Freescale Semiconductor
Technical Data

Document Number: MRF8P2160H
Rev. 1, 7/2010

√RoHS

RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

MRF8P20160HR3
MRF8P20160HSR3

Designed for CDMA base station applications with frequencies from 1880 to 2025 MHz. Can be used in Class AB and Class C for all typical cellular base station modulation formats.

- Typical Doherty Single-Carrier W-CDMA Performance: V_{DD} = 28 Volts, I_{DQA} = 550 mA, V_{GSB} = 1.6 Vdc, P_{out} = 37 Watts Avg., IQ Magnitude Clipping, Channel Bandwidth = 3.84 MHz, Input Signal PAR = 9.9 dB @ 0.01% Probability on CCDF.

Frequency	G_{ps} (dB)	η_D (%)	Output PAR (dB)	ACPR (dBc)
1880 MHz	16.5	44.8	7.0	-29.8
1900 MHz	16.6	45.3	6.9	-30.1
1920 MHz	16.5	45.8	6.9	-30.6

- Capable of Handling 10:1 VSWR, @ 32 Vdc, 1900 MHz, 150 Watts CW Output Power (3 dB Input Overdrive from Rated P_{out})
- Typical P_{out} @ 3 dB Compression Point ≃ 160 Watts CW

2025 MHz

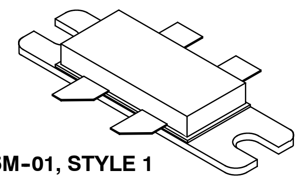
- Typical Doherty Single-Carrier W-CDMA Performance: V_{DD} = 28 Volts, I_{DQA} = 550 mA, V_{GSB} = 1.6 Vdc, P_{out} = 37 Watts Avg., IQ Magnitude Clipping, Channel Bandwidth = 3.84 MHz, Input Signal PAR = 9.9 dB @ 0.01% Probability on CCDF.

Frequency	G_{ps} (dB)	η_D (%)	Output PAR (dB)	ACPR (dBc)
2025 MHz	15.3	44.0	6.8	-30.0

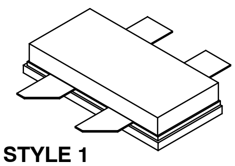
Features

- Production Tested in a Symmetrical Doherty Configuration
- 100% PAR Tested for Guaranteed Output Power Capability
- Characterized with Large-Signal Load-Pull Parameters and Common Source S-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
- NI-780-4 in Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel. NI-780S-4 in Tape and Reel. R3 Suffix = 250 Units per 32 mm, 13 inch Reel.

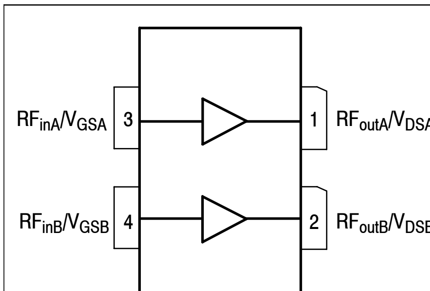
1880-2025 MHz, 37 W AVG., 28 V
SINGLE W-CDMA
LATERAL N-CHANNEL
RF POWER MOSFETs



CASE 465M-01, STYLE 1
NI-780-4
MRF8P20160HR3



CASE 465H-02, STYLE 1
NI-780S-4
MRF8P20160HSR3



(Top View)

Figure 1. Pin Connections

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

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.

freescale™ semiconductor

Table 2. Thermal Characteristics

Characteristic	Symbol	Value [1,2]	Unit
Thermal Resistance, Junction to Case Case Temperature 81°C, 37 W CW, 28 Vdc, I_{DQA} = 550 mA, V_{GSB} = 1.3 Vdc, 1900 MHz	$R_{\theta JC}$	0.75	°C/W

Table 3. ESD Protection Characteristics

Test Methodology	Class
Human Body Model (per JESD22-A114)	2 (Minimum)
Machine Model (per EIA/JESD22-A115)	A (Minimum)
Charge Device Model (per JESD22-C101)	IV (Minimum)

Table 4. Electrical Characteristics (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Off Characteristics [3]					
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 [3]					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 116 μAdc)	$V_{GS(th)}$	1.2	1.8	2.7	Vdc
Gate Quiescent Voltage (V_{DD} = 28 Vdc, I_{DA} = 550 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	1.9	2.7	3.4	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 1.5 Adc)	$V_{DS(on)}$	0.1	0.27	0.5	Vdc

Functional Tests [4,5] (In Freescale Doherty Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQA} = 550 mA, V_{GSB} = 1.6 Vdc, P_{out} = 37 W Avg., f = 1920 MHz, Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 9.9 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @ ±5 MHz Offset.

Characteristic	Symbol	Min	Typ	Max	Unit
Power Gain	G_{ps}	15.5	16.5	18.5	dB
Drain Efficiency	η_D	43.5	45.8	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	6.4	6.9	—	dB
Adjacent Channel Power Ratio	ACPR	—	-30.6	-28.5	dBc

Typical Broadband Performance [5] (In Freescale Doherty Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQA} = 550 mA, V_{GSB} = 1.6 Vdc, P_{out} = 37 W Avg., f = 1920 MHz, Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 9.9 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @ ±5 MHz Offset.

Frequency	G_{ps} (dB)	η_D (%)	Output PAR (dB)	ACPR (dBc)
1880 MHz	16.5	44.8	7.0	-29.8
1900 MHz	16.6	45.3	6.9	-30.1
1920 MHz	16.5	45.8	6.9	-30.6

1. MTTF calculator available at http://www.freescale.com/rf. Select Software & Tools/Development Tools/Calculators to access 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. Each side of device measured separately.
4. Part internally matched both on input and output.
5. Measurement made with device in a Symmetrical Doherty configuration.

