Freescale Semiconductor
Technical Data

Document Number: MW6IC1940N
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RF LDMOS Wideband Integrated Power Amplifiers

MW6IC1940NBR1
MW6IC1940GNBR1

1920-2000 MHz, 40 W, 28 V
2 x W-CDMA
RF LDMOS WIDEBAND
INTEGRATED POWER AMPLIFIERS

The MW6IC1940NB/GNB wideband integrated circuit is designed with on-chip matching that makes it usable from 1920 to 2000 MHz. This multi-stage structure is rated for 26 to 32 Volt operation and covers all typical cellular base station modulation formats.

Final Application

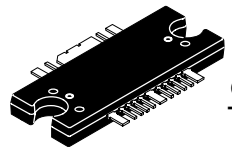
- Typical 2-Carrier W-CDMA Performance: V_{DD} = 28 Volts, I_{DQ1} = 200 mA, I_{DQ2} = 440 mA, P_{out} = 4.5 Watts Avg., Full Frequency Band (1920-2000 MHz), Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.
  Power Gain — 28.5 dB
  Power Added Efficiency — 13.5%
  IM3 @ 10 MHz Offset — -43 dBc in 3.84 MHz Bandwidth
  ACPR @ 5 MHz Offset — -46 dBc in 3.84 MHz Bandwidth

Driver Applications

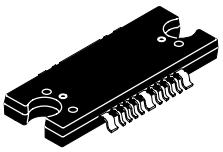
- Typical 2-Carrier W-CDMA Performance: V_{DD} = 28 Volts, I_{DQ1} = 200 mA, I_{DQ2} = 350 mA, P_{out} = 26 dBm, Full Frequency Band (1920-2000 MHz), Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.
  Power Gain — 27 dB
  IM3 @ 10 MHz Offset — -59 dBc in 3.84 MHz Bandwidth
  ACPR @ 5 MHz Offset — -62 dBc in 3.84 MHz Bandwidth
- Capable of Handling 3:1 VSWR, @ 28 Vdc, 1960 MHz, 40 Watts CW Output Power
- Stable into a 3:1 VSWR. All Spurs Below -60 dBc @ 100 mW to 20 W CW P_{out}.

Features

- Characterized with Series Equivalent Large-Signal Impedance Parameters and Common Source Scattering Parameters
- On-Chip Matching (50 Ohm Input, DC Blocked, >3 Ohm Output)
- Integrated Quiescent Current Temperature Compensation with Enable/Disable Function
- Integrated ESD Protection
- 200°C Capable Plastic Package
- Designed for Lower Memory Effects and Wide Instantaneous Bandwidth Applications
- RoHS Compliant
- In Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.



CASE 1329-09
TO-272 WB-16
PLASTIC
MW6IC1940NBR1



CASE 1329A-03
TO-272 WB-16 GULL
PLASTIC
MW6IC1940GNBR1

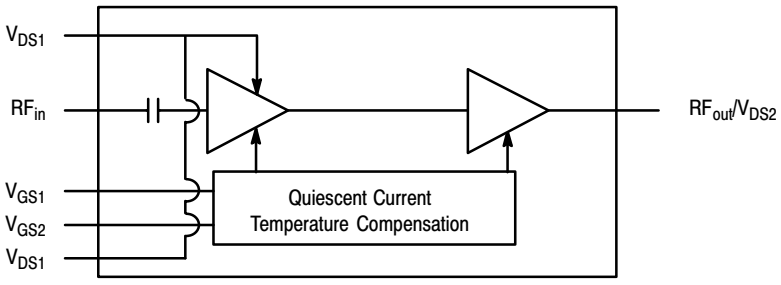
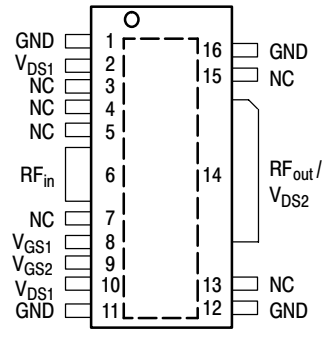


Figure 1. Functional Block Diagram



(Top View)

Note: Exposed backside flag is source terminal for transistors.

Figure 2. Pin Connections

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	-0.5, +68	Vdc
Gate-Source Voltage	V_{GS}	-0.5, +6	Vdc
Storage Temperature Range	T_{stg}	-65 to +200	°C
Operating Junction Temperature	T_J	200	°C
Input Power	P_{in}	20	dBm

Table 2. Thermal Characteristics

Characteristic		Symbol	Value (1)	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$		°C/W
W-CDMA Application	Stage 1, 28 Vdc, I_{DQ1} = 200 mA		2.1	
(P_{out} = 4.5 W Avg.)	Stage 2, 28 Vdc, I_{DQ2} = 440 mA		1.2	

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)

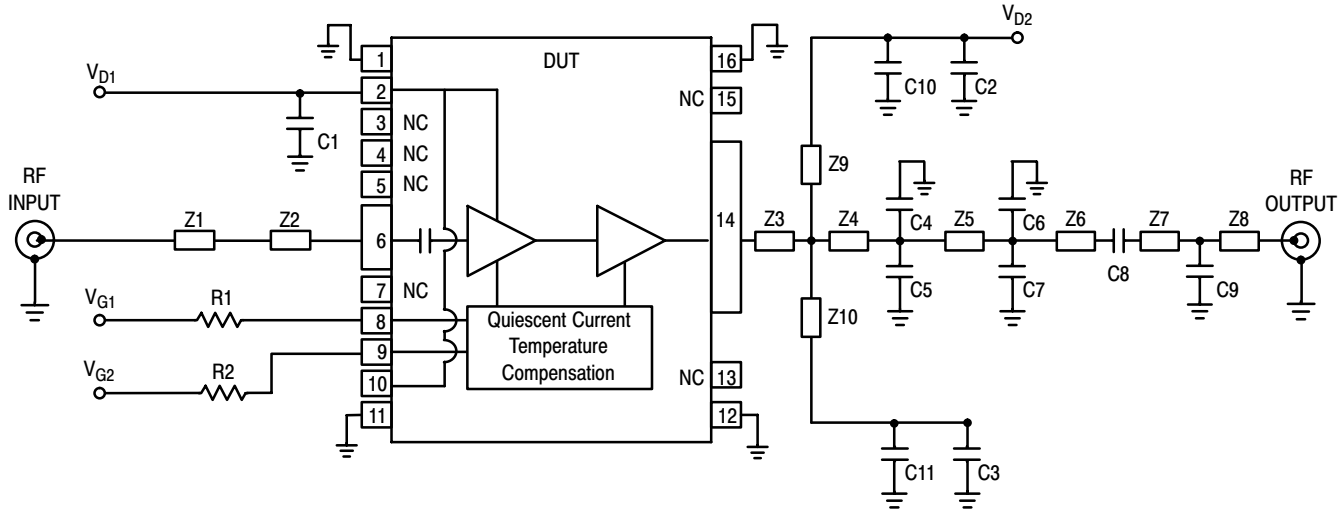
Table 4. Moisture Sensitivity Level

Test Methodology	Rating	Package Peak Temperature	Unit
Per JESD 22-A113, IPC/JEDEC J-STD-020	3	260	°C

