

# RF Power LDMOS Transistor

## N-Channel Enhancement-Mode Lateral MOSFET

Designed for Class A or Class AB power amplifier applications with frequencies up to 2000 MHz. Suitable for analog and digital modulation and multicarrier amplifier applications.

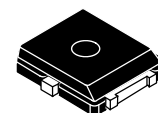
- Typical Two-Tone Performance @ 1960 MHz, 28 Vdc, I<sub>DQ</sub> = 50 mA,  
 P<sub>out</sub> = 4 W PEP  
 Power Gain — 18 dB  
 Drain Efficiency — 33%  
 IMD — -34 dBc
- Typical Two-Tone Performance @ 900 MHz, 28 Vdc, I<sub>DQ</sub> = 50 mA,  
 P<sub>out</sub> = 4 W PEP  
 Power Gain — 19 dB  
 Drain Efficiency — 33%  
 IMD — -39 dBc
- Capable of Handling 5:1 VSWR @ 28 Vdc, 1960 MHz, 4 W CW Output Power

### Features

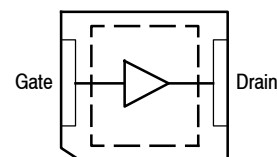
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- On-Chip RF Feedback for Broadband Stability
- Integrated ESD Protection
- In Tape and Reel. T1 Suffix = 1,000 Units, 16 mm Tape Width, 7-inch Reel.

**MMRF1014NT1**

**1-2000 MHz, 4 W, 28 V  
 CLASS A/AB  
 RF POWER MOSFET**



**PLD-1.5  
 PLASTIC**



Note: The center pad on the backside of the package is the source terminal for the transistor.

**Figure 1. Pin Connections**

**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	V <sub>DSS</sub>	-0.5, +68	Vdc
Gate-Source Voltage	V <sub>GS</sub>	-0.5, +12	Vdc
Storage Temperature Range	T <sub>stg</sub>	-65 to +150	°C
Operating Junction Temperature	T <sub>J</sub>	150	°C

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (1,2)	Unit
Thermal Resistance, Junction to Case Case Temperature 76°C, 4 W PEP, Two-Tone Case Temperature 79°C, 4 W CW	R <sub>θJC</sub>	8.8 8.5	°C/W

**Table 3. ESD Protection Characteristics**

Test Methodology	Class
Human Body Model (per JESD22-A114)	1C
Machine Model (per EIA/JESD22-A115)	A
Charge Device Model (per JESD22-C101)	IV

1. MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
2. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1955.

**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** ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
----------------	--------	-----	-----	-----	------

**Off Characteristics**

Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 68\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	10	$\mu\text{Adc}$
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	10	$\mu\text{Adc}$
Gate-Source Leakage Current ( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )	$I_{GSS}$	—	—	500	$\text{nAdc}$

**On Characteristics**

Gate Threshold Voltage ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 50\text{ mAdc}$ )	$V_{GS(th)}$	1.2	2	2.7	Vdc
Gate Quiescent Voltage ( $V_{DS} = 28\text{ Vdc}$ , $I_D = 50\text{ mAdc}$ )	$V_{GS(Q)}$	—	2.7	—	Vdc
Fixture Gate Quiescent Voltage <sup>(1)</sup> ( $V_{DD} = 28\text{ Vdc}$ , $I_D = 50\text{ mAdc}$ , Measured in Functional Test)	$V_{GG(Q)}$	2.2	3	4.2	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 50\text{ mAdc}$ )	$V_{DS(on)}$	—	0.27	0.37	Vdc

**Dynamic Characteristics**

Reverse Transfer Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{rss}$	—	21	—	pF
Output Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{oss}$	—	25	—	pF
Input Capacitance ( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz)	$C_{iss}$	—	30	—	pF

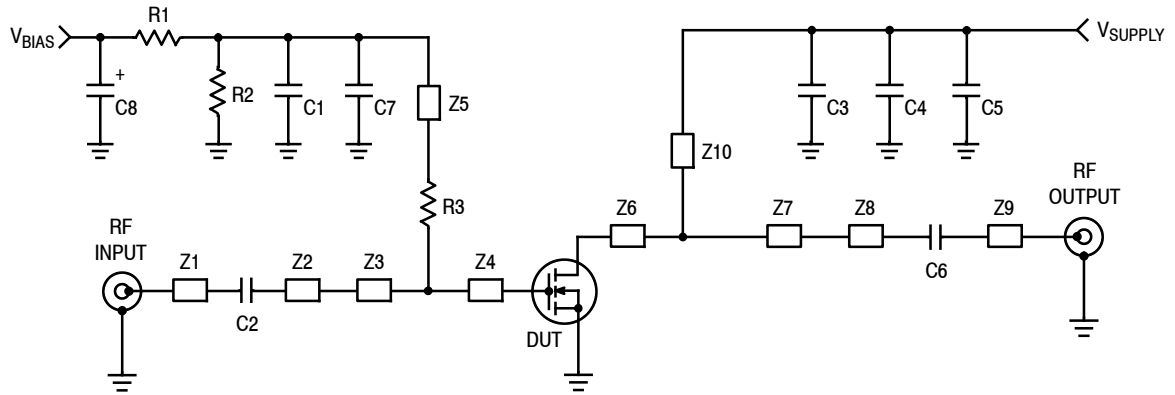
**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 50\text{ mA}$ ,  $P_{out} = 4\text{ W PEP}$ ,  $f_1 = 1960\text{ MHz}$ ,  $f_2 = 1960.1\text{ MHz}$ , Two-Tone Test

