Freescale Semiconductor
Technical Data

Document Number: MMRF5015N
Rev. 0, 9/2015

VRoHS

RF Power GaN on SiC Transistor

Depletion Mode HEMT

This 125 W CW RF power GaN transistor is optimized for wideband operation up to 2700 MHz and includes input matching for extended bandwidth performance. With its high gain and high ruggedness, this device is ideally suited for CW, pulse and wideband RF applications.

This part is characterized and performance is guaranteed for applications operating in the 1–2700 MHz band. There is no guarantee of performance when this part is used in applications designed outside of these frequencies.

Typical Narrowband Performance: V_{DD} = 50 Vdc, I_{DQ} = 350 mA, T_A = 25°C

Frequency (MHz)	Signal Type	P_{out} (W)	G_{ps} (dB)	η_D (%)
2500 (1)	CW	125 CW	16.0	64.2
2500 (1)	Pulse (100 μsec, 20% Duty Cycle)	125 Peak	16.6	68.0

Typical Wideband Performance: V_{DD} = 50 Vdc, I_{DQ} = 300 mA, T_A = 25°C

Frequency (MHz)	Signal Type	P_{out} (W)	G_{ps} (dB)	η_D (%)
200–2500 (2)	Pulse (100 μsec, 50% Duty Cycle)	100 Peak	12.0	40.0

Load Mismatch/Ruggedness

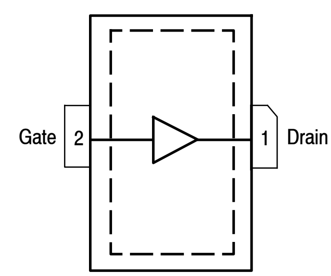
Frequency (MHz)	Signal Type	VSWR	P_{in} (W)	Test Voltage	Result
2500 (1)	Pulse (100 μsec, 20% Duty Cycle)	> 20:1 at All Phase Angles	8.0 Peak (3 dB Overdrive)	50	No Device Degradation

1. Measured in 2500 MHz narrowband test circuit.
2. Measured in 200–2500 MHz broadband reference circuit.

MMRF5015N

1–2700 MHz, 125 W CW, 50 V WIDEBAND RF POWER GaN ON SiC TRANSISTOR

OM-270-2 PLASTIC



(Top View)

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

Figure 1. Pin Connections

Features

- Decade bandwidth performance
- Plastic package enables improved thermal resistance
- Advanced GaN on SiC, offering high power density
- Input matched for extended wideband performance
- High ruggedness: > 20:1 VSWR

Applications

- Ideal for military end-use applications, including the following:
  - Narrowband and multi-octave wideband amplifiers
  - Radar
  - Jammers
  - EMC testing
- Also suitable for commercial applications, including the following:
  - Public mobile radios, including emergency service radios
  - Industrial, scientific and medical
  - Wideband laboratory amplifiers
  - Wireless cellular infrastructure

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	125	Vdc
Gate-Source Voltage	V_{GS}	–8, 0	Vdc
Operating Voltage	V_{DD}	0 to +50	Vdc
Storage Temperature Range	T_{stg}	–65 to +150	°C
Case Operating Temperature Range	T_C	–55 to +150	°C
Operating Junction Temperature Range (1)	T_J	–55 to +225	°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	303 1.52	W W/°C

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (2)	Unit
Thermal Resistance, Junction to Case CW: Case Temperature 80°C, 125 W CW, 50 Vdc, I_{DQ} = 350 mA, 2500 MHz	$R_{\theta JC}$	0.66	°C/W
Thermal Impedance, Junction to Case Pulse: Case Temperature 56°C, 125 W Peak, 100 μsec Pulse Width, 20% Duty Cycle, 50 Vdc, I_{DQ} = 350 mA, 2500 MHz	$Z_{\theta JC}$	0.16	°C/W

