Freescale Semiconductor
Technical Data

Document Number: MRF7S21170H
Rev. 7, 2/2012

RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

MRF7S21170HR3
MRF7S21170HSR3

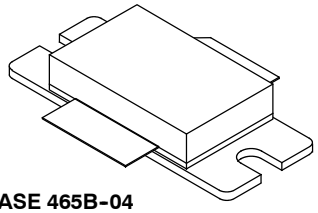
2110-2170 MHz, 50 W AVG., 28 V
SINGLE W-CDMA
LATERAL N-CHANNEL
RF POWER MOSFETs

Designed for CDMA base station applications with frequencies from 2110 to 2170 MHz. Suitable for CDMA and multicarrier amplifier applications. To be used in Class AB and Class C for PCN-PCS/cellular radio and WLL applications.

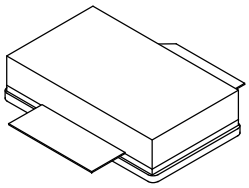
- Typical Single-Carrier W-CDMA Performance: V_{DD} = 28 Volts, I_{DQ} = 1400 mA, P_{out} = 50 Watts Avg., f = 2167.5 MHz, IQ Magnitude Clipping, Channel Bandwidth = 3.84 MHz, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF.
  - Power Gain — 16 dB
  - Drain Efficiency — 31%
  - Device Output Signal PAR — 6.1 dB @ 0.01% Probability on CCDF
  - ACPR @ 5 MHz Offset — -37 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 5:1 VSWR, @ 32 Vdc, 2140 MHz, 170 Watts CW Output Power
- P_{out} @ 1 dB Compression Point ≃ 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
- Optimized for Doherty Applications
- In Tape and Reel. R3 Suffix = 250 Units, 56 mm Tape Width, 13 inch Reel.



CASE 465B-04
NI-880
MRF7S21170HR3



CASE 465C-03
NI-880S
MRF7S21170HSR3

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 73°C, 25 W CW	$R_{\theta JC}$	 0.31 0.36	°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
Machine Model (per EIA/JESD22-A115)	B
Charge Device Model (per JESD22-C101)	IV

Table 4. Electrical Characteristics (T_A = 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}	—	—	500	nAdc
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	5.4	6.5	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 = 2167.5 MHz, Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @ ±5 MHz Offset.					
Power Gain	G_{ps}	15	16	18	dB
Drain Efficiency	η_D	29	31	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	5.7	6.1	—	dB
Adjacent Channel Power Ratio	ACPR	—	-37	-35	dBc
Input Return Loss	IRL	—	-15	-9	dB

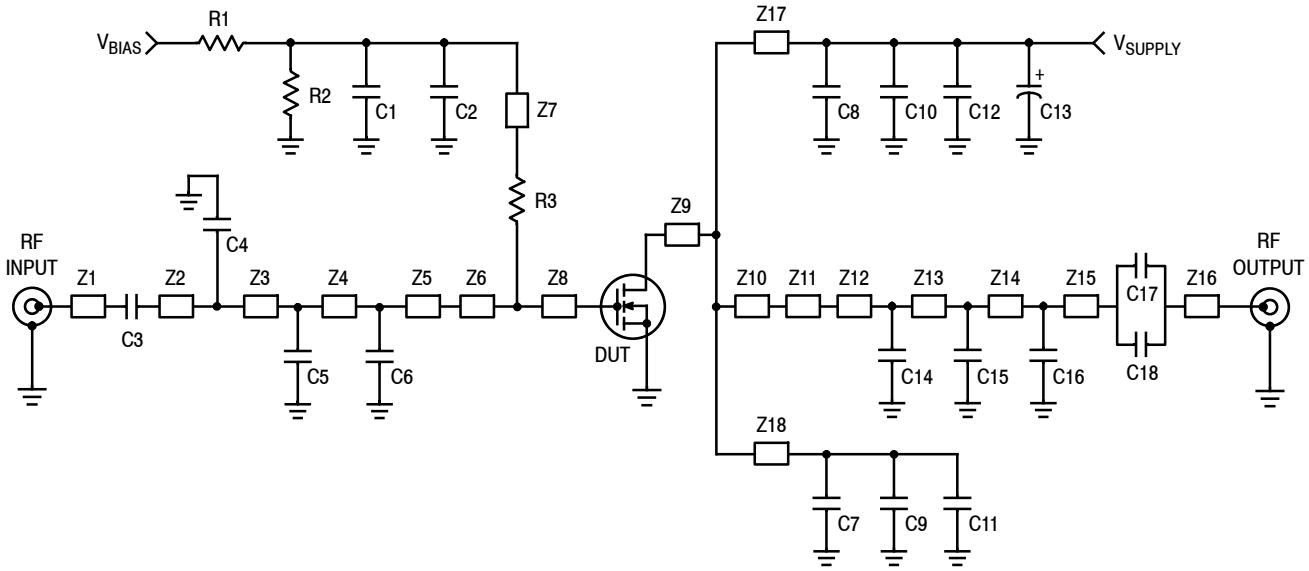
1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at http://www.freescale.com/rf. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.

(continued)

Table 4. Electrical Characteristics (T_A = 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, 2110–2170 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} = 50 W Avg.	G_F	—	0.4	—	dB
Average Deviation from Linear Phase in 60 MHz Bandwidth @ P_{out} = 170 W CW	Φ	—	1.95	—	°
Average Group Delay @ P_{out} = 170 W CW, f = 2140 MHz	Delay	—	1.7	—	ns
Part–to–Part Insertion Phase Variation @ P_{out} = 170 W CW f = 2140 MHz, Six Sigma Window	ΔΦ	—	18	—	°
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	—	dB/°C

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.



