Freescale Semiconductor
Technical Data

Document Number: MRFE6VP6600N
Rev. 0, 5/2015

RF Power LDMOS Transistors

High Ruggedness N-Channel Enhancement-Mode Lateral MOSFETs

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 (1,3)	CW	600 CW	24.0	81.8
230 (2)	Pulse (100 μsec, 20% Duty Cycle)	600 Peak	24.7	73.5

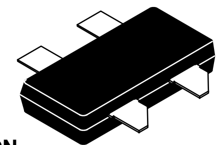
Load Mismatch/Ruggedness

Frequency (MHz)	Signal Type	VSWR	P_{in} (W)	Test Voltage	Result
230 (2)	Pulse (100 μsec, 20% Duty Cycle)	> 65:1 at all Phase Angles	4.0 Peak (3 dB Overdrive)	50	No Device Degradation

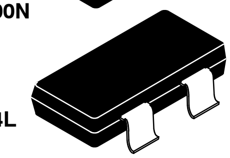
1. Measured in 87.5–108 MHz broadband reference circuit.
2. Measured in 230 MHz narrowband production test circuit.
3. The values shown are the center band performance numbers across the indicated frequency range.

MRFE6VP6600N
MRFE6VP6600GN

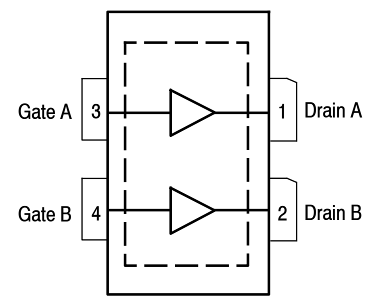
1.8–600 MHz, 600 W CW, 50 V WIDEBAND RF POWER LDMOS TRANSISTORS



OM-780-4L
PLASTIC
MRFE6VP6600N



OM-780G-4L
PLASTIC
MRFE6VP6600GN



(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

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

Table 2. Thermal Characteristics

Characteristic	Symbol	Value [2,3]	Unit
Thermal Impedance, Junction to Case Pulse: Case Temperature 78°C, 600 W Pulse, 100 μsec Pulse Width, 20% Duty Cycle, $I_{DQ(A+B)}$ = 100 mA, 230 MHz	$Z_{\theta JC}$	0.033	°C/W

Table 3. ESD Protection Characteristics

Test Methodology	Class
Human Body Model (per JESD22-A114)	Class 2, passes 2500 V
Machine Model (per EIA/JESD22-A115)	Class B, passes 200 V
Charge Device Model (per JESD22-C101)	Class 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 = 50 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 = 888 μAdc)	$V_{GS(th)}$	1.7	2.2	2.7	Vdc
Gate Quiescent Voltage (V_{DD} = 50 Vdc, I_D = 100 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	2.0	2.6	3.0	Vdc
Drain-Source On-Voltage [4] (V_{GS} = 10 Vdc, I_D = 1 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. 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 (1)					
Reverse Transfer Capacitance (V_{DS} = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	2.4	—	pF
Output Capacitance (V_{DS} = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	98	—	pF
Input Capacitance (V_{DS} = 50 Vdc, V_{GS} = 0 Vdc ± 30 mV(rms)ac @ 1 MHz)	C_{iss}	—	290	—	pF
Functional Tests (2) (In Freescale Production Test Fixture, 50 ohm system) V_{DD} = 50 Vdc, $I_{DQ(A+B)}$ = 100 mA, P_{out} = 600 W Peak (120 W Avg.), f = 230 MHz, 100 μsec Pulse Width, 20% Duty Cycle					
Power Gain	G_{ps}	23.3	24.7	26.6	dB
Drain Efficiency	η_D	70	73.5	—	%
Input Return Loss	IRL	—	–15	–9	dB

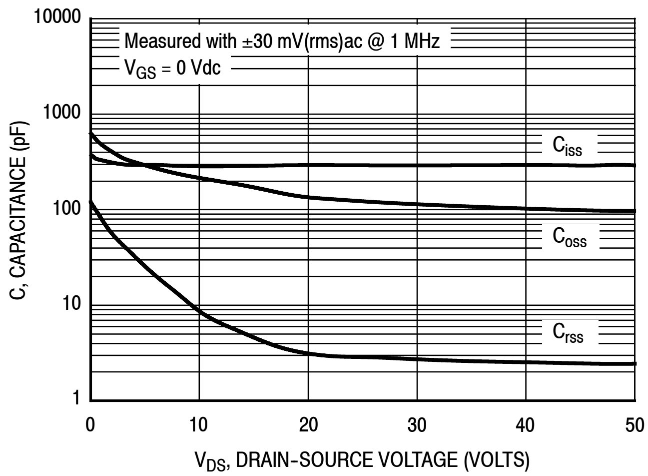
Table 6. Load Mismatch/Ruggedness (In Freescale Production Test Fixture, 50 ohm system) $I_{DQ(A+B)}$ = 100 mA

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	4.0 Peak (3 dB Overdrive)	50	No Device Degradation

Table 7. Ordering Information

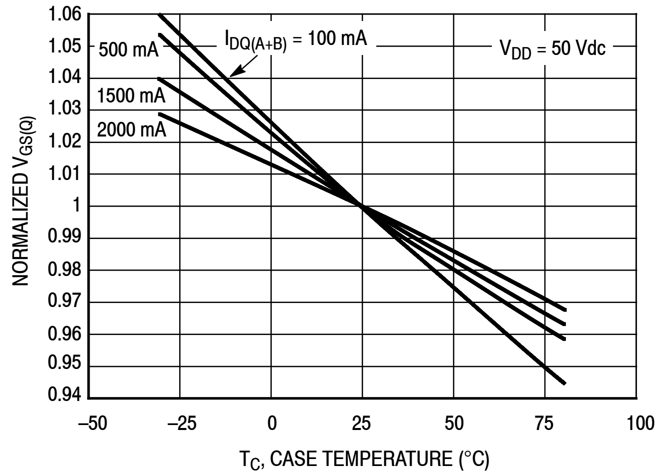
Device	Tape and Reel Information	Package
MRFE6VP6600NR3	R3 Suffix = 250 Units, 32 mm Tape Width, 13-inch Reel	OM-780-4L
MRFE6VP6600GNR3		OM-780G-4L

1. Each side of device measured separately.
2. Measurements made with device in straight lead configuration before any lead forming operation is applied. Lead forming is used for gull wing (GN) parts.



Note: Each side of device measured separately.

