RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

MRF6S9160HR3
MRF6S9160HSR3

Designed for N-CDMA, GSM and GSM EDGE base station applications with frequencies from 865 to 960 MHz. Suitable for multicarrier amplifier applications.

- Typical Single-Carrier N-CDMA Performance @ 880 MHz: V_{DD} = 28 Volts, I_{DQ} = 1200 mA, P_{out} = 35 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 — 20.9 dB
  - Drain Efficiency — 30.5%
  - ACPR @ 750 kHz Offset — -46.8 dBc @ 30 kHz Bandwidth

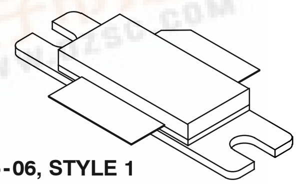
880 MHz, 35 W AVG., 28 V
SINGLE N-CDMA
LATERAL N-CHANNEL
RF POWER MOSFETs

GSM EDGE Application

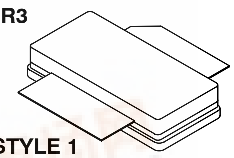
- Typical GSM EDGE Performance: V_{DD} = 28 Volts, I_{DQ} = 1200 mA, P_{out} = 76 Watts Avg., Full Frequency Band (865-895 MHz)
  - Power Gain — 20 dB
  - Drain Efficiency — 45%
  - Spectral Regrowth @ 400 kHz Offset = -66 dBc
  - Spectral Regrowth @ 600 kHz Offset = -75 dBc
  - EVM — 2% rms

GSM Application

- Typical GSM Performance: V_{DD} = 28 Volts, I_{DQ} = 1200 mA, P_{out} = 160 Watts, Full Frequency Band (921-960 MHz)
  - Power Gain — 20 dB
  - Drain Efficiency — 58%
- Capable of Handling 10:1 VSWR, @ 28 Vdc, 880 MHz, 160 Watts CW Output Power
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Input Matched for Ease of Use
- Qualified Up to a Maximum of 32 V_{DD} Operation
- Integrated ESD Protection
- Lower Thermal Resistance Package
- Low Gold Plating Thickness on Leads, 40μ″ Nominal.
- Pb-Free and RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.



CASE 465-06, STYLE 1
NI-780
MRF6S9160HR3



CASE 465A-06, STYLE 1
NI-780S
MRF6S9160HSR3

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	565 3.2	W W/°C
Storage Temperature Range	T_{stg}	- 65 to +150	°C
Operating Junction Temperature	T_J	200	°C
CW Operation	CW	160	W

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, 160 W CW Case Temperature 73°C, 35 W CW	$R_{\theta JC}$	 0.31 0.33	°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. 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 = 525 μAdc)	$V_{GS(th)}$	1	2	3	Vdc
Gate Quiescent Voltage (V_{DS} = 28 Vdc, I_D = 1200 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	2	3	4	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 3.6 Adc)	$V_{DS(on)}$	0.1	0.2	0.3	Vdc
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 8 Adc)	g_{fs}	—	9.7	—	S
Dynamic Characteristics (3)					
Output Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	80.2	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	2.2	—	pF

Functional Tests (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1200 mA, P_{out} = 35 W Avg. N-CDMA, 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

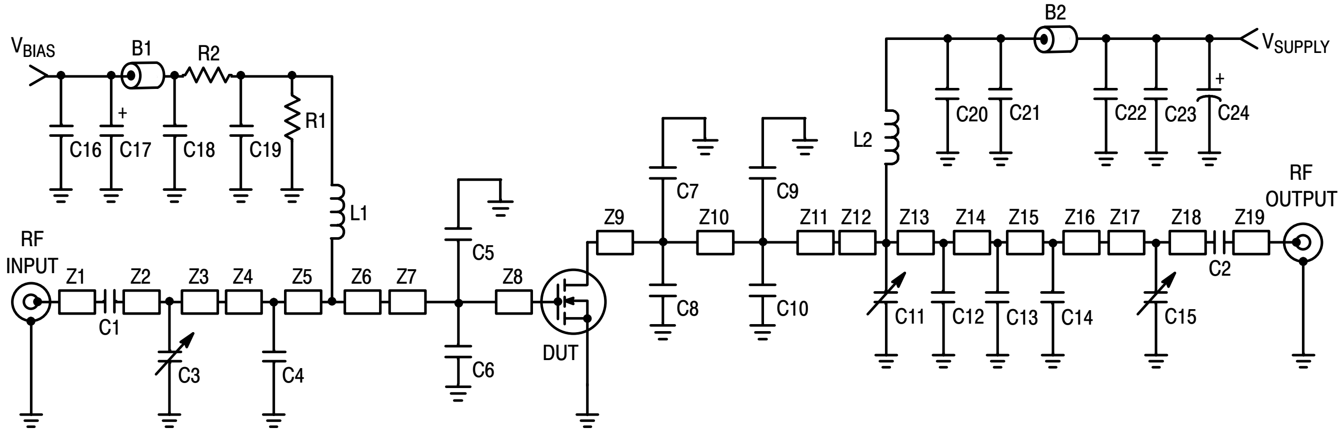
Characteristic	Symbol	Min	Typ	Max	Unit
Power Gain	G_{ps}	20	20.9	23	dB
Drain Efficiency	η_D	29	30.5	—	%
Adjacent Channel Power Ratio	ACPR	—	-46.8	-45	dBc
Input Return Loss	IRL	—	-17	-9	dB

