



# Gallium Arsenide pHEMT

## RF Power Field Effect Transistor

Designed for WLL/MMDS/BWA or UMTS driver applications. Characterized from 500 to 5000 MHz. Device is unmatched and is suitable for use in Class AB customer premise equipment (CPE) applications.

- Typical Single-Carrier W-CDMA Performance:  $V_{DD} = 12$  Vdc,  $I_{DQ} = 130$  mA, 3.84 MHz Channel Bandwidth, Input Signal PAR = 8.5 dB @ 0.01% Probability on CCDF.

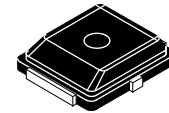
Frequency (MHz)	P <sub>out</sub> (W)	G <sub>ps</sub> (dB)	ACPR (dBc)	$\eta_D$ (%)	IRL (dB)
750	1	14.5	-44.0	24.0	-15
2140	1	13.0	-43.0	25.0	-14
2650	1	11.5	-43.0	30.0	-15

### Features

- 9 Watts P1dB @ 3550 MHz, CW
- Excellent Phase Linearity and Group Delay Characteristics
- High Efficiency and High Linearity
- In Tape and Reel. T1 Suffix = 1000 Units, 12 mm Tape Width, 7-inch Reel.

**MRF35010ANT1**

**500-5000 MHz, 9 W, 12 V  
POWER FET  
GaAs pHEMT**



**PLD-1.5  
PLASTIC**

**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	15	Vdc
Gate-Source Voltage	$V_{GS}$	-5	Vdc
RF Input Power	$P_{in}$	33	dBm
Storage Temperature Range	$T_{stg}$	-65 to +150	°C
Channel Temperature (1)	$T_{ch}$	175	°C

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (2)	Unit
Thermal Resistance, Junction to Case Case Temperature 77°C, 1 W CW	$R_{\theta JC}$	6.5	°C/W

**Table 3. ESD Protection Characteristics**

Test Methodology	Class
Human Body Model (per JESD22-A114)	2
Machine Model (per EIA/JESD22-A115)	A
Charge Device Model (per JESD22-C101)	IV

**Table 4. Moisture Sensitivity Level**

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

1. For reliable operation, the operating channel temperature should not exceed 150°C.
2. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1955.

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

Characteristic	Symbol	Min	Typ	Max	Unit
Saturated Drain Current ( $V_{DS} = 3.5\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	2.9	—	A <sub>dc</sub>
Off State Leakage Current ( $V_{GS} = -0.4\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )	$I_{GSS}$	—	< 1	100	$\mu\text{A}_{dc}$
Off State Drain Current ( $V_{DS} = 12\text{ Vdc}$ , $V_{GS} = -2.2\text{ Vdc}$ )	$I_{DSO}$	—	0.1	1	mA <sub>dc</sub>
Off State Current ( $V_{DS} = 28.5\text{ Vdc}$ , $V_{GS} = -2.5\text{ Vdc}$ )	$I_{DSX}$	—	2	15	mA <sub>dc</sub>
Gate-Source Cut-off Voltage ( $V_{DS} = 3.5\text{ Vdc}$ , $I_{DS} = 15\text{ mA}$ )	$V_{GS(th)}$	-1.2	-1.0	-0.7	V <sub>dc</sub>
Quiescent Gate Voltage ( $V_{DS} = 12\text{ Vdc}$ , $I_{DQ} = 180\text{ mA}$ )	$V_{GS(Q)}$	-1.2	-0.95	-0.7	V <sub>dc</sub>

**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 12\text{ Vdc}$ ,  $I_{DQ} = 130\text{ mA}$ ,  $P_{out} = 1\text{ W Avg.}$ ,  $f = 3550\text{ MHz}$ , Single-Carrier W-CDMA, 3.84 MHz Channel Bandwidth Carrier. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5\text{ MHz}$  Offset. PAR = 8.5 dB @ 0.01% Probability on CCDF.

Power Gain	$G_{ps}$	9	10	—	dB
Drain Efficiency	$\eta_D$	23	25	—	%
Adjacent Channel Power Ratio	ACPR	—	-43	-40	dBc

**Typical RF Performance** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 12\text{ Vdc}$ ,  $I_{DQ} = 130\text{ mA}$ ,  $f = 3550\text{ MHz}$

Output Power, 1 dB Compression Point, CW	P1dB	—	9	—	W
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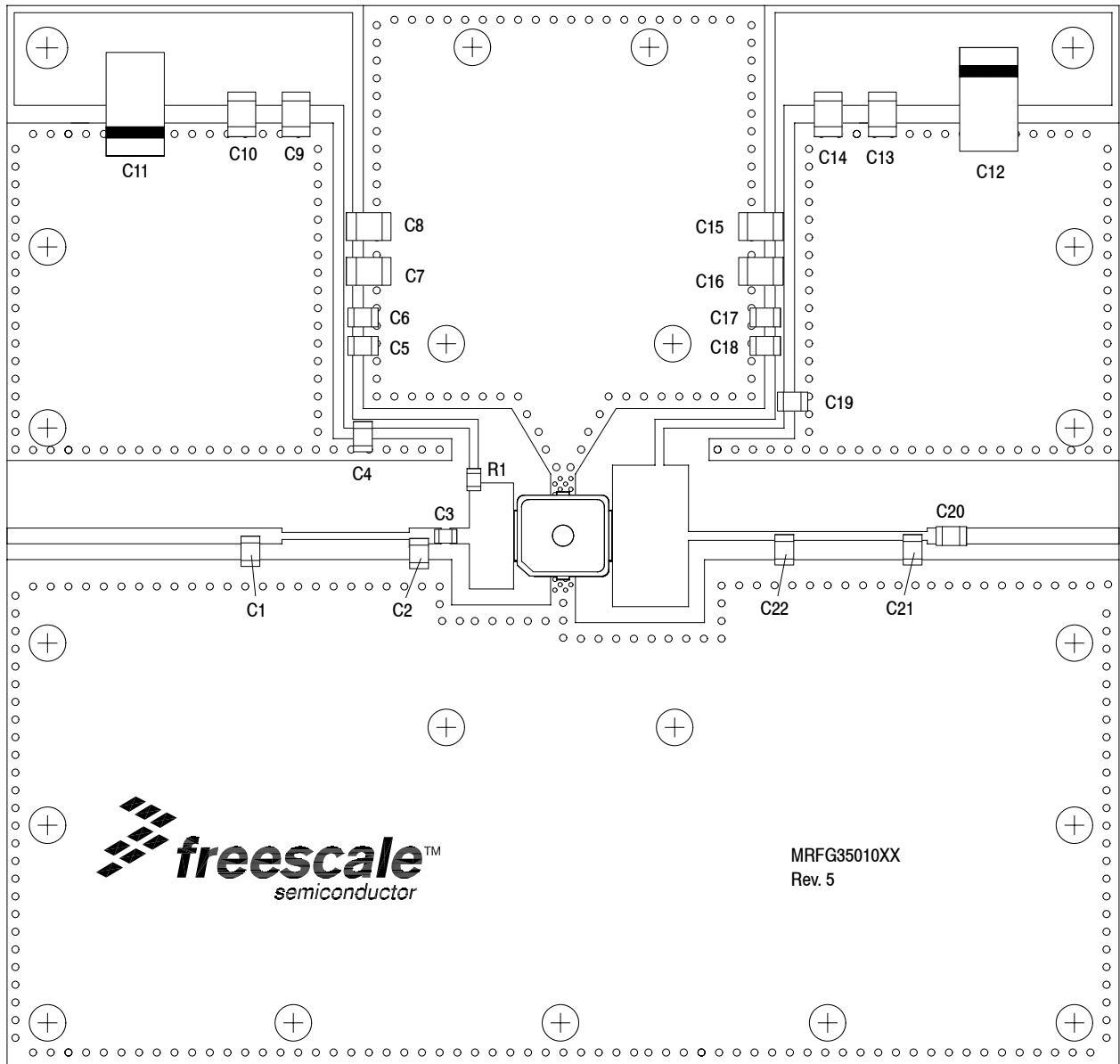


Figure 1. MRF35010ANT1 Test Circuit Component Layout — 3550 MHz

Table 6. MRF35010ANT1 Test Circuit Component Designations and Values — 3550 MHz

Part	Description	Part Number	Manufacturer
C1, C21, C22	0.5 pF Chip Capacitors	08051J0R5BBT	AVX
C2	0.2 pF Chip Capacitor	06035J0R2BBT	AVX
C3	0.5 pF Chip Capacitor	06035J0R5BBT	AVX
C4, C19, C20	6.8 pF Chip Capacitors	08051J6R8BBT	AVX
C5, C18	10 pF Chip Capacitors	ATC100A100JP150XT	ATC
C6, C17	100 pF Chip Capacitors	ATC100A101JP150XT	ATC
C7, C16	100 pF Chip Capacitors	ATC100B101JP500XT	ATC
C8, C15	1000 pF Chip Capacitors	ATC100B102JP50XT	ATC
C9, C14	0.1 $\mu$ F Chip Capacitors	CDR33BX104AKWS	Kemet
C10, C13	39K pF Chip Capacitors	ATC200B393KP50XT	ATC
C11, C12	10 $\mu$ F, 50 V Chip Capacitors	GRM55DR61H106KA88B	Murata
R1	50 $\Omega$ Chip Resistor	P51ETR-ND	Newark
PCB	0.020", $\epsilon_r = 3.5$	RO4350B	Rogers

