

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 28 volt base station equipment.

- Typical Single-Carrier W-CDMA Performance: $V_{DD} = 28$ Volts, $I_{DQ} = 1000$ mA, $P_{out} = 39$ 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 — 21 dB
Drain Efficiency — 32.3%
Device Output Signal PAR — 6.4 dB @ 0.01% Probability on CCDF
ACPR @ 5 MHz Offset — -39.5 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 32 Vdc, 940 MHz, $P_{out} = 180$ W CW (3 dB Input Overdrive from Rated P_{out}), Designed for Enhanced Ruggedness

Features

- 100% PAR Tested for Guaranteed Output Power Capability
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 32 V_{DD} Operation
- Integrated ESD Protection
- Optimized for Doherty Applications
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

MRFE6S9135HR3
MRFE6S9135HSR3

940 MHz, 39 W AVG., 28 V
SINGLE W-CDMA
LATERAL N-CHANNEL
RF POWER MOSFETs

CASE 465B-03, STYLE 1
NI-880
MRFE6S9135HR3

CASE 465C-02, STYLE 1
NI-880S
MRFE6S9135HSR3

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	-0.5, +66	Vdc
Gate-Source Voltage	V_{GS}	-0.5, +12	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 80°C, 136 W CW		0.39	
Case Temperature 80°C, 39 W CW		0.48	

- Continuous use at maximum temperature will affect MTTF.
- MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
- 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)	II (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
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Off Characteristics

Zero Gate Voltage Drain Leakage Current ($V_{DS} = 66\text{ Vdc}$, $V_{GS} = 0\text{ Vdc}$)	I_{DSS}	—	—	10	μAdc
Zero Gate Voltage Drain Leakage Current ($V_{DS} = 28\text{ Vdc}$, $V_{GS} = 0\text{ Vdc}$)	I_{DSS}	—	—	1	μAdc
Gate-Source Leakage Current ($V_{GS} = 5\text{ Vdc}$, $V_{DS} = 0\text{ Vdc}$)	I_{GSS}	—	—	10	μAdc

On Characteristics

Gate Threshold Voltage ($V_{DS} = 10\text{ Vdc}$, $I_D = 400\text{ }\mu\text{Adc}$)	$V_{GS(th)}$	1.4	2.1	2.9	Vdc
Gate Quiescent Voltage ($V_{DD} = 28\text{ Vdc}$, $I_D = 1000\text{ mAdc}$, Measured in Functional Test)	$V_{GS(Q)}$	2.2	2.9	3.7	Vdc
Drain-Source On-Voltage ($V_{GS} = 10\text{ Vdc}$, $I_D = 2.8\text{ Adc}$)	$V_{DS(on)}$	0.15	0.2	0.35	Vdc

Dynamic Characteristics ⁽¹⁾

Reverse Transfer Capacitance ($V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{rss}	—	1.3	—	pF
Output Capacitance ($V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{oss}	—	410	—	pF
Input Capacitance ($V_{DS} = 28\text{ Vdc}$, $V_{GS} = 0\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz)	C_{iss}	—	343	—	pF

Functional Tests (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$, $I_{DQ} = 1000\text{ mA}$, $P_{out} = 39\text{ W Avg. W-CDMA}$, $f = 940\text{ MHz}$, Single-Carrier W-CDMA, 3.84 MHz Channel Bandwidth Carrier. ACPR measured in 3.84 MHz Channel Bandwidth @ $\pm 5\text{ MHz}$ Offset. PAR = 7.5 dB @ 0.01% Probability on CCDF.