(continued)

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

Characteristic	Symbol	Min	Typ	Max	Unit
Typical Performance [1] (In Freescale Doherty Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQA} = 550 mA, V_{GSB} = 1.6 Vdc, 1880-1920 MHz Bandwidth					
P_{out} @ 1 dB Compression Point, CW	P1dB	—	107	—	W
P_{out} @ 3 dB Compression Point, CW	P3dB	—	160	—	W
IMD Symmetry @ 40 W PEP, P_{out} where IMD Third Order Intermodulation ≅ 30 dBc (Delta IMD Third Order Intermodulation between Upper and Lower Sidebands > 2 dB)	IMD_{sym}	—	13	—	MHz
VBW Resonance Point (IMD Third Order Intermodulation Inflection Point)	VBW_{res}	—	50	—	MHz
Gain Flatness in 40 MHz Bandwidth @ P_{out} = 37 W Avg.	G_F	—	0.2	—	dB
Gain Variation over Temperature (-30°C to +85°C)	ΔG	—	0.01	—	dB/°C
Output Power Variation over Temperature (-30°C to +85°C)	ΔP1dB	—	0.009	—	dB/°C

Typical Broadband Performance — 2025 MHz [1] (In Freescale 2025 Doherty Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQA} = 550 mA, V_{GSB} = 1.6 Vdc, P_{out} = 37 W Avg., f = 2025 MHz, Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 9.9 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @ ±5 MHz Offset.

Frequency	G_{ps} (dB)	η_D (%)	Output PAR (dB)	ACPR (dBc)
2025 MHz	15.3	44.0	6.8	-30.0

1. Measurement made with device in a Symmetrical Doherty configuration.

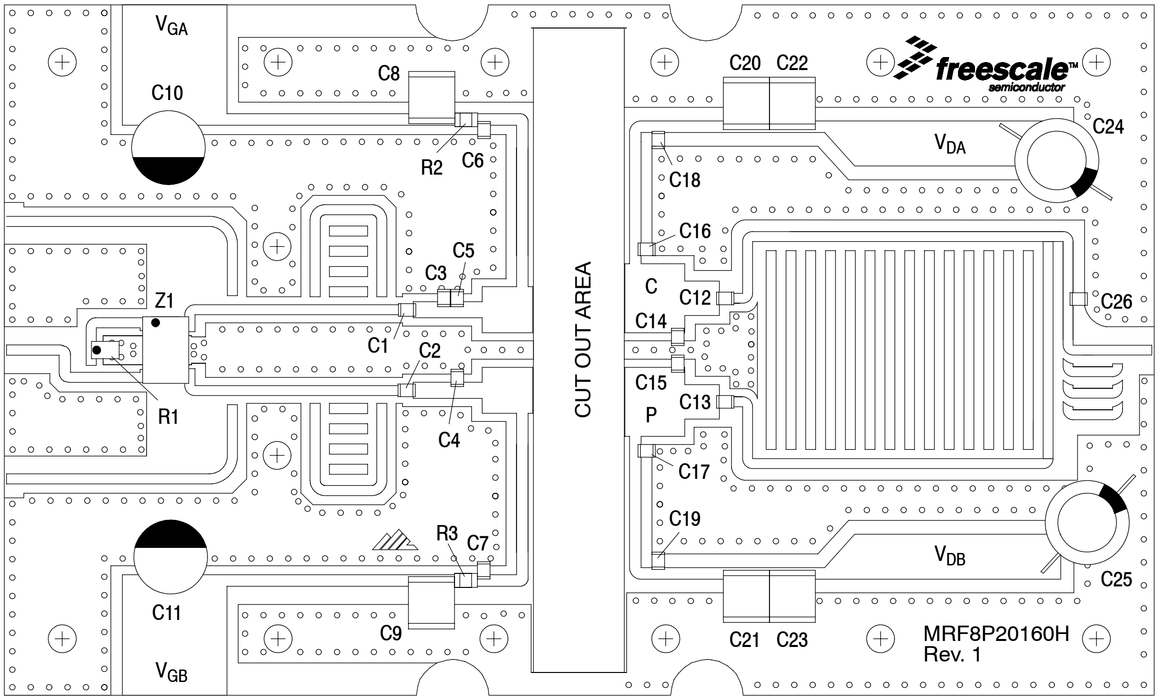


Figure 2. MRF8P20160HR3(HSR3) Test Circuit Component Layout

Table 5. MRF8P20160HR3(HSR3) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1, C2, C12, C13	10 pF Chip Capacitors	ATC600F100JT250XT	ATC
C3	0.3 pF Chip Capacitor	ATC600F0R3BT250XT	ATC
C4, C5	1.1 pF Chip Capacitors	ATC600F1R1BT250XT	ATC
C6, C7, C18, C19	12 pF Chip Capacitors	ATC600F120JT250XT	ATC
C8, C9, C20, C21, C22, C23	10 μF, 50 V Chip Capacitors	GRM55DR61H106KA88L	Murata
C10, C11	22 μF, 35 V Tantalum Capacitors	T491X226K035AT	Kemet
C14, C15	2.0 pF Chip Capacitors	ATC600F2R0BT250XT	ATC
C16, C17	2.2 pF Chip Capacitors	ATC600F2R2BT250XT	ATC
C24, C25	220 μF, 50 V Electrolytic Capacitors	227CKS505M	Illinois Cap
C26	0.8 pF Chip Capacitor	ATC600F0R8BT250XT	ATC
R1	50 Ω, 4 W Chip Resistor	CW12010T0050GBK	ATC
R2, R3	8.25 Ω, 1/4 W Chip Resistors	CRCW12068R25FKEA	Vishay
Z1	1900 MHz Band 90°, 3 dB Chip Hybrid Coupler	GCS351-HYB1900	Soshin
PCB	0.020″, $\varepsilon_r = 3.5$	RO4350B	Rogers

