

# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed for CDMA base station applications with frequencies from 1930 to 1990 MHz. Suitable for CDMA and multicarrier amplifier applications. To be used in Class AB and Class C for TD-SCDMA and PCN-PCS/cellular radio applications.

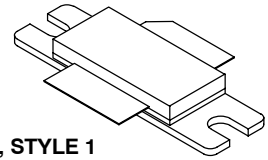
- Typical Single-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 750$  mA,  $P_{out} = 24$  Watts Avg., Full Frequency Band, 3GPP Test Model 1, 64 DPCH with 50% Clipping, Channel Bandwidth = 3.84 MHz, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF.  
Power Gain — 18 dB  
Drain Efficiency — 32%  
Device Output Signal PAR — 6.2 dB @ 0.01% Probability on CCDF  
ACPR @ 5 MHz Offset — -38 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 32 Vdc, 1960 MHz, 80 Watts CW Peak Tuned Output Power
- $P_{out}$  @ 1 dB Compression Point  $\geq 80$  Watts CW

### Features

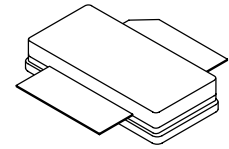
- 100% PAR Tested for Guaranteed Output Power Capability
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- Designed for Digital Predistortion Error Correction Systems
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

**MRF7S19080HR3**  
**MRF7S19080HSR3**

**1930-1990 MHz, 24 W AVG., 28 V**  
**SINGLE W-CDMA**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**



**CASE 465-06, STYLE 1**  
**NI-780**  
**MRF7S19080HR3**



**CASE 465A-06, STYLE 1**  
**NI-780S**  
**MRF7S19080HSR3**

**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5, +65	Vdc
Gate-Source Voltage	$V_{GS}$	-6.0, +10	Vdc
Operating Voltage	$V_{DD}$	32, +0	Vdc
Storage Temperature Range	$T_{stg}$	-65 to +150	°C
Case Operating Temperature	$T_C$	150	°C
Operating Junction Temperature (1,2)	$T_J$	225	°C

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$		°C/W
Case Temperature 81°C, 79 W CW		0.60	
Case Temperature 79°C, 24 W CW		0.69	

1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at <http://www.freescale.com/rf>. Select Tools/Software/Application Software/Calculators to access the MTTF calculators by product.
3. 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. 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 ( $V_{DS} = 65\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	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	$\mu\text{Adc}$
<b>On Characteristics</b>					
Gate Threshold Voltage ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 174\ \mu\text{Adc}$ )	$V_{GS(th)}$	1.2	2	2.7	Vdc
Gate Quiescent Voltage ( $V_{DS} = 28\text{ Vdc}$ , $I_D = 750\text{ mAdc}$ , Measured in Functional Test)	$V_{GS(Q)}$	2	2.7	3.8	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 1.74\text{ Adc}$ )	$V_{DS(on)}$	0.1	0.21	0.3	Vdc
<b>Dynamic Characteristics</b> <sup>(1)</sup>					
Reverse Transfer Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{rss}$	—	0.64	—	pF
Output Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{oss}$	—	297	—	pF

**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 750\text{ mA}$ ,  $P_{out} = 24\text{ W Avg.}$ ,  $f = 1932.5\text{ MHz}$  and  $f = 1987.5\text{ MHz}$ , Single-Carrier W-CDMA, 3GPP Test Model 1, 64 DPCH, 50% Clipping, PAR = 7.5 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5\text{ MHz}$  Offset.

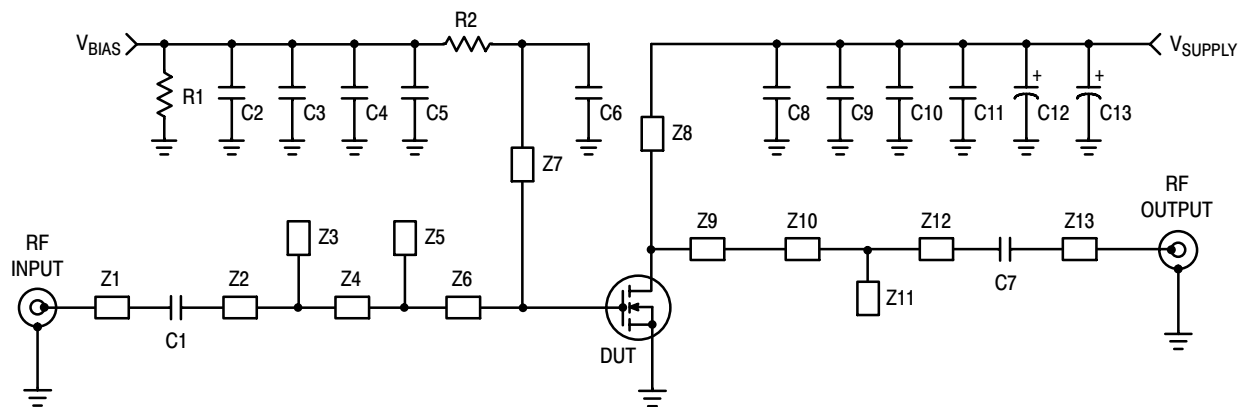
Power Gain	$G_{ps}$	17	18	20	dB
Drain Efficiency	$\eta_D$	30	32	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	5.7	6.2	—	dB
Adjacent Channel Power Ratio	ACPR	—	-38	-35	dBc
Input Return Loss	IRL	—	-20	-9	dB

1. Part internally matched both on input and output.

(continued)

**Table 4. Electrical Characteristics** ( $T_C = 25^\circ\text{C}$  unless otherwise noted) (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Typical Performances</b> (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28 \text{ Vdc}$ , $I_{DQ} = 750 \text{ mA}$ , 1930-1990 MHz Bandwidth					
Video Bandwidth @ 80 W PEP $P_{out}$ where $IM3 = -30 \text{ dBc}$ (Tone Spacing from 100 kHz to VBW) $\Delta IMD3 = IMD3 @ \text{VBW frequency} - IMD3 @ 100 \text{ kHz} < 1 \text{ dBc}$ (both sidebands)	VBW	—	90	—	MHz
Gain Flatness in 60 MHz Bandwidth @ $P_{out} = 24 \text{ W Avg.}$	$G_F$	—	0.165	—	dB
Average Deviation from Linear Phase in 60 MHz Bandwidth @ $P_{out} = 80 \text{ W CW}$	$\Phi$	—	1.14	—	$^\circ$
Average Group Delay @ $P_{out} = 80 \text{ W CW}$ , $f = 1960 \text{ MHz}$	Delay	—	2.25	—	ns
Part-to-Part Insertion Phase Variation @ $P_{out} = 80 \text{ W CW}$ , $f = 1960 \text{ MHz}$ , Six Sigma Window	$\Delta\Phi$	—	22.3	—	$^\circ$
Gain Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta G$	—	0.009	—	dB/ $^\circ\text{C}$
Output Power Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta P_{1dB}$	—	0.017	—	dBm/ $^\circ\text{C}$