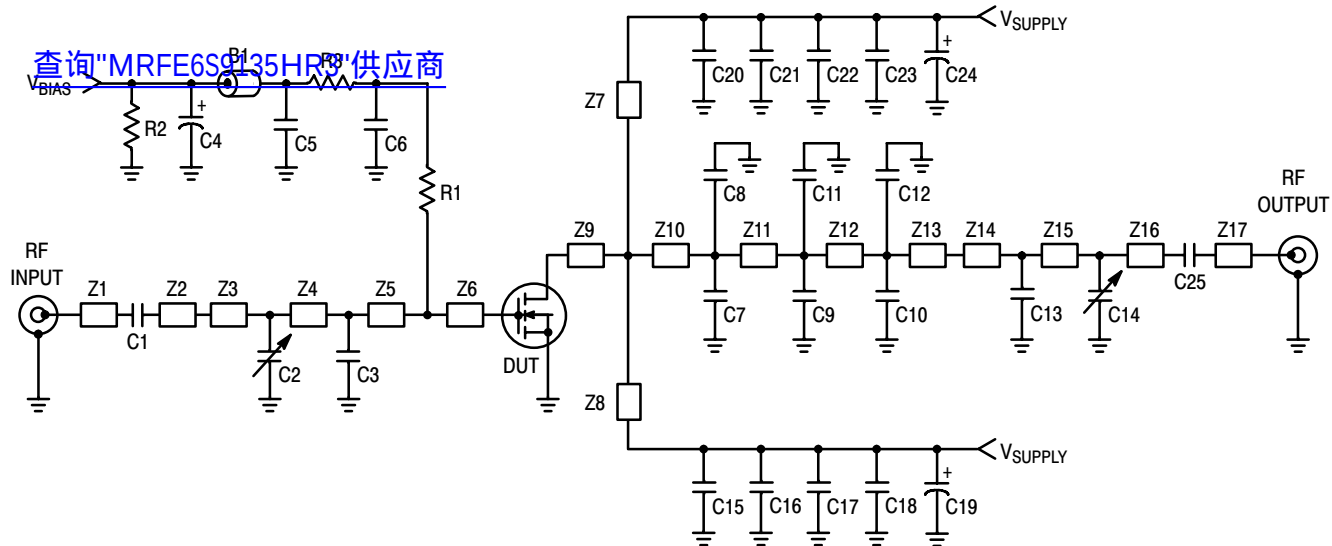
Power Gain	G_{ps}	20	21	23	dB
Drain Efficiency	η_D	30.5	32.3	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	6.1	6.4	—	dB
Adjacent Channel Power Ratio	ACPR	—	-39.5	-38	dBc
Input Return Loss	IRL	—	-15	-9	dB

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
Typical Performances (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$, $I_{DQ} = 1000\text{ mA}$, 920-960 MHz Bandwidth					
Video Bandwidth @ 160 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	—	10	—	MHz
Gain Flatness in 40 MHz Bandwidth @ $P_{out} = 39\text{ W Avg.}$	G_F	—	0.3	—	dB
Average Deviation from Linear Phase in 40 MHz Bandwidth @ $P_{out} = 135\text{ W CW}$	Φ	—	1	—	°
Average Group Delay @ $P_{out} = 135\text{ W CW}$, $f = 940\text{ MHz}$	Delay	—	3.6	—	ns
Part-to-Part Insertion Phase Variation @ $P_{out} = 135\text{ W CW}$, $f = 940\text{ MHz}$, Six Sigma Window	$\Delta\Phi$	—	19	—	°
Gain Variation over Temperature (-30°C to $+85^\circ\text{C}$)	ΔG	—	0.015	—	dB/°C
Output Power Variation over Temperature (-30°C to $+85^\circ\text{C}$)	ΔP_{1dB}	—	0.01	—	dBm/°C



Z1	0.263" x 0.065" Microstrip	Z11	0.202" x 0.980" x 0.444" Taper
Z2	0.310" x 0.065" Microstrip	Z12	0.114" x 0.444" Microstrip
Z3	0.910" x 0.120" Microstrip	Z13	0.145" x 0.444" x 0.110" Taper
Z4	0.248" x 1.020" x 0.120" Taper	Z14	0.180" x 0.110" Microstrip
Z5	0.363" x 1.020" Microstrip	Z15	0.585" x 0.110" Microstrip
Z6	0.057" x 1.120" Microstrip	Z16	0.443" x 0.065" Microstrip
Z7, Z8	0.823" x 0.120" Microstrip	Z17	0.274" x 0.065" Microstrip
Z9	0.060" x 0.980" Microstrip	PCB	Taconic RF-35, 0.030", $\epsilon_r = 3.5$
Z10	0.149" x 0.980" Microstrip		

Figure 1. MRFE6S9135HR3(HSR3) Test Circuit Schematic

Table 5. MRFE6S9135HR3(HSR3) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
B1	Short RF Bead	2743019447	Fair-Rite
C1, C6, C15, C20, C25	39 pF Chip Capacitors	ATC100B390JT500XT	ATC
C2, C14	0.8-8.0 pF Variable Capacitors, Gigatrim	27291SL	Johanson
C3	2.0 pF Chip Capacitor	ATC100B2R0JT500XT	ATC
C4	33 μ F, 25 V Electrolytic Capacitor	EMVY250ADA330MF55G	Nippon Chemi-Con
C5, C16, C17, C18, C21, C22, C23	10 μ F, 50 V Chip Capacitors	GRM55DR61H106KA88B	Murata
C7, C8	6.8 pF Chip Capacitors	ATC100B6R8JT500XT	ATC
C9, C10, C11, C12, C13	4.7 pF Chip Capacitors	ATC100B4R7JT500XT	ATC
C19, C24	470 μ F, 63 V Electrolytic Capacitors	EKME630ELL471MK25S	United Chemi-Con
R1, R3	3.3 Ω , 1/3 W Chip Resistors	CRCW12103R30FKEA	Vishay
R2	2.2 K Ω , 1/4 W Chip Resistor	CRCW12062201FKEA	Vishay

