Freescale Semiconductor
Technical Data

Document Number: MRF6S21060N
Rev. 5, 12/2008

RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

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

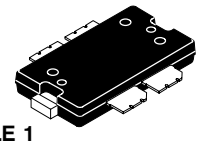
- Typical 2-Carrier W-CDMA Performance: V_{DD} = 28 Volts, I_{DQ} = 610 mA, P_{out} = 14 Watts Avg., f = 2115.5 MHz, Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.
  Power Gain — 15.5 dB
  Drain Efficiency — 26%
  IM3 @ 10 MHz Offset — -37 dBc in 3.84 MHz Bandwidth
  ACPR @ 5 MHz Offset — -40 dBc in 3.84 MHz Bandwidth
- Capable of Handling 5:1 VSWR, @ 28 Vdc, 2140 MHz, 60 Watts CW Output Power

Features

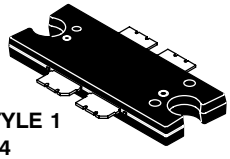
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 32 V_{DD} Operation
- Integrated ESD Protection
- Designed for Lower Memory Effects and Wide Instantaneous Bandwidth Applications
- 225°C Capable Plastic Package
- N Suffix Indicates Lead-Free Terminations. RoHS Compliant.
- In Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.

MRF6S21060NR1
MRF6S21060NBR1

2110-2170 MHz, 14 W AVG., 28 V
2 x W-CDMA
LATERAL N-CHANNEL
RF POWER MOSFETs



CASE 1486-03, STYLE 1
TO-270 WB-4
PLASTIC
MRF6S21060NR1



CASE 1484-04, STYLE 1
TO-272 WB-4
PLASTIC
MRF6S21060NBR1

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	-0.5, +68	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 Case Temperature 79°C, 60 W CW Case Temperature 76°C, 14 W CW	$R_{\theta JC}$	 0.89 1.04	°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.

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)	III (Minimum)

Table 4. Moisture Sensitivity Level

Test Methodology	Rating	Package Peak Temperature	Unit
Per JESD22-A113, IPC/JEDEC J-STD-020	3	260	°C

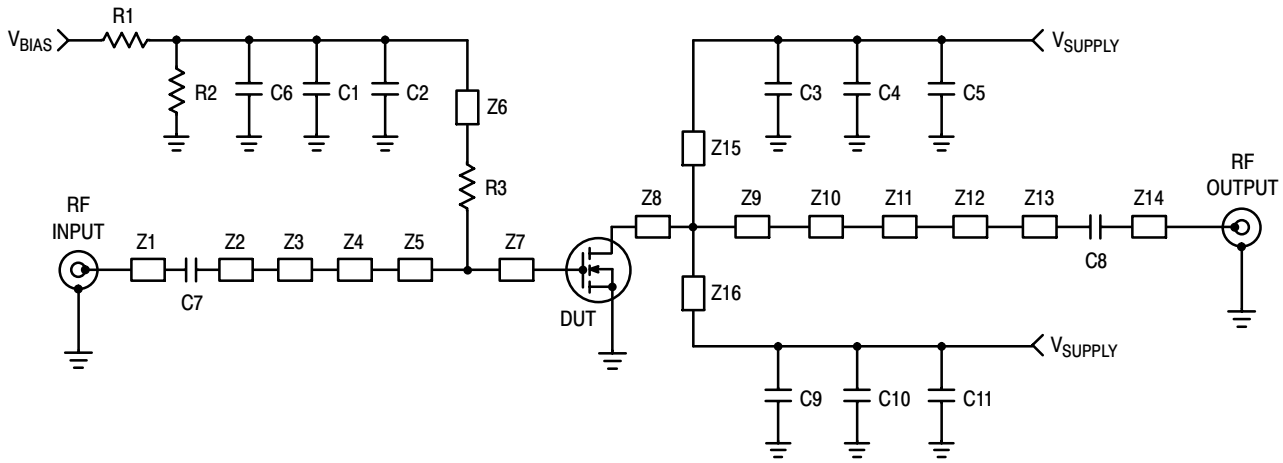
Table 5. Electrical Characteristics (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Off Characteristics					
Zero Gate Voltage Drain Leakage Current (V_{DS} = 68 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 (DC)					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 200 μAdc)	$V_{GS(th)}$	1.5	2.2	2.5	Vdc
Gate Quiescent Voltage (V_{DD} = 28 Vdc, I_D = 610 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	2	2.8	4	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 2.0 Adc)	$V_{DS(on)}$	—	0.3	—	Vdc
Dynamic Characteristics (1)					
Reverse Transfer Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	1.5	—	pF

Functional Tests (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 610 mA, P_{out} = 14 W Avg., f1 = 2115.5 MHz, f2 = 2122.5 MHz, 2-carrier W-CDMA, 3.84 MHz Channel Bandwidth Carriers. ACPR measured in 3.84 MHz Channel Bandwidth @ ±5 MHz Offset. IM3 measured in 3.84 MHz Bandwidth @ ±10 MHz Offset. PAR = 8.5 dB @ 0.01% Probability on CCDF.

Power Gain	G_{ps}	13.5	15.5	16.5	dB
Drain Efficiency	η_D	24.5	26	—	%
Intermodulation Distortion	IM3	—	-37	-35	dBc
Adjacent Channel Power Ratio	ACPR	—	-40	-38	dBc
Input Return Loss	IRL	—	-14	-10	dB

1. Part is internally matched both on input and output.



Z1	0.250″ x 0.080″ Microstrip	Z10	0.270″ x 0.300″ Microstrip
Z2	0.860″ x 0.080″ Microstrip	Z11	0.230″ x 0.080″ Microstrip
Z3	0.300″ x 0.405″ Microstrip	Z12	0.310″ x 0.300″ Microstrip
Z4	0.350″ x 0.080″ Microstrip	Z13	0.830″ x 0.080″ Microstrip
Z5	0.350″ x 0.755″ Microstrip	Z14	0.200″ x 0.080″ Microstrip
Z6	0.680″ x 0.080″ Microstrip	Z15	1.000″ x 0.080″ Microstrip
Z7	0.115″ x 0.755″ Microstrip	Z16	1.100″ x 0.070″ Microstrip
Z8	0.115″ x 1.000″ Microstrip	PCB	Arlon CuClad 250GX-0300-55-22, 0.030″, ε_r = 2.55
Z9	0.240″ x 1.000″ Microstrip		

Figure 1. MRF6S21060NR1(NBR1) Test Circuit Schematic

Table 6. MRF6S21060NR1(NBR1) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1	100 nF Chip Capacitor	CDR33BX104AKYS	Kemet
C2, C7	4.7 pF Chip Capacitors	ATC100B4R7BT500XT	ATC
C3, C8, C9	6.8 pF Chip Capacitors	ATC100B6R8BT500XT	ATC
C4, C5, C6, C10, C11	10 μF, 35 V Chip Capacitors	GRM55DR61H106KA88L	Murata
R1	1 kΩ, 1/4 W Chip Resistor	CRCW12061001FKEA	Vishay
R2	10 kΩ, 1/4 W Chip Resistor	CRCW12061002FKEA	Vishay
R3	10 Ω, 1/4 W Chip Resistor	CRCW120610R0FKEA	Vishay

