MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

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by MRF9045MR1/D

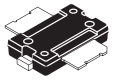
The RF Sub–Micron MOSFET Line
RF Power Field Effect Transistors
N–Channel Enhancement–Mode Lateral MOSFETs

MRF9045MR1
MRF9045MBR1

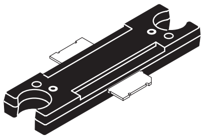
Designed for broadband commercial and industrial applications with frequencies up to 1.0 GHz. The high gain and broadband performance of these devices make them ideal for large–signal, common–source amplifier applications in 28 volt base station equipment.

- Typical Performance at 945 MHz, 28 Volts
  Output Power — 45 Watts PEP
  Power Gain — 19 dB
  Efficiency — 41% (Two Tones)
  IMD — –31 dBc
- Integrated ESD Protection
- Guaranteed Ruggedness @ Load VSWR = 5:1, @ 28 Vdc, 945 MHz, 45 Watts (CW) Output Power
- Excellent Thermal Stability
- Characterized with Series Equivalent Large–Signal Impedance Parameters
- Moisture Sensitivity Level 3
- Dual–Lead Boltdown Plastic Package Can Also Be Used As Surface Mount.
- TO–272 Available in Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.
- TO–270 Available in Tape and Reel. R1 Suffix = 500 Units per 24 mm, 13 inch Reel.

**945 MHz, 45 W, 28 V
LATERAL N–CHANNEL
BROADBAND
RF POWER MOSFETs**



**CASE 1265–07, STYLE 1
(TO–270)
PLASTIC
(MRF9045MR1)**



**CASE 1337–01, STYLE 1
(TO–272 DUAL LEAD)
PLASTIC
(MRF9045MBR1)**

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Gate–Source Voltage	V_{GS}	+15, –0.5	Vdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	177 1.18	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	175	°C

ESD PROTECTION CHARACTERISTICS

Test Conditions	Class
Human Body Model	1 (Minimum)
Machine Model	M2 (Minimum)

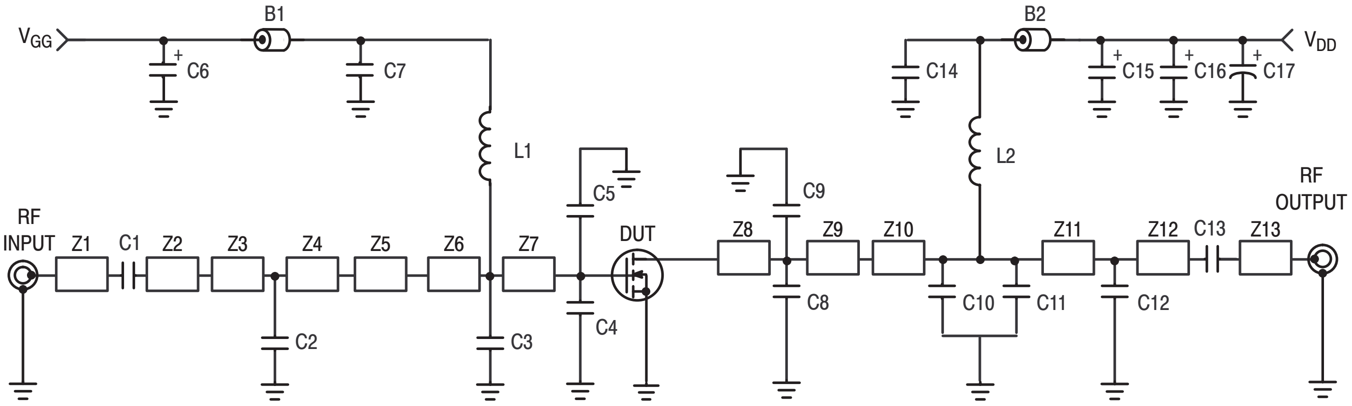
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.85	°C/W