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

Characteristic	Symbol	Min	Typ	Max	Unit
Functional Tests (In Freescale Wideband 1920-2000 MHz Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ1} = 200 mA, I_{DQ2} = 440 mA, P_{out} = 4.5 W Avg., f1 = 1922.5 MHz, f2 = 1932.5 MHz and f1 = 1987.5 MHz, f2 = 1997.5 MHz, 2-Carrier W-CDMA, 3.84 MHz Channel Bandwidth @ ±5 MHz Offset. IM3 measured in 3.84 MHz Channel Bandwidth @ ±10 MHz Offset. PAR = 8.5 dB @ 0.01% Probability on CCDF.					
Power Gain	G_{ps}	26	28.5	31.5	dB
Power Added Efficiency	PAE	12.5	13.5	—	%
Intermodulation Distortion	IM3	—	-43	-40	dBc
Adjacent Channel Power Ratio	ACPR	—	-46	-43	dBc
Input Return Loss	IRL	—	-15	-10	dB
Typical Performances (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ1} = 210 mA, I_{DQ2} = 370 mA, 1920-2000 MHz					
Video Bandwidth @ 40 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	—	30	—	MHz
Quiescent Current Accuracy over Temperature with 18 kΩ Gate Feed Resistors (-10 to 85°C) (2)	ΔI_{QT}	—	±5	—	%
Gain Flatness in 30 MHz Bandwidth @ P_{out} = 1 W CW	G_F	—	0.75	—	dB
Average Deviation from Linear Phase in 30 MHz Bandwidth @ P_{out} = 1 W CW	Φ	—	±1	—	°
Average Group Delay @ P_{out} = 1 W CW Including Output Matching	Delay	—	2.5	—	ns
Part-to-Part Insertion Phase Variation @ P_{out} = 1 W CW, Six Sigma Window	ΔΦ	—	±10	—	°
Typical Performances (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ1} = 240 mA, I_{DQ2} = 440 mA, 1920-2000 MHz					
Saturated Pulsed Output Power (12 μsec(on), 1% Duty Cycle)	P_{sat}	—	60	—	W

1. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers.* Go to http://www.freescale.com/rf. Select Documentation/Application Notes - AN1955.
2. Refer to AN1977, *Quiescent Current Thermal Tracking Circuit in the RF Integrated Circuit Family.* Go to http://www.freescale.com/rf. Select Documentation/Application Notes - AN1977.



Z1	2.20″ x 0.09″ Microstrip	Z7*	0.98″ x 0.082″ Microstrip
Z2	0.13″ x 0.04″ Microstrip	Z8*	0.76″ x 0.082″ Microstrip
Z3	0.17″ x 0.41″ Microstrip	Z9, Z10	0.08″ x 0.079″ Microstrip
Z4*	0.20″ x 0.41″ Microstrip	PCB	Taconic TLX8-0300, 0.030″, ε_r = 2.55
Z5*	0.11″ x 0.41″ Microstrip		
Z6*	0.06″ x 0.41″ Microstrip		

* Variable for tuning

Figure 3. MW6IC1940NBR1(GNBR1) Test Circuit Schematic

Table 6. MW6IC1940NBR1(GNBR1) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1, C2, C3	2.2 μF Chip Capacitors	C3225X5R1H225MT	TDK
C4, C5, C6, C7	0.5 pF Chip Capacitors	ATC100B0R5BT500XT	ATC
C8	1.5 pF Chip Capacitor	ATC100B1R5BT500XT	ATC
C9	0.2 pF Chip Capacitor	ATC100B0R2BT500XT	ATC
C10, C11	10 pF Chip Capacitors	ATC100B100JT500XT	ATC
R1	4.7 kΩ, 1/4 W Chip Resistor	CRCW12064701FKTA	Vishay
R2	3.3 kΩ, 1/4 W Chip Resistor	CRCW12063301FKTA	Vishay

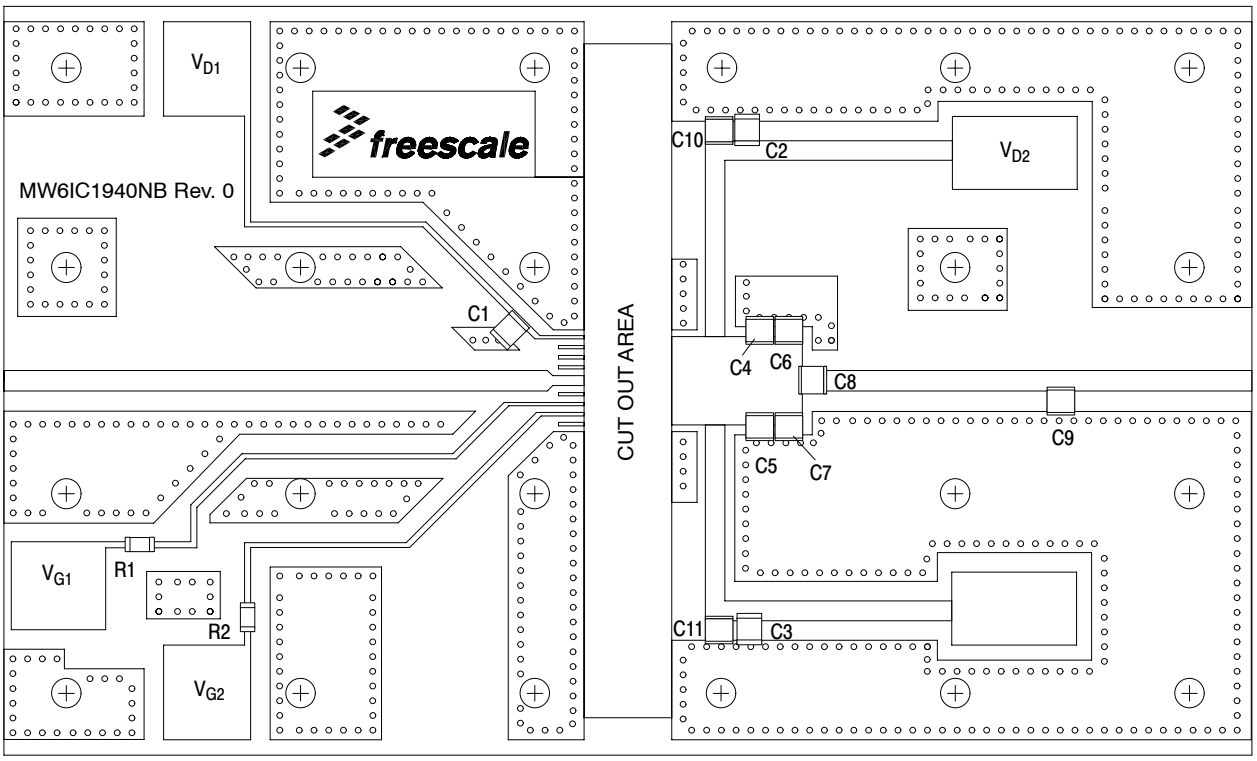


Figure 4. MW6IC1940NBR1(GNBR1) Test Circuit Component Layout

TYPICAL CHARACTERISTICS

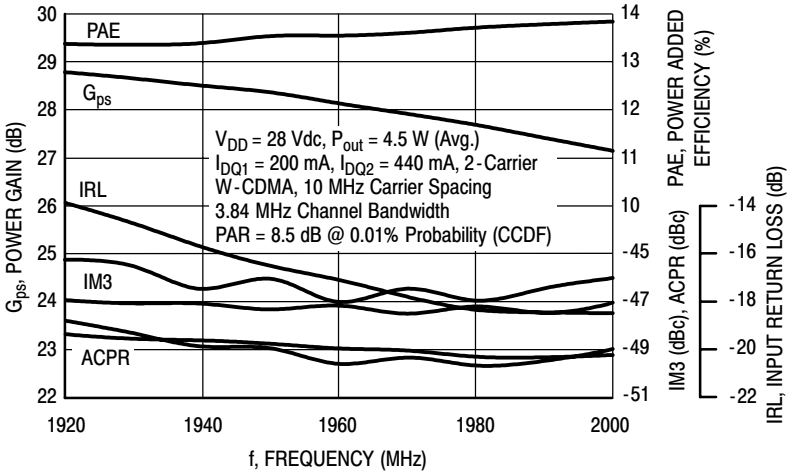


Figure 5. 2-Carrier W-CDMA Wideband Performance @ P_{out} = 4.5 Watts Avg.