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.
3. Part is internally matched on input.

(continued)

Table 4. 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, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1200 mA, P_{out} = 76 W Avg., 865 MHz<Frequency<895 MHz					
Power Gain	G_{ps}	—	20	—	dB
Drain Efficiency	η_D	—	45	—	%
Error Vector Magnitude	EVM	—	2	—	% rms
Spectral Regrowth at 400 kHz Offset	SR1	—	-66	—	dBc
Spectral Regrowth at 600 kHz Offset	SR2	—	-75	—	dBc
Typical CW Performances (In Freescale GSM Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1200 mA, P_{out} = 160 W, 921 MHz<Frequency<960 MHz					
Power Gain	G_{ps}	—	20	—	dB
Drain Efficiency	η_D	—	58	—	%
Input Return Loss	IRL	—	-12	—	dB
P_{out} @ 1 dB Compression Point, CW (f = 940 MHz)	P1dB	—	160	—	W



Z1	0.426″ x 0.080″ Microstrip	Z11	0.066″ x 0.630″ Microstrip
Z2	0.813″ x 0.080″ Microstrip	Z12	0.630″ x 0.425″ x 0.220″ Taper
Z3	0.471″ x 0.080″ Microstrip	Z13	0.120″ x 0.220″ Microstrip
Z4	0.319″ x 0.220″ Microstrip	Z14	0.292″ x 0.220″ Microstrip
Z5	0.171″ x 0.220″ Microstrip	Z15	0.023″ x 0.220″ Microstrip
Z6	0.200″ x 0.425″ x 0.630″ Taper	Z16	0.030″ x 0.220″ Microstrip
Z7	0.742″ x 0.630″ Microstrip	Z17	0.846″ x 0.080″ Microstrip
Z8	0.233″ x 0.630″ Microstrip	Z18	0.440″ x 0.080″ Microstrip
Z9	0.128″ x 0.630″ Microstrip	Z19	0.434″ x 0.080″ Microstrip
Z10	0.134″ x 0.630″ Microstrip	PCB	Arlon GX-0300-55-22, 0.030″, ε_r = 2.55

Figure 1. MRF6S9160HR3(SR3) Test Circuit Schematic

Table 5. MRF6S9160HR3(SR3) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
B1, B2	Ferrite Beads, Small	2743019447	Fair Rite
C1, C2, C19	47 pF Chip Capacitors	100B470JP500X	ATC
C3, C11	0.8-8.0 pF Variable Capacitors, Gigatrim	27291SL	Johanson
C4	2.7 pF Chip Capacitor	100B2R7JP500X	ATC
C5, C6	15 pF Chip Capacitors	100B150JP500X	ATC
C7, C8	12 pF Chip Capacitors	100B120JP500X	ATC
C9, C10	4.3 pF Chip Capacitors	100B4R3JP500X	ATC
C12	8.2 pF Chip Capacitor	100B8R2JP500X	ATC
C13, C14	3.9 pF Chip Capacitors	100B3R9JP500X	ATC
C15	0.6-4.5 pF Variable Capacitor, Gigatrim	27271SL	Johanson
C16	22 pF Chip Capacitor	100B220JP500X	ATC
C17	1 μF, 50 V Tantalum Capacitor	T491C105K0J0AS	Kemit
C18	20K pF Chip Capacitor	CDR353P203AK0S	Kemit
C20	180 pF Chip Capacitor	100B181JP500X	ATC
C21, C22, C23	10 μF, 50 V Chip Capacitors (2220)	GRM55DR61H106KA88B	Murata
C24	470 μF, 63 V Electrolytic Capacitor	KME63VB471M12x25LL	United Chemi-Con
L1, L2	10 nH Inductors	0603HC	Coilcraft
R1	180 Ω Chip Resistor		
R2	10 Ω Chip Resistor		

