



# RF LDMOS Wideband Integrated Power Amplifiers

The MW4IC915NB/GNB wideband integrated circuit is designed for GSM and GSM EDGE base station applications. It uses Freescale's newest High Voltage (26 to 28 Volts) LDMOS IC technology and integrates a multi-stage structure. Its wideband On-Chip design makes it usable from 750 to 1000 MHz. The linearity performances cover all modulations for cellular applications: GSM, GSM EDGE, TDMA, N-CDMA and W-CDMA.

## Final Application

- Typical Performance:  $V_{DD} = 26$  Volts,  $I_{DQ1} = 60$  mA,  $I_{DQ2} = 240$  mA,  $P_{out} = 15$  Watts CW, Full Frequency Band (860-960 MHz)  
 Power Gain — 30 dB  
 Power Added Efficiency — 44%

## Driver Application

- Typical GSM/GSM EDGE Performances:  $V_{DD} = 26$  Volts,  $I_{DQ1} = 60$  mA,  $I_{DQ2} = 240$  mA,  $P_{out} = 3$  Watts Avg., Full Frequency Band (869-894 MHz and 921-960 MHz)  
 Power Gain — 31 dB  
 Power Added Efficiency — 19%  
 Spectral Regrowth @ 400 kHz Offset = -65 dBc  
 Spectral Regrowth @ 600 kHz Offset = -83 dBc  
 EVM — 1.5%
- Capable of Handling 5:1 VSWR, @ 26 Vdc, 921 MHz, 15 Watts CW Output Power

## Features

- Characterized with Series Equivalent Large-Signal Impedance Parameters
- On-Chip Matching (50 Ohm Input, DC Blocked, >3 Ohm Output)
- Integrated Quiescent Current Temperature Compensation with Enable/Disable Function
- On-Chip Current Mirror  $g_m$  Reference FET for Self Biasing Application<sup>(1)</sup>
- Integrated ESD Protection
- 200°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.

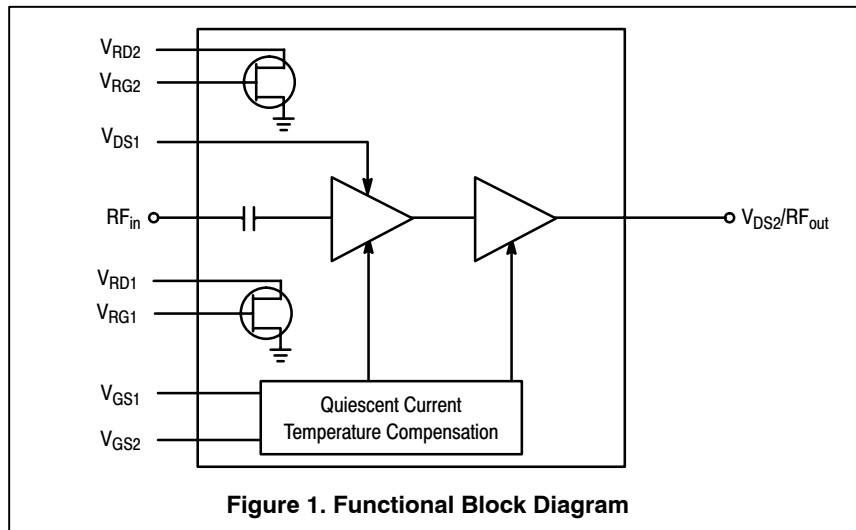
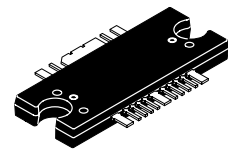


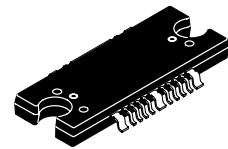
Figure 1. Functional Block Diagram

**MW4IC915NBR1**  
**MW4IC915GNBR1**

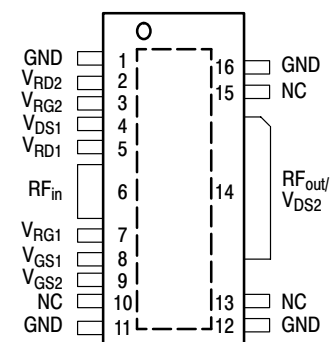
**860 - 960 MHz, 15 W, 26 V**  
**GSM/GSM EDGE, N-CDMA**  
**RF LDMOS WIDEBAND**  
**INTEGRATED POWER AMPLIFIERS**



**CASE 1329-09**  
**TO-272 WB-16**  
**PLASTIC**  
**MW4IC915NBR1**



**CASE 1329A-03**  
**TO-272 WB-16 GULL**  
**PLASTIC**  
**MW4IC915GNBR1**



(Top View)

Note: Exposed backside flag is source terminal for transistors.

Figure 2. Pin Connections

1. Refer to AN1987/D, *Quiescent Current Control for the RF Integrated Circuit Device Family*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1987.

**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5. +65	Vdc
Gate-Source Voltage	$V_{GS}$	-0.5. +15	Vdc
Storage Temperature Range	$T_{stg}$	-65 to +175	°C
Operating Junction Temperature	$T_J$	200	°C

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (1)	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$		°C/W
GSM Application ( $P_{out} = 15$ W CW)	Stage 1, 26 Vdc, $I_{DQ} = 60$ mA Stage 2, 26 Vdc, $I_{DQ} = 240$ mA	7.3 1.7	
GSM EDGE Application ( $P_{out} = 7.5$ W CW)	Stage 1, 26 Vdc, $I_{DQ} = 60$ mA Stage 2, 26 Vdc, $I_{DQ} = 240$ mA	7.3 1.8	
CDMA Application ( $P_{out} = 3.75$ W CW)	Stage 1, 26 Vdc, $I_{DQ} = 60$ mA Stage 2, 26 Vdc, $I_{DQ} = 240$ mA	7.4 1.9	

**Table 3. ESD Protection Characteristics**

Test Conditions	Class
Human Body Model	1 (Minimum)
Machine Model	M3 (Minimum)
Charge Device Model	C2 (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** ( $T_C = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DS} = 26$  Vdc,  $I_{DQ1} = 90$  mA,  $I_{DQ2} = 240$  mA,  $P_{out} = 15$  W PEP,  $f_1 = 869$  MHz,  $f_2 = 869.1$  MHz and  $f_1 = 960$  MHz and  $f_2 = 960.1$  MHz, Two-Tone

Power Gain	$G_{ps}$	29	31	—	dB
Power Added Efficiency	PAE	29	31	—	%
Intermodulation Distortion	IMD	—	-40	-29	dBc
Input Return Loss	IRL	—	-15	-10	dB

1. Refer to AN1955/D, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>.  
Select Documentation/Application Notes - AN1955.