Table 3. ESD Protection Characteristics

Test Methodology	Class
Human Body Model (per JESD22-A114)	1B, passes 500 V
Machine Model (per EIA/JESD22-A115)	A, passes 100 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					
Drain Leakage Current (V_{GS} = –8 Vdc, V_{DS} = 10 Vdc)	I_{DSS}	—	—	5	mAdc
Drain-Source Breakdown Voltage (V_{GS} = –8 Vdc, I_D = 25 mAdc)	$V_{(BR)DSS}$	150	—	—	Vdc
On Characteristics					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 25 mAdc)	$V_{GS(th)}$	–3.8	–2.9	–2.3	Vdc
Gate Quiescent Voltage (V_{DS} = 50 Vdc, I_D = 350 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	–3.3	–2.7	–2.3	Vdc
Dynamic Characteristics					
Reverse Transfer Capacitance (V_{DS} = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = –4 Vdc)	C_{rss}	—	1.0	—	pF
Output Capacitance (V_{DS} = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = –4 Vdc)	C_{oss}	—	8.7	—	pF
Input Capacitance (3) (V_{DS} = 50 Vdc, V_{GS} = –4 Vdc ± 30 mV(rms)ac @ 1 MHz)	C_{iss}	—	52.0	—	pF

1. Continuous use at maximum temperature will affect MTTF.
2. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers.* Go to http://www.freescale.com/rf and search for AN1955.
3. Part internally input matched.

(continued)

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

Characteristic	Symbol	Min	Typ	Max	Unit
Functional Tests (In Freescale Test Fixture, 50 ohm system) V_{DD} = 50 Vdc, I_{DQ} = 350 mA, P_{out} = 125 W Peak (25 W Avg.), f = 2500 MHz, 100 μsec Pulse Width, 20% Duty Cycle. **[See note on correct biasing sequence.]**					
Power Gain	G_{ps}	—	16.6	—	dB
Drain Efficiency	η_D	—	68.0	—	%
Input Return Loss	IRL	—	–12	–9	dB

Load Mismatch/Ruggedness (In Freescale Test Fixture, 50 ohm system) I_{DQ} = 350 mA

Frequency (MHz)	Signal Type	VSWR	P_{in} (W)	Test Voltage, V_{DD}	Result
2500	Pulse (100 μsec, 20% Duty Cycle)	> 20:1 at All Phase Angles	8.0 Peak (3 dB Overdrive)	50	No Device Degradation

Table 6. Ordering Information

Device	Tape and Reel Information	Package
MMRF5015NR5	R5 Suffix = 50 Units, 24 mm Tape Width, 7-inch Reel	OM-270-2