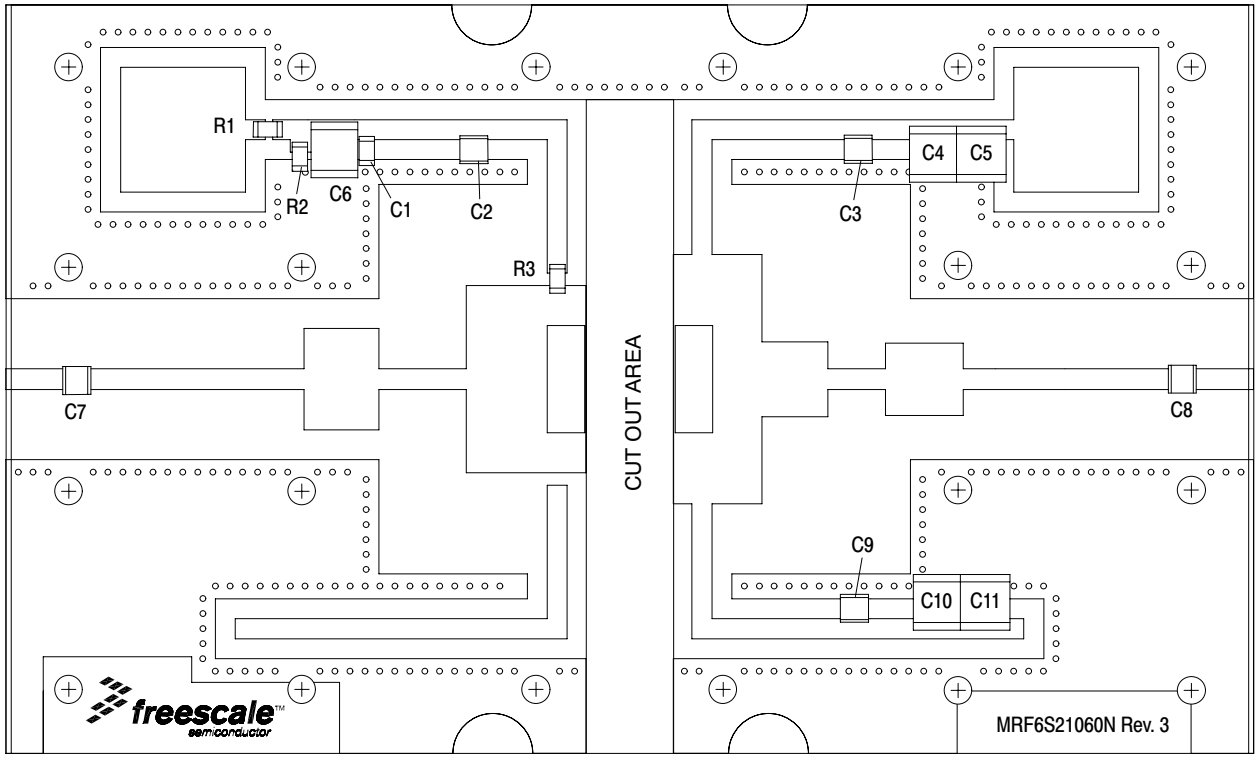


Figure 2. MRF6S21060NR1(NBR1) Test Circuit Component Layout

TYPICAL CHARACTERISTICS

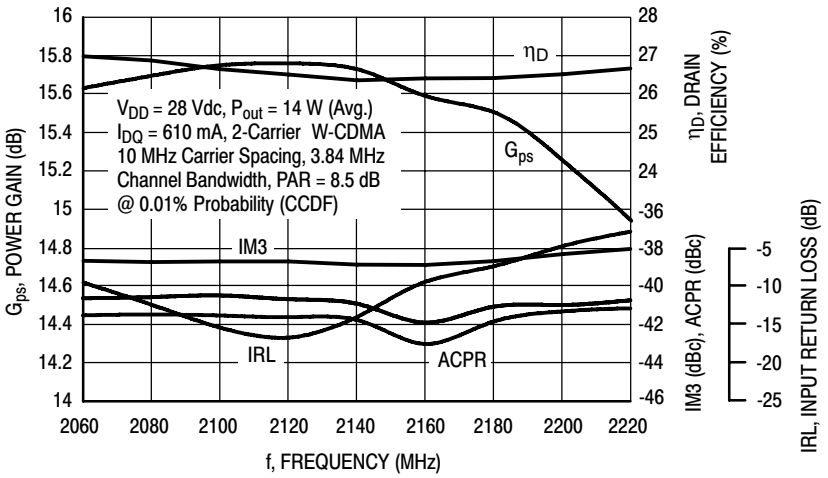


Figure 3. 2-Carrier W-CDMA Broadband Performance @ P_{out} = 14 Watts Avg.

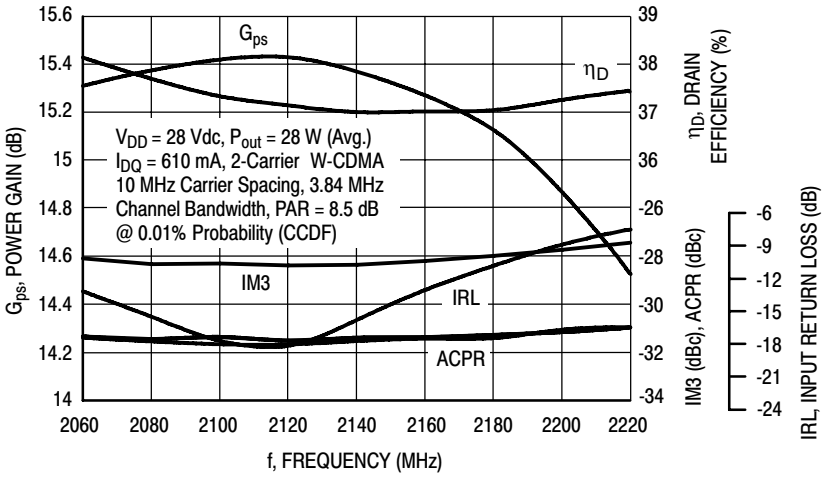


Figure 4. 2-Carrier W-CDMA Broadband Performance @ P_{out} = 28 Watts Avg.

