-272-2
PLASTIC
MRF6S9045NBR1(MBR1)

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