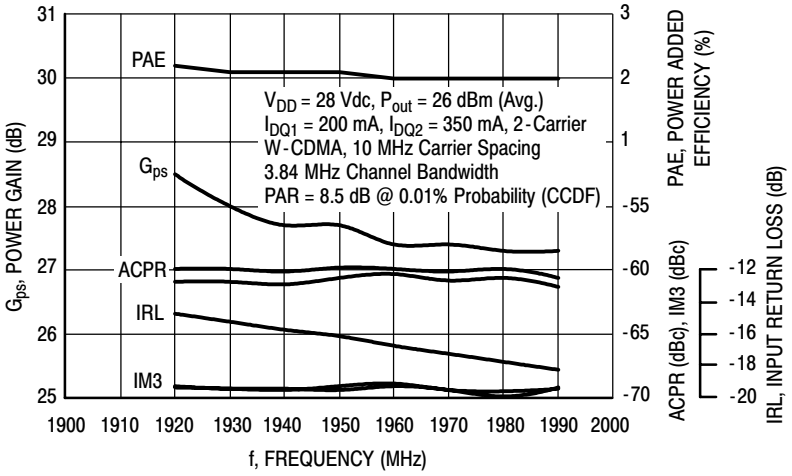


Figure 6. 2-Carrier W-CDMA Wideband Performance @ P_{out} = 26 dBm Avg.

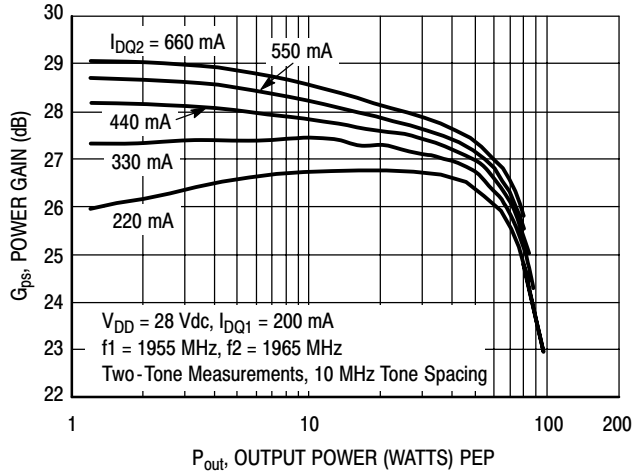


Figure 7. Two-Tone Power Gain versus Output Power @ I_{DQ1} = 200 mA

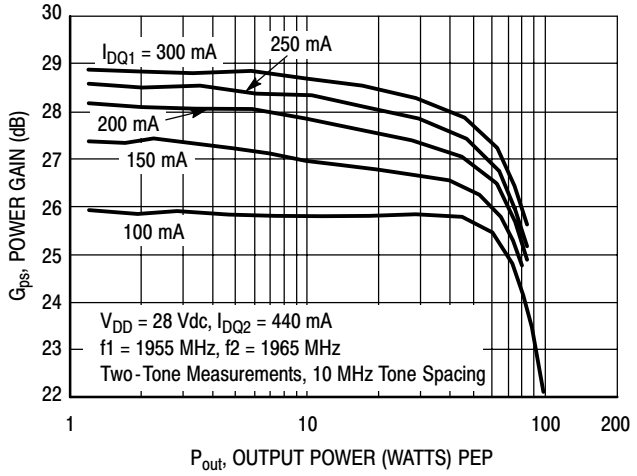


Figure 8. Two-Tone Power Gain versus Output Power @ I_{DQ2} = 440 mA

TYPICAL CHARACTERISTICS

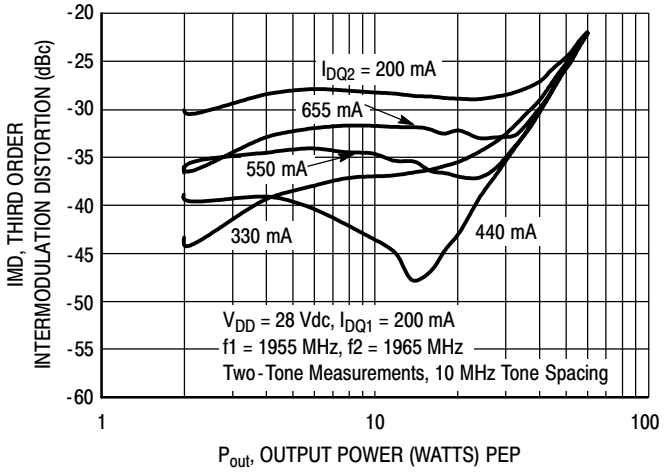


Figure 9. Third Order Intermodulation Distortion versus Output Power @ I_{DQ1} = 200 mA

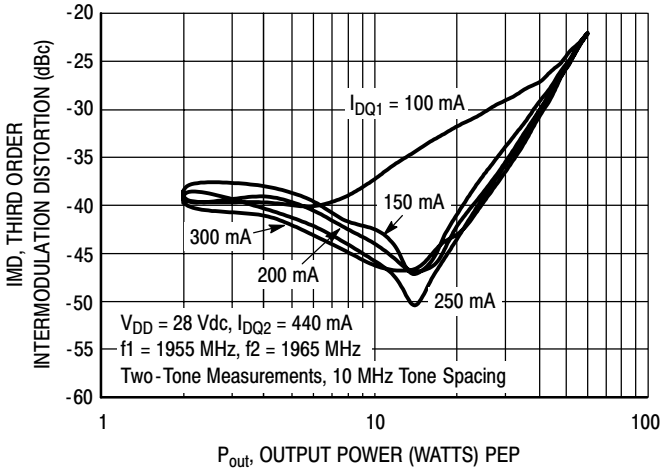


Figure 10. Third Order Intermodulation Distortion versus Output Power @ I_{DQ2} = 440 mA