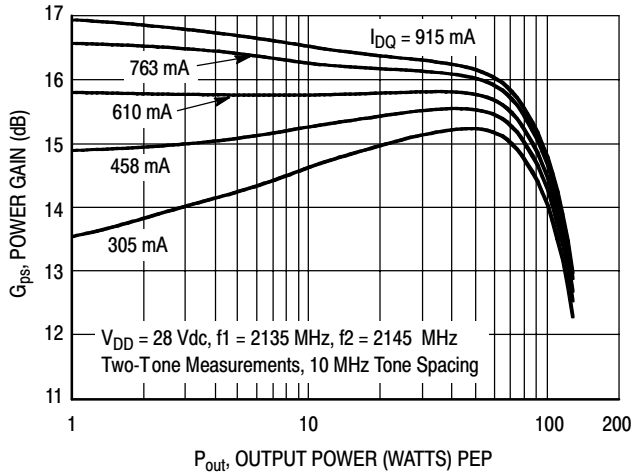


Figure 5. Two-Tone Power Gain versus Output Power

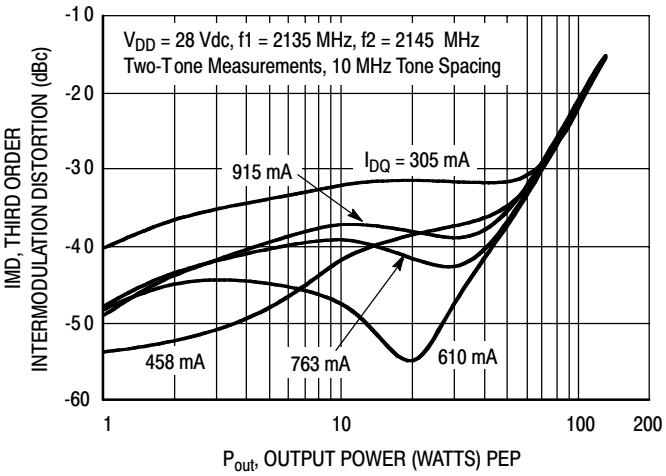


Figure 6. Third Order Intermodulation Distortion versus Output Power

TYPICAL CHARACTERISTICS

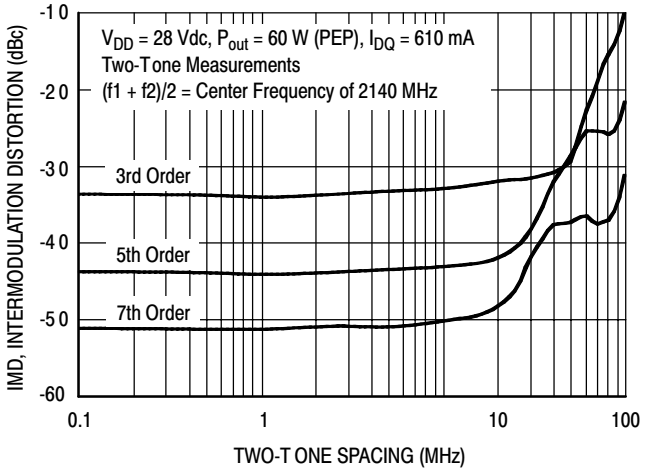


Figure 7. Intermodulation Distortion Products versus Tone Spacing

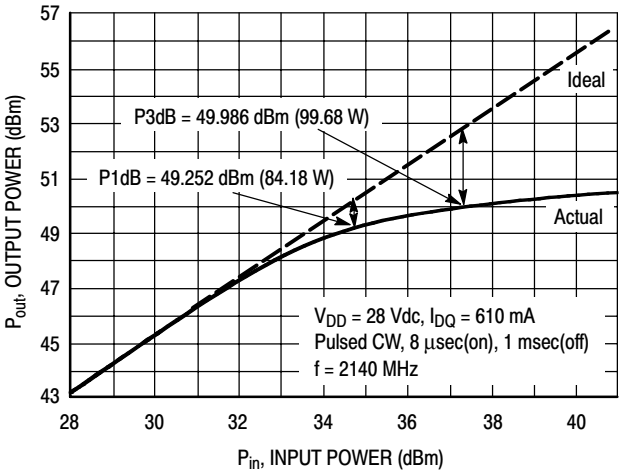


Figure 8. Pulsed CW Output Power versus Input Power

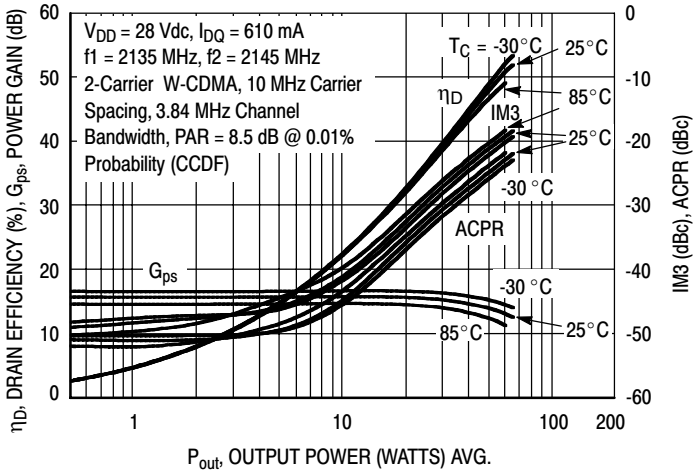


Figure 9. 2-Carrier W-CDMA ACPR, IM3, Power Gain and Drain Efficiency versus Output Power

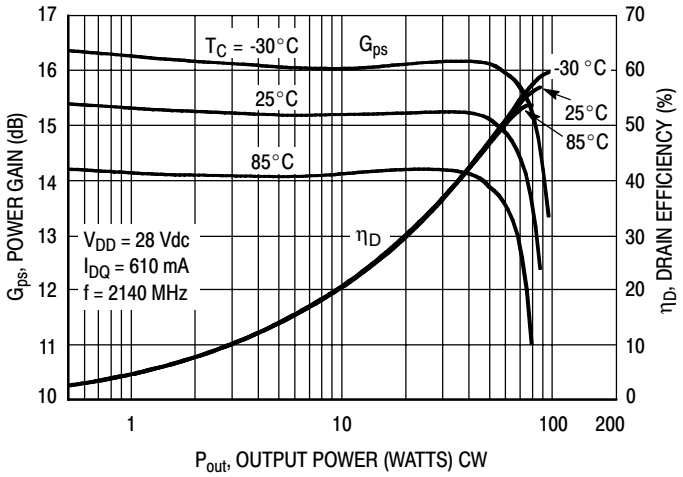


Figure 10. Power Gain and Drain Efficiency versus CW Output Power

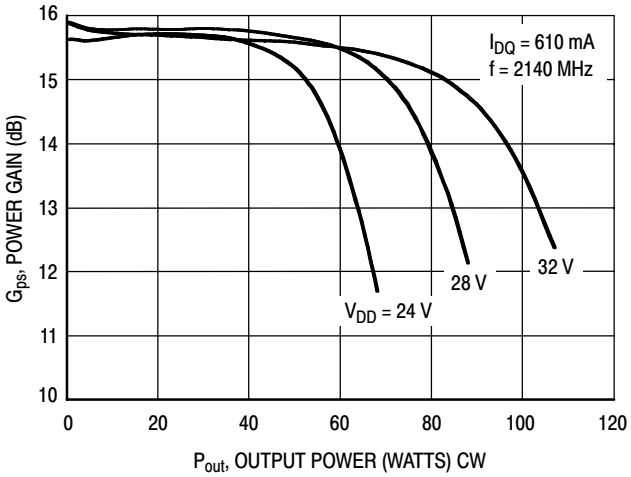
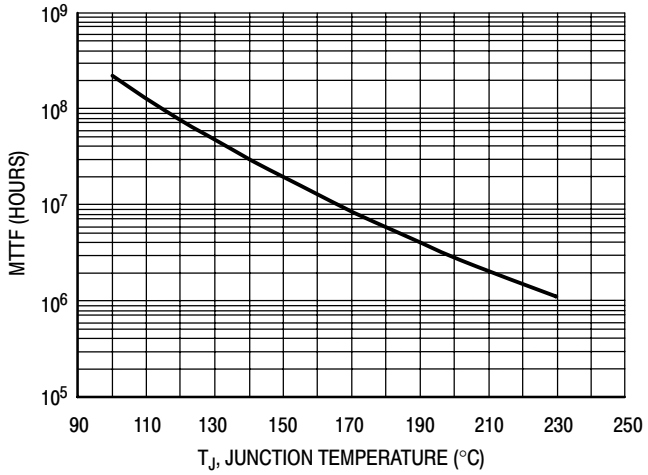


Figure 11. Power Gain versus Output Power

TYPICAL CHARACTERISTICS



This above graph displays calculated MTTF in hours when the device is operated at V_{DD} = 28 Vdc, P_{out} = 14 W Avg., and η_D = 26%.

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

Figure 12. MTTF Factor versus Junction Temperature

W-CDMA TEST SIGNAL

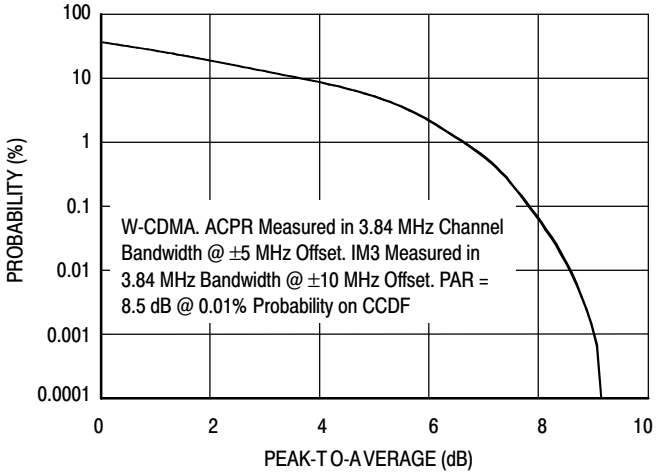


Figure 13. CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 67% Clipping, Single-Carrier Test Signal

