

# RF Power Field Effect Transistors

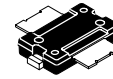
## N-Channel Enhancement-Mode Lateral MOSFETs

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 26 volt base station equipment.

- Typical Single-Carrier N-CDMA Performance @ 880 MHz,  $V_{DD} = 26$  Volts,  $I_{DQ} = 600$  mA,  $P_{out} = 14$  Watts Avg., IS-95 CDMA (Pilot, Sync, Paging, Traffic Codes 8 Through 13)  
 Power Gain — 17.8 dB  
 Drain Efficiency — 30%  
 ACPR @ 750 kHz Offset — -47 dBc @ 30 kHz Bandwidth
- Capable of Handling 10:1 VSWR, @ 26 Vdc, 880 MHz, 70 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
- In Tape and Reel. R1 Suffix = 500 Units per 24 mm, 13 inch Reel.

**MRF5S9070NR1**  
**MRF5S9070MR1**

**880 MHz, 70 W, 26 V**  
**SINGLE N-CDMA**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**



**CASE 1265-08, STYLE 1**  
**TO-270-2**  
**PLASTIC**

**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	$P_D$	219 1.25	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)	Unit
Thermal Resistance, Junction to Case Case Temperature 80°C, 70 W CW Case Temperature 78°C, 14 W CW	$R_{\theta JC}$	0.80 0.93	°C/W

**Table 3. ESD Protection Characteristics**

Test Methodology	Class
Human Body Model (per JESD22-A114-B)	2 (Minimum)
Machine Model (per EIA/JESD22-A115-A)	A (Minimum)
Charge Device Model (per JESD22-C101-A)	IV (Minimum)

**Table 4. Moisture Sensitivity Level**

Test Methodology	Rating	Package Peak Temperature	Unit
Per JESD 22-A113D, IPC/JEDEC J-STD-020C	3	260	°C

1. Refer to AN1955/D, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1955.

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

**Table 5. Electrical Characteristics** ( $T_C = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Off Characteristics</b>					
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 ( $V_{DS} = 26\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	1	$\mu\text{Adc}$
Gate-Source Leakage Current ( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )	$I_{GSS}$	—	—	1	$\mu\text{Adc}$
<b>On Characteristics</b>					
Gate Threshold Voltage ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 200\ \mu\text{A}$ )	$V_{GS(th)}$	2	2.7	4	Vdc
Gate Quiescent Voltage ( $V_{DS} = 26\text{ Vdc}$ , $I_D = 600\text{ mAdc}$ )	$V_{GS(Q)}$	—	3.7	—	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 1.0\text{ Adc}$ )	$V_{DS(on)}$	—	0.18	0.22	Vdc
Forward Transconductance ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 4\text{ Adc}$ )	$g_{fs}$	—	4.7	—	S
<b>Dynamic Characteristic</b>					
Input Capacitance ( $V_{DS} = 26\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{iss}$	—	126	—	pF
Output Capacitance ( $V_{DS} = 26\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{oss}$	—	34	—	pF
Reverse Transfer Capacitance ( $V_{DS} = 26\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{rss}$	—	1.37	—	pF
<b>Functional Tests</b> (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 26\text{ Vdc}$ , $I_{DQ} = 600\text{ mA}$ , $P_{out} = 14\text{ W Avg.}$ , $f = 880\text{ MHz}$ , Single-Carrier N-CDMA, 1.2288 MHz Channel Bandwidth Carrier. ACPR measured in 30 kHz Channel Bandwidth @ $\pm 750\text{ kHz}$ Offset. Peak/Avg. Ratio = 9.8 dB @ 0.01% Probability on CCDF					
Power Gain	$G_{ps}$	17	17.8	—	dB
Drain Efficiency	$\eta_D$	29	30	—	%
Adjacent Channel Power Ratio	ACPR	—	-47	-45	dBc
Input Return Loss	IRL	—	-19	-9	dB
<b>Typical GSM CW Performances</b> (In Freescale GSM Test Fixture Optimized for 921-960 MHz, 50 ohm system) $V_{DD} = 26\text{ Vdc}$ , $I_{DQ} = 400\text{ mA}$ , $P_{out} = 60\text{ W}$ , $f = 921\text{ -}960\text{ MHz}$					
Power Gain	$G_{ps}$	—	16.4	—	dB
Drain Efficiency	$\eta_D$	—	62	—	%
Input Return Loss	IRL	—	-12	—	dB
$P_{out}$ @ 1 dB Compression Point ( $f = 940\text{ MHz}$ )	$P_{1dB}$	—	68	—	W
<b>Typical GSM EDGE Performances</b> (In Freescale GSM EDGE Test Fixture Optimized for 921-960 MHz, 50 ohm system) $V_{DD} = 26\text{ Vdc}$ , $I_{DQ} = 400\text{ mA}$ , $P_{out} = 25\text{ W Avg.}$ , $f = 921\text{ -}960\text{ MHz}$ , GSM EDGE Signal					
Power Gain	$G_{ps}$	—	17	—	dB
Drain Efficiency	$\eta_D$	—	44	—	%
Error Vector Magnitude	EVM	—	1.5	—	%
Spectral Regrowth at 400 kHz Offset	SR1	—	-62	—	dBc
Spectral Regrowth at 600 kHz Offset	SR2	—	-78	—	dBc