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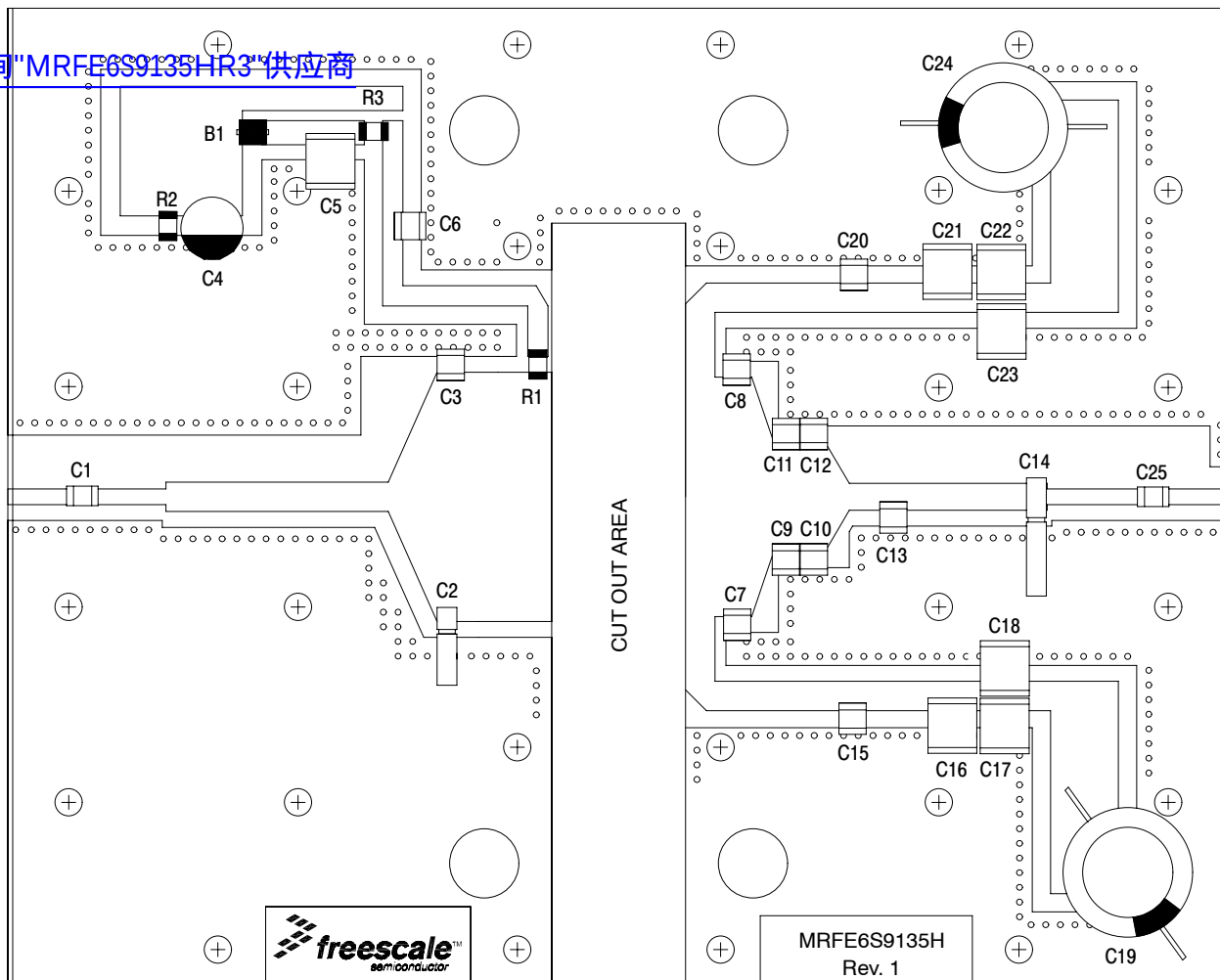
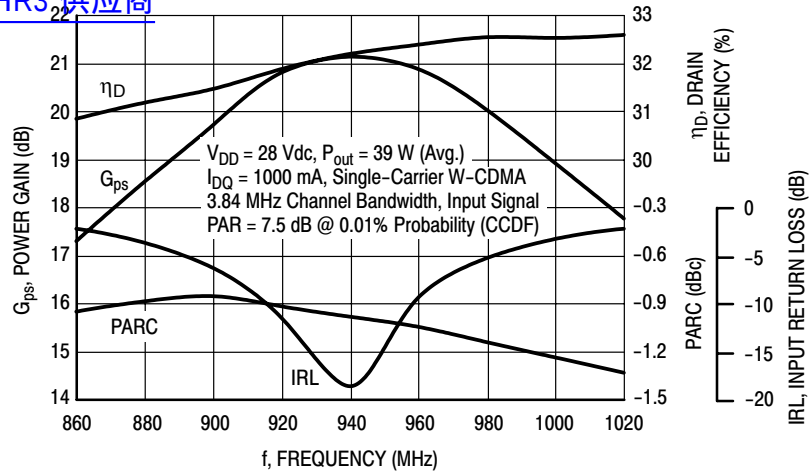