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

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} = 65 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 = 150 μAdc)	$V_{GS(th)}$	2	2.8	4	Vdc
Gate Quiescent Voltage (V_{DS} = 28 Vdc, I_D = 350 mAdc)	$V_{GS(Q)}$	3	3.7	5	Vdc
Drain–Source On–Voltage (V_{GS} = 10 Vdc, I_D = 1 Adc)	$V_{DS(on)}$	—	0.22	0.4	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}	—	70	—	pF
Output Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	38	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	1.7	—	pF
FUNCTIONAL TESTS (In Motorola Test Fixture)					
Two–Tone Common–Source Amplifier Power Gain (V_{DD} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 mA, f1 = 945.0 MHz, f2 = 945.1 MHz)	G_{ps}	17	19	—	dB
Two–Tone Drain Efficiency (V_{DD} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 mA, f1 = 945.0 MHz, f2 = 945.1 MHz)	η	38	41	—	%
3rd Order Intermodulation Distortion (V_{DD} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 mA, f1 = 945.0 MHz, f2 = 945.1 MHz)	IMD	—	–31	–28	dBc
Input Return Loss (V_{DD} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 mA, f1 = 945.0 MHz, f2 = 945.1 MHz)	IRL	—	–14	–9	dB
Two–Tone Common–Source Amplifier Power Gain (V_{DD} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 mA, f1 = 930.0 MHz, f2 = 930.1 MHz and f1 = 960.0 MHz, f2 = 960.1 MHz)	G_{ps}	—	19	—	dB
Two–Tone Drain Efficiency (V_{DD} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 mA, f1 = 930.0 MHz, f2 = 930.1 MHz and f1 = 960.0 MHz, f2 = 960.1 MHz)	η	—	41	—	%
3rd Order Intermodulation Distortion (V_{DD} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 mA, f1 = 930.0 MHz, f2 = 930.1 MHz and f1 = 960.0 MHz, f2 = 960.1 MHz)	IMD	—	–31	—	dBc
Input Return Loss (V_{DD} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 mA, f1 = 930.0 MHz, f2 = 930.1 MHz and f1 = 960.0 MHz, f2 = 960.1 MHz)	IRL	—	–13	—	dB



B1, B2	Short Ferrite Beads, Surface Mount
C1, C7, C13, C14	47 pF Chip Capacitors, B Case
C2, C8	2.7 pF Chip Capacitors, B Case
C3	3.9 pF Chip Capacitor, B Case
C4, C5, C8, C9	10 pF Chip Capacitors, B Case
C6, C15, C16	10 μF, 35 V Tantalum Surface Mount Capacitors
C10	2.2 pF Chip Capacitor, B Case
C11	4.7 pF Chip Capacitor, B Case
C12	1.2 pF Chip Capacitor, B Case
C17	220 μF, 50 V Electrolytic Capacitor
L1, L2	12.5 nH Inductors
Z1	0.20″ x 0.08″ Microstrip
Z2	0.57″ x 0.12″ Microstrip
Z3	0.14″ x 0.32″ Microstrip
Z4	0.47″ x 0.32″ Microstrip
Z5	0.16″ x 0.32″ x 0.62″ Taper
Z6	0.18″ x 0.62″ Microstrip
Z7	0.56″ x 0.62″ Microstrip
Z8	0.33″ x 0.32″ Microstrip
Z9	0.14″ x 0.32″ Microstrip
Z10	0.36″ x 0.08″ Microstrip
Z11	1.01″ x 0.08″ Microstrip
Z12	0.15″ x 0.08″ Microstrip
Z13	0.29″ x 0.08″ Microstrip

Figure 1. MRF9045MR1 930–960 MHz Broadband Test Circuit Schematic

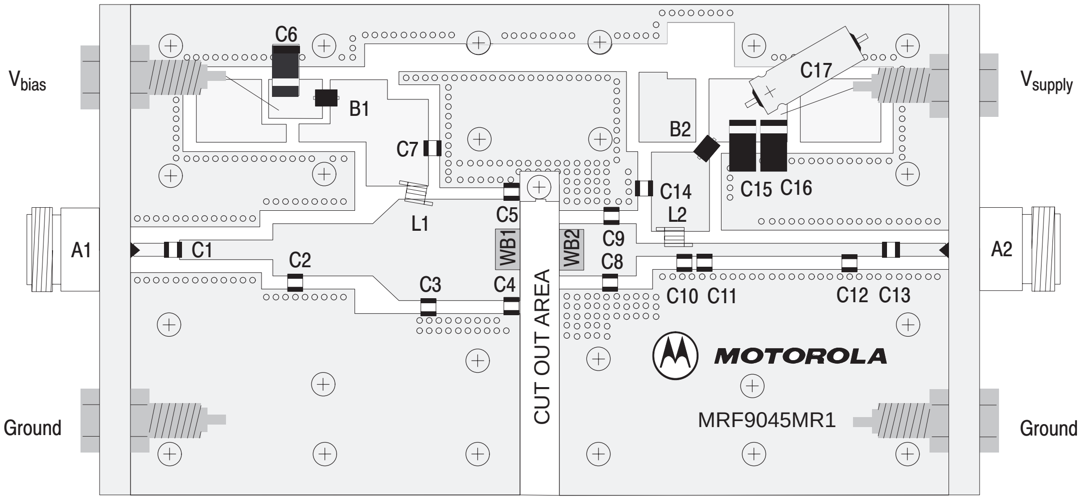
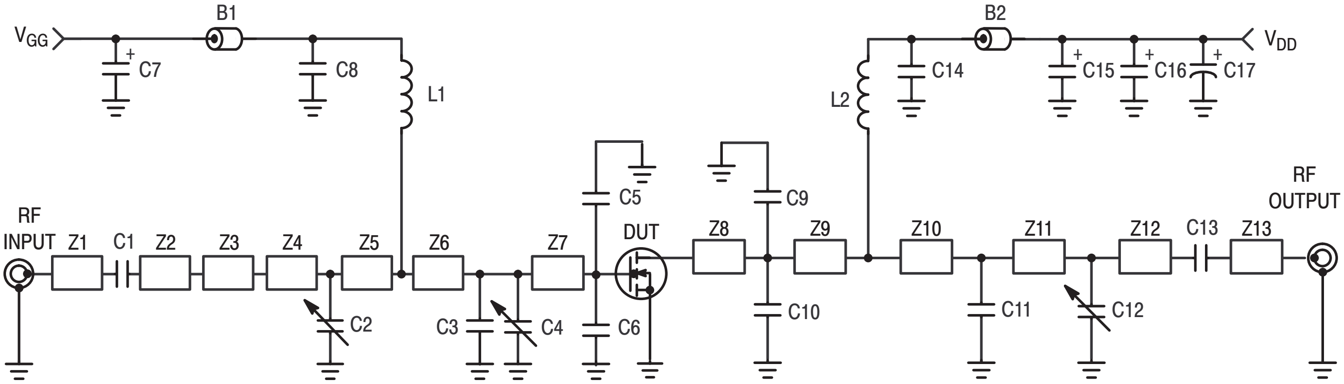