Power Gain	$G_{ps}$	16.5	18	20	dB
Drain Efficiency	$\eta_D$	28	33	—	%
Intermodulation Distortion	IMD	—	-34	-28	dBc
Input Return Loss	IRL	—	-12	-10	dB

**Typical Performance** (In Freescale 900 MHz Demo Board, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 50\text{ mA}$ ,  $P_{out} = 4\text{ W PEP}$ ,  $f = 900\text{ MHz}$ , Two-Tone Test, 100 kHz Tone Spacing

Power Gain	$G_{ps}$	—	19	—	dB
Drain Efficiency	$\eta_D$	—	33	—	%
Intermodulation Distortion	IMD	—	-39	—	dBc
Input Return Loss	IRL	—	-12	—	dB

1.  $V_{GG} = \frac{11}{10} \times V_{GS(Q)}$ . Parameter measured on Freescale Test Fixture, due to resistive divider network on the board. Refer to Test Circuit Schematic.



Z1	0.054" x 0.430" Microstrip	Z7	0.210" x 1.220" Microstrip
Z2	0.054" x 0.137" Microstrip	Z8	0.054" x 0.680" Microstrip
Z3	0.580" x 0.420" Microstrip	Z9	0.054" x 0.260" Microstrip
Z4	0.580" x 0.100" Microstrip	Z10	0.025" x 0.930" Microstrip
Z5	0.025" x 0.680" Microstrip	PCB	Arlon CuClad 250GX-0300-55-22, 0.020", $\epsilon_r = 2.5$
Z6	0.210" x 0.100" Microstrip		

**Figure 2. MMRF1014NT1 Test Circuit Schematic**

**Table 6. MMRF1014NT1 Test Circuit Component Designations and Values**

Part	Description	Part Number	Manufacturer
C1	100 nF Chip Capacitor	CDR33BX104AKYS	Kemet
C2, C3, C6, C7	9.1 pF Chip Capacitors	ATC100B9R1CT500XT	ATC
C4, C5	10 $\mu$ F, 50 V Chip Capacitors	GRM55DR61H106KA88B	Murata
C8	10 $\mu$ F, 35 V Tantalum Chip Capacitor	T490D106K035AT	Kemet
R1	1 k $\Omega$ , 1/4 W Chip Resistor	CRCW12061001FKEA	Vishay
R2	10 k $\Omega$ , 1/4 W Chip Resistor	CRCW12061002FKEA	Vishay
R3	10 $\Omega$ , 1/4 W Chip Resistor	CRCW120610R0FKEA	Vishay

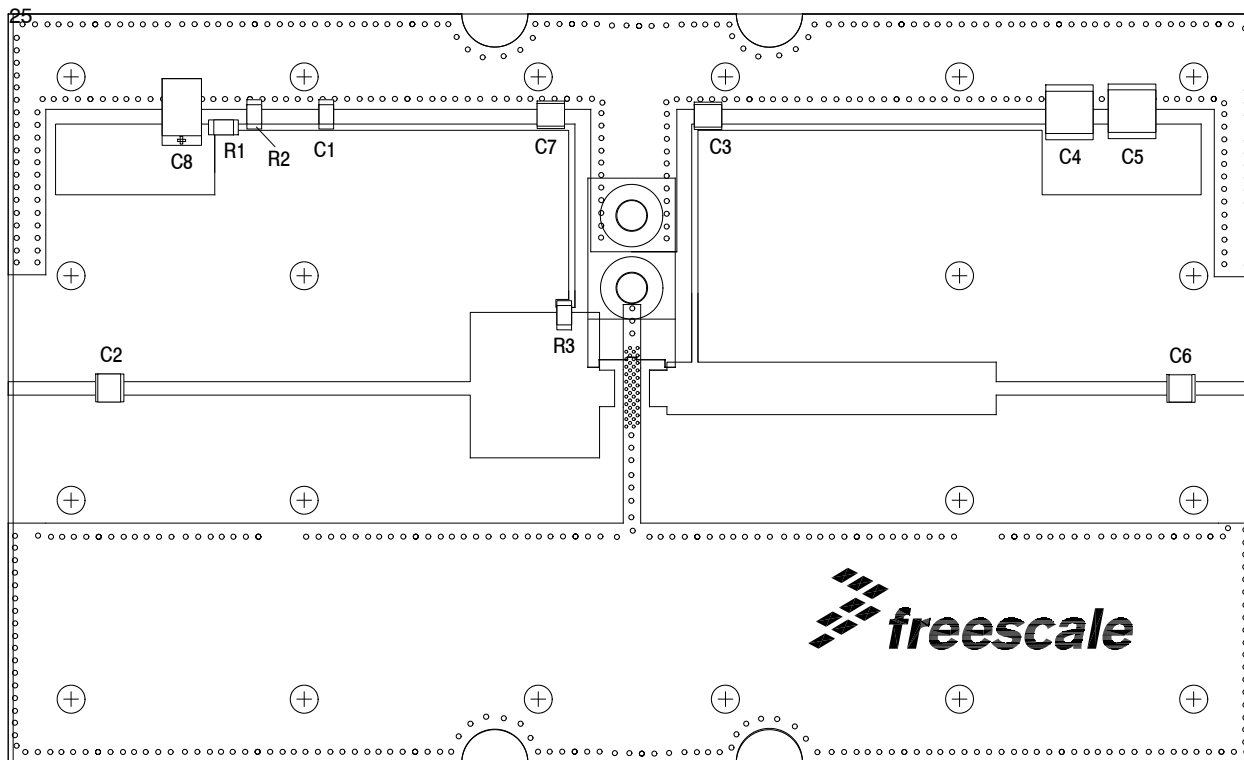
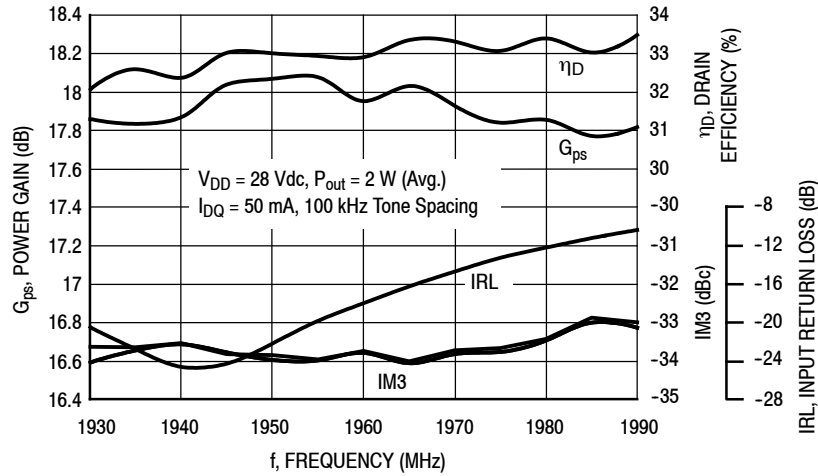
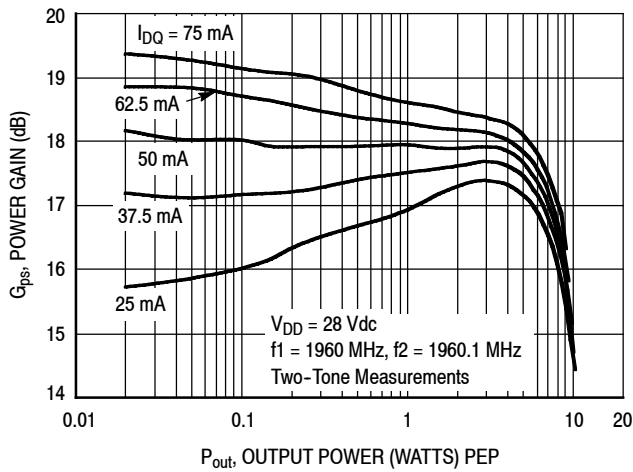