(continued)

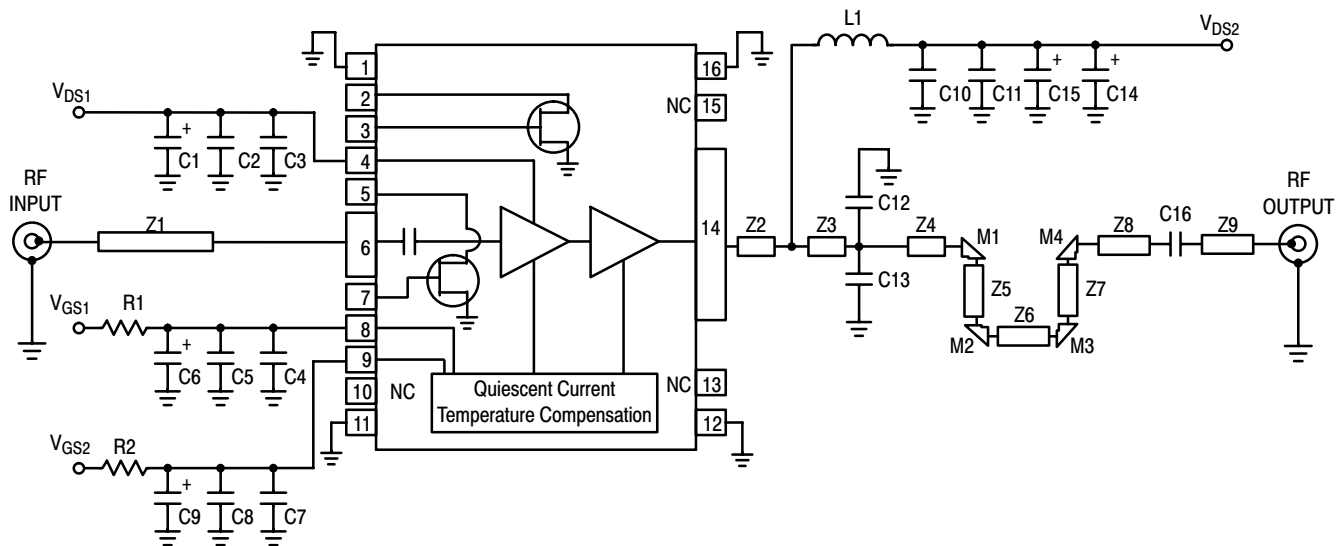
**Table 5. Electrical Characteristics** ( $T_C = 25^\circ\text{C}$  unless otherwise noted) (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Typical Performances</b> (In Freescale Reference Board) $V_{DS} = 26\text{ V}$ , $I_{DQ1} = 60\text{ mA}$ , $I_{DQ2} = 240\text{ mA}$ , 869 MHz<Frequency>960 MHz					
Quiescent Current Accuracy over Temperature with 1.8 k $\Omega$ Gate Feed Resistors (-10 to 85°C) (1)	$\Delta I_{QT}$	—	$\pm 5$	—	%
Gain Flatness in 40 MHz Bandwidth @ $P_{out} = 3\text{ W CW}$	$G_F$	—	0.2	—	dB
Deviation from Linear Phase in 40 MHz Bandwidth @ $P_{out} = 3\text{ W CW}$	$\Phi$	—	$\pm 0.6$	—	°
Delay @ $P_{out} = 3\text{ W CW}$ Including Output Matching	Delay	—	2.5	—	ns
Part-to-Part Phase Variation @ $P_{out} = 3\text{ W CW}$	$\Delta\Phi$	—	$\pm 15$	—	°

**Typical GSM/GSM EDGE Performances** (In Freescale Reference Board)  $V_{DS} = 26\text{ V}$ ,  $I_{DQ1} = 60\text{ mA}$ ,  $I_{DQ2} = 240\text{ mA}$ , 869 MHz<Frequency>960 MHz

Output Power, 1dB Compression Point	P1dB	—	20	—	Watts
Power Gain @ $P_{out} = 15\text{ W CW}$	$G_{ps}$	—	30	—	dB
Power Added Efficiency @ $P_{out} = 15\text{ W CW}$	PAE	—	44	—	%
Input Return Loss @ $P_{out} = 15\text{ W CW}$	IRL	—	-15	—	dB
Error Vector Magnitude @ $P_{out} = 3\text{ W Avg.}$ including 0.6% rms source EVM	EVM	—	1.5	—	% rms
Spectral Regrowth at 400 kHz Offset @ $P_{out} = 3\text{ W Avg.}$	SR1	—	-65	—	dBc
Spectral Regrowth at 600 kHz Offset @ $P_{out} = 3\text{ W Avg.}$	SR2	—	-83	—	dBc

1. Refer to AN1977/D, *Quiescent Current Thermal Tracking Circuit in the RF Integrated Circuit Family*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1977.

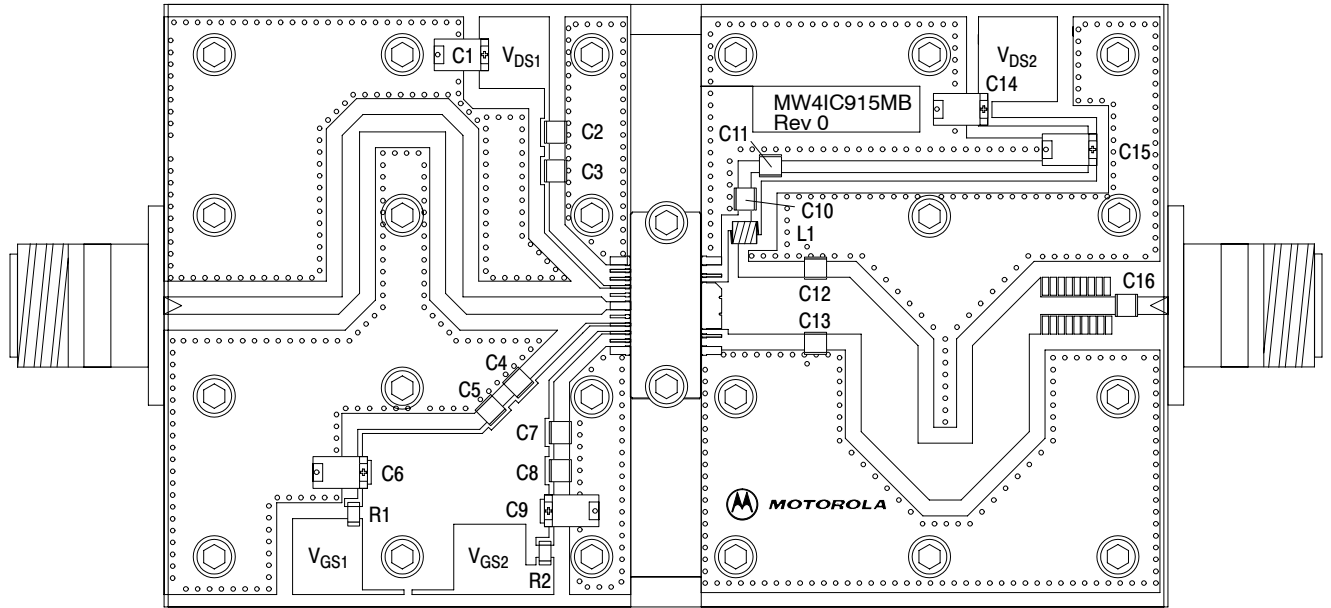


Z1	0.086" , 50 $\Omega$ Microstrip	Z6	0.157" x 0.283" Microstrip
Z2	0.133" x 0.236" Microstrip	Z7	0.429" x 0.283" Microstrip
Z3	0.435" x 0.283" Microstrip	Z8	0.394" x 0.088" Microstrip
Z4	0.171" x 0.283" Microstrip	Z9	0.181" x 0.088" Microstrip
Z5	0.429" x 0.283" Microstrip	PCB	Taconic TLX8, 0.030", $\epsilon_r = 2.55$