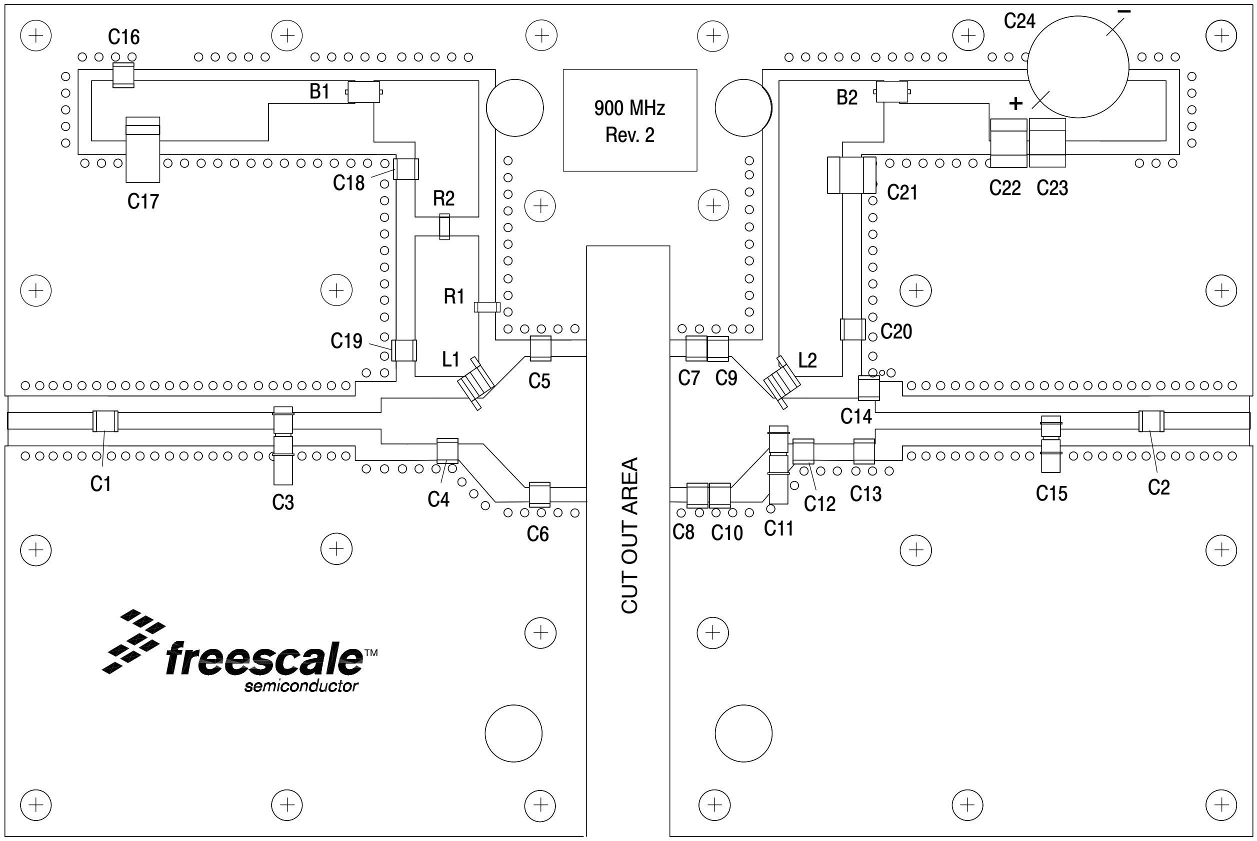


Figure 2. MRF6S9160HR3(SR3) Test Circuit Component Layout

TYPICAL CHARACTERISTICS

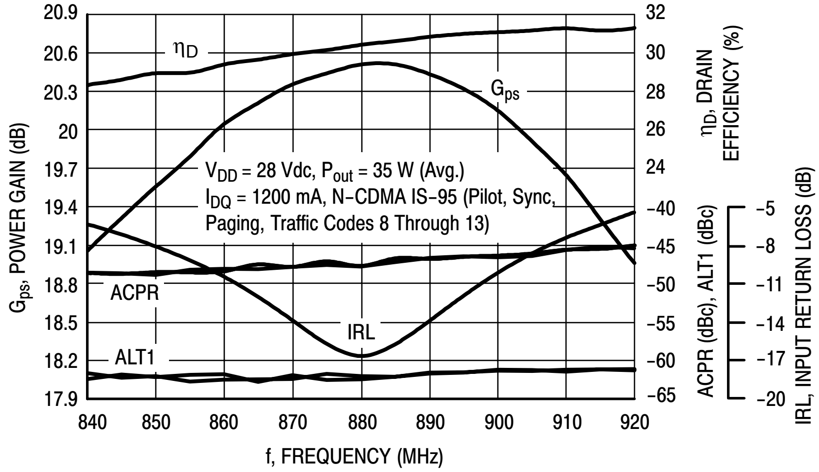


Figure 3. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 35 Watts Avg.

