

RF LDMOS Wideband Integrated Power Amplifier

The MHVIC915NR2 wideband integrated circuit is designed with on-chip matching that makes it usable from 750 to 1000 MHz. This multi-stage structure is rated for 26 to 28 Volt operation and covers all typical cellular base station modulation formats.

Final Application

- Typical Single-Carrier N-CDMA Performance: $V_{DD} = 27$ Volts, $I_{DQ1} = 80$ mA, $I_{DQ2} = 120$ mA, $P_{out} = 34$ dBm, Full Frequency Band (746 to 960 MHz), IS-95 CDMA (Pilot, Sync, Paging, Traffic Codes 8 Through 13)
Power Gain — 31 dB
Power Added Efficiency — 21%
ACPR @ 750 kHz Offset — -50 dBc in 30 kHz Bandwidth

Driver Applications

- Typical Single-Carrier N-CDMA Performance: $V_{DD} = 27$ Volts, $I_{DQ1} = 80$ mA, $I_{DQ2} = 120$ mA, $P_{out} = 23$ dBm, Full Frequency Band (869-894 MHz), IS-95 CDMA (Pilot, Sync, Paging, Traffic Codes 8 Through 13), Channel Bandwidth = 1.2288 MHz. PAR = 9.8 dB @ 0.01% Probability on CCDF.
Power Gain — 31 dB
Power Added Efficiency — 21%
ACPR @ 750 kHz Offset — -60 dBc in 30 kHz Bandwidth
ACPR @ 1.98 MHz Offset — -66 dBc in 30 kHz Bandwidth
- Typical GSM Performance: $V_{DD} = 26$ Volts, $P_{out} = 15$ W P1dB, Full Frequency Band (921-960 MHz)
Power Gain — 30 dB @ P1dB
Power Added Efficiency = 56% @ P1dB
- Capable of Handling 3:1 VSWR, @ 27 Vdc, 880 MHz, 15 Watts CW Output Power
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- On-Chip Matching (50 Ohm Input, DC Blocked, >9 Ohm Output)
- Integrated Quiescent Current Temperature Compensation with Enable/Disable Function
- On-Chip Current Mirror g_m Reference FET for Self Biasing Application ⁽¹⁾
- Integrated ESD Protection
- RoHS Compliant
- In Tape and Reel. R2 Suffix = 1,500 Units per 16 mm, 13 inch Reel.

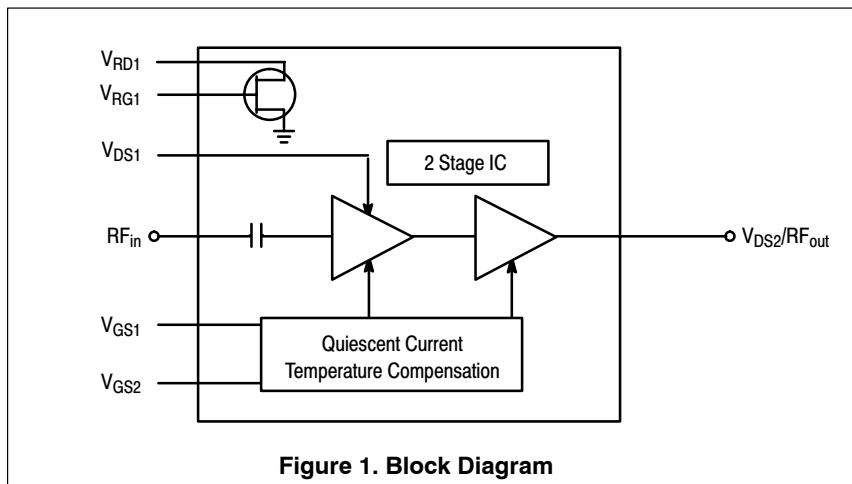


Figure 1. Block Diagram

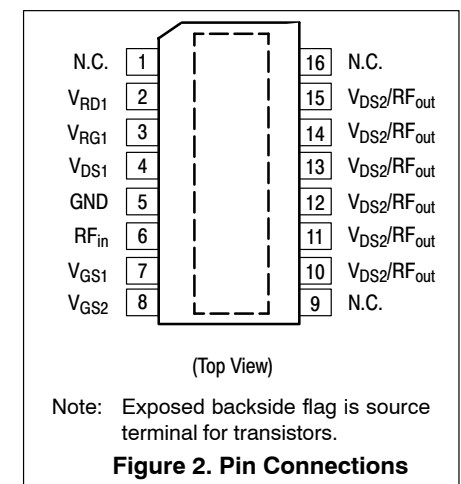


Figure 2. Pin Connections

1. Refer to AN1987, *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_{DS}	-0.5, +65	Vdc
Gate-Source Voltage	V_{GS}	-0.5, +15	Vdc
Storage Temperature Range	T_{stg}	-65 to +150	°C
Operating Junction Temperature	T_J	150	°C

Table 2. Thermal Characteristics

Characteristic	Symbol	Value ⁽¹⁾	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$		°C/W
Driver Application ($P_{out} = 0.2$ W CW)	Stage 1, 27 Vdc, $I_{DQ} = 80$ mA Stage 2, 27 Vdc, $I_{DQ} = 120$ mA	15.1 5.1	
Output Application ($P_{out} = 2.5$ W CW)	Stage 1, 27 Vdc, $I_{DQ} = 80$ mA Stage 2, 27 Vdc, $I_{DQ} = 120$ mA	15.8 5.0	
GSM Application ($P_{out} = 15$ W CW)	Stage 1, 26 Vdc, $I_{DQ} = 50$ mA Stage 2, 26 Vdc, $I_{DQ} = 140$ mA	13.8 4.5	

