√RoHS

RF Power Field Effect Transistors
N‑Channel Enhancement‑Mode Lateral MOSFETs

Designed for CDMA base station applications with frequencies from 1930 to 1990 MHz. Can be used in Class AB and Class C for all typical cellular base station modulations.

- Typical Single‑Carrier W‑CDMA Performance: V_{DD} = 28 Volts, I_{DQ} = 1400 mA, P_{out} = 50 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 — 17.2 dB
  - Drain Efficiency — 32%
  - Device Output Signal PAR — 6.2 dB @ 0.01% Probability on CCDF
  - ACPR @ 5 MHz Offset — -37.5 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 5:1 VSWR, @ 32 Vdc, 1960 MHz, 170 Watts CW Output Power
- P_{out} @ 1 dB Compression Point $\geq$ 170 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.

MRF7S19170HR3
MRF7S19170HSR3

**1930‑1990 MHz, 50 W AVG., 28 V
SINGLE W‑CDMA
LATERAL N‑CHANNEL
RF POWER MOSFETs**
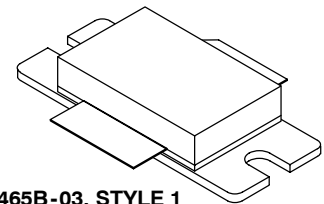
**CASE 465B‑03, STYLE 1
NI‑880
MRF7S19170HR3**
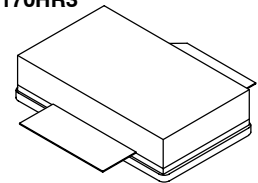
**CASE 465C‑02, STYLE 1
NI‑880S
MRF7S19170HSR3**

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 Case Temperature 80°C, 170 W CW Case Temperature 72°C, 25 W CW	$R_{\theta JC}$	 0.25 0.31	°C/W

1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at http://www.freescale.com/rf. Select Software & Tools/Development Tools/Calculators to access 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.

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Table 3. ESD Protection Characteristics

Test Methodology	Class
Human Body Model (per JESD22‑A114)	1A (Minimum)
Machine Model (per EIA/JESD22‑A115)	B (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} = 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 = 372 µAdc)	$V_{GS(th)}$	1.2	2	2.7	Vdc
Gate Quiescent Voltage (V_{DS} = 28 Vdc, I_D = 1400 mAdc)	$V_{GS(Q)}$	—	2.7	—	Vdc
Fixture Gate Quiescent Voltage [1] (V_{DD} = 28 Vdc, I_D = 1400 mAdc, Measured in Functional Test)	$V_{GG(Q)}$	4	5.4	7.6	Vdc
Drain‑Source On‑Voltage (V_{GS} = 10 Vdc, I_D = 3.72 Adc)	$V_{DS(on)}$	0.1	0.15	0.3	Vdc
Dynamic Characteristics [2]					
Reverse Transfer Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	0.9	—	pF
Output Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	703	—	pF

Functional Tests (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1400 mA, P_{out} = 50 W Avg., f = 1932.5 MHz and f = 1987.5 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 @ ±5 MHz Offset.

Power Gain	G_{ps}	16	17.2	19	dB
Drain Efficiency	η_D	29	32	—	%
Output Peak‑to‑Average Ratio @ 0.01% Probability on CCDF	PAR	5.7	6.2	—	dB
Adjacent Channel Power Ratio	ACPR	—	-37.5	-35	dBc
Input Return Loss	IRL	—	-16	-9	dB

1. V_{GG} = 2 x $V_{GS(Q)}$. Parameter measured on Freescale Test Fixture, due to resistive divider network on the board. Refer to Test Circuit schematic.
2. Part internally matched both on input and output.

(continued)

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Table 4. Electrical Characteristics (T_C = 25°C unless otherwise noted) — **continued**

Characteristic	Symbol	Min	Typ	Max	Unit
Typical Performances (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1400 mA, 1930-1990 MHz Bandwidth					
Video Bandwidth @ 170 W PEP P_{out} where IM3 = -30 dBc (Tone Spacing from 100 kHz to VBW) ΔIMD3 = IMD3 @ VBW frequency - IMD3 @ 100 kHz <1 dBc (both sidebands)	VBW	—	25	—	MHz
Gain Flatness in 60 MHz Bandwidth @ P_{out} = 170 W CW	G_F	—	0.5	—	dB
Average Deviation from Linear Phase in 60 MHz Bandwidth @ P_{out} = 170 W CW	Φ	—	2.06	—	°
Average Group Delay @ P_{out} = 170 W CW, f = 1960 MHz	Delay	—	4.7	—	ns
Part-to-Part Insertion Phase Variation @ P_{out} = 170 W CW, f = 1960 MHz, Six Sigma Window	$\Delta\Phi$	—	16	—	°
Gain Variation over Temperature (-30°C to +85°C)	ΔG	—	0.015	—	dB/°C
Output Power Variation over Temperature (-30°C to +85°C)	ΔP1dB	—	0.01	—	dBm/°C