Z1	0.530" x 0.084" Microstrip	Z8	0.306" x 0.388" x 0.090" Taper
Z2	0.336" x 0.084" Microstrip	Z9	0.880" x 0.201" x 0.795" Taper
Z3	0.211" x 0.180" x 0.084" Taper	Z10	0.415" x 0.084" Microstrip
Z4	0.704" x 0.216" Microstrip	Z11	0.191" x 0.243" x 0.084" Taper
Z5	0.220" x 0.216" x 0.084" Taper	Z12	0.510" x 0.084" Microstrip
Z6	0.504" x 0.800" x 0.084" Taper	Z13	0.525" x 0.084" Microstrip
Z7	0.265" x 0.313" x 0.332" x 0.040" Taper	PCB	Arlon, GX-0300-55-22, 0.030", $\epsilon_r = 2.55$

**Figure 1. MRF7S19080HR3(HSR3) Test Circuit Schematic**

**Table 5. MRF7S19080HR3(HSR3) Test Circuit Component Designations and Values**

Part	Description	Part Number	Manufacturer
C1, C7	15 pF Chip Capacitors	ATC100B150JT500XT	ATC
C2, C11	13 pF Chip Capacitors	ATC100B130JT500XT	ATC
C3	10 $\mu$ F Chip Capacitor	GRM31MF51A106ZA01B	TDK
C4	1000 pF Chip Capacitor	ATC100B102JT50XT	ATC
C5, C10	0.1 $\mu$ F Chip Capacitors	C1206C104K5RAC	Kemet
C6	5.1 pF Chip Capacitor	ATC100B5R1CT500XT	ATC
C8	6.8 pF Chip Capacitor	ATC100B6R8CT500XT	ATC
C9	2.2 $\mu$ F Chip Capacitor	C1825C225J5RAC	Kemet
C12	470 $\mu$ F, 63 V Electrolytic Capacitor	MCR63V477M13X26	Multicomp
C13	100 $\mu$ F, 50 V Electrolytic Capacitor	MCR50V107M8X11	Multicomp
R1	330 $\Omega$ , 1/4 W Chip Resistor	CRCW12063300FKTA	Vishay
R2	10 $\Omega$ , 1/4 W Chip Resistor	CRCW120610R0FKTA	Vishay

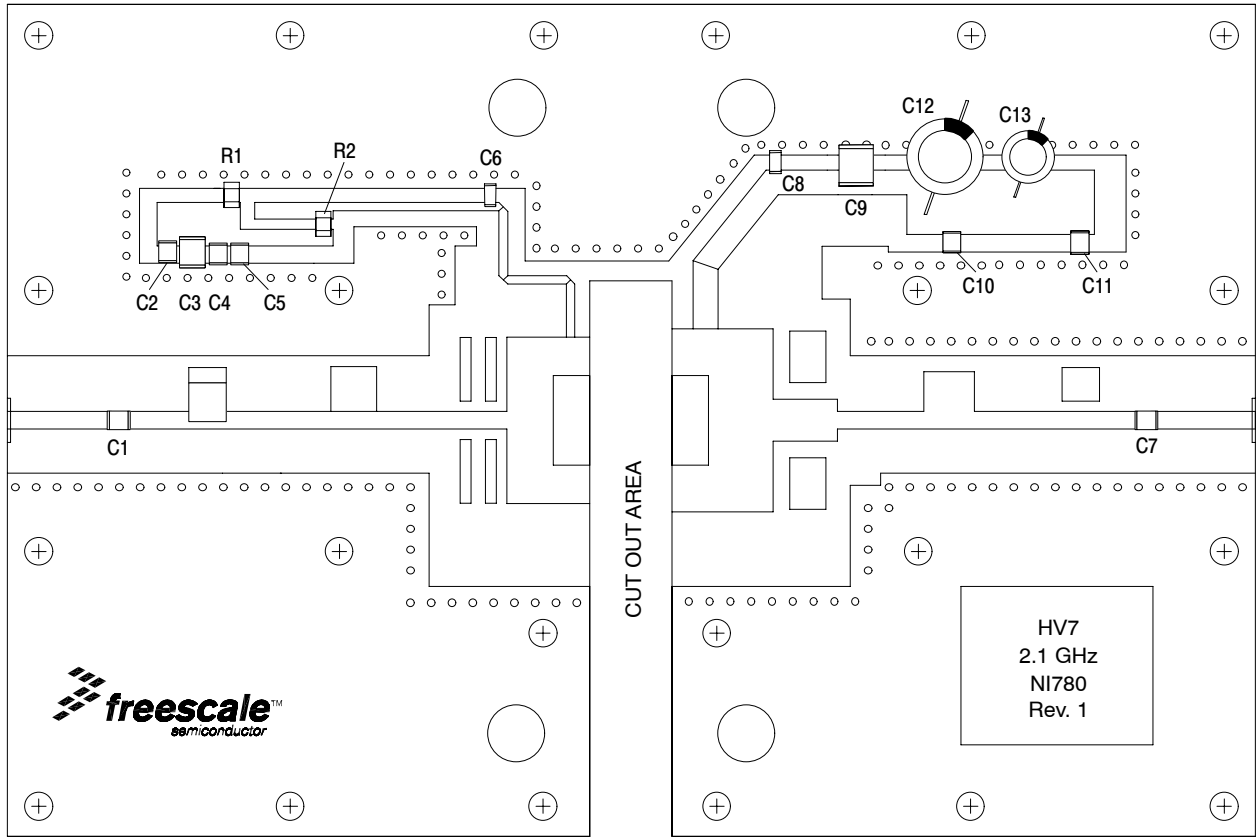
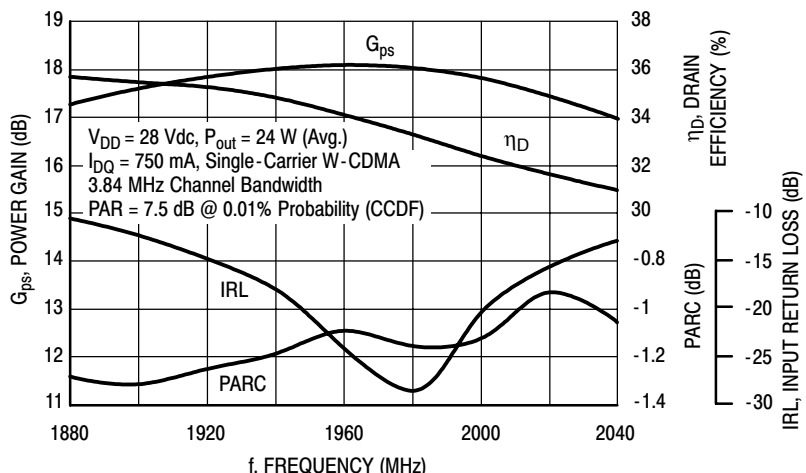
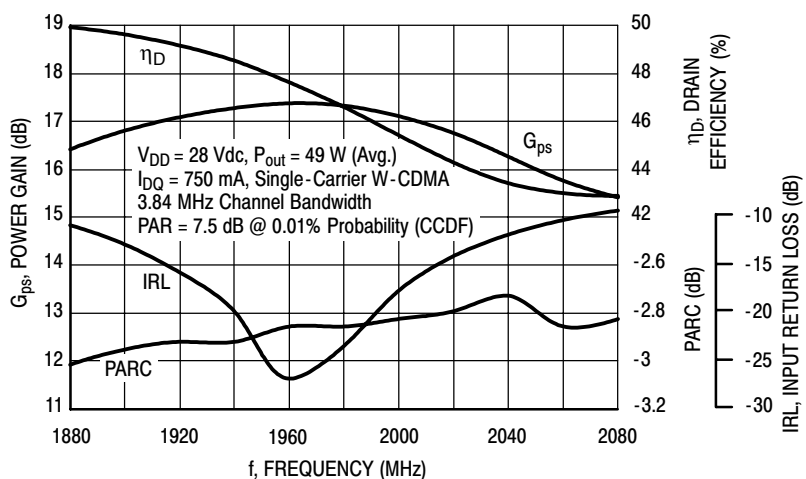


