Freescale Semiconductor
Technical Data

Document Number: MMRF1006H
Rev. 0, 12/2013

RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

Designed for pulse and CW wideband applications with frequencies up to 500 MHz. Devices are unmatched and are suitable for use in communications, radar and industrial applications.

- Typical Pulse Performance at 450 MHz: V_{DD} = 50 Vdc, I_{DQ} = 150 mA, P_{out} = 1000 W Peak (200 W Avg.), Pulse Width = 100 μsec, Duty Cycle = 20%
  Power Gain — 20 dB
  Drain Efficiency — 64%
- Capable of Handling 10:1 VSWR @ 50 Vdc, 450 MHz, 1000 W Peak Power

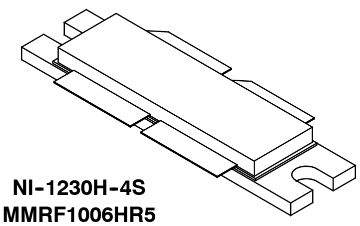
Features

- Characterized with Series Equivalent Large-Signal Impedance Parameters
- CW Operation Capability with Adequate Cooling
- Qualified Up to a Maximum of 50 V_{DD} Operation
- Integrated ESD Protection
- Designed for Push-Pull Operation
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- In Tape and Reel. R5 Suffix = 50 Units, 56 mm Tape Width, 13-inch Reel.

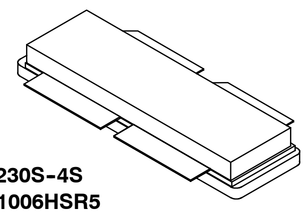
RoHS

MMRF1006HR5
MMRF1006HSR5

10-500 MHz, 1000 W, 50 V
LATERAL N-CHANNEL
BROADBAND
RF POWER MOSFETs

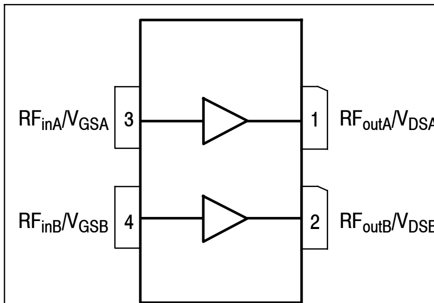


NI-1230H-4S
MMRF1006HR5



NI-1230S-4S
MMRF1006HSR5

PARTS ARE PUSH-PULL



(Top View)

Figure 1. Pin Connections

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	-0.5, +110	Vdc
Gate-Source Voltage	V_{GS}	-6, +10	Vdc
Storage Temperature Range	T_{stg}	- 65 to +150	°C
Case Operating Temperature	T_C	150	°C
Operating Junction Temperature (1)	T_J	225	°C
Total Device Dissipation @ T_C = 25°C, CW only (2)	P_D	1333	W

1. Continuous use at maximum temperature will affect MTTF.
2. Refer to Fig. 12, Transient Thermal Impedance, for information to calculate value for pulsed operation.

freescale

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (1)	Unit
Thermal Impedance, Junction to Case Pulse: Case Temperature 80°C, 1000 W Peak, 100 μsec Pulse Width, 20% Duty Cycle, 450 MHz (2)	$Z_{\theta JC}$	0.03	°C/W
Thermal Resistance, Junction to Case CW: Case Temperature 84°C, 1000 W CW, 352.2 MHz	$R_{\theta JC}$	0.15	°C/W

Table 3. ESD Protection Characteristics

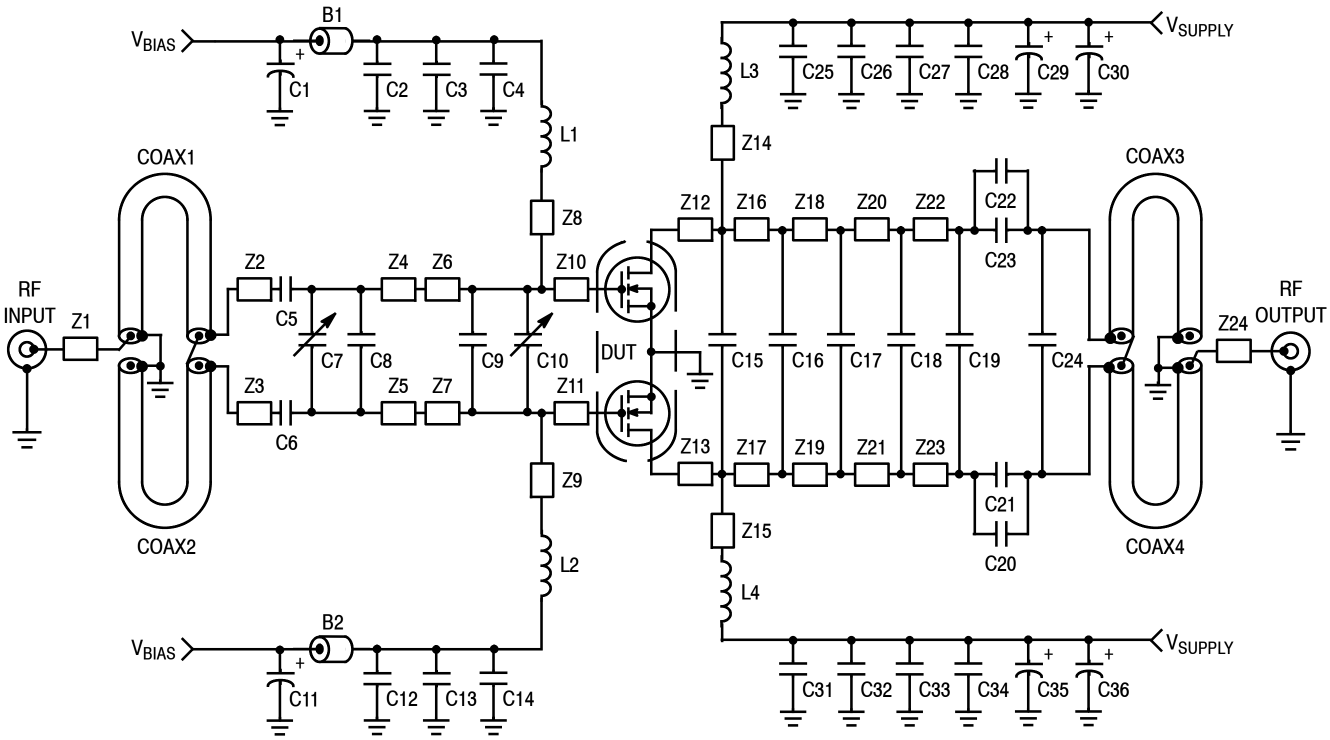
Test Methodology	Class
Human Body Model (per JESD22-A114)	2, passes 2000 V
Machine Model (per EIA/JESD22-A115)	A, passes 125 V
Charge Device Model (per JESD22-C101)	IV, passes 2000 V