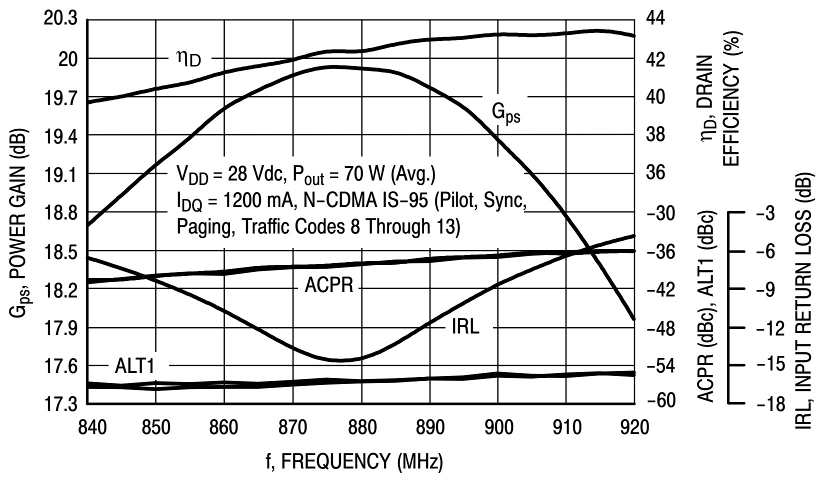


Figure 4. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 70 Watts Avg.