Figure 2. MRF9045MR1 930–960 MHz Broadband Test Circuit Component Layout



B1	Short Ferrite Bead
B2	Long Ferrite Bead
C1, C8, C13, C14	47 pF Chip Capacitors, B Case
C2	0.4–2.5 pF Variable Capacitor, Johanson Gigatrim
C3	3.6 pF Chip Capacitor, B Case
C4	0.8–8.0 pF Variable Capacitor, Johanson Gigatrim
C5, C6, C9, C10	10 pF Chip Capacitors, B Case
C7, C15, C16	10 µF, 35 V Tantalum Chip Capacitors
C11	7.5 pF Chip Capacitor, B Case
C12	0.6–4.5 pF Variable Capacitor, Johanson Gigatrim
C17	220 µF Electrolytic Chip Capacitor
L1, L2	12.5 nH Surface Mount Inductors
WB1, WB2	10 mil Brass Wear Blocks

Z1	0.260″ x 0.060″ Microstrip
Z2	0.240″ x 0.060″ Microstrip
Z3	0.500″ x 0.100″ Microstrip
Z4	0.215″ x 0.270″ Microstrip
Z5	0.315″ x 0.270″ Microstrip
Z6	0.160″ x 0.270″ x 0.520″ Taper
Z7	0.285″ x 0.520″ Microstrip
Z8	0.140″ x 0.270″ Microstrip
Z9	0.450″ x 0.270″ Microstrip
Z10	0.250″ x 0.060″ Microstrip
Z11	0.720″ x 0.060″ Microstrip
Z12	0.490″ x 0.060″ Microstrip
Z13	0.290″ x 0.060″ Microstrip
Board	Taconic RF–35–0300, $\varepsilon_r = 3.5$

