Freescale Semiconductor
Technical Data

Document Number: MRFE6S9201H
Rev. 1, 12/2008

RoHS

RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

MRFE6S9201HR3
MRFE6S9201HSR3

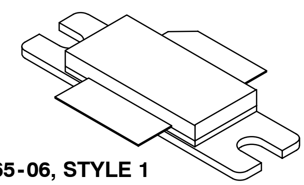
Designed for broadband commercial and industrial applications with frequencies up to 1000 MHz. The high gain and broadband performance of these devices make them ideal for large-signal, common-source amplifier applications in 28 volt base station equipment.

- Typical Single-Carrier N-CDMA Performance: V_{DD} = 28 Volts, I_{DQ} = 1400 mA, P_{out} = 40 Watts Avg., f = 880 MHz, 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 — 20.8 dB
  - Drain Efficiency — 31.3%
  - Device Output Signal PAR — 8.1 dB @ 0.01% Probability on CCDF
  - ACPR @ 750 kHz Offset — -46.5 dBc in 30 kHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 32 Vdc, 880 MHz, P_{out} = 270 W CW (2 dB Input Overdrive from Rated P_{out}), Designed for Enhanced Ruggedness

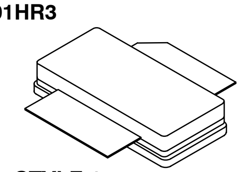
Features

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

880 MHz, 40 W AVG., 28 V
SINGLE N-CDMA
LATERAL N-CHANNEL
RF POWER MOSFETs



CASE 465-06, STYLE 1
NI-780
MRFE6S9201HR3



CASE 465A-06, STYLE 1
NI-780S
MRFE6S9201HSR3

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	-0.5, +66	Vdc
Gate-Source Voltage	V_{GS}	-6.0, +10	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 85°C, 197 W CW Case Temperature 75°C, 40 W CW	$R_{\theta JC}$	 0.34 0.33	°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)	1B (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} = 66 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}	—	—	10	μAdc
On Characteristics					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 400 μAdc)	$V_{GS(th)}$	1.5	2.2	3	Vdc
Gate Quiescent Voltage (V_{DD} = 28 Vdc, I_D = 1400 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	2.25	2.9	3.75	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 4.11 Adc)	$V_{DS(on)}$	0.1	0.21	0.35	Vdc
Dynamic Characteristics (1)					
Reverse Transfer Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	2.3	—	pF
Output Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	90	—	pF
Input Capacitance (V_{DS} = 28 Vdc, V_{GS} = 0 Vdc ± 30 mV(rms)ac @ 1 MHz)	C_{iss}	—	480	—	pF

Functional Tests (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1400 mA, P_{out} = 40 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.

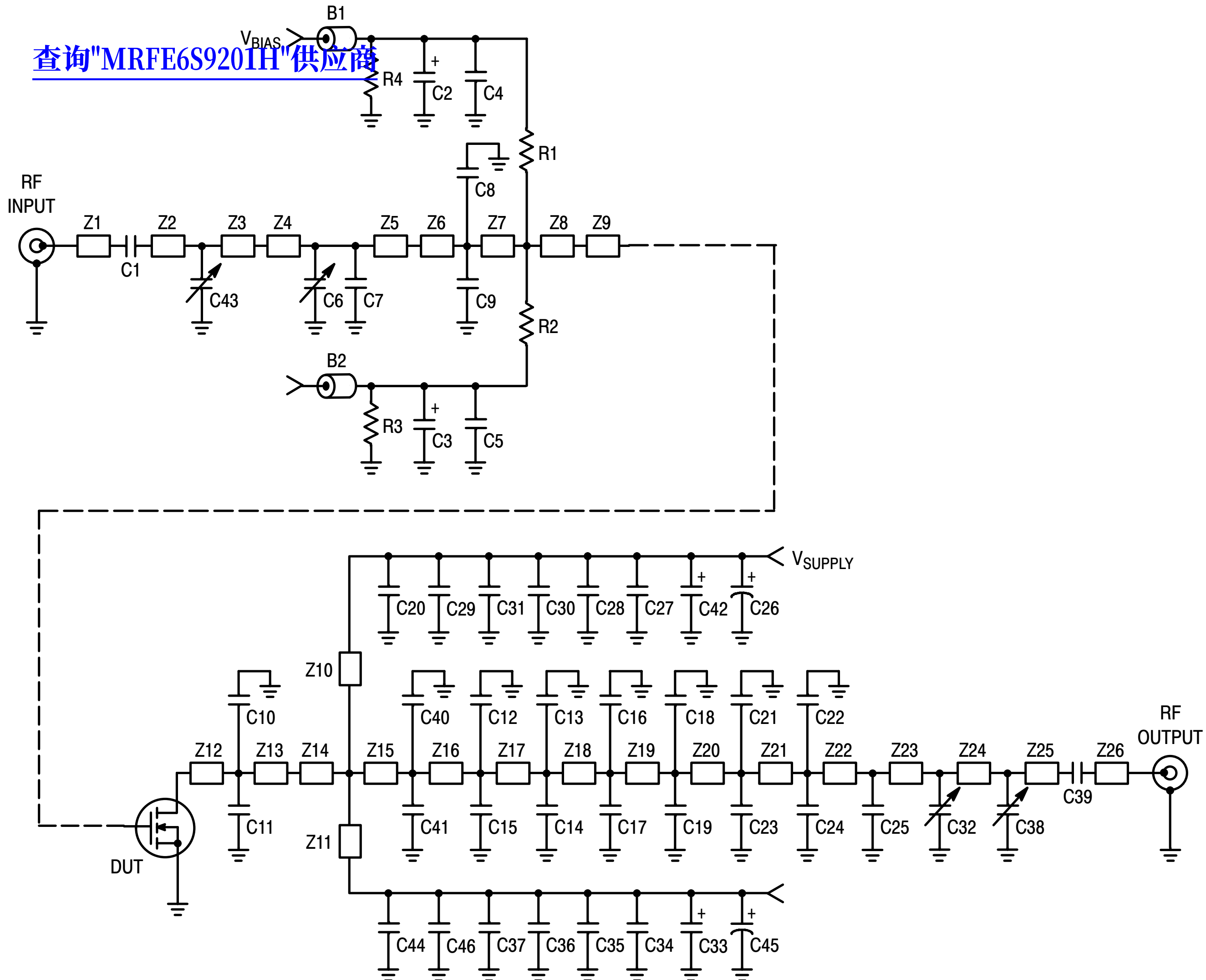
Characteristic	Symbol	Min	Typ	Max	Unit
Power Gain	G_{ps}	19.5	20.8	22.5	dB
Drain Efficiency	η_D	29	31.3	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	7.7	8.1	—	dB
Adjacent Channel Power Ratio	ACPR	—	-46.5	-45	dBc
Input Return Loss	IRL	—	-16	-9	dB