Figure 2. MRF7S19080HR3(HSR3) Test Circuit Component Layout

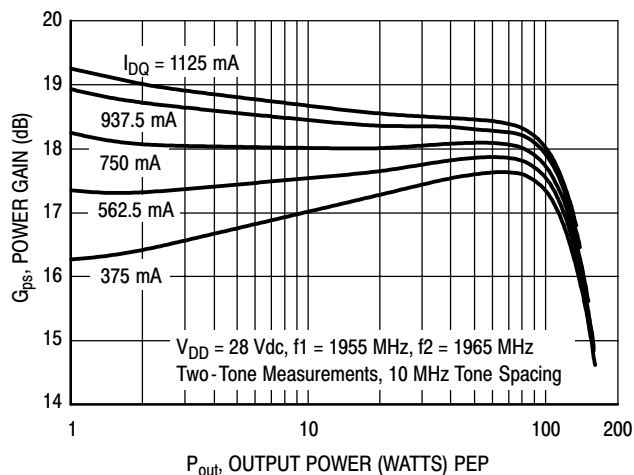
## TYPICAL CHARACTERISTICS



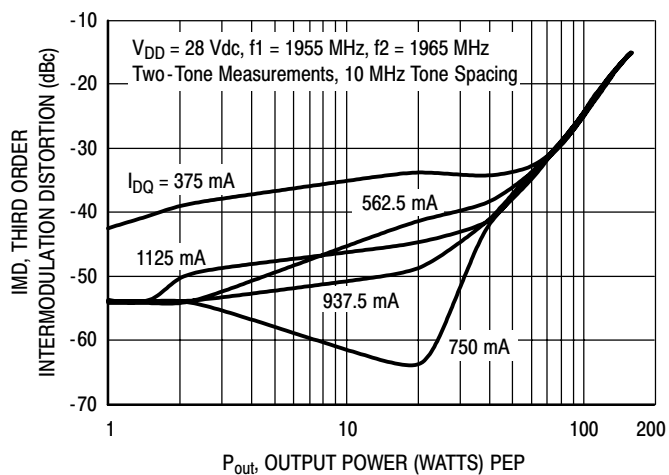
**Figure 3. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 24$  Watts Avg.**