Table 3. ESD Protection Characteristics

Test Methodology	Class
Human Body Model (per JESD22-A114)	0 (Minimum)
Machine Model (per EIA/JESD22-A115)	A (Minimum)
Charge Device Model (per JESD22-C101)	II (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) $V_{DD} = 27$ Vdc, $I_{DQ1} = 80$ mA, $I_{DQ2} = 120$ mA, $f = 880$ MHz, Single-Carrier N-CDMA, 1.2288 MHz Channel Bandwidth Carrier. ACPR measured in 30 kHz Bandwidth @ ± 750 MHz. PAR = 9.8 dB @ 0.01% Probability on CCDF

Power Gain ($P_{out} = 23$ dBm)	G_{ps}	29	31	—	dB
Power Added Efficiency ($P_{out} = 34$ dBm)	PAE	—	21	—	%
Input Return Loss ($P_{out} = 23$ dBm)	IRL	—	-12	-9	dB
Adjacent Channel Power Ratio ($P_{out} = 23$ dBm)	ACPR	—	-60	-55	dBc
Adjacent Channel Power Ratio ($P_{out} = 34$ dBm)	ACPR	—	-50	—	dBc
Gain Flatness @ $P_{out} = 23$ dBm (865 MHz to 895 MHz)	G_F	—	0.2	0.4	dB
Bias Sense FET Drain Current $V_{BSD} = 27$ V $V_{BIAS\ BSG} = V_{BIAS2\ Q2}$ @ $I_{DQ2} = 120$ mA	I_{BSD}	0.8	1.2	1.6	mA

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

(continued)

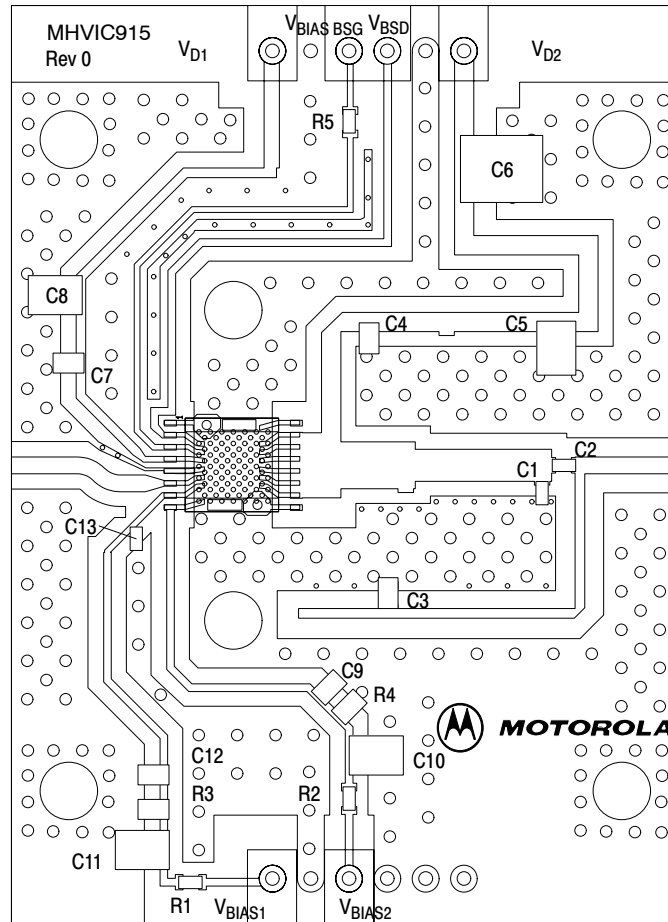
Table 5. Electrical Characteristics ($T_C = 25^\circ\text{C}$ unless otherwise noted) (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
Typical Performances (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 27\text{ Vdc}$, $I_{DQ1} = 80\text{ mA}$, $I_{DQ2} = 120\text{ mA}$, 865-895 MHz					
Quiescent Current Accuracy over Temperature (-10 to 85°C) at Nominal Value ⁽¹⁾	ΔI_{QT}	—	± 5	—	%
Gain Flatness in 30 MHz Bandwidth @ $P_{out} = 23\text{ dBm}$ (800 MHz to 960 MHz)	G_F	—	0.20	—	dB
Deviation from Linear Phase in 30 MHz Bandwidth @ $P_{out} = 23\text{ dBm}$	Φ	—	± 0.2	—	°
Group Delay @ $P_{out} = 23\text{ dBm}$ Including Output Matching	Delay	—	2.2	—	ns
Part to Part Phase Variation @ $P_{out} = 23\text{ dBm}$	$\Phi\Delta$	—	± 10	—	°

Typical GSM Performances (In Freescale GSM Test Fixture, 50 ohm system) $V_{DD} = 26\text{ Vdc}$, $I_{DQ1} = 50\text{ mA}$, $I_{DQ2} = 140\text{ mA}$, 921-960 MHz, CW

Output Power, 1 dB Compression Point	P1dB	—	15	—	W
Power Gain @ P1dB	G_{ps}	—	30	—	dB
Power Added Efficiency @ P1dB	PAE	—	56	—	%
Input Return Loss @ P1dB	IRL	—	-16	—	dB
Error Vector Magnitude @ 5 W	—	—	0.9	—	%
Intermodulation Distortion (15 W PEP, 2-Tone, 100 kHz Tone Spacing)	IMD	—	-30	—	dBc
Power Added Efficiency (15 W PEP, 2-Tone, 100 kHz Tone Spacing)	PAE	—	35	—	%

1. 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.