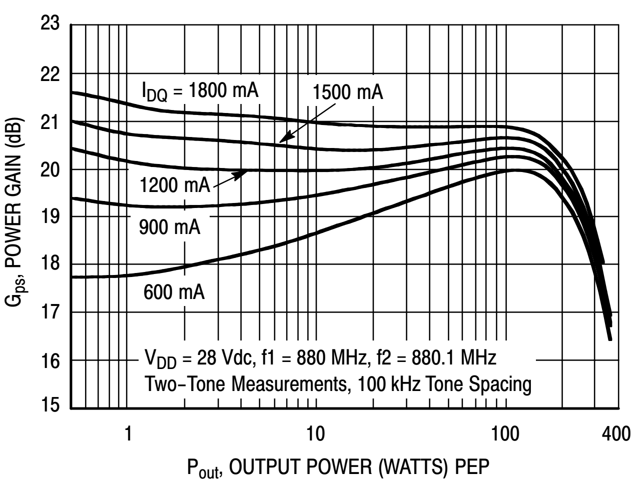


Figure 5. Two-Tone Power Gain versus Output Power

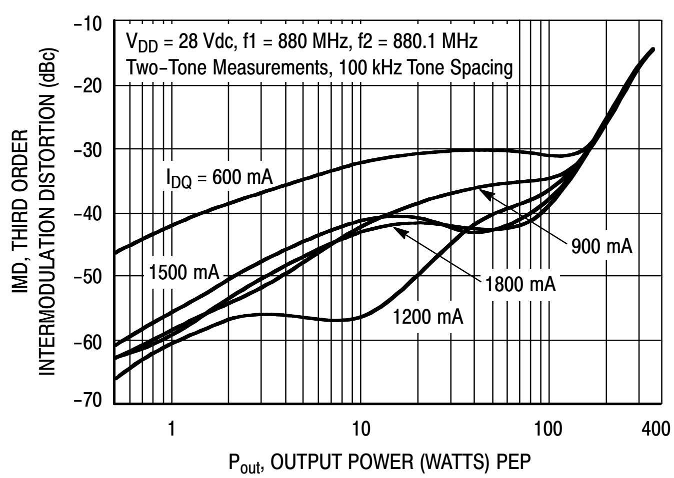


Figure 6. Third Order Intermodulation Distortion versus Output Power

TYPICAL CHARACTERISTICS

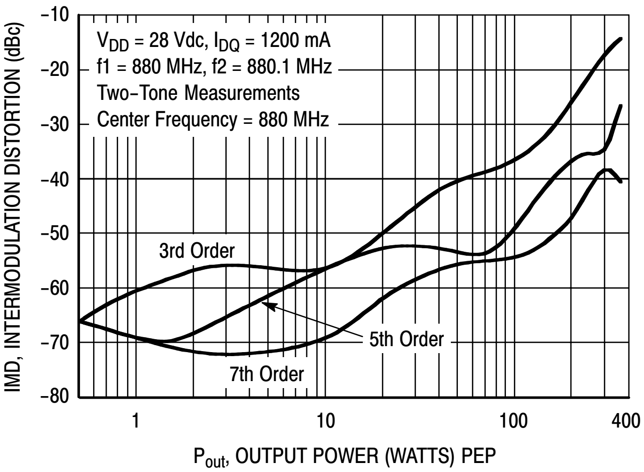


Figure 7. Intermodulation Distortion Products versus Output Power

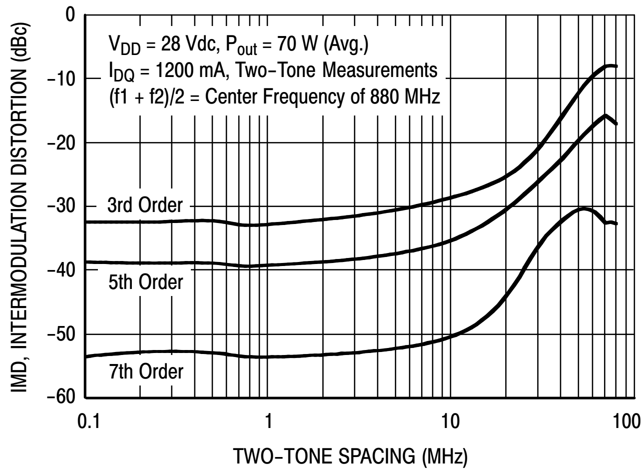


Figure 8. Intermodulation Distortion Products versus Tone Spacing

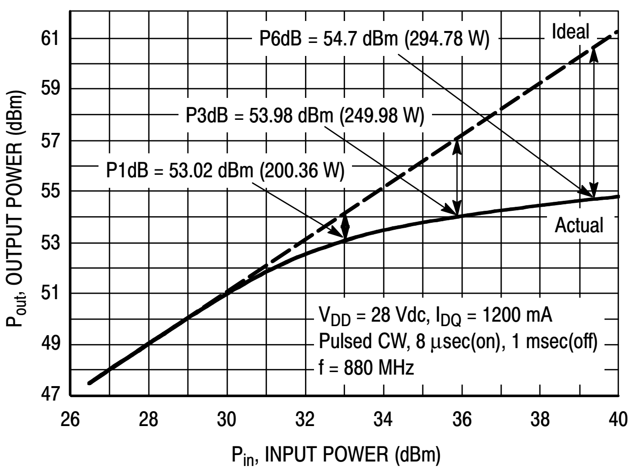


Figure 9. Pulse CW Output Power versus Input Power

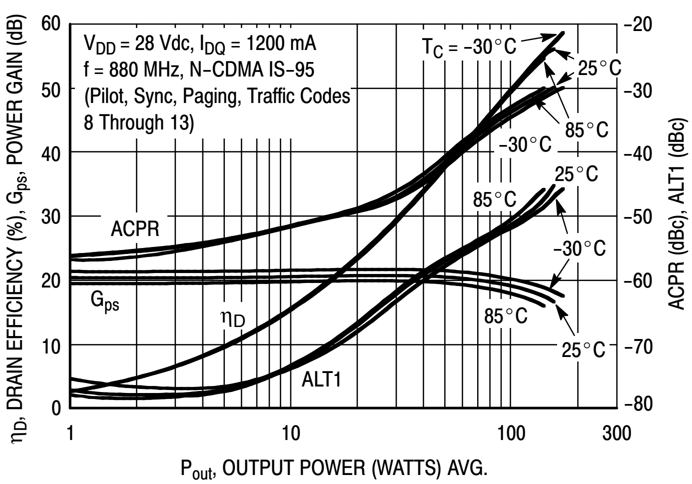


Figure 10. Single-Carrier N-CDMA ACPR, ALT1, Power Gain and Drain Efficiency versus Output Power