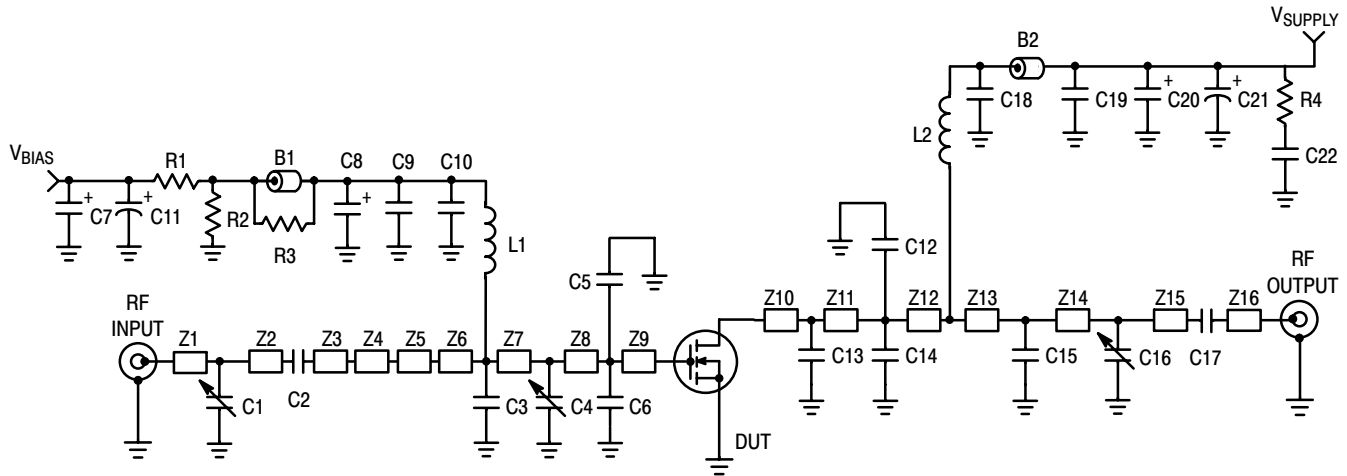
(continued)

**Table 5. Electrical Characteristics** ( $T_C = 25^\circ\text{C}$  unless otherwise noted) (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Typical GSM CW Performances</b> (In Freescale GSM Test Fixture Optimized for 865-895 MHz, 50 ohm system) $V_{DD} = 26\text{ Vdc}$ , $I_{DQ} = 400\text{ mA}$ , $P_{out} = 60\text{ W}$ , $f = 865\text{-}895\text{ MHz}$					
Power Gain	$G_{ps}$	—	16.4	—	dB
Drain Efficiency	$\eta_D$	—	59	—	%
Input Return Loss	IRL	—	-15	—	dB
$P_{out}$ @ 1 dB Compression Point ( $f = 880\text{ MHz}$ )	P1dB	—	71	—	W

**Typical GSM EDGE Performances** (In Freescale GSM EDGE Test Fixture Optimized for 865-895 MHz, 50 ohm system)  
 $V_{DD} = 26\text{ Vdc}$ ,  $I_{DQ} = 400\text{ mA}$ ,  $P_{out} = 25\text{ W Avg.}$ ,  $f = 865\text{-}895\text{ MHz}$ , GSM EDGE Signal