Figure 3. MMRF1014NT1 Test Circuit Component Layout

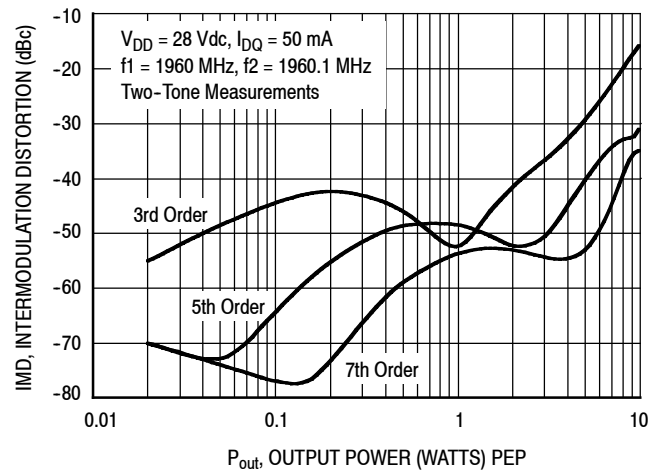
## TYPICAL CHARACTERISTICS



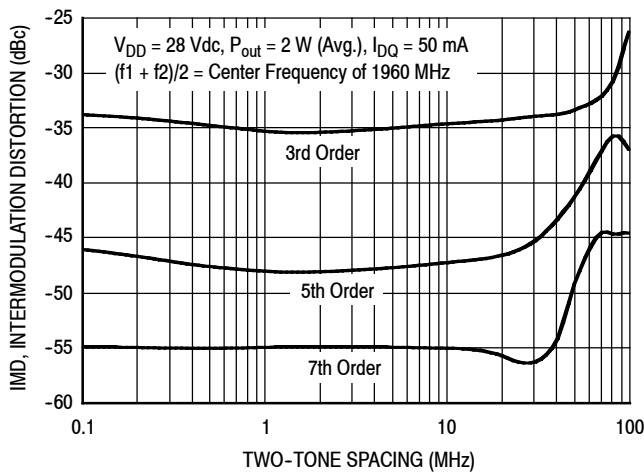
**Figure 4. Two-Tone Wideband Performance @  $P_{out} = 2 \text{ Watts Avg.}$**



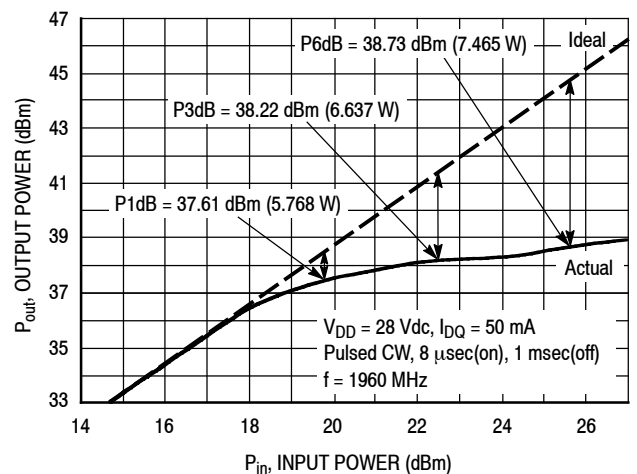
**Figure 5. Two-Tone Power Gain versus Output Power**