Z1	0.250″ x 0.083″ Microstrip	Z11	0.060″ x 0.760″ Microstrip
Z2*	0.090″ x 0.083″ Microstrip	Z12*	0.129″ x 0.083″ Microstrip
Z3*	0.842″ x 0.083″ Microstrip	Z13*	0.436″ x 0.083″ Microstrip
Z4*	0.379″ x 0.083″ Microstrip	Z14*	0.490″ x 0.083″ Microstrip
Z5*	0.307″ x 0.083″ Microstrip	Z15*	0.275″ x 0.083″ Microstrip
Z6	0.156″ x 0.787″ Microstrip	Z16	0.230″ x 0.083″ Microstrip
Z7	1.160″ x 0.080″ Microstrip	Z17, Z18	0.900″ x 0.080″ Microstrip
Z8	0.119″ x 0.787″ Microstrip	PCB	Taconic TLX8-0300, 0.030″, ε_r =2.55
Z9	0.077″ x 0.880″ Microstrip		
Z10	0.459″ x 1.000″ Microstrip	* Variable for tuning	

Figure 1. MRF7S21170HR3(HSR3) Test Circuit Schematic

Table 5. MRF7S21170HR3(HSR3) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1	100 pF Chip Capacitor	ATC100B101JT500XT	ATC
C2, C3, C7, C8, C17, C18	6.8 pF Chip Capacitors	ATC100B6R8BT500XT	ATC
C4, C15	0.3 pF Chip Capacitors	ATC100B0R3BT500XT	ATC
C5	0.8 pF Chip Capacitor	ATC100B0R8BT500XT	ATC
C6	0.2 pF Chip Capacitor	ATC100B0R2BT500XT	ATC
C9, C10, C11, C12	10 μF Chip Capacitors	C5750X5R1H106MT	TDK
C13	470 μF, 63 V Electrolytic Capacitor, Radial	477KXM063M	Illinois Capacitor
C14	0.4 pF Chip Capacitor	ATC100B0R4BT500XT	ATC
C16	0.1 pF Chip Capacitor	ATC100B0R1BT500XT	ATC
R1, R2	10 kΩ, 1/4 W Chip Resistors	CRCW12061002FKEA	Vishay
R3	10 Ω, 1/4 W Chip Resistor	CRCW120610R0FKEA	Vishay