Figure 1. MRF7S19170HR3(HSR3) Test Circuit Schematic
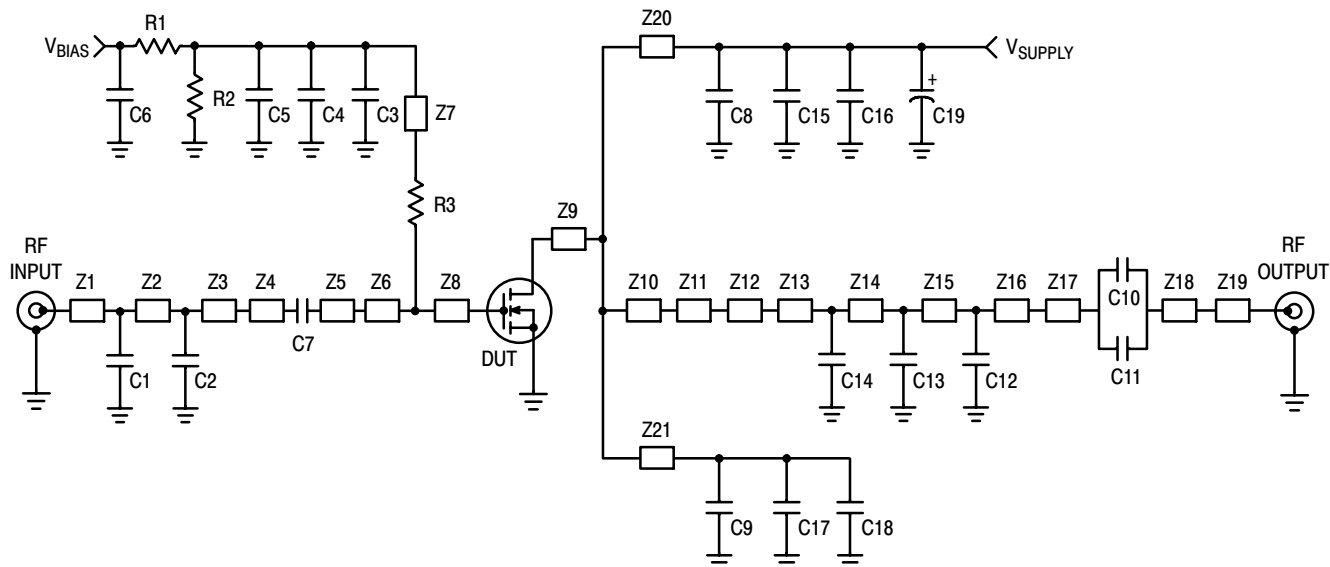
Z1*   0.588″ x 0.083″ Microstrip
Z2*   0.146″ x 0.083″ Microstrip
Z3*   0.068″ x 0.083″ Microstrip
Z4   0.865″ x 0.098″ Microstrip
Z5   0.154″ x 0.098″ Microstrip
Z6   0.271″ x 0.787″ Microstrip
Z7   1.410″ x 0.080″ Microstrip
Z8   0.194″ x 0.787″ Microstrip
Z9   0.115″ x 1.360″ Microstrip
Z10   0.230″ x 1.360″ Microstrip
Z11   0.185″ x 1.120″ Microstrip

Z12   0.060″ x 0.420″ Microstrip
Z13* 0.197″ x 0.083″ Microstrip
Z14* 0.332″ x 0.083″ Microstrip
Z15* 0.158″ x 0.083″ Microstrip
Z16* 0.572″ x 0.083″ Microstrip
Z17, Z18 0.063″ x 0.220″ Microstrip
Z19   0.160″ x 0.083″ Microstrip
Z20, Z21 1.120″ x 0.080″ Microstrip
PCB   Taconic TLX‑0300, 0.030″, $\varepsilon_r = 2.5$

* Variable for tuning

Table 5. MRF7S19170HR3(HSR3) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1, C2	1.8 pF Chip Capacitors	ATC100B1R8BT500XT	ATC
C3, C8, C9, C10, C11	8.2 pF Chip Capacitors	ATC100B8R2CT500XT	ATC
C4	100 pF Chip Capacitor	ATC100B101JT500XT	ATC
C5	100 nF Chip Capacitor	200B104MT	ATC
C6, C15, C16, C17, C18	10 µF Chip Capacitors	C5750X5R1H106MT	TDK
C7	0.5 pF Chip Capacitor	ATC100B0R5BT500XT	ATC
C12	1.5 pF Chip Capacitor	ATC100B1R5BT500XT	ATC
C13	0.3 pF Chip Capacitor	ATC100B0R3BT500XT	ATC
C14	0.8 pF Chip Capacitor	ATC100B0R8BT500XT	ATC
C19	470 µF, 63 V Electrolytic Capacitor, Axial	EKME630ELL471M12X25LL	United Chemi‑Con
R1, R2	10 kΩ, 1/4 W Chip Resistors	CRCW12061002FKEA	Vishay
R3	10 Ω, 1/4 W Chip Resistor	CRCW120610R0FKEA	Vishay