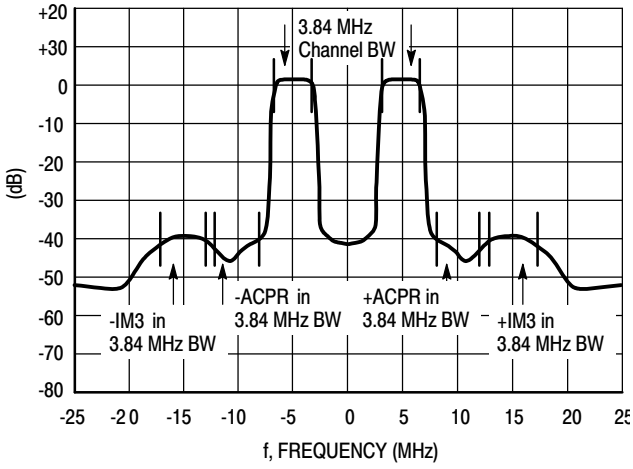
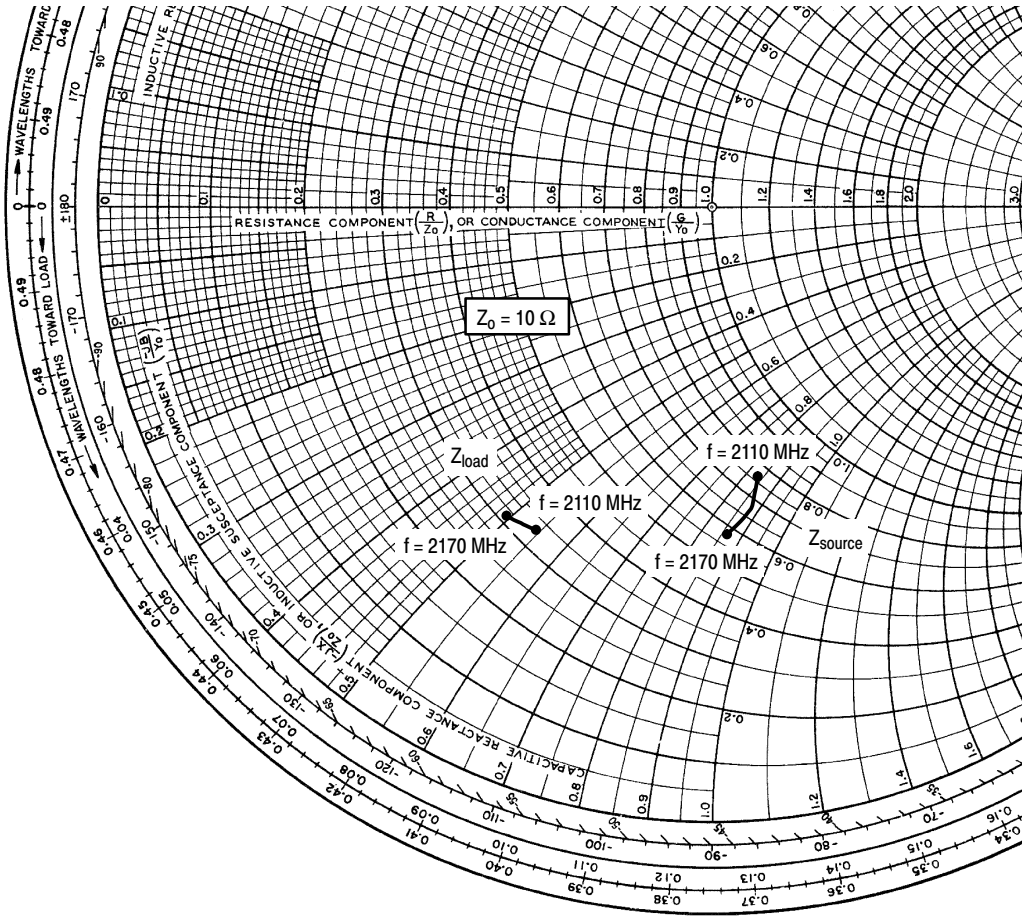


Figure 14. 2-Carrier W-CDMA Spectrum



V_{DD} = 28 Vdc, I_{DQ} = 610 mA, P_{out} = 14 W Avg.

f MHz	Z_{source} Ω	Z_{load} Ω
2110	7.59 - j8.39	3.31 - j5.35
2140	6.71 - j8.83	3.17 - j5.16
2170	5.84 - j8.62	3.06 - j4.92

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

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

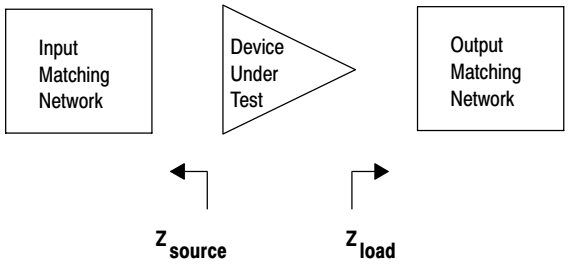
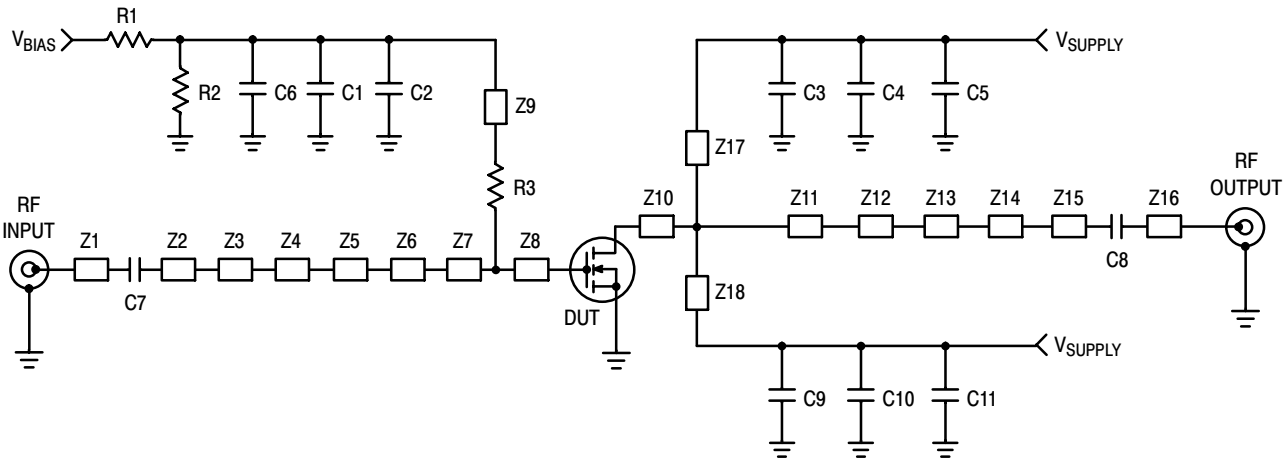


Figure 15. Series Equivalent Source and Load Impedance



Z1	0.250″ x 0.080″ Microstrip	Z11	0.240″ x 1.000″ Microstrip
Z2	0.129″ x 0.080″ Microstrip	Z12*	0.270″ x 0.360″ Microstrip
Z3*	0.565″ x 0.258″ Microstrip	Z13	0.230″ x 0.080″ Microstrip
Z4	0.160″ x 0.080″ Microstrip	Z14*	0.588″ x 0.290″ Microstrip
Z5*	0.300″ x 0.455″ Microstrip	Z15	0.595″ x 0.080″ Microstrip
Z6	0.350″ x 0.080″ Microstrip	Z16	0.200″ x 0.080″ Microstrip
Z7	0.350″ x 0.755″ Microstrip	Z17	0.935″ x 0.080″ Microstrip
Z8	0.115″ x 0.755″ Microstrip	Z18	0.955″ x 0.080″ Microstrip
Z9	0.680″ x 0.080″ Microstrip	PCB	Arlon CuClad 250GX-0300-55-22, 0.030″, ε_r = 2.55
Z10	0.115″ x 1.000″ Microstrip		

* Copper foil tape soldered onto PCB

Figure 16. MRF6S21060NR1(NBR1) Test Circuit Schematic — TD-SCDMA

Table 7. MRF6S21060NR1(NBR1) Test Circuit Component Designations and Values — TD-SCDMA

Part	Description	Part Number	Manufacturer
C1	100 nF Chip Capacitor	CDR33BX104AKYS	Kemet
C2, C7	4.7 pF Chip Capacitors	ATC100B4R7BT500XT	ATC
C3, C8, C9	6.8 pF Chip Capacitors	ATC100B6R8BT500XT	ATC
C4, C5, C6, C10, C11	10 μF, 35 V Chip Capacitors	GRM55DR61H106KA88L	Murata
R1	1 kΩ, 1/4 W Chip Resistor	CRCW12061001FKEA	Vishay
R2	10 kΩ, 1/4 W Chip Resistor	CRCW12061002FKEA	Vishay
R3	10 Ω, 1/4 W Chip Resistor	CRCW120610R0FKEA	Vishay