**Figure 4. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 49$  Watts Avg.**

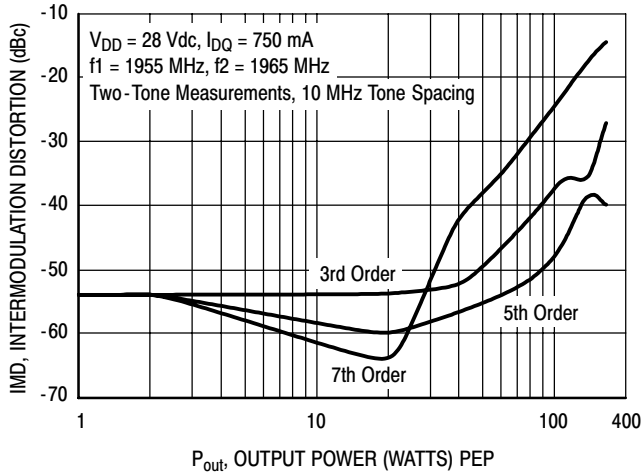


**Figure 5. Two-Tone Power Gain versus Output Power**

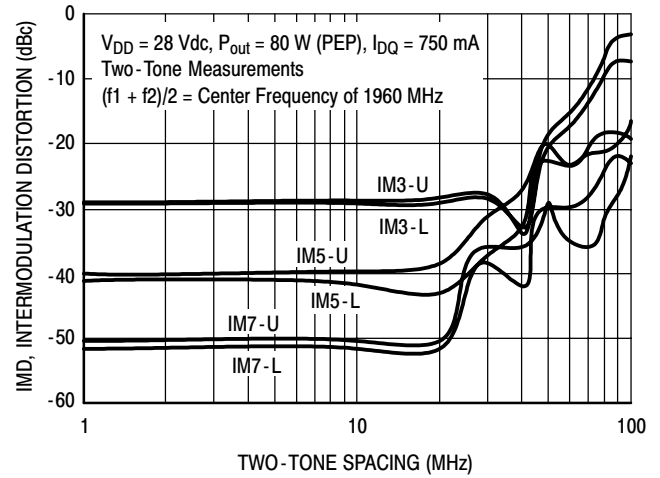


**Figure 6. Third Order Intermodulation Distortion versus Output Power**

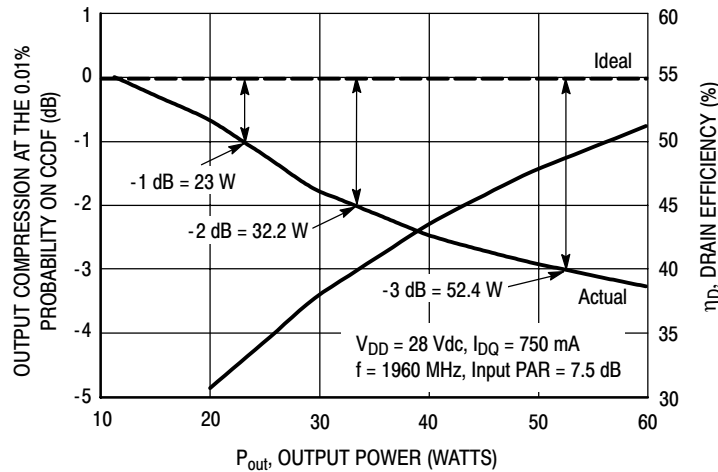
## TYPICAL CHARACTERISTICS



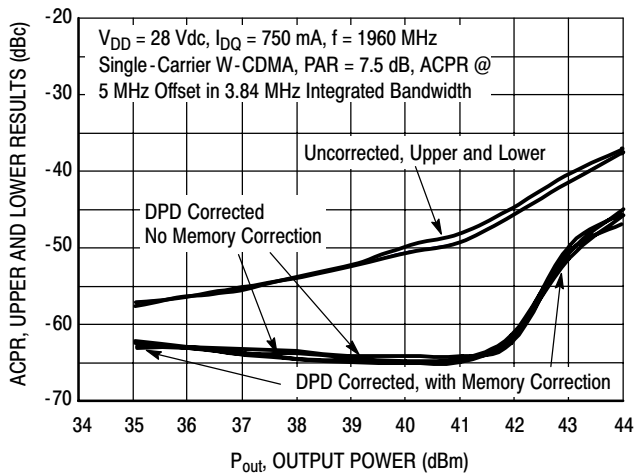
**Figure 7. Intermodulation Distortion Products versus Output Power**



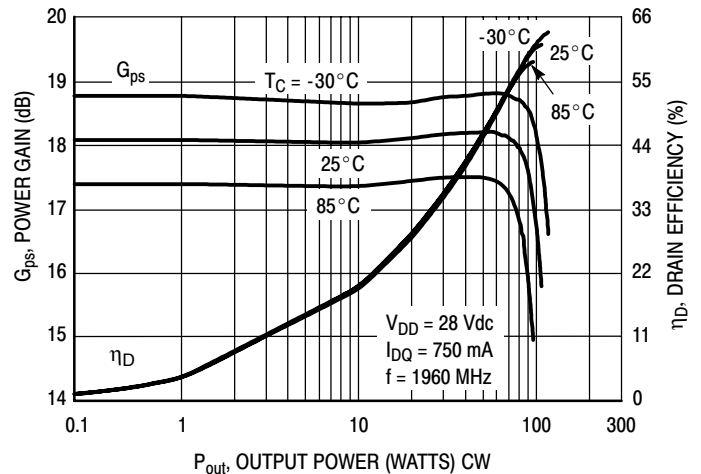
**Figure 8. Intermodulation Distortion Products versus Tone Spacing**



**Figure 9. Output Peak-to-Average Ratio Compression (PARC) versus Output Power**



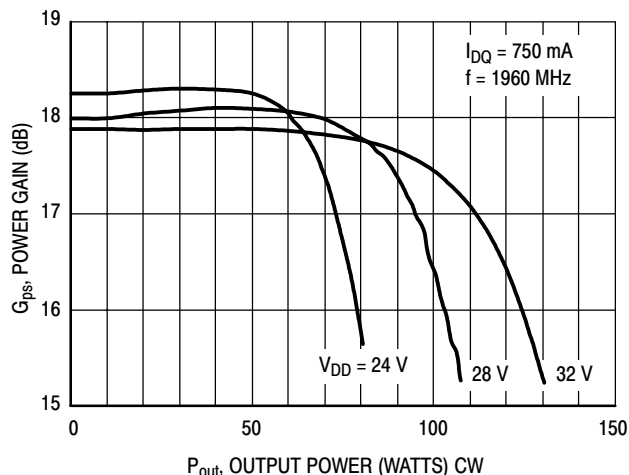
**Figure 10. Digital Predistortion Correction versus ACPR and Output Power**



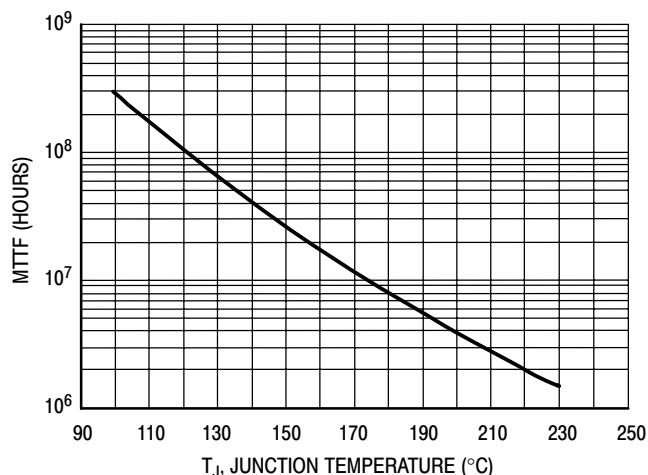
**Figure 11. Power Gain and Drain Efficiency versus CW Output Power**

MRF7S19080HR3 MRF7S19080HSR3

## TYPICAL CHARACTERISTICS



**Figure 12. Power Gain versus Output Power**

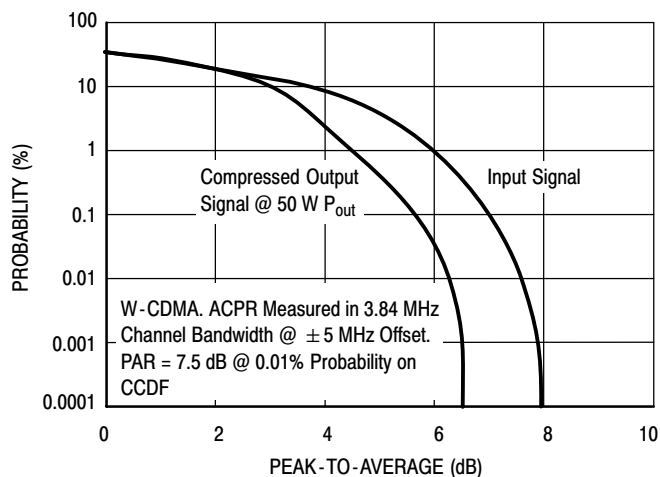


This above graph displays calculated MTTF in hours when the device is operated at  $V_{DD} = 28$  Vdc,  $P_{out} = 24$  W Avg., and  $\eta_D = 32\%$ .