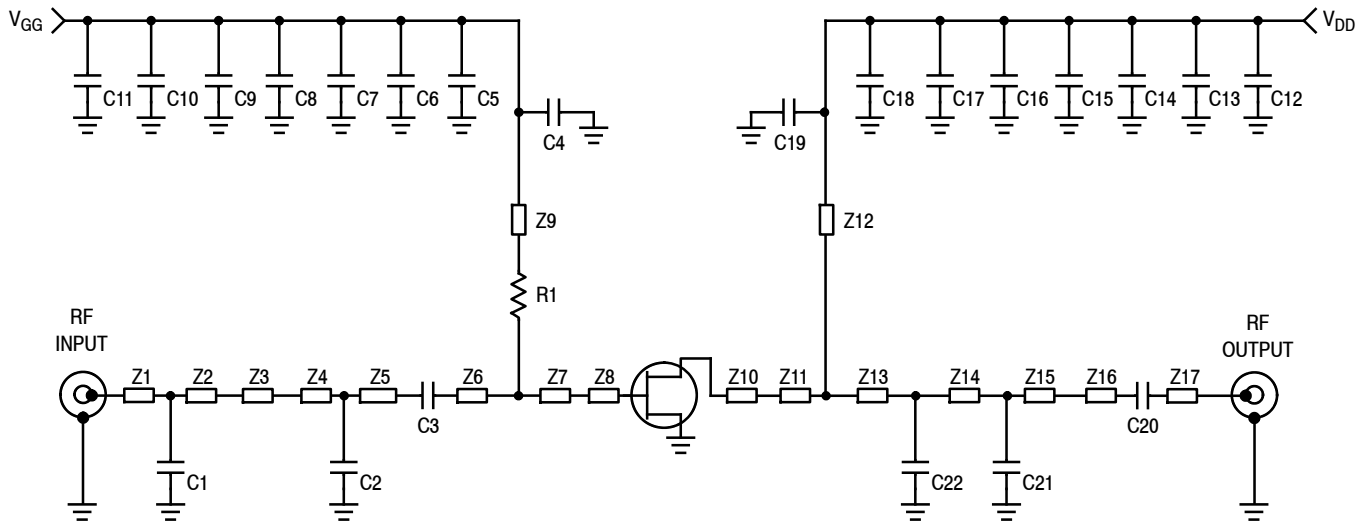


Figure 2. MRFG35010ANT1 Test Circuit Schematic — 3550 MHz

Table 7. MRFG35010ANT1 Test Circuit Microstrips — 3550 MHz

Microstrip	Description	Microstrip	Description
Z1	0.045" x 0.689" Microstrip	Z9	0.025" x 0.485" Microstrip
Z2	0.045" x 0.089" Microstrip	Z11	0.400" x 0.215" Microstrip
Z3	0.020" x 0.360" Microstrip	Z12	0.025" x 0.497" Microstrip
Z4	0.045" x 0.029" Microstrip	Z13	0.025" x 0.271" Microstrip
Z5	0.045" x 0.061" Microstrip	Z14	0.025" x 0.363" Microstrip
Z6	0.045" x 0.055" Microstrip	Z15	0.025" x 0.041" Microstrip
Z7	0.300" x 0.125" Microstrip	Z16	0.045" x 0.050" Microstrip
Z8, Z10	0.146" x 0.070" Microstrip	Z17	0.045" x 0.467" Microstrip

TYPICAL CHARACTERISTICS — 3550 MHz

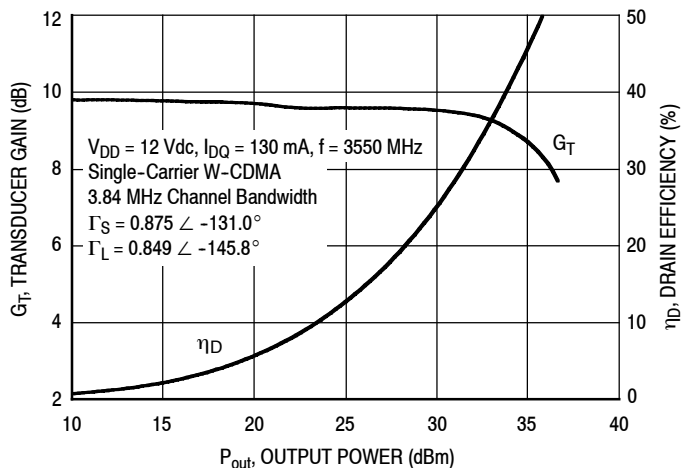


Figure 3. Single-Carrier W-CDMA Power Gain and Drain Efficiency versus Output Power

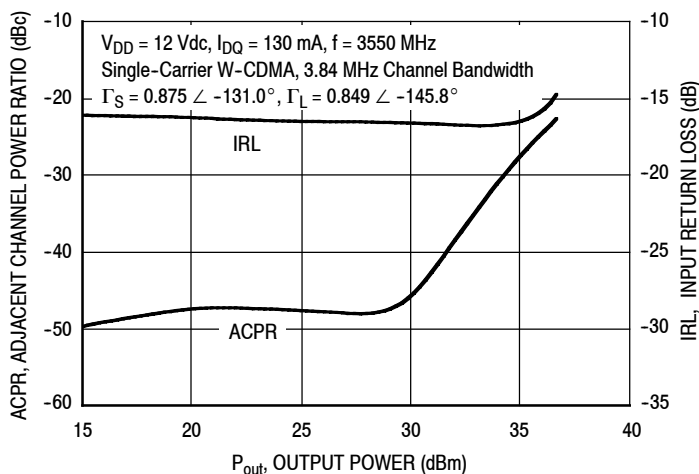
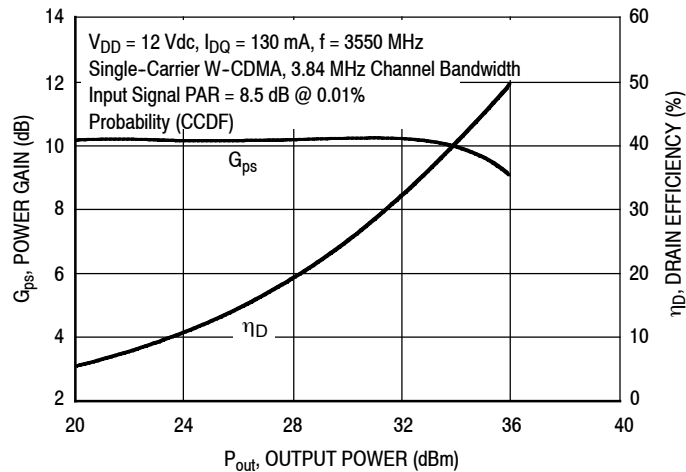


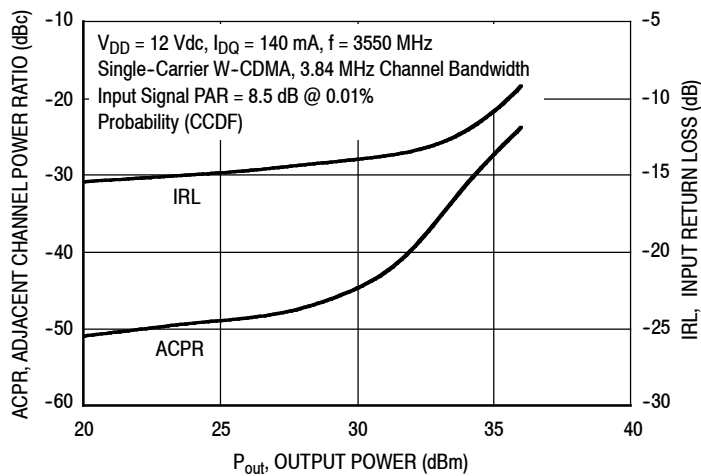
Figure 4. Single-Carrier W-CDMA ACPR and Input Return Loss versus Output Power

**NOTE:** All data is referenced to package lead interface.  $\Gamma_S$  and  $\Gamma_L$  are the impedances presented to the DUT. All data is generated from load pull, not from the test circuit shown.

## TYPICAL CHARACTERISTICS — 3550 MHz

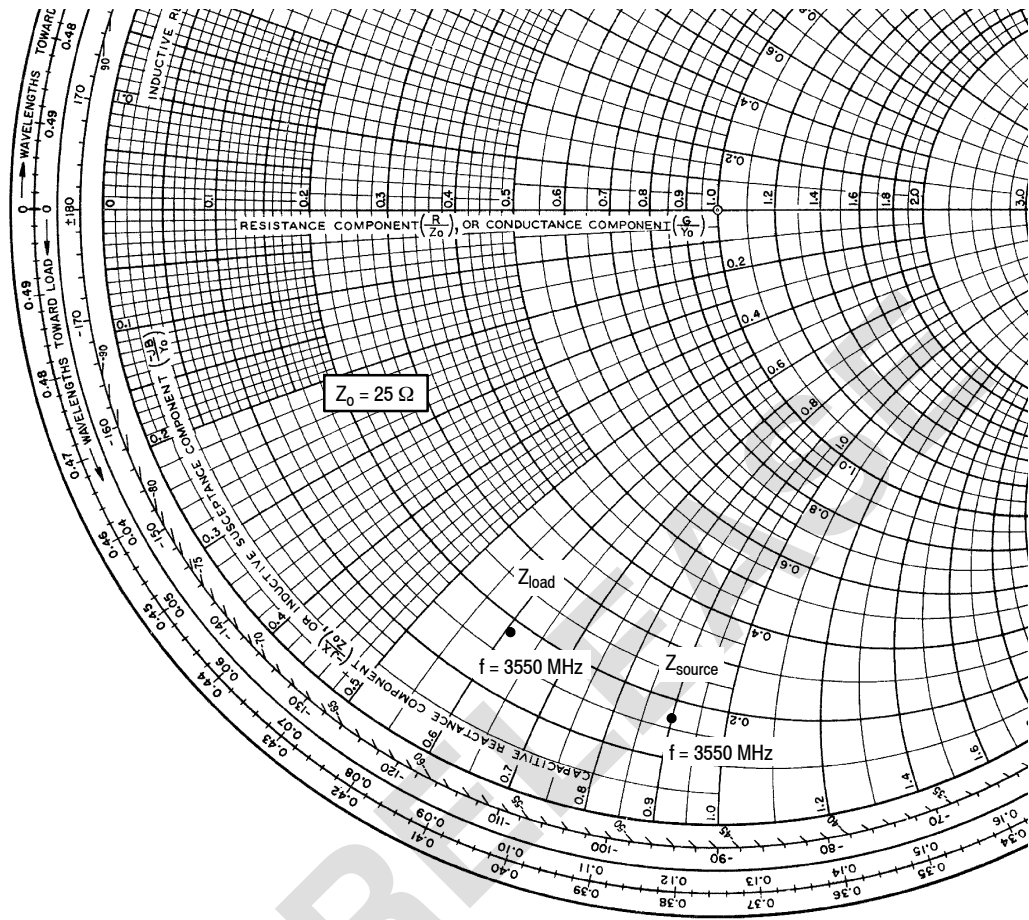


**Figure 5. Single-Carrier W-CDMA Power Gain and Drain Efficiency versus Output Power**



**Figure 6. Single-Carrier W-CDMA ACPR and Input Return Loss versus Output Power**

**NOTE:** Data is generated from the test circuit shown.



$V_{DD} = 12 \text{ Vdc}$ ,  $I_{DQ} = 130 \text{ mA}$ ,  $P_{out} = 1 \text{ W Avg.}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
3550	$4.0 - j22.6$	$4.5 - j15.3$