**Figure 3. MW4IC915NBR1(GNBR1) Test Fixture Schematic**

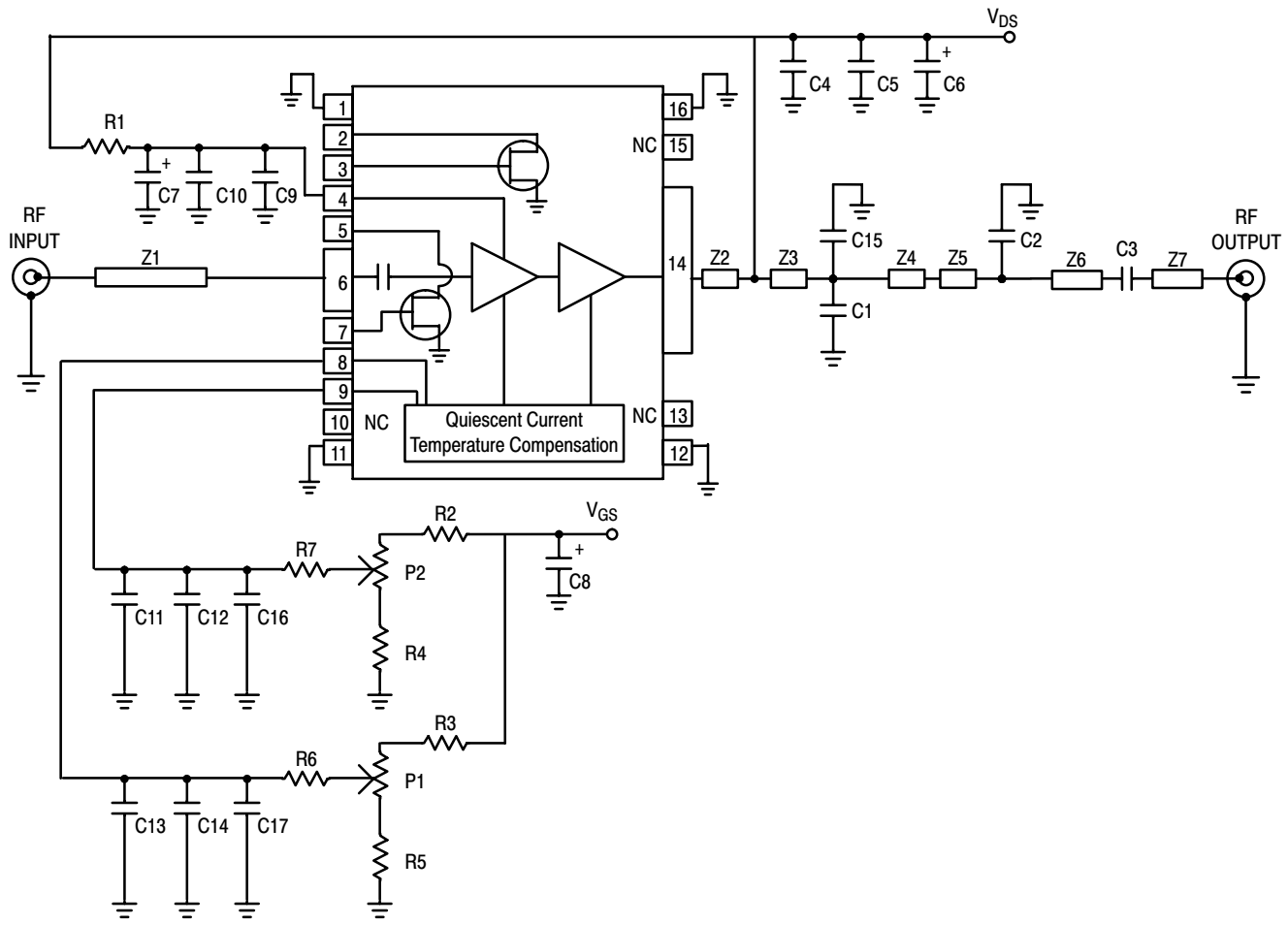
**Table 6. MW4IC915NBR1(GNBR1) Test Fixture Component Designations and Values**

Part	Description	Part Number	Manufacturer
C1, C6, C9, C14	22 $\mu$ F, 35 V Tantalum Chip Capacitors	TAJE226M035R	AVX
C2, C5, C8, C11	1000 pF Chip Capacitors	100B102JCA500X	ATC
C3, C4, C7, C10, C16	22 pF Chip Capacitors	100B220JCA500X	ATC
C12, C13	10 pF Chip Capacitors	100B100JCA500X	ATC
C15	10 $\mu$ F Tantalum Chip Capacitor	T491X226K035AS4394	Kemet
L1	12.5 nH Inductor		
M1, M2, M3, M4	0.283", 90° Mitered Microstrip Bends		
R1, R2	10 k $\Omega$ , 1/4 W Chip Resistor (1206)		



Freescale has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescale Semiconductor signature/logo. PCBs may have either Motorola or Freescale markings during the transition period. These changes will have no impact on form, fit or function of the current product.