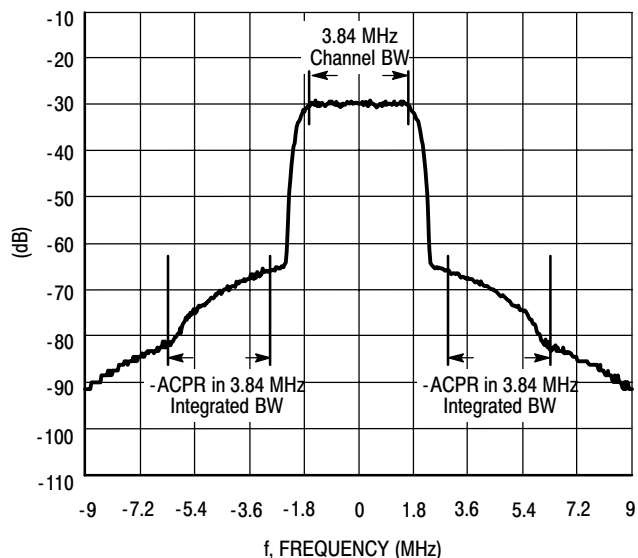
MTTF calculator available at <http://www.freescale.com/rf>. Select Tools/Software/Application Software/Calculators to access the MTTF calculators by product.

**Figure 13. MTTF versus Junction Temperature**

## W-CDMA TEST SIGNAL

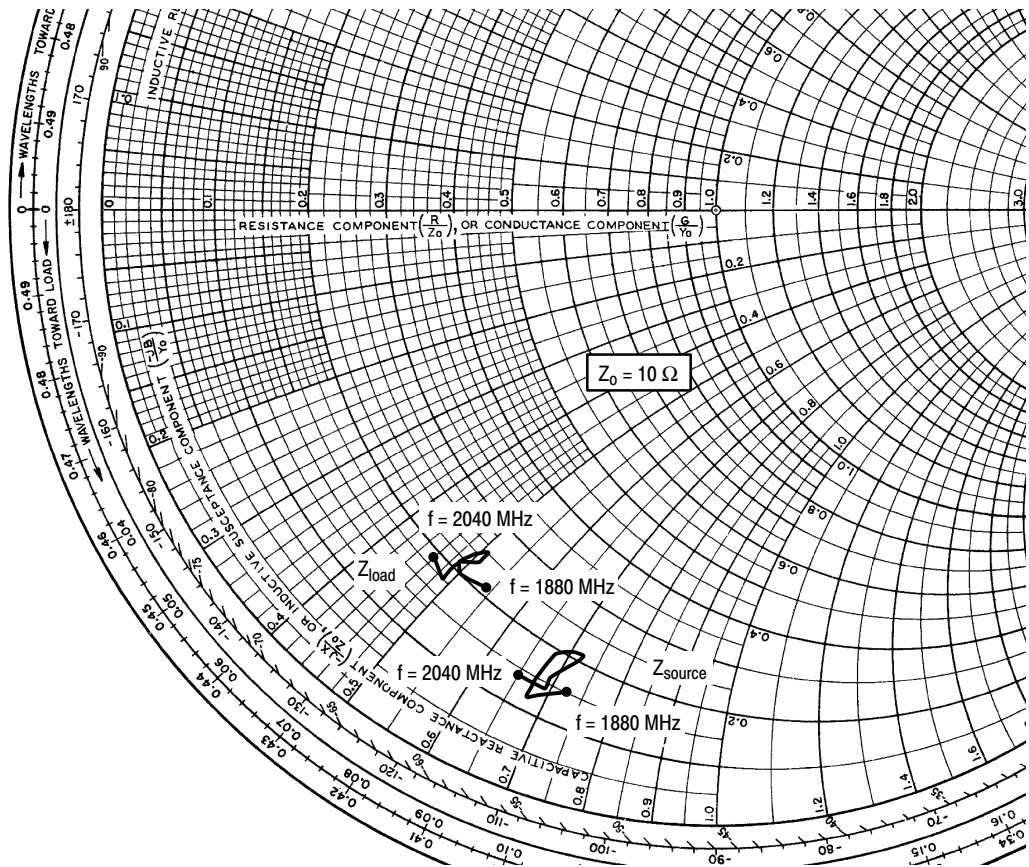


**Figure 14. CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 50% Clipping, Single-Carrier Test Signal**



**Figure 15. Single-Carrier W-CDMA Spectrum**





$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 750 \text{ mA}$ ,  $P_{out} = 24 \text{ W Avg.}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
1880	$1.47 - j7.3$	$2.10 - j5.4$
1900	$1.22 - j6.7$	$1.96 - j5.0$
1920	$1.43 - j6.7$	$2.06 - j4.9$
1940	$1.89 - j6.8$	$2.27 - j5.1$
1960	$2.10 - j7.1$	$2.45 - j5.1$
1980	$2.11 - j7.2$	$2.38 - j5.0$
2000	$1.60 - j6.9$	$2.08 - j4.9$
2020	$1.41 - j6.9$	$1.84 - j4.9$
2040	$1.43 - j6.5$	$1.89 - j4.6$

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

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

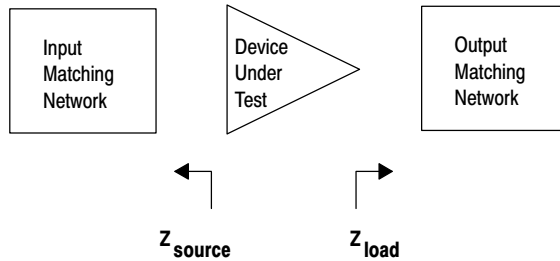
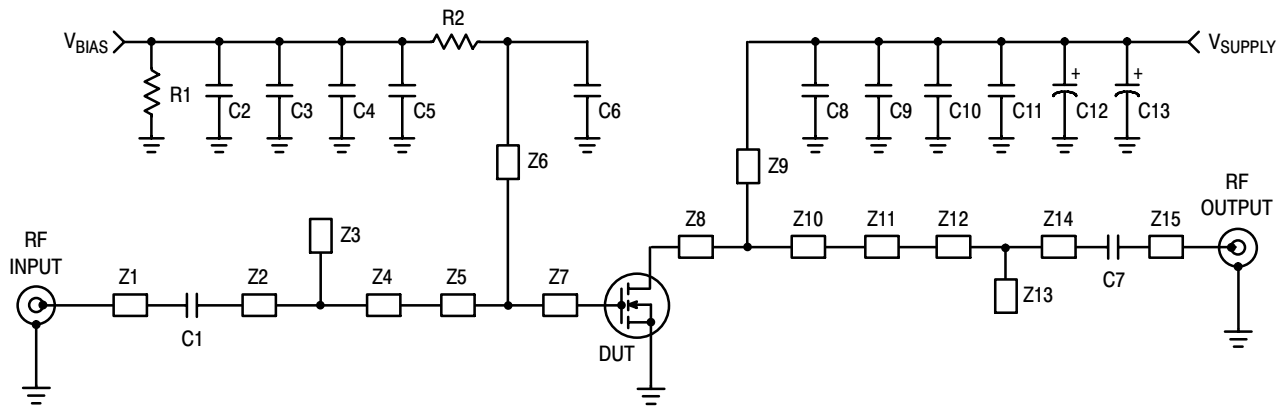