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

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

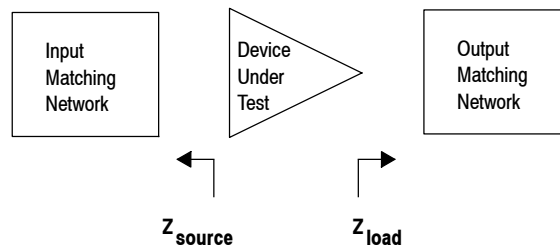


Figure 7. Series Equivalent Source and Load Impedance — 3550 MHz

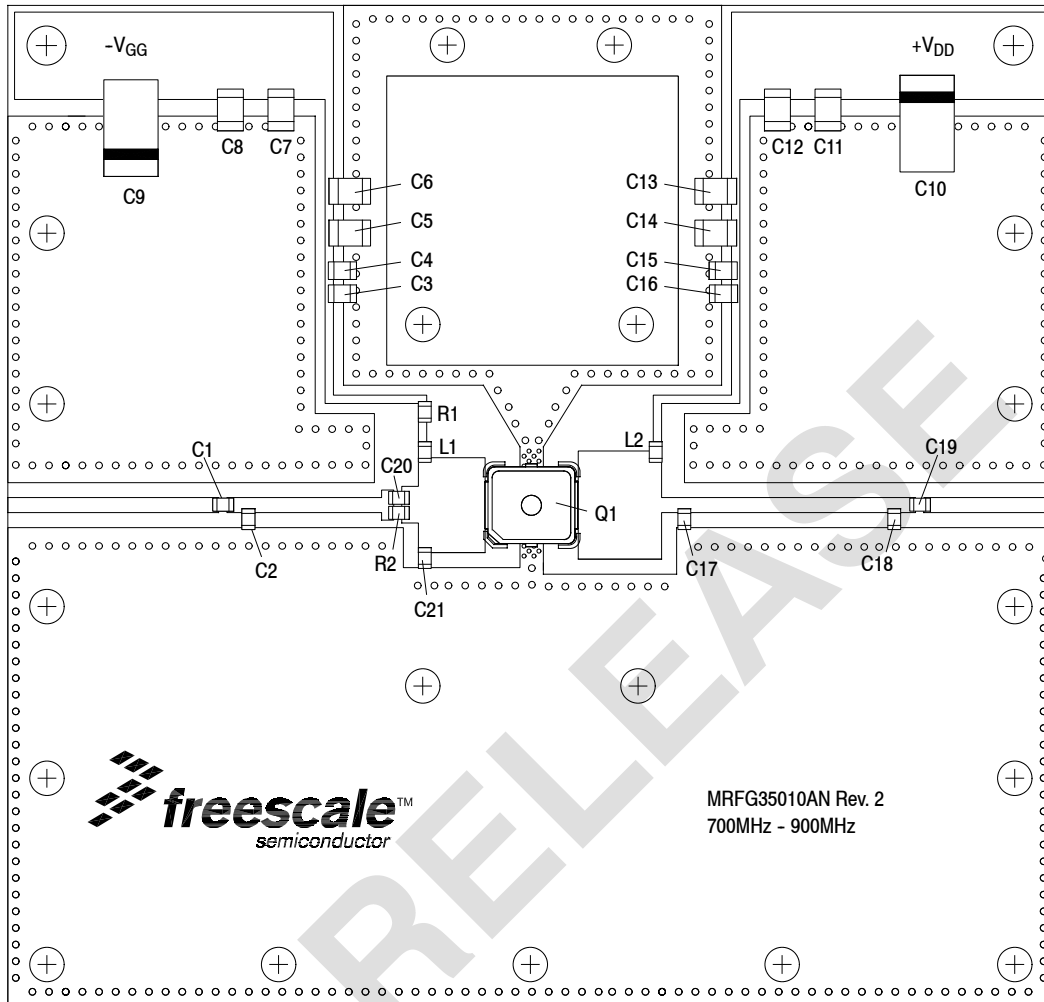


Figure 8. MRF35010ANT1 Test Circuit Component Layout — 750 MHz

Table 8. MRF35010ANT1 Test Circuit Component Designations and Values — 750 MHz

Part	Description	Part Number	Manufacturer
C1, C19	100 pF Chip Capacitors	ATC600F101JT250XT	ATC
C2	10 pF Chip Capacitor	ATC600F100JT250XT	ATC
C3, C16	10 pF Chip Capacitors	ATC100A100JP150XT	ATC
C4, C15	100 pF Chip Capacitors	ATC100A101JP150XT	ATC
C5, C14	100 pF Chip Capacitors	ATC100B101JP500XT	ATC
C6, C13	1000 pF Chip Capacitors	ATC100B102JP50XT	ATC
C7, C12	0.1 $\mu$ F Chip Capacitors	CDR33BX104AKWS	AVX
C8, C11	39K pF Chip Capacitors	ATC200B393KP500XT	ATC
C9, C10	22 $\mu$ F, 35 V Tantalum Capacitors	T491X226K035AT	Kemet
C17	1.8 pF Chip Capacitor	ATC600F1R8BT250XT	ATC
C18	6.8 pF Chip Capacitor	ATC600F6R8BT250XT	ATC
C20	22 pF Chip Capacitor	ATC600F220JT250XT	ATC
C21	1 pF Chip Capacitor	ATC600F1R0BT250XT	ATC
L1, L2	18 nH Chip Inductors	LL1608-FSL18NJ	TOKO
Q1	Power FET GaAs Transistor	MRF35010ANT1	Freescale
R1	51 $\Omega$ , 1/10 W Chip Resistor	RM73B1JT510J	KOA Speer
R2	4.7 $\Omega$ , 1/10 W Chip Resistor	CR10-4R7J-T	Kyocera
PCB	0.020", $\epsilon_r = 3.5$	RO4350B	Rogers



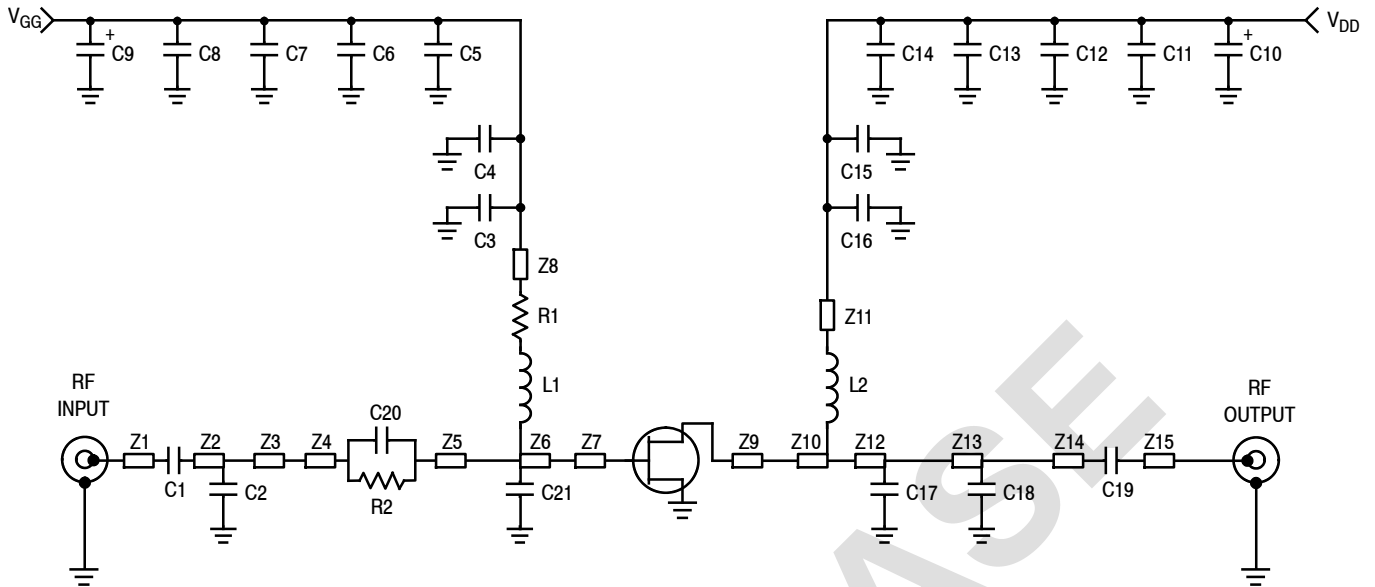


Figure 9. MRFG35010ANT1 Test Circuit Schematic — 750 MHz

Table 9. MRFG35010ANT1 Test Circuit Microstrips — 750 MHz

Microstrip	Description	Microstrip	Description
Z1	0.045" x 0.633" Microstrip	Z8	0.025" x 0.155" Microstrip
Z2	0.045" x 0.044" Microstrip	Z10	0.325" x 0.255" Microstrip
Z3	0.045" x 0.422" Microstrip	Z11	0.025" x 0.168" Microstrip
Z4	0.090" x 0.030" Microstrip	Z12	0.045" x 0.080" Microstrip
Z5	0.110" x 0.050" Microstrip	Z13	0.045" x 0.600" Microstrip
Z6	0.285" x 0.200" Microstrip	Z14	0.045" x 0.089" Microstrip
Z7, Z9	0.146" x 0.070" Microstrip	Z15	0.045" x 0.400" Microstrip