1. 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 Performances (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1400 mA, 865-900 MHz Bandwidth					
Video Bandwidth @ 200 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	—	10	—	MHz
Gain Flatness in 35 MHz Bandwidth @ P_{out} = 40 W Avg.	G_F	—	0.19	—	dB
Average Deviation from Linear Phase in 35 MHz Bandwidth @ P_{out} = 200 W CW	Φ	—	0.461	—	°
Average Group Delay @ P_{out} = 200 W CW, f = 880 MHz	Delay	—	11.66	—	ns
Part-to-Part Insertion Phase Variation @ P_{out} = 200 W CW, f = 880 MHz, Six Sigma Window	ΔΦ	—	14.97	—	°
Gain Variation over Temperature (-30°C to +85°C)	ΔG	—	0.011	—	dB/°C
Output Power Variation over Temperature (-30°C to +85°C)	ΔP1dB	—	0.39	—	dBm/°C



Z1	0.227″ x 0.065" Microstrip	Z10, Z11	0.853″ x 0.100″ Microstrip	Z19	0.020″ x 0.365″ Microstrip
Z2	0.938″ x 0.065" Microstrip	Z12	0.084″ x 0.780″ Microstrip	Z20	0.097″ x 0.065″ Microstrip
Z3	0.492″ x 0.065" Microstrip	Z13	0.086″ x 0.780″ Microstrip	Z21, Z22	0.050″ x 0.065″ Microstrip
Z4	0.046″ x 0.300″ Microstrip	Z14	0.035″ x 0.780″ x 0.709″ Taper	Z23	0.305″ x 0.065″ Microstrip
Z5	0.094″ x 0.300″ Microstrip	Z15	0.093″ x 0.709″ x 0.499″ Taper	Z24	0.456″ x 0.065″ Microstrip
Z6	0.141″ x 0.546″ x 0.300″ Taper	Z16	0.131″ x 0.499″ x 0.286″ Taper	Z25	0.357″ x 0.065″ Microstrip
Z7	0.076″ x 0.734″ x 0.546″ Taper	Z17	0.047″ x 0.365″ Microstrip	Z26	0.340″ x 0.065″ Microstrip
Z8	0.023″ x 0.780″ x 0.734″ Taper	Z18	0.054″ x 0.365″ Microstrip	PCB	Taconic RF-35, 0.030″, ε_r = 3.5
Z9	0.170″ x 0.780″ Microstrip				