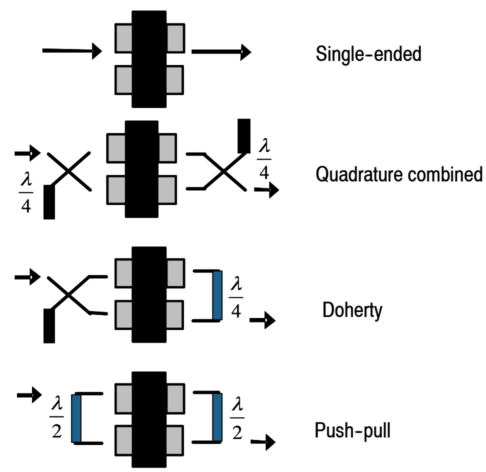


Figure 3. Possible Circuit Topologies

TYPICAL CHARACTERISTICS

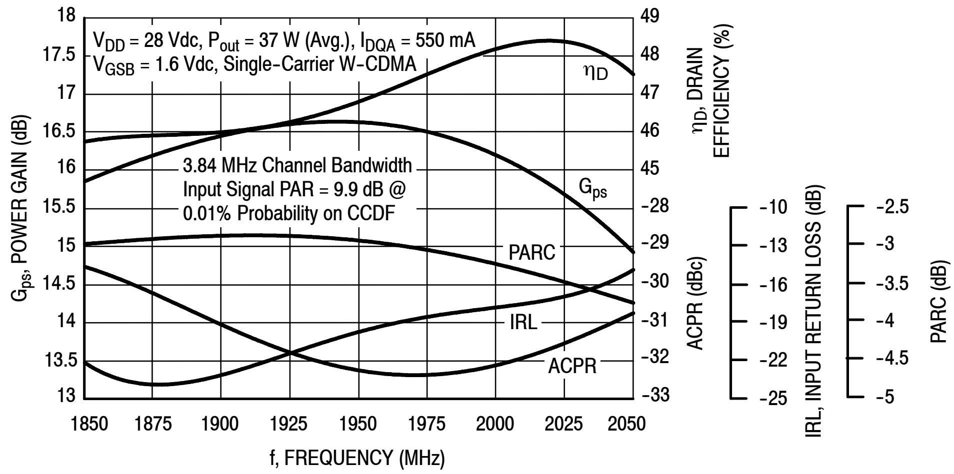


Figure 4. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @ P_{out} = 37 Watts Avg.