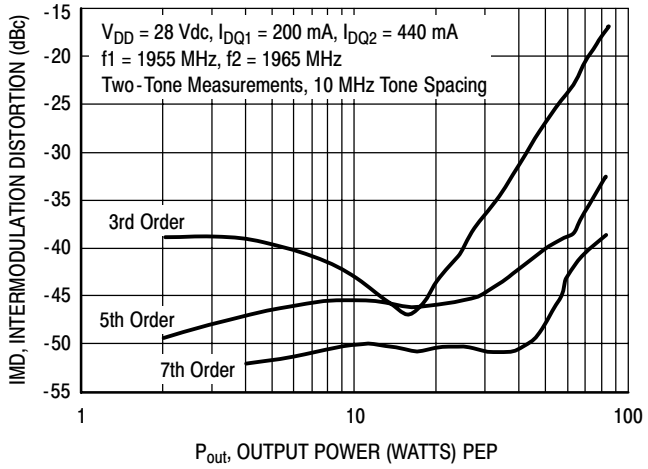


Figure 11. Intermodulation Distortion Products versus Output Power

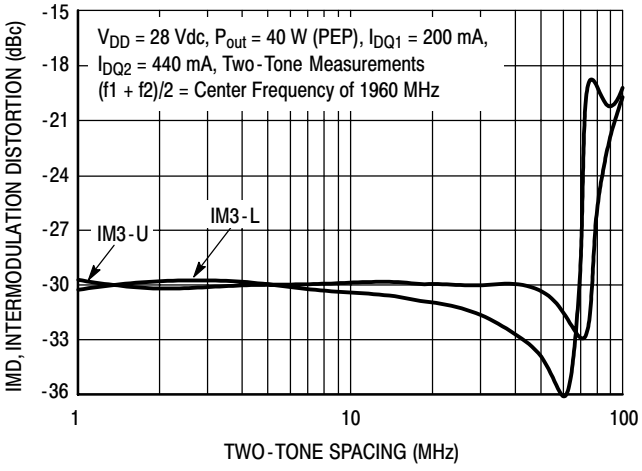


Figure 12. Intermodulation Distortion Products versus Tone Spacing

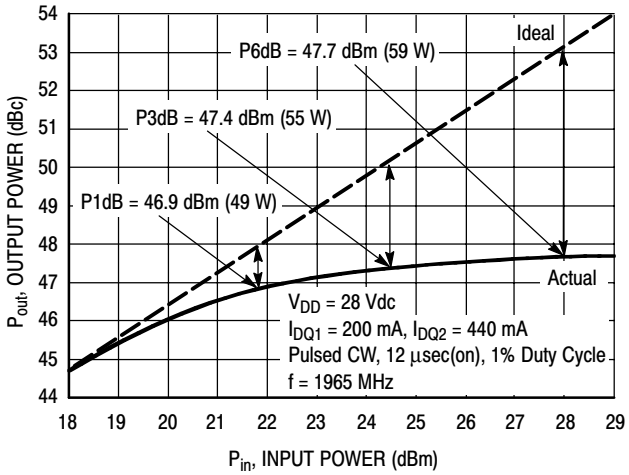


Figure 13. Pulsed CW Output Power versus Input Power

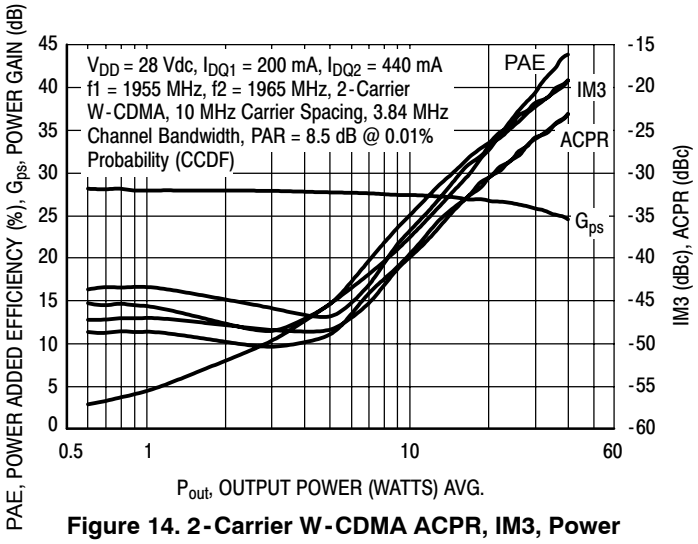


Figure 14. 2-Carrier W-CDMA ACPR, IM3, Power Gain and Drain Efficiency versus Output Power