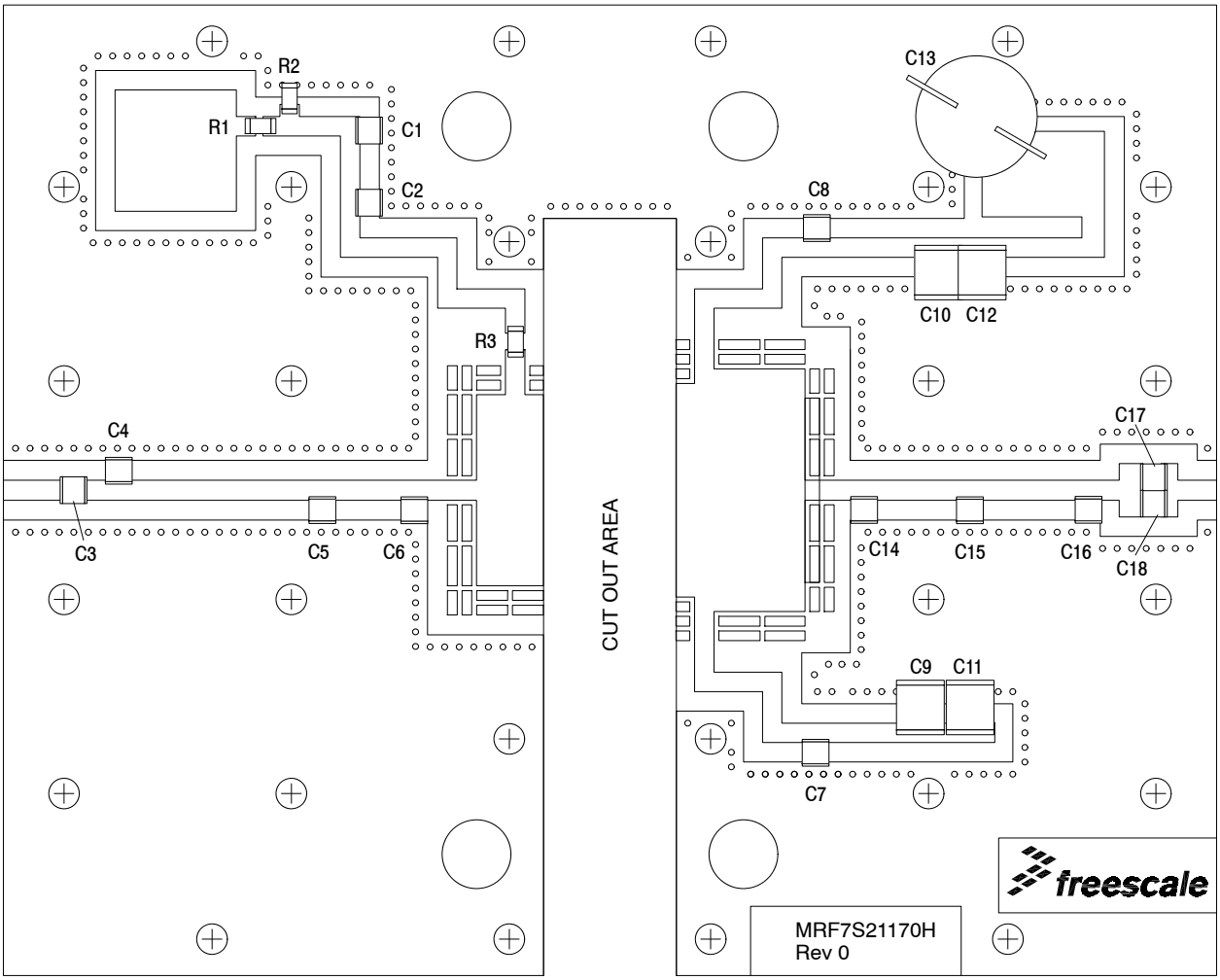


Figure 2. MRF7S21170HR3(HSR3) Test Circuit Component Layout

TYPICAL CHARACTERISTICS

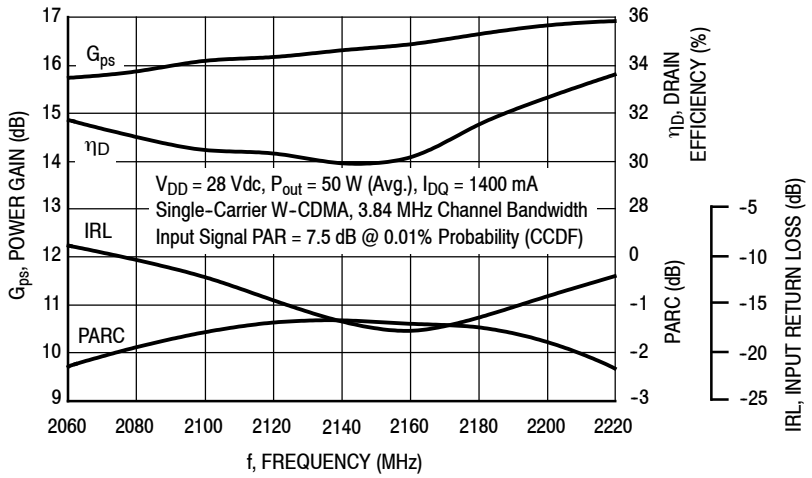


Figure 3. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @ P_{out} = 50 Watts Avg.

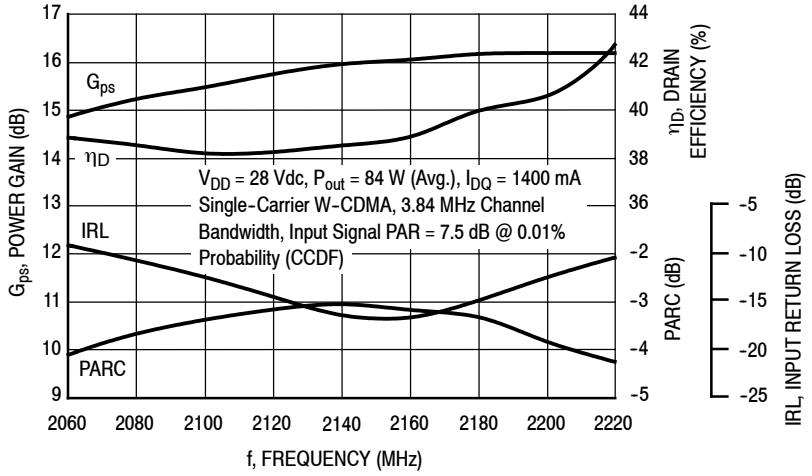


Figure 4. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @ P_{out} = 84 Watts Avg.