**Figure 6. Intermodulation Distortion Products versus Output Power**

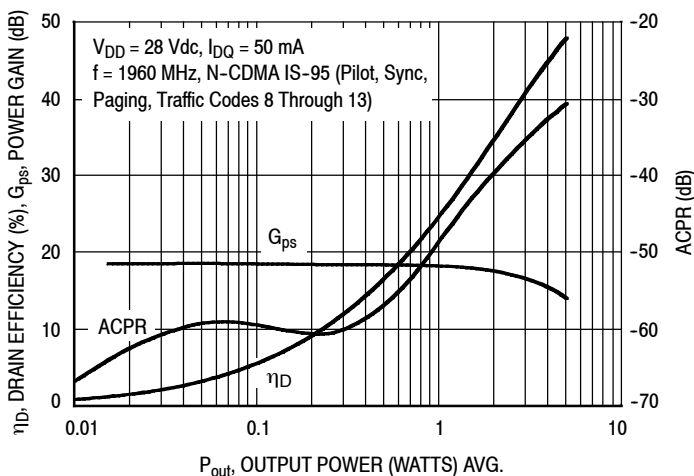


**Figure 7. Intermodulation Distortion Products versus Tone Spacing**

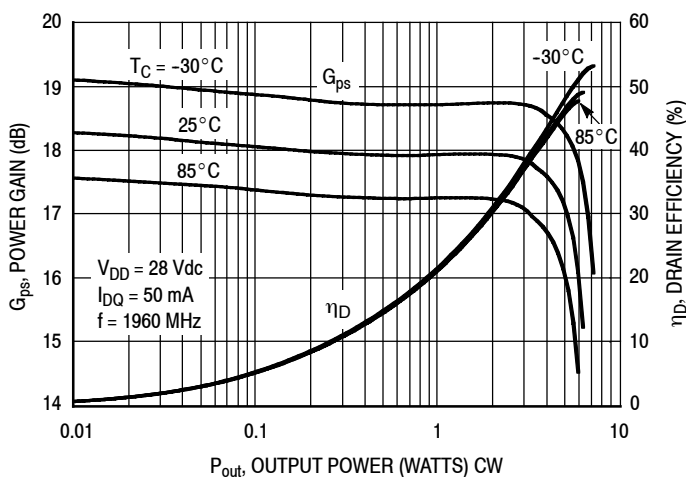


**Figure 8. Pulsed CW Output Power versus Input Power**

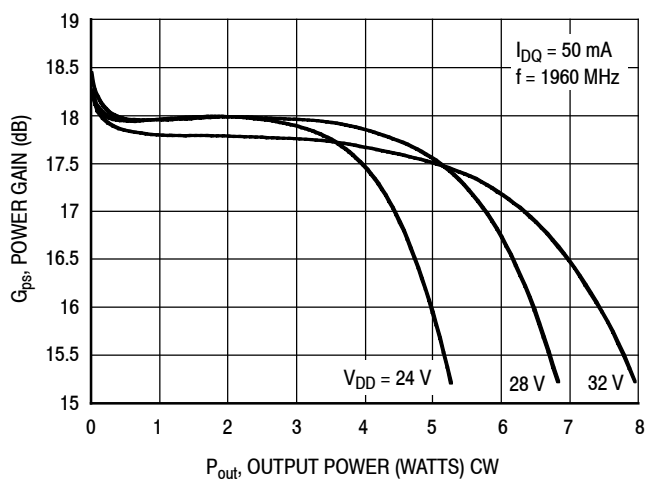
### TYPICAL CHARACTERISTICS



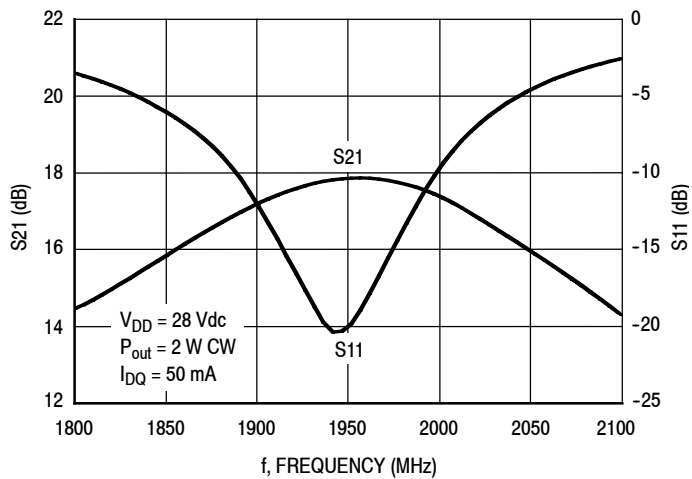
**Figure 9. Single-Carrier CDMA ACPR, Power Gain and Drain Efficiency versus Output Power**