TYPICAL CHARACTERISTICS

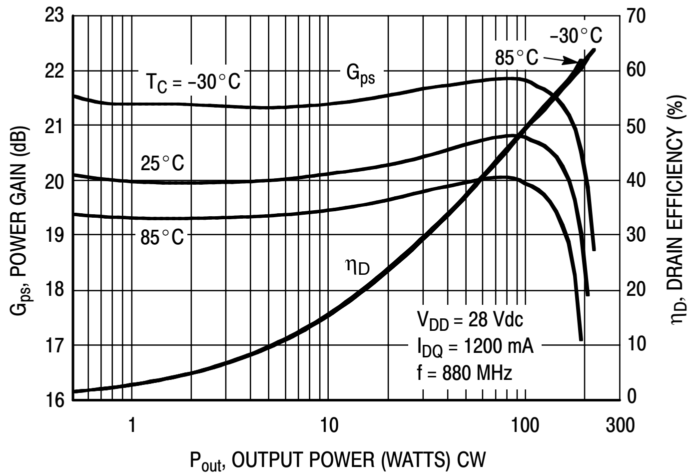


Figure 11. Power Gain and Drain Efficiency versus CW Output Power

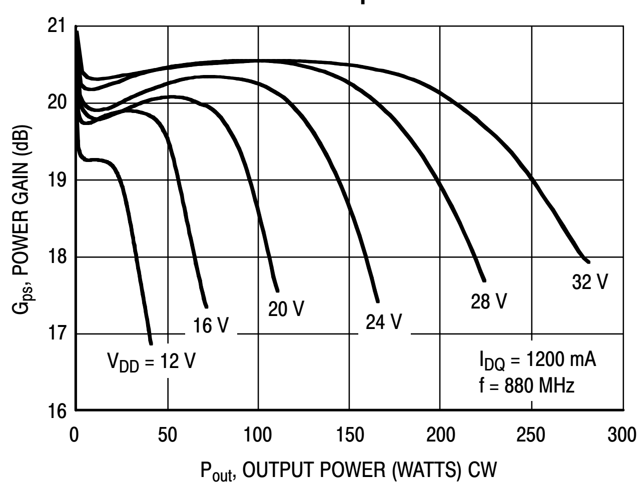
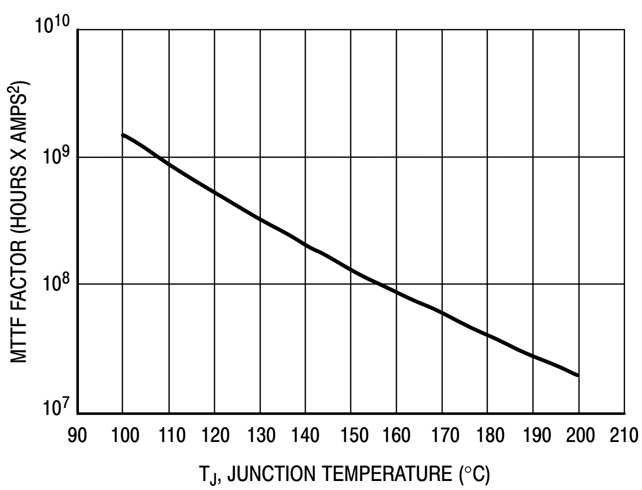