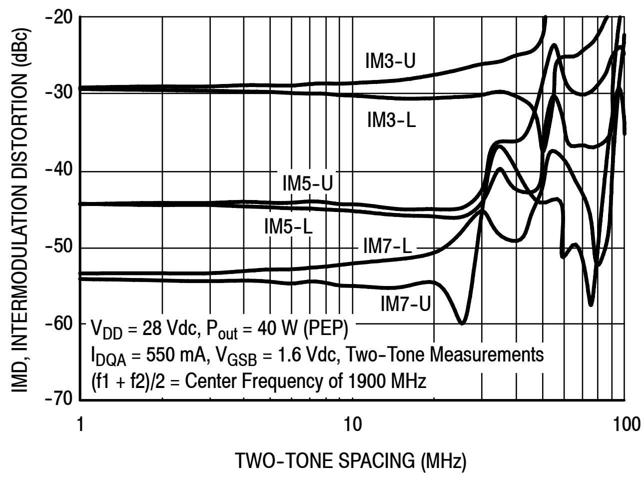


Figure 5. Intermodulation Distortion Products versus Two-Tone Spacing

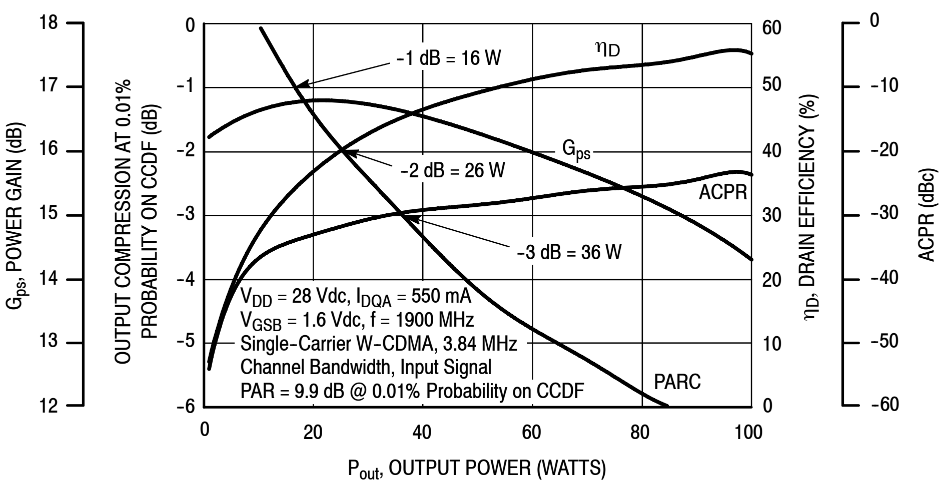


Figure 6. Output Peak-to-Average Ratio Compression (PARC) versus Output Power

TYPICAL CHARACTERISTICS

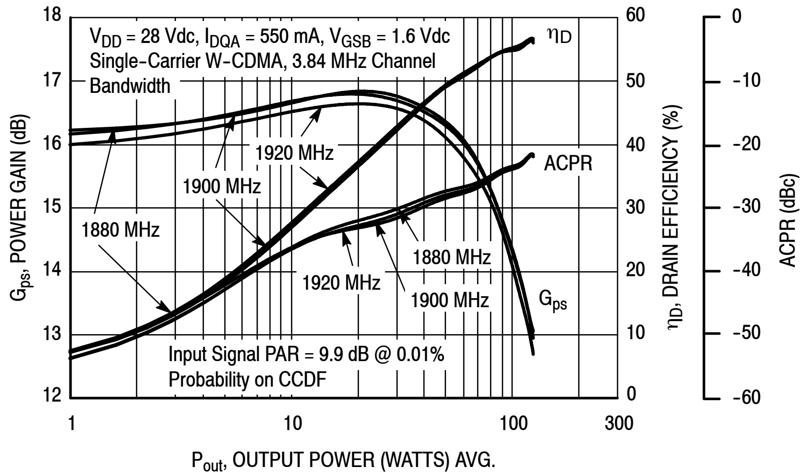


Figure 7. Single-Carrier W-CDMA Power Gain, Drain Efficiency and ACPR versus Output Power

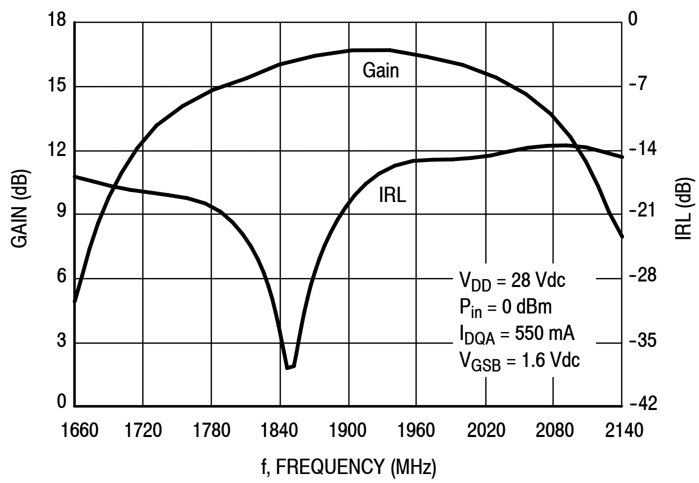


Figure 8. Broadband Frequency Response

W-CDMA TEST SIGNAL

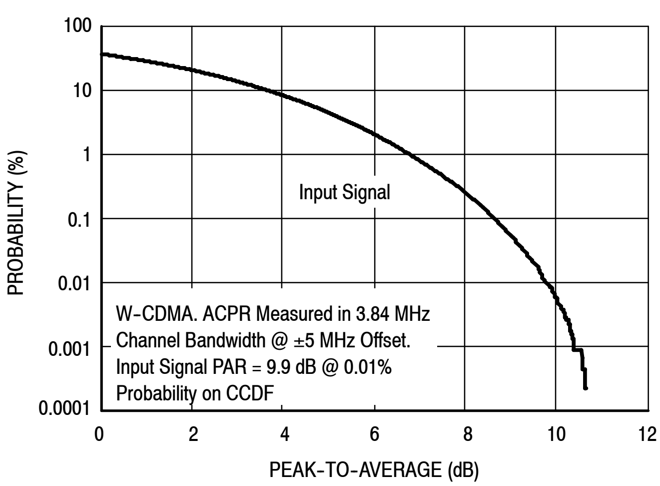


Figure 9. CCDF W-CDMA IQ Magnitude Clipping, Single-Carrier Test Signal

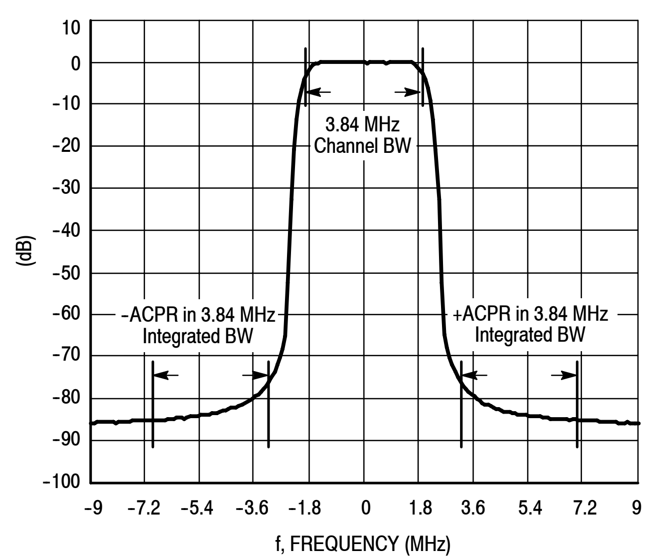


Figure 10. Single-Carrier W-CDMA Spectrum

V_{DD} = 28 Vdc, I_{DQA} = 550 mA

f MHz	Max P_{out} (1)		Z_{source} Ω	Z_{load} Ω
	Watts	dBm		
1880	98	49.9	5.14 – j9.41	1.56 – j5.24
1900	98	49.9	7.59 – j9.88	1.58 – j5.37
1920	97	49.9	8.90 – j9.65	1.57 – j5.48

(1) Maximum output power measurement reflects pulsed 1 dB gain compression.

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

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

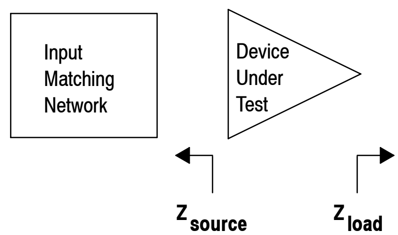


Figure 11. Maximum Output Power — Doherty Load Pull Optimization for Carrier Side

V_{DD} = 28 Vdc, I_{DQA} = 550 mA

f MHz	Max Eff. (1) %	Z_{source} Ω	Z_{load} Ω
1880	65.1	5.14 – j9.41	3.04 – j3.65
1900	64.6	7.59 – j9.88	4.13 – j2.87
1920	64.6	8.90 – j9.65	4.12 – j3.15

(1) Maximum efficiency measurement reflects pulsed 1 dB gain compression.