MRF7S19170HR3 MRF7S19170HSR3
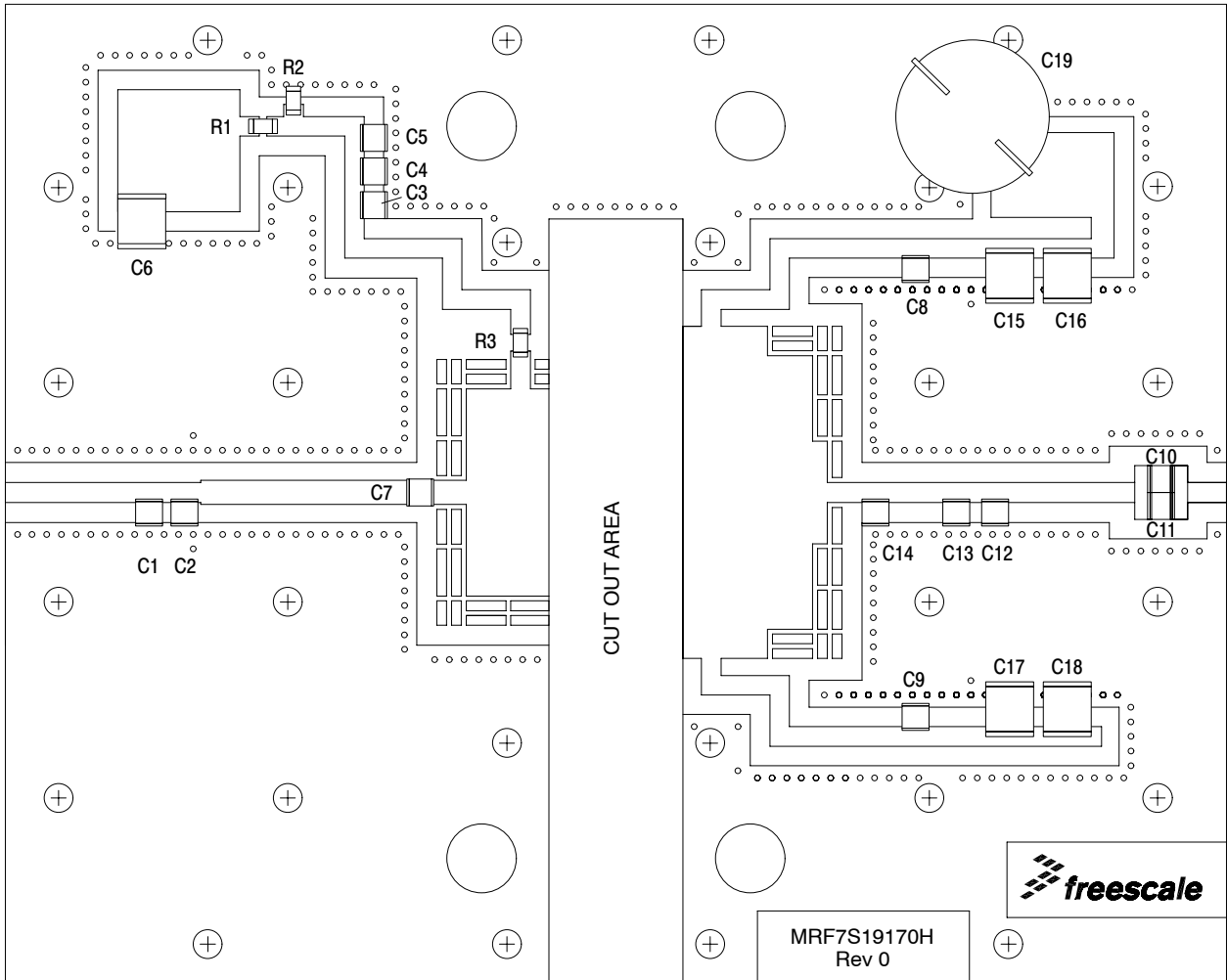
Figure 2. MRF7S19170HR3(HSR3) Test Circuit Component Layout

RF Device Data
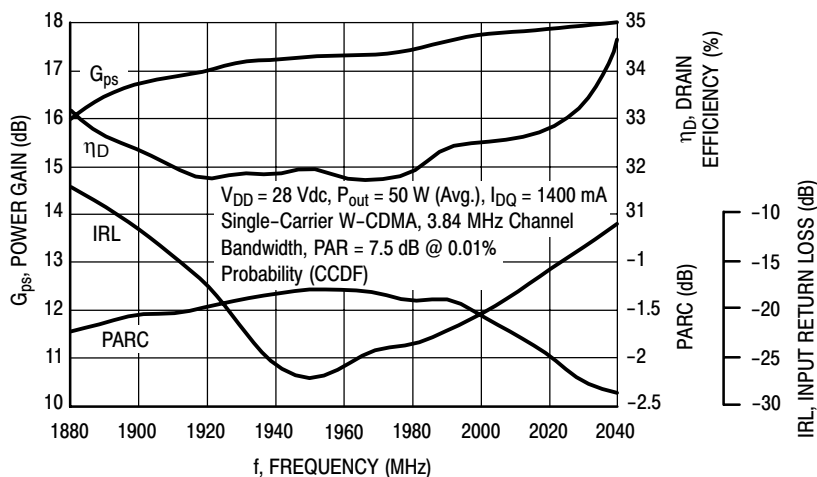Freescale Semiconductor

TYPICAL CHARACTERISTICS

**Figure 3. Output Peak-to-Average Ratio Compression (PARC)
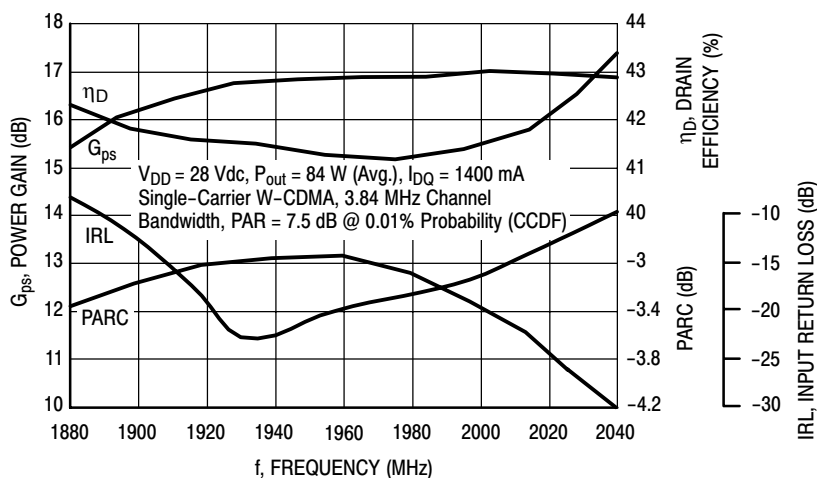Broadband Performance @ P_out = 50 Watts Avg.**