Figure 12. Power Gain versus Output Power



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

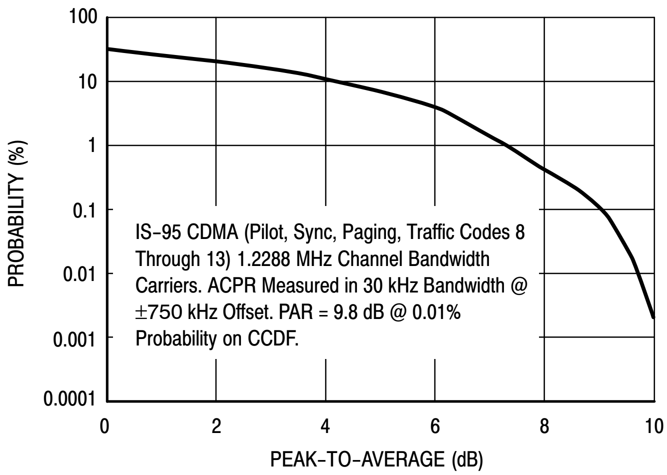


Figure 14. Single-Carrier CCDF N-CDMA

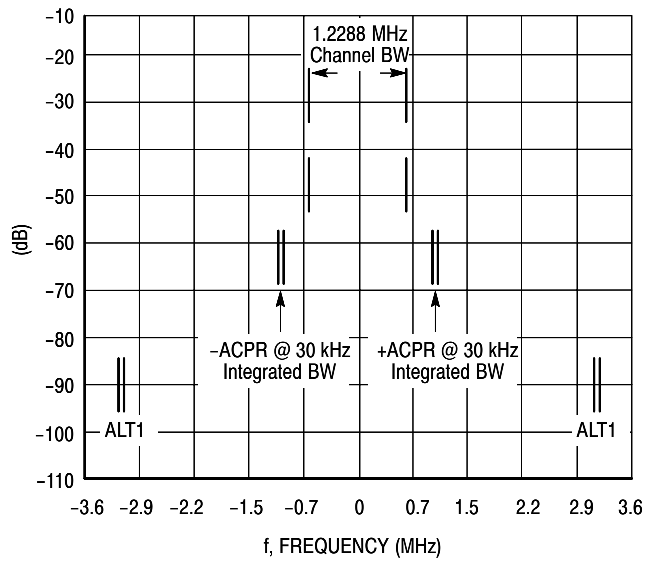
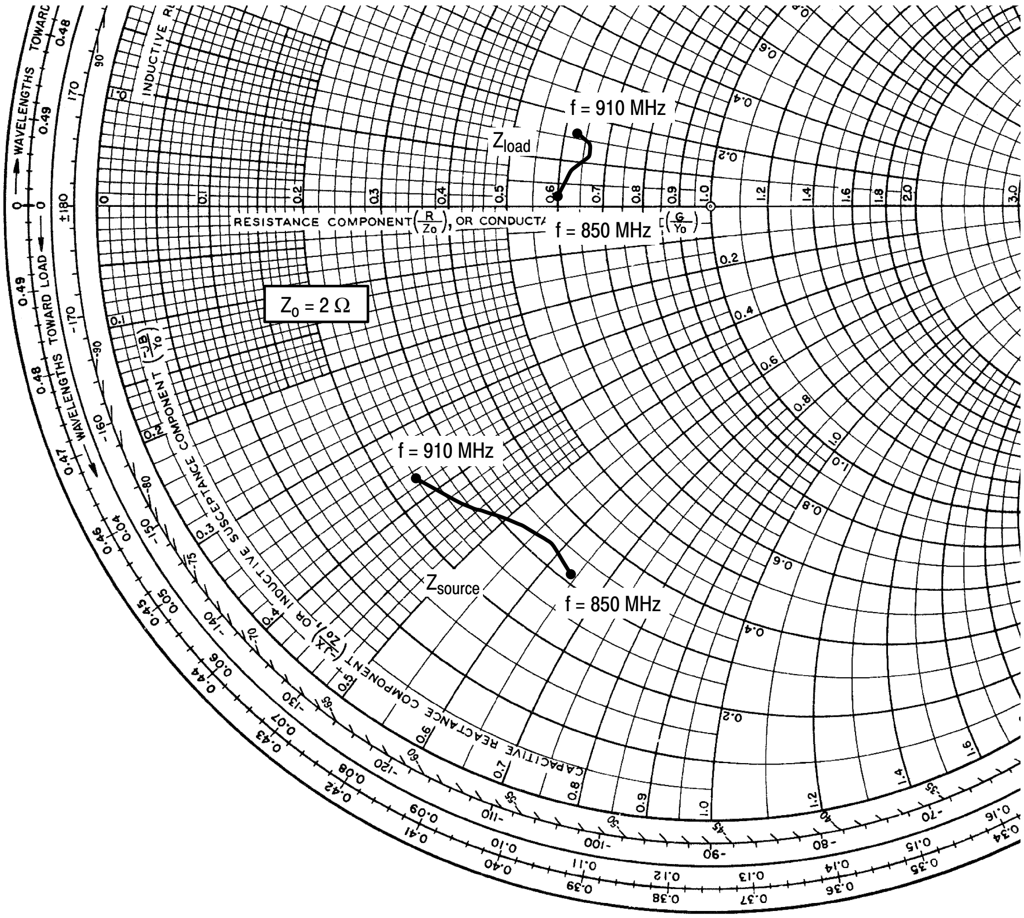


Figure 15. Single-Carrier N-CDMA Spectrum



V_{DD} = 28 Vdc, I_{DQ} = 1200 mA, P_{out} = 35 W Avg.

f MHz	Z_{source} Ω	Z_{load} Ω
850	0.61 - j1.27	1.20 + j0.03
865	0.66 - j1.15	1.26 + j0.15
880	0.64 - j1.05	1.31 + j0.22
895	0.55 - j0.90	1.32 + j0.28
910	0.48 - j0.74	1.26 + j0.32

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

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

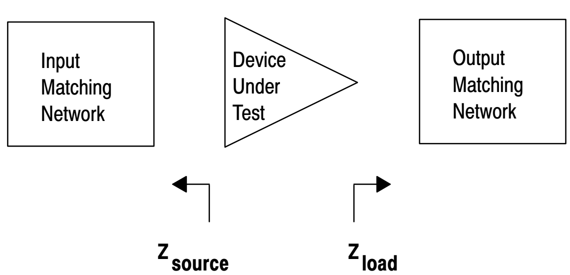
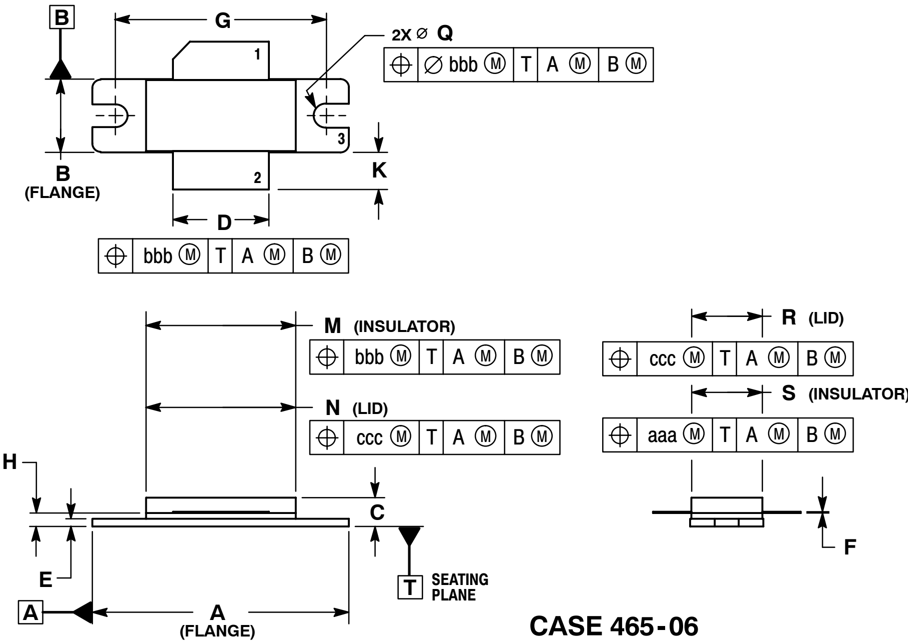