PRE-RELEASE

TYPICAL CHARACTERISTICS — 750 MHz

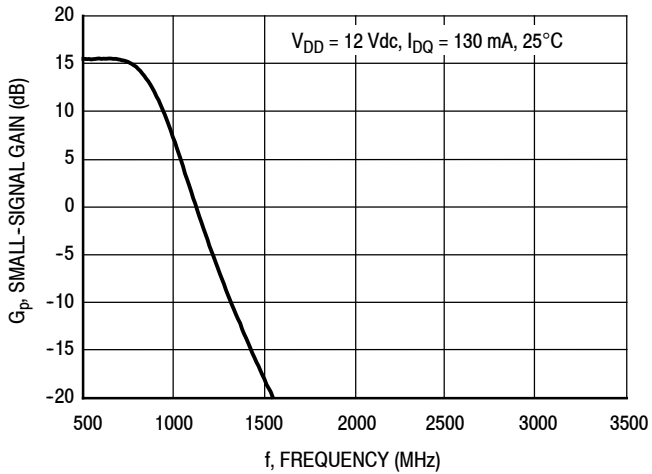


Figure 10. Small-Signal Gain versus Frequency

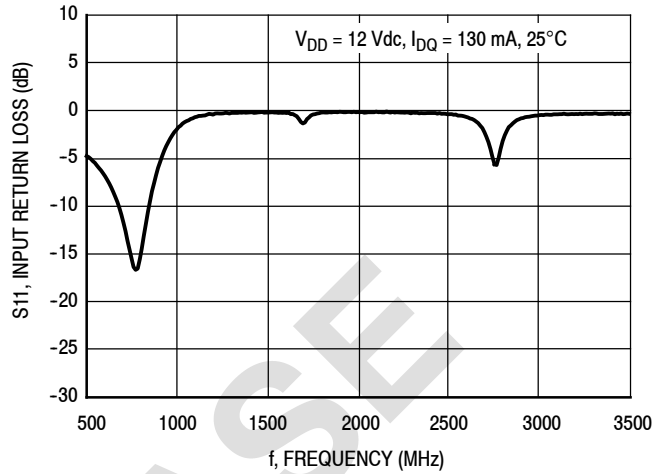


Figure 11. Input Return Loss versus Frequency

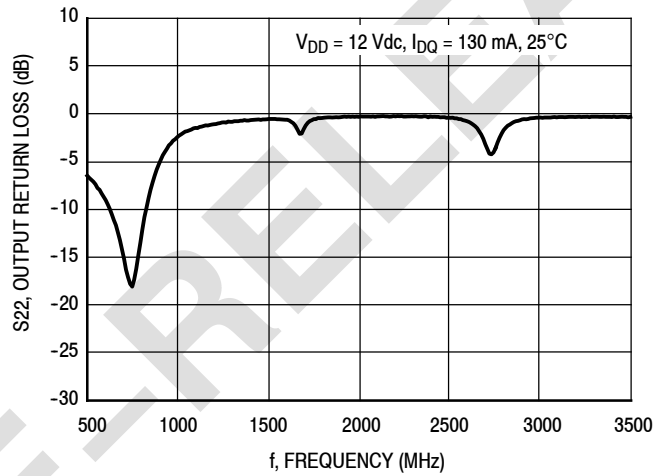
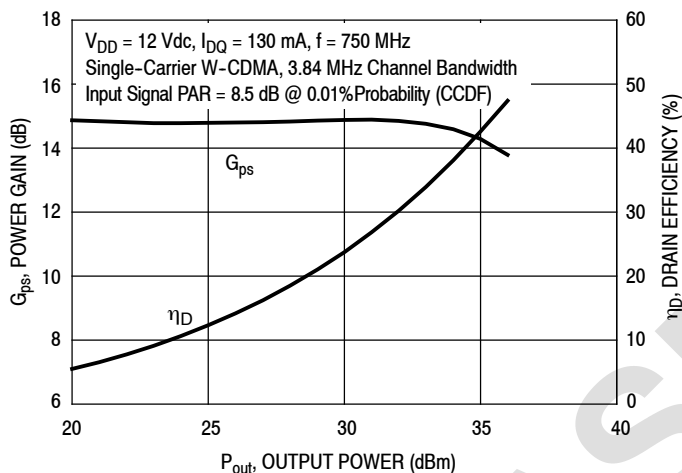
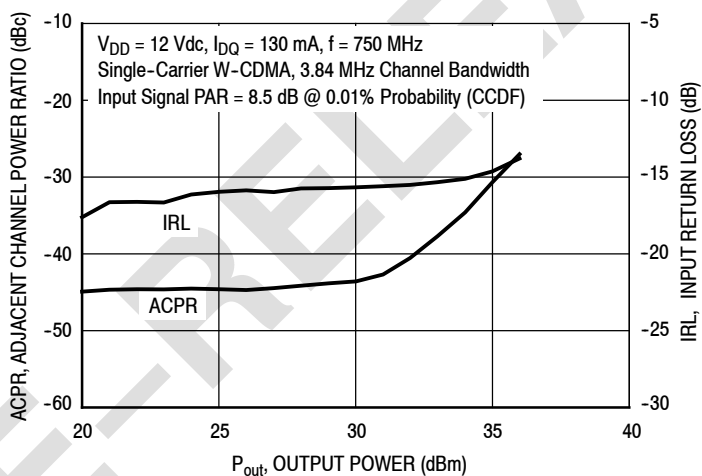


Figure 12. Output Return Loss versus Frequency

### TYPICAL CHARACTERISTICS — 750 MHz



**Figure 13. Single-Carrier W-CDMA Power Gain and Drain Efficiency versus Output Power**



**Figure 14. Single-Carrier W-CDMA ACPR and Input Return Loss versus Output Power**

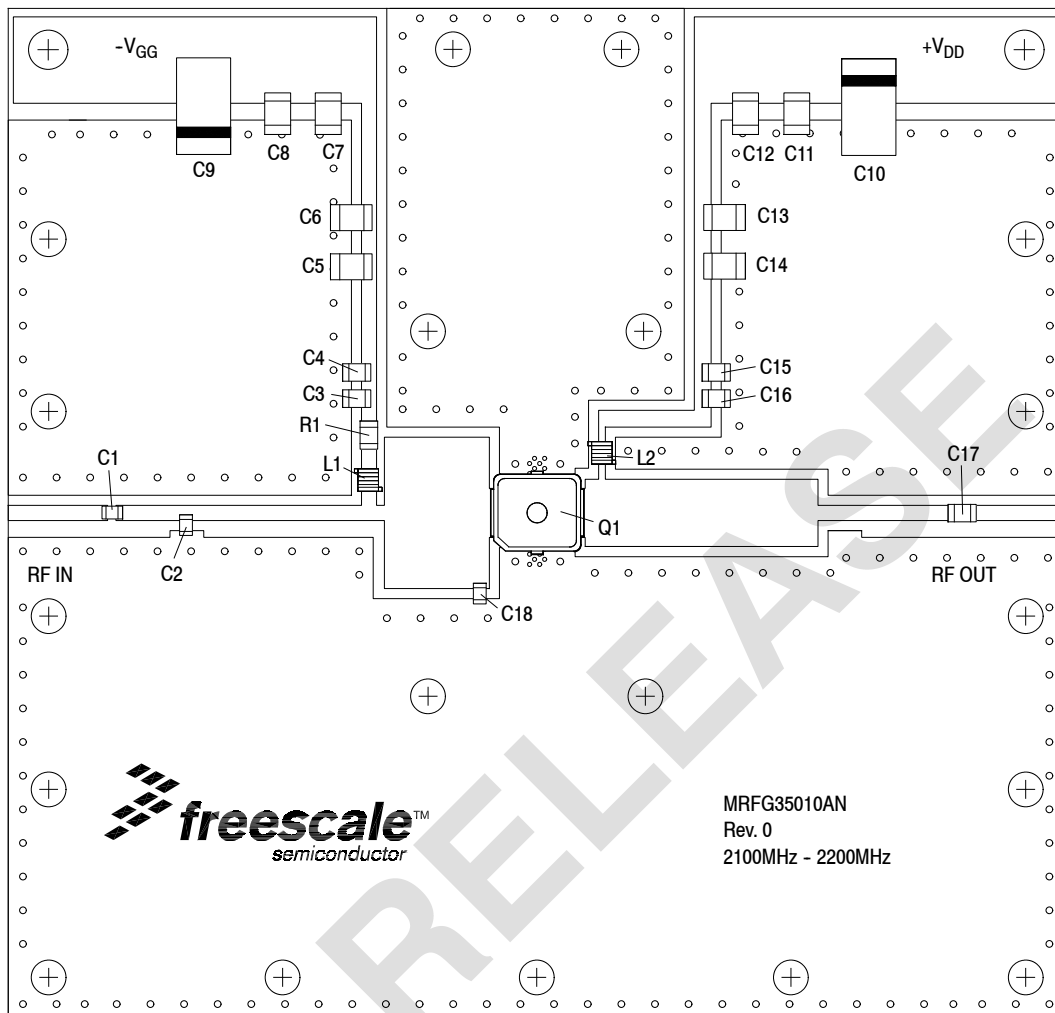


Figure 15. MRFG35010ANT1 Test Circuit Component Layout — 2140 MHz

Table 10. MRFG35010ANT1 Test Circuit Component Designations and Values — 2140 MHz