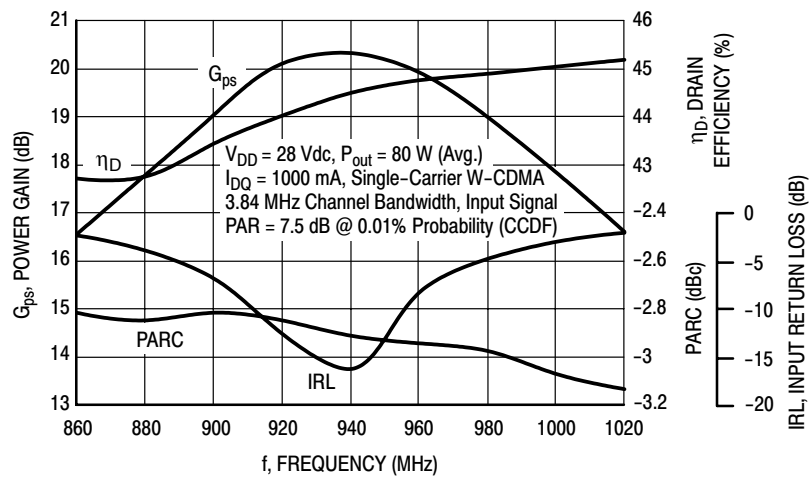
Figure 2. MRFE6S9135HHR3 (HSR3) Test Circuit Component Layout

TYPICAL CHARACTERISTICS

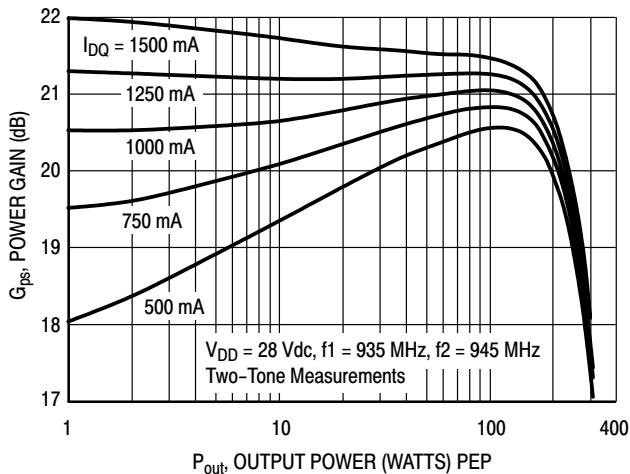
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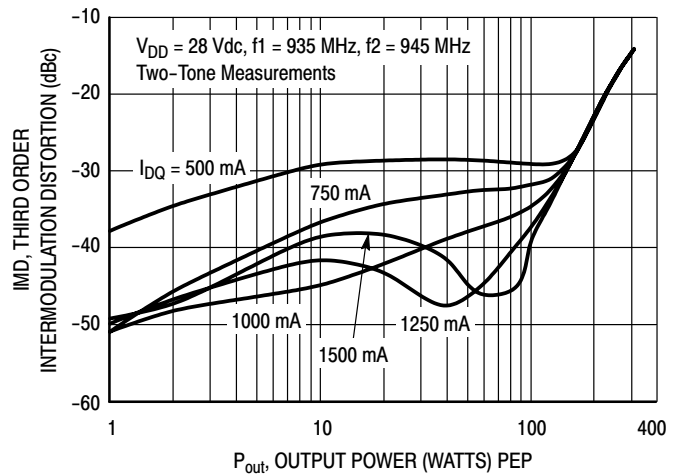
**Figure 3. Single-Carrier W-CDMA Broadband Performance
@ $P_{out} = 39$ Watts Avg.**