TYPICAL CHARACTERISTICS

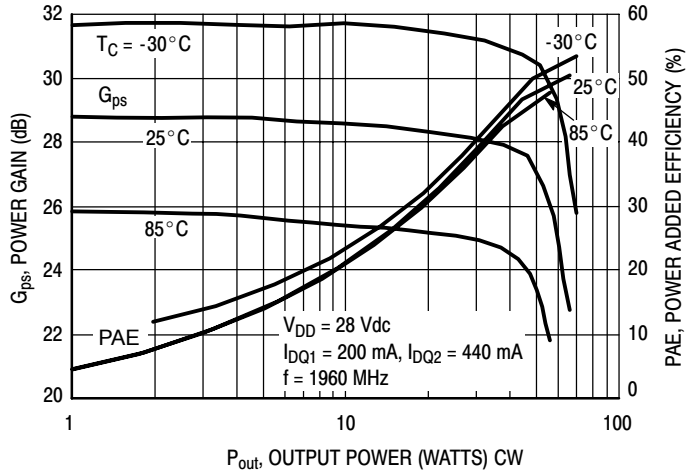


Figure 15. Power Gain and Power Added Efficiency versus Output Power

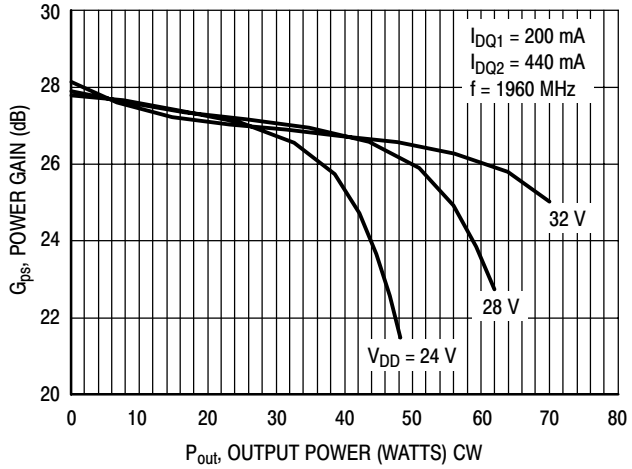


Figure 16. Power Gain versus Output Power

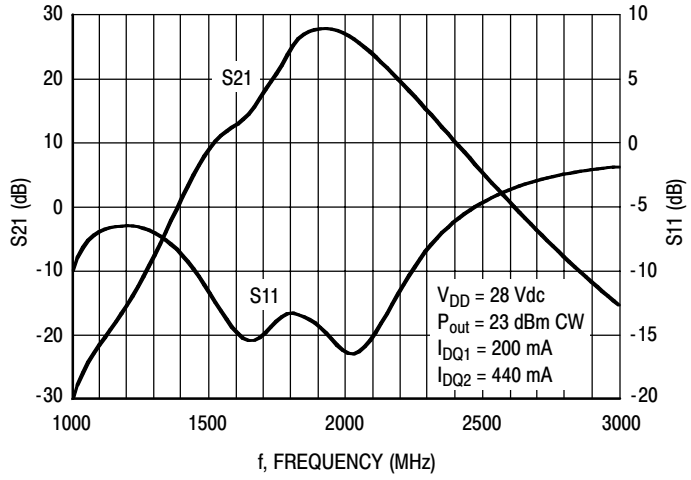


Figure 17. Broadband Frequency Response

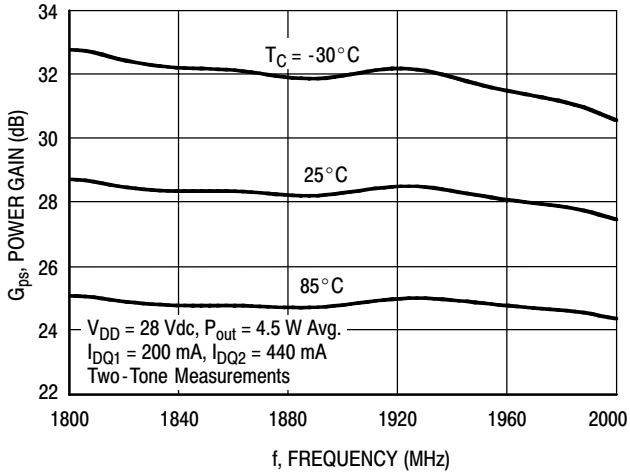
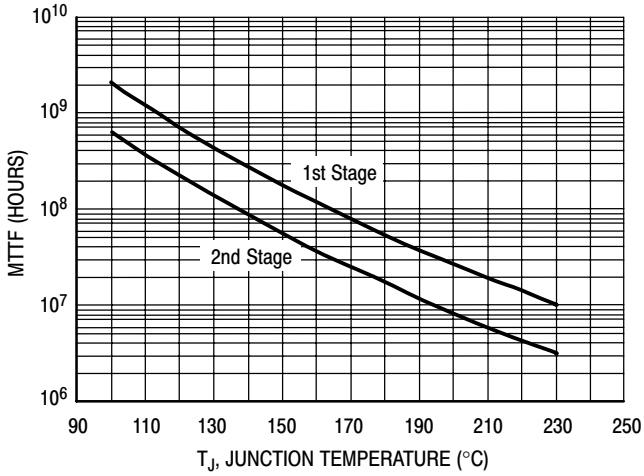


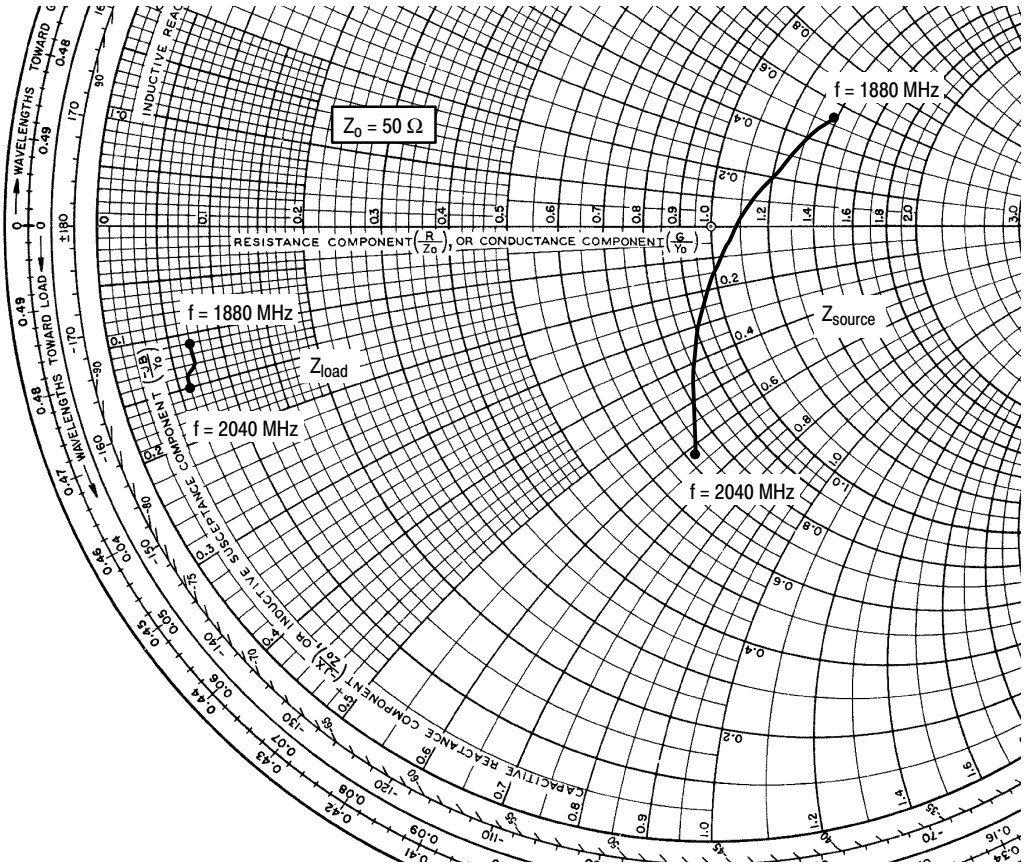
Figure 18. Power Gain versus Frequency



This above graph displays calculated MTTF in hours when the device is operated at V_{DD} = 28 Vdc, P_{out} = 4.5 W Avg., and PAE = 13.5%.

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

Figure 19. MTTF versus Junction Temperature



V_{DD} = 28 Vdc, I_{DQ1} = 200 mA, I_{DQ2} = 440 mA, P_{out} = 4.5 W Avg.

f MHz	Z_{source} Ω	Z_{load} Ω
1880	69.33 + j26.65	3.65 - j5.717
1900	65.20 + j19.39	3.55 - j5.95
1920	61.07 + j12.13	3.45 - j6.18
1940	56.93 + j4.87	3.35 - j6.42
1960	52.80 - j2.39	3.25 - j6.65
1980	48.67 - j9.65	3.15 - j6.88
2000	44.53 - j16.91	3.05 - j7.12
2020	40.40 - j24.17	2.95 - j7.35
2040	36.27 - j31.43	2.85 - j7.583