**Figure 4. MW4IC915NBR1(GNBR1) Test Fixture Component Layout**

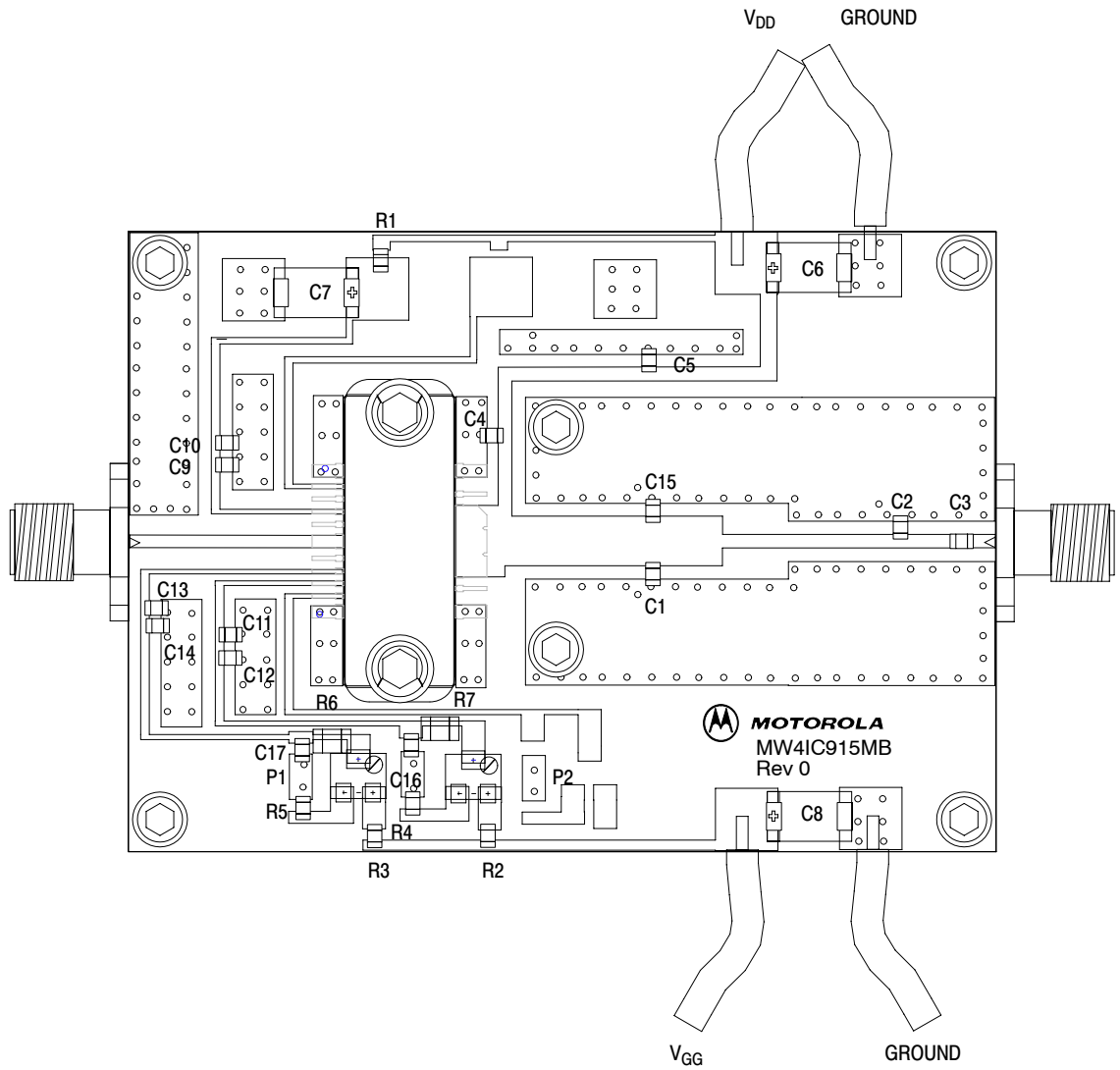


Z1	0.681" x 0.039", 50 Ω Microstrip	Z5	0.566" x 0.043" Microstrip
Z2	0.157" x 0.228" Microstrip	Z6	0.165" x 0.043" Microstrip
Z3	0.468" x 0.157" Microstrip	Z7	0.078" x 0.043" Microstrip
Z4	0.220" x 0.157" Microstrip	PCB	Taconic RF35, 0.02", ε <sub>r</sub> = 3.5

**Figure 5. MW4IC915NBR1 (GNBR1) Reference Board Schematic**

**Table 7. MW4IC915NBR1 (GNBR1) Reference Board Component Designations and Values**

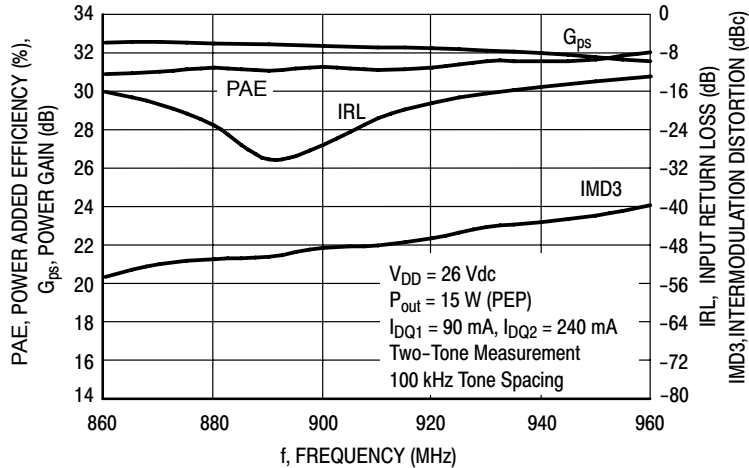
Part	Description	Part Number	Manufacturer
C1, C15	10 pF Chip Capacitors (0805), ACCU-P	08051J100GBT	AVX
C2	5.6 pF Chip Capacitor (0805), ACCU-P	08051J5R6BBT	AVX
C3, C4, C9, C11, C13	33 pF Chip Capacitors (0805), ACCU-P	08051J330GB	AVX
C5, C10, C12, C14	10 nF Chip Capacitors (0805)	08055C103KAT	AVX
C6, C7, C8	22 μF, 35 V Tantalum Capacitors	TAJE226MO35R	AVX
C16, C17	100 nF Chip Capacitors (0805)	08055C104KAT	AVX
P1, P2	5 kΩ Potentiometer CMS Cermet Multi-turn	3224W	Bourns
R1, R2, R3, R4, R5	0 Ω, 1/8 W Chip Resistors (0805)		
R6, R7	10 kΩ, 1/4 W Chip Resistors (1206)		



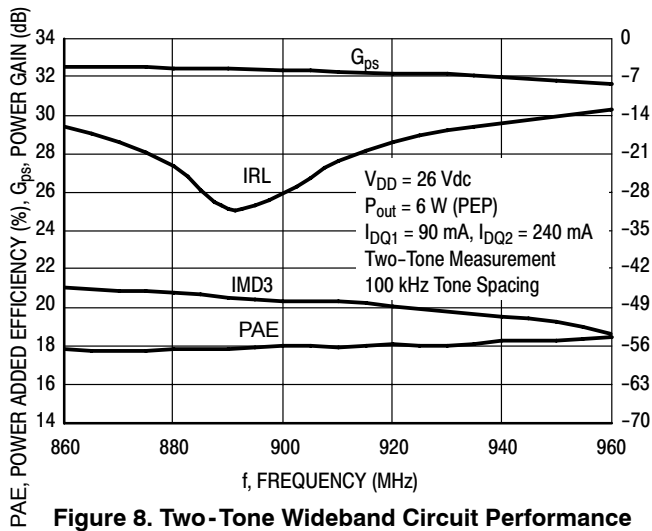
Freescale has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescale Semiconductor signature/logo. PCBs may have either Motorola or Freescale markings during the transition period. These changes will have no impact on form, fit or function of the current product.