Part	Description	Part Number	Manufacturer
C1	4.7 pF Chip Capacitor	080514R7BBS	AVX
C2	0.5 pF Chip Capacitor	08051J0R5BBS	AVX
C3, C16	10 pF Chip Capacitors	ATC100A100JP150XT	ATC
C4, C15	100 pF Chip Capacitors	ATC100A101JP150XT	ATC
C5, C14	100 pF Chip Capacitors	ATC100B101JP500XT	ATC
C6, C13	1000 pF Chip Capacitors	ATC100B102JP50XT	ATC
C7, C12	0.1 $\mu$ F Chip Capacitors	CDR33BX104AKWS	AVX
C8, C11	39K pF Chip Capacitors	ATC200B393KP500XT	ATC
C9, C10	22 $\mu$ F, 35 V Chip Capacitors	T491X226K035AT	Kemet
C17	15 pF Chip Capacitor	08051J150GBS	AVX
C18	1.5 pF Chip Capacitor	08051J1R5BBS	AVX
L1	3.9 nH Inductor	LL1608-FH3N9S	TOKO
L2	8.2 nH Inductor	LL1608-FH8N2S	TOKO
Q1	Power FET GaAs Transistor	MRFG35010ANT1	Freescale
R1	75 $\Omega$ , 1/8 W Chip Resistor	ERJ-6GEYJ750V	Panasonic
PCB	0.020", $\epsilon_r = 3.5$	RO4350B	Rogers

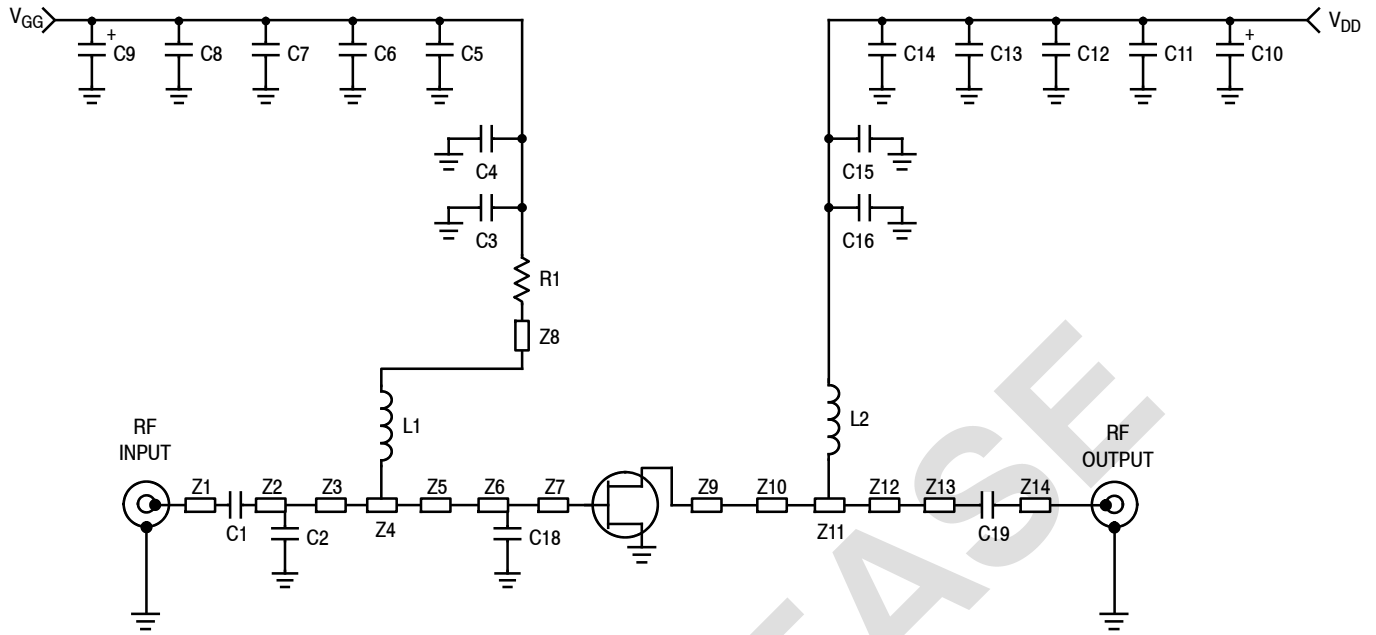


Figure 16. MRFG35010ANT1 Test Circuit Schematic — 2140 MHz

Table 11. MRFG35010ANT1 Test Circuit Microstrips — 2140 MHz

Microstrip	Description	Microstrip	Description
Z1, Z14	0.045" x 0.295" Microstrip	Z7, Z9	0.146" x 0.070" Microstrip
Z2	0.045" x 0.224" Microstrip	Z8	0.045" x 0.098" Microstrip
Z3	0.045" x 0.515" Microstrip	Z10	0.200" x 0.040" Microstrip
Z4	0.105" x 0.045" Microstrip	Z11	0.260" x 0.020" Microstrip
Z5	0.045" x 0.023" Microstrip	Z12	0.200" x 0.632" Microstrip
Z6	0.450" x 0.312" Microstrip	Z13	0.045" x 0.420" Microstrip

## TYPICAL CHARACTERISTICS — 2140 MHz

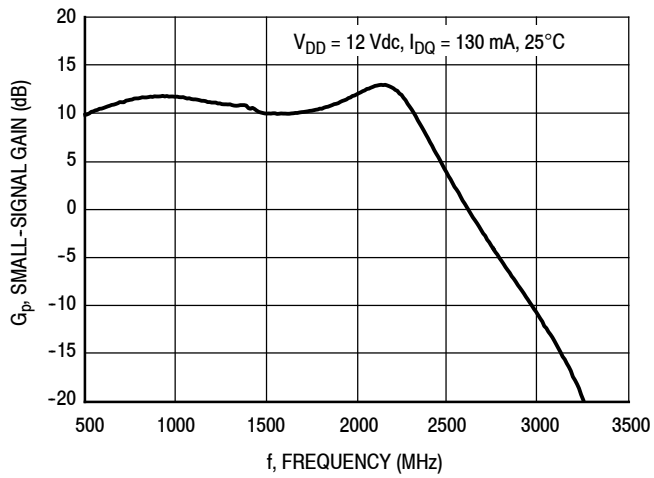


Figure 17. Small-Signal Gain versus Frequency

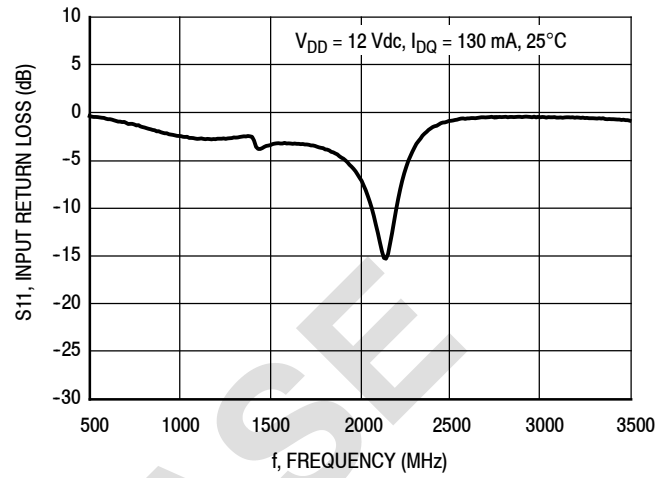


Figure 18. Input Return Loss versus Frequency

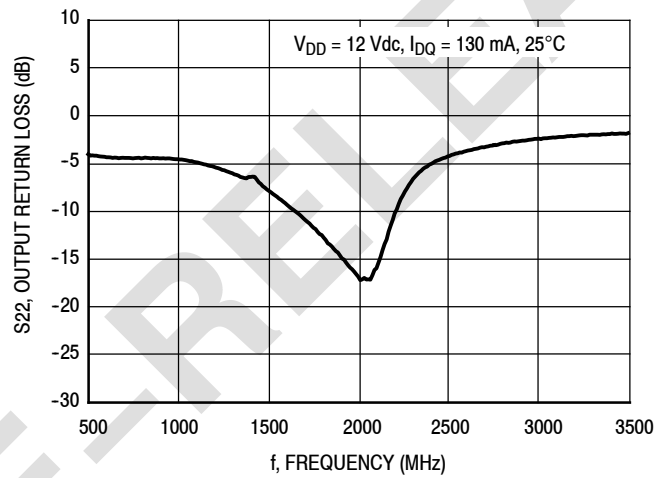
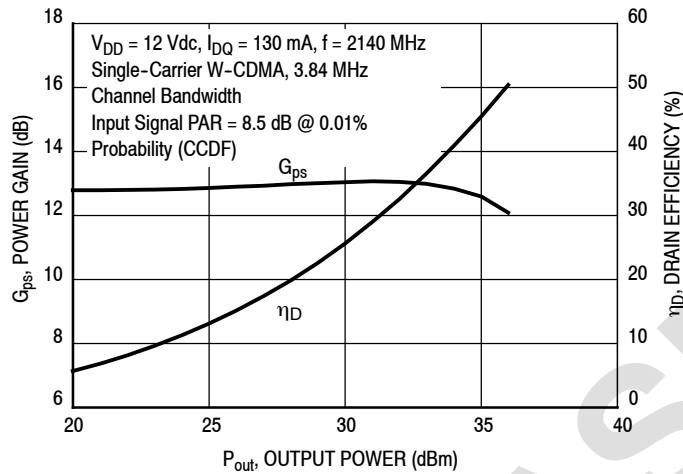
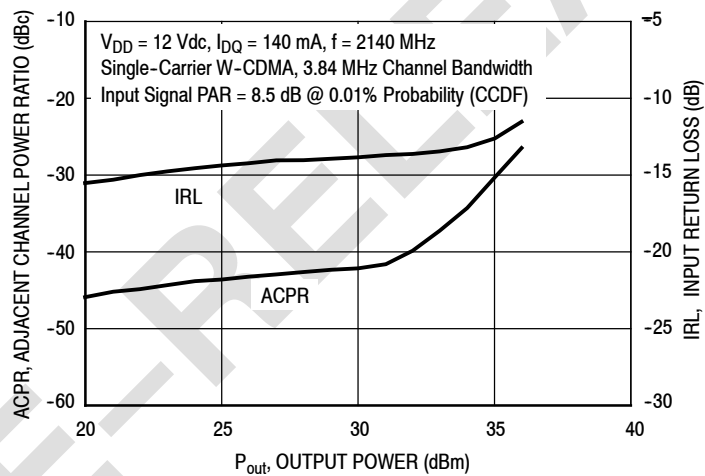