Figure 16. Series Equivalent Source and Load Impedance

## TD-SCDMA CHARACTERIZATION



Z1	0.490" x 0.084" Microstrip	Z9	0.432" x 0.121" Microstrip
Z2	1.082" x 0.084" Microstrip	Z10	0.327" x 0.974" Microstrip
Z3	0.131" x 0.220" Microstrip	Z11	0.505" x 0.201" Microstrip
Z4	0.734" x 0.084" Microstrip	Z12	0.220" x 0.084" Microstrip
Z5	0.308" x 0.800" Microstrip	Z13	0.191" x 0.243" Microstrip
Z6	0.889" x 0.040" Microstrip	Z14	0.781" x 0.084" Microstrip
Z7	0.092" x 0.800" Microstrip	Z15	0.500" x 0.084" Microstrip
Z8	0.160" x 0.880" Microstrip	PCB	Arlon, GX-0300-55-22, 0.030", $\epsilon_r = 2.55$

**Figure 17. MRF7S19080HR3(HSR3) Test Circuit Schematic — TD-SCDMA**

**Table 6. MRF7S19080HR3(HSR3) Test Circuit Component Designations and Values — TD-SCDMA**

Part	Description	Part Number	Manufacturer
C1, C7	15 pF Chip Capacitors	ATC100B150JT500XT	ATC
C2, C11	13 pF Chip Capacitors	ATC100B130JT500XT	ATC
C3	10 $\mu$ F Chip Capacitor	GRM31MF51A106ZA01B	TDK
C4	1000 pF Chip Capacitor	ATC100B102JT50XT	ATC
C5, C10	0.1 $\mu$ F Chip Capacitors	C1206C104K5RAC	Kemet
C6	5.1 pF Chip Capacitor	ATC100B5R1CT500XT	ATC
C8	6.8 pF Chip Capacitor	ATC100B6R8CT500XT	ATC
C9	2.2 $\mu$ F Chip Capacitor	C1825C225J5RAC	Kemet
C12	470 $\mu$ F, 63 V Electrolytic Capacitor	MCR63V477M13X26	Multicomp
C13	100 $\mu$ F, 50 V Electrolytic Capacitor	MCR50V107M8X11	Multicomp
R1	330 $\Omega$ , 1/4 W Chip Resistor	CRCW12063300FKTA	Vishay
R2	10 $\Omega$ , 1/4 W Chip Resistor	CRCW120610R0FKTA	Vishay

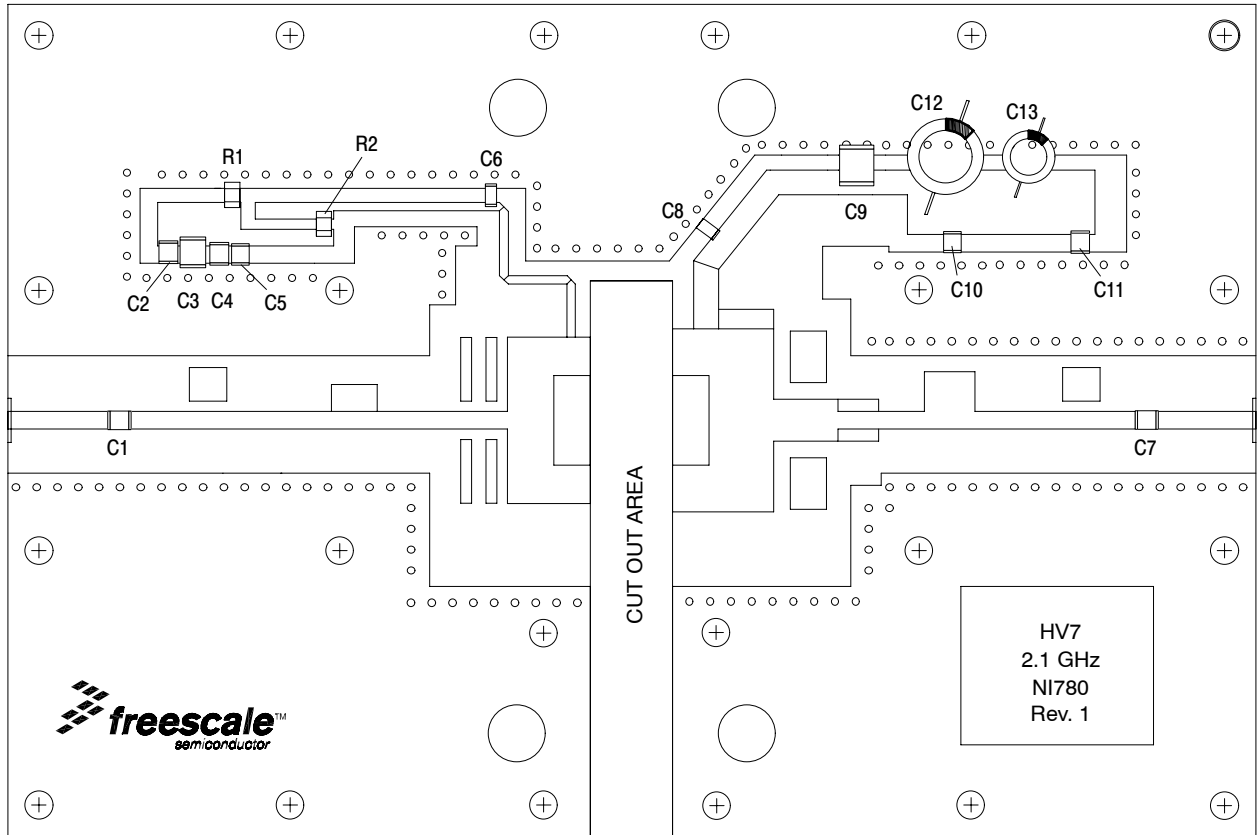
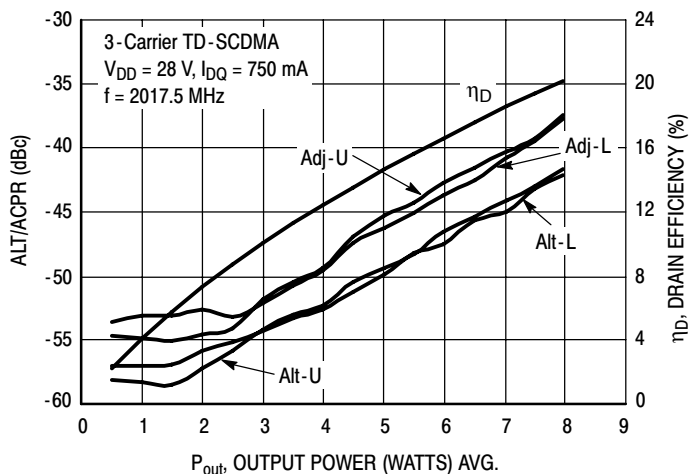
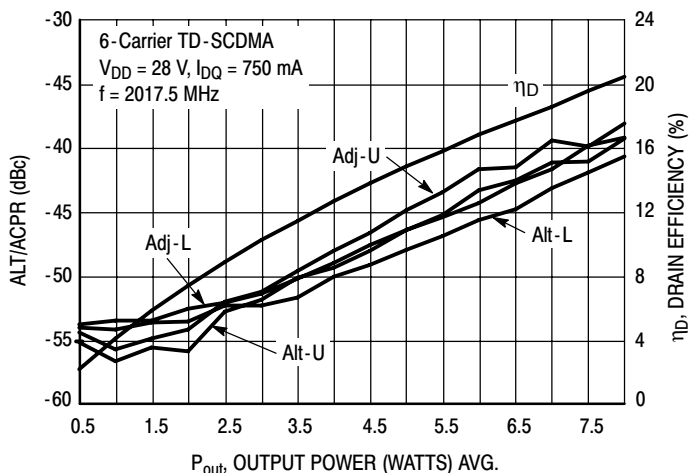


