Freescale Semiconductor
Technical Data

Document Number: MRFE6VP61K25N
Rev. 2, 4/2015

RF Power LDMOS Transistors

High Ruggedness N-Channel Enhancement-Mode Lateral MOSFETs

MRFE6VP61K25N
MRFE6VP61K25GN

1.8–600 MHz, 1250 W CW, 50 V
WIDEBAND
RF POWER LDMOS TRANSISTORS

These high ruggedness devices are designed for use in high VSWR industrial, medical, broadcast, aerospace and mobile radio applications. Their unmatched input and output design allows for wide frequency range use from 1.8 to 600 MHz.

Typical Performance: V_{DD} = 50 Vdc

Frequency (MHz)	Signal Type	P_{out} (W)	G_{ps} (dB)	η_D (%)
87.5–108 (1,2)	CW	1309 CW	24.1	77.6
230 (3)	Pulse (100 μsec, 20% Duty Cycle)	1250 Peak	23.0	72.3

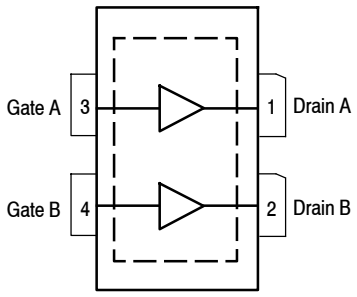
Load Mismatch/Ruggedness

Frequency (MHz)	Signal Type	VSWR	P_{in} (W)	Test Voltage	Result
230 (3)	Pulse (100 μsec, 20% Duty Cycle)	> 65:1 at all Phase Angles	11.5 Peak (3 dB Overdrive)	50	No Device Degradation

1. Measured in 87.5–108 MHz broadband reference circuit.
2. The values shown are the center band performance numbers across the indicated frequency range.
3. Measured in 230 MHz narrowband test circuit.

OM-1230-4L
PLASTIC
MRE6VP61K25N

OM-1230G-4L
PLASTIC
MRE6VP61K25GN



(Top View)

Note: Exposed backside of the package is the source terminal for the transistors.

Figure 1. Pin Connections

Features

- Unmatched Input and Output Allowing Wide Frequency Range Utilization
- Device can be used Single-Ended or in a Push-Pull Configuration
- Qualified up to a Maximum of 50 V_{DD} Operation
- Characterized from 30 to 50 V for Extended Power Range
- Suitable for Linear Application with Appropriate Biasing
- Integrated ESD Protection with Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Recommended drivers: AFT05MS004N (4 W) or MRFE6VS25N (25 W)

Typical Applications

- Broadcast
  - FM broadcast
  - HF and VHF broadcast
- Industrial, Scientific, Medical (ISM)
  - CO_2 laser generation
  - Plasma etching
  - Particle accelerators (synchrotrons)
  - MRI
  - Industrial heating/welding
- Aerospace
  - VHF omnidirectional range (VOR)
  - Weather radar
- Mobile Radio
  - HF and VHF communications
  - PMR base stations

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Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	–0.5, +133	Vdc
Gate-Source Voltage	V_{GS}	–6.0, +10	Vdc
Storage Temperature Range	T_{stg}	–65 to +150	°C
Case Operating Temperature Range	T_C	–40 to +150	°C
Operating Junction Temperature Range (1,2)	T_J	–40 to +225	°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3333 16.67	W W/°C

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case CW: Case Temperature 109°C, 1250 W CW, 50 Vdc, $I_{DQ(A+B)}$ = 245 mA, 98 MHz	$R_{\theta JC}$	0.06	°C/W
Thermal Impedance, Junction to Case Pulse: Case Temperature 74°C, 1250 W Peak, 100 μsec Pulse Width, 20% Duty Cycle, $I_{DQ(A+B)}$ = 100 mA, 230 MHz	$Z_{\theta JC}$	0.016	°C/W

Table 3. ESD Protection Characteristics

Test Methodology	Class
Human Body Model (per JESD22-A114)	2, passes 2500 V
Machine Model (per EIA/JESD22-A115)	B, passes 250 V
Charge Device Model (per JESD22-C101)	IV, passes 2000 V

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°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Off Characteristics (4)					
Gate-Source Leakage Current (V_{GS} = 5 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	1	μAdc
Drain-Source Breakdown Voltage (V_{GS} = 0 Vdc, I_D = 100 mAdc)	$V_{(BR)DSS}$	133	—	—	Vdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 50 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	10	μAdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 100 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	20	μAdc
On Characteristics					
Gate Threshold Voltage (4) (V_{DS} = 10 Vdc, I_D = 1776 μAdc)	$V_{GS(th)}$	1.7	2.2	2.7	Vdc
Gate Quiescent Voltage (V_{DD} = 50 Vdc, $I_{D(A+B)}$ = 100 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	1.9	2.4	2.9	Vdc
Drain-Source On-Voltage (4) (V_{GS} = 10 Vdc, I_D = 2 Adc)	$V_{DS(on)}$	—	0.2	—	Vdc
Forward Transconductance (4) (V_{DS} = 10 Vdc, I_D = 30 Adc)	g_{fs}	—	28.0	—	S

1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at http://www.freescale.com/rf/calculators.
3. Refer to AN1955 – *Thermal Measurement Methodology of RF Power Amplifiers.* Go to http://www.freescale.com/rf and search AN1955.
4. Each side of device measured separately.

(continued)

Table 5. Electrical Characteristics (T_A = 25°C unless otherwise noted) **(continued)**

Characteristic	Symbol	Min	Typ	Max	Unit
Dynamic Characteristics					
Reverse Transfer Capacitance (1) (V_{DS} = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	2.8	—	pF
Output Capacitance (1) (V_{DS} = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	185	—	pF
Input Capacitance (1) (V_{DS} = 50 Vdc, V_{GS} = 0 Vdc ± 30 mV(rms)ac @ 1 MHz)	C_{iss}	—	562	—	pF
Functional Tests (2,3) (In Freescale Test Fixture, 50 ohm system) V_{DD} = 50 Vdc, $I_{DQ(A+B)}$ = 100 mA, P_{out} = 1250 W Peak (250 W Avg.), f = 230 MHz, 100 μsec Pulse Width, 20% Duty Cycle					
Power Gain	G_{ps}	22.0	23.0	24.5	dB
Drain Efficiency	η_D	68.5	72.3	—	%
Input Return Loss	IRL	—	–13	–9	dB

Table 6. Load Mismatch/Ruggedness (In Freescale Test Fixture, 50 ohm system) $I_{DQ(A+B)}$ = 100 mA

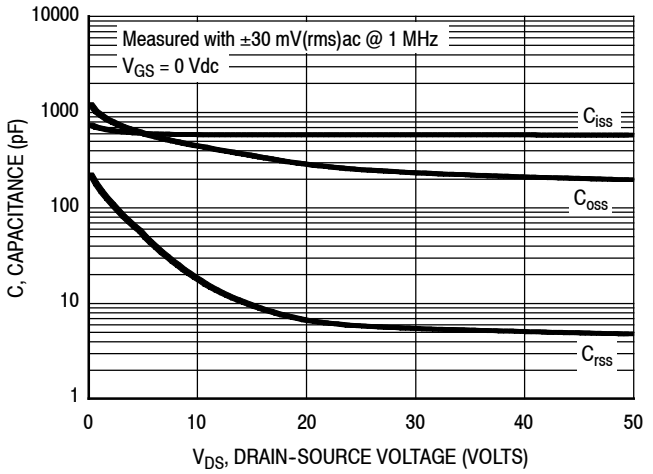
Frequency (MHz)	Signal Type	VSWR	P_{in} (W)	Test Voltage, V_{DD}	Result
230	Pulse (100 μsec, 20% Duty Cycle)	> 65:1 at all Phase Angles	11.5 Peak (3 dB Overdrive)	50	No Device Degradation