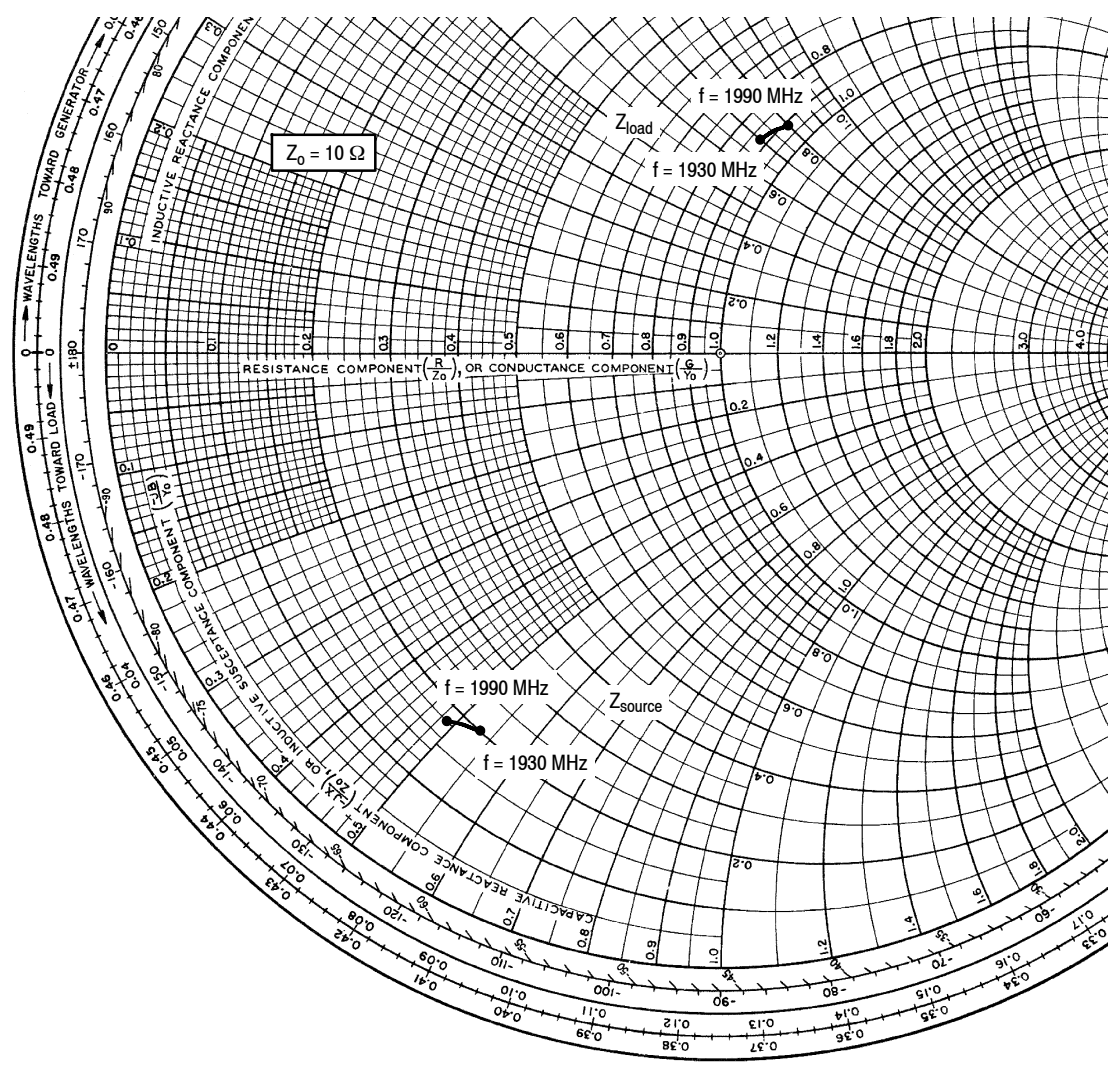
**Figure 10. Power Gain and Drain Efficiency versus CW Output Power**



**Figure 11. Power Gain versus Output Power**



**Figure 12. Broadband Frequency Response**



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 50 \text{ mA}$ ,  $P_{out} = 4 \text{ W PEP}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
1930	$1.96 - j5.34$	$8.78 + j6.96$
1960	$1.89 - j5.10$	$8.93 + j7.46$
1990	$1.82 - j4.85$	$9.11 + j7.97$

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

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

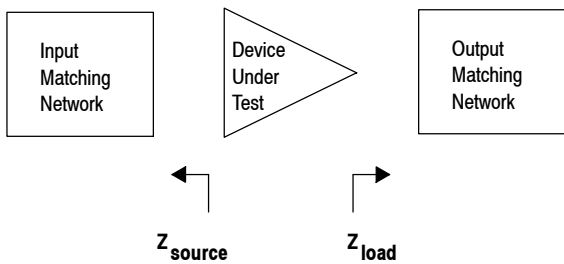


Figure 13. Series Equivalent Source and Load Impedance

**Table 7. Common Source S-Parameters** ( $V_{DD} = 28$  Vdc,  $I_{DQ} = 50$  mA,  $T_A = 25^\circ\text{C}$ , 50 Ohm System)