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

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

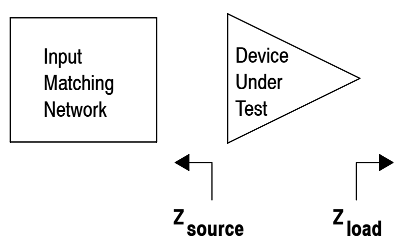
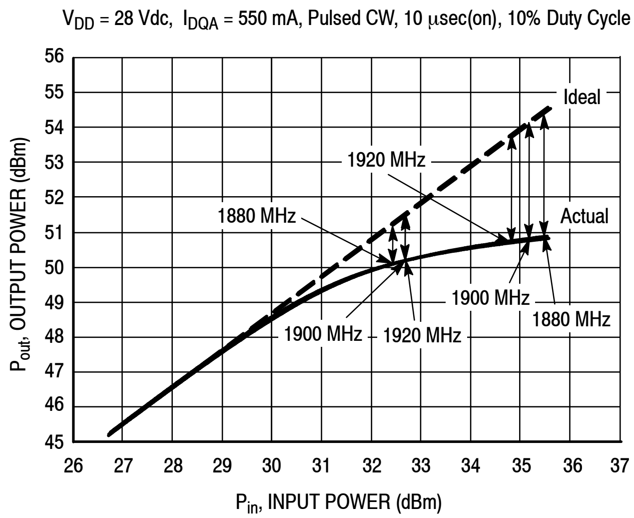


Figure 12. Maximum Efficiency — Doherty Load Pull Optimization for Carrier Side

ALTERNATIVE PEAK TUNE LOAD PULL CHARACTERISTICS



NOTE: Load Pull Test Fixture Tuned for Peak P1dB Output Power @ 28 V

f (MHz)	P1dB		P3dB	
	Watts	dBm	Watts	dBm
1880	103	50.1	122	50.9
1900	104	50.2	120	50.8
1920	104	50.2	118	50.7

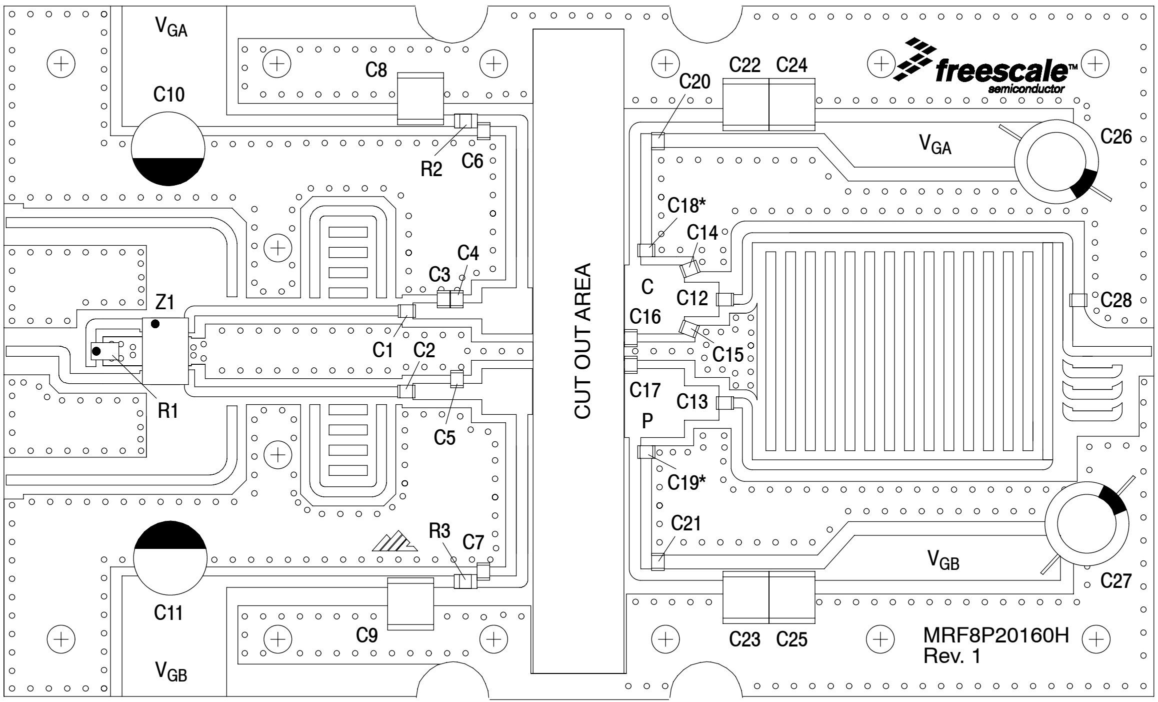
Test Impedances per Compression Level

f (MHz)		Z_{source} Ω	Z_{load} Ω
1880	P1dB	5.14 – j9.41	1.65 – j5.46
1900	P1dB	7.59 – j9.88	1.67 – j5.43
1920	P1dB	8.90 – j9.65	1.66 – j5.50

Figure 13. Pulsed CW Output Power versus Input Power @ 28 V

NOTE: Measurement made on the Class AB, carrier side of the device.