**Figure 4. Single-Carrier W-CDMA Broadband Performance
@ $P_{out} = 80$ Watts Avg.**



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



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

TYPICAL CHARACTERISTICS

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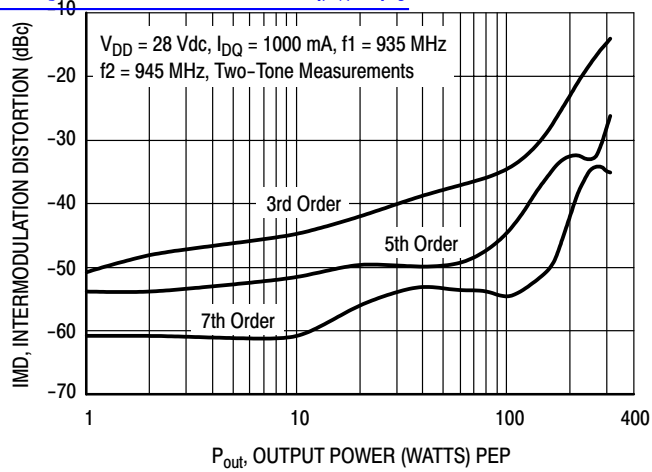


Figure 7. Intermodulation Distortion Products versus Output Power

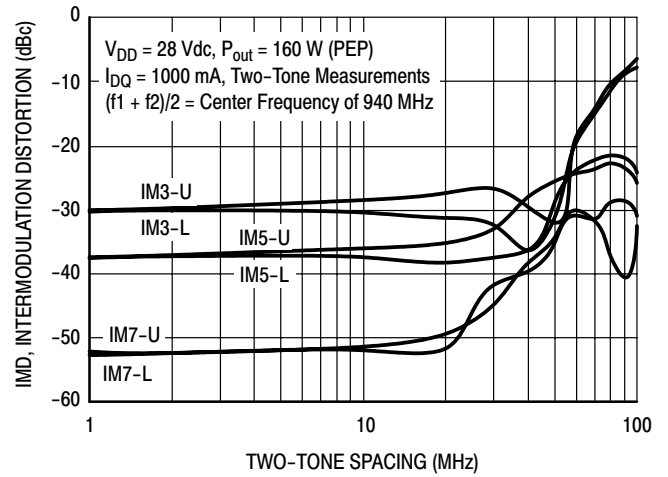


Figure 8. Intermodulation Distortion Products versus Tone Spacing

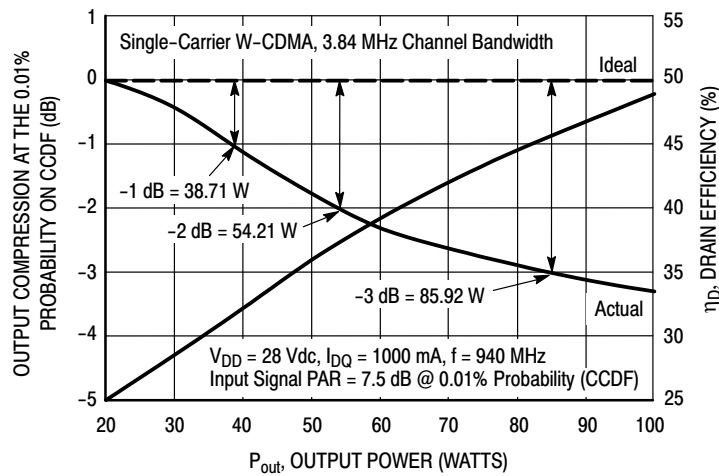


Figure 9. Output Peak-to-Average Ratio Compression (PARC) versus Output Power

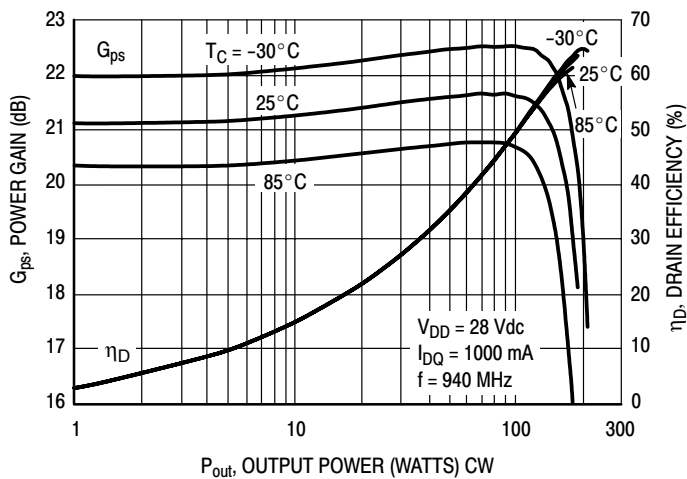