Figure 18. MRF7S19080HR3(HSR3) Test Circuit Component Layout — TD-SCDMA

## TYPICAL CHARACTERISTICS

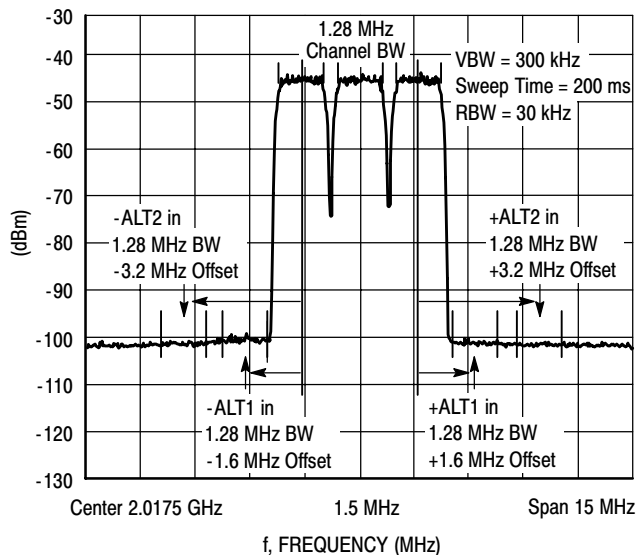


**Figure 19. 3-Carrier TD-SCDMA ACPR, ALT and Drain Efficiency versus Output Power**

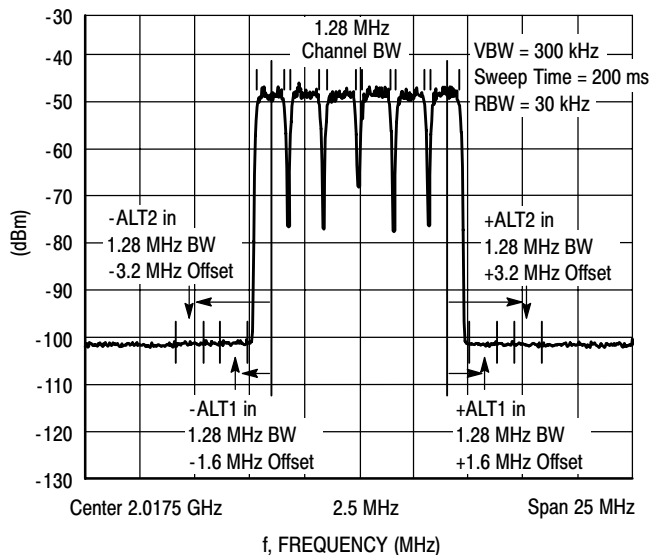


**Figure 20. 6-Carrier TD-SCDMA ACPR, ALT and Drain Efficiency versus Output Power**

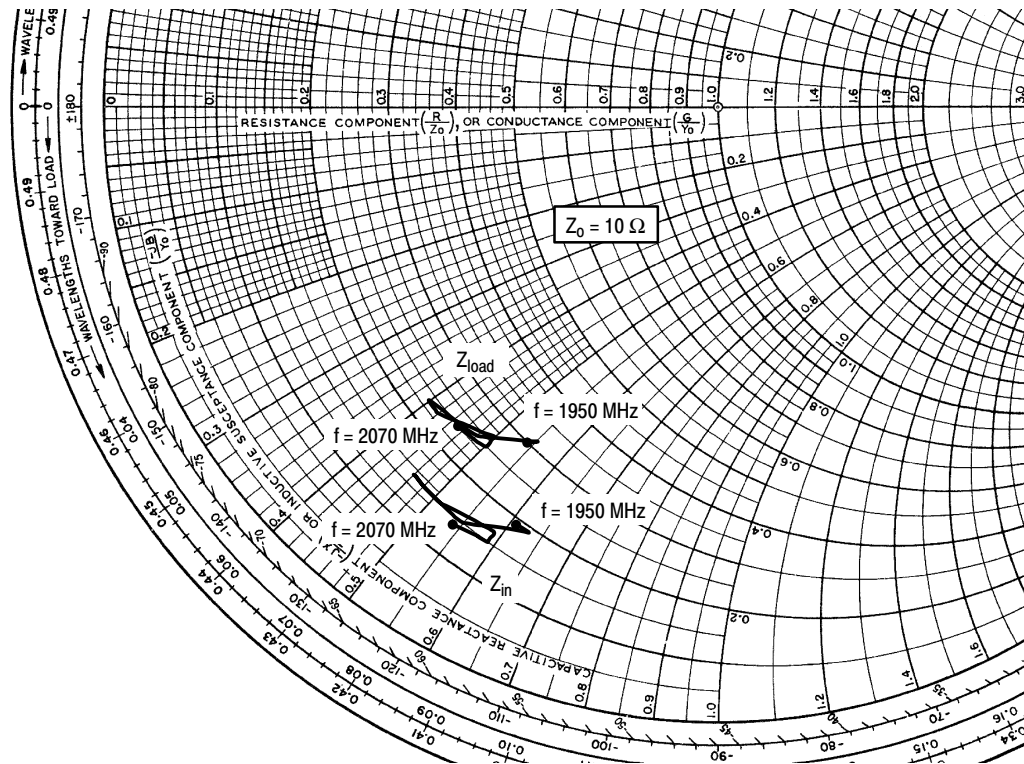
## TD-SCDMA TEST SIGNAL



**Figure 21. 3-Carrier TD-SCDMA Spectrum**



**Figure 22. 6-Carrier TD-SCDMA Spectrum**



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 750 \text{ mA}$

f MHz	$Z_{in}$ $\Omega$	$Z_{load}$ $\Omega$
1950	$1.87 - j6.10$	$2.98 - j5.42$
1960	$1.94 - j6.25$	$3.07 - j5.47$
1970	$1.77 - j6.04$	$2.87 - j5.26$
1980	$1.52 - j5.47$	$2.53 - j4.77$
1990	$1.46 - j4.92$	$2.35 - j4.26$
2000	$1.49 - j4.62$	$2.30 - j3.99$
2010	$1.53 - j4.64$	$2.34 - j3.98$
2020	$1.50 - j4.85$	$2.34 - j4.20$
2030	$1.50 - j5.15$	$2.40 - j4.44$
2040	$1.62 - j5.56$	$2.59 - j4.75$
2050	$1.63 - j5.90$	$2.68 - j5.03$
2060	$1.47 - j5.86$	$2.52 - j4.98$
2070	$1.38 - j5.40$	$2.35 - j4.54$

$Z_{in}$  = Device input impedance as measured from gate to ground.

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