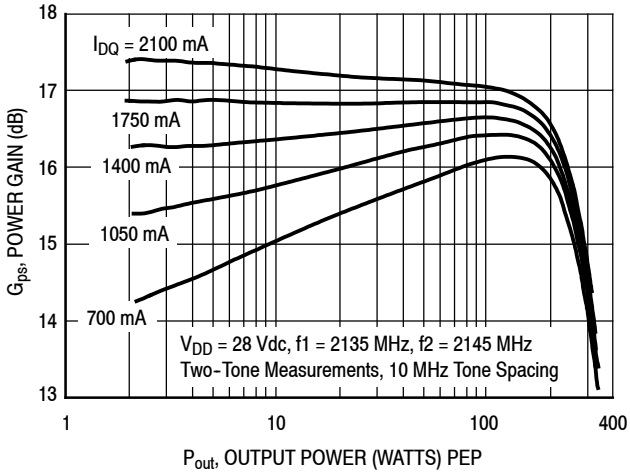


Figure 5. Two-Tone Power Gain versus Output Power

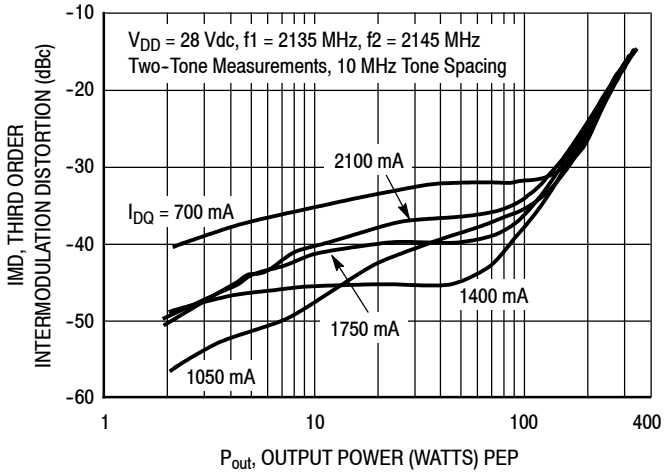


Figure 6. Third Order Intermodulation Distortion versus Output Power

TYPICAL CHARACTERISTICS

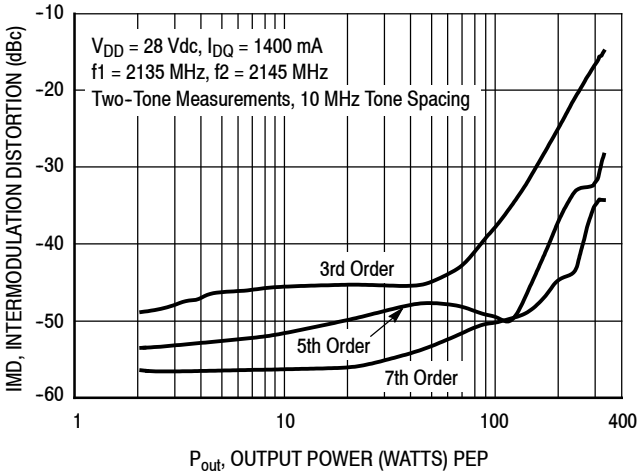


Figure 7. Intermodulation Distortion Products versus Output Power

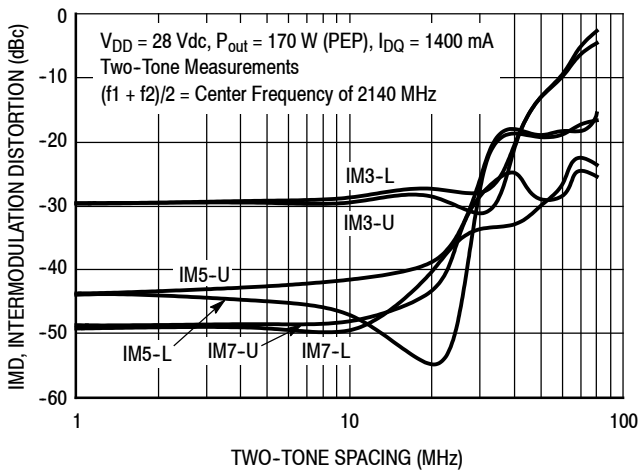


Figure 8. Intermodulation Distortion Products versus Tone Spacing

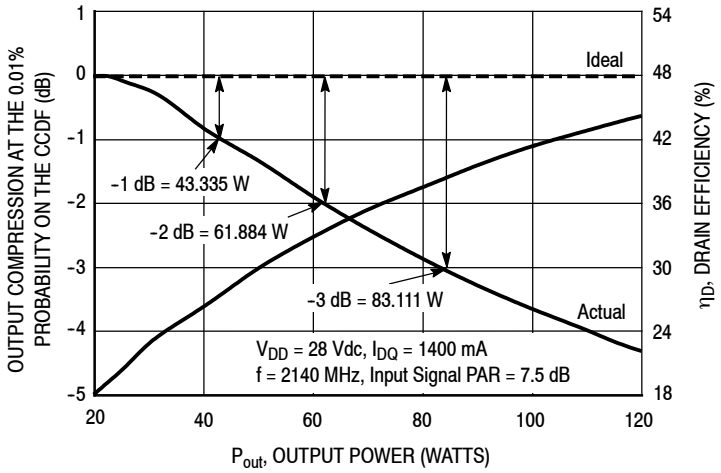


Figure 9. Output Peak-to-Average Ratio Compression (PARC) versus Output Power

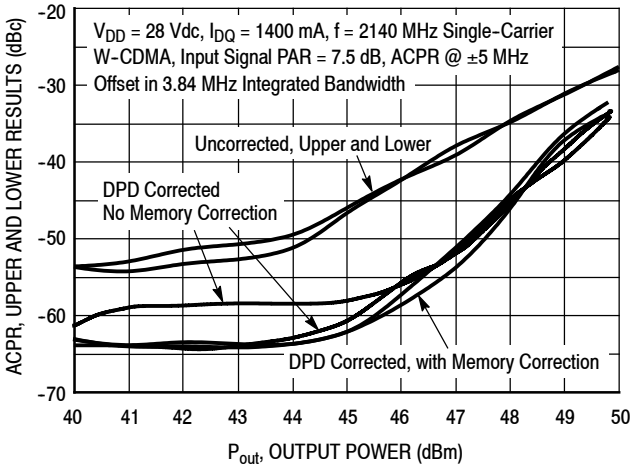


Figure 10. Digital Predistortion Correction versus ACPR and Output Power

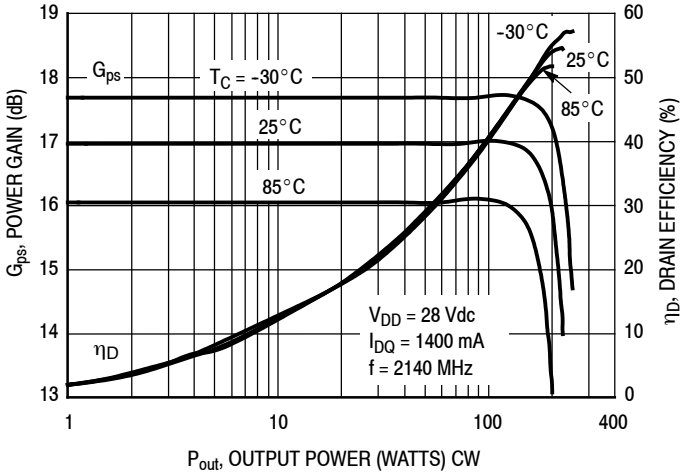


Figure 11. Power Gain and Drain Efficiency versus CW Output Power