f MHz	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>	
	S <sub>11</sub>	∠ φ	S <sub>21</sub>	∠ φ	S <sub>12</sub>	∠ φ	S <sub>22</sub>	∠ φ
500	0.649	-116.340	7.902	105.420	0.056	-73.750	0.548	-33.570
550	0.695	-121.680	7.502	98.790	0.053	-80.570	0.593	-41.480
600	0.733	-126.560	7.111	92.380	0.049	-87.010	0.632	-48.890
650	0.770	-131.340	6.699	86.290	0.045	-93.280	0.669	-56.000
700	0.800	-135.740	6.302	80.450	0.041	-99.120	0.701	-62.810
750	0.827	-140.030	5.922	74.850	0.038	-104.850	0.727	-69.290
800	0.848	-143.950	5.552	69.630	0.035	-110.110	0.750	-75.350
850	0.866	-147.690	5.220	64.580	0.032	-115.220	0.770	-81.130
900	0.882	-151.140	4.891	59.970	0.029	-119.960	0.786	-86.570
950	0.895	-154.560	4.597	55.490	0.026	-124.790	0.800	-91.730
1000	0.907	-157.590	4.315	51.240	0.024	-129.090	0.813	-96.660
1050	0.916	-160.540	4.060	47.170	0.022	-133.370	0.824	-101.340
1100	0.923	-163.310	3.819	43.340	0.020	-137.460	0.833	-105.790
1150	0.929	-165.930	3.601	39.650	0.018	-141.440	0.840	-110.050
1200	0.935	-168.430	3.398	36.110	0.017	-145.330	0.847	-114.170
1250	0.938	-170.770	3.210	32.740	0.015	-149.540	0.851	-118.060
1300	0.942	-173.030	3.036	29.490	0.014	-153.430	0.856	-121.880
1350	0.945	-175.140	2.875	26.360	0.013	-157.460	0.859	-125.520
1400	0.948	-177.170	2.728	23.330	0.012	-161.910	0.863	-129.020
1450	0.951	-179.090	2.590	20.440	0.011	-166.180	0.866	-132.390
1500	0.953	179.030	2.464	17.640	0.010	-170.630	0.869	-135.650
1550	0.954	177.270	2.347	14.920	0.009	-174.890	0.872	-138.760
1600	0.955	175.570	2.240	12.320	0.008	179.950	0.875	-141.750
1650	0.956	173.980	2.139	9.740	0.008	173.920	0.877	-144.650
1700	0.957	172.350	2.047	7.250	0.007	167.710	0.880	-147.480
1750	0.957	170.800	1.958	4.810	0.007	161.810	0.882	-150.180
1800	0.958	169.340	1.879	2.440	0.006	155.370	0.884	-152.760
1850	0.959	167.920	1.806	0.260	0.006	148.940	0.886	-155.230
1900	0.959	166.510	1.736	-1.980	0.005	142.630	0.887	-157.580
1950	0.960	165.200	1.668	-4.310	0.005	136.740	0.888	-160.050
2000	0.959	163.800	1.611	-6.240	0.005	129.910	0.890	-162.070
2050	0.959	162.420	1.555	-8.290	0.005	123.810	0.891	-164.190
2100	0.958	161.170	1.504	-10.270	0.005	118.200	0.892	-166.140
2150	0.958	159.840	1.456	-12.210	0.005	112.740	0.893	-168.060
2200	0.957	158.560	1.412	-14.130	0.005	108.460	0.894	-169.840
2250	0.957	157.160	1.372	-16.010	0.005	103.840	0.896	-171.610
2300	0.955	155.870	1.334	-17.870	0.005	99.310	0.896	-173.260
2350	0.954	154.510	1.300	-19.700	0.005	95.360	0.897	-174.830
2400	0.953	153.120	1.268	-21.510	0.005	91.030	0.898	-176.390
2450	0.953	151.730	1.238	-23.250	0.005	87.460	0.899	-177.840

(continued)



**Table 7. Common Source S-Parameters** ( $V_{DD} = 28$  Vdc,  $I_{DQ} = 50$  mA,  $T_A = 25^\circ\text{C}$ , 50 Ohm System) (continued)

f MHz	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>	
	S <sub>11</sub>	∠ φ	S <sub>21</sub>	∠ φ	S <sub>12</sub>	∠ φ	S <sub>22</sub>	∠ φ
2500	0.952	150.340	1.211	-25.120	0.006	84.160	0.899	-179.270
2550	0.950	149.010	1.187	-26.920	0.006	80.780	0.897	179.420
2600	0.949	147.380	1.166	-28.650	0.006	77.880	0.897	178.120
2650	0.948	145.920	1.144	-30.420	0.007	74.670	0.898	176.840
2700	0.944	144.200	1.121	-32.310	0.007	71.360	0.896	175.480
2750	0.944	142.790	1.105	-34.230	0.007	67.980	0.897	174.060
2800	0.943	141.020	1.088	-36.000	0.007	63.950	0.897	172.930
2850	0.941	139.410	1.073	-37.870	0.007	61.230	0.896	171.630
2900	0.940	137.640	1.058	-39.760	0.008	59.810	0.896	170.330
2950	0.938	135.900	1.045	-41.680	0.008	58.280	0.896	169.040
3000	0.937	133.860	1.032	-43.610	0.008	56.740	0.895	167.510