Figure 2. Capacitance versus Drain-Source Voltage



I_{DQ} (mA)	Slope (mV/°C)
100	–2.554
500	–2.254
1500	–1.973
2000	–1.573

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

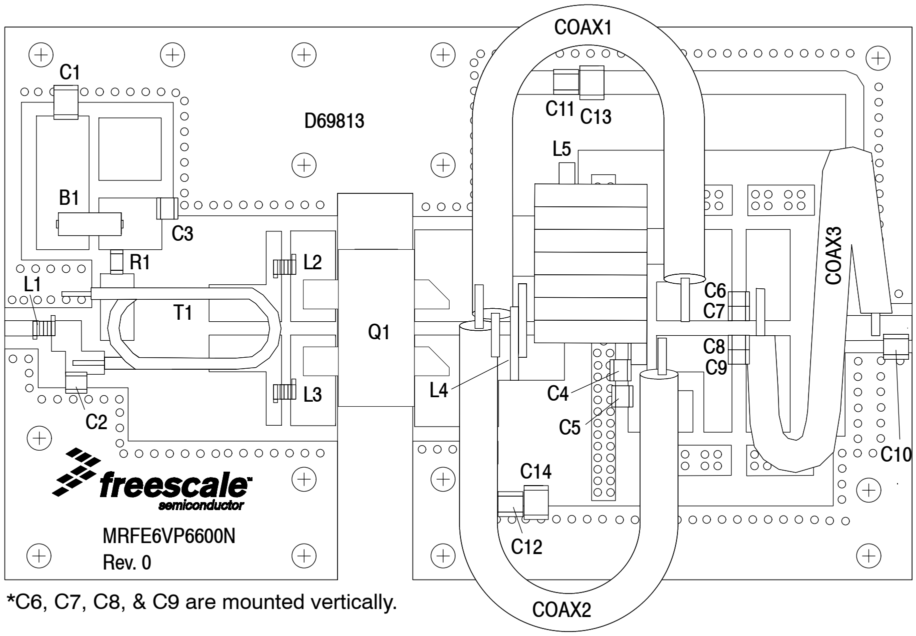
87.5–108 MHz BROADBAND REFERENCE CIRCUIT — 4.73″ × 2.88″ (12.0 cm × 7.32 cm)

Table 8. 87.5–108 MHz Broadband Performance (In Freescale Reference Circuit, 50 ohm system)

V_{DD} = 50 Vdc, $I_{DQ(A+B)}$ = 150 mA, P_{in} = 3 W, CW

Frequency (MHz)	G_{ps} (dB)	η_D (%)	P_{out} (W)
87.5	23.8	82.4	722
98	24.0	81.8	746
108	23.5	80.9	679

87.5–108 MHz BROADBAND REFERENCE CIRCUIT — 4.73″ × 2.88″ (12.0 cm × 7.32 cm)



*C6, C7, C8, & C9 are mounted vertically.

Figure 4. MRFE6VP6600N 87.5–108 MHz Broadband Reference Circuit Component Layout

Table 9. MRFE6VP6600N 87.5–108 MHz Broadband Reference Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
B1	95 Ω, 100 MHz, Long RF Bead	2743021447	Fair-Rite
C1	6.8 μF Chip Capacitor	C4532X7R1H685M250KB	TDK
C2	33 pF Chip Capacitor	ATC100B330JT500XT	ATC
C3, C6, C7, C8, C9, C11, C12	1000 pF Chip Capacitors	ATC100B102JT50XT	ATC
C4, C5	470 pF Chip Capacitors	ATC100B471JT200XT	ATC
C10	8.2 pF Chip Capacitor	ATC100B8R2CT500XT	ATC
C13, C14	2.2 μF Chip Capacitors	HMK432B7225KM-T	Taiyo Yuden
Coax1, Coax2	Coax Cable, 12 Ω, 4.72″ (12 cm) Shield Length	TC-12	Communication Concepts, RF Power Systems
Coax3	Coax Cable, 50 Ω, 6.69″ (17 cm) Shield Length, 2 Loops, ≈ 0.750″ (19 mm) ∅ (FEP)	Sucoform 141	Huber & Suhner
L1	100 nH Inductor	1812SMS-R10JLC	Coilcraft
L2, L3	8.0 nH, 3 Turn Inductors	A03TKLC	Coilcraft
L4	2 Turns, #14 AWG Copper Loop, ID = 0.26″ (7 mm) Inductor, Hand Wound	Copper Wire	
L5	7 Turns, #14 AWG Copper Loop, ID = 0.39″ (10 mm) Inductor, Hand Wound	Copper Wire	
Q1	RF Power LDMOS Transistor	MRFE6VP6600NR3	Freescale
R1	11 Ω, 1/4 W Chip Resistor	CRCW120611R0FKEA	Vishay
T1	TUI-LF-9 Transformer	TUI-LF-9	Communication Concepts, RF Power Systems
PCB	Arlon TC-350, ε_r = 3.50, 0.03″	D69813	Shenzhen Multilayer PCB Technology Co.