Table 7. Ordering Information

Device	Tape and Reel Information	Package
MRFE6VP61K25NR6	R6 Suffix = 150 Units, 56 mm Tape Width, 13-Reel	OM-1230-4L
MRFE6VP61K25GNR6		OM-1230G-4L

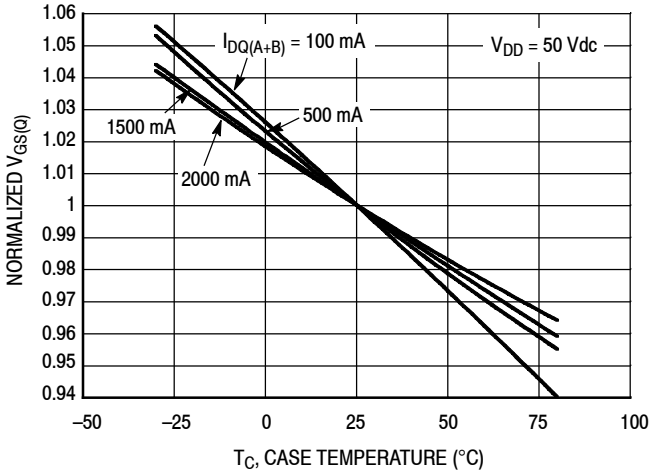
1. Each side of device measured separately.
2. Devices tested without thermal grease.
3. Measurements made with device in straight lead configuration before any lead forming operation is applied. Lead forming is used for gull wing (GN) parts.

TYPICAL CHARACTERISTICS



Note: Each side of device measured separately.

Figure 2. Capacitance versus Drain-Source Voltage



I_{DQ} (mA)	Slope (mV/°C)
100	–2.70
500	–2.42
1500	–2.22
2000	–2.05

Figure 3. Normalized V_{GS} versus Quiescent Current and Case Temperature

230 MHz NARROWBAND PRODUCTION TEST FIXTURE

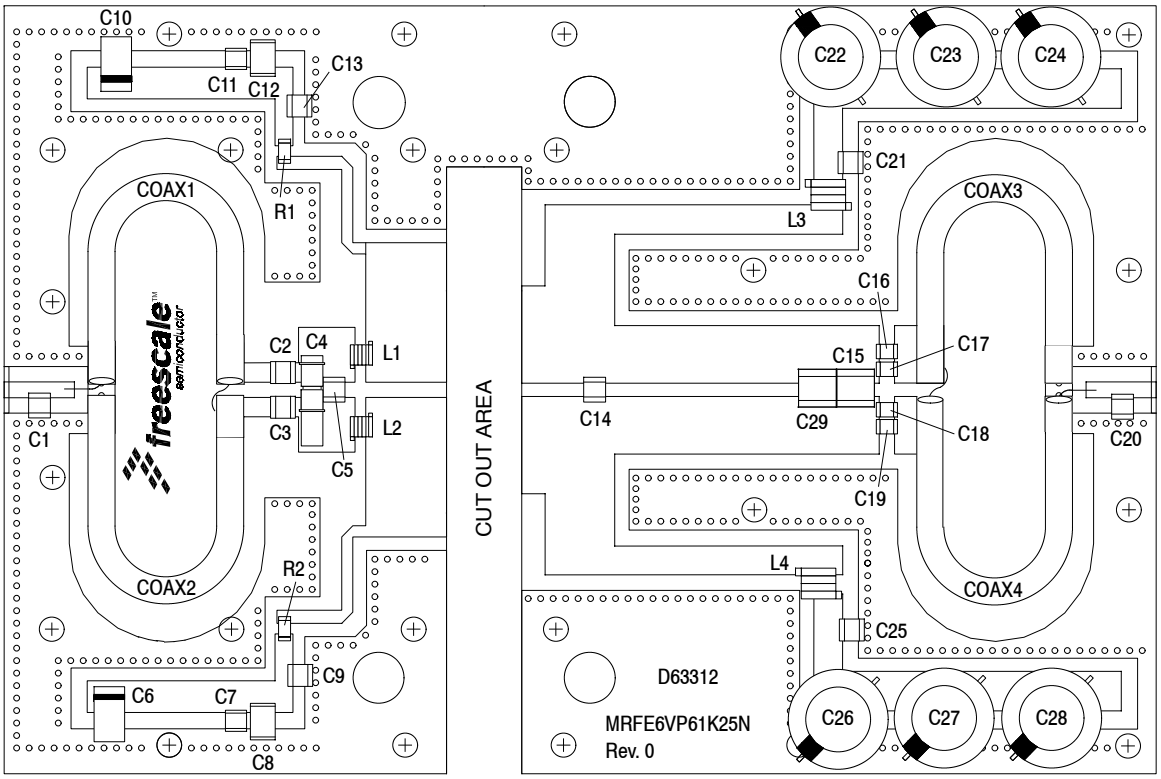


Figure 4. MRFE6VP61K25N Narrowband Test Circuit Component Layout — 230 MHz

Table 8. MRFE6VP61K25N Narrowband Test Circuit Component Designations and Values — 230 MHz

Part	Description	Part Number	Manufacturer
C1	20 pF Chip Capacitor	ATC100B200JT500XT	ATC
C2, C3, C5	27 pF Chip Capacitors	ATC100B270JT500XT	ATC
C4	0.8–8.0 pF Variable Capacitor, Gigatrim	27291SL	Johanson
C6, C10	22 μF, 35 V Tantalum Capacitors	T491X226K035AT	Kemet
C7, C11	0.1 μF Chip Capacitors	CDR33BX104AKWS	AVX
C8, C12	220 nF Chip Capacitors	C1812C224K5RAC-TU	Kemet
C9, C13, C21, C25	1000 pF Chip Capacitors	ATC100B102JT50XT	ATC
C14	39 pF Chip Capacitor	ATC100B390JT500XT	ATC
C15	39 pF Chip Capacitor	ATC100C390JT250XT	ATC
C16, C17, C18, C19	240 pF Chip Capacitors	ATC100B241JT200XT	ATC
C20	9.1 pF Chip Capacitor	ATC100B9R1BT500XT	ATC
C22, C23, C24, C26, C27, C28	470 μF, 63 V Electrolytic Capacitors	MCGPR63V477M13X26-RH	Multicomp
C29	47 pF Chip Capacitor	ATC100C470JT250XT	ATC
Coax1, 2, 3, 4	25 Ω Semi Rigid Coax, 2.2″ Shield Length	UT-141C-25	Micro-Coax
L1, L2	5 nH Inductors	A02TKLC	Coilcraft
L3, L4	6.6 nH Inductors	GA3093-ALC	Coilcraft
R1, R2	10 Ω, 1/4 W Chip Resistors	CRCW120610R0JNEA	Vishay
PCB	Arlon AD255A 0.030″, ε_r = 2.55	D63312	MTL