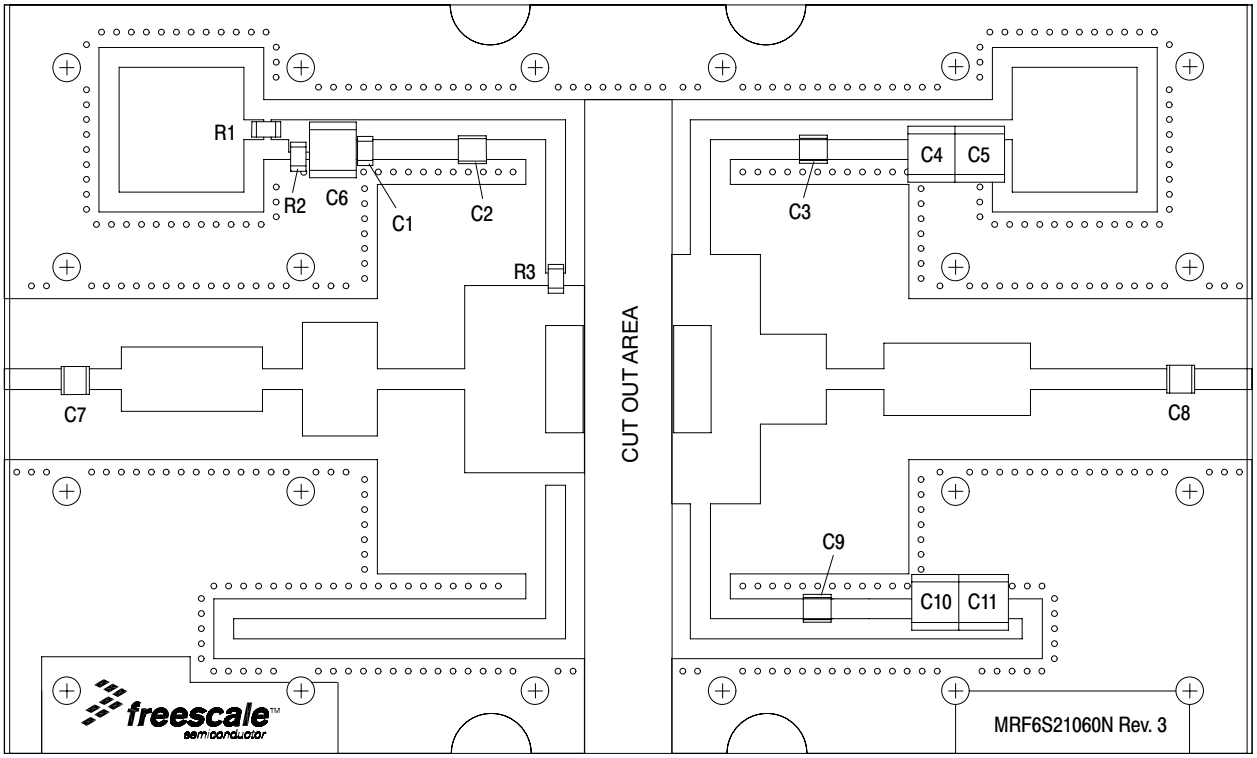


Figure 17. MRF6S21060NR1(NBR1) Test Circuit Component Layout — TD-SCDMA

TYPICAL CHARACTERISTICS

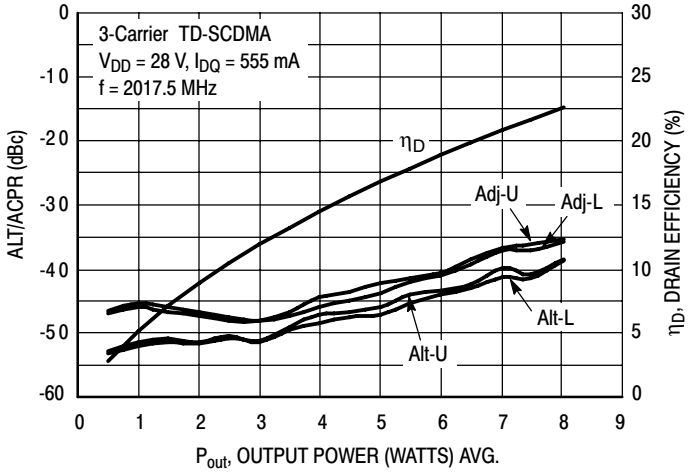


Figure 18. 3-Carrier TD-SCDMA ACPR, ALT and Drain Efficiency versus Output Power

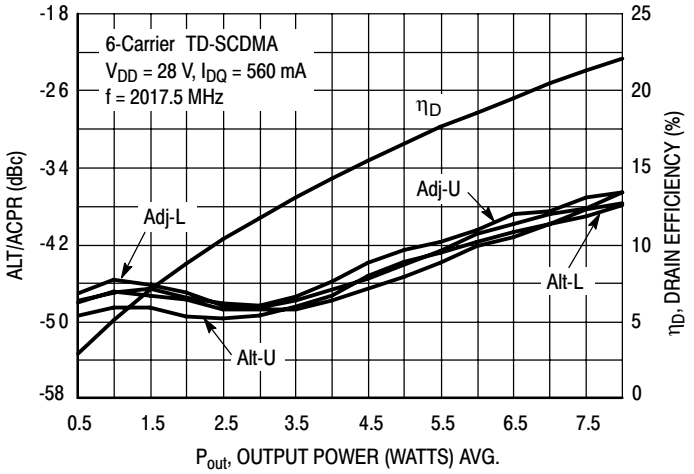


Figure 19. 6-Carrier TD-SCDMA ACPR, ALT and Drain Efficiency versus Output Power

TD-SCDMA TEST SIGNAL

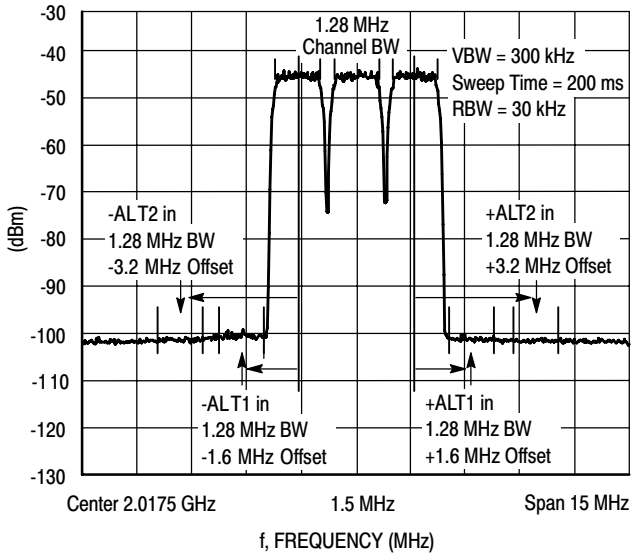


Figure 20. 3-Carrier TD-SCDMA Spectrum

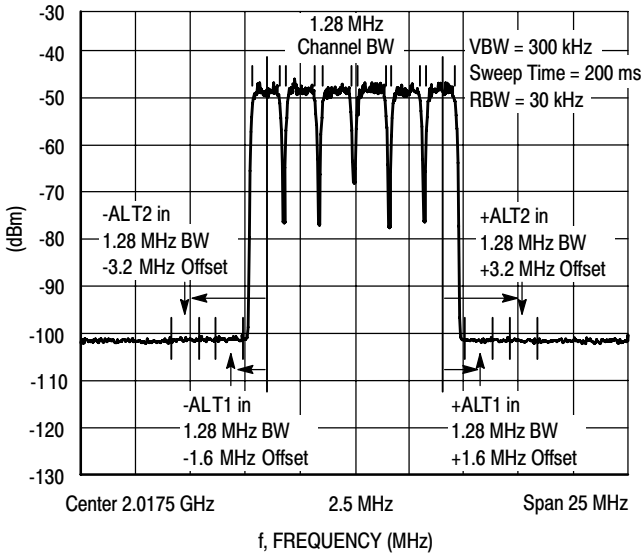
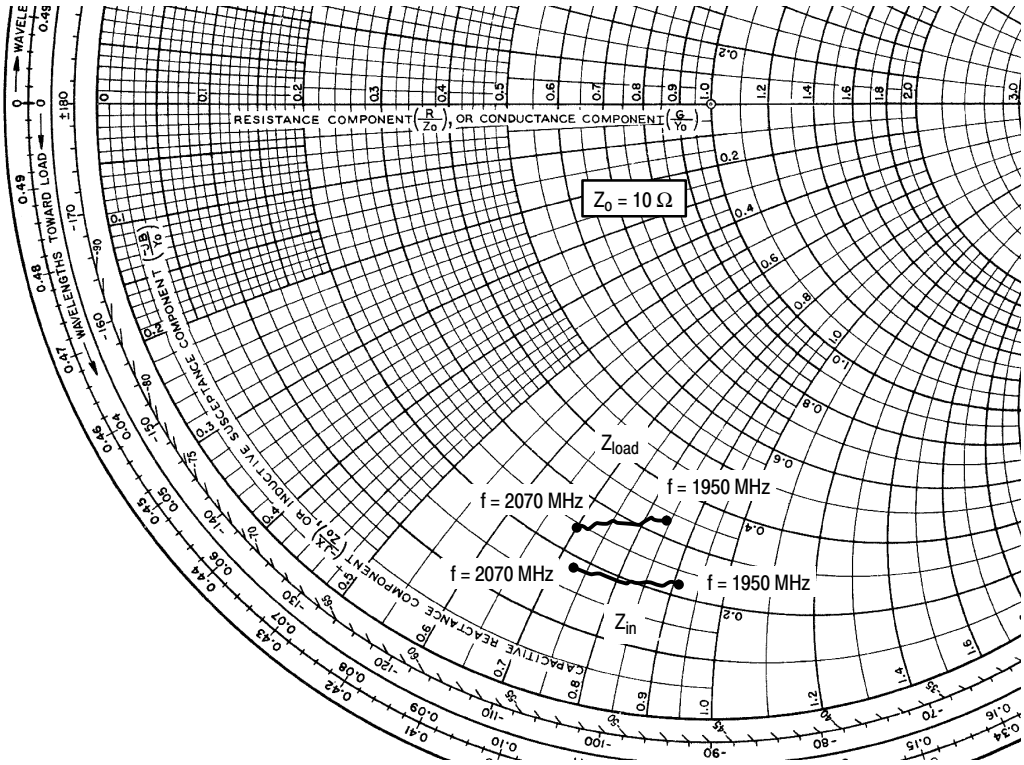


Figure 21. 6-Carrier TD-SCDMA Spectrum



V_{DD} = 28 Vdc, I_{DQ} = 560 mA

f MHz	Z_{in} Ω	Z_{load} Ω