NOTE: Correct Biasing Sequence for GaN Depletion Mode Transistors

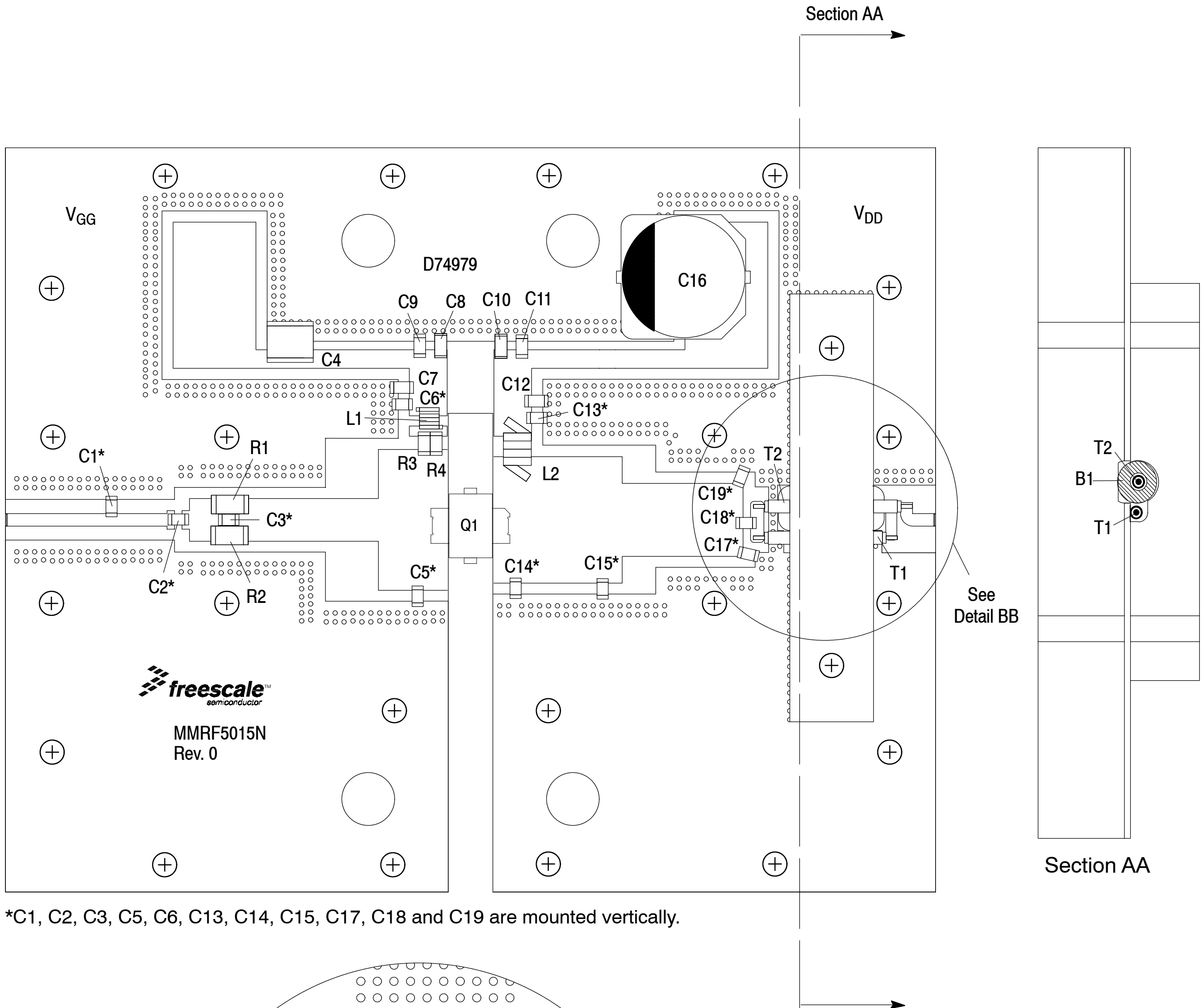
Turning the device ON

1. Set V_{GS} to the pinch-off (V_P) voltage, typically –5 V
2. Turn on V_{DS} to nominal supply voltage (50 V)
3. Increase V_{GS} until I_{DS} current is attained
4. Apply RF input power to desired level

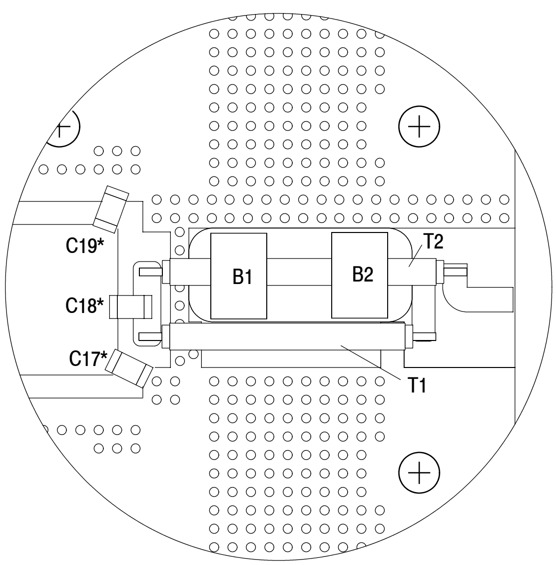
Turning the device OFF

1. Turn RF power off
2. Reduce V_{GS} down to V_P, typically –5 V
3. Reduce V_{DS} down to 0 V (Adequate time must be allowed for V_{DS} to reduce to 0 V to prevent severe damage to device.)
4. Turn off V_{GS}

200–2500 MHz WIDEBAND REFERENCE CIRCUIT



*C1, C2, C3, C5, C6, C13, C14, C15, C17, C18 and C19 are mounted vertically.