**Figure 6. MW4IC915NBR1(GNBR1) Reference Board Component Layout**

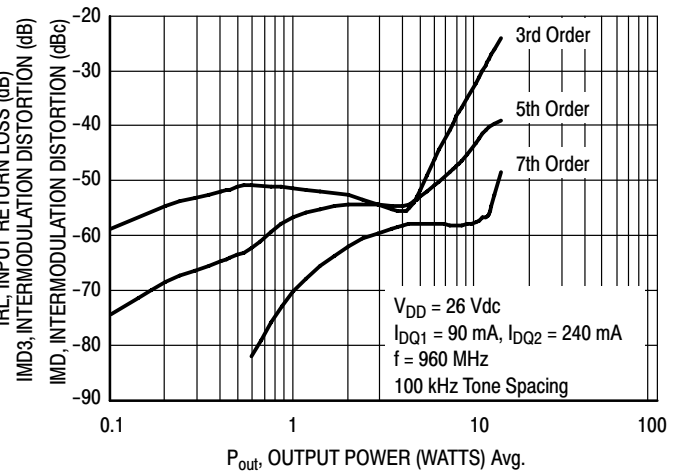
**TYPICAL CHARACTERISTICS (FREESCALE TEST FIXTURE, 50 OHM SYSTEM)**



**Figure 7. Two-Tone Wideband Circuit Performance @  $P_{out} = 15$  Watts PEP**

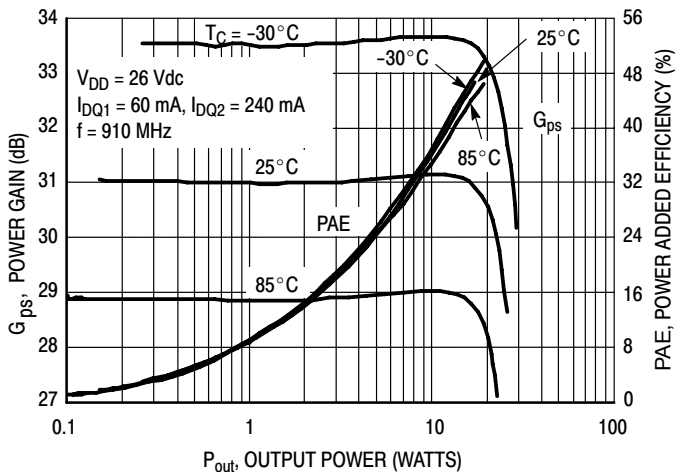


**Figure 8. Two-Tone Wideband Circuit Performance @  $P_{out} = 6$  Watts**

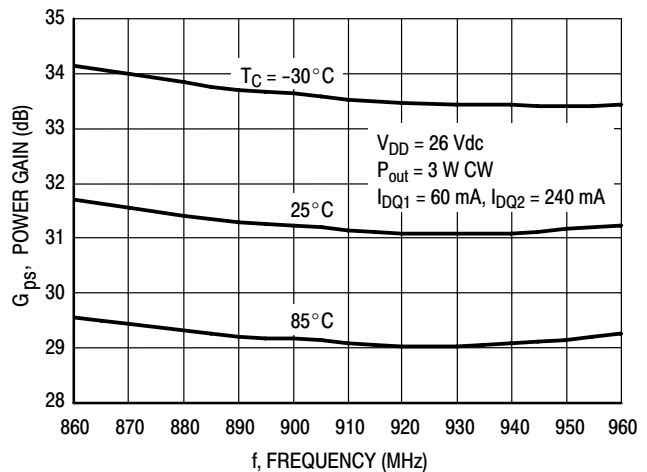


**Figure 9. Intermodulation Distortion Products versus Output Power**

**TYPICAL CHARACTERISTICS (FREESCALE REFERENCE BOARD)**



**Figure 10. Power Gain and Power Added Efficiency versus Output Power**



**Figure 11. Power Gain versus Frequency**



TYPICAL CHARACTERISTICS (FREESCALE REFERENCE BOARD) - CONTINUED

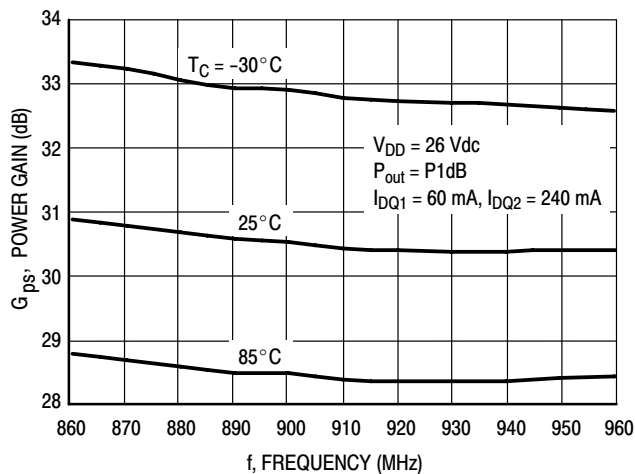