Figure 3. MRF9045MBR1 930–960 MHz Broadband Test Circuit Schematic

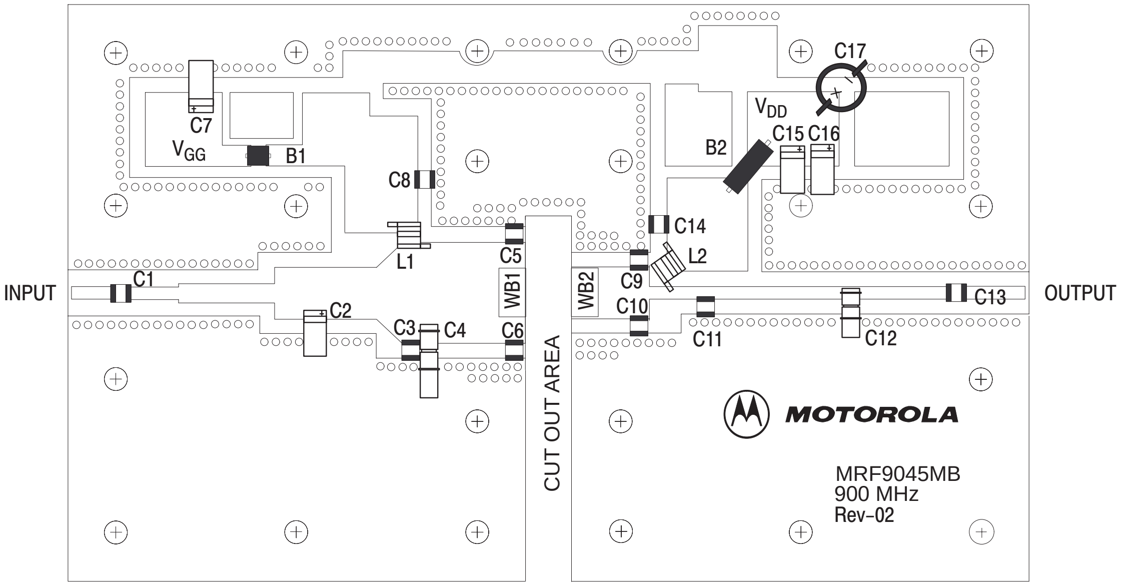


Figure 4. MRF9045MBR1 930–960 MHz Broadband Test Circuit Component Layout

TYPICAL CHARACTERISTICS

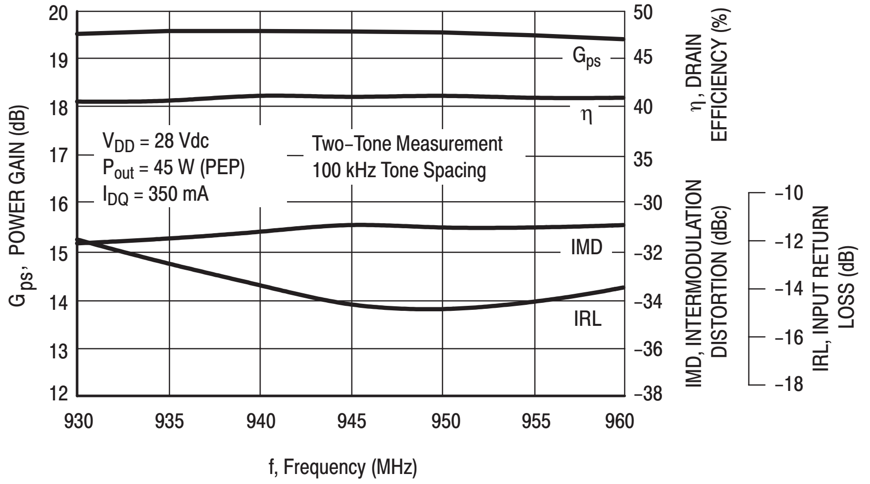


Figure 5. Class AB Broadband Circuit Performance

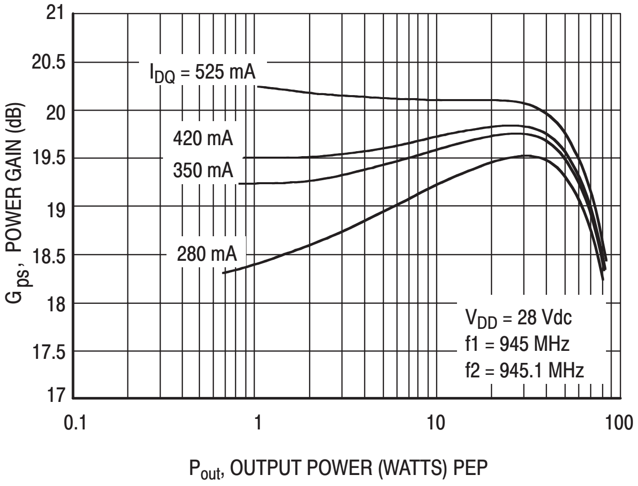


Figure 6. Power Gain versus Output Power