Power Gain	$G_{ps}$	—	17	—	dB
Drain Efficiency	$\eta_D$	—	41	—	%
Error Vector Magnitude	EVM	—	1.35	—	%
Spectral Regrowth at 400 kHz Offset	SR1	—	-66	—	dBc
Spectral Regrowth at 600 kHz Offset	SR2	—	-81	—	dBc

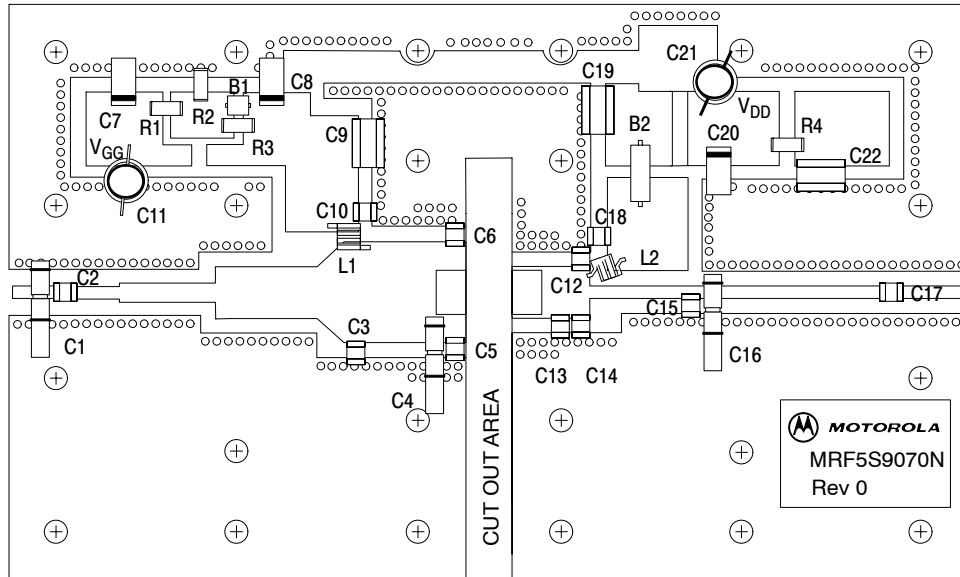


Z1	0.140" x 0.060" Microstrip	Z10	0.245" x 0.270" Microstrip
Z2	0.141" x 0.060" Microstrip	Z11	0.110" x 0.270" Microstrip
Z3	0.280" x 0.060" Microstrip	Z12	0.055" x 0.270" Microstrip
Z4	0.500" x 0.100" Microstrip	Z13	0.512" x 0.060" Microstrip
Z5	0.530" x 0.270" Microstrip	Z14	0.106" x 0.060" Microstrip
Z6	0.155" x 0.270" x 0.530" Taper	Z15	0.930" x 0.060" Microstrip
Z7	0.376" x 0.530" Microstrip	Z16	0.365" x 0.060" Microstrip
Z8	0.116" x 0.530" Microstrip	PCB	Taconic RF-35, 0.030", $\epsilon_r = 3.5$
Z9	0.055" x 0.530" Microstrip		