Figure 1. MRFE6S9201HR3(HSR3) Test Circuit Schematic

Table 5. MRFE6S9201HR3(HSR3) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
B1, B2	Short RF Beads	2743019447ROP50	Fair-Rite
C1, C4, C5, C20, C39, C44	33 pF Chip Capacitors	ATC100B330JT500XT	ATC
C2, C3	10 μF, 50 V Tantalum Capacitors	T491C106K050AT	Kemet
C6, C32, C38, C43	0.6-4.5 pF Variable Capacitors, Gigatrim	27271SL	Johanson
C7, C12, C13, C14, C15, C16, C17, C25	3.3 pF Chip Capacitors	ATC600F3R3BT250XT	ATC
C8, C9	4.7 pF Chip Capacitors	ATC600F4R7BT250XT	ATC
C10, C11	15 pF Chip Capacitors	ATC100B6R8JT500XT	ATC
C18, C19, C21, C22, C23, C24	1.0 pF Chip Capacitors	ATC600F1R0BT250XT	ATC
C26, C45	470 μF, 63 V Electrolytic Capacitors	EKMG630ELL331MJ20S	United Chemi-Con
C27, C34	1.2K pF Chip Capacitors	ATC100B1R2BT500XT	ATC
C28, C35	20K pF Chip Capacitors	ATC200B203MT50XT	ATC
C29, C31, C37, C46	10 μF, 50 V Chip Capacitors	GRM55DR61H106KA88B	Murata
C30, C36	0.047 pF, 50 V Chip Capacitors	C1825C473J5RAC	Kemet
C33, C42	22 μF, 50 V Tantalum Capacitors	T491C226K050AT	Kemet
C40, C41	5.6 pF Chip Capacitors	ATC600F5R6BT250XT	ATC
R1, R2	12 Ω, 1/4 W Chip Resistors	CRCW120612R0FKEA	Vishay
R3, R4	1 KΩ, 1/4 W Chip Resistors	CRCW12061001FKEA	Vishay