Figure 12. Power Gain versus Frequency

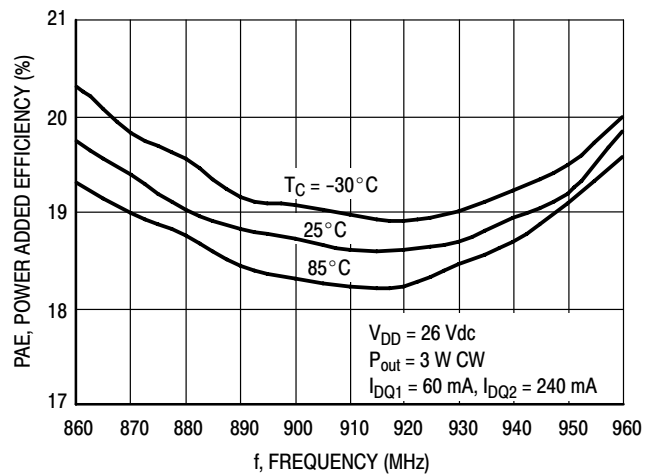


Figure 13. Power Added Efficiency versus Frequency

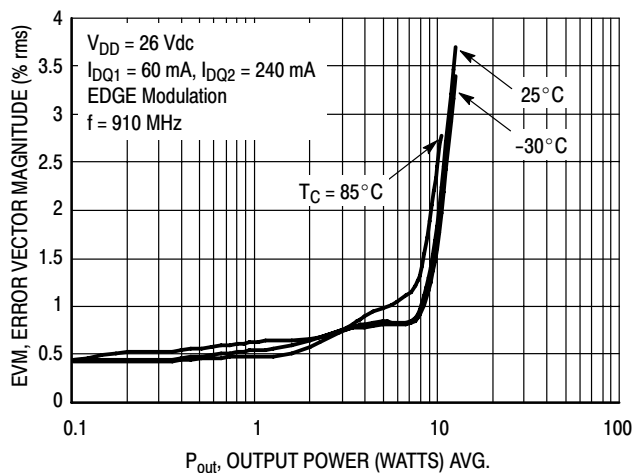


Figure 14. Error Vector Magnitude versus Output Power

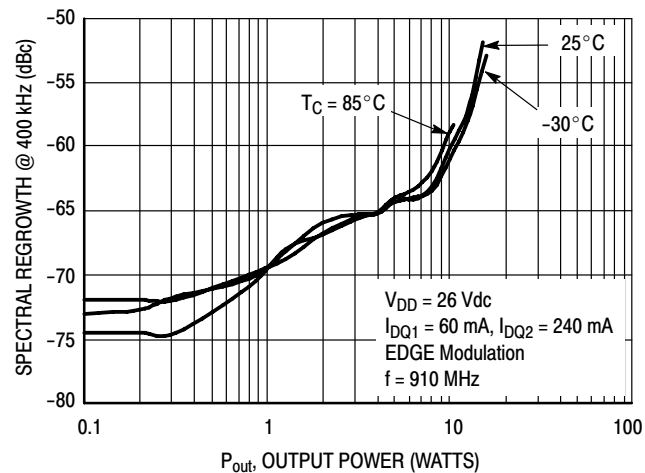


Figure 15. Spectral Regrowth at 400 kHz versus Output Power

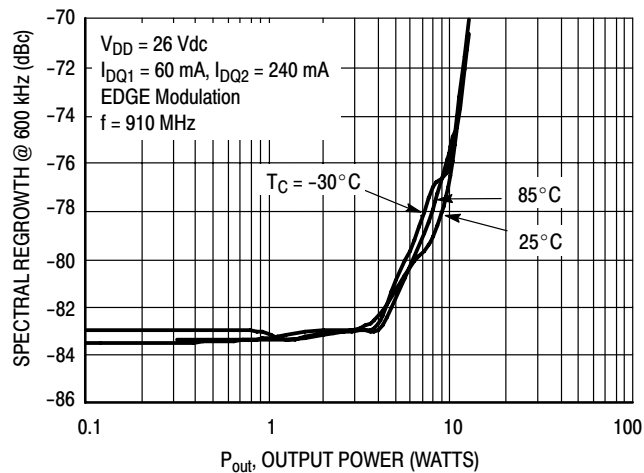
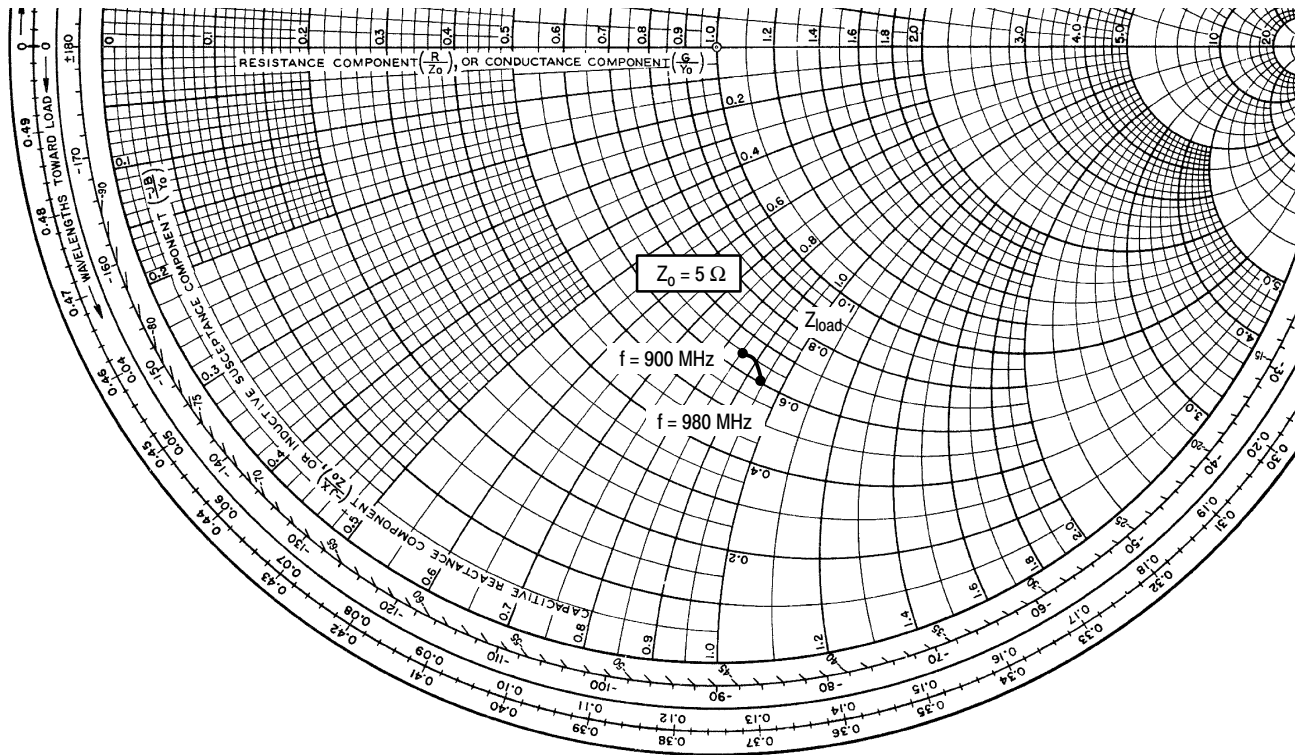


Figure 16. Spectral Regrowth at 600 kHz versus Output Power



$V_{DD} = 26 \text{ V}$ ,  $I_{DQ1} = 60 \text{ mA}$ ,  $I_{DQ2} = 240 \text{ mA}$ ,  $P_{out} = P_{1dB}$

f MHz	$Z_{load}$ $\Omega$
900	3.23 - j4.30
910	3.24 - j4.36
920	3.25 - j4.42
930	3.25 - j4.47
940	3.23 - j4.52
950	3.21 - j4.56
960	3.16 - j4.60
970	3.11 - j4.65
980	3.04 - j4.70