ALTERNATE CHARACTERIZATION — 2025 MHz



* Stacked

Figure 14. MRF8P20160HR3(HSR3) Test Circuit Component Layout — 2025 MHz

Table 6. MRF8P20160HR3(HSR3) Test Circuit Component Designations and Values — 2025 MHz

Part	Description	Part Number	Manufacturer
C1, C2, C6, C7, C12, C13, C20, C21	15 pF Chip Capacitors	ATC600F150JT250XT	ATC
C3, C14, C15	0.3 pF Chip Capacitors	ATC600F0R3BT250XT	ATC
C4, C5	2.4 pF Chip Capacitors	ATC600F2R4BT250XT	ATC
C8, C9, C22, C23, C24, C25	10 μF, 50 V Chip Capacitors	GRM55DR61H106KA88L	Murata
C10, C11	22 μF, 35 V Tantalum Capacitors	T491X226K035AT	Kemet
C16, C17	0.6 pF Chip Capacitors	ATC600F0R6BT250XT	ATC
C18, C19	1.1 pF Chip Capacitors	ATC600F1R1BT250XT	ATC
C26, C27	220 μF, 50 V Electrolytic Capacitors	227CKS505M	Illinois Cap
C28	0.8 pF Chip Capacitors	ATC600F0R8BT250XT	ATC
R1	50 Ω, 4 W Chip Resistor	CW12010T0050GBK	ATC
R2, R3	8.25 Ω, 1/4 W Chip Resistors	CRCW12068R25FKEA	Vishay
Z1	1900 MHz Band 90°, 3 dB Chip Hybrid Coupler	GCS351-HYB1900	Soshin
PCB	0.020″, ε_r = 3.5	RO4350B	Rogers

TYPICAL CHARACTERISTICS — 2025 MHz

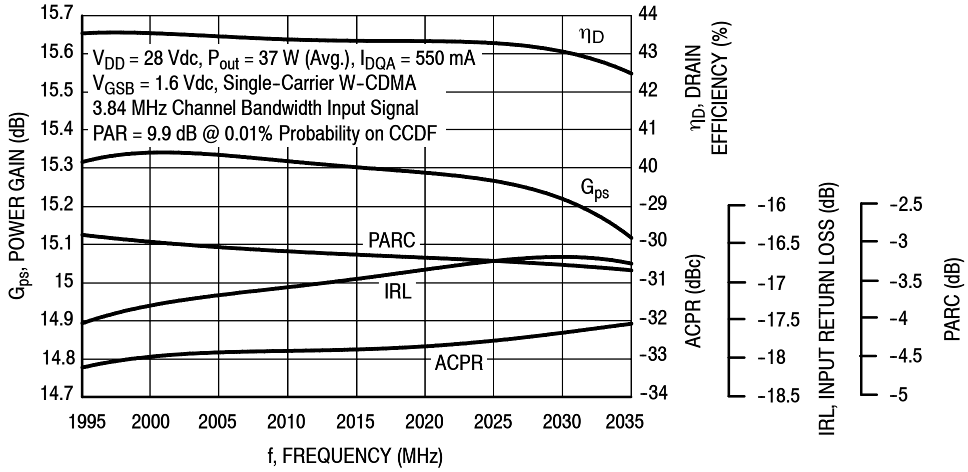


Figure 15. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @ P_{out} = 20 Watts Avg.

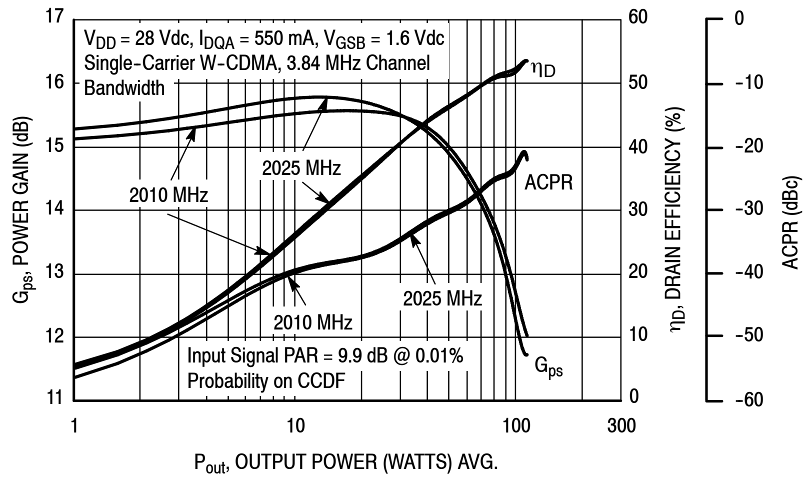


Figure 16. Single-Carrier W-CDMA Power Gain, Drain Efficiency and ACPR versus Output Power