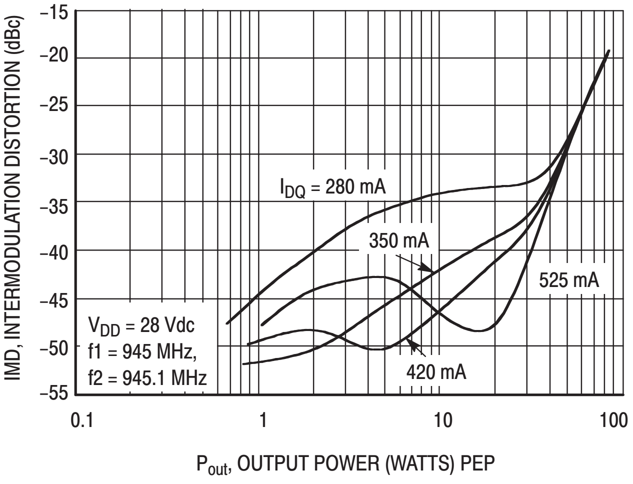


Figure 7. Intermodulation Distortion versus Output Power

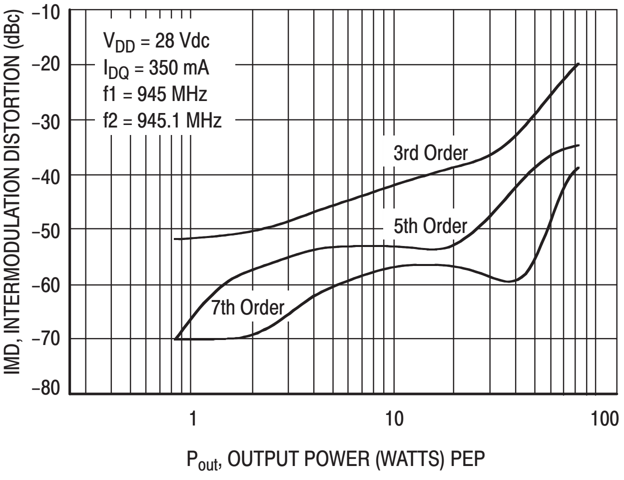


Figure 8. Intermodulation Distortion Products versus Output Power

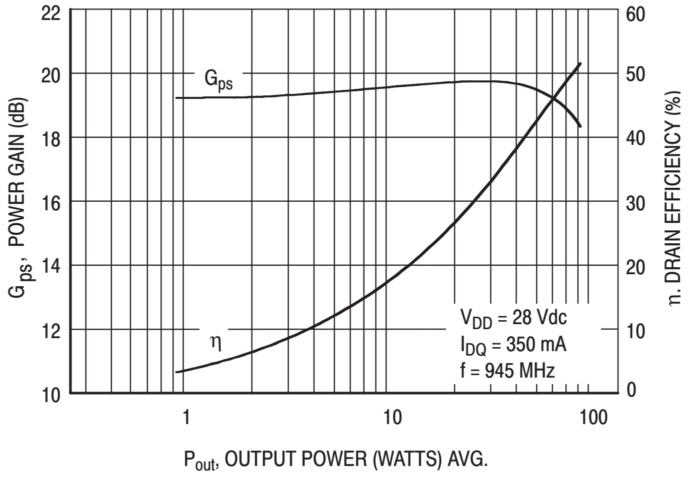


Figure 9. Power Gain and Efficiency versus Output Power

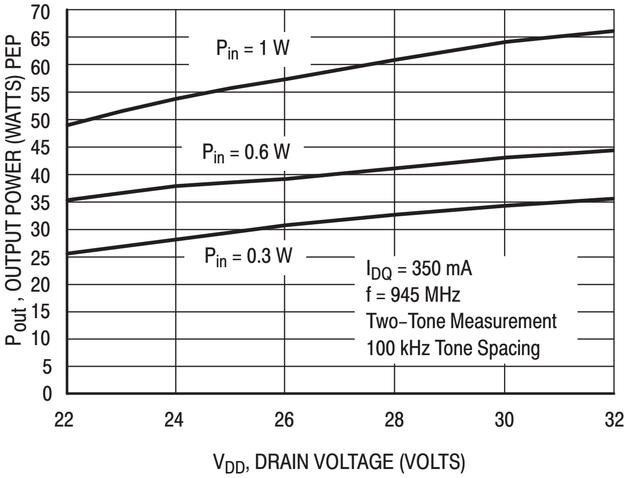


Figure 10. Output Voltage versus Supply Voltage (MRF9045MR1)