TYPICAL CHARACTERISTICS — 87.5–108 MHz
BROADBAND REFERENCE CIRCUIT

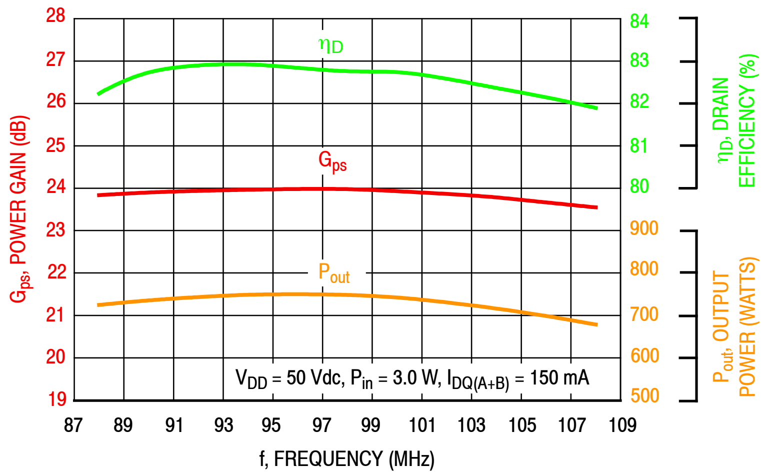


Figure 5. Power Gain, Pout and Drain Efficiency versus Frequency

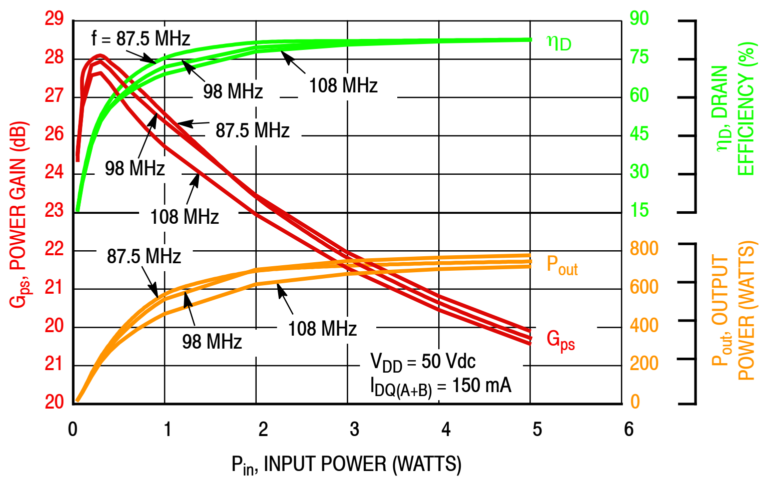
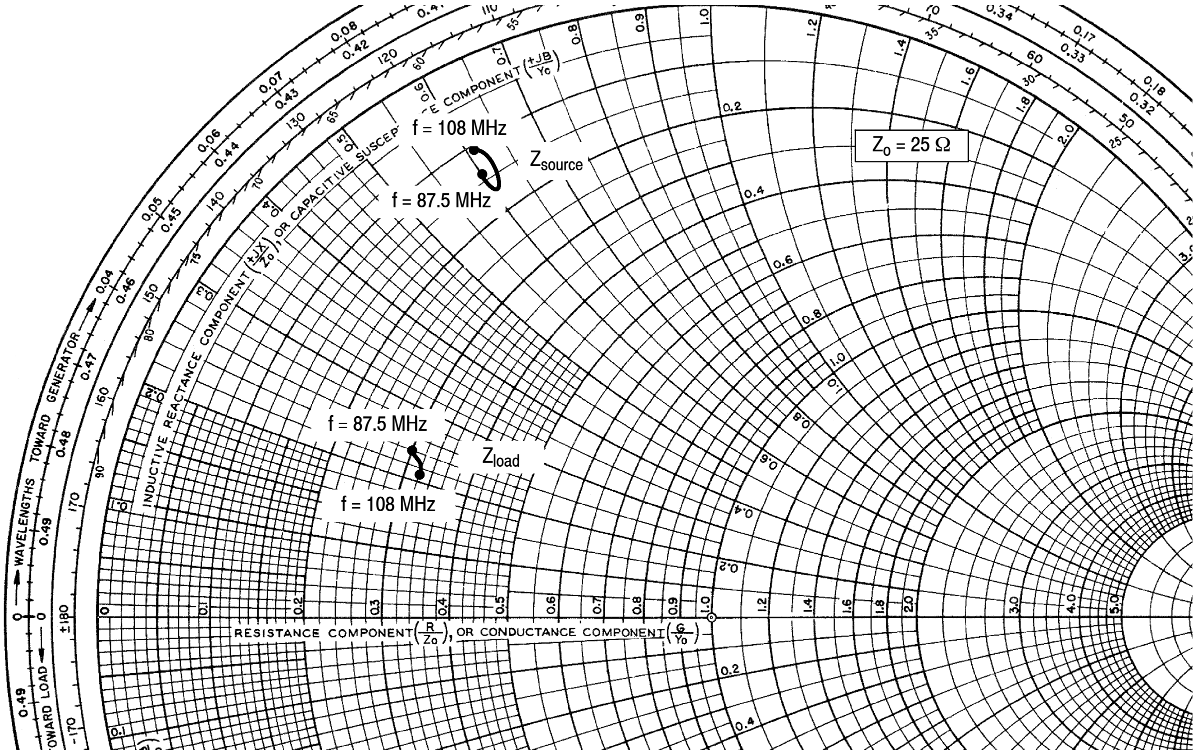


Figure 6. Power Gain, Drain Efficiency and CW Output Power versus Input Power and Frequency



f MHz	Z_{source} Ω	Z_{load} Ω
87.5	3.4 + j15.0	7.5 + j6.12
98	3.9 + j14.9	7.9 + j5.57
108	2.8 + j15.3	8.0 + j5.19

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.

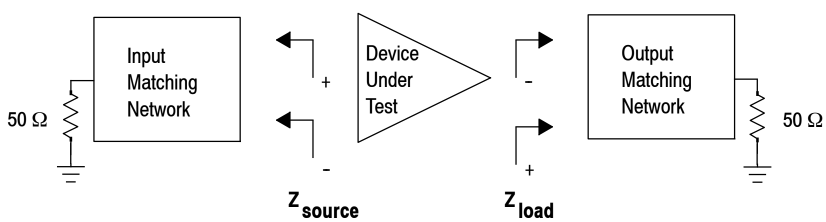


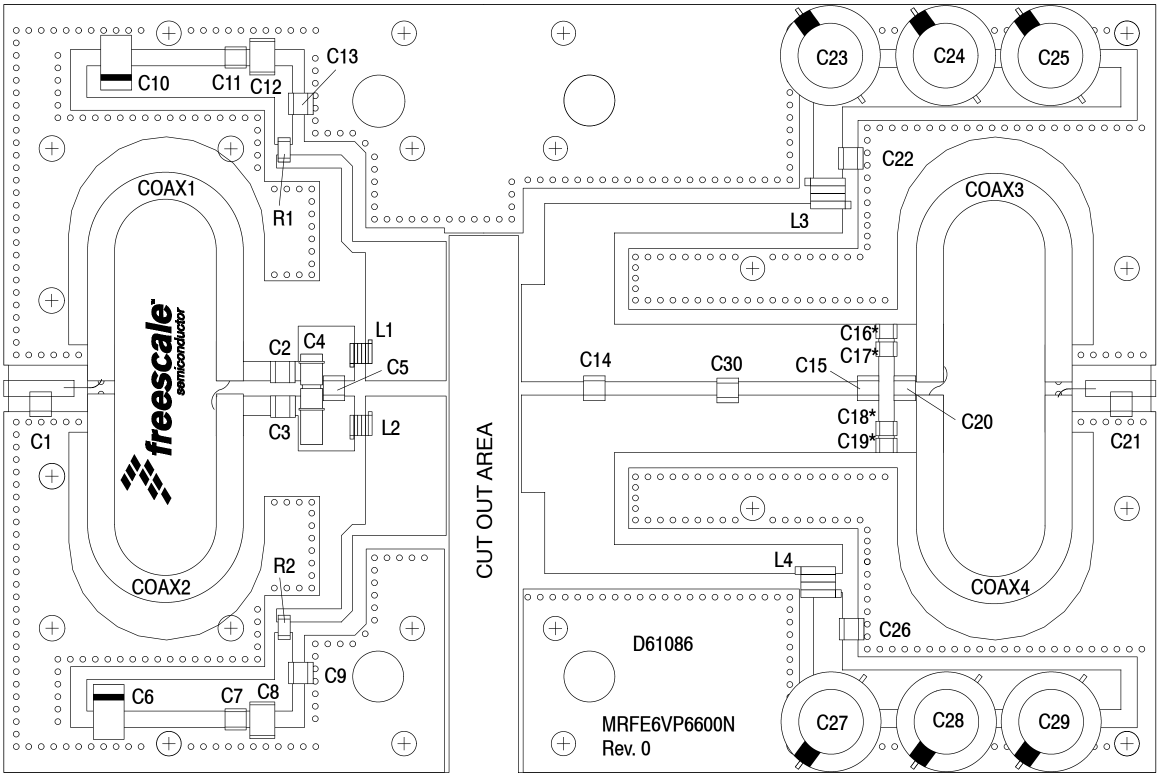
Figure 7. Broadband Series Equivalent Source and Load Impedance — 87.5–108 MHz