1950	2.227 - j9.127	3.341 - j8.372
1960	2.168 - j8.942	3.239 - j8.218
1970	2.124 - j8.757	3.168 - j8.084
1980	2.073 - j8.606	3.083 - j7.966
1990	2.031 - j8.447	3.009 - j7.865
2000	1.987 - j8.306	2.929 - j7.743
2010	1.940 - j8.155	2.845 - j7.639
2020	1.911 - j8.000	2.775 - j7.529
2030	1.891 - j7.835	2.696 - j7.410
2040	1.856 - j7.711	2.615 - j7.309
2050	1.831 - j7.589	2.549 - j7.207
2060	1.808 - j7.461	2.479 - j7.086
2070	1.782 - j7.325	2.422 - j6.983

Z_{in} = Device input impedance as measured from gate to ground.

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

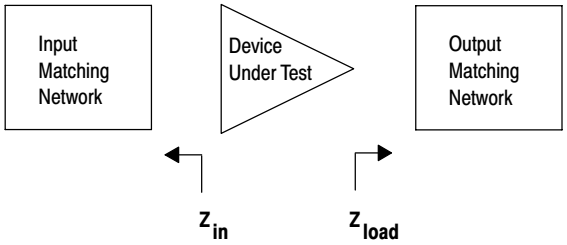
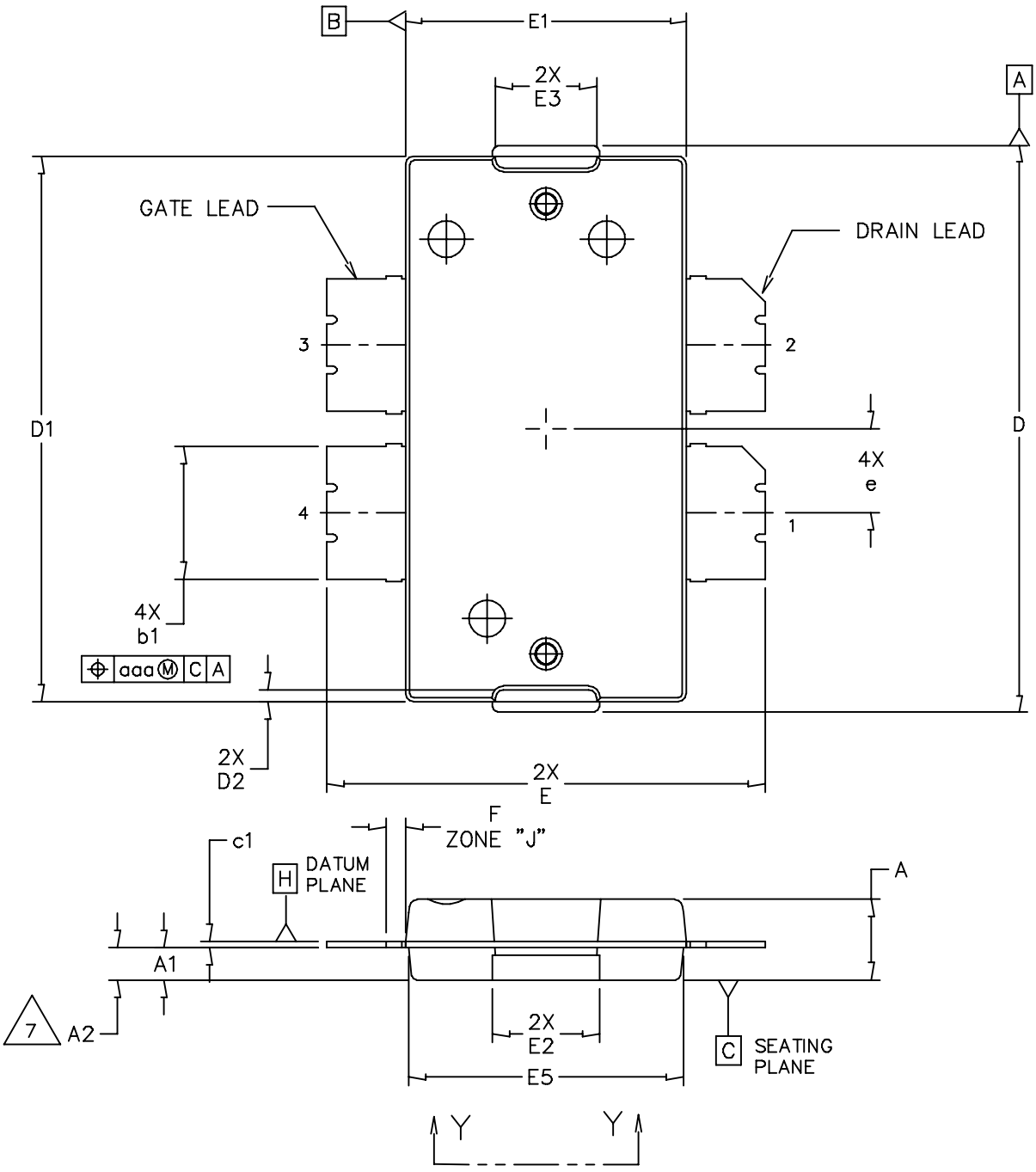