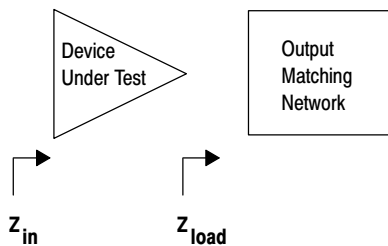
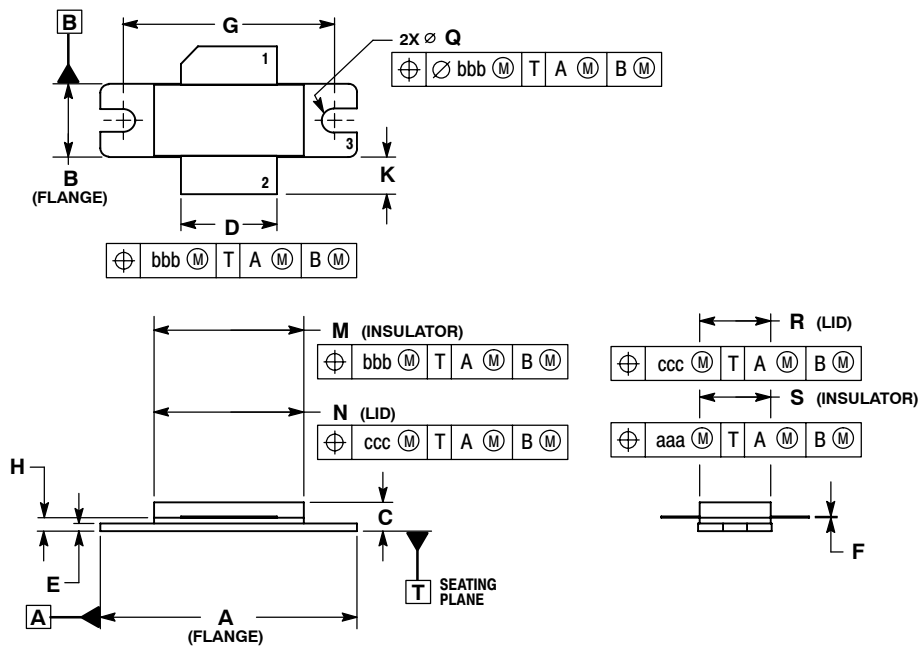


Figure 23. Series Equivalent Input and Load Impedance — TD-SCDMA

## PACKAGE DIMENSIONS

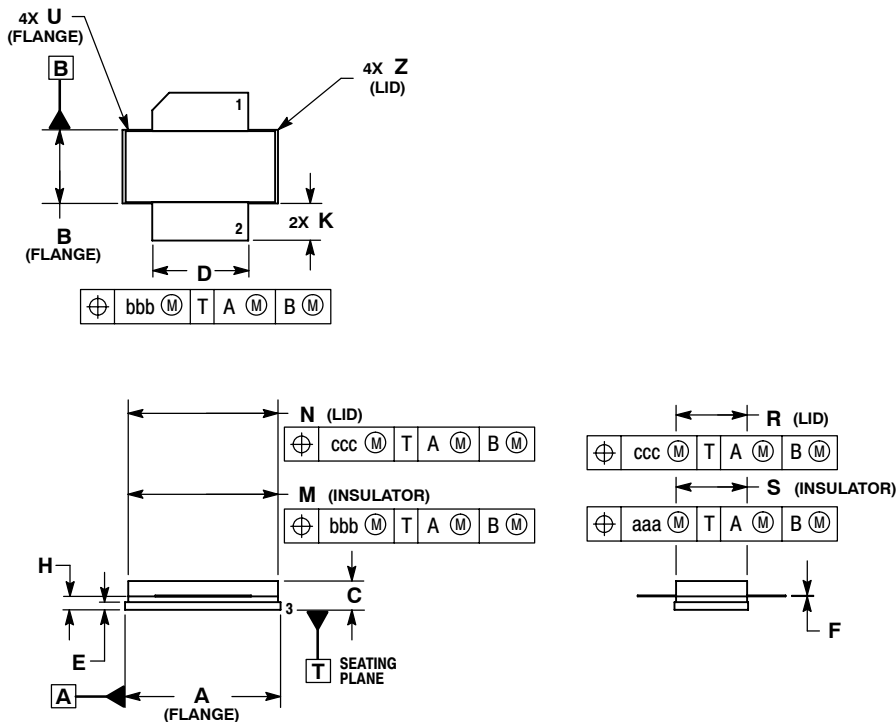


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
  2. CONTROLLING DIMENSION: INCH.
  3. DELETED
  4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

DIM	INCHES		MILLIMETERS	
	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	Ø .118	Ø .138	Ø 3.00	Ø 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  
 MRF7S19080HR3**



- 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.

DIM	INCHES		MILLIMETERS	
	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

**CASE 465A-06  
 ISSUE H  
 NI-780S  
 MRF7S19080HSR3**

## PRODUCT DOCUMENTATION

Refer to the following documents to aid your design process.

### Application Notes

- AN1955: Thermal Measurement Methodology of RF Power Amplifiers

### Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

## REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	Jan. 2007	<ul style="list-style-type: none"><li>• Initial Release of Data Sheet</li></ul>

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