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

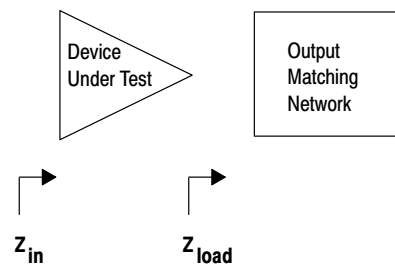


Figure 17. Series Equivalent Input and Load Impedance



# NOTES

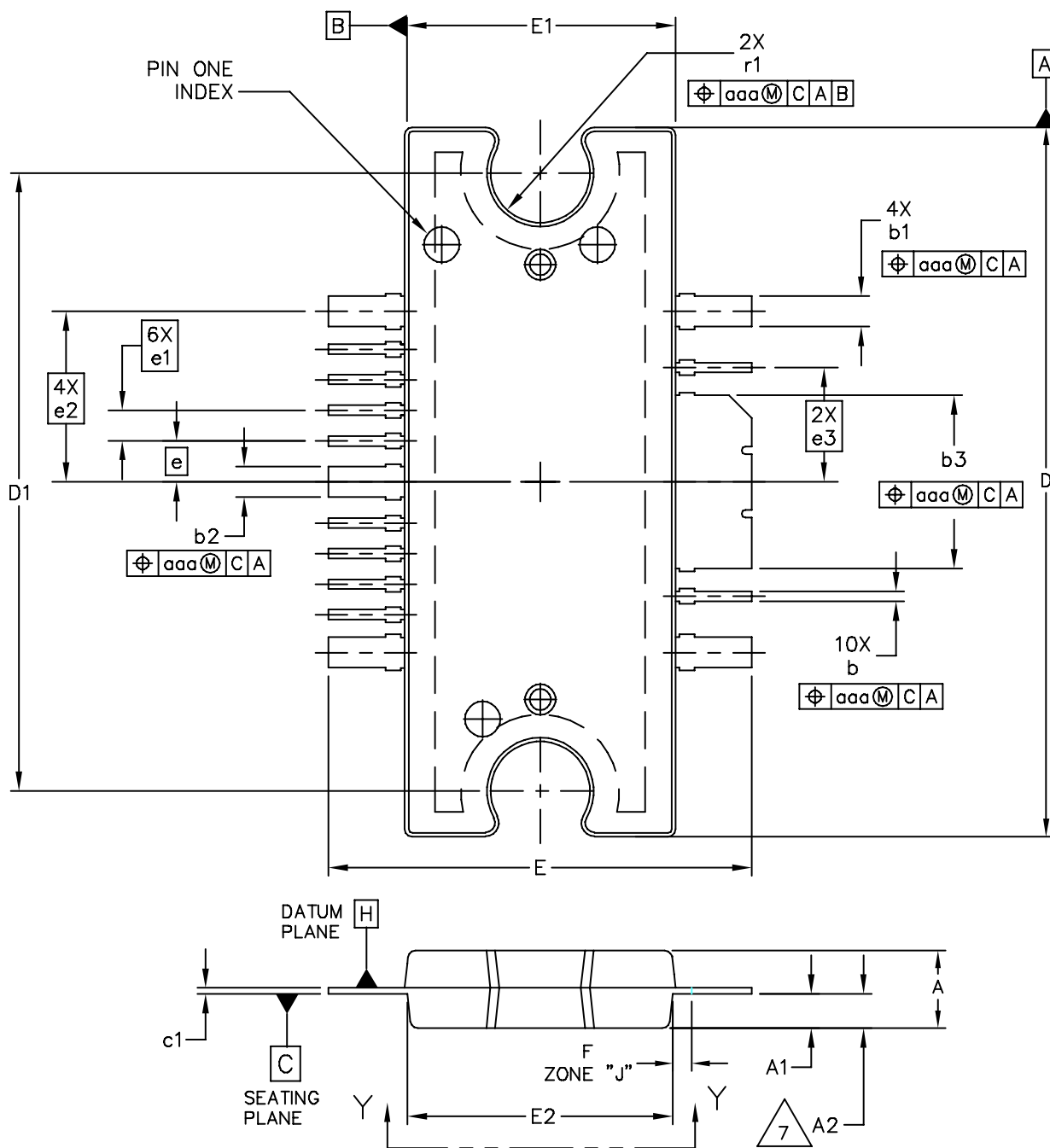


# NOTES

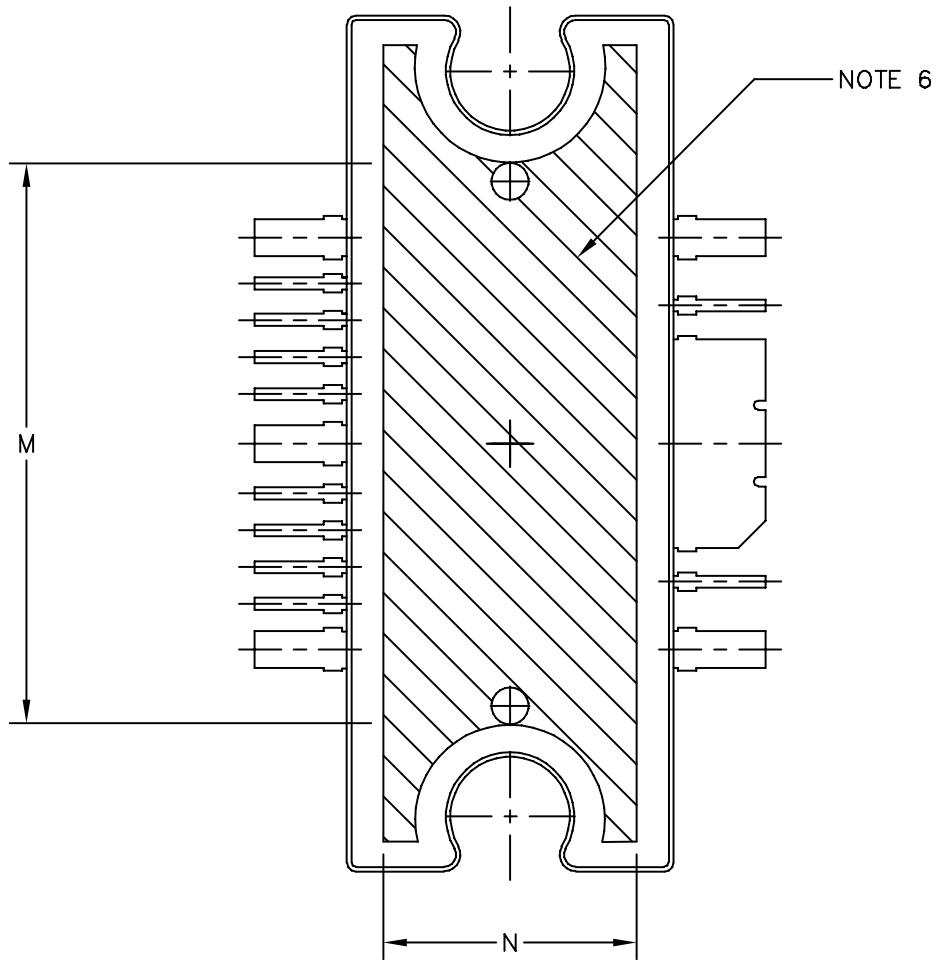


# NOTES

**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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MW4IC915NBR1 MW4IC915GNBR1