TYPICAL CHARACTERISTICS

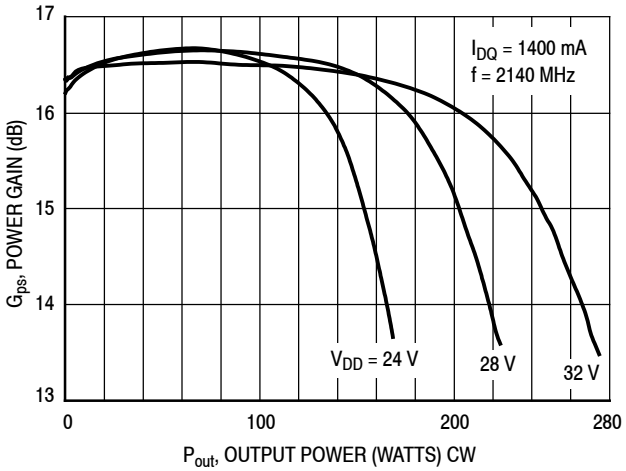


Figure 12. Power Gain versus Output Power

W-CDMA TEST SIGNAL

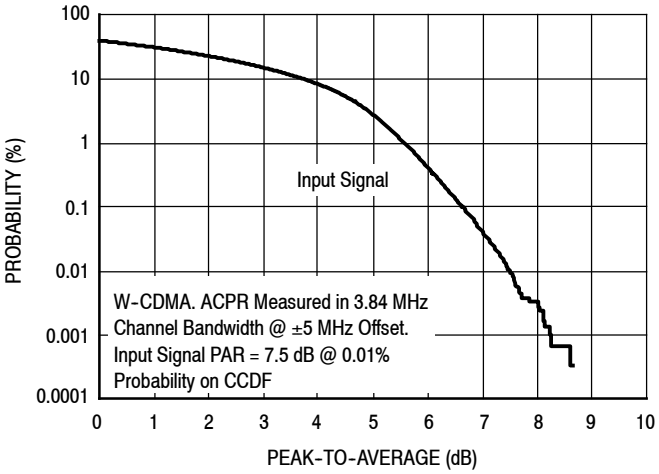


Figure 13. CCDF W-CDMA IQ Magnitude Clipping, Single-Carrier Test Signal

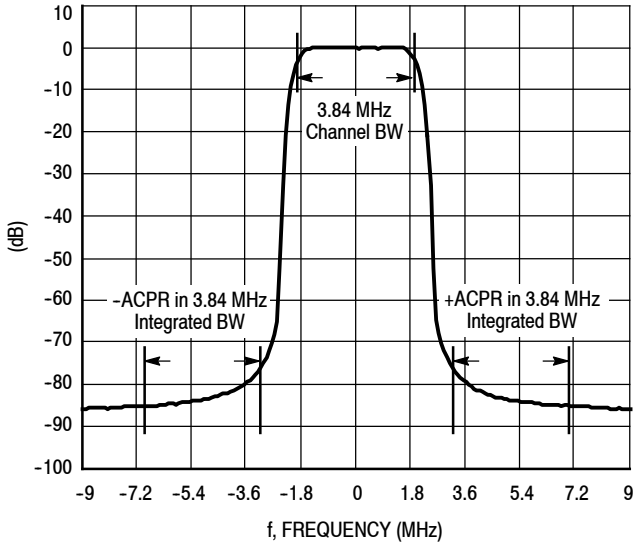
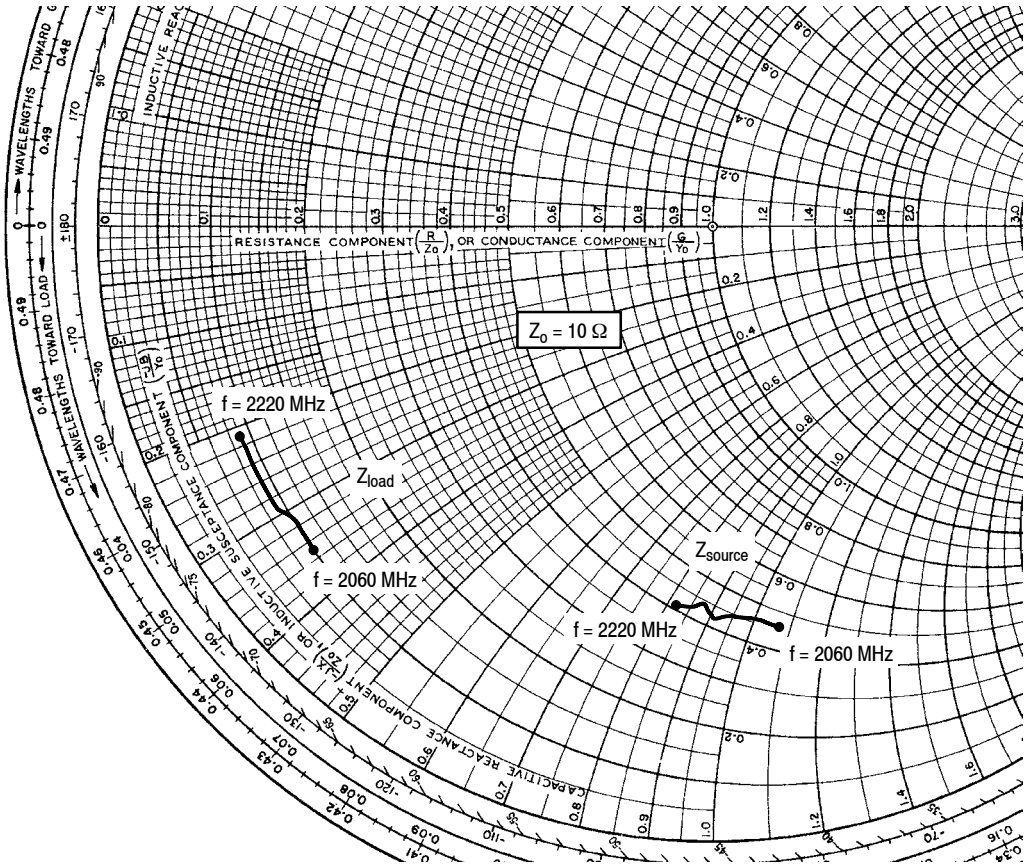


Figure 14. Single-Carrier W-CDMA Spectrum



V_{DD} = 28 Vdc, I_{DQ} = 1400 mA, P_{out} = 50 W Avg.

f MHz	Z_{source} Ω	Z_{load} Ω
2060	4.57 – j10.70	1.02 – j3.54
2080	4.57 – j10.38	0.99 – j3.34
2100	4.57 – j10.06	0.96 – j3.14
2120	4.52 – j9.72	0.93 – j2.94
2140	4.40 – j9.42	0.92 – j2.76
2160	4.15 – j9.12	0.91 – j2.59
2180	4.44 – j8.82	0.89 – j2.42
2200	4.19 – j8.53	0.88 – j2.25
2220	4.12 – j8.23	0.88 – j2.09