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

Figure 4. MHVIC915NR2 Test Circuit Component Layout

TYPICAL CHARACTERISTICS (FREESCALE TEST FIXTURE, 50 OHM SYSTEM)

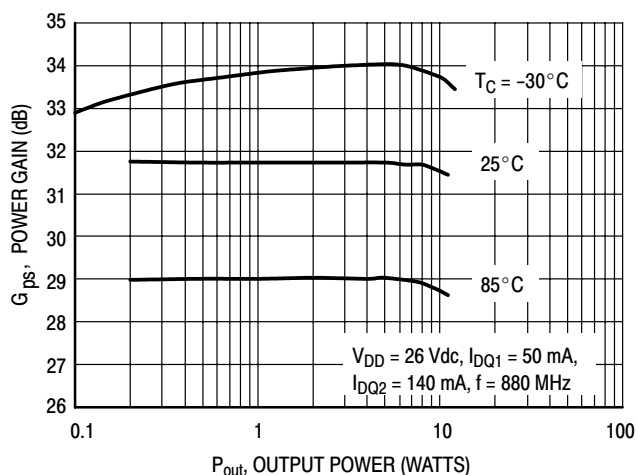


Figure 5. Power Gain versus Output Power

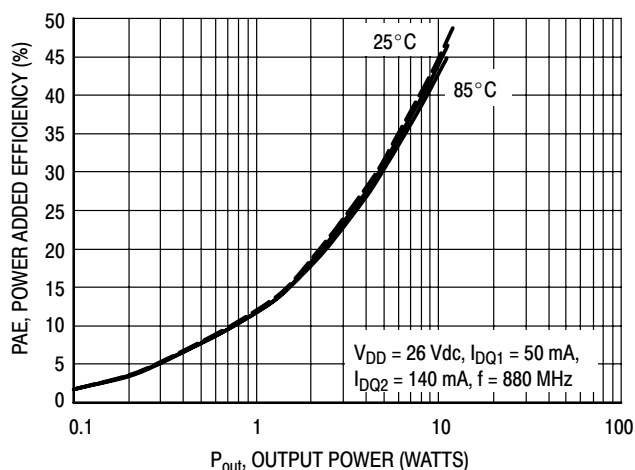


Figure 6. Power Added Efficiency versus Output Power

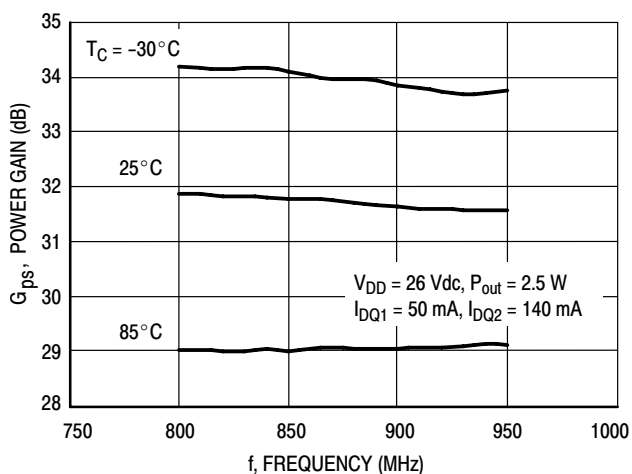


Figure 7. Power Gain versus Frequency

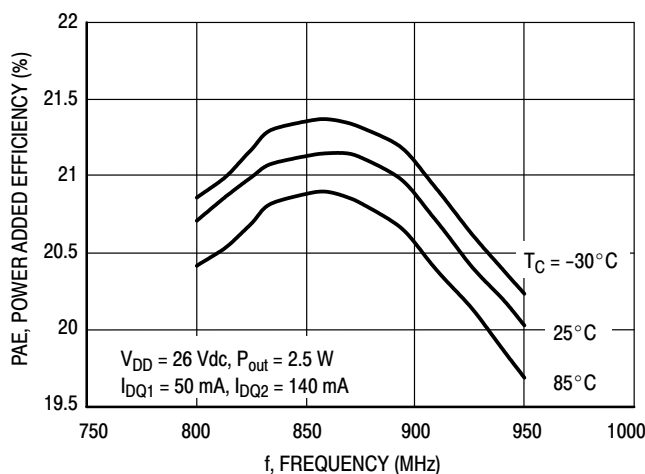


Figure 8. Power Added Efficiency versus Frequency

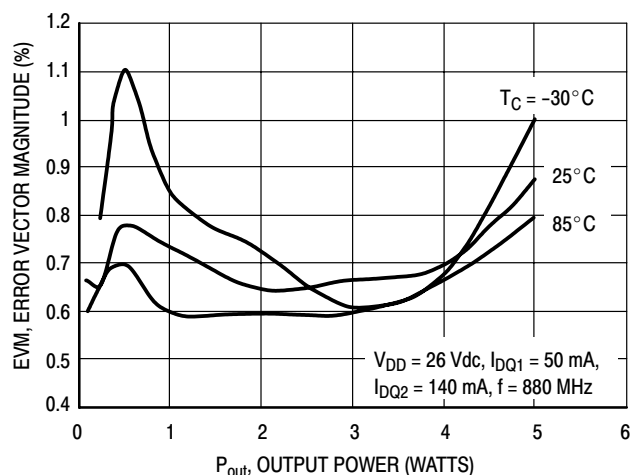


Figure 9. Error Vector Magnitude versus Output Power

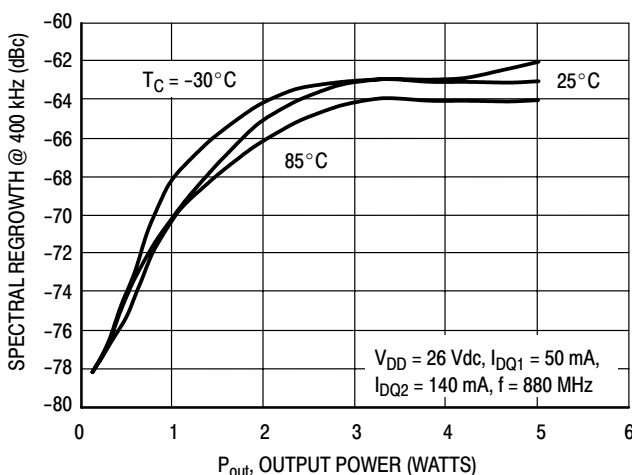


Figure 10. Spectral Regrowth @ 400 kHz versus Output Power

TYPICAL CHARACTERISTICS (FREESCALE TEST FIXTURE, 50 OHM SYSTEM)