Figure 19. Output Return Loss versus Frequency

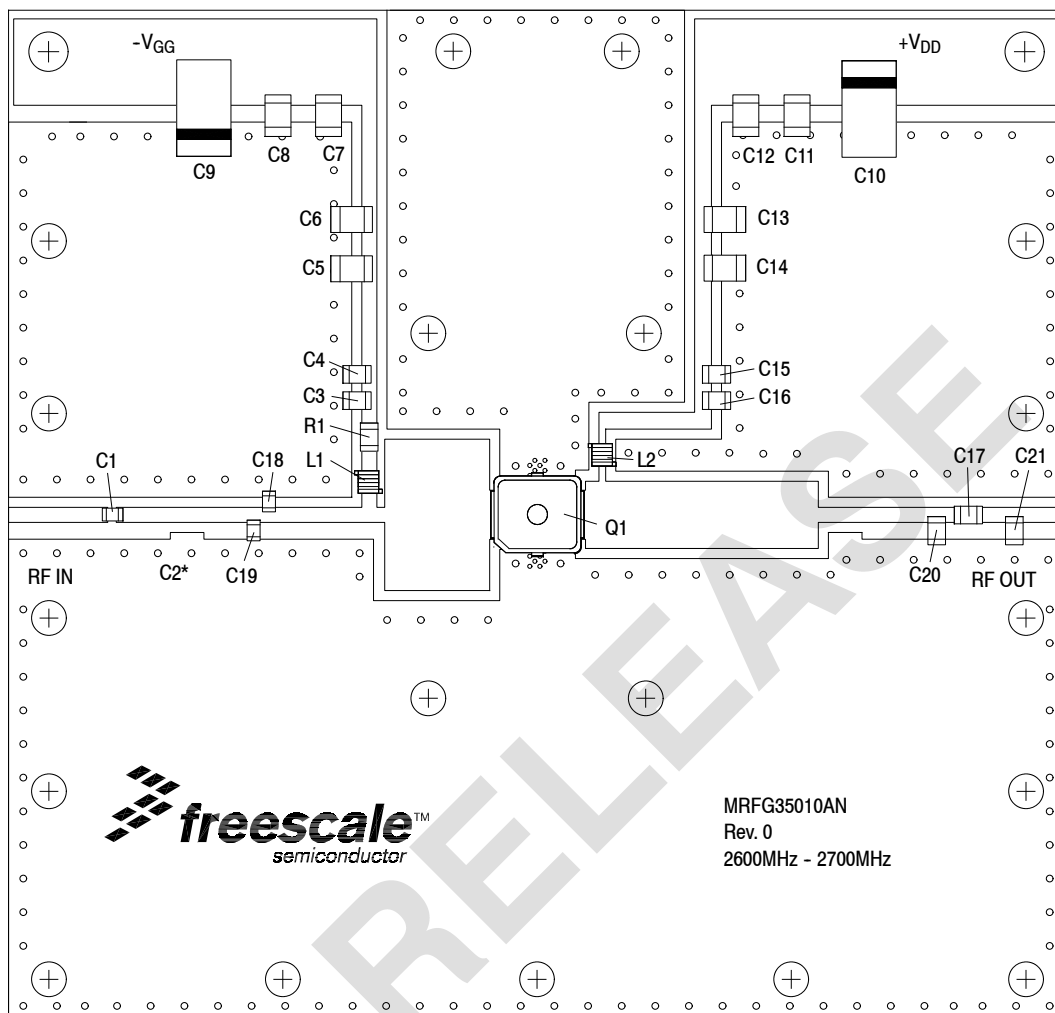
## TYPICAL CHARACTERISTICS — 2140 MHZ



**Figure 20. Single-Carrier W-CDMA Power Gain and Drain Efficiency versus Output Power**



**Figure 21. Single-Carrier W-CDMA ACPR and Input Return Loss versus Output Power**



Note: Component number C2\* is labeled on board but not placed.

Figure 22. MRFG35010ANT1 Test Circuit Component Layout — 2650 MHz

Table 12. MRFG35010ANT1 Test Circuit Component Designations and Values — 2650 MHz

Part	Description	Part Number	Manufacturer
C1	4.7 pF Chip Capacitor	080514R7BBS	AVX
C2	Component Not Placed		
C3, C16	10 pF Chip Capacitors	ATC100A100JP150XT	ATC
C4, C15	100 pF Chip Capacitors	ATC100A101JP150XT	ATC
C5, C14	100 pF Chip Capacitors	ATC100B101JP500XT	ATC
C6, C13	1000 pF Chip Capacitors	ATC100B102JP50XT	ATC
C7, C12	0.1 $\mu$ F Chip Capacitors	CDR33BX104AKWS	AVX
C8, C11	39K pF Chip Capacitors	ATC200B393KP500XT	ATC
C9, C10	22 $\mu$ F, 35 V Chip Capacitors	T491X226K035AT	Kemet
C17	15 pF Chip Capacitor	08051J150GBS	AVX
C18	0.5 pF Chip Capacitor	08051J0R5BBS	AVX
C19	1.5 pF Chip Capacitor	08051J1R5BBS	AVX
C20	1 pF Chip Capacitor	08051J1R0BBS	AVX
C21	0.4 pF Chip Capacitor	08051J0R4BBS	AVX
L1	5.6 nH Inductor	LL1608-FH5N6S	TOKO
L2	6.8 nH Inductor	LL1608-FH6N8S	TOKO
Q1	Power FET GaAs Transistor	MRFG35010ANT1	Freescale
R1	75 $\Omega$ , 1/8 W Chip Resistor	ERJ-6GEYJ750V	Panasonic
PCB	0.020", $\epsilon_r = 3.5$	RO4350B	Rogers



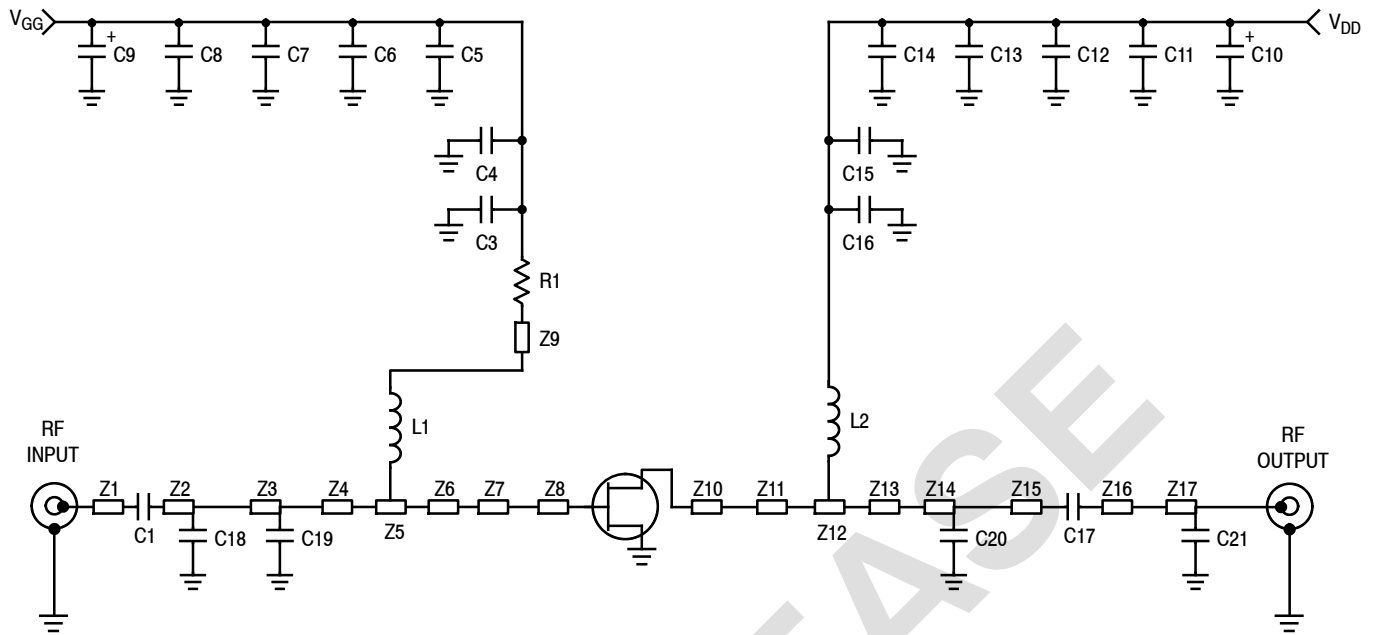


Figure 23. MRFG35010ANT1 Test Circuit Schematic — 2650 MHz

Table 13. MRFG35010ANT1 Test Circuit Microstrips — 2650 MHz

Microstrip	Description	Microstrip	Description
Z1	0.045" x 0.295" Microstrip	Z9	0.045" x 0.098" Microstrip
Z2	0.045" x 0.385" Microstrip	Z11	0.200" x 0.040" Microstrip
Z3	0.045" x 0.077" Microstrip	Z12	0.260" x 0.020" Microstrip
Z4	0.045" x 0.273" Microstrip	Z13	0.200" x 0.632" Microstrip
Z5	0.105" x 0.045" Microstrip	Z14	0.045" x 0.348" Microstrip
Z6	0.045" x 0.023" Microstrip	Z15	0.045" x 0.075" Microstrip
Z7	0.450" x 0.312" Microstrip	Z16	0.045" x 0.150" Microstrip
Z8, Z10	0.146" x 0.070" Microstrip	Z17	0.045" x 0.152" Microstrip