Table 4. Electrical Characteristics (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Off Characteristics (3)					
Gate-Source Leakage Current (V_{GS} = 5 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	10	μAdc
Drain-Source Breakdown Voltage (I_D = 300 mA, V_{GS} = 0 Vdc)	$V_{(BR)DSS}$	110	—	—	Vdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 50 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	100	μAdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 100 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	5	mA
On Characteristics					
Gate Threshold Voltage (3) (V_{DS} = 10 Vdc, I_D = 1600 μAdc)	$V_{GS(th)}$	1	1.68	3	Vdc
Gate Quiescent Voltage (4) (V_{DD} = 50 Vdc, I_D = 150 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	1.5	2.2	3.5	Vdc
Drain-Source On-Voltage (3) (V_{GS} = 10 Vdc, I_D = 4 Adc)	$V_{DS(on)}$	—	0.28	—	Vdc
Dynamic Characteristics (3)					
Reverse Transfer Capacitance (V_{DS} = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	3.3	—	pF
Output Capacitance (V_{DS} = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	147	—	pF
Input Capacitance (V_{DS} = 50 Vdc, V_{GS} = 0 Vdc ± 30 mV(rms)ac @ 1 MHz)	C_{iss}	—	506	—	pF
Functional Tests (4) (In Freescale Test Fixture, 50 ohm system) V_{DD} = 50 Vdc, I_{DQ} = 150 mA, P_{out} = 1000 W Peak (200 W Avg.), f = 450 MHz, 100 μsec Pulse Width, 20% Duty Cycle					
Power Gain	G_{ps}	19	20	22	dB
Drain Efficiency	η_D	60	64	—	%
Input Return Loss	IRL	—	-18	-9	dB

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 Fig. 12, Transient Thermal Impedance, for other pulsed conditions.
3. Each side of device measured separately.
4. Measurement made with device in push-pull configuration.

(continued)



Z1	0.366″ x 0.082″ Microstrip	Z14*, Z15*	0.764″ x 0.150″ Microstrip
Z2*, Z3*	0.170″ x 0.100″ Microstrip	Z16, Z17	0.290″ x 0.430″ Microstrip
Z4*, Z5*	0.220″ x 0.451″ Microstrip	Z18, Z19	0.100″ x 0.430″ Microstrip
Z6, Z7	0.117″ x 0.726″ Microstrip	Z20, Z21, Z22, Z23	0.080″ x 0.430″ Microstrip
Z8*, Z9*	0.792″ x 0.058″ Microstrip	Z24	0.257″ x 0.215″ Microstrip
Z10, Z11	0.316″ x 0.726″ Microstrip	PCB	Arlon CuClad 250GX-0300-55-22, 0.030″, ε_r = 2.55
Z12, Z13	0.262″ x 0.507″ Microstrip		

* Line length includes microstrip bends

Figure 2. MMRF1006HR5(HSR5) Pulse Test Circuit Schematic — 450 MHz

Table 5. MMRF1006HR5(HSR5) Pulse Test Circuit Component Designations and Values — 450 MHz