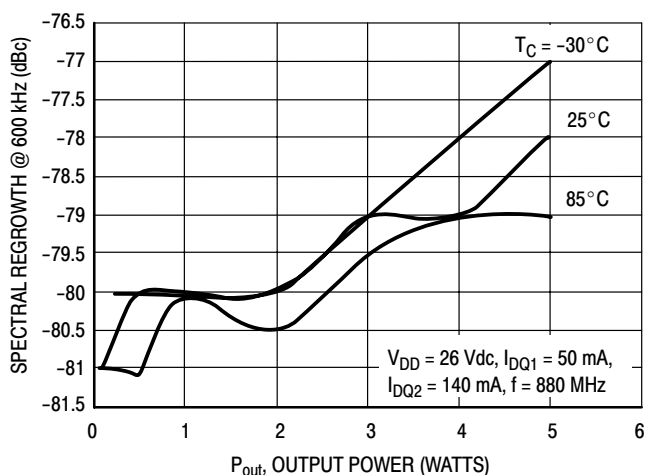


Figure 11. Spectral Regrowth @ 600 kHz versus Output Power

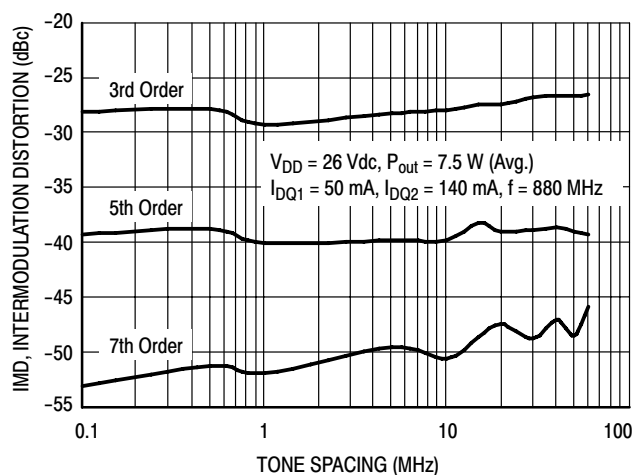


Figure 12. Two-Tone Broadband Performance

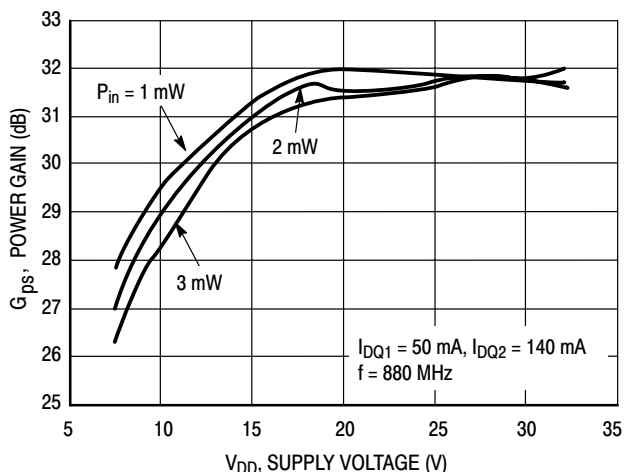


Figure 13. Power Gain versus Supply Voltage

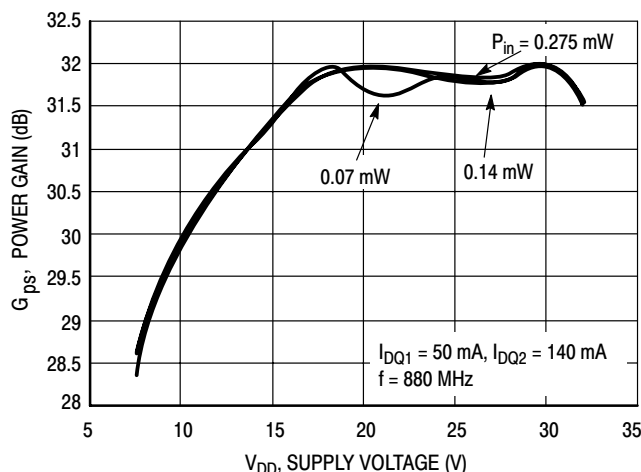


Figure 14. Power Gain versus Supply Voltage

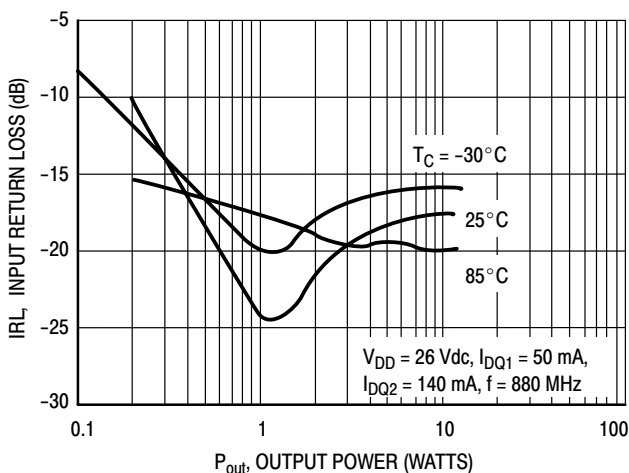


Figure 15. Input Return Loss versus Output Power

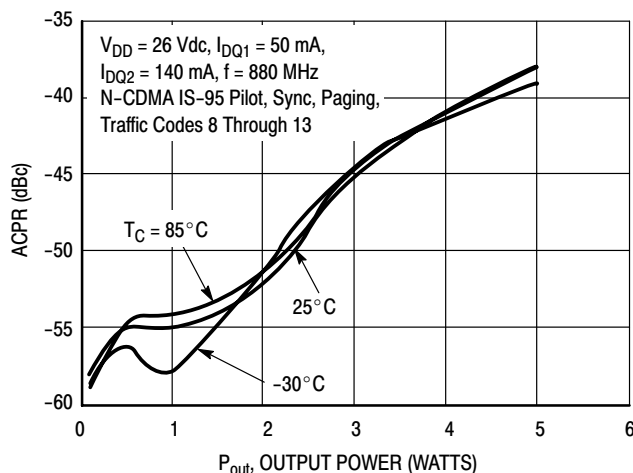
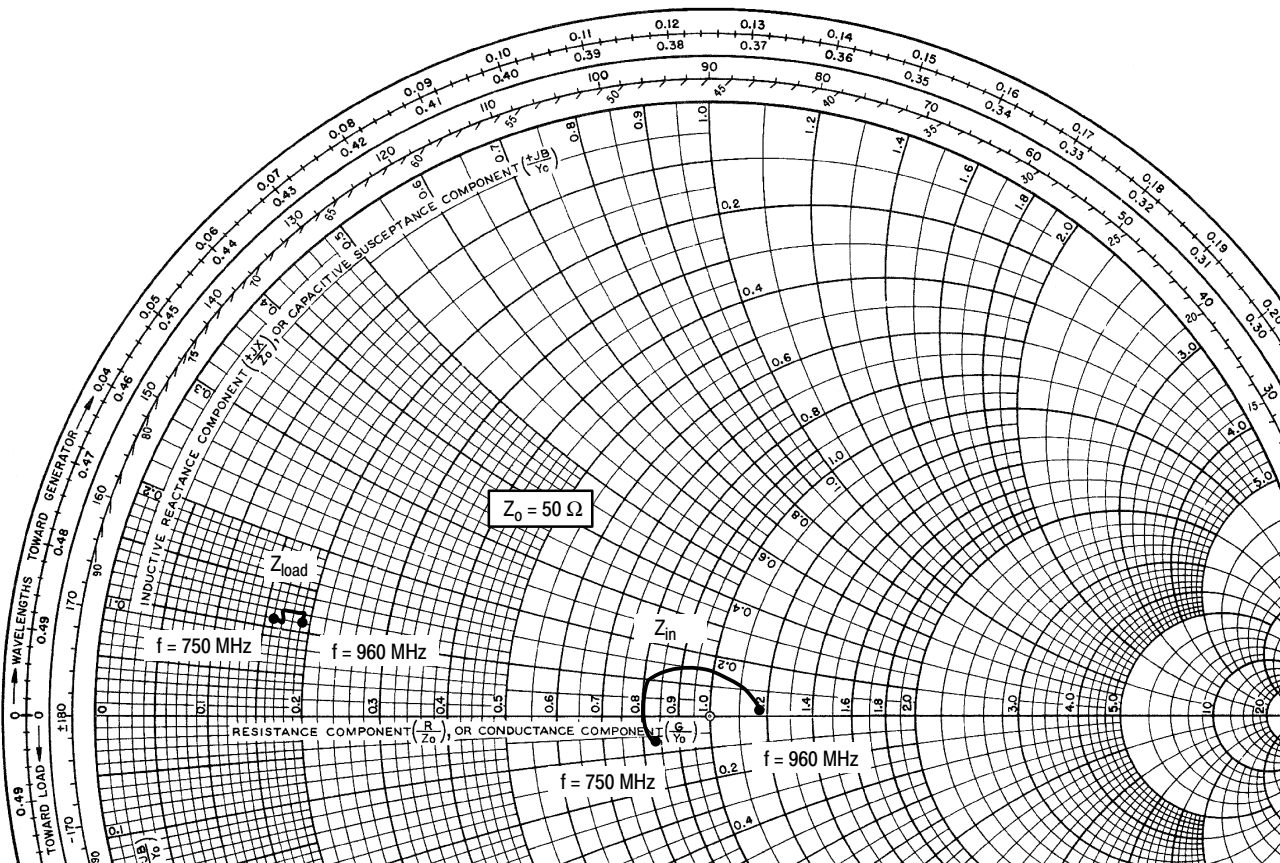


Figure 16. Adjacent Channel Power Ratio versus Output Power



$V_{DD} = 26 \text{ Vdc}$, $I_{DQ1} = 50 \text{ mA}$, $I_{DQ2} = 140 \text{ mA}$, $P_{out} = 1.25 \text{ W CW}$

f MHz	Z_{in} Ω	Z_{load} Ω
750	$42.11 - j2.79$	$8.24 + j5.33$
765	$40.86 - j1.37$	$8.31 + j5.56$
780	$40.09 + j0.06$	$8.39 + j5.82$
795	$39.77 + j1.52$	$8.50 + j5.95$
810	$39.89 + j3.01$	$8.62 + j6.02$
825	$40.49 + j4.39$	$8.82 + j6.12$
840	$41.48 + j5.70$	$8.94 + j6.19$
855	$42.89 + j6.73$	$9.12 + j6.17$
870	$43.51 + j7.03$	$9.16 + j6.12$
885	$46.81 + j7.87$	$9.33 + j6.09$
900	$49.21 + j7.74$	$9.38 + j5.95$
915	$51.79 + j7.02$	$9.50 + j5.85$
930	$54.48 + j5.65$	$9.47 + j5.73$
945	$57.05 + j3.61$	$9.54 + j5.63$
960	$59.16 + j0.75$	$9.42 + j5.45$