Figure 1. MRF5S9070NR1(MR1) Test Circuit Schematic

Table 6. MRF5S9070NR1(MR1) Test Circuit Component Designations and Values

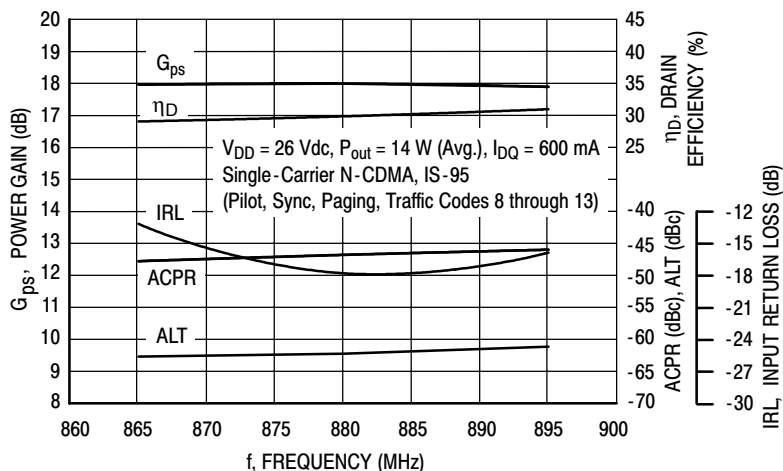
Part	Description	Part Number	Manufacturer
B1	Small Ferrite Bead, Surface Mount	2743019447	Fair-Rite
B2	Large Ferrite Bead, Surface Mount	2743021447	Fair-Rite
C1	0.6 - 6.0 pF Variable Capacitor, Gigatrim	272715L	Johanson
C2	16 pF Chip Capacitor	100B160JP500X	ATC
C3	7.5 pF Chip Capacitor	100B7R5JP500X	ATC
C4, C16	0.8 - 8.0 pF Variable Capacitor, Gigatrim	272915L	Johanson
C5, C6	15 pF Chip Capacitors	100B150JP500X	ATC
C7, C8, C20	10 $\mu$ F, 35 V Tantalum Capacitors	T491D106K035AS	Kemet
C9, C19, C22	0.58 $\mu$ F Chip Capacitors	700A561MP150X	ATC
C10, C18	18 pF Chip Capacitors	100B180JP500X	ATC
C11	100 $\mu$ F, 50 V Electrolytic Capacitor	515D107M050BB6A	Vishay-Dale
C12	0.7 pF Chip Capacitor	100B0R7BP500X	ATC
C13, C14	13 pF Chip Capacitors	100B130JP500X	ATC
C15	3.9 pF Chip Capacitor	100B3R9JP500X	ATC
C17	22 pF Chip Capacitor	100B180JP500X	ATC
C21	470 $\mu$ F, 63 V Electrolytic Capacitor	SME63VB471M12X25LL	United Chemi-Con
L1, L2	12.5 nH Surface Mount Inductors	A04T-5	Coilcraft
R1	1 k $\Omega$ Chip Resistor	CRCW12061001F100	Vishay-Dale
R2	560 k $\Omega$ Chip Resistor	CRCW12065603F100	Vishay-Dale
R3	12 $\Omega$ Chip Resistor	CRCW120612R0F100	Vishay-Dale
R4	27 $\Omega$ Chip Resistor	CRCW120627R0F100	Vishay-Dale



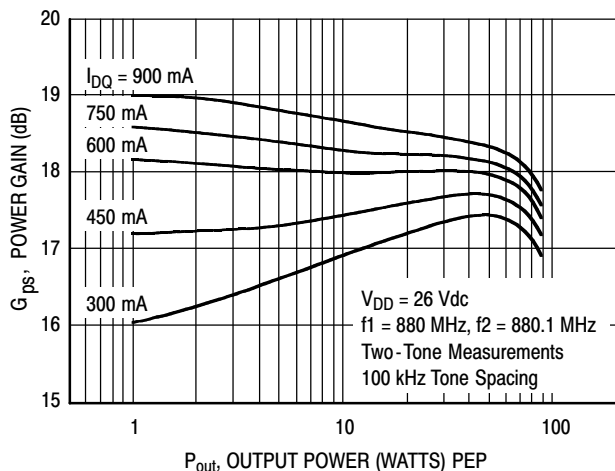
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**Figure 2. MRF5S9070NR1(MR1) Test Circuit Component Layout**