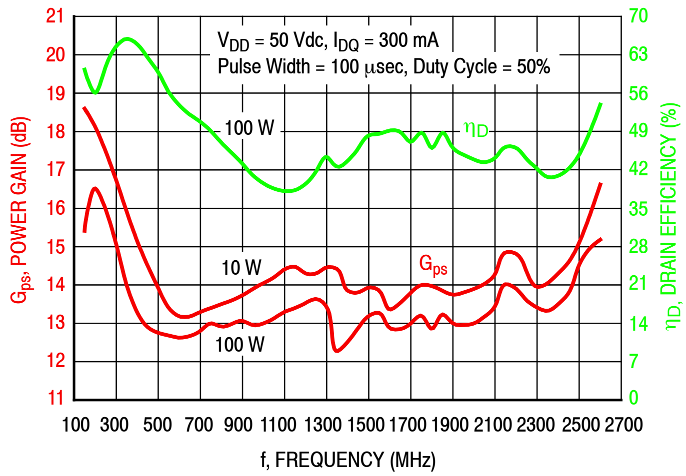


Detail BB 2X

Figure 2. MMRF5015N Wideband Reference Circuit Component Layout — 200–2500 MHz

Table 7. MMRF5015N Wideband Reference Circuit Component Designations and Values — 200–2500 MHz

Part	Description	Part Number	Manufacturer
B1, B2	Ferrite Beads	T22-6	Micro Metals
C1	0.3 pF Chip Capacitor	ATC800B0R3BT500XT	ATC
C2	75 pF Chip Capacitor	ATC800B750JT500XT	ATC
C3	24 pF Chip Capacitor	ATC800B240JT500XT	ATC
C4	6.8 μF Chip Capacitor	C4532X7R1H685K250KB	TDK
C5	0.5 pF Chip Capacitor	ATC800B0R5BT500XT	ATC
C6, C13	5.6 pF Chip Capacitors	ATC800B5R6BT500XT	ATC
C7, C8, C10, C12	0.015 μF Chip Capacitors	GRM319R72A153KA01D	Murata
C9, C11	1 μF Chip Capacitors	GRM31CR72A105KAO1L	Murata
C14, C15	1.0 pF Chip Capacitors	ATC800B1R0BT500XT	ATC
C16	220 μF, 100 V Electrolytic Capacitor	EEV-FK2A221M	Panasonic-ECG
C17	0.8 pF Chip Capacitor	ATC800B0R8BT500XT	ATC
C18	56 pF Chip Capacitor	ATC800B560JT500XT	ATC
C19	1.2 pF Chip Capacitor	ATC800B1R2BT500XT	ATC
L1	12.5 nH Inductor	A04TJLC	Coilcraft
L2	22 nH Inductor	1812SMS-22NJLC	Coilcraft
Q1	RF Power GaN Transistor	MMRF5015NR5	Freescale
R1, R2	100 Ω, 1/2 W Chip Resistors	CRCW2010100RFKEF	Vishay
R3, R4	39 Ω, 1/4 W Chip Resistors	CRCW120639R0FKEA	Vishay
T1	25 Ω Semi Rigid Coax, 0.770″ Shield Length	UT-070-25	Micro-Coax
T2	25 Ω Semi Rigid Coax, 0.850″ Shield Length	UT-070-25	Micro-Coax
PCB	Rogers RO4350B, 0.030″, ε_r = 3.66	D74979	MTL



Note: Pulse performance achieved with device clamped into the reference circuit; similar CW performance can be achieved by soldering the device to the heatsink.

Figure 3. 200–2500 MHz Wideband Circuit Performance

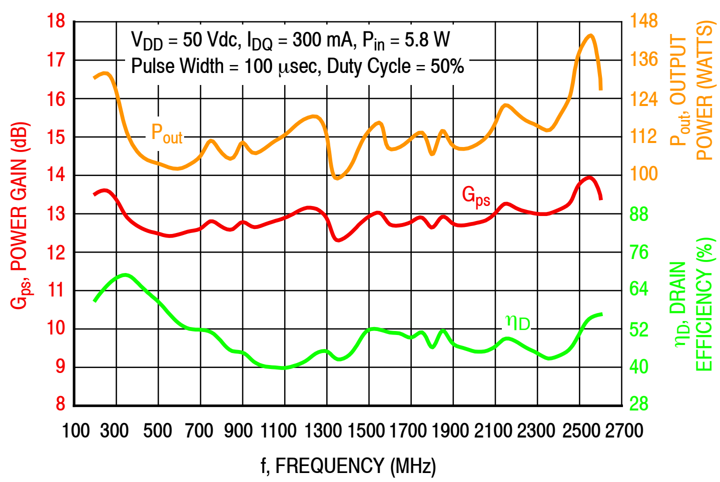


Figure 4. Power Gain, Output Power and Drain Efficiency versus Frequency at a Constant Input Power

Narrowband Performance and Impedance Information (T_C = 25°C)

The measured input and output impedances are presented to the input of the device at the package reference plane. Measurements are performed in Freescale narrowband fixture tuned at 500, 1000, 1500, 2000 and 2500 MHz.