Part	Description	Part Number	Manufacturer
B1, B2	47 Ω, 100 MHz Short Ferrite Beads	2743019447	Fair-Rite
C1, C11	47 μF, 50 V Electrolytic Capacitors	476KXM063M	Illinois
C2, C12, C28, C34	0.1 μF Chip Capacitors	CDR33BX104AKYS	Kemet
C3, C13, C27, C33	220 nF, 50 V Chip Capacitors	C1812C224K5RAC	Kemet
C4, C14	2.2 μF, 50 V Chip Capacitors	C1825C225J5RAC	Kemet
C5, C6, C8, C15	27 pF Chip Capacitors	ATC100B270JT500XT	ATC
C7, C10	0.8-8.0 pF Variable Capacitors	27291SL	Johanson Components
C9	33 pF Chip Capacitor	ATC100B330JT500XT	ATC
C16	12 pF Chip Capacitor	ATC100B120JT500XT	ATC
C17	10 pF Chip Capacitor	ATC100B100JT500XT	ATC
C18	9.1 pF Chip Capacitor	ATC100B9R1CT500XT	ATC
C19	8.2 pF Chip Capacitor	ATC100B8R2CT500XT	ATC
C20, C21, C22, C23, C25, C32	240 pF Chip Capacitors	ATC100B241JT200XT	ATC
C24	5.6 pF Chip Capacitor	ATC100B5R6CT500XT	ATC
C26, C31	2.2 μF, 100 V Chip Capacitors	2225X7R225KT3AB	ATC
C29, C30, C35, C36	330 μF, 63 V Electrolytic Capacitors	EMVY630GTR331MMH0S	Nippon Chemi-Con
Coax1, 2, 3, 4	25 Ω Semi Rigid Coax, 2.2″ Shield Length	UT-141C-25	Micro-Coax
L1, L2	2.5 nH, 1 Turn Inductors	A01TKLC	Coilcraft
L3, L4	43 nH, 10 Turn Inductors	B10TJLC	Coilcraft

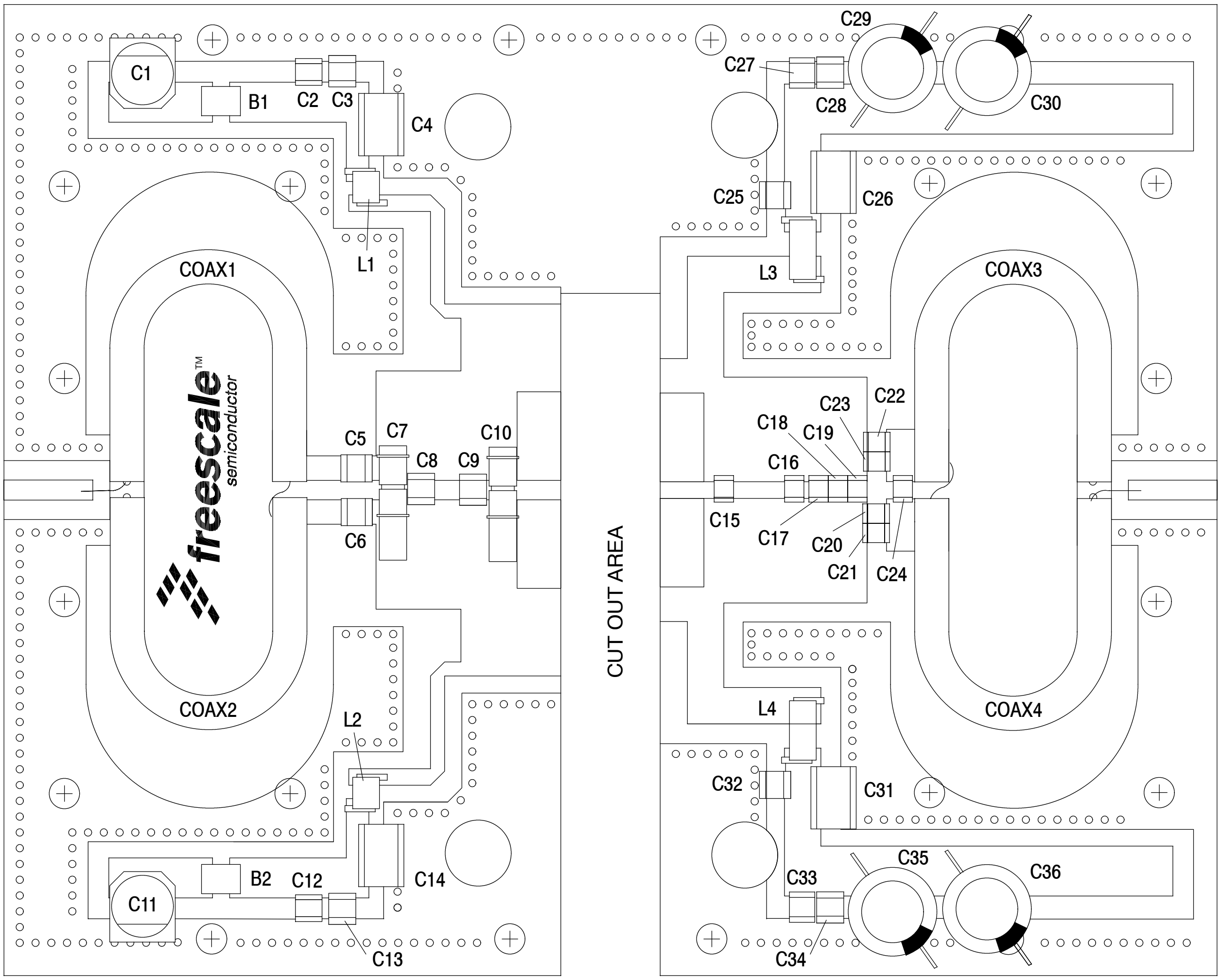
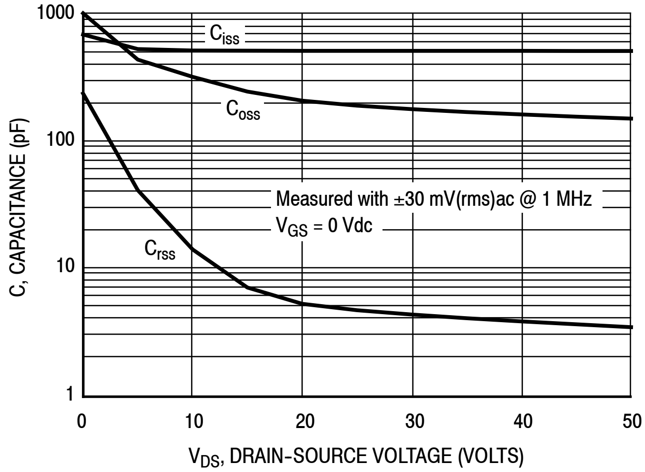
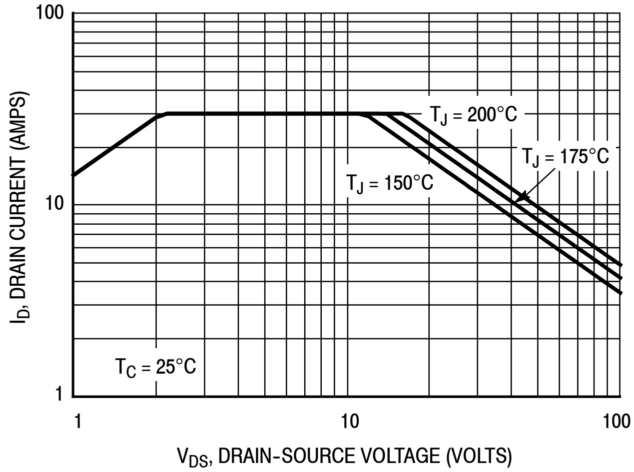