230 MHz NARROWBAND PRODUCTION TEST FIXTURE — 4″ × 6″ (10.16 cm × 15.24 cm)

Table 10. 230 MHz Narrowband Performance [1] V_{DD} = 50 Vdc, $I_{DQ(A+B)}$ = 100 mA, P_{out} = 600 W Peak (120 W Avg.), f = 230 MHz, 100 μsec Pulse Width, 20% Duty Cycle

Characteristic	Symbol	Min	Typ	Max	Unit
Power Gain	G_{ps}	23.3	24.7	26.6	dB
Drain Efficiency	η_D	70	73.5	—	%
Input Return Loss	IRL	—	–15	–9	dB

1. Measurements made with device in straight lead configuration before any lead forming operation is applied. Lead forming is used for gull wing (GN) parts.



* C16, C17, C18, and C19 are vertically mounted

Figure 8. MRFE6VP6600N Narrowband Test Circuit Component Layout — 230 MHz

Table 11. MRFE6VP6600N Narrowband Test Circuit Component Designations and Values — 230 MHz

Part	Description	Part Number	Manufacturer
C1	12 pF Chip Capacitor	ATC100B120JT500XT	ATC
C2, C3	27 pF Chip Capacitors	ATC100B270JT500XT	ATC
C4	0.8–8.0 pF Variable Capacitor, Gigatrim	27291SL	Johanson
C5	33 pF Chip Capacitor	ATC100B330JT500XT	ATC
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, C22, C26	1000 pF Chip Capacitors	ATC100B102JT50XT	ATC
C14,C20	39 pF Chip Capacitors	ATC100B390JT500XT	ATC
C15	30 pF Chip Capacitor	ATC100B300JT500XT	ATC
C16, C17, C18, C19	240 pF Chip Capacitors	ATC100B241JT200XT	ATC
C21	13 pF Chip Capacitor	ATC100B130JT500XT	ATC
C23, C24, C25, C27, C28, C29	470 μF, 63 V Electrolytic Capacitors	MCGPR63V477M13X26-RH	Multicomp
C30	16 pF Chip Capacitor	ATC100B160JT500XT	ATC
Coax1, 2, 3, 4	25 Ω Semi-Rigid Coax, 2.2″ (5.6 mm) 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	D61086	MTL

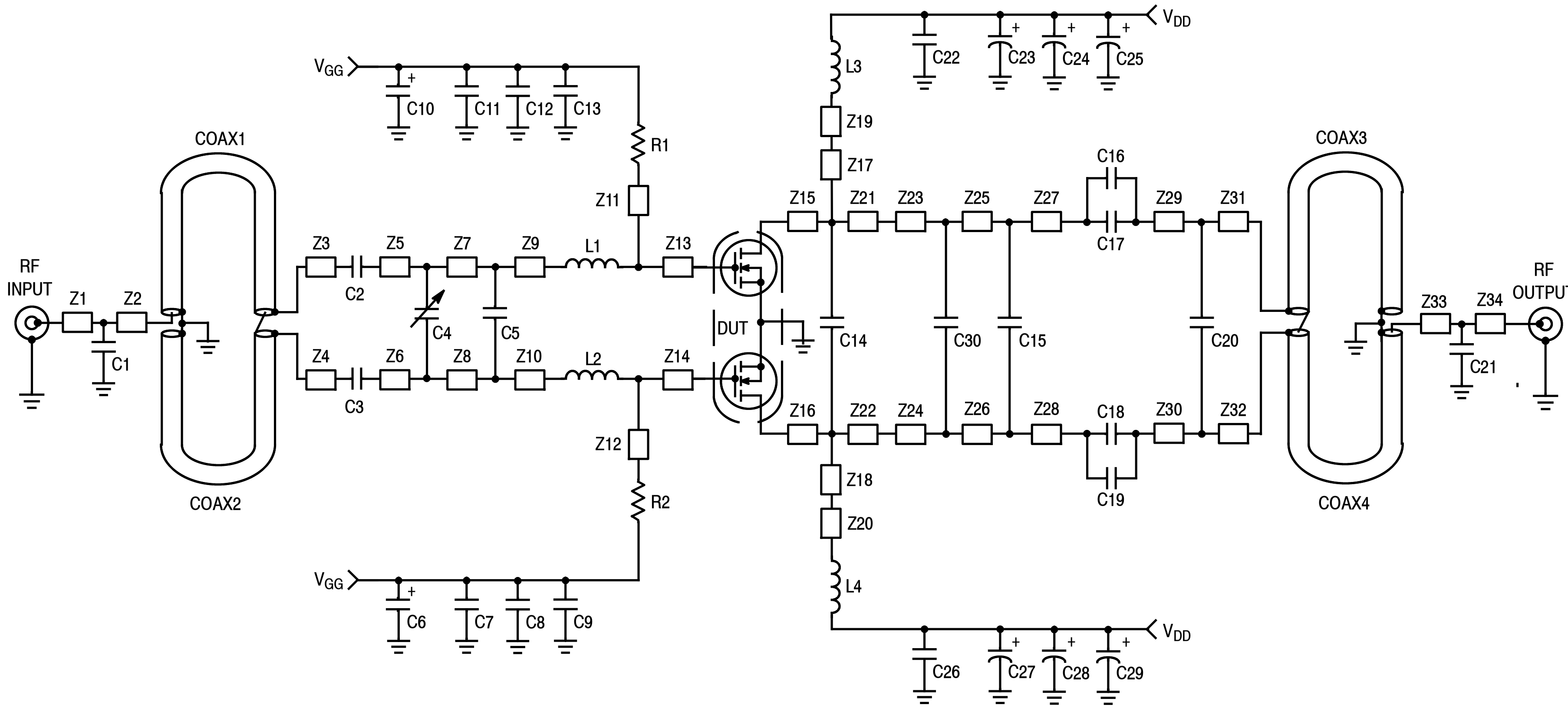


Figure 9. MRFE6VP6600N Narrowband Test Circuit Schematic — 230 MHz

Table 12. MRFE6VP6600N Narrowband Test Circuit Microstrips — 230 MHz

Microstrip	Description	Microstrip	Description
Z1	0.192″ × 0.082″ Microstrip	Z19*, Z20*	1.187″ × 0.154″ Microstrip
Z2	0.175″ × 0.082″ Microstrip	Z21, Z22	0.104″ × 0.507″ Microstrip
Z3, Z4	0.170″ × 0.100″ Microstrip	Z23, Z24	0.590″ × 0.300″ Microstrip
Z5, Z6	0.116″ × 0.285″ Microstrip	Z25, Z26	0.731″ × 0.300″ Microstrip
Z7, Z8	0.116″ × 0.285″ Microstrip	Z27, Z28	0.056″ × 0.300″ Microstrip
Z9, Z10	0.108″ × 0.285″ Microstrip	Z29, Z30	0.055″ × 0.300″ Microstrip
Z11*, Z12*	0.872″ × 0.058″ Microstrip	Z31, Z32	0.061″ × 0.300″ Microstrip
Z13, Z14	0.412″ × 0.726″ Microstrip	Z33	0.186″ × 0.082″ Microstrip
Z15, Z16	0.371″ × 0.507″ Microstrip	Z34	0.179″ × 0.082″ Microstrip
Z17*, Z18*	0.422″ × 0.363″ Microstrip		