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

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

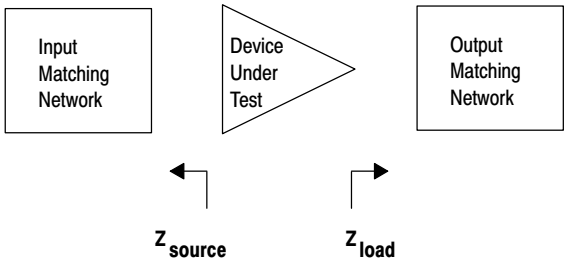


Figure 20. Series Equivalent Source and Load Impedance

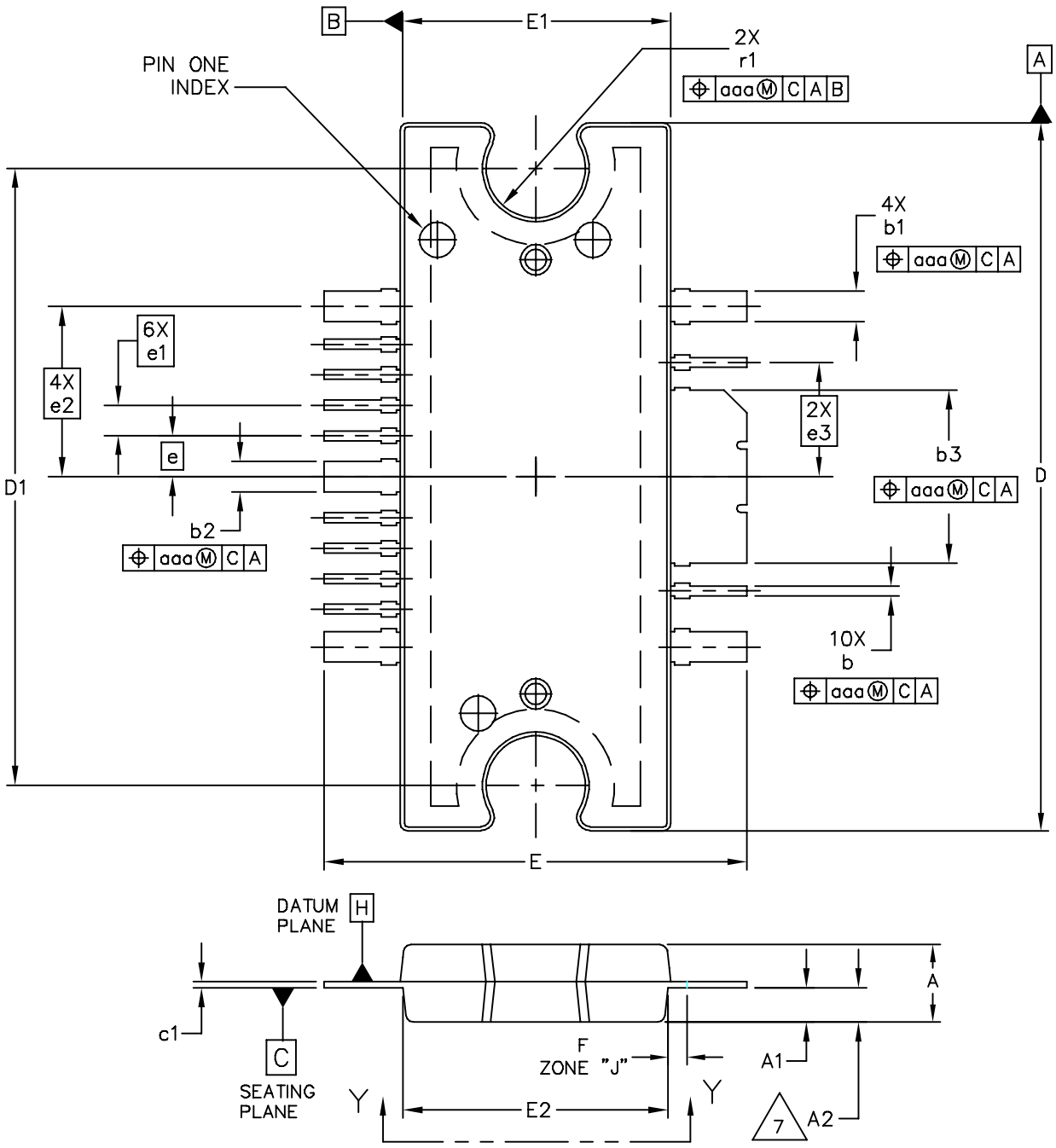
Table 7. Common Source Scattering Parameters (V_{DD} = 28 V, I_{DQ1} = 200 mA, I_{DQ2} = 440 mA, T_C = 25°C, 50 ohm system)

f MHz	S_{11}		S_{21}		S_{12}		S_{22}	
	$\|S_{11}\|$	∠ ϕ	$\|S_{21}\|$	∠ ϕ	$\|S_{12}\|$	∠ ϕ	$\|S_{22}\|$	∠ ϕ
1.00	0.196	-167	0.014	-146	0.001	67	0.994	172
1.05	0.331	-176	0.026	-164	0.001	79	0.991	172
1.10	0.419	170	0.041	178	0.001	67	0.990	171
1.15	0.461	157	0.057	160	0.001	66	0.990	170
1.20	0.474	145	0.068	147	0.001	55	0.990	169
1.25	0.467	134	0.084	144	0.001	56	0.989	168
1.30	0.446	122	0.116	143	0.001	56	0.987	167
1.35	0.411	109	0.171	138	0.001	59	0.987	166
1.40	0.365	94	0.256	131	0.001	39	0.986	165
1.45	0.312	78	0.384	122	0.001	45	0.984	164
1.50	0.255	56	0.580	111	0.001	78	0.982	163
1.55	0.205	29	0.879	98	0.001	116	0.980	161
1.60	0.173	-6	1.345	85	0.001	101	0.977	159
1.65	0.172	-45	2.121	70	0.001	130	0.973	157
1.70	0.191	-80	3.478	53	0.001	125	0.968	153
1.75	0.217	-110	6.197	33	0.002	141	0.958	147
1.80	0.236	-144	13.515	5	0.003	157	0.920	130
1.85	0.154	136	39.126	-69	0.009	129	0.453	23
1.90	0.090	-117	20.507	-160	0.006	66	0.816	-159
1.95	0.081	-143	12.215	170	0.005	54	0.881	-178
2.00	0.026	-151	9.054	147	0.003	47	0.892	175
2.05	0.049	-31	7.340	126	0.003	48	0.894	172
2.10	0.119	-31	6.199	105	0.002	41	0.895	170
2.15	0.198	-42	5.298	85	0.002	57	0.895	169
2.20	0.270	-52	4.537	66	0.002	60	0.896	168
2.25	0.334	-61	3.875	47	0.002	66	0.899	167
2.30	0.391	-70	3.282	29	0.002	68	0.905	167
2.35	0.441	-78	2.771	13	0.002	75	0.913	166
2.40	0.485	-85	2.330	-3	0.002	74	0.921	166
2.45	0.523	-92	1.965	-17	0.002	73	0.930	165
2.50	0.557	-97	1.661	-31	0.002	67	0.937	165
2.55	0.587	-103	1.413	-43	0.002	73	0.944	164
2.60	0.617	-109	1.213	-55	0.003	76	0.950	163
2.65	0.643	-114	1.044	-66	0.002	76	0.955	162
2.70	0.665	-119	0.905	-77	0.003	78	0.959	162
2.75	0.687	-124	0.789	-88	0.003	75	0.961	161
2.80	0.706	-129	0.693	-99	0.003	74	0.963	160
2.85	0.723	-134	0.610	-109	0.003	74	0.966	160
2.90	0.737	-139	0.538	-120	0.003	78	0.967	159
2.95	0.751	-143	0.475	-130	0.003	79	0.969	158

Table 7. Common Source Scattering Parameters (V_{DD} = 28 V, I_{DQ1} = 200 mA, I_{DQ2} = 440 mA, T_C = 25°C, 50 ohm system) (continued)

f MHz	S_{11}		S_{21}		S_{12}		S_{22}	
	$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
3.00	0.763	-147	0.418	-141	0.003	80	0.968	158
3.05	0.774	-152	0.367	-152	0.004	75	0.969	157
3.10	0.785	-156	0.319	-162	0.004	80	0.966	157
3.15	0.796	-159	0.278	-173	0.004	75	0.967	156
3.20	0.806	-163	0.239	177	0.004	77	0.965	156
3.25	0.815	-166	0.206	167	0.005	75	0.964	155
3.30	0.825	-170	0.176	157	0.005	73	0.964	155
3.35	0.833	-173	0.151	148	0.005	74	0.962	154
3.40	0.841	-176	0.128	140	0.005	71	0.961	154
3.45	0.849	-178	0.110	132	0.005	71	0.958	153
3.50	0.856	179	0.095	125	0.005	65	0.957	153
3.55	0.864	177	0.081	117	0.005	63	0.955	152
3.60	0.872	174	0.070	111	0.006	66	0.952	152
3.65	0.877	172	0.061	104	0.006	60	0.950	151
3.70	0.885	170	0.053	99	0.006	61	0.946	151
3.75	0.891	169	0.047	93	0.006	57	0.943	150
3.80	0.898	167	0.041	89	0.006	57	0.941	150
3.85	0.902	166	0.037	84	0.006	52	0.938	149
3.90	0.911	164	0.033	80	0.006	55	0.934	149
3.95	0.915	163	0.030	76	0.007	54	0.932	148
4.00	0.921	162	0.028	72	0.007	55	0.928	148