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

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

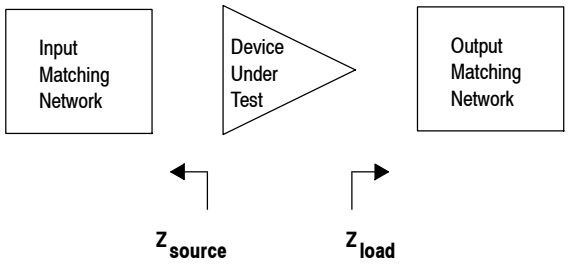
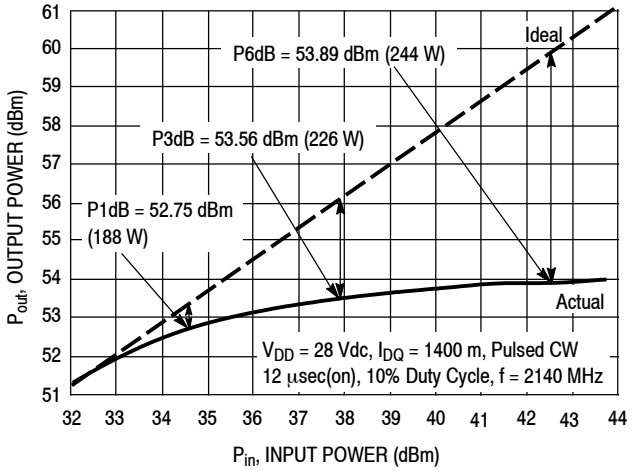


Figure 15. Series Equivalent Source and Load Impedance

ALTERNATIVE PEAK TUNE LOAD PULL CHARACTERISTICS

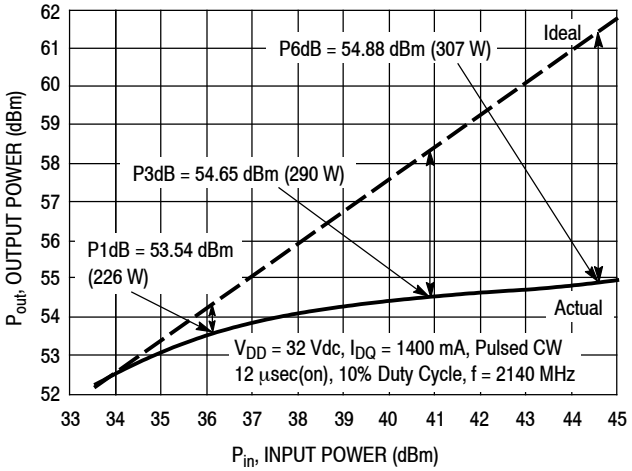


NOTE: Measured in a Peak Tuned Load Pull Fixture

Test Impedances per Compression Level

	Z_{source} Ω	Z_{load} Ω
P3dB	4.43 – j11.85	0.81 – j2.87

Figure 16. Pulsed CW Output Power versus Input Power @ 28 V



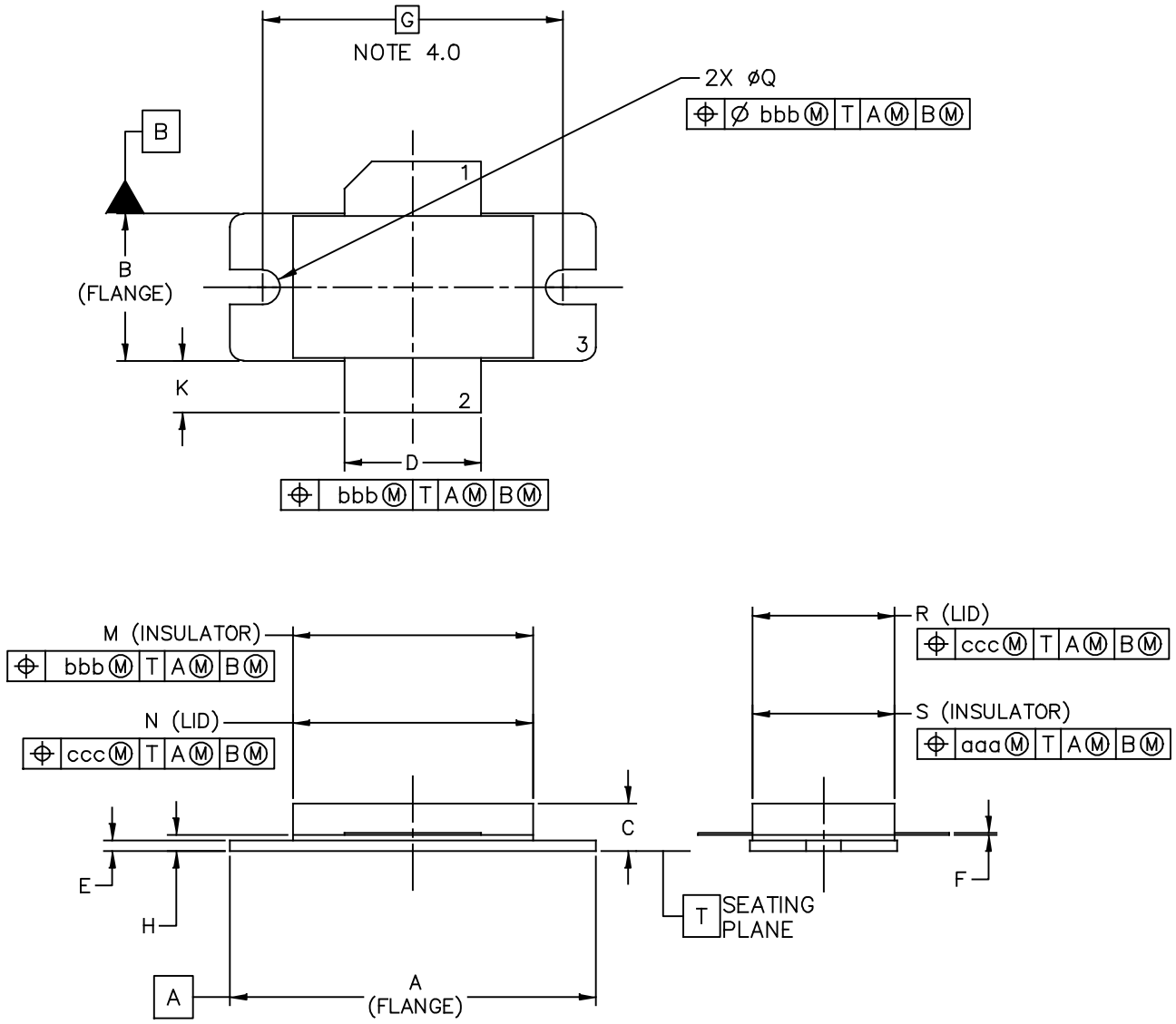
NOTE: Measured in a Peak Tuned Load Pull Fixture

Test Impedances per Compression Level

	Z_{source} Ω	Z_{load} Ω
P3dB	4.43 – j11.85	0.72 – j2.87

Figure 17. Pulsed CW Output Power versus Input Power @ 32 V

PACKAGE DIMENSIONS



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TITLE: NI-880	DOCUMENT NO: 98ARB18493C	REV: F
	CASE NUMBER: 465B-04	26 MAY 2011
	STANDARD: NON-JEDEC	

NOTES:
1.0 DIMENSIONING AND TOLERANCING PER ANSI Y14.5M–1994.