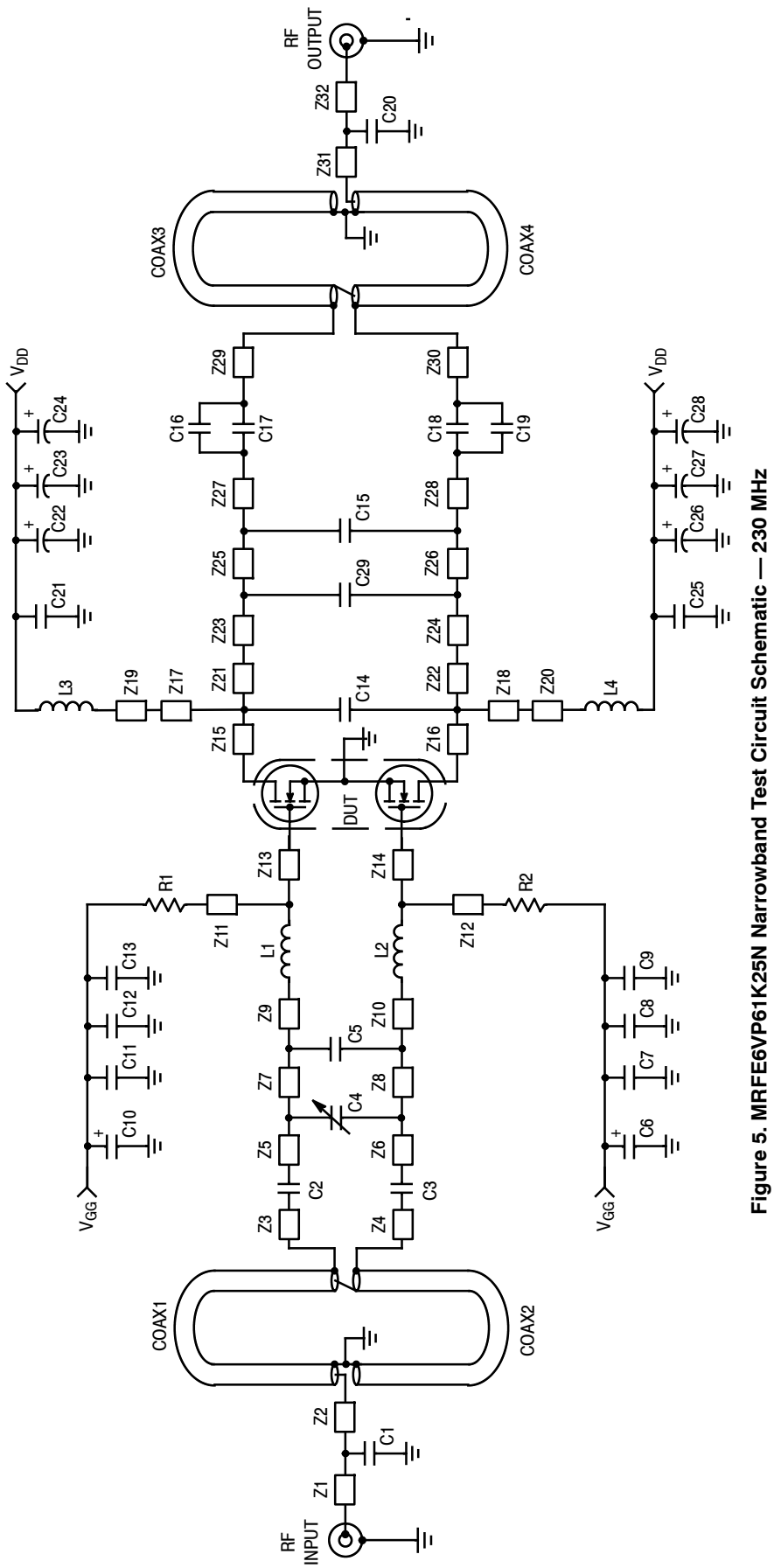


Figure 5. MRFE6VP61K25N Narrowband Test Circuit Schematic — 230 MHz

Table 9. MRFE6VP61K25N Narrowband Test Circuit Microstrips — 230 MHz

Microstrip	Description	Microstrip	Description
Z1	0.192″ × 0.082″ Microstrip	Z17*, Z18*	0.466″ × 0.363″ Microstrip
Z2	0.175″ × 0.082″ Microstrip	Z19*, Z20*	0.187″ × 0.154″ Microstrip
Z3, Z4	0.170″ × 0.100″ Microstrip	Z21, Z22	0.059″ × 0.507″ Microstrip
Z5, Z6	0.116″ × 0.285″ Microstrip	Z23, Z24	1.006″ × 0.300″ Microstrip
Z7, Z8	0.116″ × 0.285″ Microstrip	Z25, Z26	0.247″ × 0.300″ Microstrip
Z9, Z10	0.108″ × 0.285″ Microstrip	Z27, Z28	0.125″ × 0.300″ Microstrip
Z11*, Z12*	0.872″ × 0.058″ Microstrip	Z29, Z30	0.116″ × 0.300″ Microstrip
Z13, Z14	0.412″ × 0.726″ Microstrip	Z31	0.186″ × 0.082″ Microstrip
Z15, Z16	0.416″ × 0.507″ Microstrip	Z32	0.179″ × 0.082″ Microstrip

* Line lengths include microstrip bends

TYPICAL CHARACTERISTICS — 230 MHz

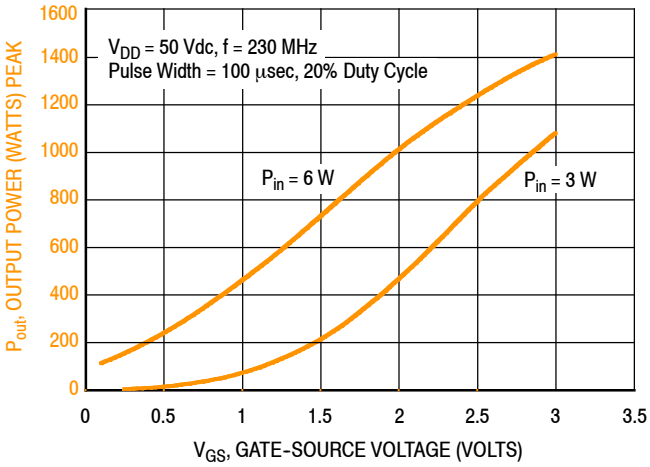
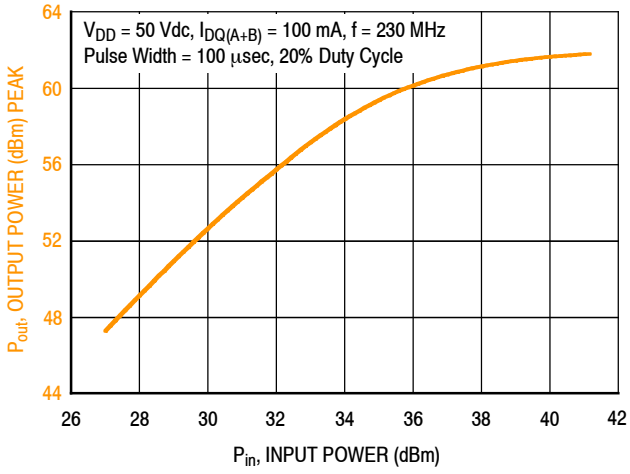


Figure 6. Output Power versus Gate-Source Voltage at a Constant Input Power



f (MHz)	P1dB (W)	P3dB (W)
230	1295	1518

Figure 7. Output Power versus Input Power

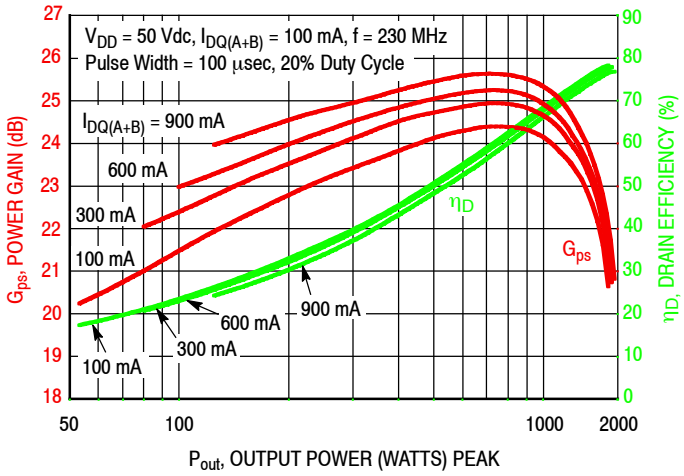


Figure 8. Power Gain and Drain Efficiency versus Output Power and Quiescent Current