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

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

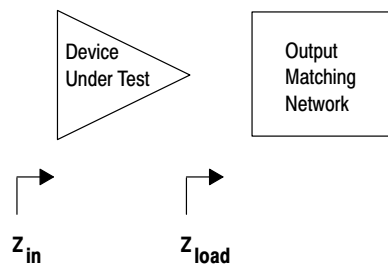
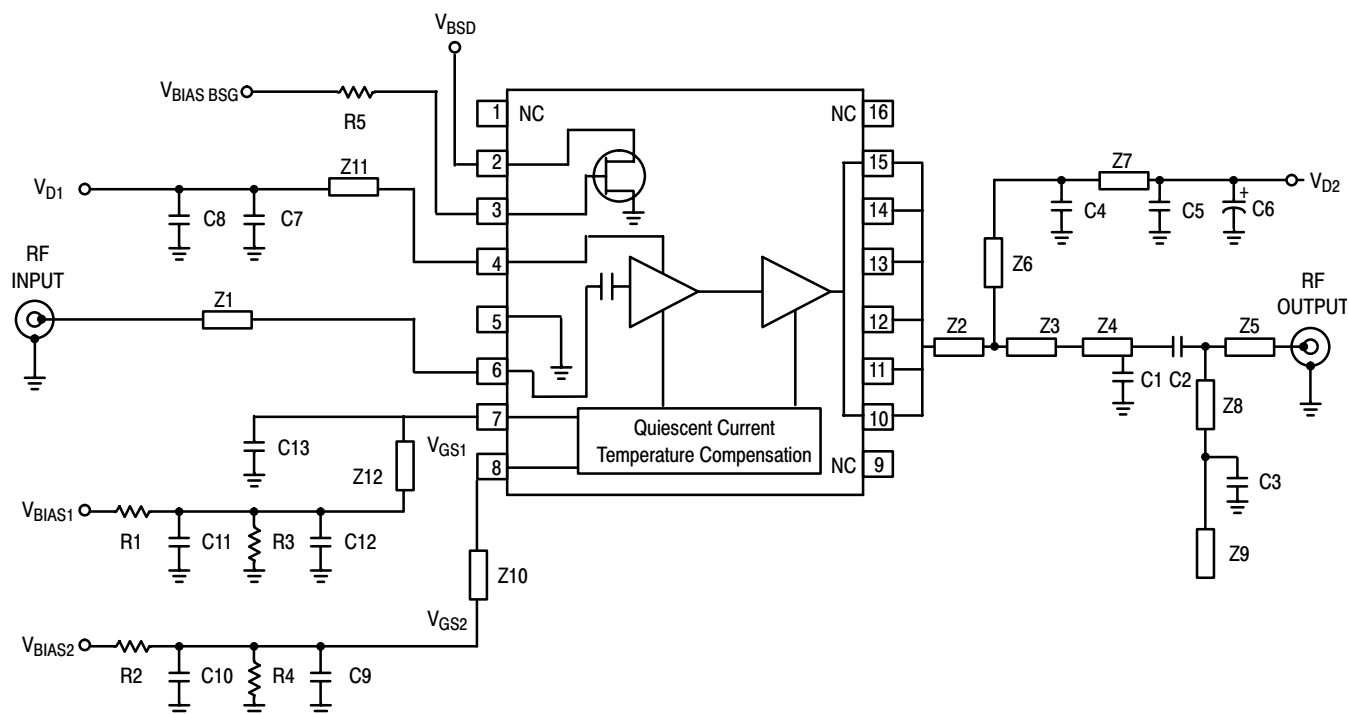


Figure 17. Series Equivalent Input and Load Impedance

DRIVER/PRE-DRIVER PERFORMANCE



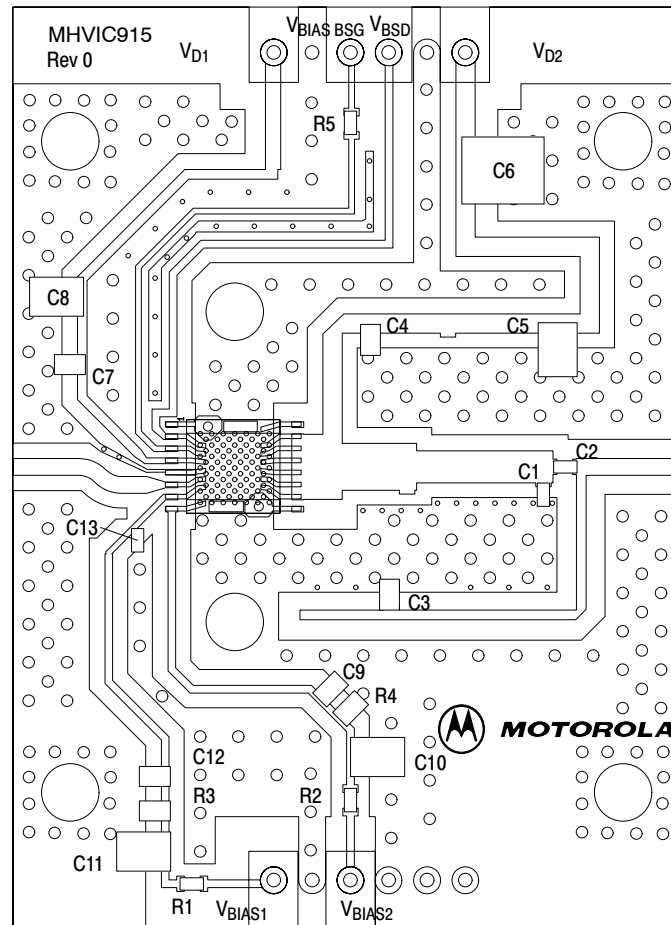
Z1	0.0438" x 0.400" 50 Ω Microstrip	Z7	0.0504" x 0.480" Microstrip
Z2	0.1709" x 0.1004" Microstrip (not including IC pad length)	Z8	0.0252" x 0.843" Microstrip
Z3	0.1222" x 0.1944" Microstrip	Z9	0.0252" x 0.167" Microstrip
Z4	0.0836" x 0.3561" Microstrip	Z10	0.040" x 0.850" Microstrip
Z5	0.0438" x 0.2725" Microstrip	Z11	0.025" x 0.400" Microstrip
Z6	0.0504" x 0.3378" Microstrip	Z12	0.020" x 0.710" Microstrip
		PCB	Rogers 4350, 0.020", $\epsilon_r = 3.50$