Figure 10. Power Gain and Drain Efficiency versus CW Output Power

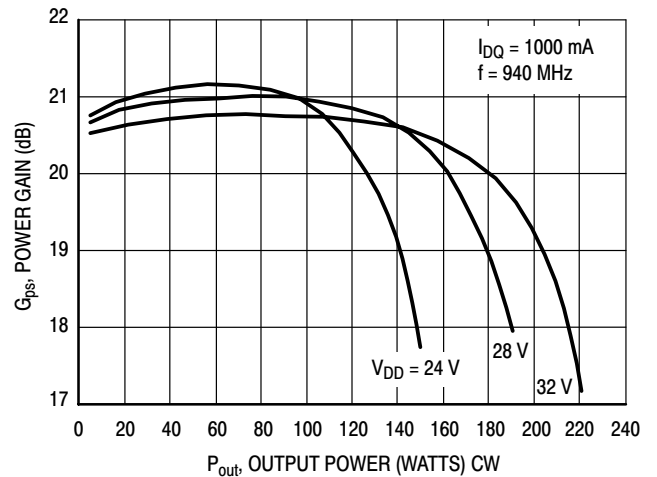
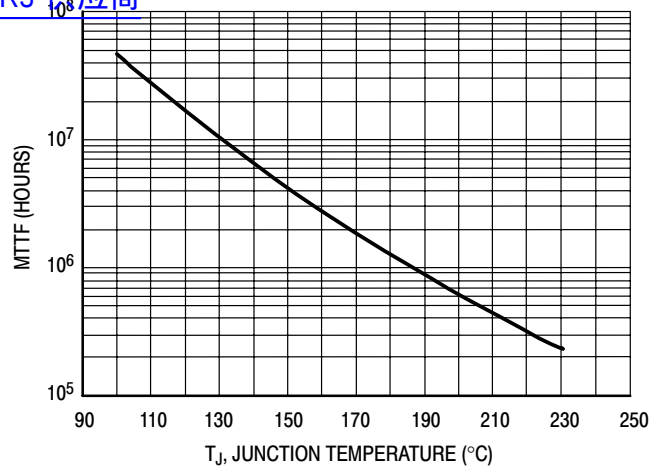


Figure 11. Power Gain versus Output Power

MRFE6S9135HR3 MRFE6S9135HSR3

TYPICAL CHARACTERISTICS

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This above graph displays calculated MTTF in hours when the device is operated at $V_{DD} = 28$ Vdc, $P_{out} = 39$ W Avg., and $\eta_D = 32.3\%$.

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

Figure 12. MTTF versus Junction Temperature

W-CDMA TEST SIGNAL

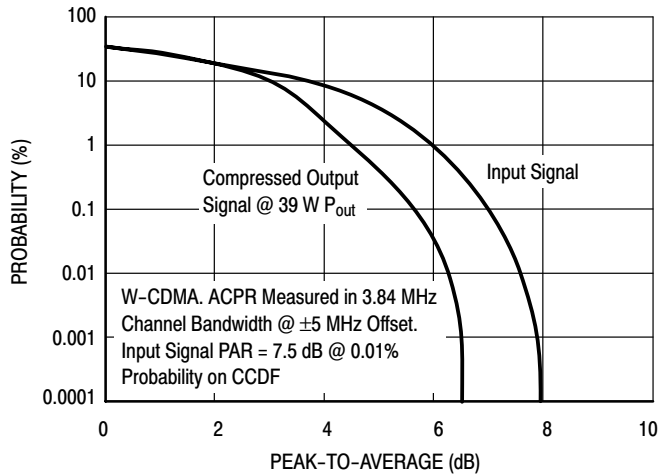


Figure 13. CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 50% Clipping, Single-Carrier Test Signal