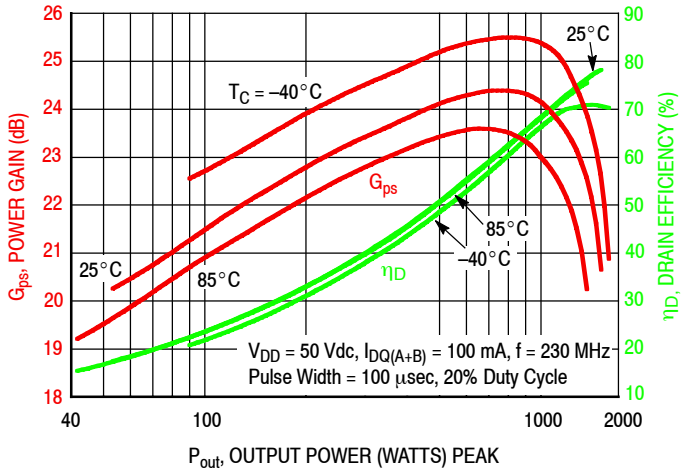


Figure 9. Power Gain and Drain Efficiency versus Output Power

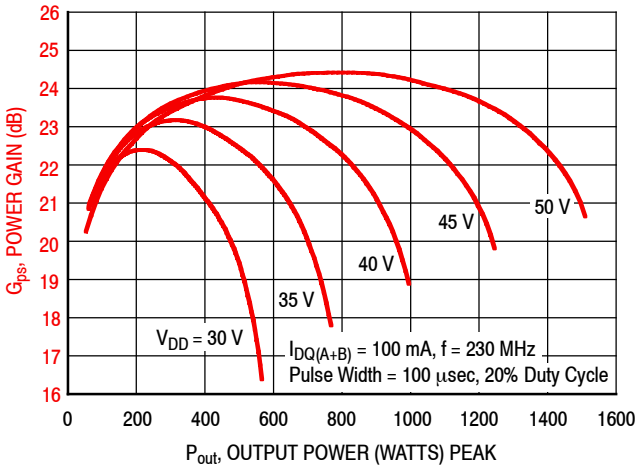


Figure 10. Power Gain versus Output Power and Drain-Source Voltage

230 MHz NARROWBAND PRODUCTION TEST FIXTURE

f MHz	Z_{source} Ω	Z_{load} Ω
230	2.10 + j3.70	2.55 + j1.90

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.

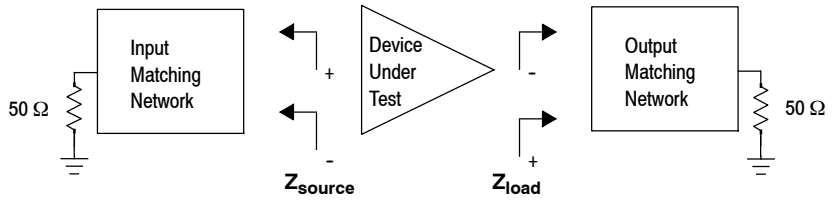


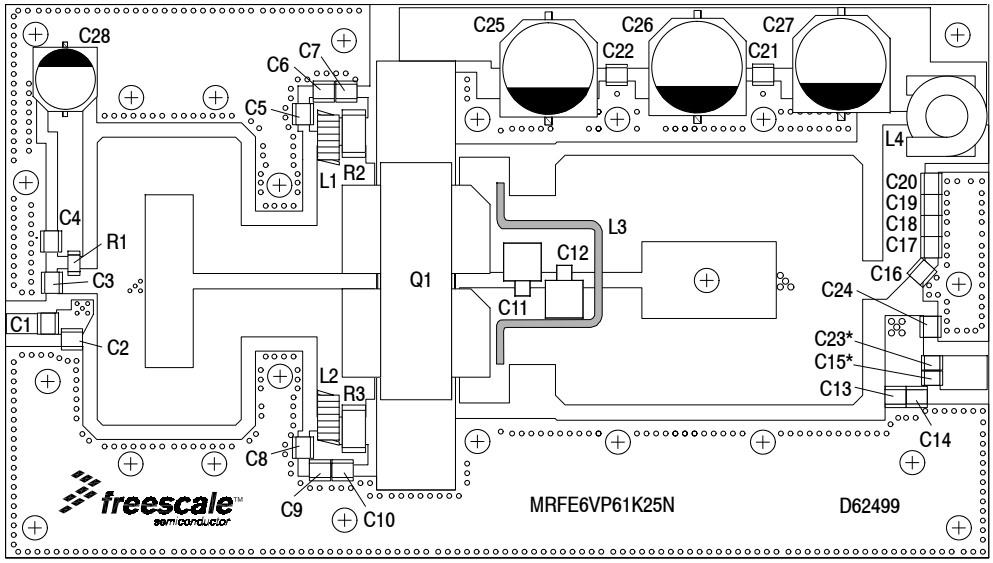
Figure 11. Narrowband Series Equivalent Source and Load Impedance — 230 MHz

87.5–108 MHz BROADBAND REFERENCE CIRCUIT

Table 10. 87.5–108 MHz Broadband Performance (In Freescale Reference Circuit, 50 ohm system)
V_{DD} = 50 Vdc, $I_{DQ(A+B)}$ = 250 mA, P_{in} = 5 W, CW

Frequency (MHz)	G_{ps} (dB)	η_D (%)	P_{out} (W)
87.5	23.8	78.3	1212
98	24.1	77.6	1309
108	23.6	77.8	1161

87.5–108 MHz BROADBAND REFERENCE CIRCUIT — 2.88″ × 5.11″ (73.1 mm × 130 mm)



*C15 and C23 are mounted vertically.

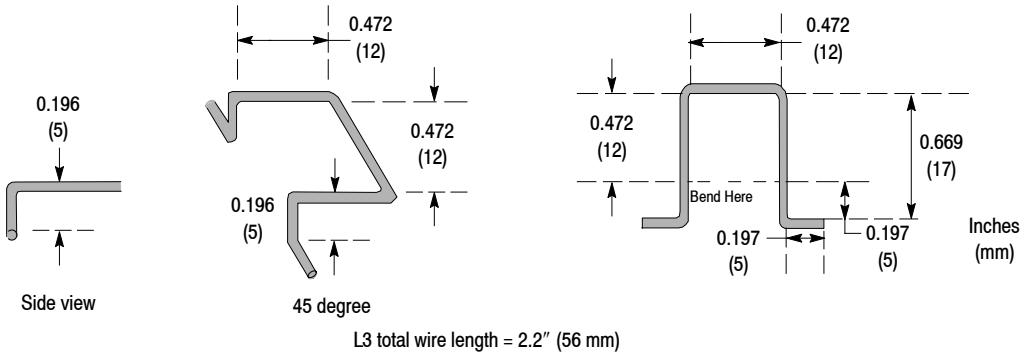


Figure 12. MRFE6VP61K25N 87.5–108 MHz Broadband Reference Circuit Component Layout

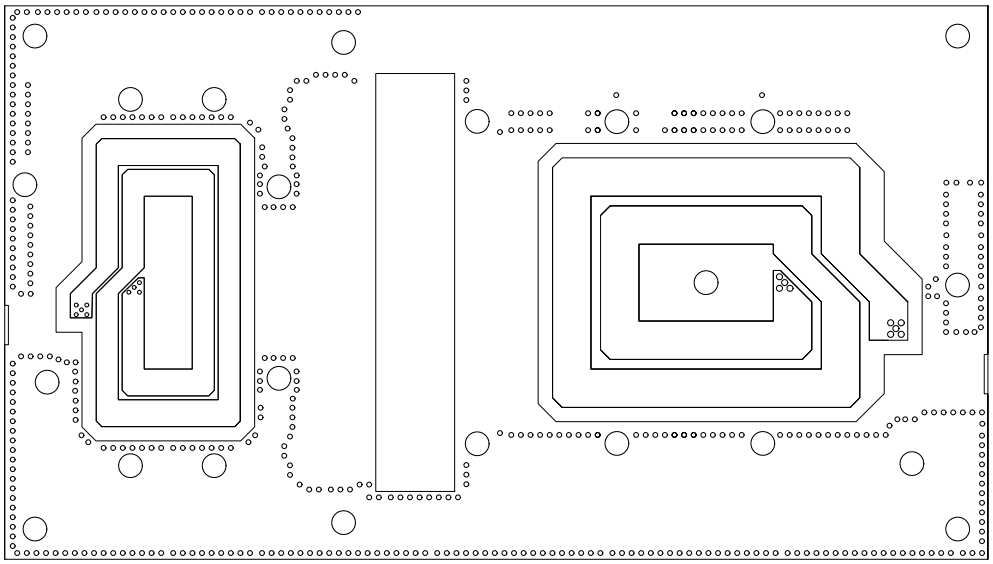


Figure 13. MRFE6VP61K25N 87.5–108 MHz Broadband Reference Circuit Component Layout — Bottom