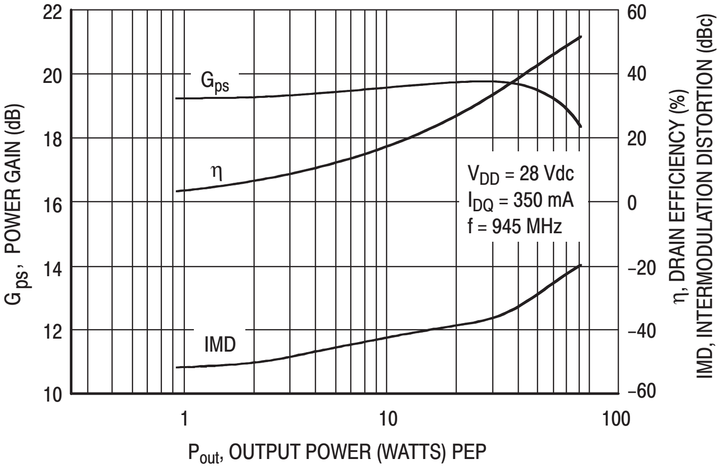
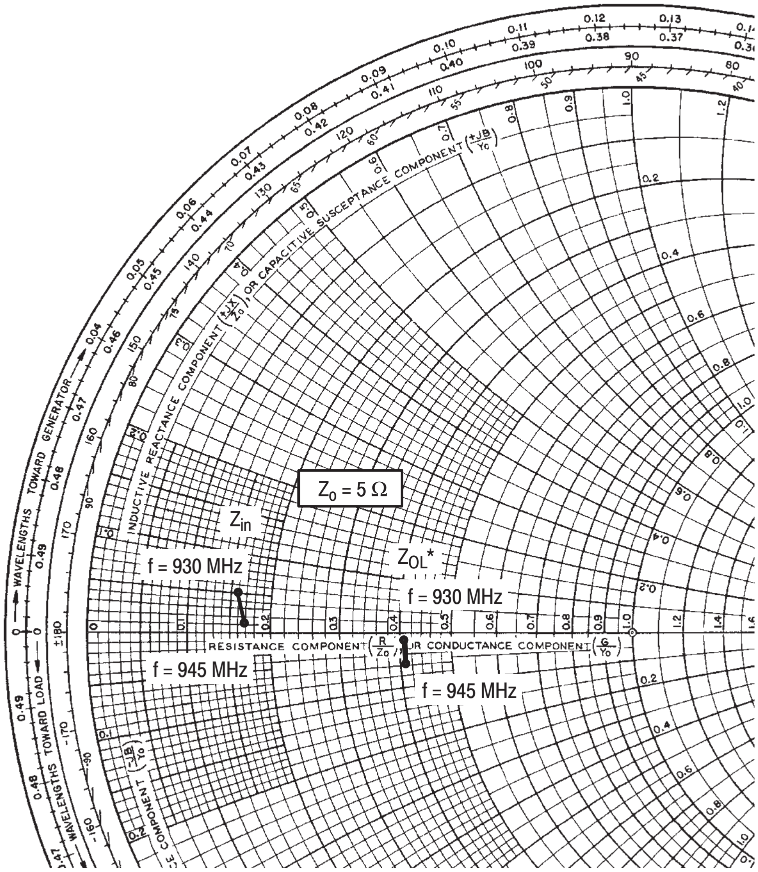


Figure 11. Power Gain, Efficiency and IMD versus Output Power (MRF9045MBR1)



V_{DD} = 28 V, I_{DQ} = 350 mA, P_{out} = 45 W (PEP)

f MHz	Z_{in} Ω	Z_{OL}* Ω
930	0.81 + j0.25	2.03 – j0.09
945	0.85 + j0.05	2.03 – j0.28

Z_{in} = Complex conjugate of source impedance.

Z_{OL}* = Complex conjugate of the optimum load impedance at a given output power, voltage, IMD, bias current and frequency.

Note: Z_{OL}* was chosen based on tradeoffs between gain, output power, drain efficiency and intermodulation distortion.

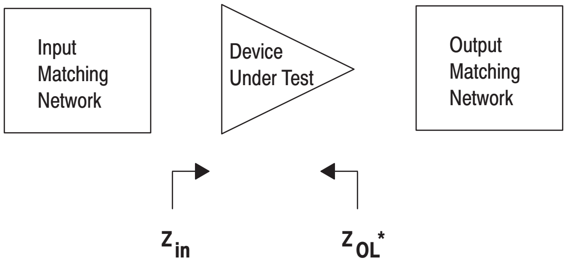
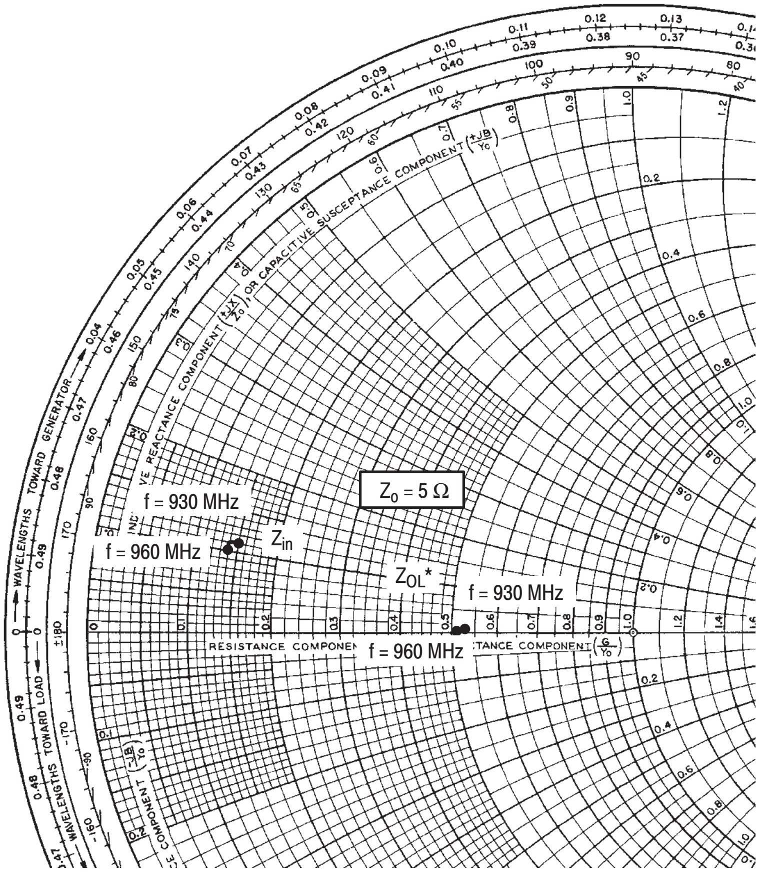