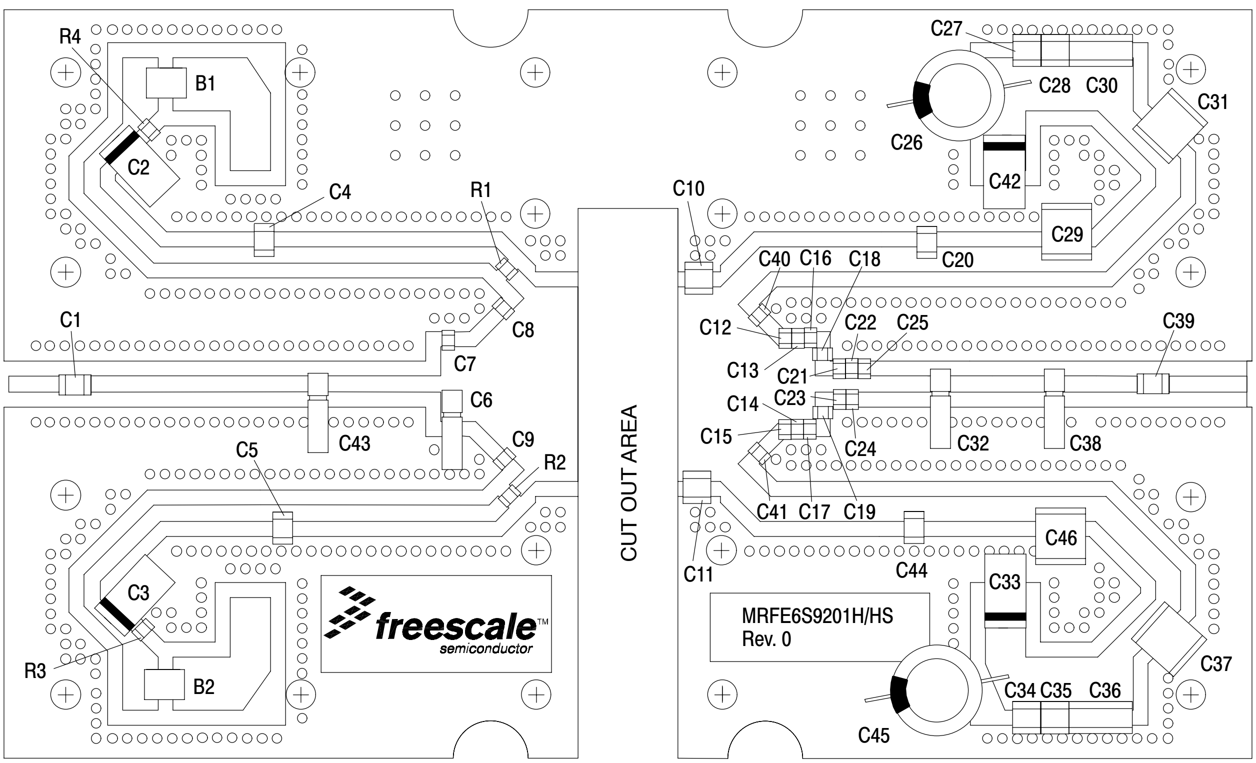


Figure 2. MRFE6S9201HR3(HSR3) Test Circuit Component Layout

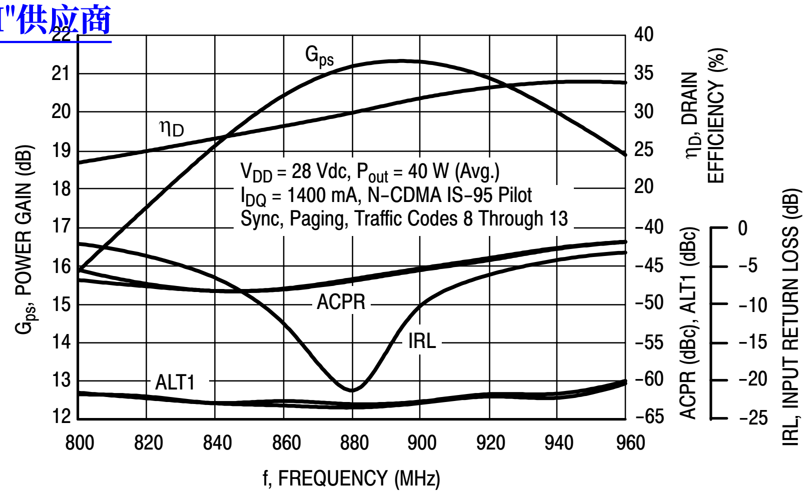


Figure 3. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 40 Watts Avg.

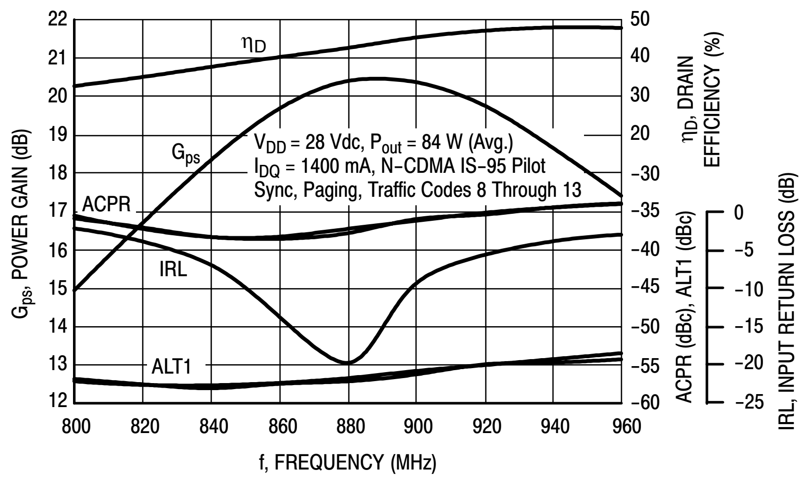


Figure 4. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 84 Watts Avg.