87.5–108 MHz BROADBAND REFERENCE CIRCUIT

Table 11. MRFE6VP61K25N 87.5–108 MHz Broadband Reference Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1, C3, C6, C9, C18, C19, C20, C21, C22	1000 pF Chip Capacitors	ATC100B102JT50XT	ATC
C2	22 pF Chip Capacitor	ATC100B220JT500XT	ATC
C4, C5, C8	10000 pF Chip Capacitors	ATC200B103KT50XT	ATC
C7, C10, C15, C16, C17, C23	470 pF Chip Capacitors	ATC100B471JT200XT	ATC
C11	100 pF, 300 V Mica	MIN02-002EC101J-F	CDE
C12	15 pF, 300 V Mica	MIN02-002CC150J-F	CDE
C13	6.2 pF Chip Capacitor	ATC100B6R2BT500XT	ATC
C14	15 pF Chip Capacitor	ATC100B150JT500XT	ATC
C24	12 pF Chip Capacitor	ATC100B120JT500XT	ATC
C25, C26, C27	220 μF, 63 V Electrolytic Capacitors	EEU-FC1J221	Panasonic
C28	22 μF, 35 V Electrolytic Capacitor	UUD1V220MCL1GS	Nichicon
L1, L2	17.5 nH Inductors, 6 Turns	B06TJLC	Coilcraft
L3	1.5 mm Non-Tarnish Silver Plated Copper Wire, Total Wire Length = 2.2″/56 mm	SP1500NT-001	—
L4	22 nH Inductor	1212VS-22NMEB	Coilcraft
Q1	RF Power LDMOS Transistor	MRFE6VP61K25NR6	Freescale
R1	10 Ω, 1/4 W Chip Resistor	CRCW120610R0JNEA	Vishay
R2, R3	33 Ω, 2 W Chip Resistors	1-2176070-3	TE Connectivity
PCB	Arlon TC350 0.030″, ε_r = 3.5	D62499	MTL

Note: Refer to MRFE6VP61K25N's printed circuit boards and schematics to download the 87.5–108 MHz heatsink drawing.

TYPICAL CHARACTERISTICS — 87.5–108 MHz BROADBAND REFERENCE CIRCUIT

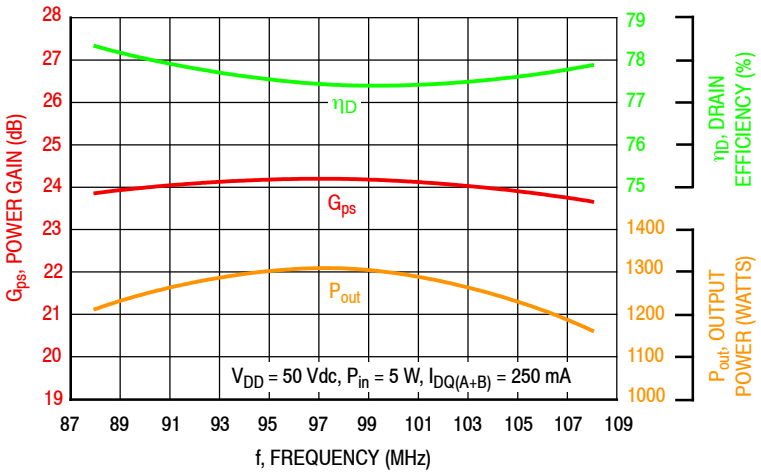


Figure 14. Power Gain, Drain Efficiency and CW Output Power versus Frequency

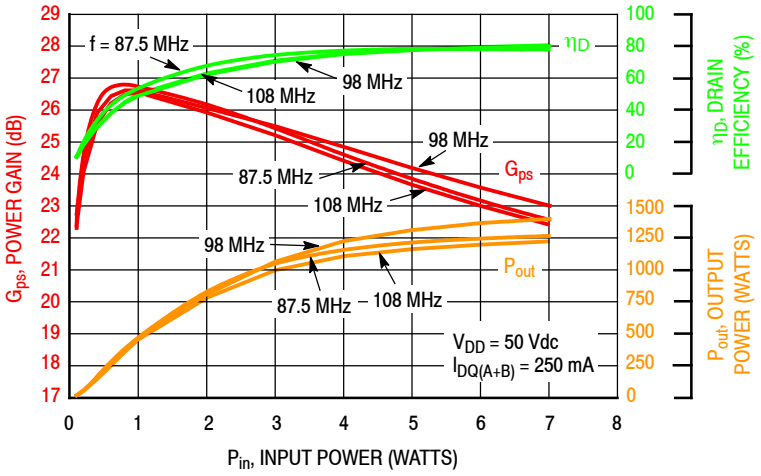
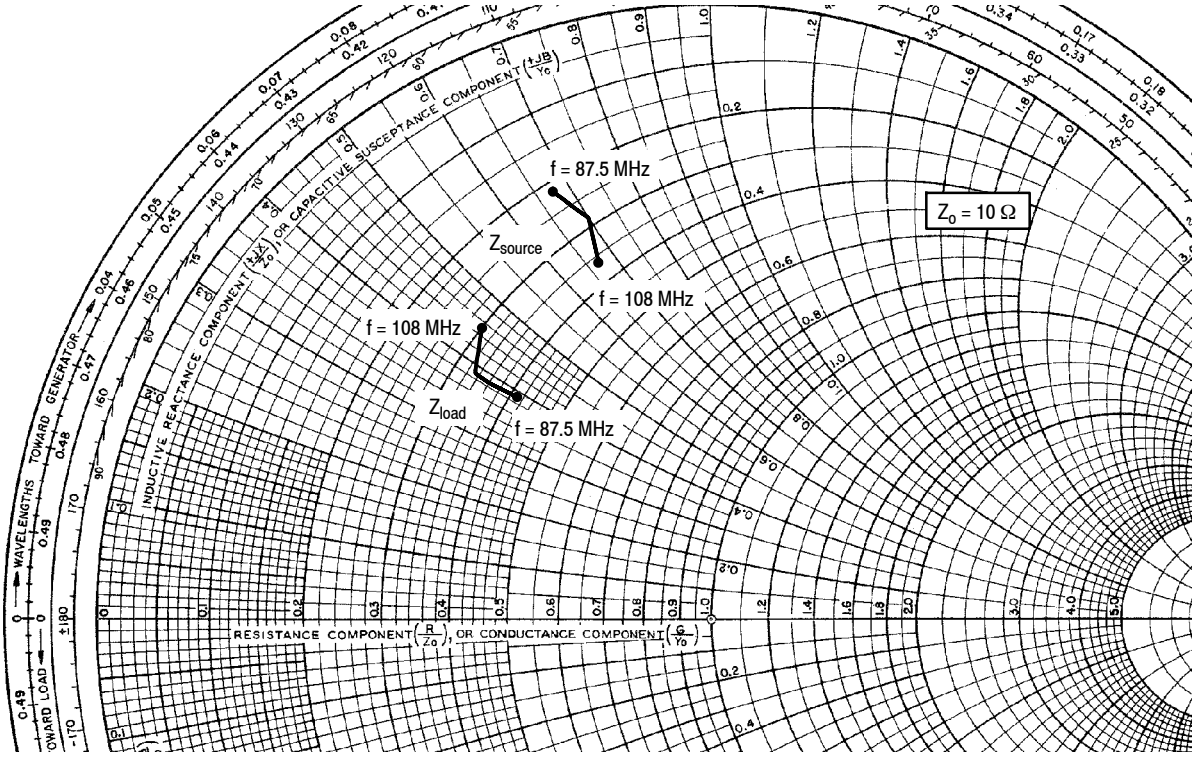


Figure 15. Power Gain, Drain Efficiency and CW Output Power versus Input Power and Frequency

87.5–108 MHz BROADBAND REFERENCE CIRCUIT



f MHz	Z_{source} Ω	Z_{load} Ω
87.5	2.10 + j6.67	4.11 + j3.87
98	2.80 + j6.96	3.33 + j3.85
108	3.60 + j6.65	2.97 + j4.45

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.