Figure 22. Series Equivalent Input and Load Impedance — TD-SCDMA

PACKAGE DIMENSIONS



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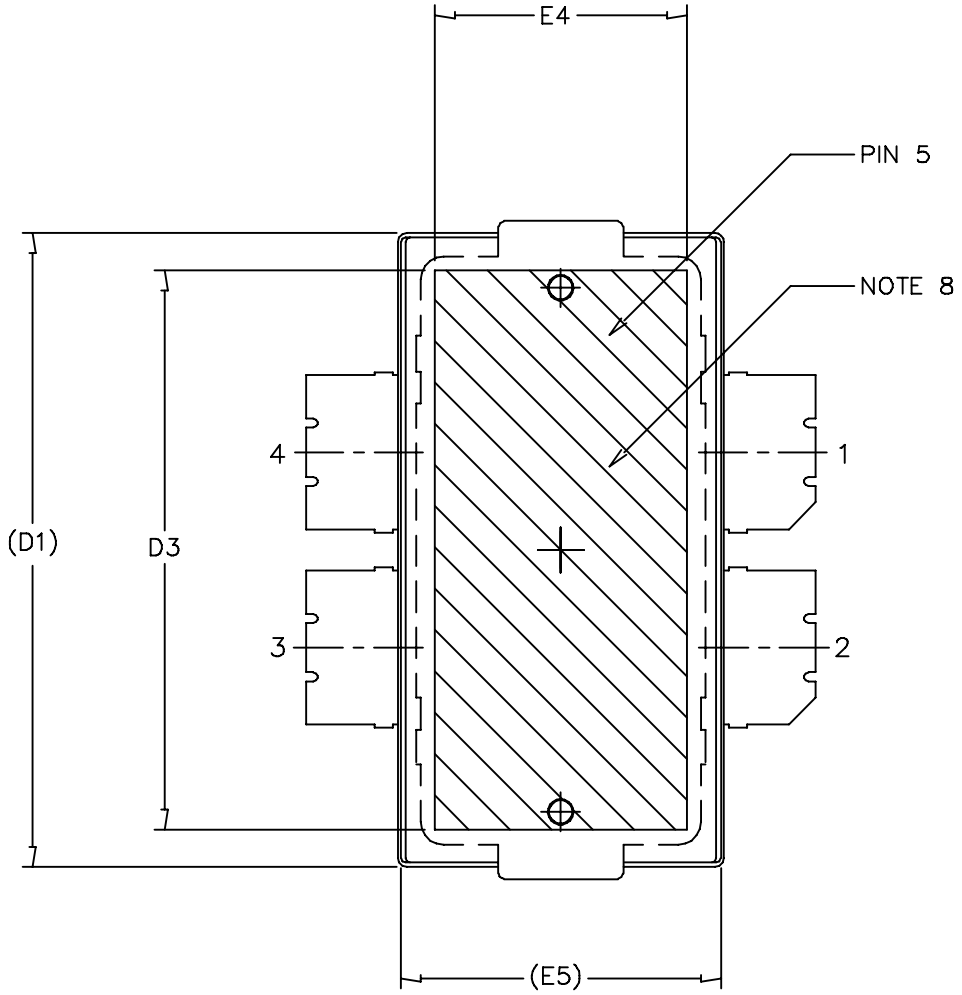
TITLE: TO−270 4 LEAD, WIDE BODY	DOCUMENT NO: 98ASA10577D	REV: D	
	CASE NUMBER: 1486−03	13 AUG 2007	
	STANDARD: NON−JEDEC		



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TITLE: TO−270 4 LEAD, WIDE BODY	DOCUMENT NO: 98ASA10577D	REV: D
	CASE NUMBER: 1486−03	13 AUG 2007
	STANDARD: NON−JEDEC	

NOTES:

1. CONTROLLING DIMENSION: INCH

2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M–1994.

3. DATUM PLANE –H– IS LOCATED AT THE TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.

4. DIMENSIONS "D" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 PER SIDE. DIMENSIONS "D" AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE –H–.

5. DIMENSIONS "b1" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE "b1" DIMENSION AT MAXIMUM MATERIAL CONDITION.

6. DATUMS –A– AND –B– TO BE DETERMINED AT DATUM PLANE –H–.

7. DIMENSION A2 APPLIES WITHIN ZONE "J" ONLY.

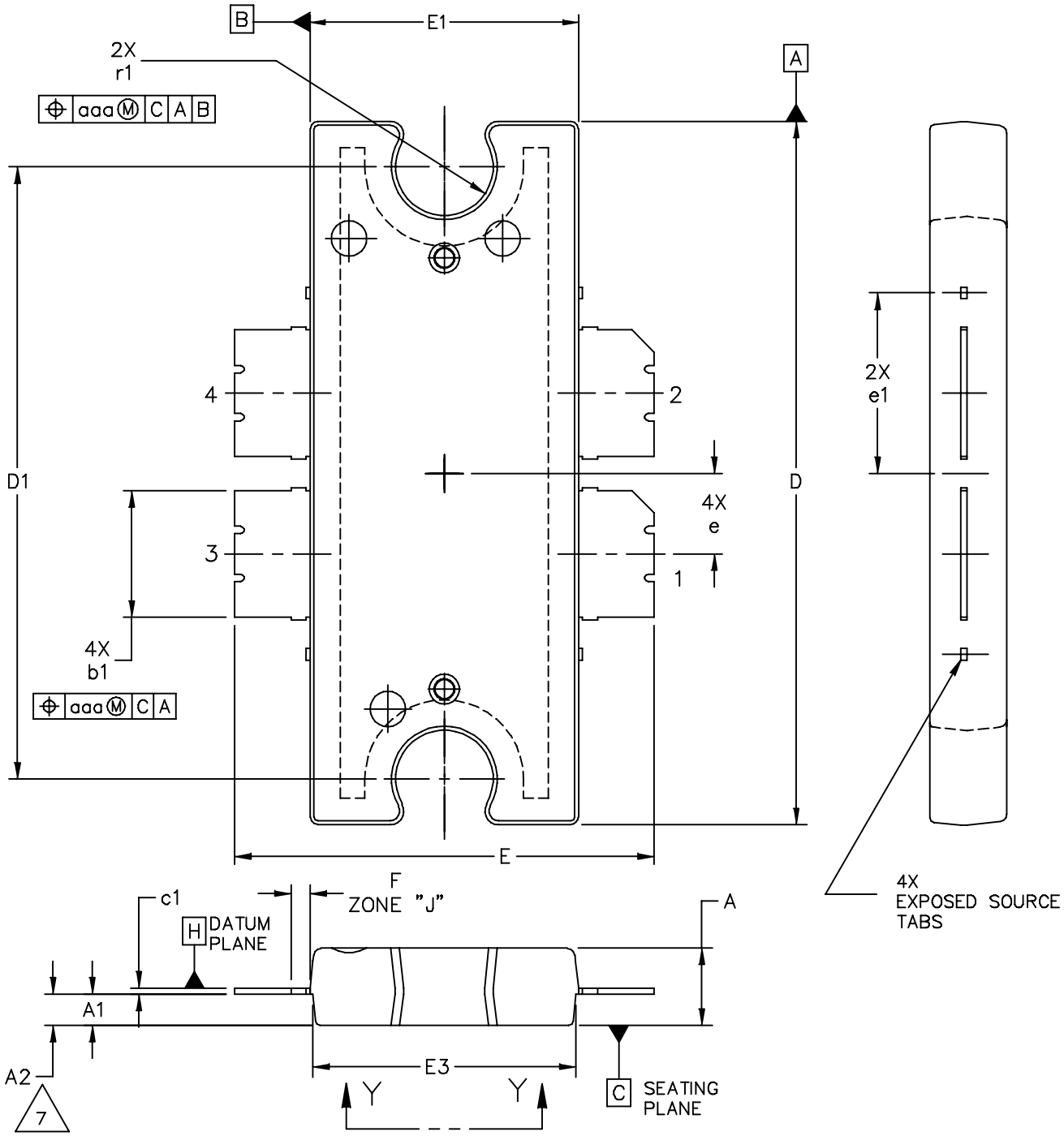
8. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG.