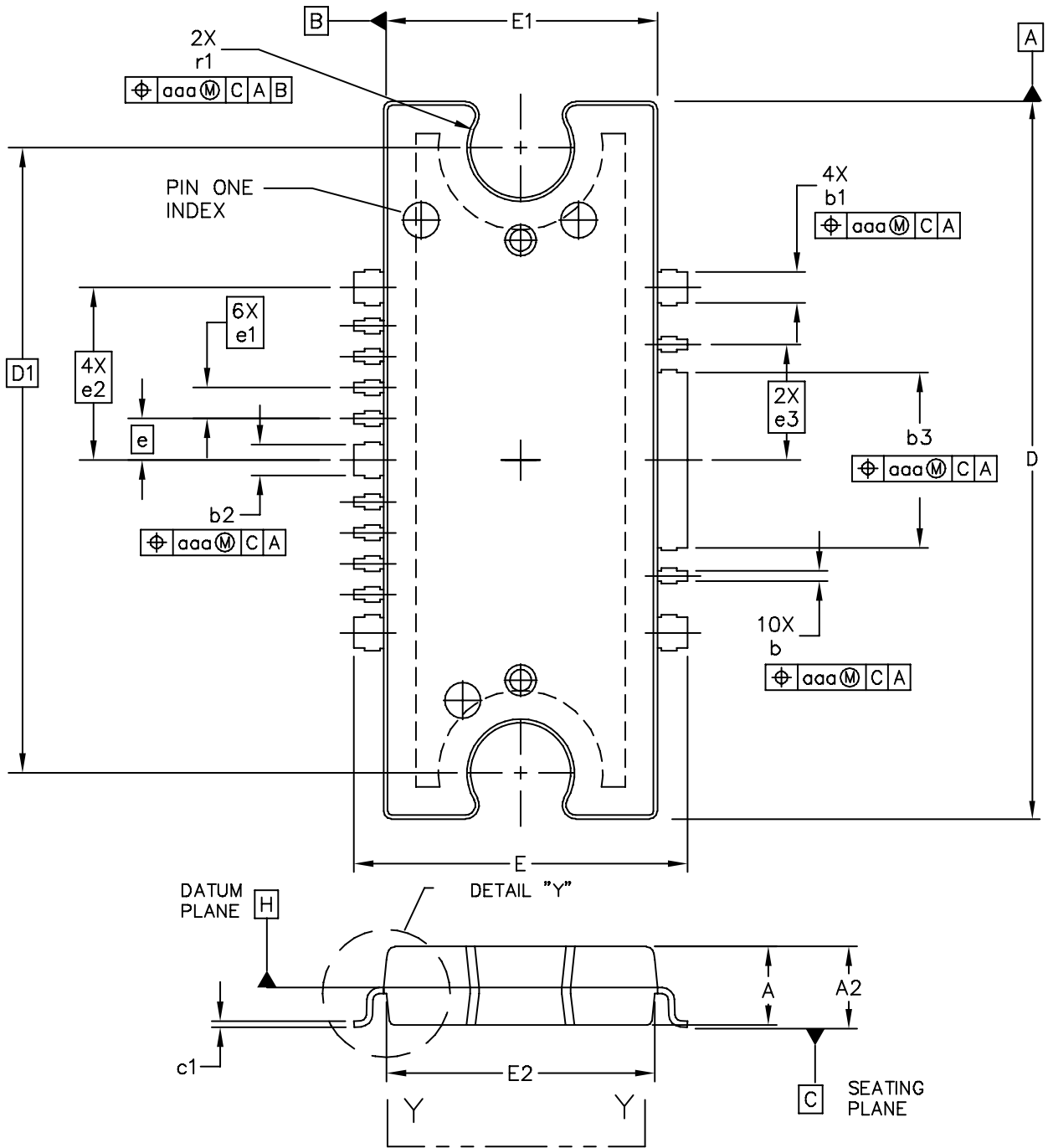
NOTES:

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 OF THE HEAT SLUG. HATCHED AREA SHOWN IS ON THE SAME PLANE.
7. DIM A2 APPLIES WITHIN ZONE "J" ONLY.

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		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	

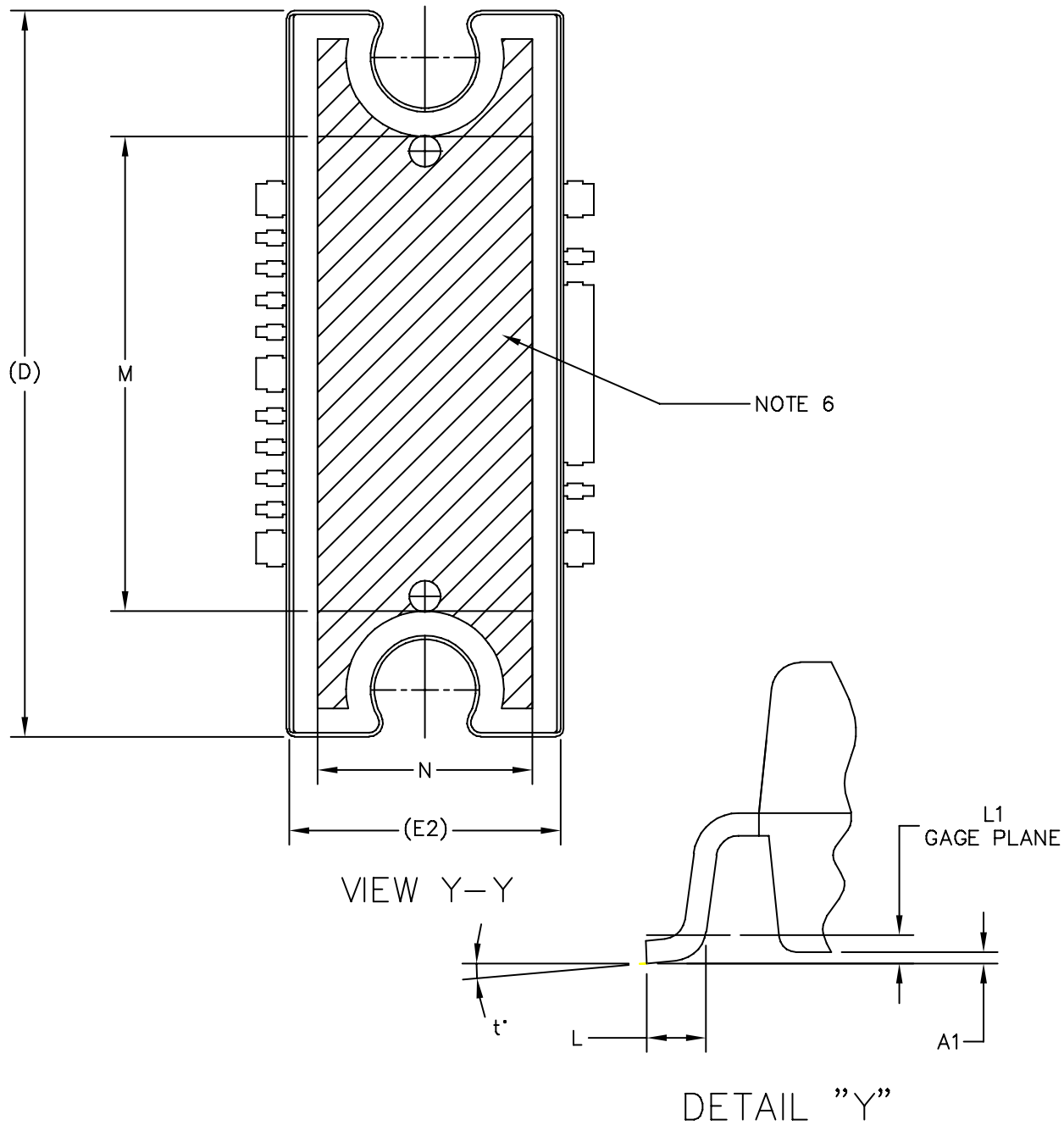
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		STANDARD: NON-JEDEC			





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

MW4IC915NBR1 MW4IC915GNBR1



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

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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.

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		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	
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					STANDARD: NON-JEDEC				

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