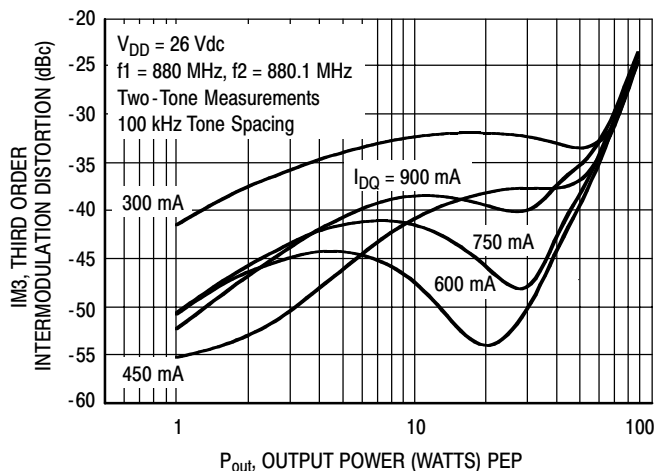
## TYPICAL CHARACTERISTICS



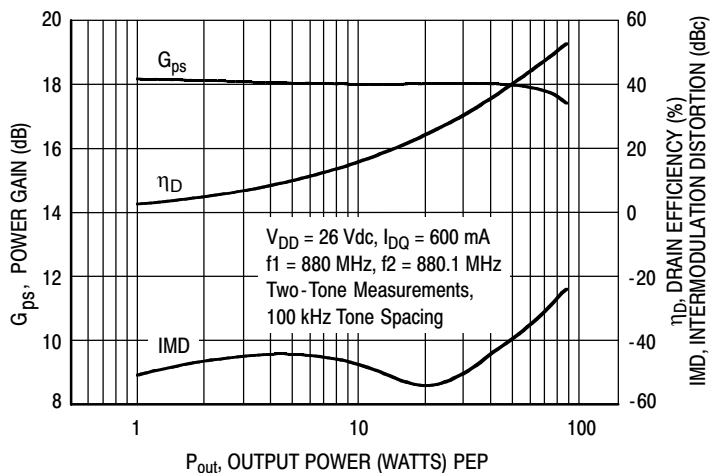
**Figure 3. Class AB Broadband Performance**



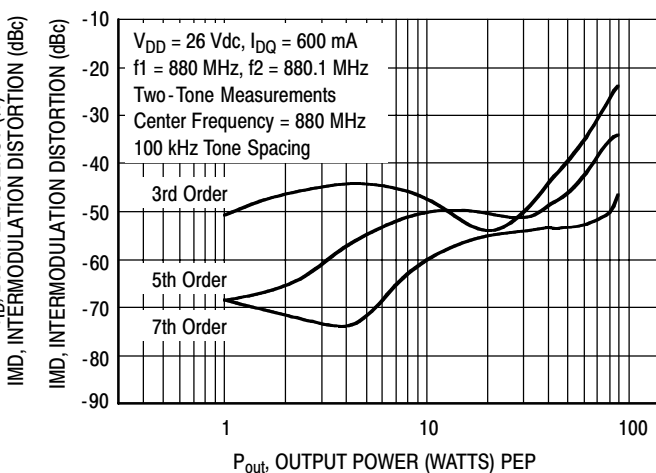
**Figure 4. Two-Tone Power Gain versus Output Power**