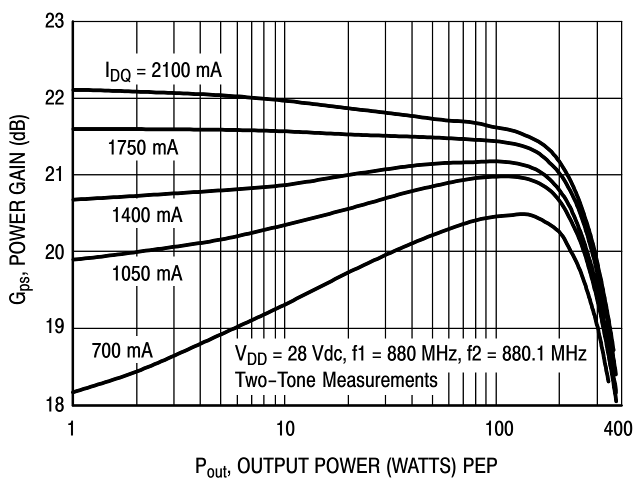


Figure 5. Two-Tone Power Gain versus Output Power

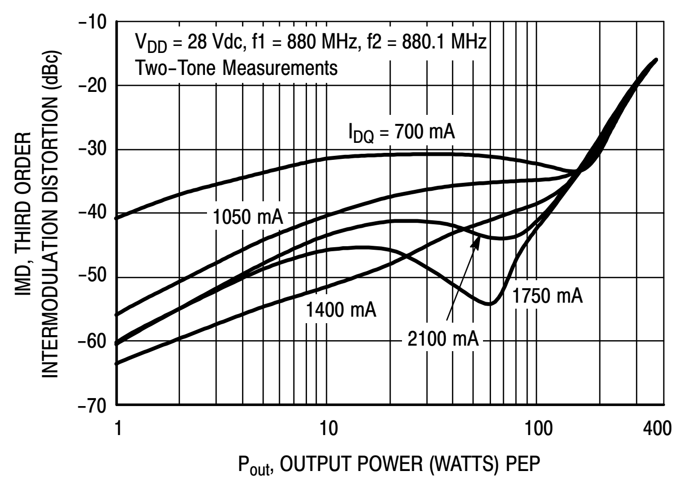


Figure 6. Third Order Intermodulation Distortion versus Output Power

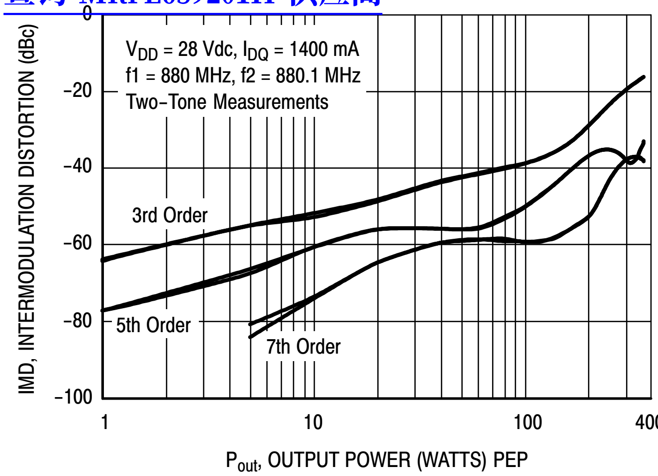


Figure 7. Intermodulation Distortion Products versus Output Power

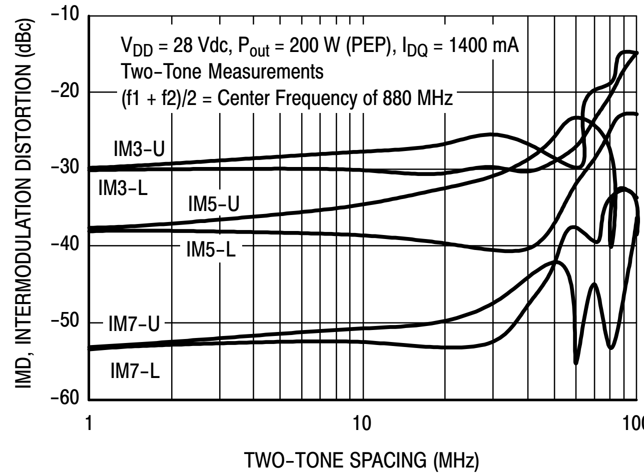


Figure 8. Intermodulation Distortion Products versus Tone Spacing

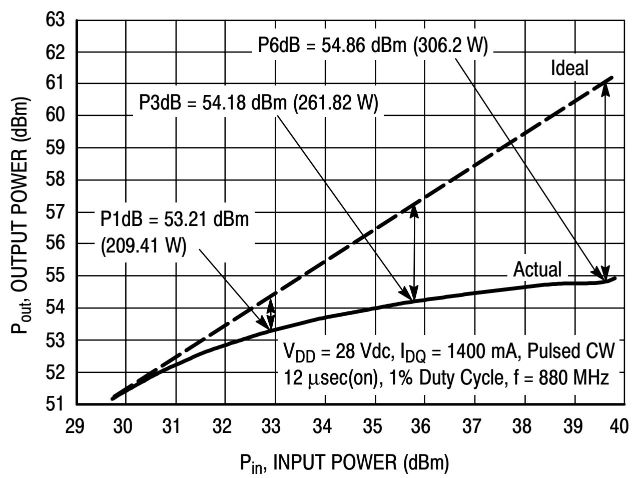


Figure 9. Pulsed CW Output Power versus Input Power

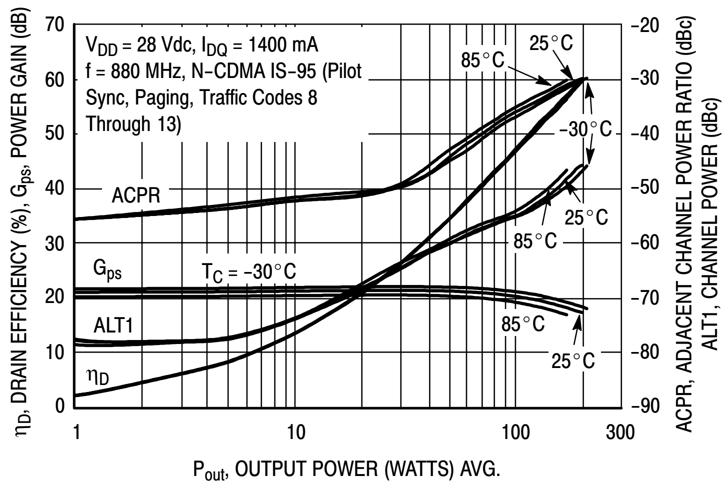


Figure 10. Single-Carrier N-CDMA ACPR, ALT1, Power Gain and Drain Efficiency versus Output Power