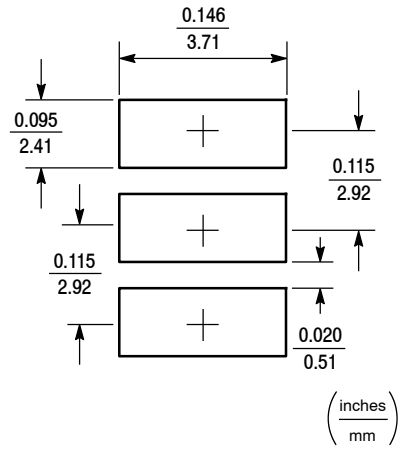


Figure 14. Solder Footprint for PLD-1.5

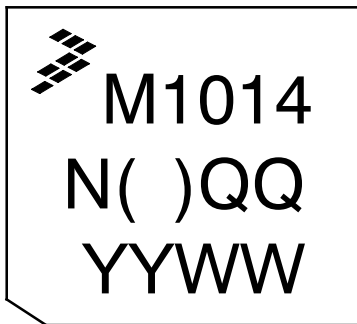
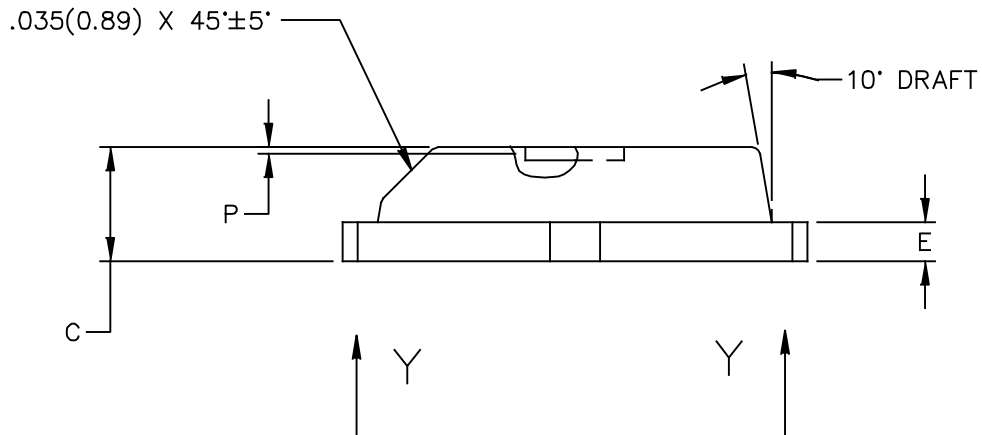
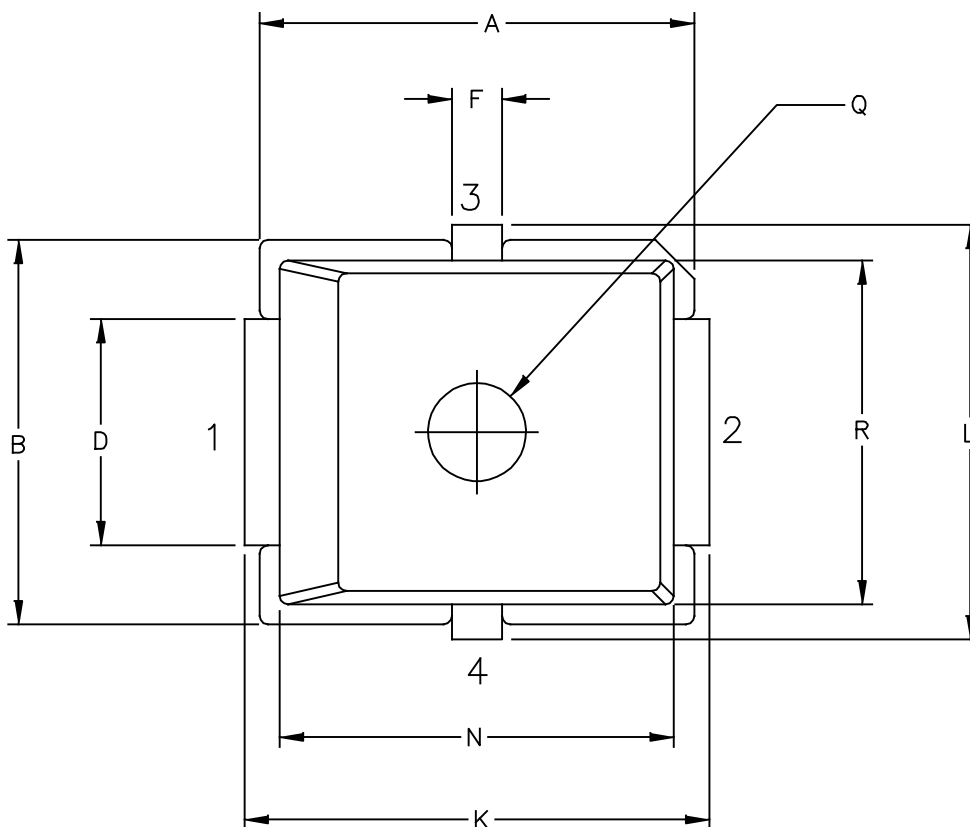
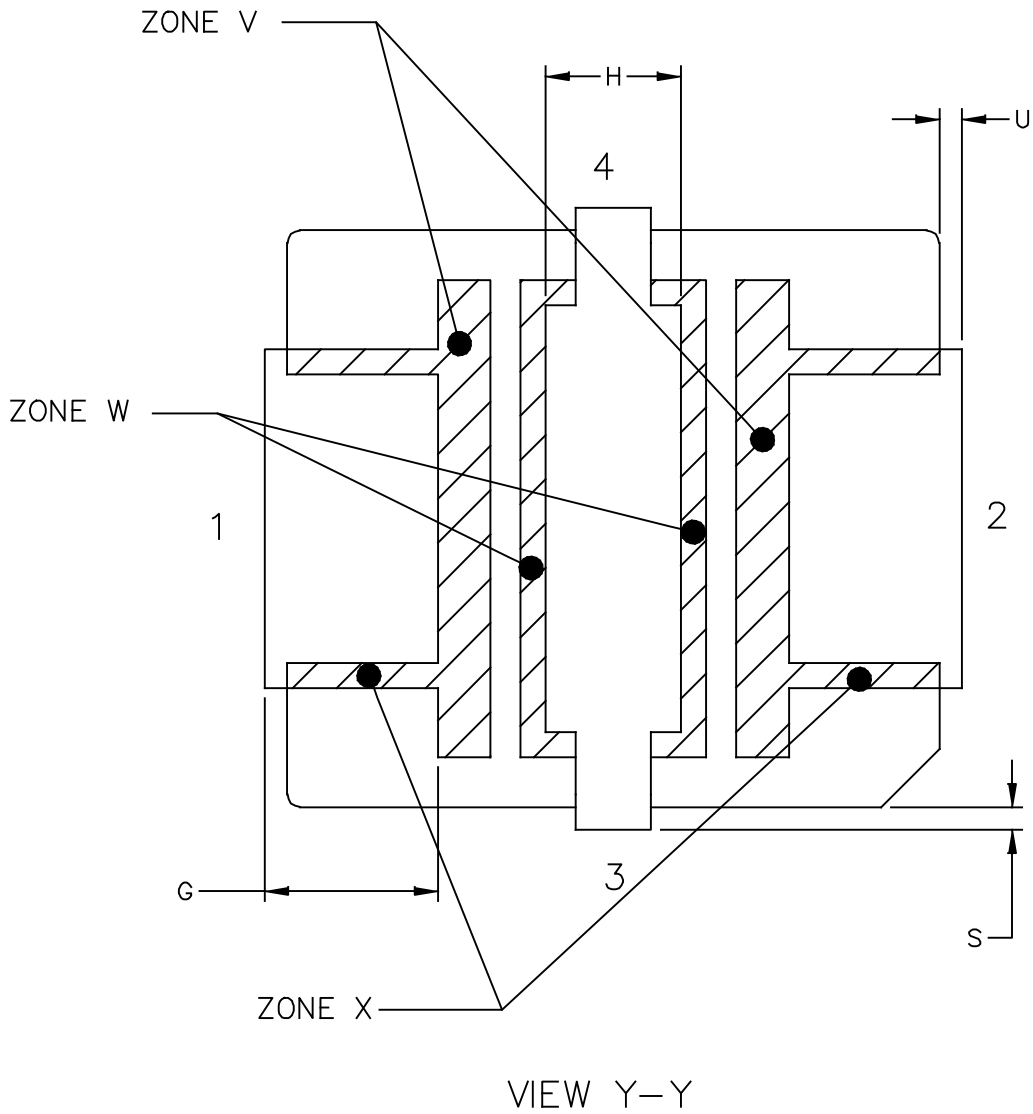