Figure 3. MMRF1006HR5(HSR5) Pulse Test Circuit Component Layout — 450 MHz



Note: Each side of device measured separately.

Figure 4. Capacitance versus Drain-Source Voltage



Note: Each side of device measured separately.

Figure 5. DC Safe Operating Area

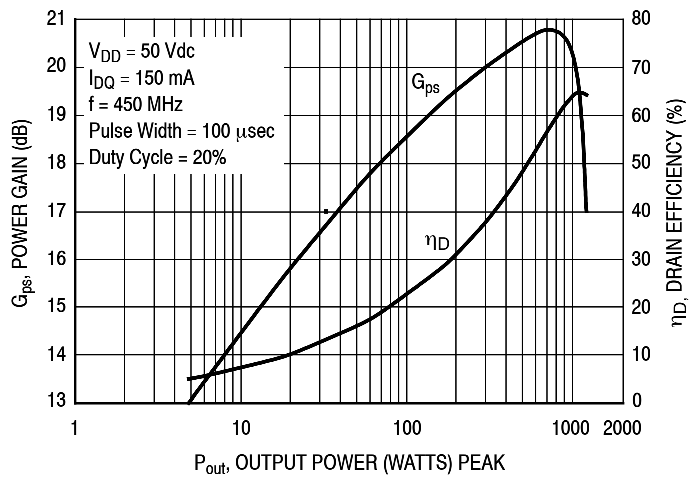


Figure 6. Power Gain and Drain Efficiency versus Output Power

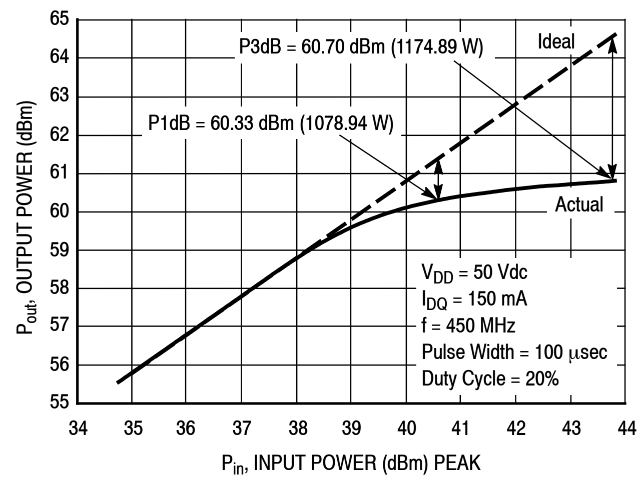


Figure 7. Output Power versus Input Power