TYPICAL CHARACTERISTICS

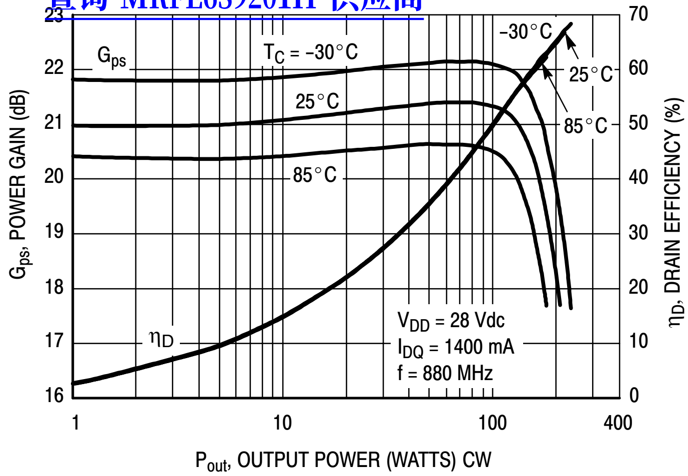


Figure 11. Power Gain and Drain Efficiency versus CW Output Power

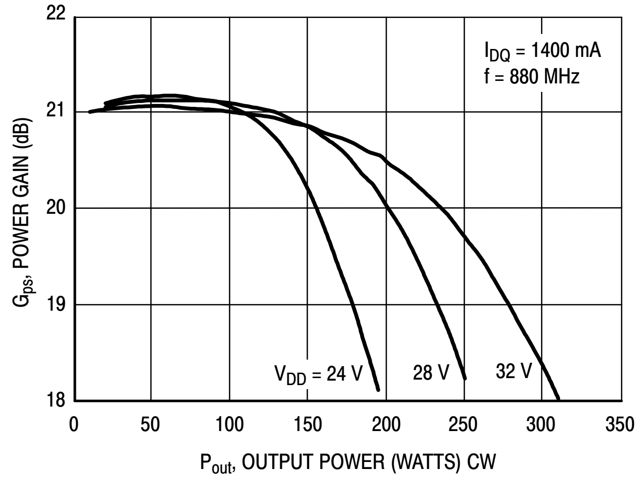
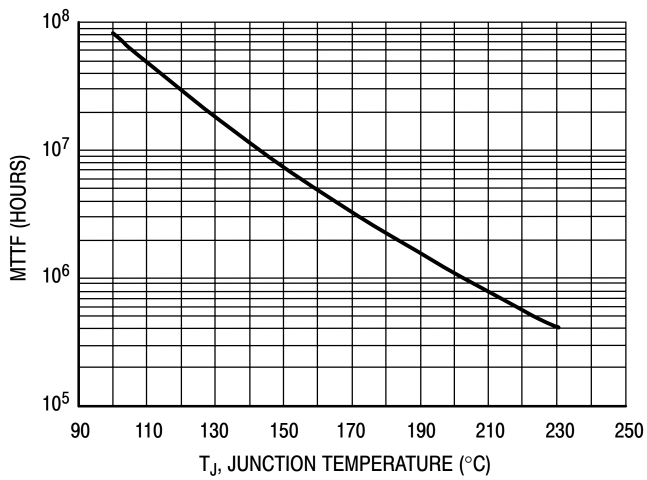


Figure 12. Power Gain versus Output Power



This above graph displays calculated MTTF in hours when the device is operated at V_{DD} = 28 Vdc, P_{out} = 40 W Avg., and η_D = 31.3%.