* Line lengths include microstrip bends

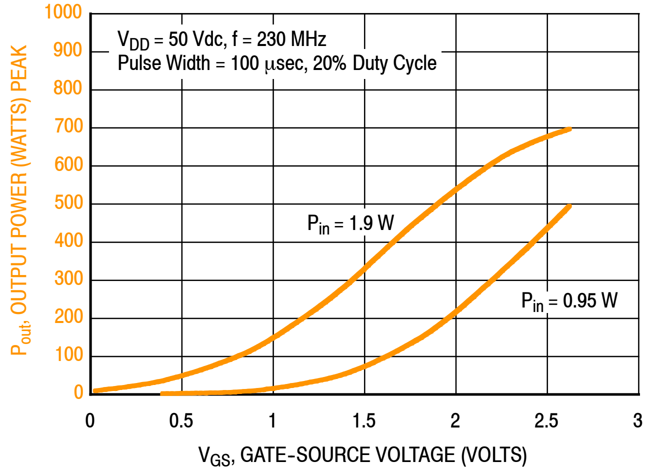
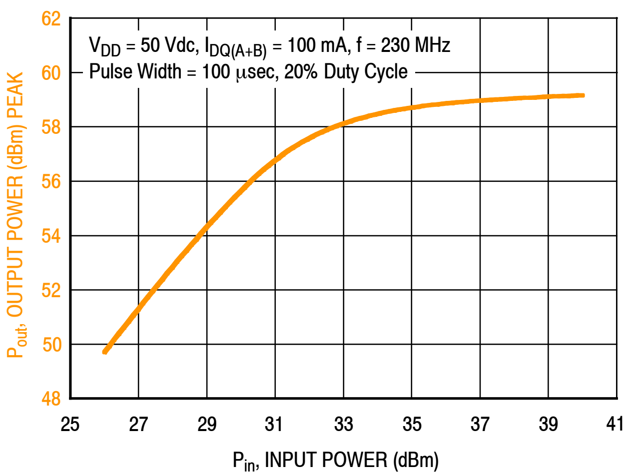


Figure 10. Output Power versus Gate-Source Voltage at a Constant Input Power



f (MHz)	P1dB (W)	P3dB (W)
230	682	771

Figure 11. Output Power versus Input Power

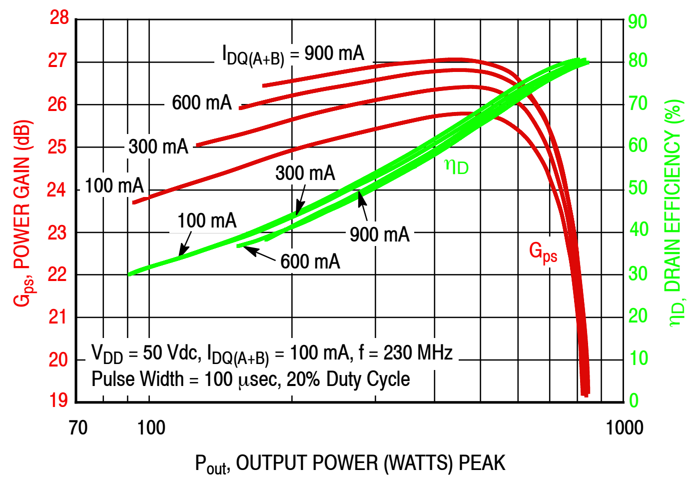


Figure 12. Power Gain and Drain Efficiency versus Output Power and Quiescent Current

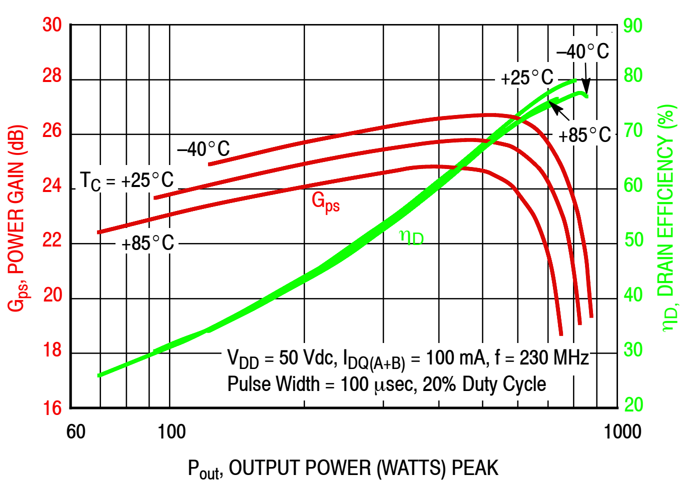


Figure 13. Power Gain and Drain Efficiency versus Pulse Output Power

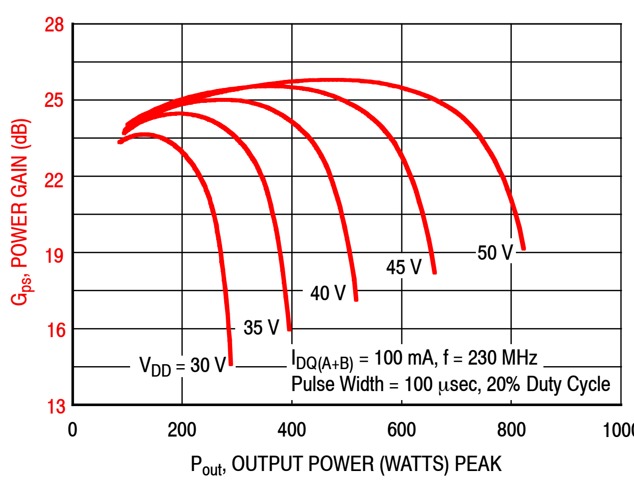


Figure 14. Power Gain versus Output Power and Drain-Source Voltage

230 MHz NARROWBAND PRODUCTION TEST FIXTURE

f MHz	Z_{source} Ω	Z_{load} Ω
230	1.9 + j4.8	4.0 + j4.0

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.