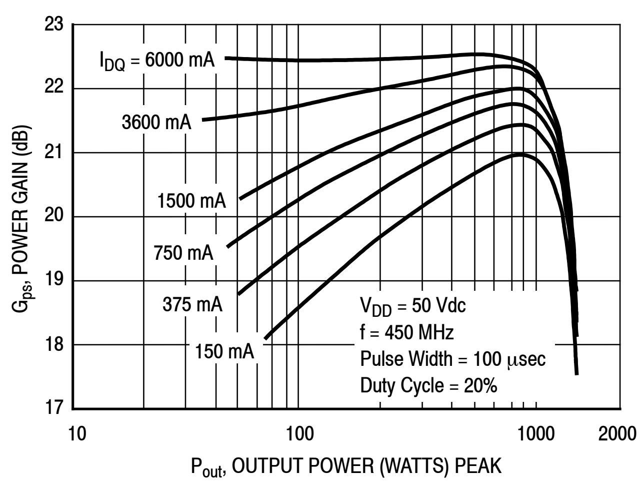


Figure 8. Power Gain versus Output Power

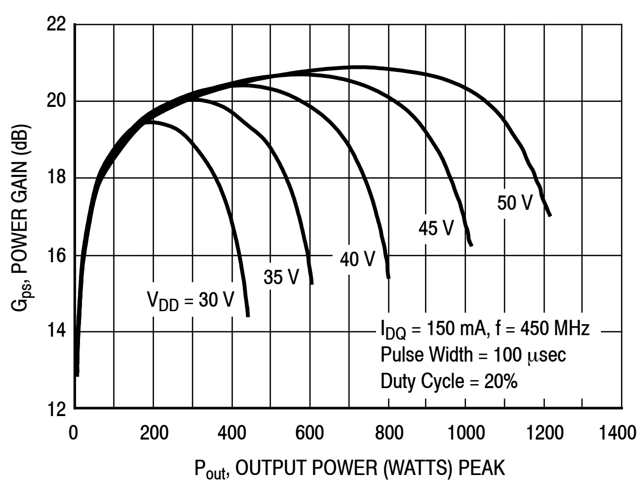


Figure 9. Power Gain versus Output Power

TYPICAL CHARACTERISTICS

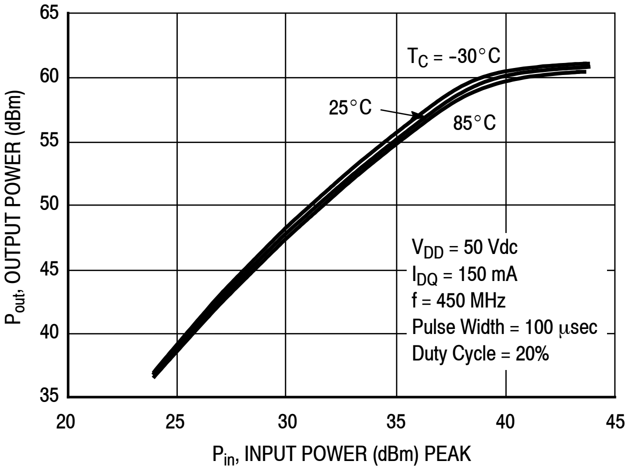


Figure 10. Output Power versus Input Power

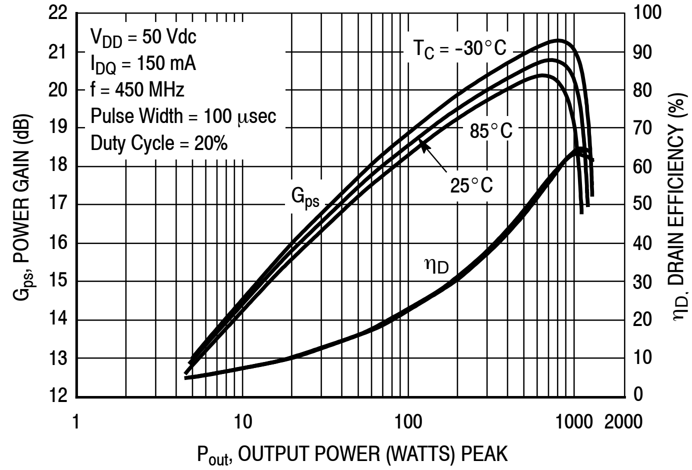


Figure 11. Power Gain and Drain Efficiency versus Output Power

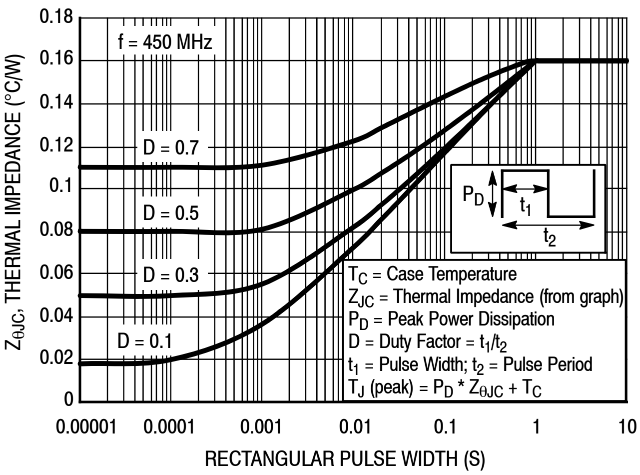
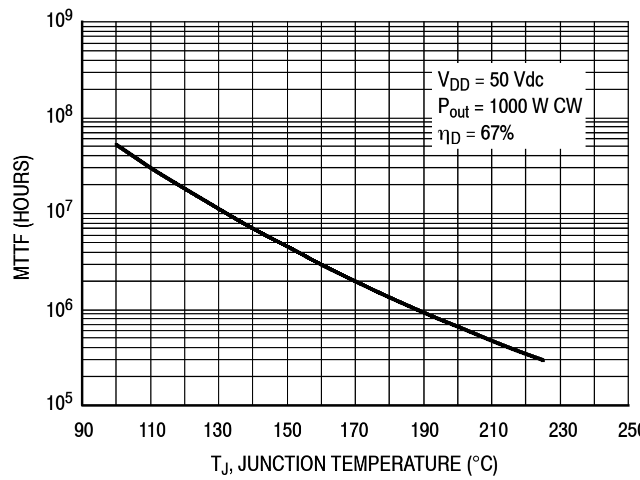