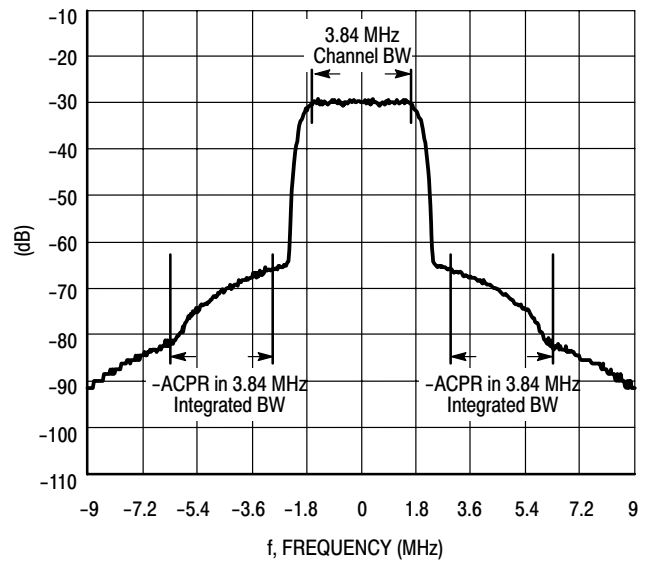
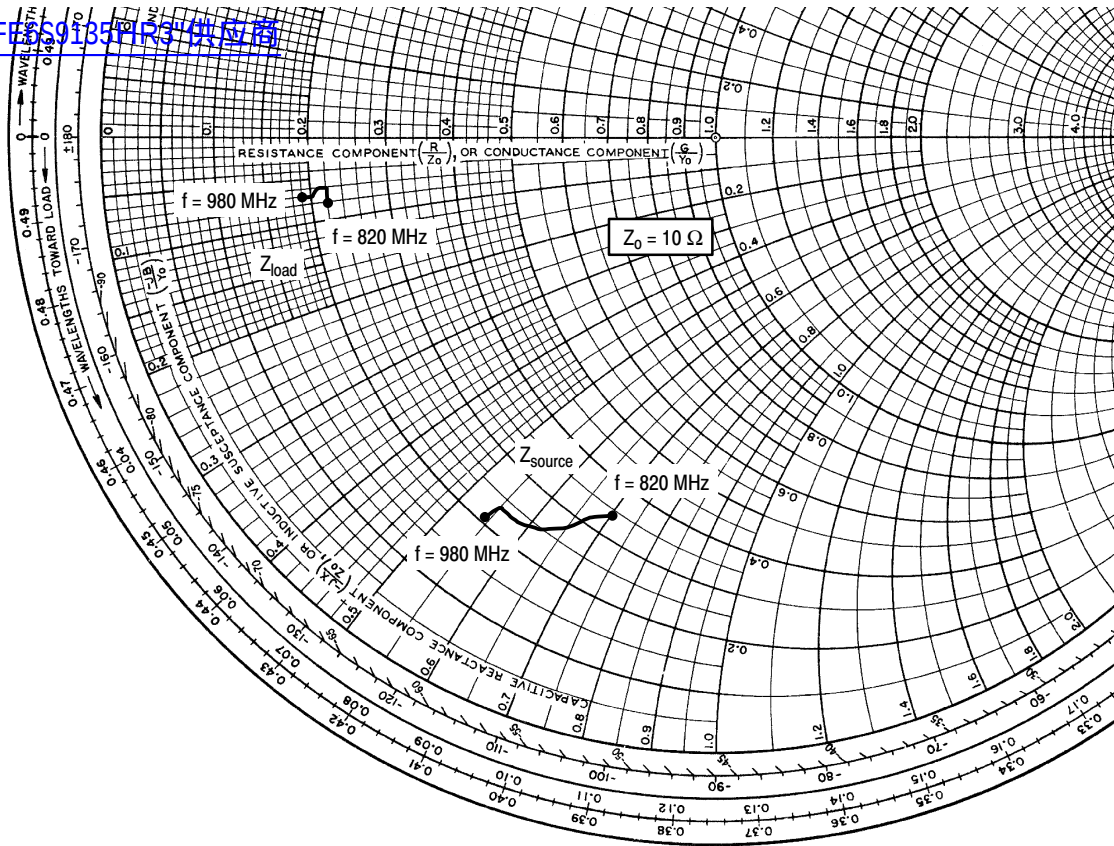


Figure 14. Single-Carrier W-CDMA Spectrum



$V_{DD} = 28 \text{ Vdc}$, $I_{DQ} = 1000 \text{ mA}$, $P_{out} = 39 \text{ W Avg.}$

f MHz	Z_{source} Ω	Z_{load} Ω
820	3.39 - j6.99	2.18 - j0.80
840	3.32 - j6.86	2.20 - j0.71
860	3.05 - j6.74	2.21 - j0.66
880	2.72 - j6.47	2.20 - j0.64
900	2.46 - j6.16	2.20 - j0.64
920	2.41 - j5.80	2.18 - j0.62
940	2.41 - j5.58	2.13 - j0.63
960	2.38 - j5.45	2.03 - j0.66
980	2.13 - j5.38	1.87 - j0.70