2.0 CONTROLLING DIMENSION: INCH.

3.0 DIMENSION H IS MEASURED .030 (0.762) AWAY FROM PACKAGE BODY.

4.0 RECOMMENDED BOLT CENTER DIMENSION OF 1.16 (29.57) BASED ON M3 SCREW.

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	.515	.525	13.08	13.34
B	.535	.545	13.59	13.84	S	.515	.525	13.08	13.34
C	.147	.200	3.73	5.08	aaa	—	.007	—	0.178
D	.495	.505	12.57	12.83	bbb	—	.010	—	0.254
E	.035	.045	0.89	1.14	ccc	—	.015	—	0.381
F	.003	.006	0.08	0.15	—	—	—	—	—
G	1.100 BSC		27.94 BSC		—	—	—	—	—
H	.057	.067	1.45	1.70	—	—	—	—	—
K	.175	.205	4.45	5.21	—	—	—	—	—
M	.872	.888	22.15	22.56	—	—	—	—	—
N	.871	.889	22.12	22.58	—	—	—	—	—
Q	ø.118	ø.138	ø3.00	ø3.51	—	—	—	—	—

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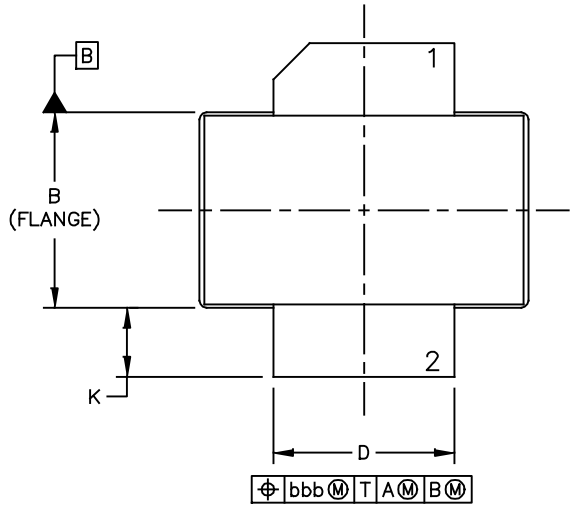
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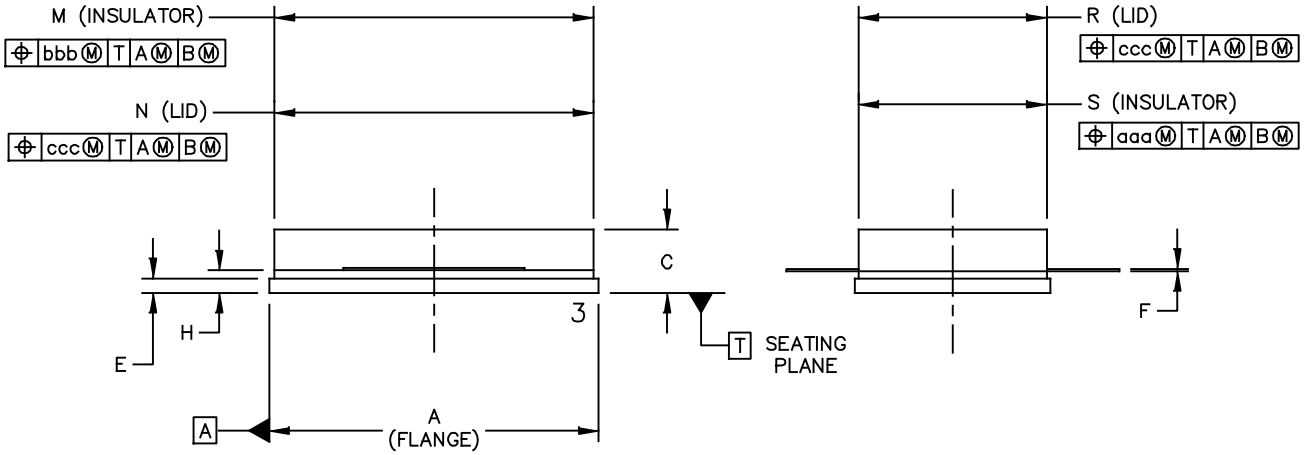
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STANDARD: NON–JEDEC





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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.

DIM	INCH MIN		INCH MAX	MILLIMETER MIN		MILLIMETER MAX	DIM	INCH MIN		INCH MAX	MILLIMETER MIN		MILLIMETER MAX
A	.905	–	.915	22.99	–	23.24	aaa	–	.007	–	–	0.178	–
B	.535	–	.545	13.59	–	13.84	bbb	–	.010	–	–	0.254	–
C	.147	–	.200	3.73	–	5.08	ccc	–	.015	–	–	0.381	–
D	.495	–	.505	12.57	–	12.83	–	–	–	–	–	–	–
E	.035	–	.045	0.89	–	1.14	–	–	–	–	–	–	–
F	.003	–	.006	0.08	–	0.15	–	–	–	–	–	–	–
H	.057		.067	1.45		1.70	–	–	–	–	–	–	–
K	.170	–	.210	4.32	–	5.33	–	–	–	–	–	–	–
M	.872	–	.888	22.15	–	22.56	–	–	–	–	–	–	–
N	.871	–	.889	22.12	–	22.58	–	–	–	–	–	–	–
R	.515	–	.525	13.08	–	13.34	–	–	–	–	–	–	–
S	.515	–	.525	13.08	–	13.34	–	–	–	–	–	–	–