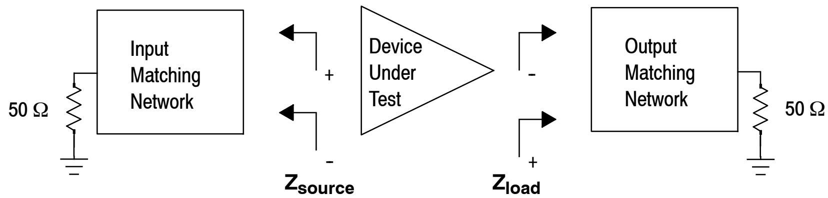
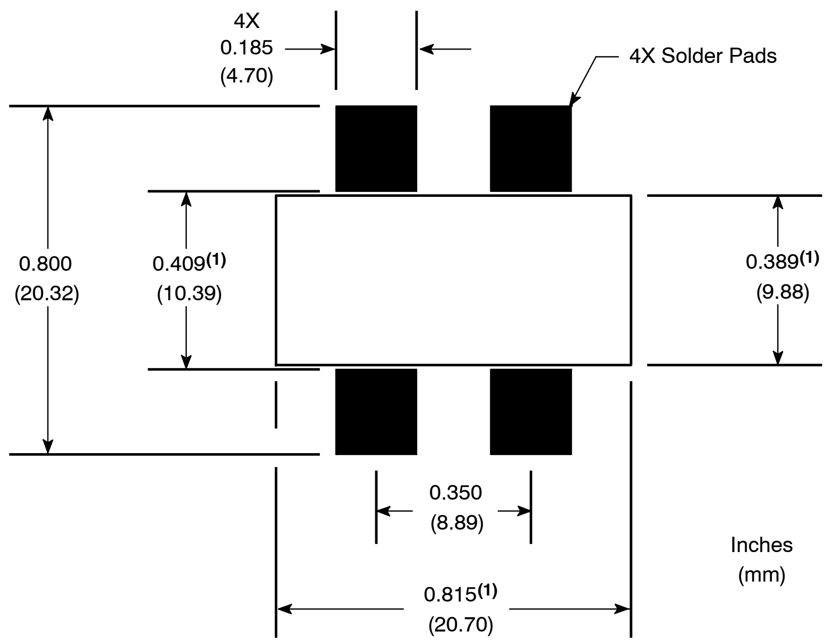


Figure 15. Narrowband Series Equivalent Source and Load Impedance — 230 MHz

PCB PAD LAYOUTS



1. Slot dimensions are minimum dimensions and exclude milling tolerances.

Figure 16. PCB Pad Layout for OM-780-4L

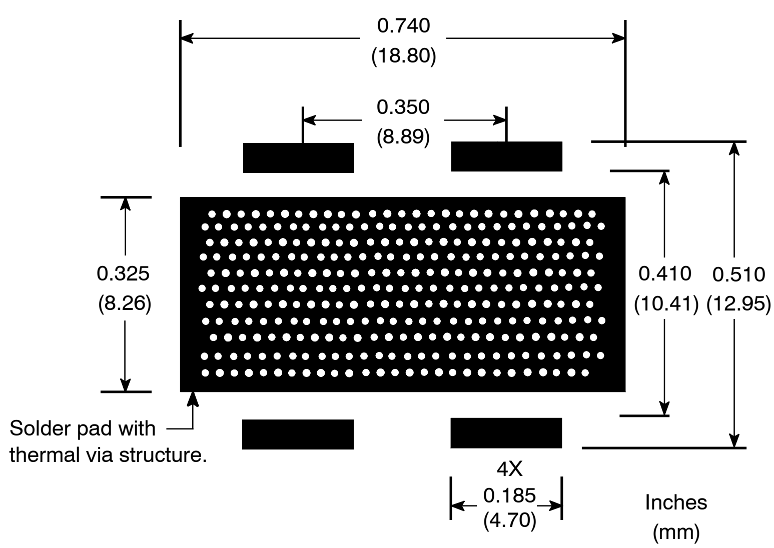
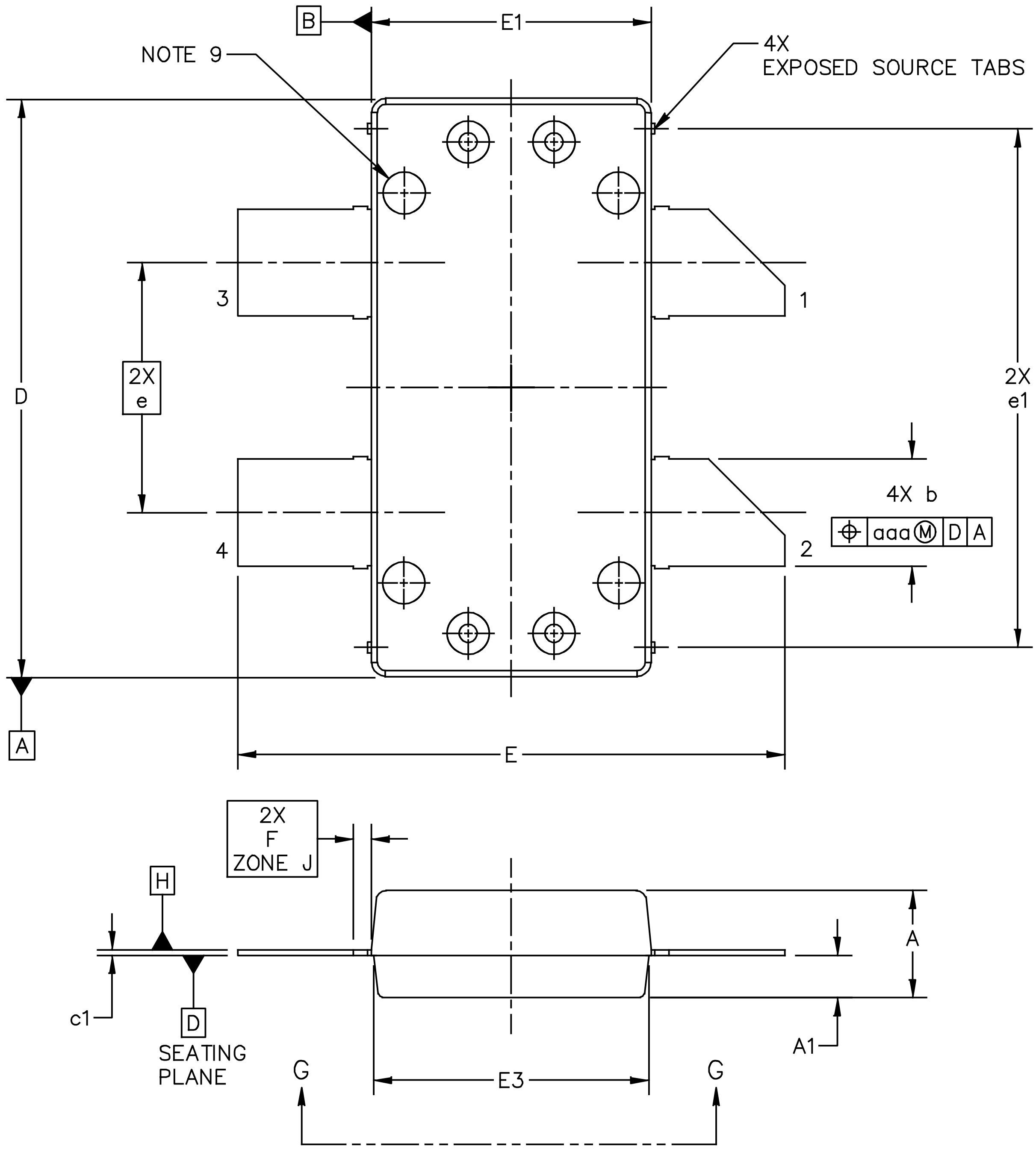