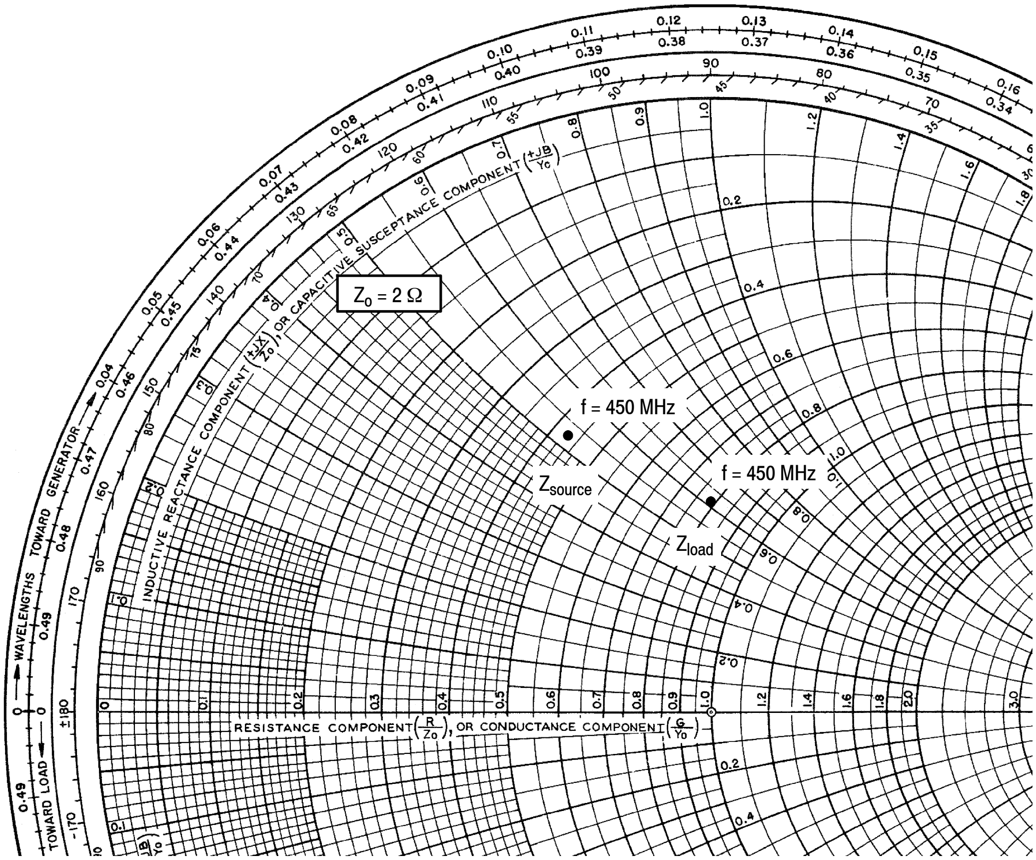
Figure 12. Transient Thermal Impedance



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

NOTE: For pulse applications or CW conditions, use the MTTF calculator referenced above.

Figure 13. MTTF versus Junction Temperature – CW



V_{DD} = 50 Vdc, I_{DQ} = 150 mA, P_{out} = 1000 W Peak

f MHz	Z_{source} Ω	Z_{load} Ω
450	0.86 + j1.06	1.58 + j1.22

Z_{source} = Test circuit impedance as measured from gate to gate, balanced configuration.

Z_{load} = Test circuit impedance as measured from drain to drain, balanced configuration.