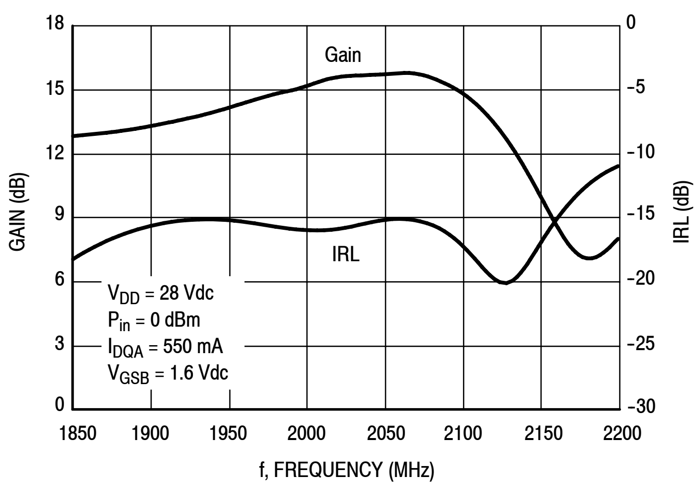
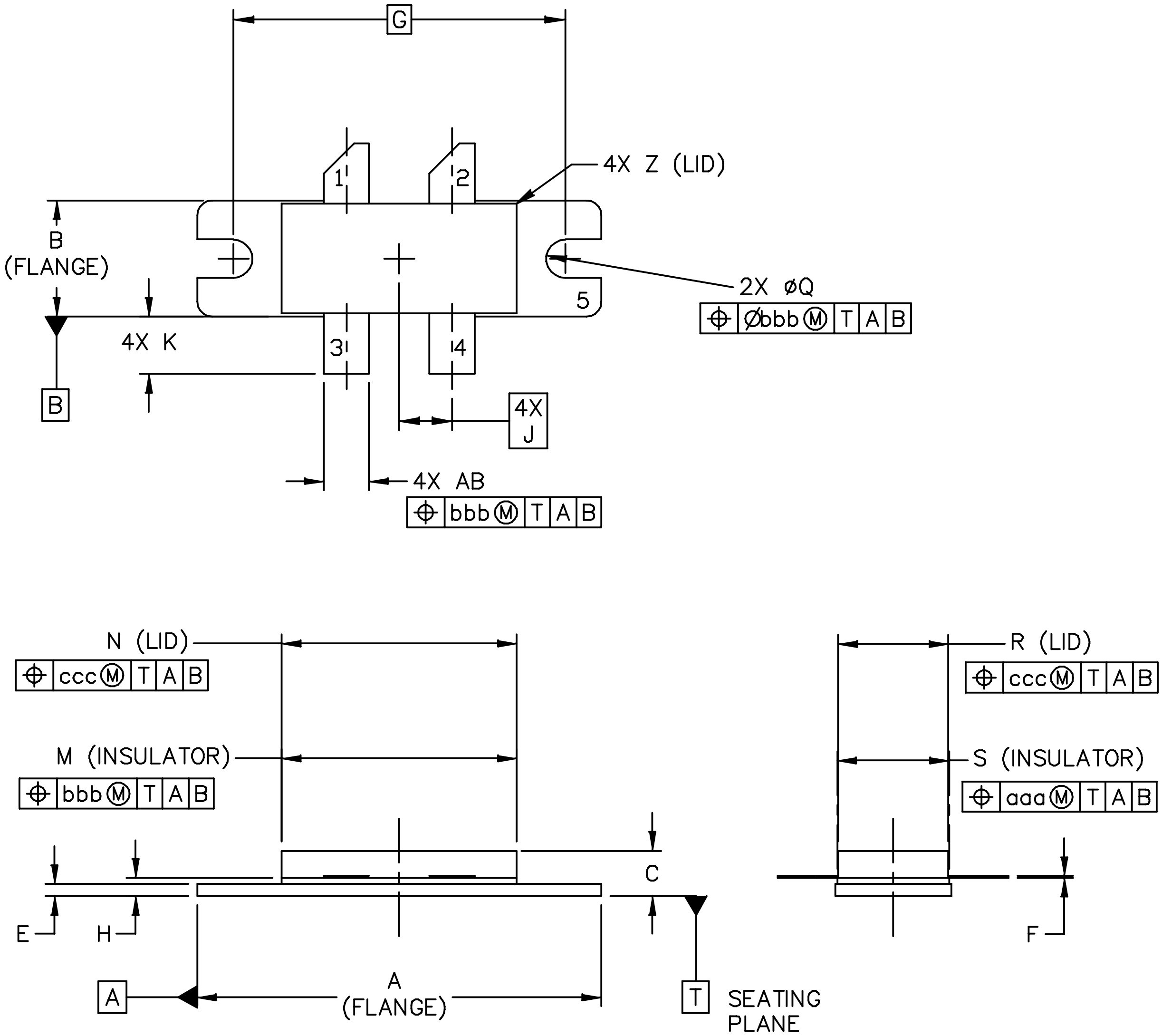


Figure 17. Broadband Frequency Response

PACKAGE DIMENSIONS



	MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE
TITLE: NI 780−4	DOCUMENT NO: 98ASA10793D	REV: 0
	CASE NUMBER: 465M−01	27 MAR 2007
	STANDARD: NON−JEDEC	