Figure 17. PCB Pad Layout for OM-780G-4L

PACKAGE DIMENSIONS



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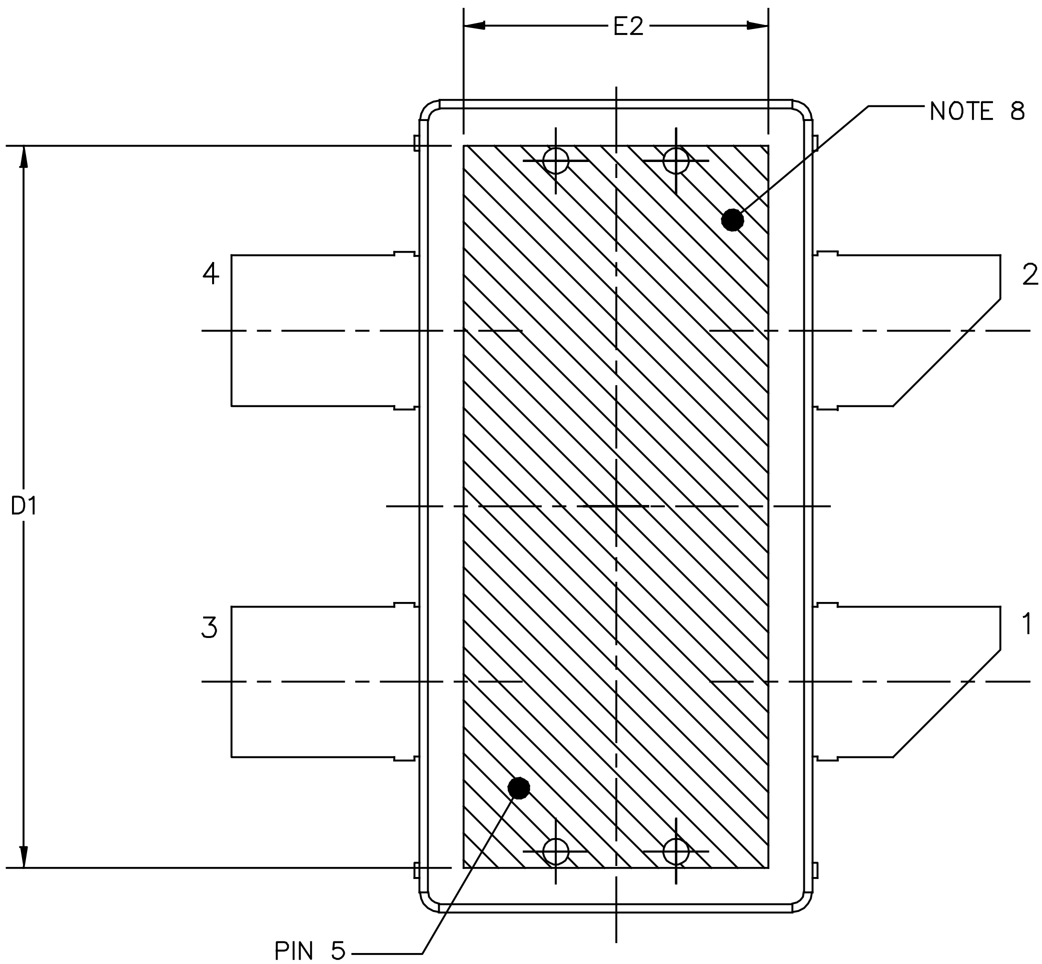
TITLE: OM780–4 STRAIGHT LEAD	DOCUMENT NO: 98ASA10833D		REV: A
	CASE NUMBER: 2023–02		10 FEB 2010
	STANDARD: NON–JEDEC		



BOTTOM VIEW
VIEW G–G

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TITLE: OM780–4 STRAIGHT LEAD	DOCUMENT NO: 98ASA10833D	REV: A
	CASE NUMBER: 2023–02	10 FEB 2010
	STANDARD: NON–JEDEC	

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 "D" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 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 SHALL BE .005 TOTAL IN EXCESS OF THE b 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.

	INCH		MILLIMETER			INCH		MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
A	0.148	.152	3.76	3.86	b	.147	.153	3.73	3.89
A1	.059	.065	1.50	1.65	c1	.007	.011	0.18	0.28
D	.808	.812	20.52	20.62	e	.350 BSC		8.89 BSC	
D1	.720	----	18.29	----	e1	.721	.729	18.31	18.52
E	.762	.770	19.36	19.56					
E1	.390	.394	9.91	10.01	aaa	.004		0.10	
E2	.306	----	7.77	----					
E3	.383	.387	9.72	9.83					
F	.025 BSC		0.635 BSC						

MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE

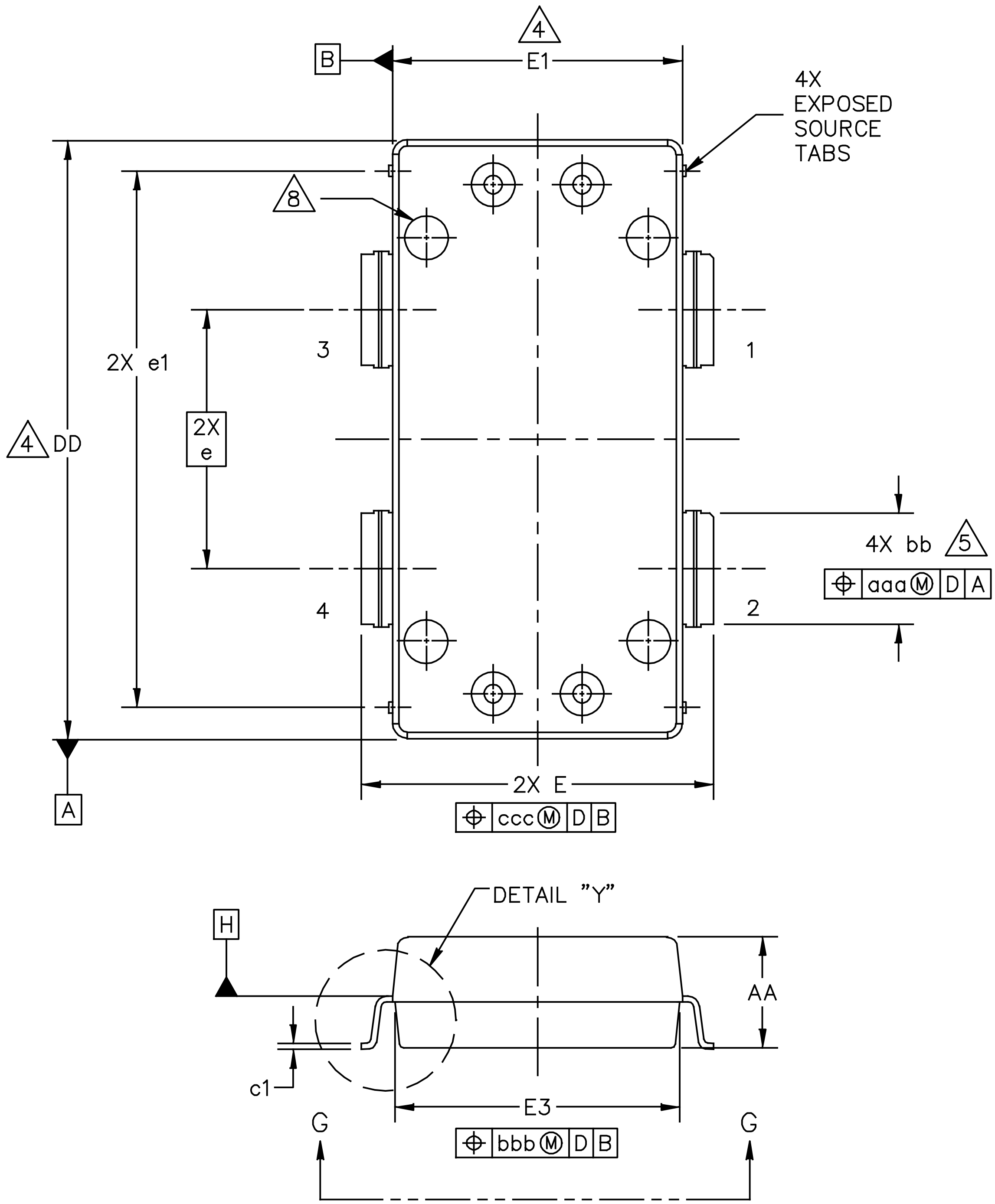
TITLE: OM780–4 STRAIGHT LEAD

DOCUMENT NO: 98ASA10833D | REV: A

CASE NUMBER: 2023–02 | 10 FEB 2010

STANDARD: NON–JEDEC

PACKAGE DIMENSIONS



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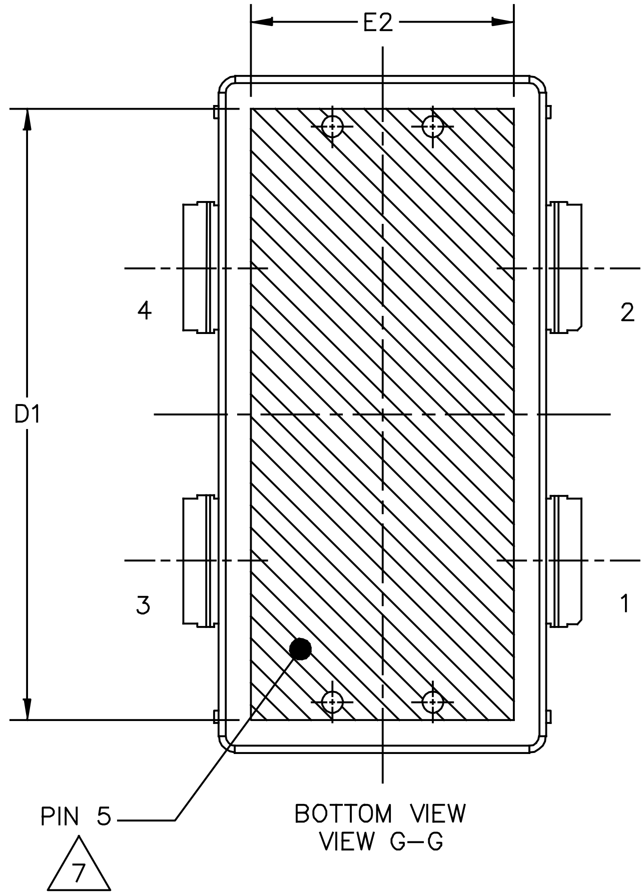

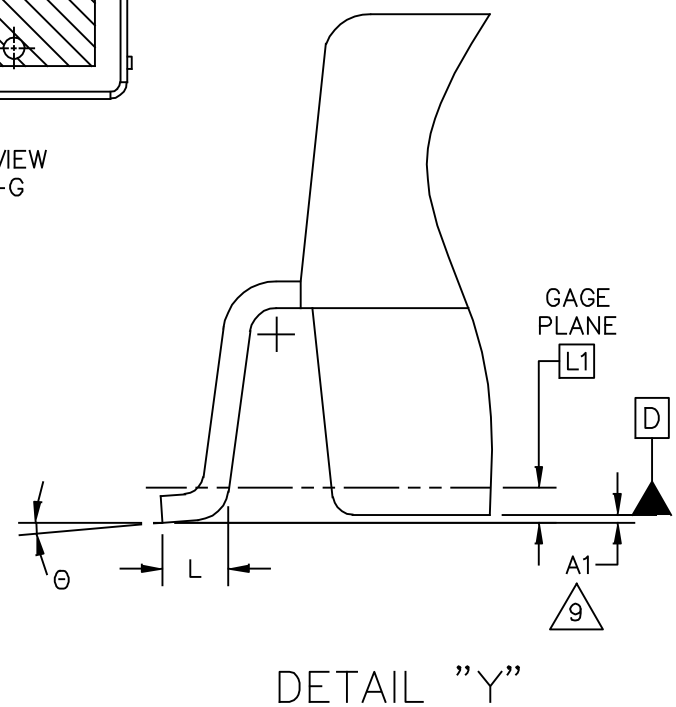

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NOTES:

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 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 PACKAGE IS HIGHER THAN THE BOTTOM OF THE LEAD.

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	.147	.153	3.73	3.89
A1	-.002	.002	-0.05	0.05	c1	.007	.011	0.18	0.28
DD	.808	.812	20.52	20.62	e	0.350 BSC		8.89 BSC	
D1	.720	----	18.29	----	e1	.721	.729	18.31	18.52
E	.470	.482	11.94	12.24	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	.018	.024	0.46	0.61					
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	May 2015	• Initial Release of Data Sheet

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