**Figure 18. MHVIC915NR2 Test Fixture Schematic—
Alternate Characterization for Driver/Pre-Driver Performance**

**Table 7. MHVIC915NR2 Test Fixture Component Designations and Values —
Alternate Characterization for Driver/Pre-Driver Performance**

Part	Description	Part Number	Manufacturer
C1, C2	2.4 pF High Q Capacitors (0603)	ATC600S4R7CW	ATC
C3, C4	47 pF NPO Capacitors (0805)	GRM40-001COG470J050BD	Murata
C5, C8, C10, C11	1 μ F X7R Chip Capacitors (1214)	GRM42-2X7R105K050AL	Murata
C6	10 μ F, 50 V Electrolytic Capacitor	ECEV1HA100SP	Panasonic
C7, C9, C12	0.01 μ F X7R Chip Capacitors (0805)	GRM40X7R103J050BD	Murata
C13	8.2 pF NPO Chip Capacitor (0805)	GRM40-001COG8R2C050BD	Murata
R1, R2, R5	1 k Ω Chip Resistors (0603)	RM73B2AT102J	KOA Speer
R3, R4	100 k Ω Chip Resistors (0603)	RM73B2AT104J	KOA Speer

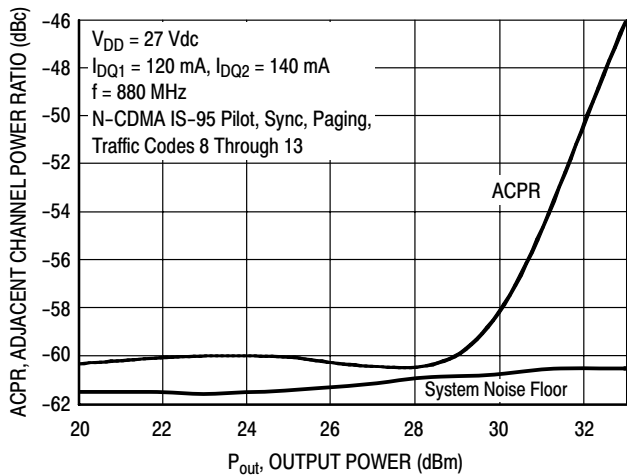
DRIVER/PRE-DRIVER PERFORMANCE



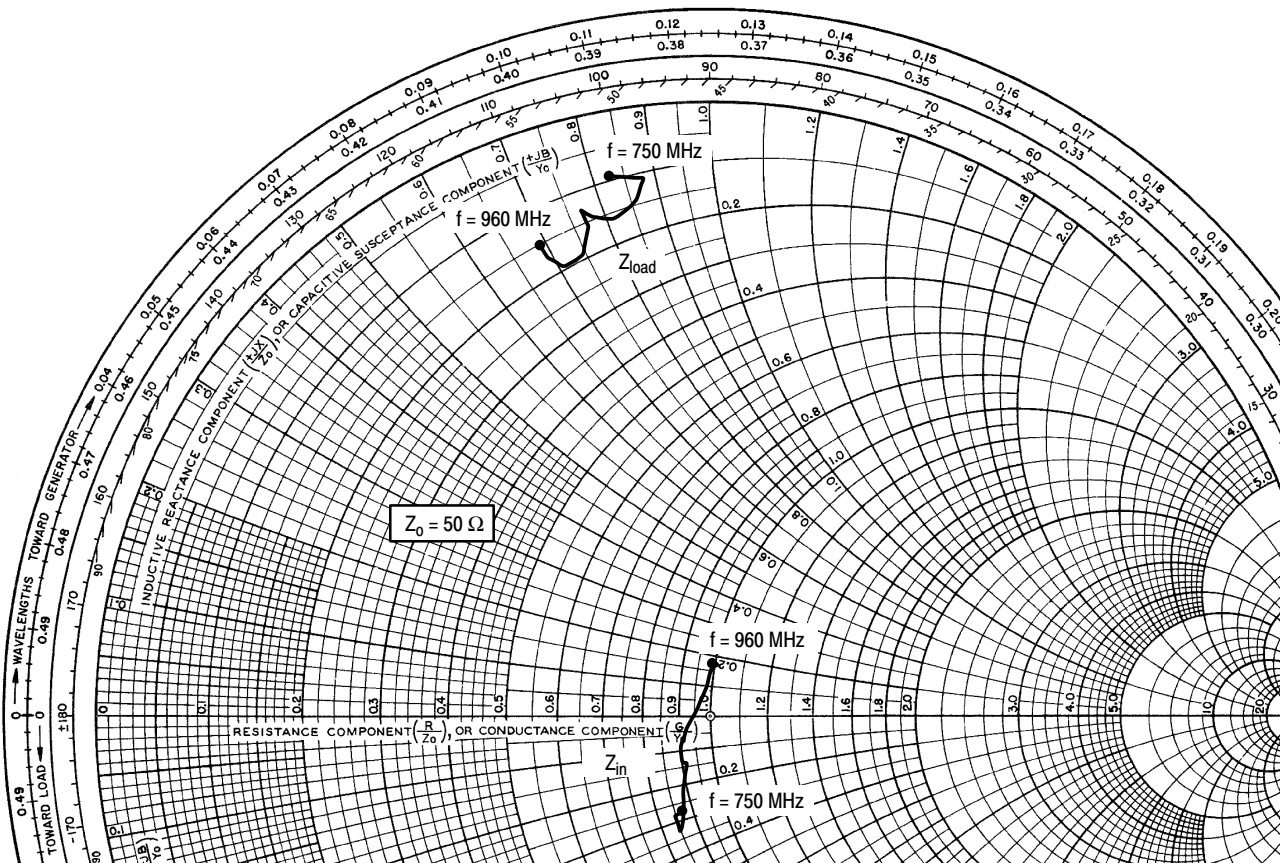
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**Figure 19. MHVIC915NR2 Test Circuit Component Layout—
Alternate Characterization for Driver/Pre-Driver Performance**