Figure 16. Series Equivalent Source and Load Impedance

PACKAGE DIMENSIONS

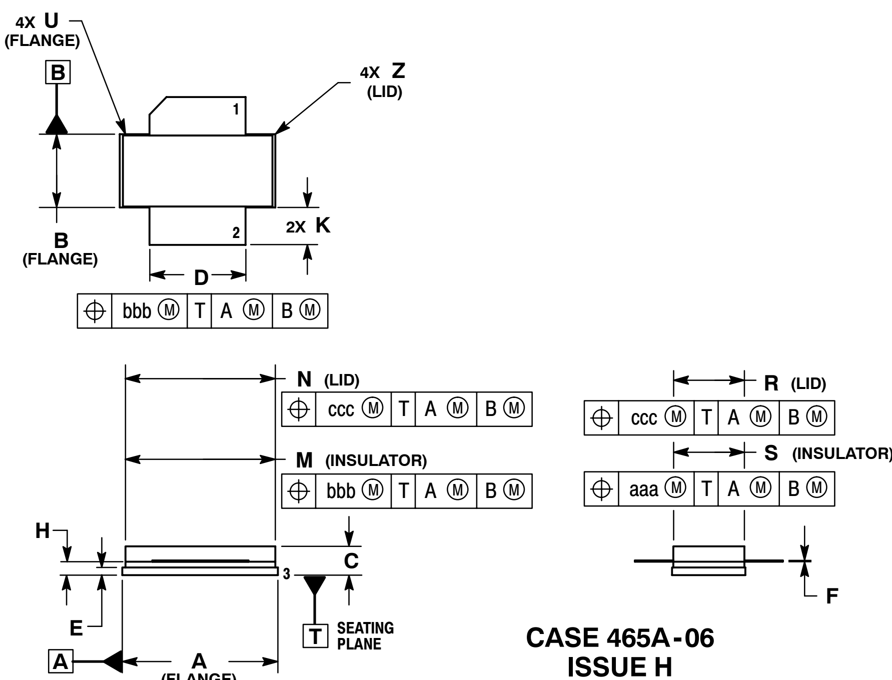


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M−1994.
2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	1.335	1.345	33.91	34.16
B	0.380	0.390	9.65	9.91
C	0.125	0.170	3.18	4.32
D	0.495	0.505	12.57	12.83
E	0.035	0.045	0.89	1.14
F	0.003	0.006	0.08	0.15
G	1.100 BSC		27.94 BSC	
H	0.057	0.067	1.45	1.70
K	0.170	0.210	4.32	5.33
M	0.774	0.786	19.66	19.96
N	0.772	0.788	19.60	20.00
Q	∅.118	∅.138	∅3.00	∅3.51
R	0.365	0.375	9.27	9.53
S	0.365	0.375	9.27	9.52
aaa	0.005 REF		0.127 REF	
bbb	0.010 REF		0.254 REF	
ccc	0.015 REF		0.381 REF	

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

CASE 465-06
ISSUE G
NI-780
MRF6S9160HR3



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3. DELETED
4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.805	0.815	20.45	20.70
B	0.380	0.390	9.65	9.91
C	0.125	0.170	3.18	4.32
D	0.495	0.505	12.57	12.83
E	0.035	0.045	0.89	1.14
F	0.003	0.006	0.08	0.15
H	0.057	0.067	1.45	1.70
K	0.170	0.210	4.32	5.33
M	0.774	0.786	19.61	20.02
N	0.772	0.788	19.61	20.02
R	0.365	0.375	9.27	9.53
S	0.365	0.375	9.27	9.52
U	---	0.040	---	1.02
Z	---	0.030	---	0.76
aaa	0.005 REF		0.127 REF	
bbb	0.010 REF		0.254 REF	
ccc	0.015 REF		0.381 REF	

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

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ISSUE H
NI-780S
MRF6S9160HSR3

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