Figure 15. Product Marking

**PACKAGE DIMENSIONS**



© FREESCALE SEMICONDUCTOR, INC. ALL RIGHTS RESERVED.	MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE	
TITLE:  PLD-1.5	DOCUMENT NO: 98ASB15740C	REV: D	
	CASE NUMBER: 466-03	31 MAR 2005	
	STANDARD: NON-JEDEC		



© FREESCALE SEMICONDUCTOR, INC. ALL RIGHTS RESERVED.		MECHANICAL OUTLINE		PRINT VERSION NOT TO SCALE	
TITLE:  PLD-1.5		DOCUMENT NO: 98ASB15740C		REV: D	
		CASE NUMBER: 466-03		31 MAR 2005	
		STANDARD: NON-JEDEC			

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					
© FREESCALE SEMICONDUCTOR, INC. ALL RIGHTS RESERVED.			MECHANICAL OUTLINE			PRINT VERSION NOT TO SCALE			
TITLE:  PLD-1.5					DOCUMENT NO: 98ASB15740C			REV: D	
					CASE NUMBER: 466-03			31 MAR 2005	
					STANDARD: NON-JEDEC				

## PRODUCT DOCUMENTATION AND SOFTWARE

Refer to the following resources to aid your design process.

### Application Notes

- AN1955: Thermal Measurement Methodology of RF Power Amplifiers

### Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

### Software

- Electromigration MTTF Calculator

For Software, 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	July 2014	<ul style="list-style-type: none"> <li>• Initial Release of Data Sheet</li> </ul>

### ***How to Reach Us:***

**Home Page:**  
[freescale.com](http://freescale.com)

**Web Support:**  
[freescale.com/support](http://freescale.com/support)

Information in this document is provided solely to enable system and software implementers to use Freescale products. There are no express or implied copyright licenses granted hereunder to design or fabricate any integrated circuits based on the information in this document.

Freescale reserves the right to make changes without further notice to any products herein. Freescale makes no warranty, representation, or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters that may be provided in Freescale data sheets and/or specifications can and do vary in different applications, and actual performance may vary over time. All operating parameters, including "typicals," must be validated for each customer application by customer's technical experts. Freescale does not convey any license under its patent rights nor the rights of others. Freescale sells products pursuant to standard terms and conditions of sale, which can be found at the following address: [freescale.com/SalesTermsandConditions](http://freescale.com/SalesTermsandConditions).

Freescale and the Freescale logo are trademarks of Freescale Semiconductor, Inc., Reg. U.S. Pat. & Tm. Off. All other product or service names are the property of their respective owners.

© 2014 Freescale Semiconductor, Inc.