TYPICAL CHARACTERISTICS **DRIVER/PRE- DRIVER PERFORMANCE**



**Figure 20. Single-Carrier N-CDMA ACPR
 versus Output Power**



$V_{DD} = 27 \text{ Vdc}$, $I_{DQ1} = 120 \text{ mA}$, $I_{DQ2} = 140 \text{ mA}$, $P_{out} = 0.5 \text{ W CW}$

f MHz	Z_{in} Ω	Z_{load} Ω
750	$43.5 - j13.4$	$4.7 + j41.5$
765	$42.9 - j13.9$	$5.5 + j43.8$
780	$42.7 - j14.2$	$6.0 + j43.7$
795	$42.3 - j15.9$	$6.8 + j42.8$
810	$42.7 - j16.0$	$7.5 + j42.2$
825	$44.5 - j10.5$	$7.8 + j40.5$
840	$45.5 - j7.0$	$7.2 + j39.2$
855	$45.0 - j6.5$	$6.3 + j38.4$
870	$45.0 - j4.5$	$6.4 + j38.7$
885	$46.0 - j1.5$	$7.9 + j38.5$
900	$48.3 + j2.4$	$9.3 + j36.8$
915	$49.5 + j7.3$	$9.4 + j35.3$
930	$49.6 + j7.8$	$8.6 + j34.5$
945	$49.8 + j8.4$	$7.8 + j34.3$
960	$49.5 + j8.6$	$7.6 + j34.3$

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

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

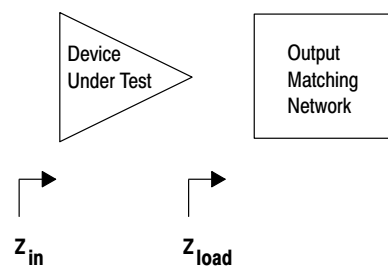


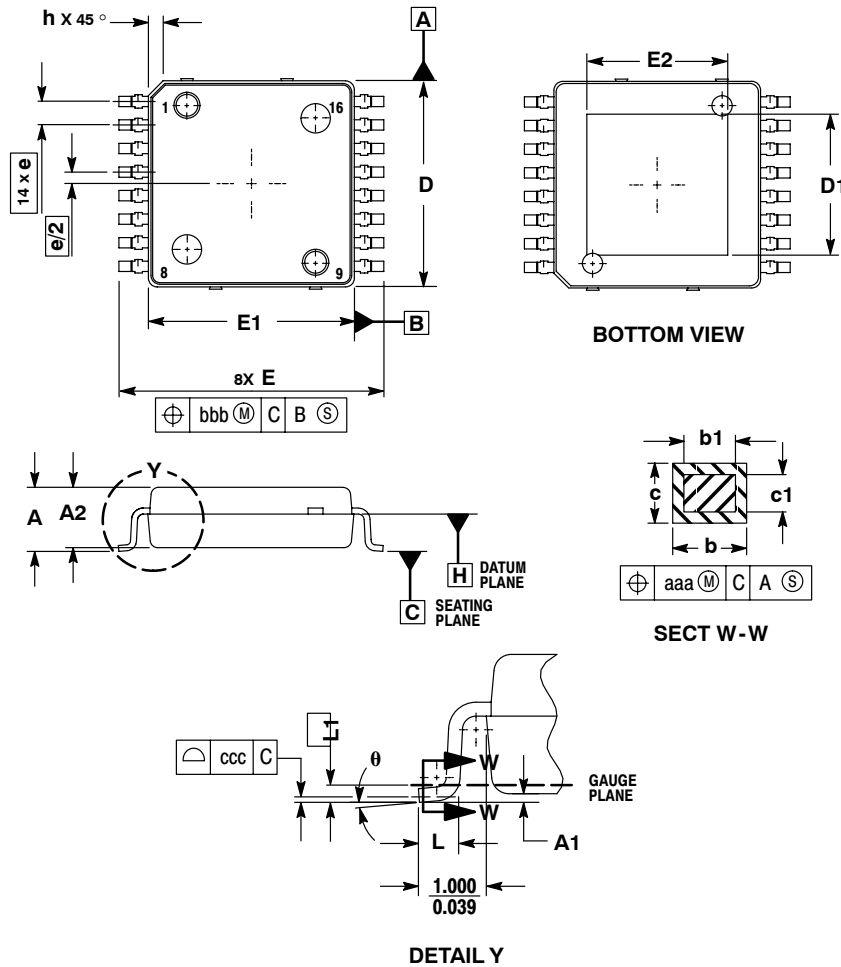
Figure 21. Series Equivalent Input and Load Impedance — Alternate Characterization for Driver/Pre-Driver Performance



NOTES

NOTES

PACKAGE DIMENSIONS



NOTES:

1. CONTROLLING DIMENSION: MILLIMETER.
2. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.
3. DATUM PLANE -H- IS LOCATED AT BOTTOM OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE BOTTOM OF THE PARTING LINE.
4. DIMENSIONS D AND E1 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS 0.250 PER SIDE. DIMENSIONS D AND E1 DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -H-.
5. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION IS 0.127 TOTAL IN EXCESS OF THE b DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUMS -A- AND -B- TO BE DETERMINED AT DATUM PLANE -H-.

DIM	MILLIMETERS	
	MIN	MAX
A	2.000	2.300
A1	0.025	0.100
A2	1.950	2.100
D	6.950	7.100
D1	4.372	5.180
E	8.850	9.150
E1	6.950	7.100
E2	4.372	5.180
L	0.466	0.720
L1	0.250 BSC	
b	0.300	0.432
b1	0.300	0.375
c	0.180	0.279
c1	0.180	0.230
e	0.800 BSC	
h	---	0.600
θ	0°	7°
aaa	0.200	
bbb	0.200	
ccc	0.100	

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