PACKAGE DIMENSIONS



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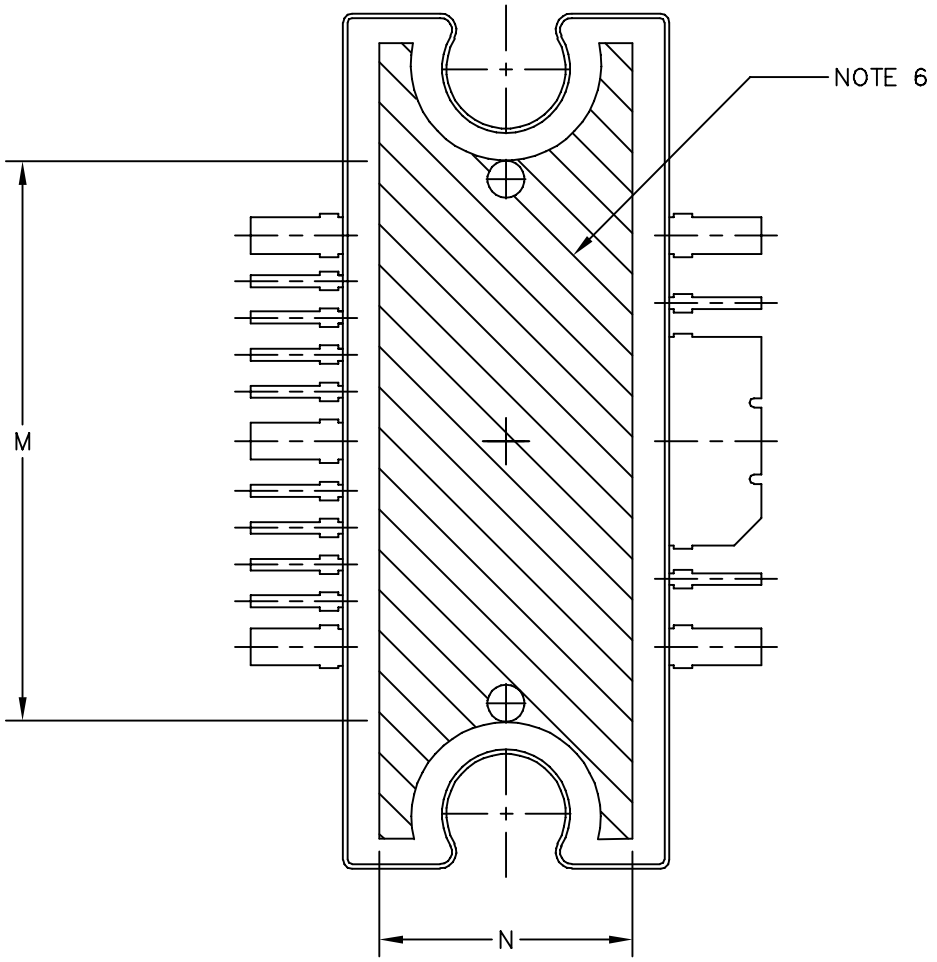
TITLE: TO−272 WIDE BODY MULTI−LEAD	DOCUMENT NO: 98ARH99164A	REV: L
	CASE NUMBER: 1329−09	13 MAR 2006
	STANDARD: NON−JEDEC	



VIEW Y–Y

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	CASE NUMBER: 1329–09	13 MAR 2006
	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 (0.15) PER SIDE. DIMENSIONS "D" AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE −H−.

5. DIMENSIONS "b", "b1", "b2" AND "b3" DO NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 (0.13) TOTAL IN EXCESS OF THE "b", "b1", "b2" AND "b3" DIMENSIONS AT MAXIMUM MATERIAL CONDITION.

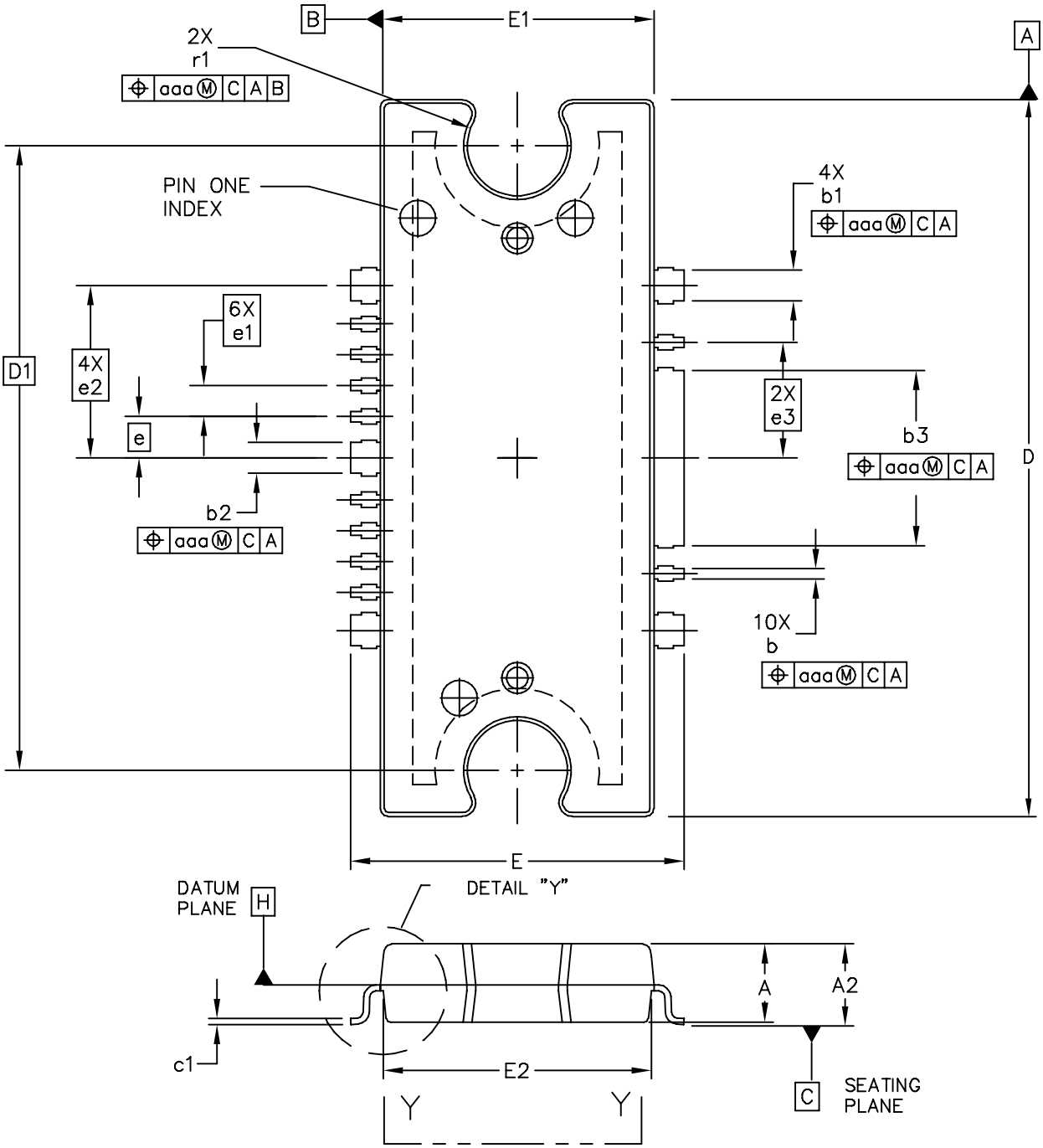
6. HATCHING REPRESENTS THE EXPOSED AREA OFTHE HEAT SLUG. HATCHED AREA SHOWN IS ON THE SAME PLANE.