**Figure 4. Output Peak-to-Average Ratio Compression (PARC)
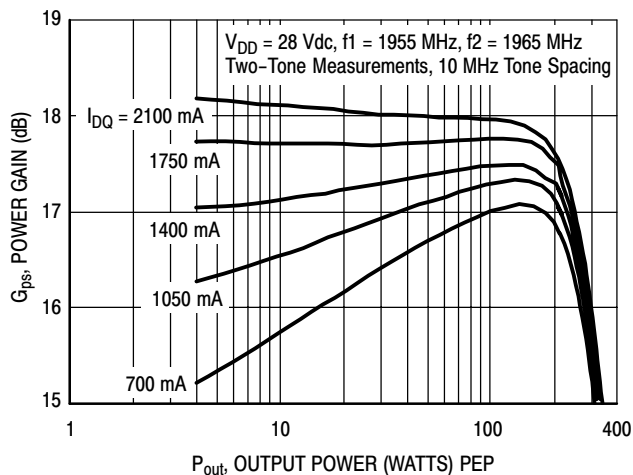Broadband Performance @ P_out = 84 Watts Avg.**

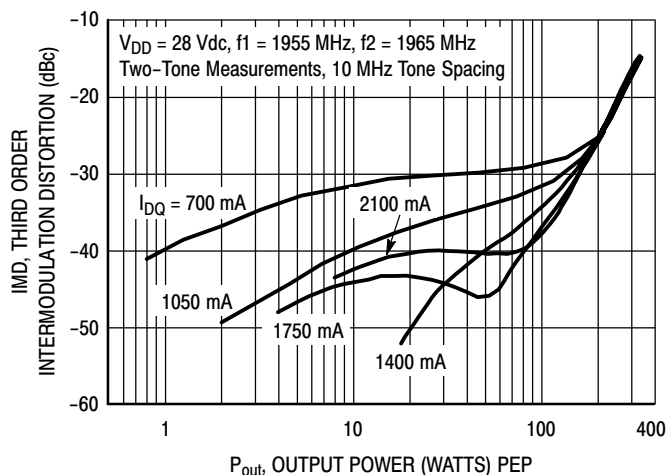
**Figure 5. Two-Tone Power Gain versus
Output Power**

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

MRF7S19170HR3 MRF7S19170HSR3

TYPICAL CHARACTERISTICS
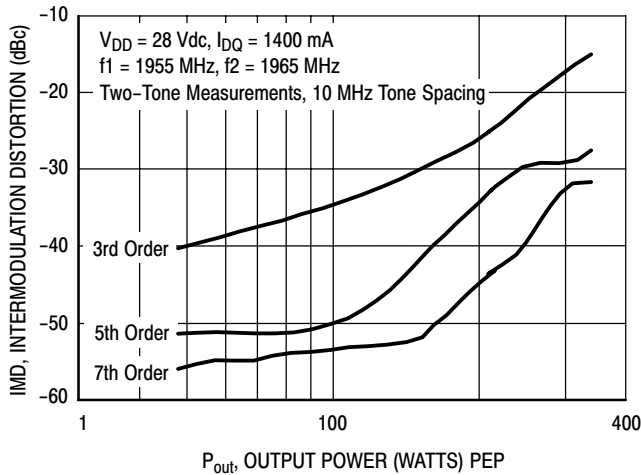
Figure 7. Intermodulation Distortion Products versus Output Power

V_{DD} = 28 Vdc, I_{DQ} = 1400 mA
f1 = 1955 MHz, f2 = 1965 MHz
Two–Tone Measurements, 10 MHz Tone Spacing

3rd Order
5th Order
7th Order

IMD, INTERMODULATION DISTORTION (dBc)
P_{out}, OUTPUT POWER (WATTS) PEP
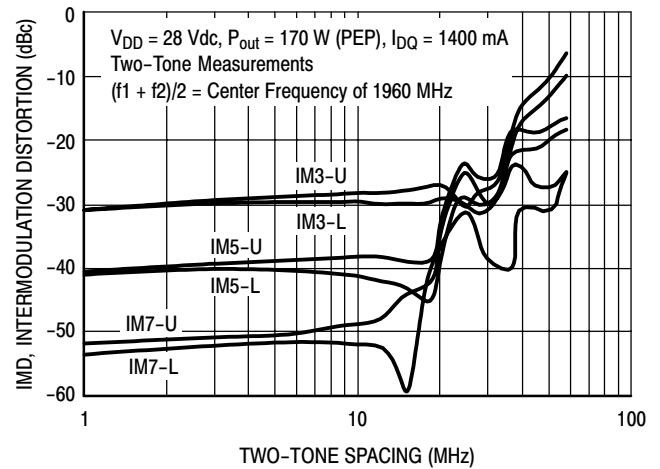
Figure 8. Intermodulation Distortion Products versus Tone Spacing

V_{DD} = 28 Vdc, P_{out} = 170 W (PEP), I_{DQ} = 1400 mA
Two–Tone Measurements
(f1 + f2)/2 = Center Frequency of 1960 MHz