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	CASE NUMBER: 465C–03	26 MAY 2011
	STANDARD: NON–JEDEC	

PRODUCT DOCUMENTATION AND SOFTWARE

Refer to the following documents 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

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	May 2006	• Initial Release of Data Sheet
1	June 2006	• Added Class C to description of parts, pg. 1 • Changeded “≥” to “–” in the Device Output Signal Par bullet, pg. 1 • Changed typ value from ±9 to 18 in Part–to–Part Phase Variation characteristic description in Table 4, Typical Performances, p. 2 • Expanded the characterization range in the MTTF Factor graph from 200°C to 230°C, Fig. 12, p. 7
2	Aug. 2006	• Added Greater Negative Source bullet to Features section, p. 1 • Corrected Fig. 14, Single–Carrier W–CDMA Spectrum, to 3.84 MHz, p. 7
3	Sept. 2006	• Changed “Capable of Handling” bullet from 10:1 VSWR @ 28 Vdc to 5:1 VSWR @ 32 Vdc, pg. 1 • Added “Insertion” to Part–to–Part Phase Variation characteristic description in Table 4, Typical Performances, p. 2 • Added Gain Flatness, Group Delay and Deviation from Linear Phase characteristics to Table 4, Typical Performances, p. 2 • Corrected Z6 value from “0.119” to “0.156”, corrected Z8 value from “0.156” to “0.119”, corrected Z9 value from “0.770” to “0.077”, corrected Z11 value from “0.076” to “0.760”, Fig. 1, Test Circuit Schematic, p. 3 • Added Part Number and Manufacturer for R1, R2 and R3 in Table 5, Test Circuit Component Designations and Values, p. 3 • Added Figure 10, Digital Predistortion Correction, p. 6 • Corrected Fig. 15, Single–Carrier W–CDMA Spectrum, to correctly reflect integrated bandwidth offsets, p. 7 • Added Figure 17, Pulsed CW Output Power versus Input Power @ 28 Vdc, p. 9 • Added Figure 18, Pulsed CW Output Power versus Input Power @ 32 Vdc, p. 9
4	May 2007	• Removed “Designed for Digital Predistortion Error Correction Systems” bullet as functionality is standard, p. 1 • Added “Optimized for Doherty Applications” bullet to Features section, p. 1 • Operating Junction Temperature increased from 200°C to 225°C in Maximum Ratings table and related “Continuous use at maximum temperature will affect MTTF” footnote added, p. 1 • Removed footnote and “Measured in Functional Test” from the RF test condition voltage callout for $V_{GS(Q)}$, and added Fixture Gate Quiescent Voltage, $V_{GG(Q)}$ to On Characteristics table, p. 2 • Updated verbiage in Typical Performances table, p. 3 • Updated Part Numbers in Table 5, Component Designations and Values, to RoHS compliant part numbers and updated obsoleted ATC600 series capacitors to ATC100 series, 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 • Fig. 14, CCDF W–CDMA 3GPP, Test Model 1, 64 DPCH, 50% Clipping, Single–Carrier Test Signal, updated to include output power level at functional test, p. 8

(continued)

REVISION HISTORY (continued)

Revision	Date	Description
5	Apr. 2008	• Corrected On Characteristics table I_D value for $V_{GS(th)}$ from 270 μAdc to 372 μAdc and $V_{DS(on)}$ from 2.7 Adc to 3.72 Adc; tightened $V_{GS(th)}$ minimum and maximum values to match production test values, p. 2 • Updated Part Numbers in Table 5, Component Designations and Values, to latest RoHS compliant part numbers, p. 4 • Updated Fig. 14, CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 50% Clipping, Single-Carrier Test Signal, to better represent production test signal, p. 8
6	Mar. 2011	• Modified data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN13628, p. 1, 2 • Fig. 13, MTTF versus Junction Temperature removed, p. 8. Refer to the device's MTTF Calculator available at freescale.com/RFpower. Go to Design Resources > Software and Tools. • Fig. 14, CCDF W-CDMA IQ Magnitude Clipping, Single-Carrier Test Signal and Fig. 15, Single-Carrier W-CDMA Spectrum updated to show the undistorted input test signal, p. 8 (renumbered as Figs. 13 and 14 respectively after Fig. 13 removed) • Added Electromigration MTTF Calculator and RF High Power Model availability to Product Software, p. 15
7	Feb. 2012	• Table 3, ESD Protection Characteristics, removed the word "Minimum" after the ESD class rating. ESD ratings are characterized during new product development but are not 100% tested during production. ESD ratings provided in the data sheet are intended to be used as a guideline when handling ESD sensitive devices, p. 2. • Replaced Case Outline 465B-03, Issue D, with 465B-04, Issue F, p. 1, 11-12. Deleted Style 1 pin note on Sheet 2. On Sheet 2, changed dimension B in mm from 13.6-13.8 to 13.59-13.84, changed dimension H in mm from 1.45-1.7 to 1.45-1.70, changed dimension K in mm from 4.44-5.21 to 4.45-5.21, changed dimension M in mm from 22.15-22.55 to 22.15-22.56, changed dimension N in mm from 19.3-22.6 to 22.12-22.58, changed dimension Q in mm from 3-3.51 to 3.00-3.51, changed dimension R and S in mm from 13.1-13.3 to 13.08-13.34. • Replaced Case Outline 465C-02, Issue D, with 465C-03, Issue E, p. 1, 13-14. Deleted Style 1 pin note on Sheet 2. On Sheet 2, changed dimension B in mm from 13.6-13.8 to 13.59-13.84, changed dimension H in mm from 1.45-1.7 to 1.45-1.70, changed dimension M in mm from 22.15-22.55 to 22.15-22.56, changed dimension N in mm from 19.3-22.6 to 22.12-22.58, changed dimension R and S in mm from 13.1-13.3 to 13.08-13.34.

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