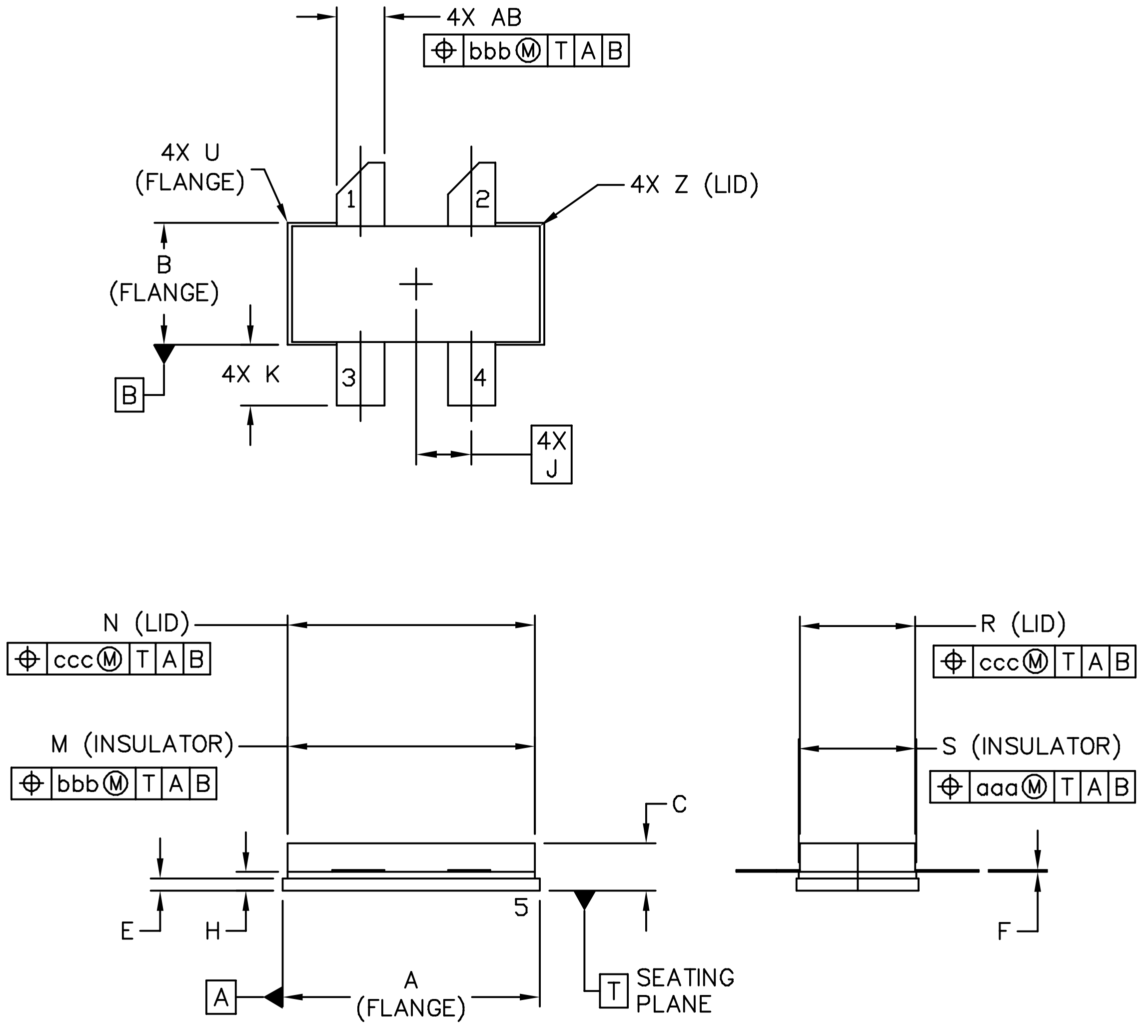
NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION H IS MEASURED .030 (0.762) AWAY FROM PACKAGE BODY.

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

DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX
A	1.335	1.345	33.91	34.16	R	.365	.375	9.27	9.53
B	.380	.390	9.65	9.91	S	.365	.375	9.27	9.52
C	.125	.170	3.18	4.32	U		.040		1.02
E	.035	.045	0.89	1.14	Z		.030		0.76
F	.003	.006	0.08	0.15	AB	.145	.155	3.68	3.94
G	1.100 BSC		27.94 BSC						
H	.057	.067	1.45	1.7	aaa	.005		0.127	
J	.175 BSC		4.44 BSC		bbb	.010		0.254	
K	.170	.210	4.32	5.33	ccc	.015		0.381	
M	.774	.786	19.61	20.02					
N	.772	.788	19.61	20.02					
Q	ø.118	ø.138	ø3	ø3.51					

	MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE
TITLE: NI 780-4	DOCUMENT NO: 98ASA10793D	REV: 0
	CASE NUMBER: 465M-01	27 MAR 2007
	STANDARD: NON-JEDEC	



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TITLE: NI 780S–4	DOCUMENT NO: 98ASA10718D	REV: A
	CASE NUMBER: 465H–02	27 MAR 2007
	STANDARD: NON–JEDEC	

NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M–1994.
2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED .030 (0.762) AWAY FROM PACKAGE BODY.

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

DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX
A	.805	.815	20.45	20.7	U		.040		1.02
B	.380	.390	9.65	9.91	Z		.030		0.76
C	.125	.170	3.18	4.32	AB	.145	.155	3.68 –	3.94
E	.035	.045	0.89	1.14					
F	.003	.006	0.08	0.15	aaa	.005		0.127	
H	.057	.067	1.45	1.7	bbb	.010		0.254	
J	.175 BSC		4.44 BSC		ccc	.015		0.381	
K	.170	.210	4.32	5.33					
M	.774	.786	19.61	20.02					
N	.772	.788	19.61	20.02					
R	.365	.375	9.27	9.53					
S	.365	.375	9.27	9.52					

MECHANICAL OUTLINE

PRINT VERSION NOT TO SCALE

TITLE:

NI 780S–4

DOCUMENT NO: 98ASA10718D

REV: A

CASE NUMBER: 465H–02

27 MAR 2007

STANDARD: NON–JEDEC

PRODUCT DOCUMENTATION AND SOFTWARE

Refer to the following documents, tools and software 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

Software

- Electromigration MTTF Calculator
- RF High Power Model
- .s2p File

For Software, do a Part Number search at http://www.freescale.com, and select the "Part Number" link. Go to the Software & Tools tab on the part's Product Summary page to download the respective tool.

REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	Apr. 2010	• Initial Release of Data Sheet
1	July 2010	• Added part number MRF8P20160HR3 (NI-780-4), p. 1 • Corrected I_{DQ1A} value from 554 to 550 mA in Thermal Characteristics table and changed thermal resistance value from 0.95 to 0.75°C/W. Thermal value now reflects the use of the combined dissipated power from the carrier amplifier and peaking amplifier, p. 2 • Changed $V_{DS(on)}$ values from 0.05 to 0.1 Min, 0.11 to 0.27 Typ and 0.15 to 0.5 Max. Revised numbers reflect per side measurement versus previous combined measurements, p. 2 • Replaced Fig. 4, Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @ P_{out} = 37 Watts Avg. to show a wider bandwidth capability, p. 6 • Replaced Fig. 15, Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @ P_{out} = 20 Watts Avg. to show more detailed RF performance capability, p. 11

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