**Figure 5. Third Order Intermodulation Distortion versus Output Power**

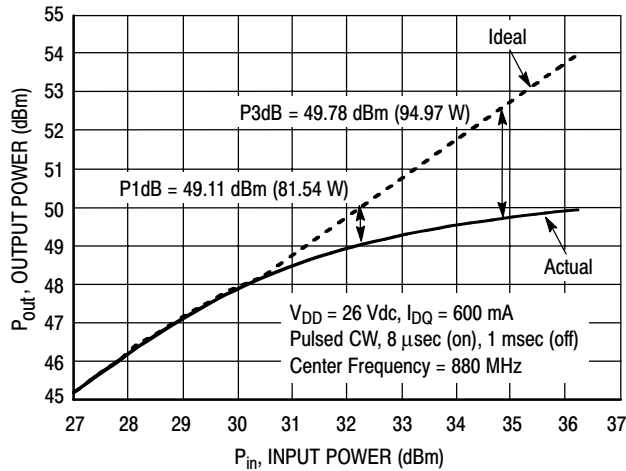


**Figure 6. Power Gain, Drain Efficiency and IMD versus Output Power**

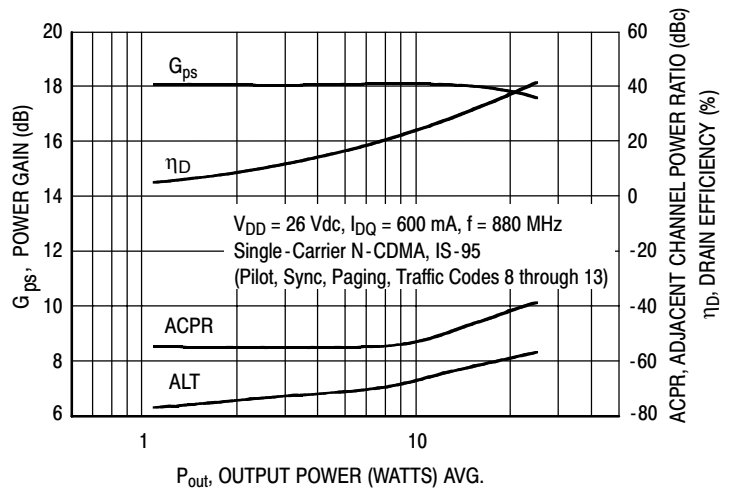


**Figure 7. Intermodulation Distortion Products versus Output Power**

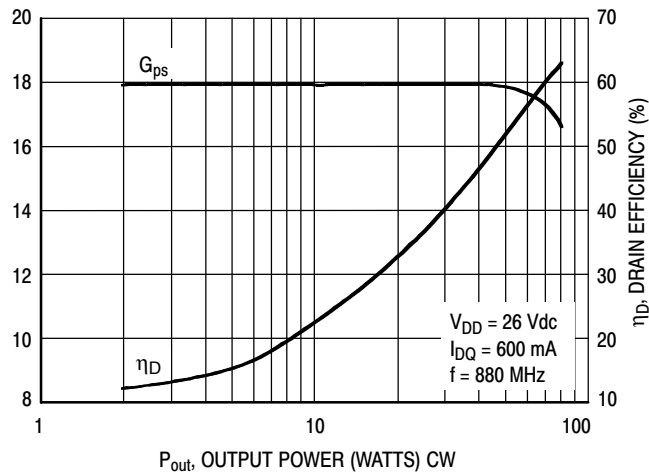
## TYPICAL CHARACTERISTICS



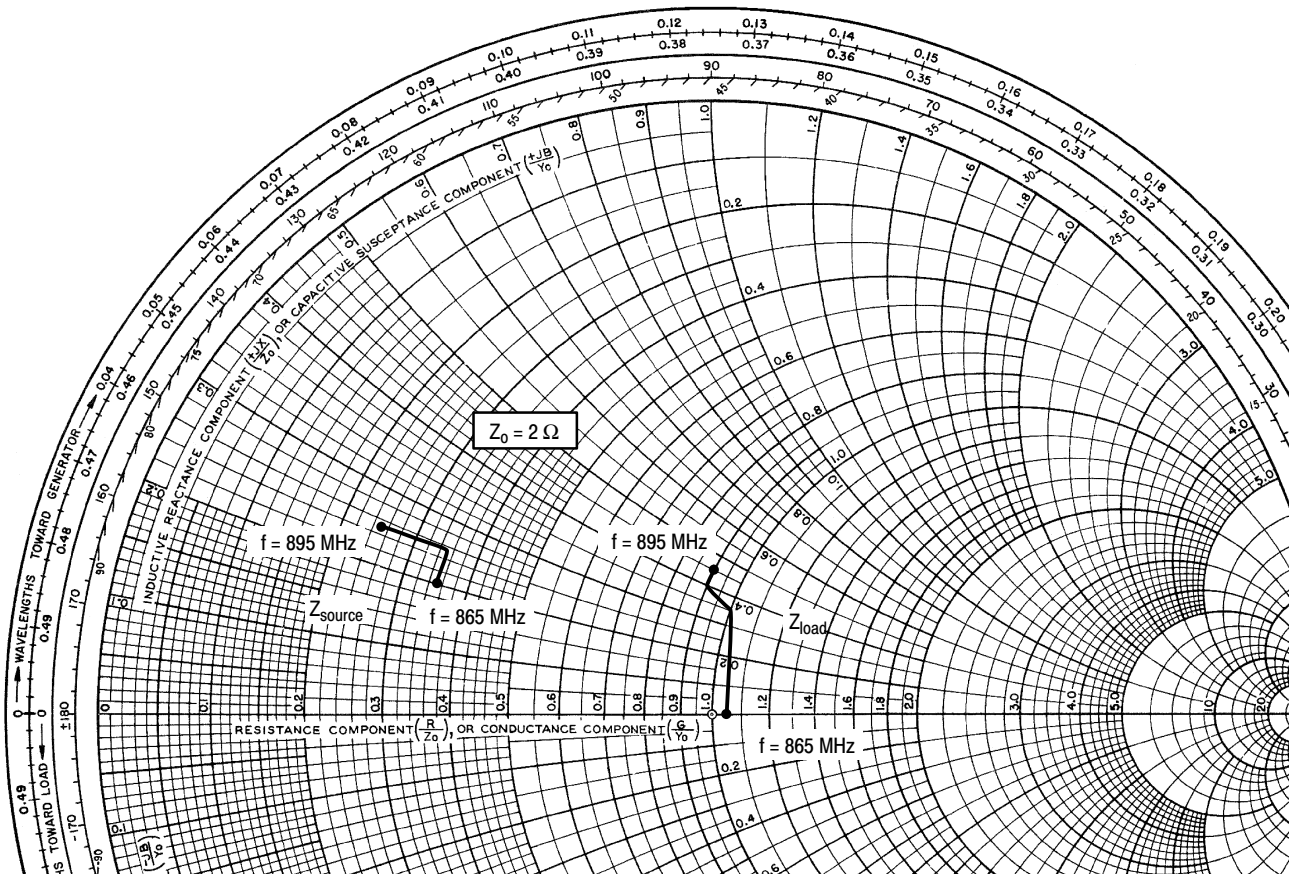
**Figure 8. Pulse CW Output Power versus Input Power**