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

DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX
A	.100	.104	2.54	2.64	F	.025 BSC		0.64 BSC	
A1	.039	.043	0.99	1.09	b1	.164	.170	4.17	4.32
A2	.040	.042	1.02	1.07	c1	.007	.011	.18	.28
D	.712	.720	18.08	18.29	e	.106 BSC		2.69 BSC	
D1	.688	.692	17.48	17.58	aaa	.004		.10	
D2	.011	.019	0.28	0.48					
D3	.600	---	15.24	---					
E	.551	.559	14	14.2					
E1	.353	.357	8.97	9.07					
E2	.132	.140	3.35	3.56					
E3	.124	.132	3.15	3.35					
E4	.270	---	6.86	---					
E5	.346	.350	8.79	8.89					

MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE

TITLE:	DOCUMENT NO: 98ASA10577D	REV: D
TO–270 4 LEAD WIDE BODY	CASE NUMBER: 1486–03	13 AUG 2007
	STANDARD: NON–JEDEC	



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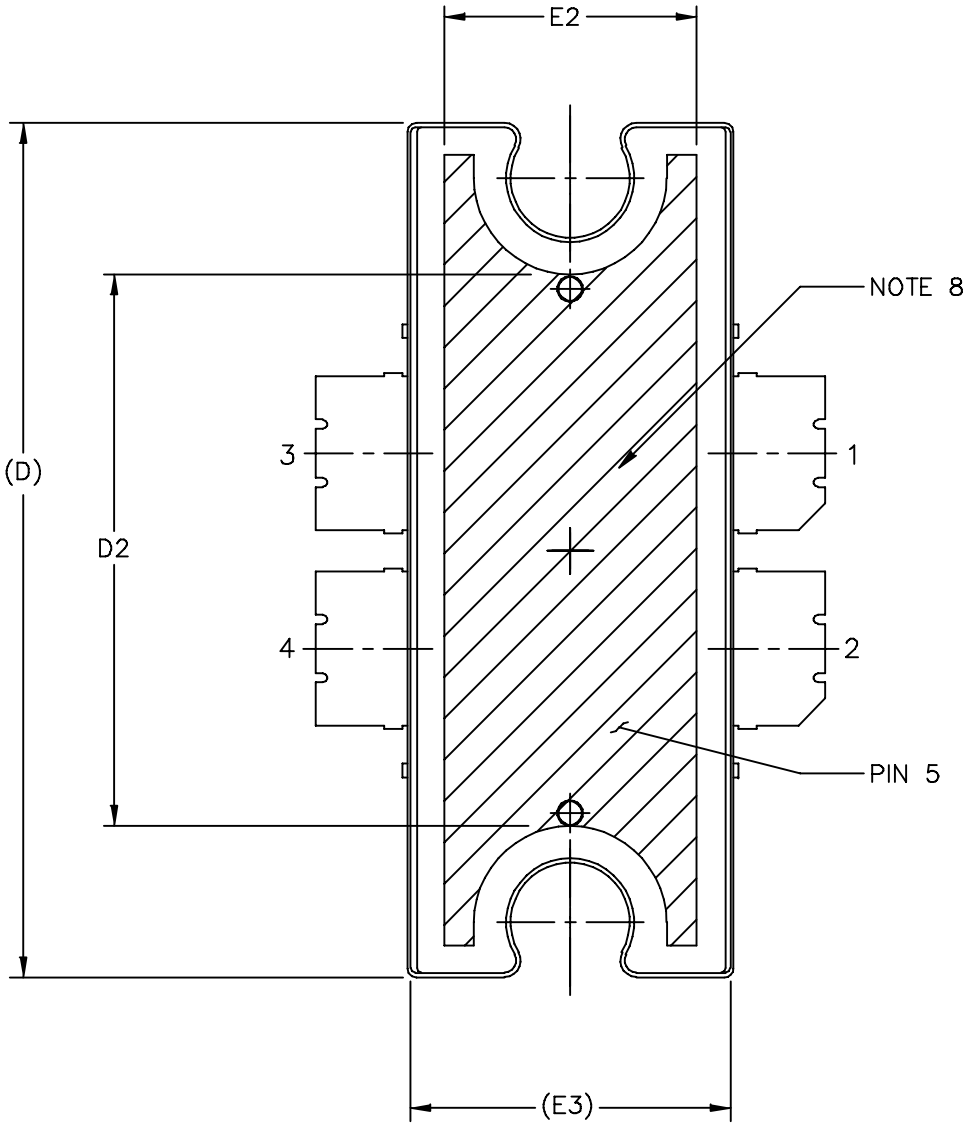
TITLE: TO−272 4 LEAD, WIDE BODY	DOCUMENT NO: 98ASA10575D	REV: E
	CASE NUMBER: 1484−04	31 AUG 2007
	STANDARD: NON−JEDEC	



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TITLE: TO−272 4 LEAD, WIDE BODY	DOCUMENT NO: 98ASA10575D	REV: E
	CASE NUMBER: 1484−04	31 AUG 2007
	STANDARD: NON−JEDEC	

NOTES:

1. CONTROLLING DIMENSION: INCH
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M–1994.
3. DATUM PLANE H IS LOCATED AT THE TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
4. DIMENSIONS "D" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 PER SIDE. DIMENSIONS "D" AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H.
5. DIMENSIONS "b1" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE "b1" DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUM A AND B TO BE DETERMINED AT DATUM PLANE H.
7. DIMENSION A2 APPLIES WITHIN ZONE "J" ONLY.
8. HATCHING REPRESENTS EXPOSED AREA OF THE HEAT SLUG. HATCHED AREA SHOWN IS ON THE SAME PLANE.

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

DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX
A	.100	.104	2.54	2.64	b1	.164	.170	4.17	4.32
A1	.039	.043	0.99	1.09	c1	.007	.011	.18	.28
A2	.040	.042	1.02	1.07	r1	.063	.068	1.60	1.73
D	.928	.932	23.57	23.67	e	.106 BSC		2.69 BSC	
D1	.810 BSC		20.57 BSC		e1	.239 INFO ONLY		6.07 INFO ONLY	
D2	.600	---	15.24	---	aaa	.004		.10	
E	.551	.559	14	14.2					
E1	.353	.357	8.97	9.07					
E2	.270	---	6.86	---					
E3	.346	.350	8.79	8.89					
F	.025 BSC		0.64 BSC						

MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE

TITLE:	DOCUMENT NO: 98ASA10575D	REV: E
TO–272 4 LEAD WIDE BODY	CASE NUMBER: 1484–04	31 AUG 2007
	STANDARD: NON–JEDEC	

PRODUCT DOCUMENTATION

Refer to the following documents to aid your design process.

Application Notes

- AN1907: Solder Reflow Attach Method for High Power RF Devices in Plastic Packages
- AN1955: Thermal Measurement Methodology of RF Power Amplifiers
- AN3263: Bolt Down Mounting Method for High Power RF Transistors and RFICs in Over-Molded Plastic Packages

Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
4	Dec. 2006	• Added “TD-SCDMA” to data sheet description, p. 1 • Updated Part Numbers in Table 7, Component Designations and Values, to RoHS compliant part numbers, p. 4 • Added TD-SCDMA test circuit schematic, component designations and values, component layout, typical characteristic curves, test signal and series impedance, p. 9-12 • Added Product Documentation and Revision History, p. 17
5	Dec. 2008	• Modified data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN13232, p. 1, 2 • Added Case Operating Temperature limit to the Maximum Ratings table and set limit to 150°C, 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 and changed 220°C to 225°C in Capable Plastic Package bullet, p. 1 • 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 PCB information to show more specific material details, Figs. 1, 16, Test Circuit Schematic, p. 3, 9 • Updated Part Numbers in Tables 6, 7, Component Designations and Values, to latest RoHS compliant part numbers, p. 3, 9 • Removed lower voltage tests from Fig. 11, Power Gain versus Output Power, due to fixed tuned fixture limitations, p. 6 • Replaced Fig. 12, MTTF versus Junction Temperature with updated graph. Removed $Amps^2$ and listed operating characteristics and location of MTTF calculator for device, p. 7 • Replaced Case Outline 1486-03, Issue C, with 1486-03, Issue D, p. 13-15. Added pin numbers 1 through 4 on Sheet 1. • Replaced Case Outline 1484-04, Issue D, with 1484-04, Issue E, p. 16-18. Added pin numbers 1 through 4 on Sheet 1, replacing Gate and Drain notations with Pin 1 and Pin 2 designations.

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Document Number: MRF6S21060N
Rev. 5, 12/2008