IM3–U
IM3–L
IM5–U
IM5–L
IM7–U
IM7–L

IMD, INTERMODULATION DISTORTION (dBc)
TWO–TONE SPACING (MHz)
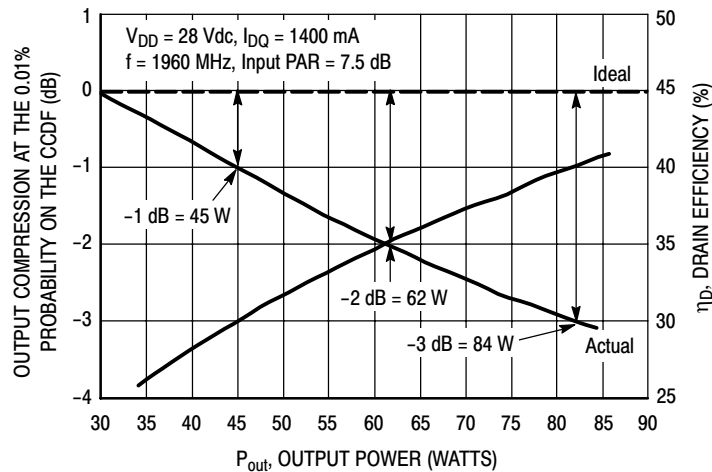
Figure 9. Output Peak‑to‑Average Ratio Compression (PARC) versus Output Power

V_{DD} = 28 Vdc, I_{DQ} = 1400 mA
f = 1960 MHz, Input PAR = 7.5 dB

Ideal
–1 dB = 45 W
–2 dB = 62 W
–3 dB = 84 W
Actual

OUTPUT COMPRESSION AT THE 0.01% PROBABILITY ON THE CCDF (dB)
η_D, DRAIN EFFICIENCY (%)
P_{out}, OUTPUT POWER (WATTS)
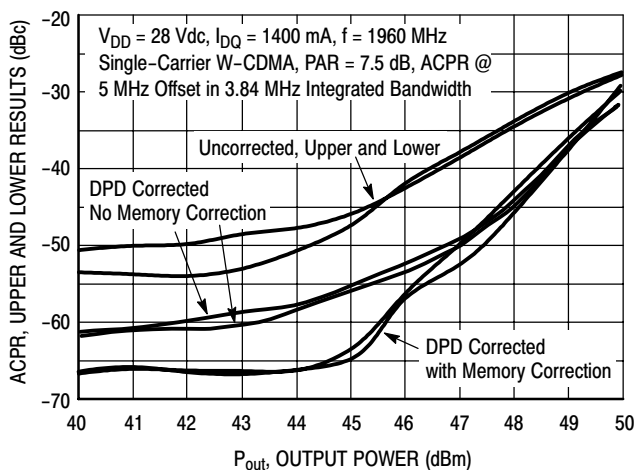
Figure 10. Digital Predistortion Correction versus ACPR and Output Power

V_{DD} = 28 Vdc, I_{DQ} = 1400 mA, f = 1960 MHz
Single–Carrier W–CDMA, PAR = 7.5 dB, ACPR @
5 MHz Offset in 3.84 MHz Integrated Bandwidth

Uncorrected, Upper and Lower
DPD Corrected
No Memory Correction
DPD Corrected
with Memory Correction

ACPR, UPPER AND LOWER RESULTS (dBc)
P_{out}, OUTPUT POWER (dBm)
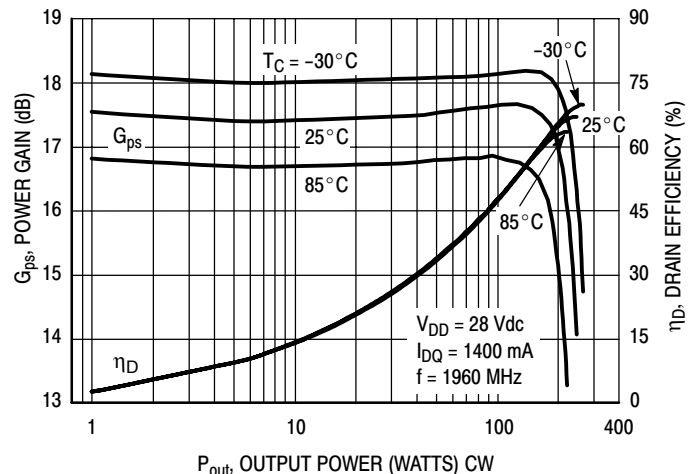
Figure 11. Power Gain and Drain Efficiency versus CW Output Power

T_C = –30°C
–30°C
G_{ps}
25°C
25°C
85°C
85°C
η_D
V_{DD} = 28 Vdc
I_{DQ} = 1400 mA
f = 1960 MHz