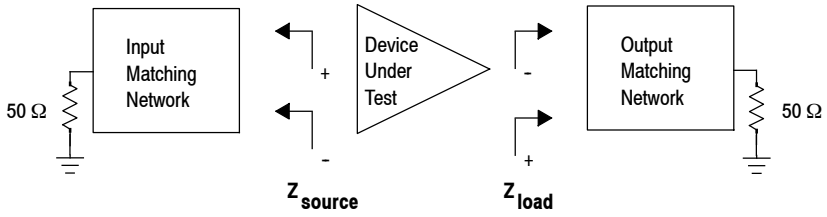
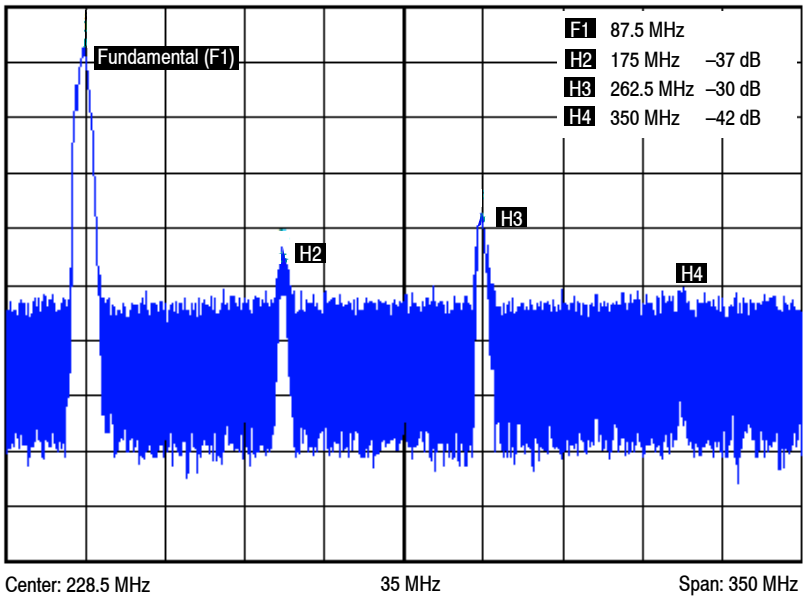


Figure 16. Broadband Series Equivalent Source and Load Impedance — 87.5–108 MHz

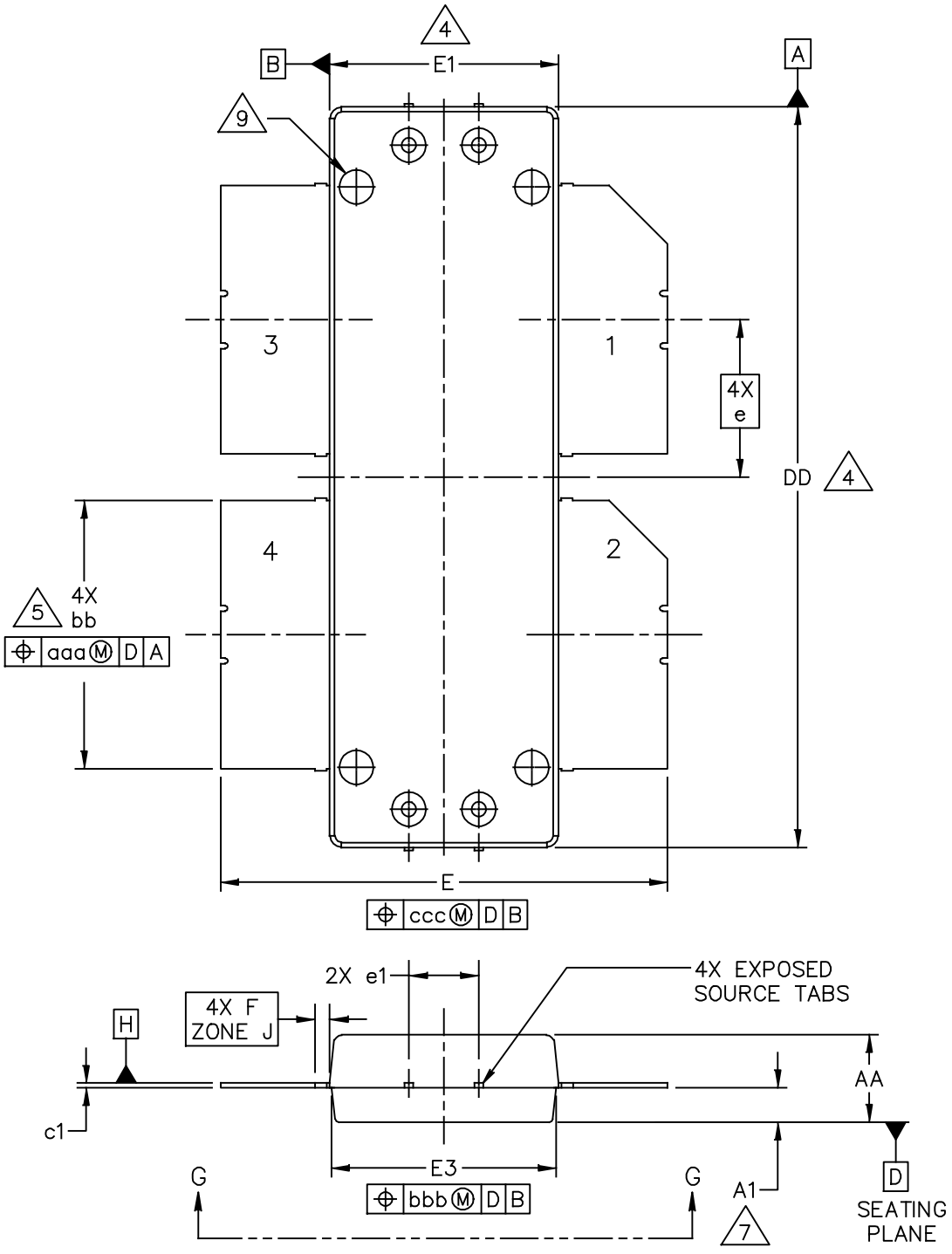
HARMONIC MEASUREMENTS — 87.5–108 MHz
BROADBAND REFERENCE CIRCUIT