Figure 12. Series Equivalent Input and Output Impedance (MRF9045MR1)



V_{DD} = 28 V, I_{DQ} = 350 mA, P_{out} = 45 W (PEP)

f **MHz**	**Z_{in}** Ω	**Z_{OL}*** Ω
930	0.75 + j0.6	2.65 + j0.05
945	0.72 + j0.6	2.60 + j0.05
960	0.70 + j0.5	2.55 + j0.02

Z_{in} = Complex conjugate of source impedance.

Z_{OL}* = Complex conjugate of the optimum load impedance at a given output power, voltage, IMD, bias current and frequency.

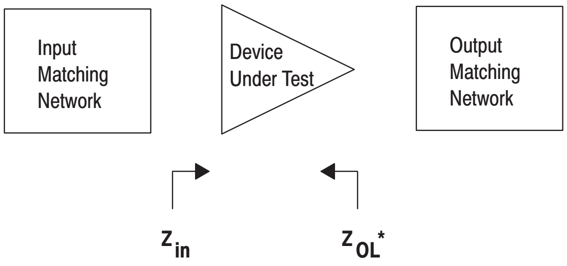
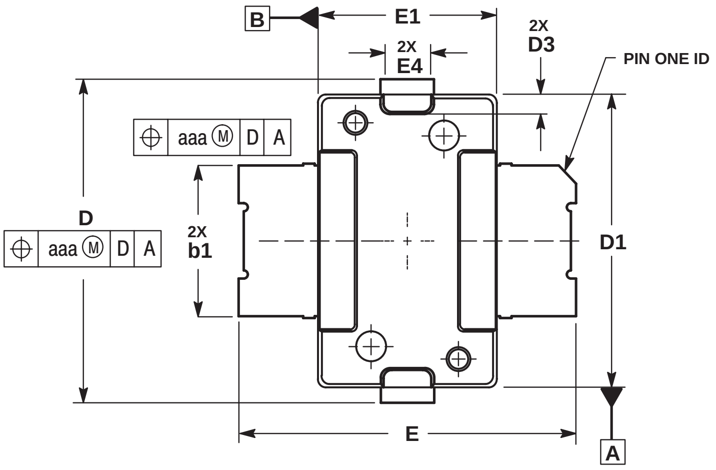
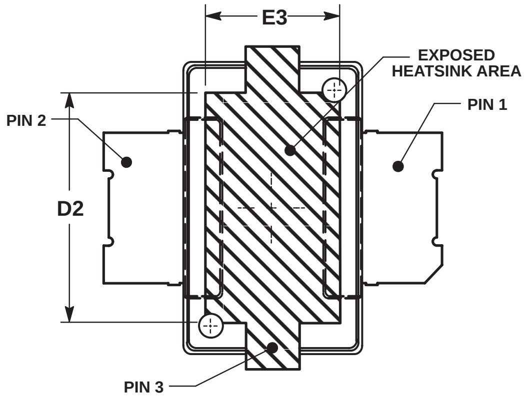


Figure 13. Series Equivalent Input and Output Impedance (MRF9045MBR1)