G_{ps}, POWER GAIN (dB)
η_D, DRAIN EFFICIENCY (%)
P_{out}, OUTPUT POWER (WATTS) CW

MRF7S19170HR3 MRF7S19170HSR3

TYPICAL CHARACTERISTICS
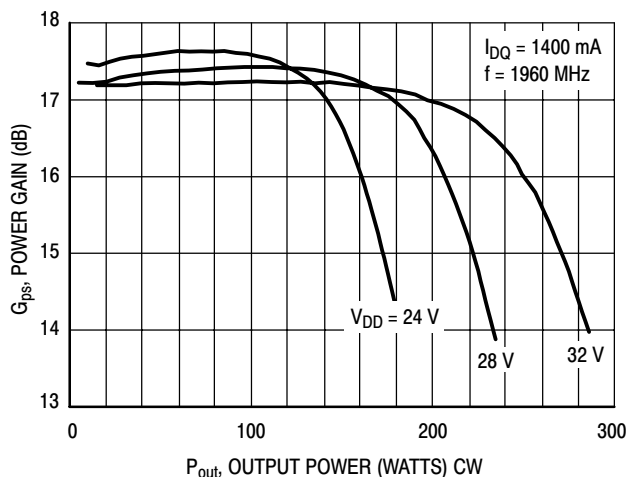
Figure 12. Power Gain versus Output Power
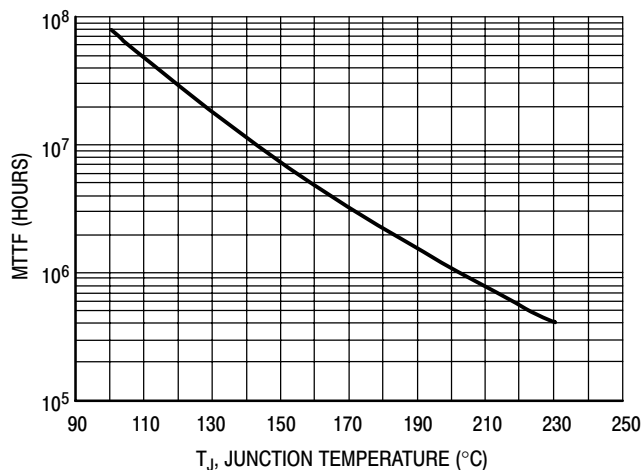
This above graph displays calculated MTTF in hours when the device is operated at V_{DD} = 28 Vdc, P_{out} = 50 W Avg., and η_D = 32%.

MTTF calculator available at http://www.freescale.com/rf. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.

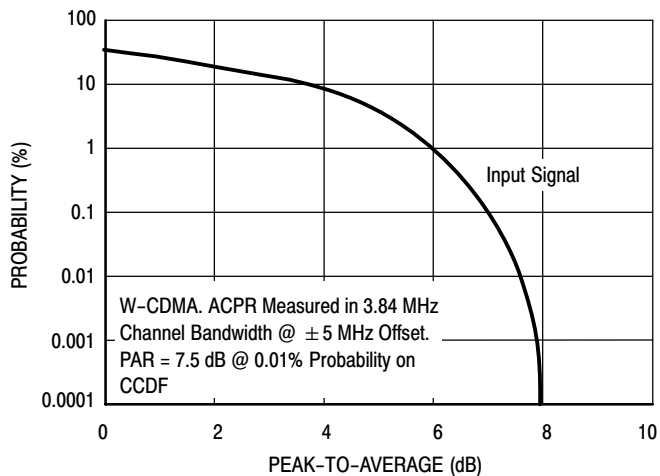Figure 13. MTTF Factor versus Junction Temperature

W-CDMA TEST SIGNAL

Figure 14. CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 50% Clipping, Single-Carrier Test Signal
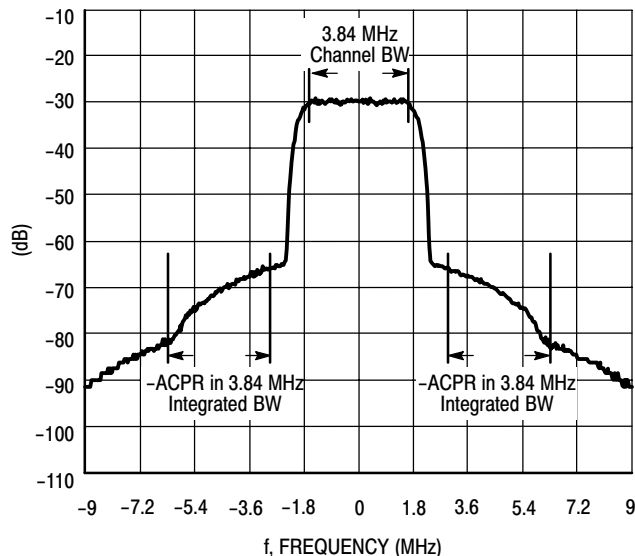
Figure 15. Single-Carrier W-CDMA Spectrum
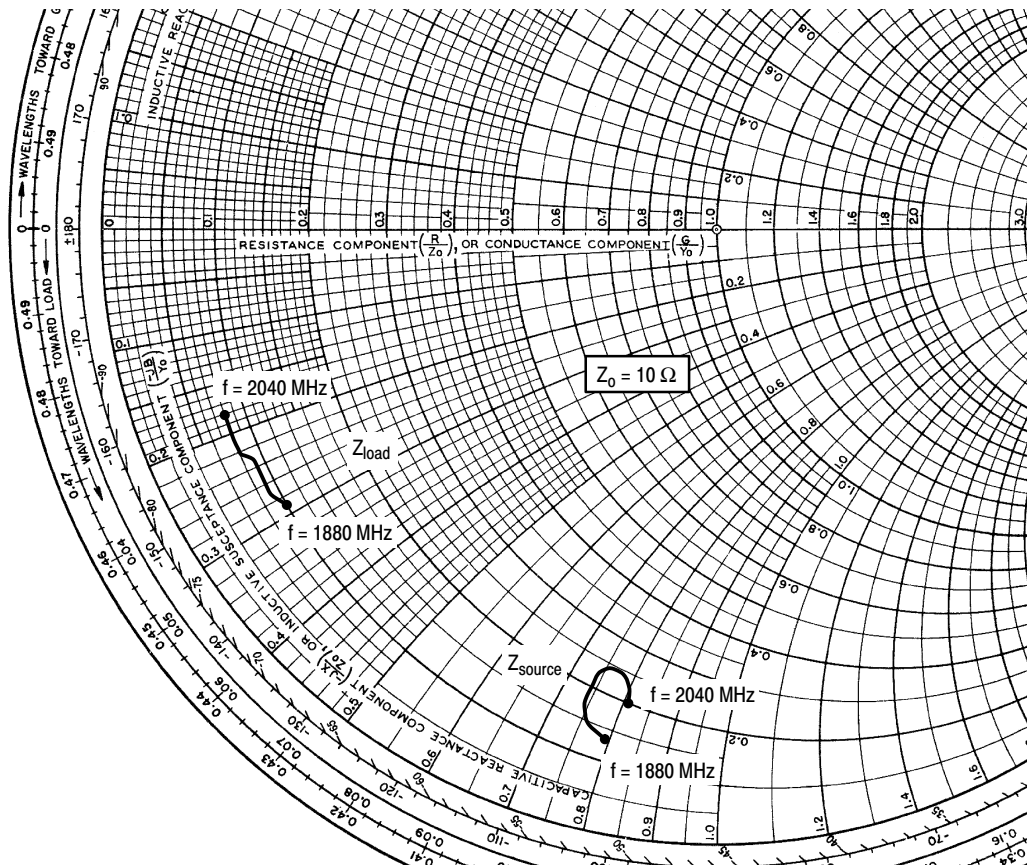
V_{DD} = 28 Vdc, I_{DQ} = 1400 mA, P_{out} = 50 W Avg.