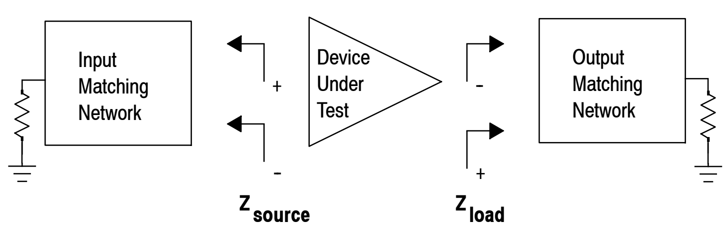
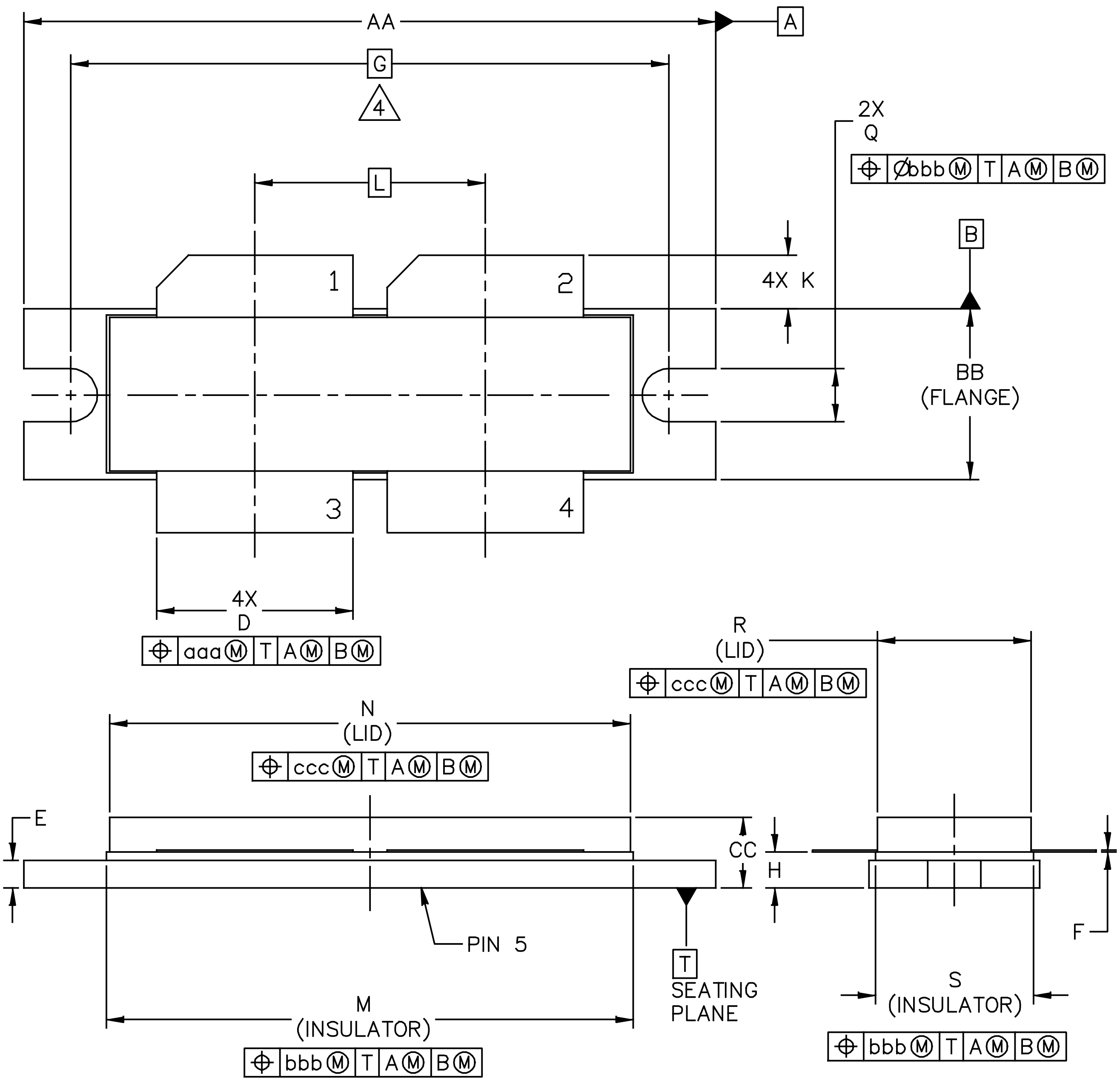