H2 (175 MHz)	H3 (262.5 MHz)	H4 (350 MHz)
–37 dB	–30 dB	–42 dB

Figure 17. 87.5 MHz Harmonics @ 1215 W CW

PACKAGE DIMENSIONS



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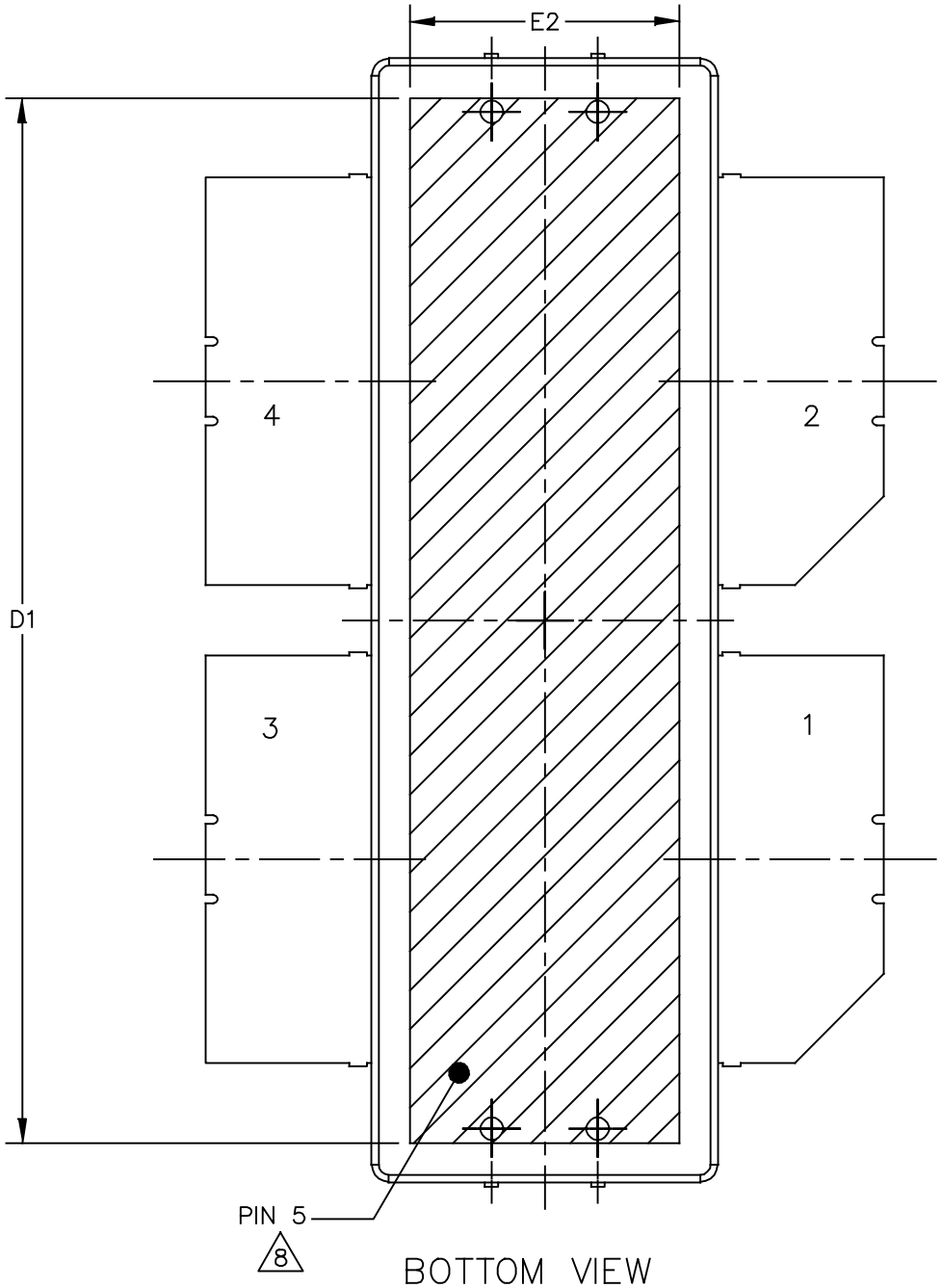
	STANDARD: NON−JEDEC	
	03 DEC 2014	



BOTTOM VIEW
VIEW G–G

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TITLE: OM–1230–4L	DOCUMENT NO: 98ASA00506D	REV: B
	STANDARD: NON–JEDEC	
	03 DEC 2014	

NOTES:

1. CONTROLLING DIMENSION: INCH
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M–1994.
3. DATUM PLANE H IS LOCATED AT 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 DD AND E1 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 INCH (0.15 MM) PER SIDE. DIMENSIONS DD AND E1 DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H.
5. DIMENSION bb DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 INCH (0.13 MM) TOTAL IN EXCESS OF THE bb DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUMS A AND B TO BE DETERMINED AT DATUM PLANE H.
7. DIMENSION A1 APPLIES WITHIN ZONE J ONLY.
8. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG. THE DIMENSIONS D1 AND E2 REPRESENT THE VALUES BETWEEN THE TWO OPPOSITE POINTS ALONG THE EDGES OF EXPOSED AREA OF HEAT SLUG.
9. DIMPLED HOLE REPRESENTS INPUT SIDE.

DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX
AA	.148	.152	3.76	3.86	bb	.457	.463	11.61	11.76
A1	.059	.065	1.50	1.65	c1	.007	.011	0.18	0.28
DD	1.267	1.273	32.18	32.33	e	.270 BSC		6.86 BSC	
D1	1.180	----	29.97	----	e1	.116	.124	2.95	3.15
E	.762	.770	19.35	19.56					
E1	.390	.394	9.91	10.01	aaa	.004		0.10	
E2	.306	----	7.77	----	bbb	.006		0.15	
E3	.383	.387	9.73	9.83	ccc	.010		0.25	
F	.025 BSC		0.635 BSC						

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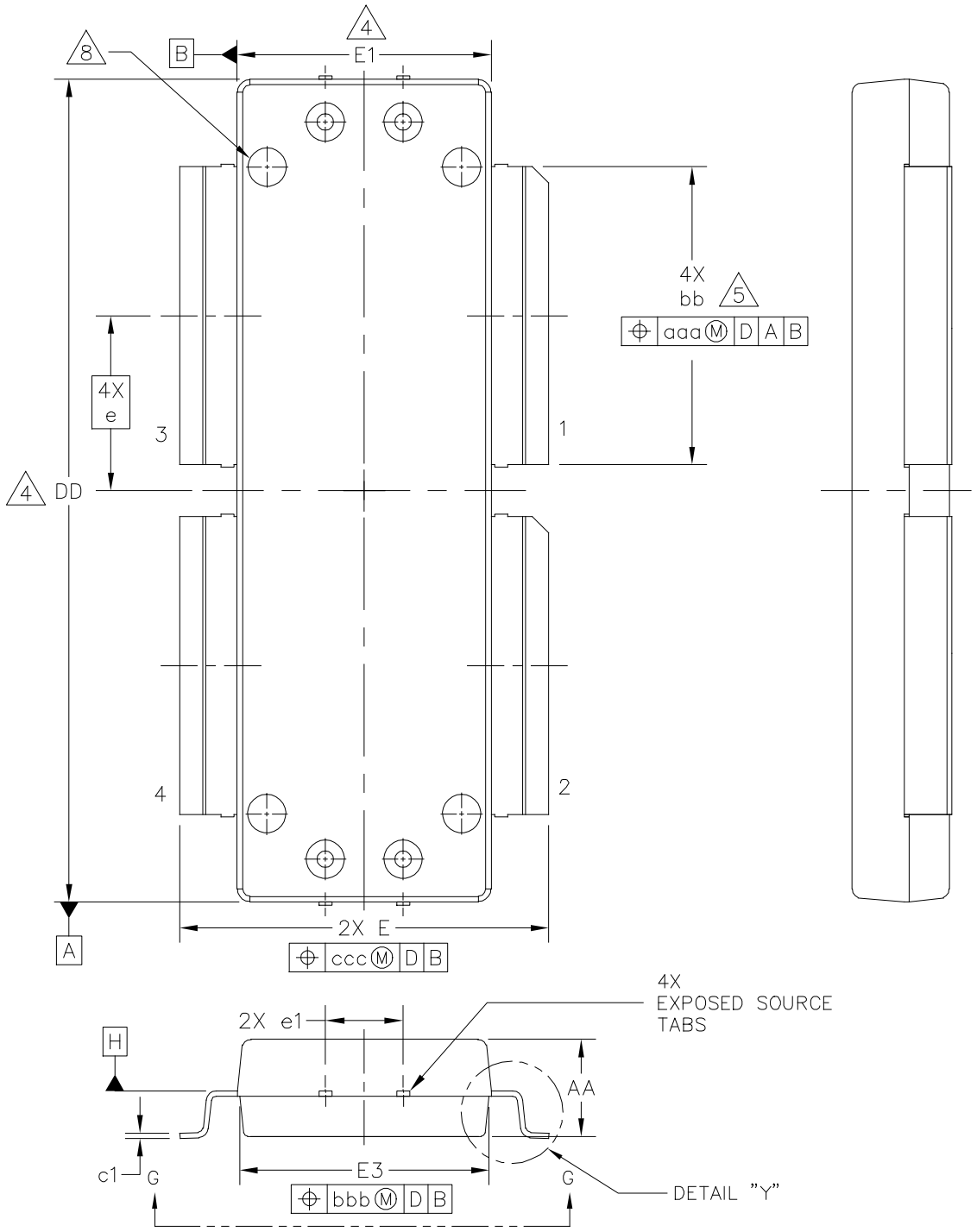