**Figure 9. N-CDMA ACPR, Power Gain and Drain Efficiency versus Output Power**



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



$V_{DD} = 26 \text{ Vdc}$ ,  $I_{DQ} = 600 \text{ mA}$ ,  $P_{out} = 14 \text{ W Avg.}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
865	$0.7 + j0.4$	$2.1 + j0.6$
875	$0.7 + j0.5$	$2.0 + j0.7$
885	$0.6 + j0.5$	$1.8 + j0.8$
895	$0.5 + j0.5$	$1.8 + j0.9$

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

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

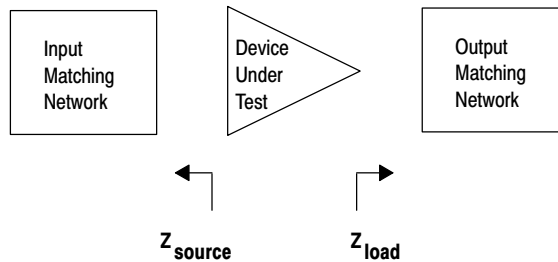


Figure 11. Series Equivalent Source and Load Impedance

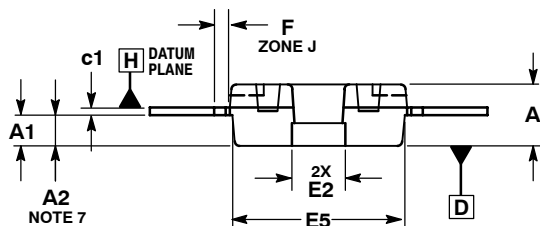
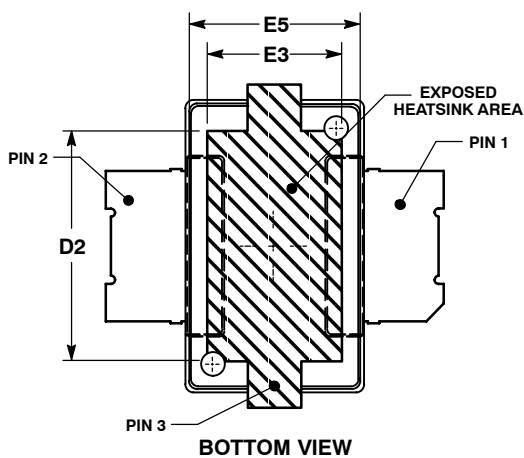
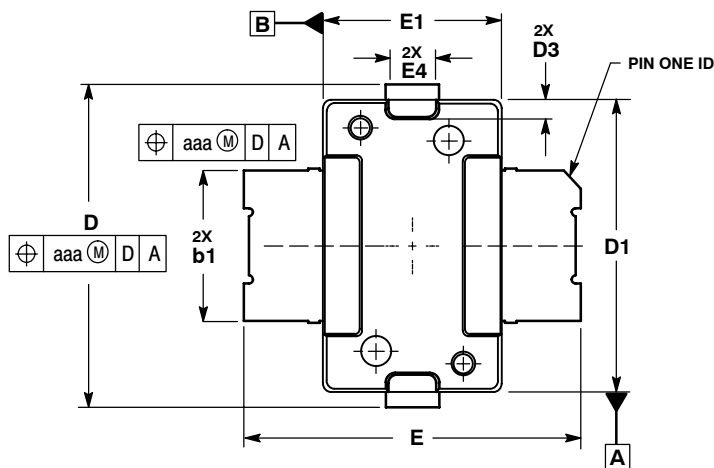




# NOTES

# 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 -.

DIM	INCHES		MILLIMETERS	
	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 G  
 TO-270-2  
 PLASTIC

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