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

	INCH		MILLIMETER			INCH		MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
A	.100	.104	2.54	2.64	b	.011	.017	0.28	0.43
A1	.038	.044	0.96	1.12	b1	.037	.043	0.94	1.09
A2	.040	.042	1.02	1.07	b2	.037	.043	0.94	1.09
D	.928	.932	23.57	23.67	b3	.225	.231	5.72	5.87
D1	.810 BSC		20.57 BSC		c1	.007	.011	.18	.28
E	.551	.559	14.00	14.20	e	.054 BSC		1.37 BSC	
E1	.353	.357	8.97	9.07	e1	.040 BSC		1.02 BSC	
E2	.346	.350	8.79	8.89	e2	.224 BSC		5.69 BSC	
F	.025 BSC		0.64 BSC		e3	.150 BSC		3.81 BSC	
M	.600	----	15.24	----	r1	.063	.068	1.6	1.73
N	.270	----	6.86	----					
					aaa	.004		.10	

MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE

TITLE:	DOCUMENT NO: 98ARH99164A	REV: L
TO−272 WIDE BODY MULTI−LEAD	CASE NUMBER: 1329−09	13 MAR 2006
	STANDARD: NON−JEDEC	



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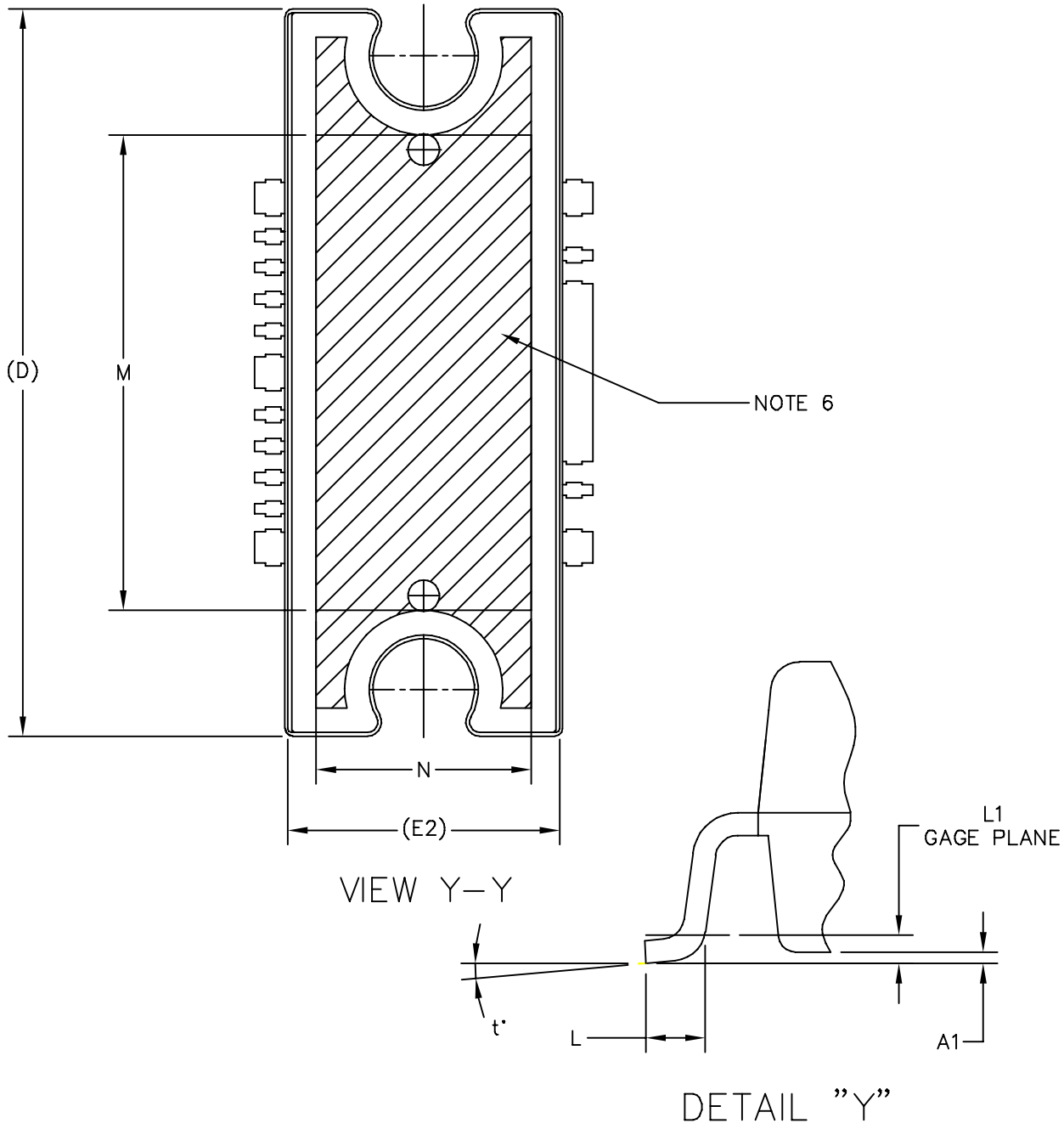
	CASE NUMBER: 1329A-03	3 APR 2006
	STANDARD: NON-JEDEC	



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TITLE: TO–272WB, 16 LEAD GULL WING PLASTIC	DOCUMENT NO: 98ASA10532D	REV: E
	CASE NUMBER: 1329A–03	3 APR 2006
	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.

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5. DIMENSIONS "b", "b1", "b2" AND "b3" DO NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 (0.13) TOTAL IN EXCESS OF THE "b", "b1", "b2" AND "b3" DIMENSIONS AT MAXIMUM MATERIAL CONDITION.

6. HATCHING REPRESENTS EXPOSED AREA OF THE HEAT SLUG. HATCHED AREA SHOWN IS ON THE SAME PLANE.

	INCH		MILLIMETER			INCH		MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
A	.100	.104	2.54	2.64	b	.011	.017	0.28	0.43
A1	.001	.004	0.02	0.10	b1	.037	.043	0.94	1.09
A2	.099	.110	2.51	2.79	b2	.037	.043	0.94	1.09
D	.928	.932	23.57	23.67	b3	.225	.231	5.72	5.87
D1	.810 BSC		20.57 BSC		c1	.007	.011	.18	.28
E	.429	.437	10.9	11.1	e	.054 BSC		1.37 BSC	
E1	.353	.357	8.97	9.07	e1	.040 BSC		1.02 BSC	
E2	.346	.350	8.79	8.89	e2	.224 BSC		5.69 BSC	
L	.018	.024	4.90	5.06	e3	.150 BSC		3.81 BSC	
L1	.01 BSC		.025 BSC		r1	.063	.068	1.6	1.73
M	.600	----	15.24	----	t	2°	8°	2°	8°
N	.270	----	6.86						
				----	aaa	.004		.10	

MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE

TITLE:	DOCUMENT NO: 98ASA10532D	REV: E
TO–272WB, 16 LEAD GULL WING PLASTIC	CASE NUMBER: 1329A–03	3 APR 2006
	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
- AN1977: Quiescent Current Thermal Tracking Circuit in the RF Integrated Circuit Family
- 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
0	Nov. 2006	• Initial Release of Data Sheet
1	Jan. 2007	• Updated verbiage on Typical Performances table, p. 2 • Updated Part Numbers in Table 6, Component Designations and Values, to RoHS compliant part numbers, p. 3 • Added new Figure 13, Pulsed CW Output Power versus Input Power, p. 6 • Added new Figure 18, Power Gain versus Frequency, p. 7 • Replaced Figure 19, MTTF versus Junction Temperature with updated graph. Removed $Amps^2$ and listed operating characteristics and location of MTTF calculator for device, p. 7 • Updated Product Documentation adding AN1907 and AN3263, p. 17

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