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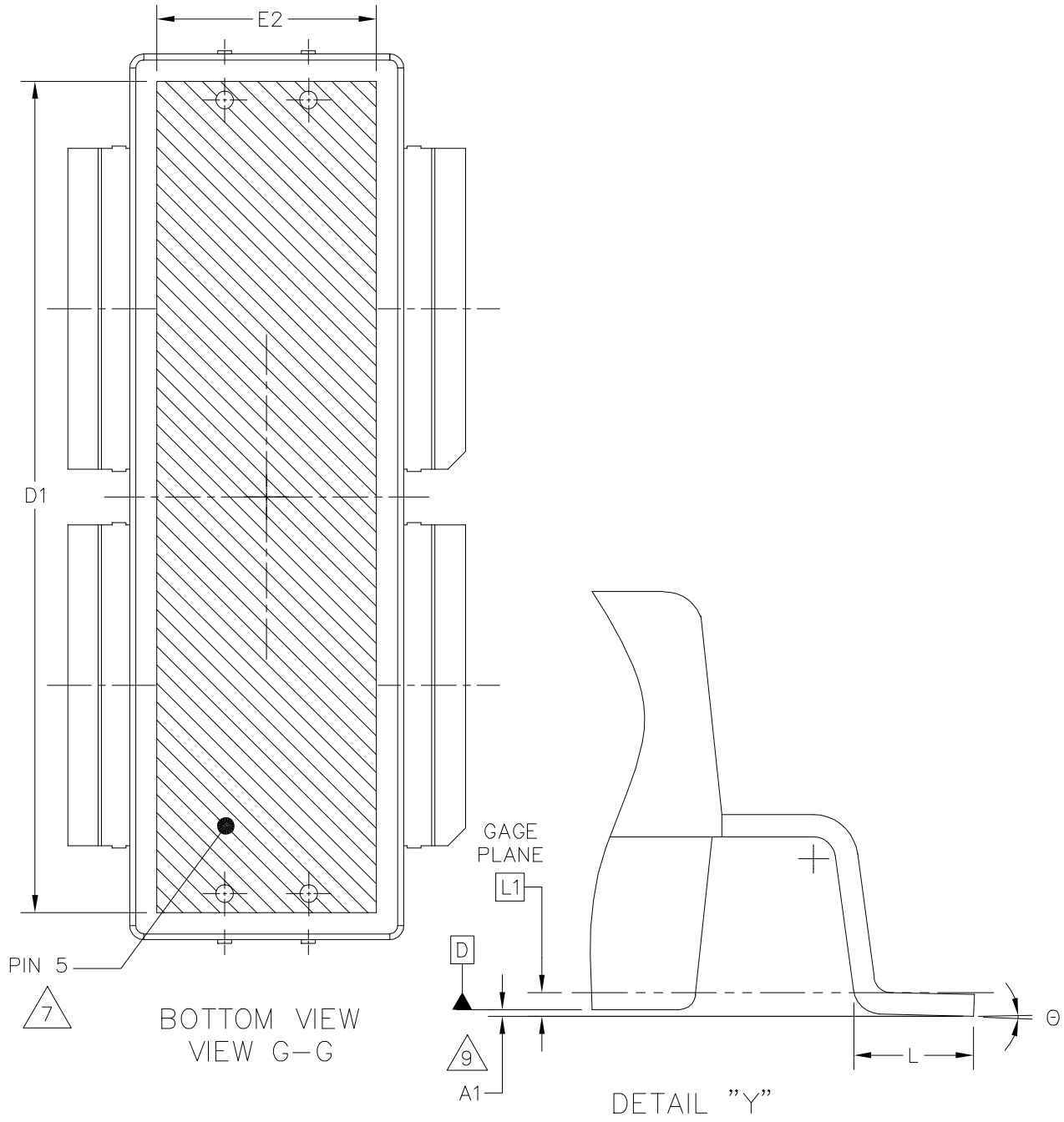

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NOTES:

1. CONTROLLING DIMENSION: INCH

2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M−1994.

3. DATUM PLANE H IS LOCATED AT 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 DD AND E1 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 INCH (0.15 MM) PER SIDE. DIMENSIONS DD AND E1 DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H.

5. DIMENSION bb DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 INCH (0.13 MM) TOTAL IN EXCESS OF THE bb DIMENSION AT MAXIMUM MATERIAL CONDITION.

6. DATUMS A AND B TO BE DETERMINED AT DATUM PLANE H.

7. HATCHING REPRESENTS THE EXPOSED AND SOLDERABLE AREA OF THE HEAT SLUG. THE DIMENSIONS D1 AND E2 REPRESENT THE VALUES BETWEEN THE TWO OPPOSITE POINTS ALONG THE EDGES OF EXPOSED AREA OF HEAT SLUG.

8. DIMPLED HOLE REPRESENTS INPUT SIDE.

9. DIMENSION A1 IS MEASURED WITH REFERENCE TO DATUM D. THE POSITIVE VALUE IMPLIES THAT THE BOTTOM OF THE PACKAGE IS HIGHER THAN THE BOTTOM OF THE LEAD.

	INCH		MILLIMETER			INCH		MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
AA	.148	.152	3.76	3.86	bb	.457	.463	11.61	11.76
A1	−.003	.003	−0.08	0.08	c1	.007	.011	0.18	0.28
DD	1.267	1.273	32.18	32.33	e	.270 BSC		6.86 BSC	
D1	1.180	----	29.97	----	e1	.116	.124	2.95	3.15
E	.563	.575	14.30	14.61	Θ	0°	8°	0°	8°
E1	.390	.394	9.91	10.01	aaa	.004		0.10	
E2	.306	----	7.77	----	bbb	.006		0.15	
E3	.383	.387	9.73	9.83	ccc	.010		0.25	
L	.034	.046	0.86	1.17					
L1	.010 BSC		0.25 BSC						

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PRODUCT DOCUMENTATION, SOFTWARE AND TOOLS

Refer to the following resources to aid your design process.

Application Notes

- AN1907: Solder Reflow Attach Method for High Power RF Devices in Over-Molded Plastic Packages
- AN1955: Thermal Measurement Methodology of RF Power Amplifiers

Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

White Paper

- RFPLASTICWP: Designing with Plastic RF Power Transistors

Software

- Electromigration MTTF Calculator
- RF High Power Model
- .s2p File

Development Tools

- Printed Circuit Boards

To Download Resources Specific to a Given Part Number:

1. Go to http://www.freescale.com/rf
2. Search by part number
3. Click part number link
4. Choose the desired resource from the drop down menu

REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	Feb. 2015	• Initial Release of Data Sheet
1	Feb. 2015	• Table 2, Maximum Ratings: added Total Device Dissipation, p. 2 • Table 3, Thermal Characteristics: added CW Thermal Resistance, p. 2 • Added Fig. 11, Narrowband Series Equivalent Source and Load Impedance - 230 MHz, p. 8
2	Apr. 2015	• Added part number MRFE6VP61K25GN, p. 1 • Added OM-1230G-4L package photo, p. 1, and Mechanical Outline, pp. 18-20

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