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

Figure 13. MTTF versus Junction Temperature

N-CDMA TEST SIGNAL

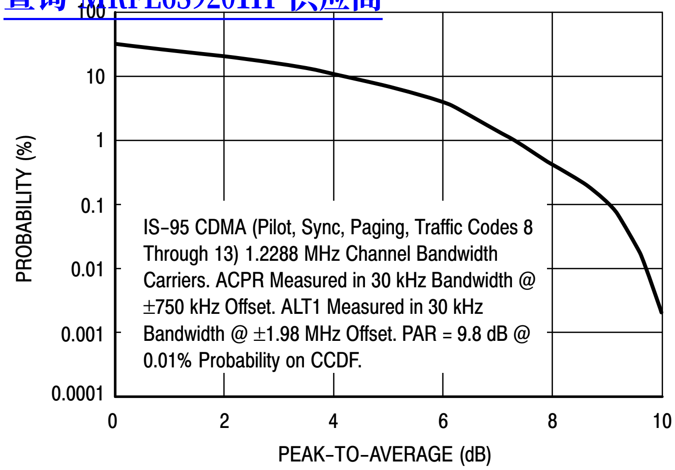


Figure 14. Single-Carrier CCDF N-CDMA

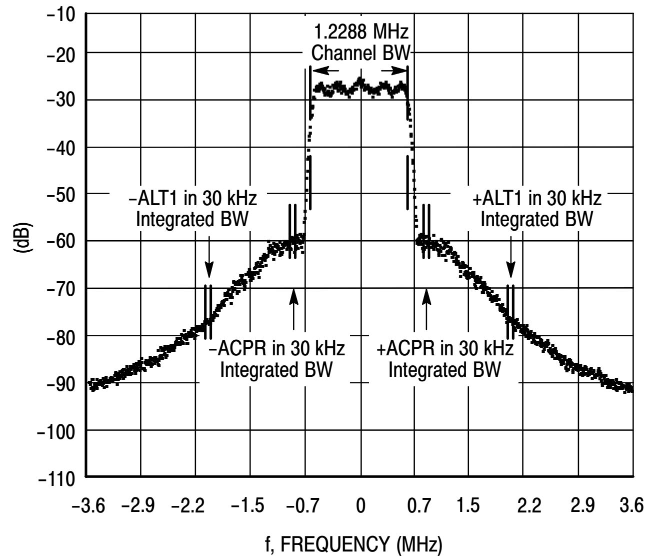
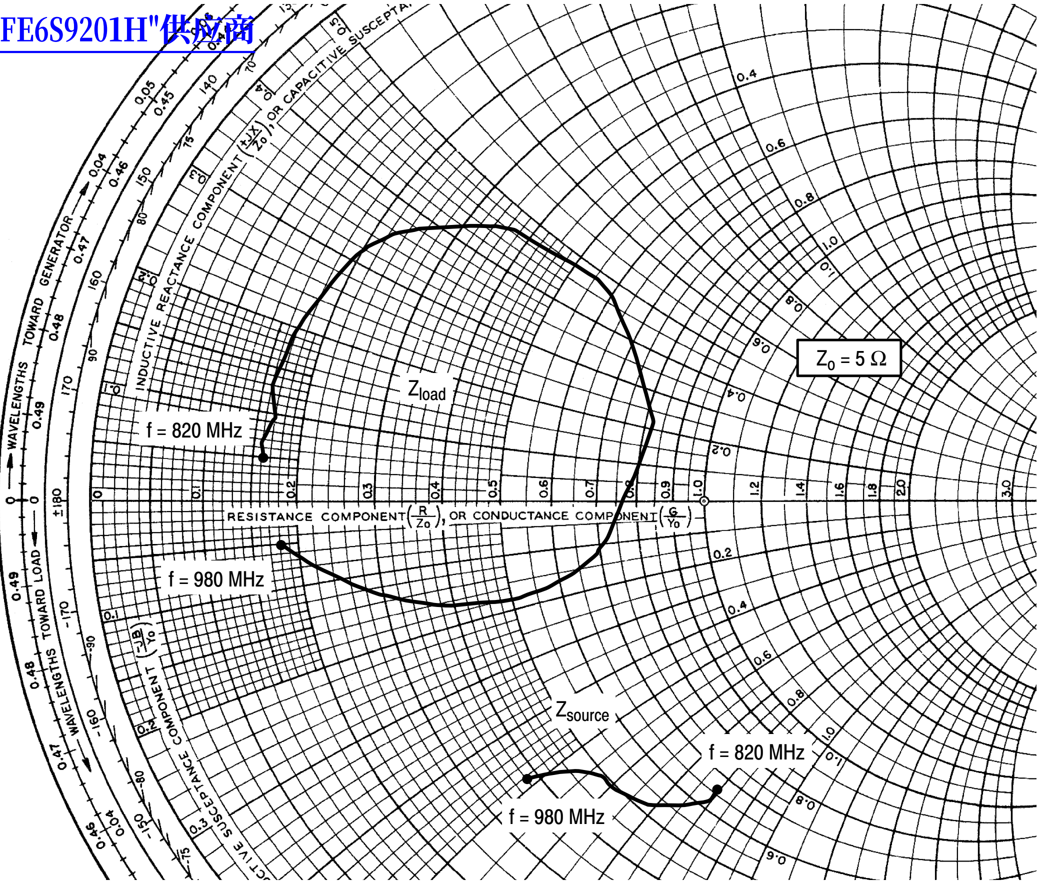


Figure 15. Single-Carrier N-CDMA Spectrum



V_{DD} = 28 Vdc, I_{DQ} = 1400 mA, P_{out} = 40 W Avg.

f MHz	Z_{source} Ω	Z_{load} Ω
820	3.28 - j3.94	0.78 + j0.24
840	3.12 - j3.93	0.81 + j0.36
860	2.85 - j3.73	0.83 + j0.51
880	2.58 - j3.39	0.82 + j0.70
900	2.44 - j2.98	0.83 + j0.98
920	2.43 - j2.87	1.02 + j1.60
940	2.31 - j2.66	4.12 + j1.11
960	2.17 - j2.54	1.49 - j0.66
980	1.91 - j2.39	0.90 - j0.26