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

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

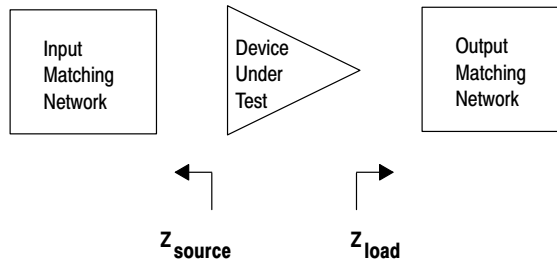
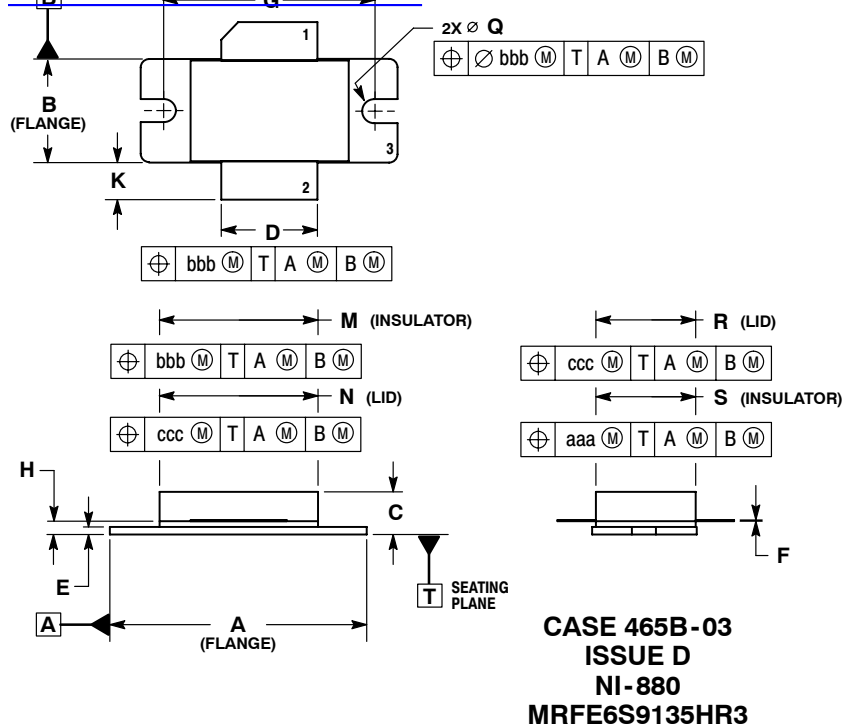


Figure 15. Series Equivalent Source and Load Impedance

PACKAGE DIMENSIONS

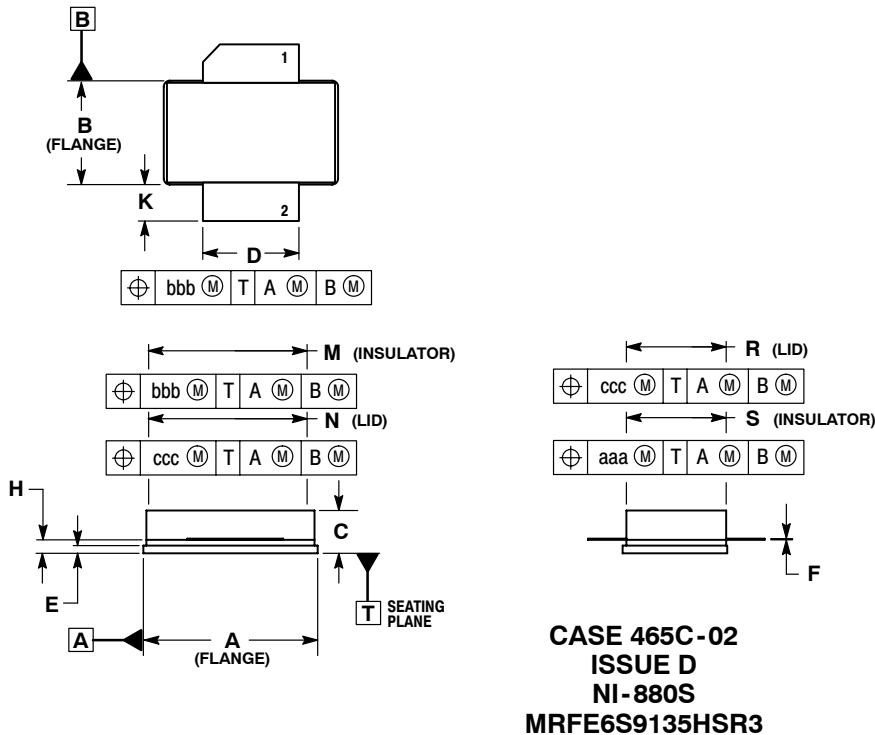
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- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
 2. CONTROLLING DIMENSION: INCH.
 3. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.
 4. DELETED

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	0.170	0.210	4.32	5.33
M	0.872	0.888	22.15	22.55
N	0.871	0.889	19.30	22.60
Q	0.118	0.138	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



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
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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

PRODUCT DOCUMENTATION

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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	Nov. 2007	• Initial Release of Data Sheet
1	Nov. 2007	• Updated Fig. 12, MTTF versus Junction Temperature, to reflect a 32.3% typical efficiency rating, p. 8

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