Figure 14. Series Equivalent Source and Load Impedance — 450 MHz

PACKAGE DIMENSIONS



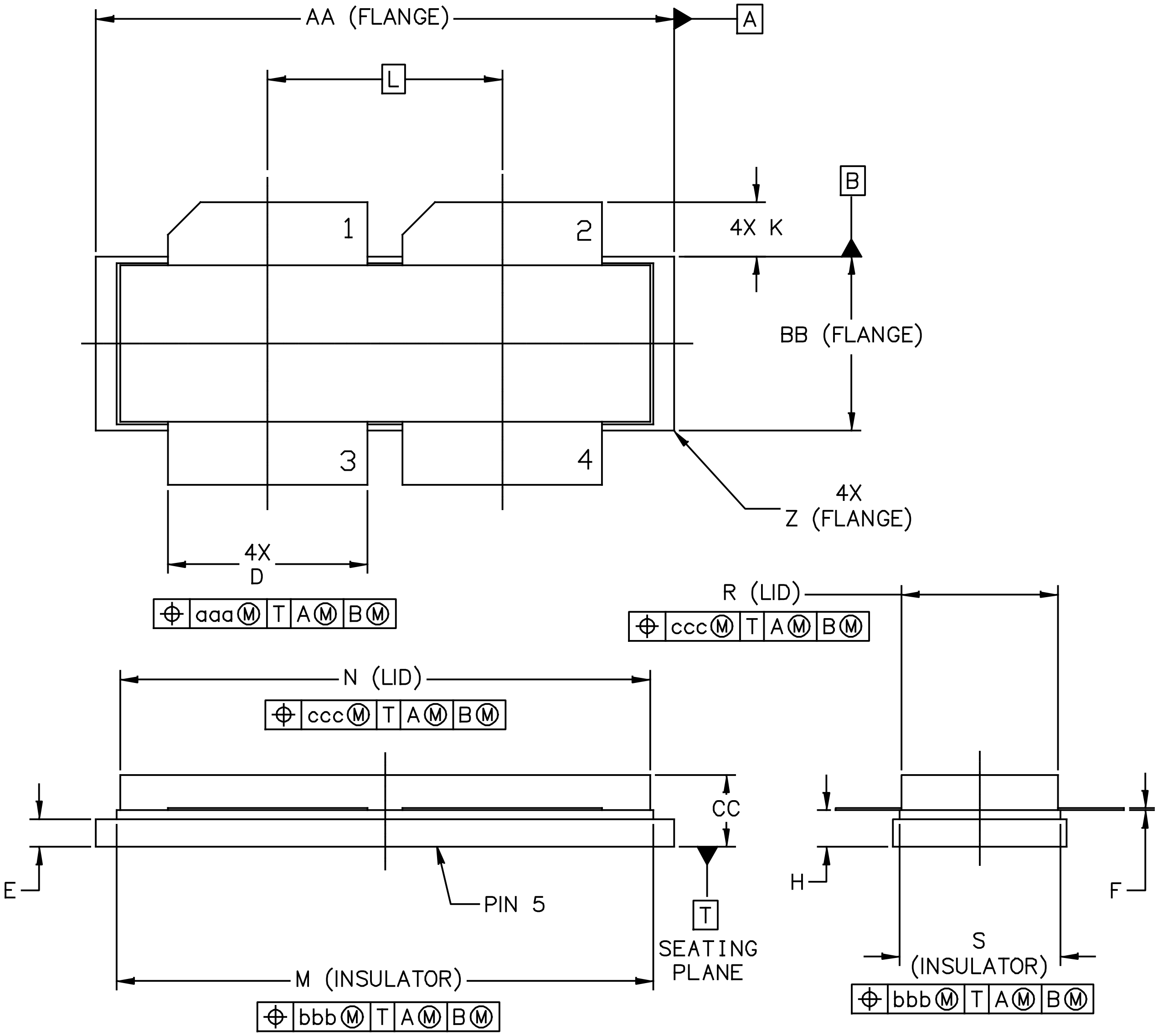
© FREESCALE SEMICONDUCTOR, INC. ALL RIGHTS RESERVED.	MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE
TITLE: NI–1230–4H	DOCUMENT NO: 98ASB16977C REV: F	
	STANDARD: NON–JEDEC	
	28 FEB 2013	

NOTES:

1. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
2. CONTROLLING DIMENSION: INCH
3. DIMENSION H IS MEASURED .030 INCH (0.762 MM) AWAY FROM PACKAGE BODY.
4. RECOMMENDED BOLT CENTER DIMENSION OF 1.52 INCH (38.61 MM) BASED ON M3 SCREW.

DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX
AA	1.615	1.625	41.02	41.28	N	1.218	1.242	30.94	31.55
BB	.395	.405	10.03	10.29	Q	.120	.130	3.05	3.30
CC	.170	.190	4.32	4.83	R	.355	.365	9.02	9.27
D	.455	.465	11.56	11.81	S	.365	.375	9.27	9.53
E	.062	.066	1.57	1.68					
F	.004	.007	0.10	0.18					
G	1.400 BSC		35.56 BSC		aaa	.013		0.33	
H	.082	.090	2.08	2.29	bbb	.010		0.25	
K	.117	.137	2.97	3.48	ccc	.020		0.51	
L	.540 BSC		13.72 BSC						
M	1.219	1.241	30.96	31.52					

© FREESCALE SEMICONDUCTOR, INC. ALL RIGHTS RESERVED.	MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE
TITLE: NI-1230-4H	DOCUMENT NO: 98ASB16977C	REV: F
	STANDARD: NON-JEDEC	
		28 FEB 2013



	MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE
TITLE: NI–1230–4S	DOCUMENT NO: 98ARB18247C	REV: G
	STANDARD: NON–JEDEC	
	01 MAR 2013	

NOTES:

1. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M–1994.
2. CONTROLLING DIMENSION: INCH
3. DIMENSION H IS MEASURED .030 INCH (0.762 MM) AWAY FROM PACKAGE BODY

DIM	INCHES		MILLIMETERS		DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
AA	1.265	1.275	32.13	32.39	R	.355	.365	9.02	9.27
BB	.395	.405	10.03	10.29	S	.365	.375	9.27	9.53
CC	.170	.190	4.32	4.83	Z	R.000	R.040	R0.00	R1.02
D	.455	.465	11.56	11.81					
E	.062	.066	1.57	1.68	aaa	.013		0.33	
F	.004	.007	0.10	0.18	bbb	.010		0.25	
H	.082	.090	2.08	2.29	ccc	.020		0.51	
K	.117	.137	2.97	3.48					
L	.540 BSC		13.72 BSC						
M	1.219	1.241	30.96	31.52					
N	1.218	1.242	30.94	31.55					

MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE

TITLE: NI–1230–4S

DOCUMENT NO: 98ARB18247C REV: G

STANDARD: NON–JEDEC

01 MAR 2013

PRODUCT DOCUMENTATION

Refer to the following documents 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

REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	Dec. 2013	• Initial Release of Data Sheet

How to Reach Us:

Home Page:
freescale.com

Web Support:
freescale.com/support

freescale™

Document Number: MMRF1006H
Rev. 0, 12/2013