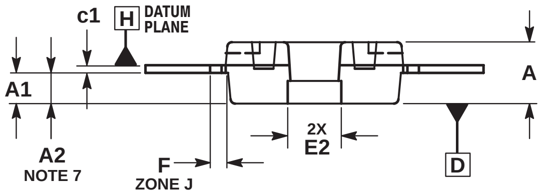
NOTES

PACKAGE DIMENSIONS





BOTTOM VIEW

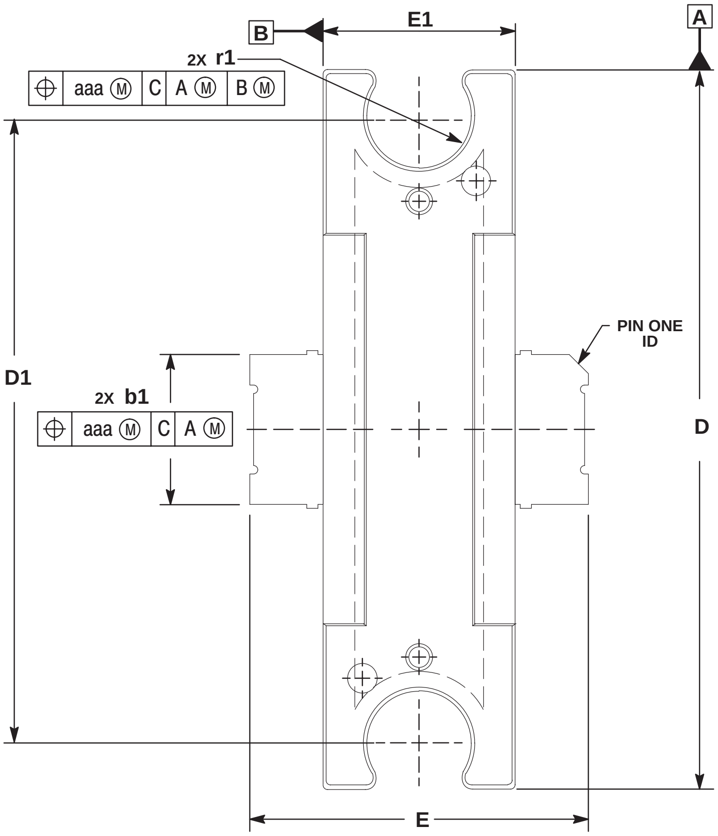


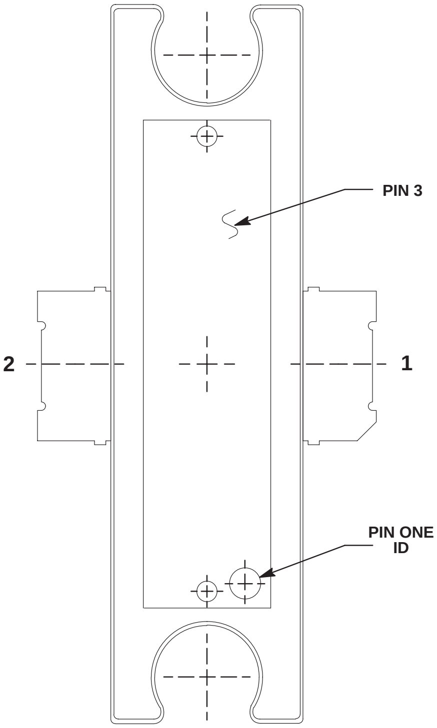
NOTES:
1. CONTROLLING DIMENSION: INCH.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M–1994.
3. DATUM PLANE –H– IS LOCATED AT TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
4. DIMENSIONS “D1” AND “E1” DO NOT INCLUDE MOLD PROTRUSION. 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	.076	.084	1.93	2.13
A1	.038	.044	0.96	1.12
A2	.040	.042	1.02	1.07
D	.416	.424	10.57	10.77
D1	.376	.384	9.55	9.75
D2	.290	.320	7.37	8.13
D3	.016	.024	0.41	0.61
E	.436	.444	11.07	11.28
E1	.236	.244	5.99	6.20
E2	.066	.074	1.68	1.88
E3	.150	.180	3.81	4.57
E4	.058	.066	1.47	1.68
F	.025 BSC		0.64 BSC	
b1	.193	.199	4.90	5.06
c1	.007	.011	0.18	0.28
aaa	.004		0.10	

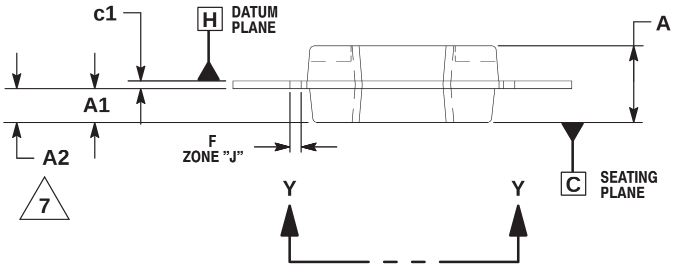
STYLE 1:
PIN 1. DRAIN
2. GATE
3. SOURCE

CASE 1265–07
ISSUE F
(TO–270)
PLASTIC
(MRF9045MR1)





VIEW Y–Y



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. 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.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	.098	.110	2.49	2.79
A1	.038	.044	0.96	1.12
A2	.040	.042	1.02	1.07
D	.926	.934	23.52	23.72
D1	.810 BSC		20.57 BSC	
E	.438	.442	11.12	11.23
E1	.246	.254	6.25	6.45
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 1337–01
ISSUE O
(TO–272 DUAL LEAD)
PLASTIC
(MRF9045MBR1)

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