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

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

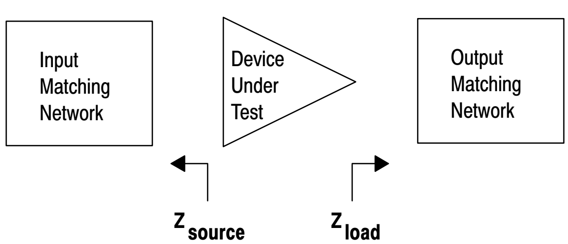
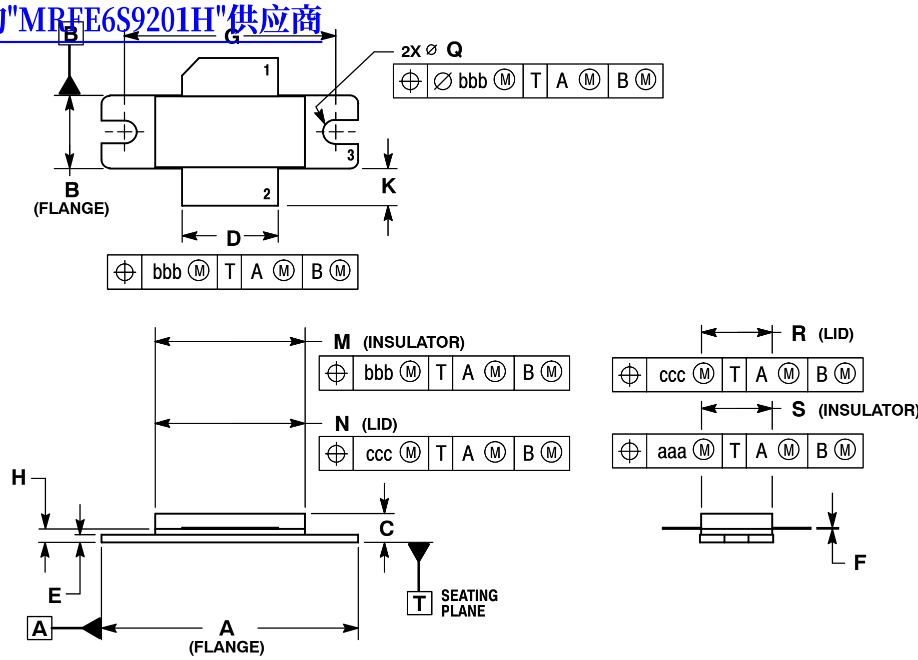


Figure 16. Series Equivalent Source and Load Impedance

PACKAGE DIMENSIONS

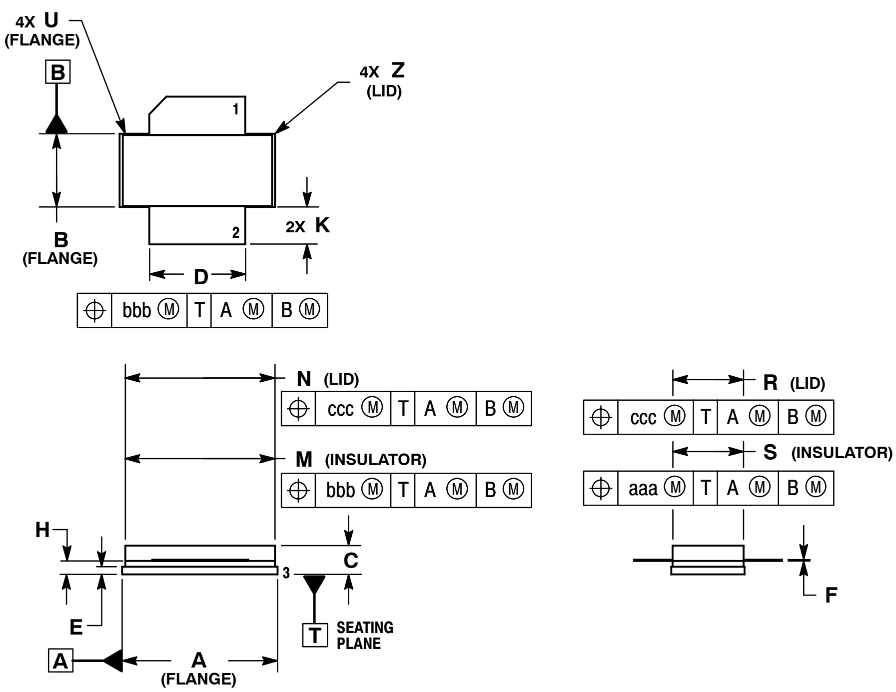


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

	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
MRFE6S9201HR3



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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

CASE 465A-06
ISSUE H
NI-780S
MRFE6S9201HSR3

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	Sept. 2007	• Initial Release of Data Sheet
1	Dec. 2008	• Updated Typical Performance Full Frequency Band to f = 880 MHz to match production test, p. 1 • Updated Part Numbers in Table 5, Component Designations and Values, to latest RoHS compliant part numbers, p. 5

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