f MHz	Z_{source} Ω	Z_{load} Ω
1880	1.338 - j7.859	0.967 - j2.868
1900	1.515 - j7.609	0.942 - j2.725
1920	1.743 - j7.432	0.920 - j2.585
1940	2.007 - j7.352	0.893 - j2.449
1960	2.249 - j7.393	0.865 - j2.313
1980	2.410 - j7.553	0.841 - j2.192
2000	2.411 - j7.788	0.820 - j2.073
2020	2.244 - j7.995	0.802 - j1.957
2040	1.966 - j8.101	0.779 - j1.834

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

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

Input Matching Network

Device Under Test

Output Matching Network
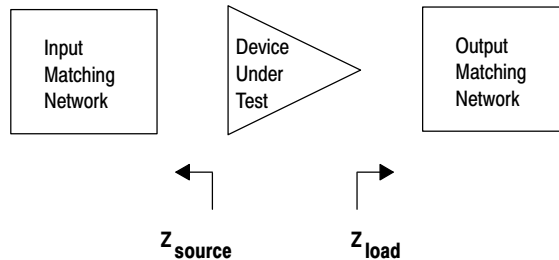
Z_{source} Z_{load}

Figure 16. Series Equivalent Source and Load Impedance

ALTERNATIVE PEAK TUNE LOAD PULL CHARACTERISTICS
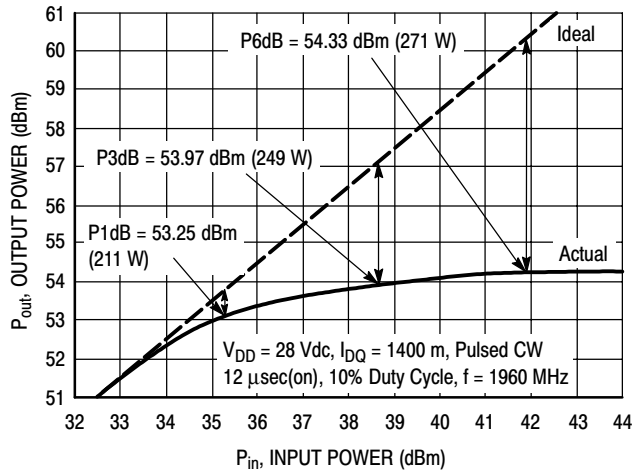
NOTE: Measured in a Peak Tuned Load Pull Fixture

Test Impedances per Compression Level

|	Z_{source} Ω	Z_{load} Ω
P3dB	2.34 - j9.24	0.79 - j2.94

Figure 17. Pulsed CW Output Power versus Input Power
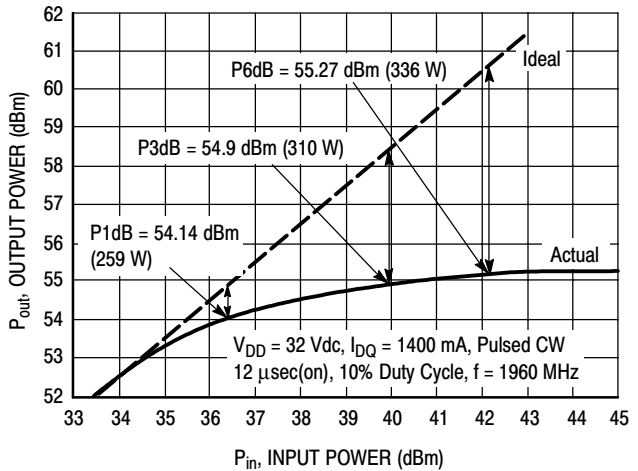
NOTE: Measured in a Peak Tuned Load Pull Fixture

Test Impedances per Compression Level

	Z_{source} Ω	Z_{load} Ω
P3dB	2.34 - j9.24	0.79 - j2.94

Figure 18. Pulsed CW Output Power versus Input Power
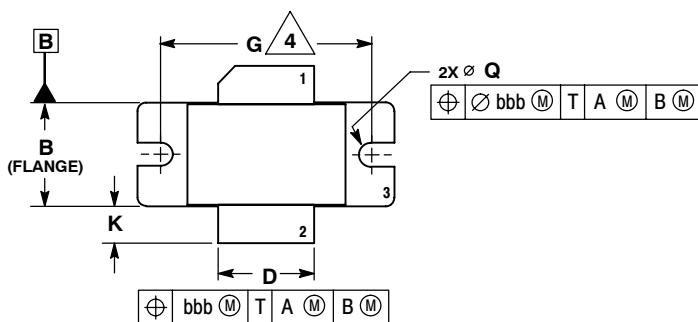
MRF7S19170HR3 MRF7S19170HSR3