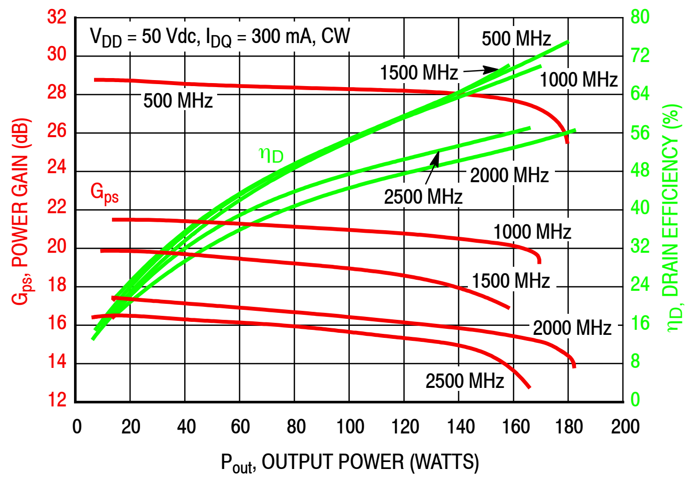


Figure 5. Power Gain and Drain Efficiency versus Output Power

f MHz	Z_{source} Ω	Z_{load} Ω
500	0.7 + j2.9	6.0 + j3.3
1000	1.1 – j0.03	5.6 + j2.3
1500	0.9 – j1.2	3.3 + j3.0
2000	1.3 – j1.8	3.8 + j0.9
2500	3.5 – j4.0	3.1 + j0.3