TYPICAL CHARACTERISTICS — 2650 MHz

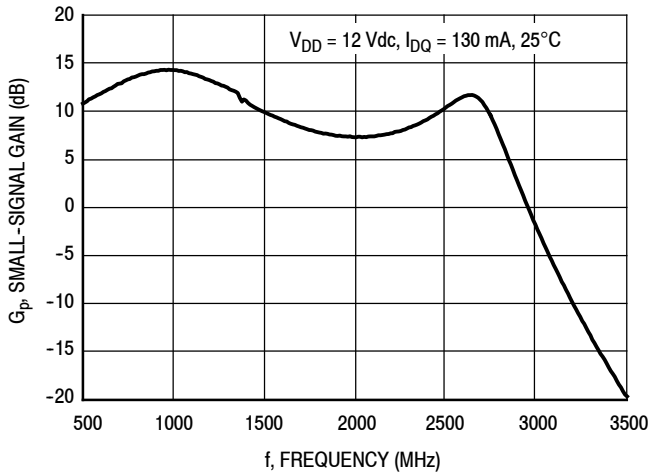


Figure 24. Small-Signal Gain versus Frequency

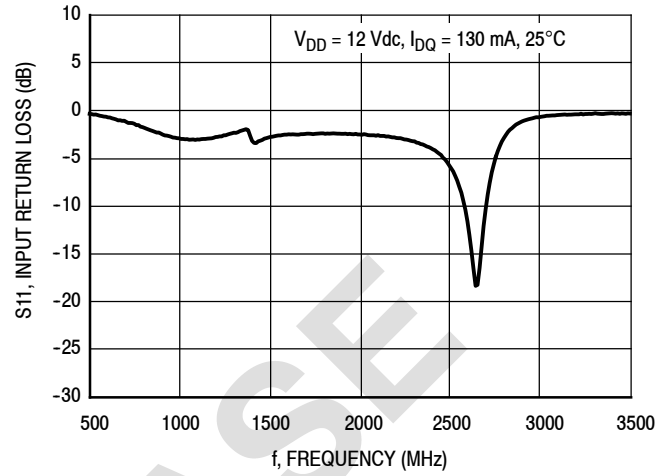


Figure 25. Input Return Loss versus Frequency

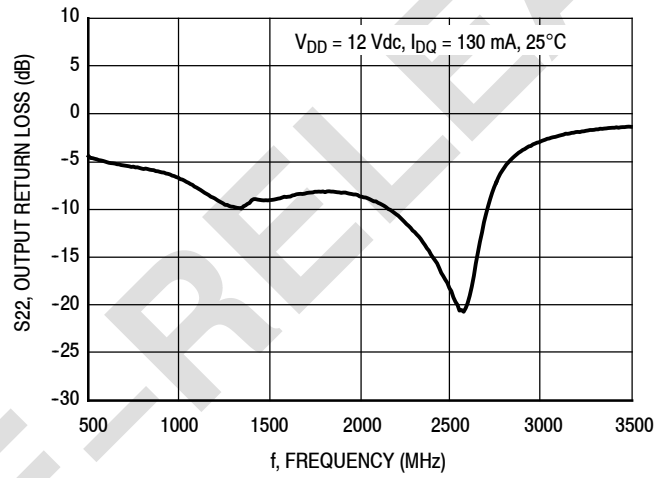
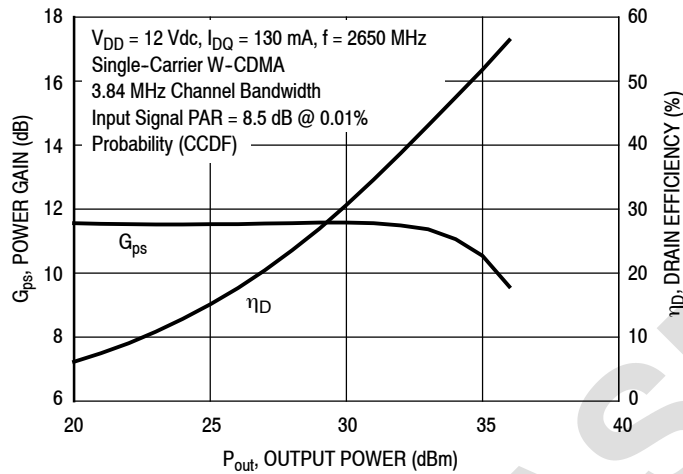
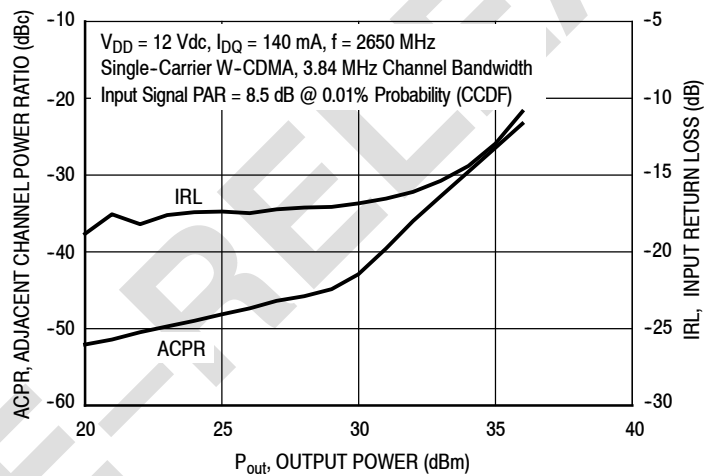