PACKAGE DIMENSIONS

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.335	1.345	33.91	34.16
B	0.535	0.545	13.6	13.8
C	0.147	0.200	3.73	5.08
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	0.175	0.205	4.44	5.21
M	0.872	0.888	22.15	22.55
N	0.871	0.889	19.30	22.60
Q	∅.118	∅.138	∅3.00	∅3.51
R	0.515	0.525	13.10	13.30
S	0.515	0.525	13.10	13.30
aaa	0.007 REF		0.178 REF	
bbb	0.010 REF		0.254 REF	
ccc	0.015 REF		0.381 REF	

STYLE 1:
PIN 1. DRAIN
2. GATE
3. SOURCE
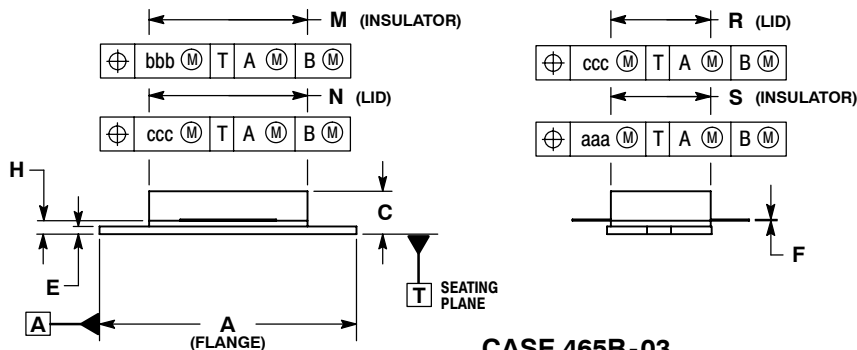
**CASE 465B-03
ISSUE D
NI-880
MRF7S19170H**
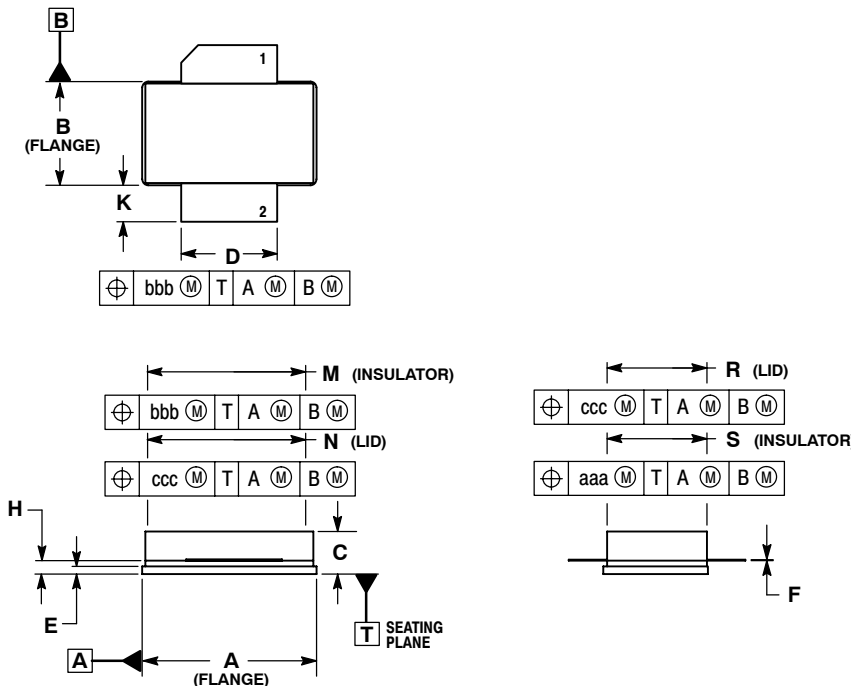
DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.905	0.915	22.99	23.24
B	0.535	0.545	13.60	13.80
C	0.147	0.200	3.73	5.08
D	0.495	0.505	12.57	12.83
E	0.035	0.045	0.89	1.14
F	0.003	0.006	0.08	0.15
H	0.057	0.067	1.45	1.70
K	0.170	0.210	4.32	5.33
M	0.872	0.888	22.15	22.55
N	0.871	0.889	19.30	22.60
R	0.515	0.525	13.10	13.30
S	0.515	0.525	13.10	13.30
aaa	0.007 REF		0.178 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 465C-02
ISSUE D
NI-880S
MRF7S19170HS**

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	Oct. 2006	• Initial Release of Data Sheet
1	Dec. 2008	• Corrected V_{DS} to V_{DD} in the RF test condition voltage callout for $V_{GS(Q)}$, and added "Measured in Functional Test", On Characteristics table, p. 2
		• Updated Typical Performance table to provide better definition of characterization attributes, p. 3
		• Updated Part Numbers in Table 5, Component Designations and Values, to latest RoHS compliant part numbers, p. 4
		• Adjusted scale for Fig. 8, Intermodulation Distortion Products versus Tone Spacing, to show wider dynamic range, p. 7
		• Replaced Fig. 13, MTTF versus Junction Temperature with updated graph. Removed Amps^2 and listed operating characteristics and location of MTTF calculator for device, p. 8
		• Deleted output signal data from Fig. 14, CCDF W‑CDMA 3GPP, Test Model 1, 64 DPCH, 50% Clipping, Single‑Carrier Test Signal, p. 8

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Japan:
Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064
Japan
0120 191014 or +81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:
Freescale Semiconductor China Ltd.
Exchange Building 23F
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