Figure 26. Output Return Loss versus Frequency

## TYPICAL CHARACTERISTICS — 2650 MHZ



**Figure 27. Single-Carrier W-CDMA Power Gain and Drain Efficiency versus Output Power**



**Figure 28. Single-Carrier W-CDMA ACPR and Input Return Loss versus Output Power**

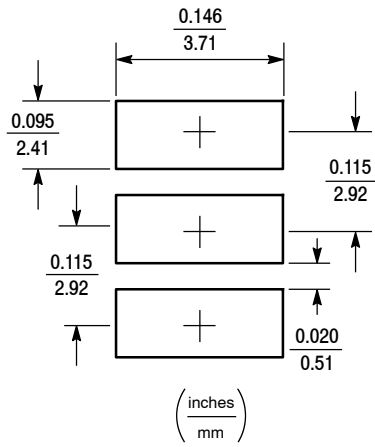


Figure 29. PLD-1.5 Solder Footprint

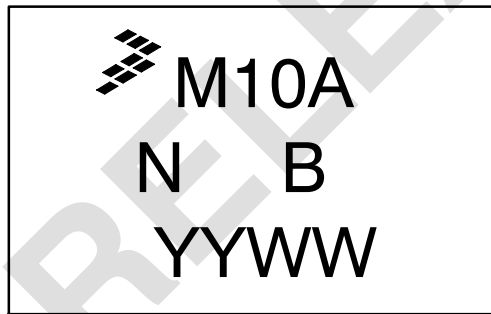
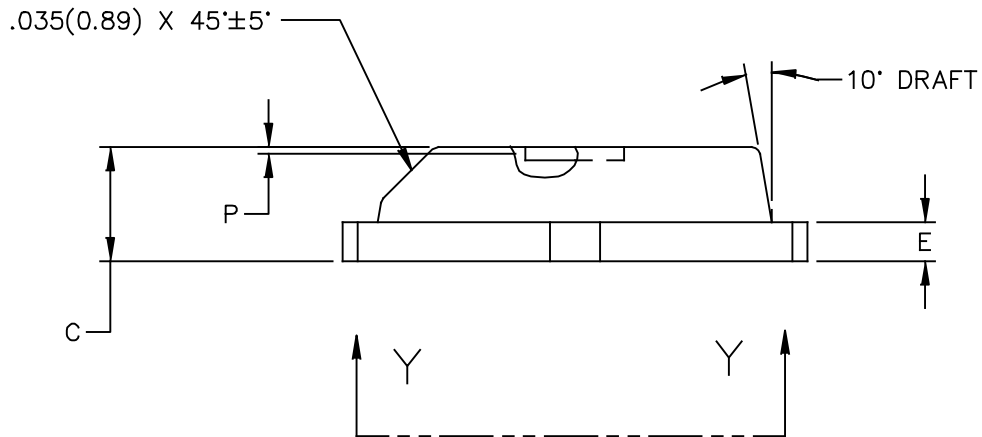
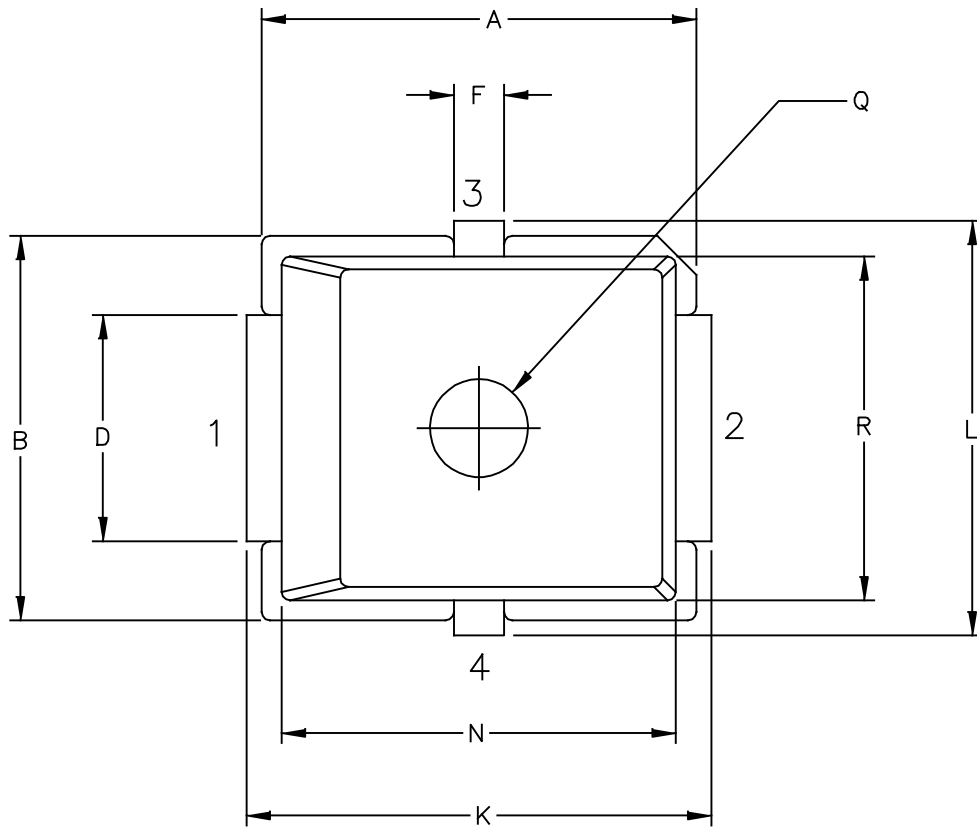
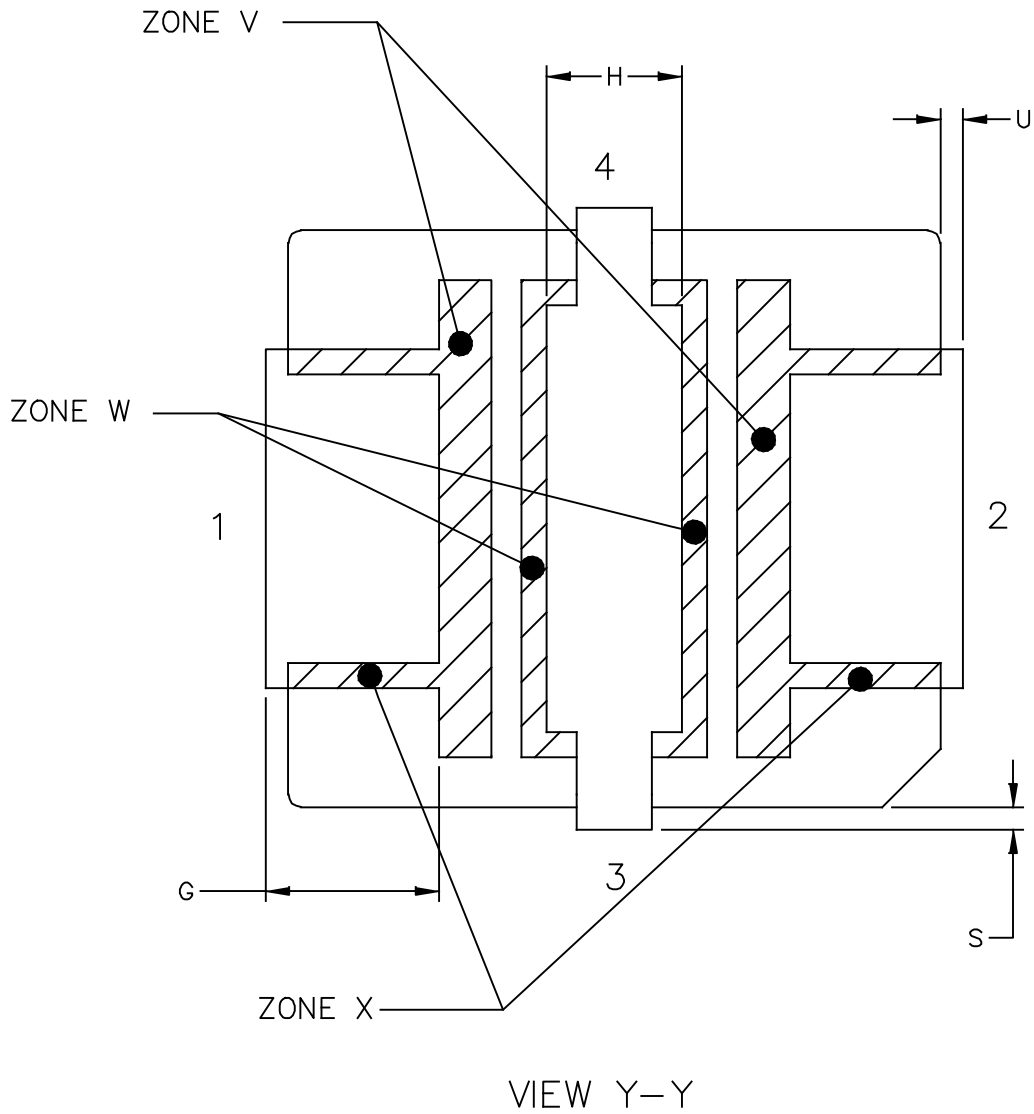


Figure 30. Product Marking

**PACKAGE DIMENSIONS**



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NOTES:

1. CONTROLLING DIMENSION: INCH
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
3. RESIN BLEED/FLASH ALLOWABLE IN ZONES V, W AND X.

STYLE 1:

- PIN 1 - DRAIN
- PIN 2 - GATE
- PIN 3 - SOURCE
- PIN 4 - SOURCE

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.255	.265	6.48	6.73	Q	.055	.063	1.40	1.60
B	.225	.235	5.72	5.97	R	.200	.210	5.08	5.33
C	.065	.072	1.65	1.83	S	.006	.012	0.15	0.31
D	.130	.150	3.30	3.81	U	.006	.012	0.15	0.31
E	.021	.026	0.53	0.66	ZONE V	.000	.021	0.00	0.53
F	.026	.044	0.66	1.12	ZONE W	.000	.010	0.00	0.25
G	.050	.070	1.27	1.78	ZONE X	.000	.010	0.00	0.25
H	.045	.063	1.14	1.60					
J	.160	.180	4.06	4.57					
K	.273	.285	6.93	7.24					
L	.245	.255	6.22	6.48					
N	.230	.240	5.84	6.10					
P	.000	.008	0.00	0.20					
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TITLE:  PLD-1.5					DOCUMENT NO: 98ASB15740C			REV: D	
					CASE NUMBER: 466-03			31 MAR 2005	
					STANDARD: NON-JEDEC				

## PRODUCT DOCUMENTATION, SOFTWARE AND TOOLS

Refer to the following documents, software and tools to aid your design process.

### Application Notes

- AN1955: Thermal Measurement Methodology of RF Power Amplifiers

### Software

- .s2p File
- RF High Power Model

### Development Tools

- Printed Circuit Boards

### Reference Designs

- W-CDMA Reference Design for 2.4–2.5 GHz, 900 mW MRFG35010ANT1 Device
- 725–760 MHz, 1.0 W AVG., 12 V LTE Amplifier Lineup Reference Design

For Software and Tools, 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	<ul style="list-style-type: none"><li>• Initial Release of Data Sheet</li></ul>
1	Dec. 2008	<ul style="list-style-type: none"><li>• Removed “Operating Case Temperature Range” from Maximum Ratings table so that the maximum channel temperature rating is the limiting thermal design criteria and not the case temperature range, p. 1</li><li>• Added Table 3, ESD Protection Characteristics, p. 1; renumbered subsequent tables</li></ul>
2	June 2009	<ul style="list-style-type: none"><li>• Modified data sheet to reflect MSL rating change from 1 to 3 as a result of the standardization of packing process as described in Product and Process Change Notification number, PCN13516, p. 1</li></ul>
3	Dec. 2012	<ul style="list-style-type: none"><li>• Added Typical Performance table, p. 1.</li><li>• 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. 1.</li><li>• Added Figs. 8, 15 and 22, Test Circuit Component Layout — 750 MHz, 2140 MHz and 2650 MHz, and Tables 8, 10 and 12, Test Circuit Component Designations and Values — 750 MHz, 2140 MHz and 2650 MHz, p. 8, 12 and 16</li><li>• Added Figs. 9, 16 and 23, Test Circuit Schematic — 750 MHz, 2140 MHz and 2650 MHz, and Tables 9, 11 and 13, Test Circuit Microstrips — 750 MHz, 2140 MHz and 2650 MHz, p. 9, 13 and 17</li><li>• Added Figs. 10, 17 and 24, Small-Signal Gain versus Frequency — 750 MHz, 2140 MHz and 2650 MHz, Figs. 11, 18 and 25, Input Return Loss versus Frequency — 750 MHz, 2140 MHz and 2650 MHz, and Figs. 12, 19 and 26, Output Return Loss versus Frequency — 750 MHz, 2140 MHz and 2650 MHz, p. 10, 14 and 18</li><li>• Added Figs. 13, 20 and 27, Single-Carrier W-CDMA Power Gain and Drain Efficiency versus Output Power — 750 MHz, 2140 MHz and 2650 MHz, and Figs. 14, 21 and 28, Single-Carrier W-CDMA ACPR and Input Return Loss versus Output Power — 750 MHz, 2140 MHz and 2650 MHz, p. 11, 15 and 19</li></ul>



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