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

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

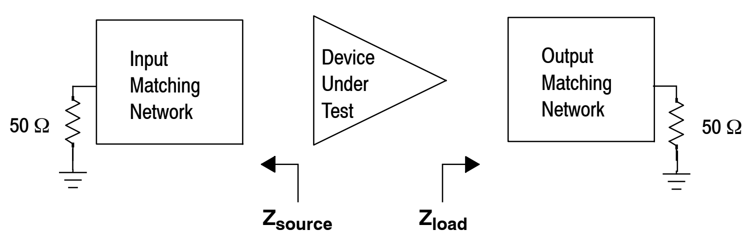


Figure 6. Narrowband Fixtures: Series Equivalent Source and Load Impedances

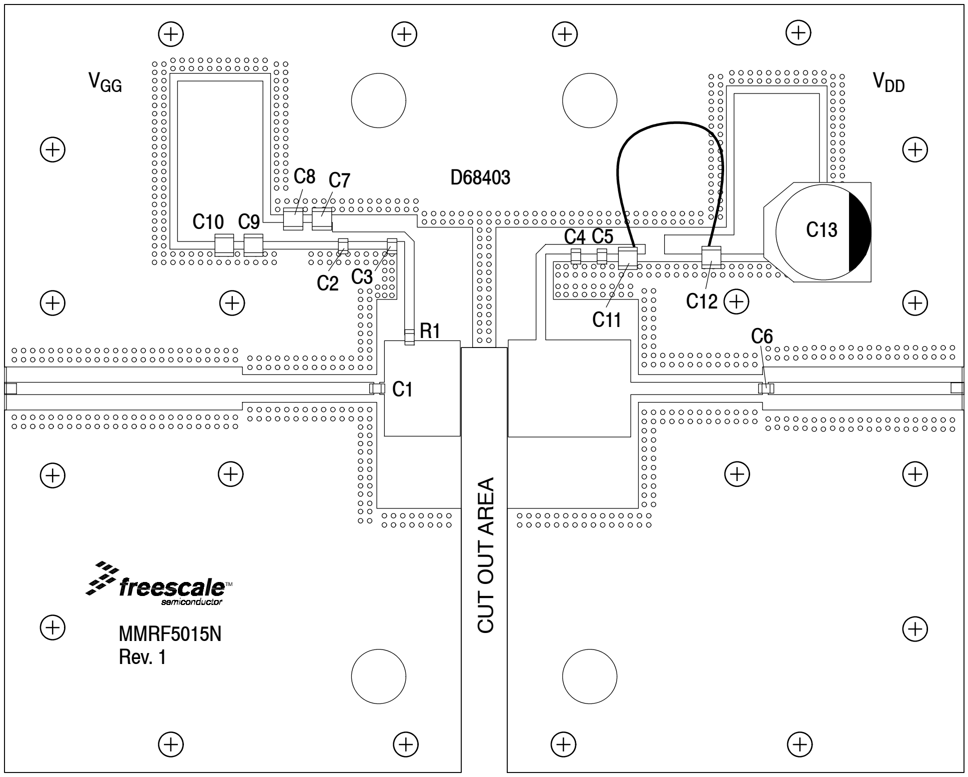
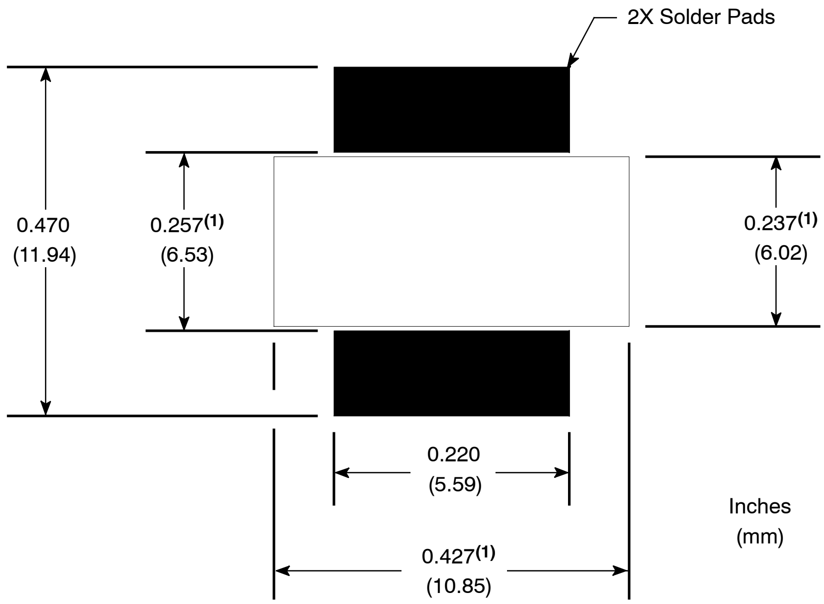


Figure 7. MMRF5015N Narrowband Test Circuit Component Layout — 2500 MHz

Table 8. MMRF5015N Narrowband Test Circuit Component Designations and Values — 2500 MHz

Part	Description	Part Number	Manufacturer
C1	3.0 pF Chip Capacitor	ATC600F3R0BT250XT	ATC
C2, C3, C4, C5, C6	12 pF Chip Capacitors	ATC600F120JT250XT	ATC
C7, C11	1000 pF Chip Capacitors	ATC800B102JT50XT	ATC
C8	0.1 μF Chip Capacitor	GRM319R72A104KA01D	Murata
C9, C10	4.7 μF Chip Capacitors	GRM32ER71H475KA88B	Murata
C12	1.0 μF Chip Capacitor	GRM32CR72A105KA35L	Murata
C13	220 μF, 100 V Electrolytic Capacitor	EEV-FK2A221M	Panasonic-ECG
R1	51 Ω, 1/8 W Chip Resistor	SG732ATTD51R0F	KOA Speer
—	18 AWG Teflon Wire, Total Wire Length = 4.0″/101.6 mm	—	—
PCB	Rogers RO4350B, 0.030″, ε_r = 3.66	D68403	MTL



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

Figure 8. PCB Pad Layout for OM-270-2

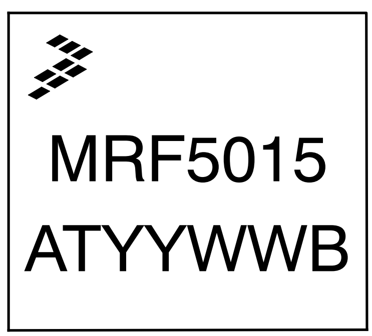
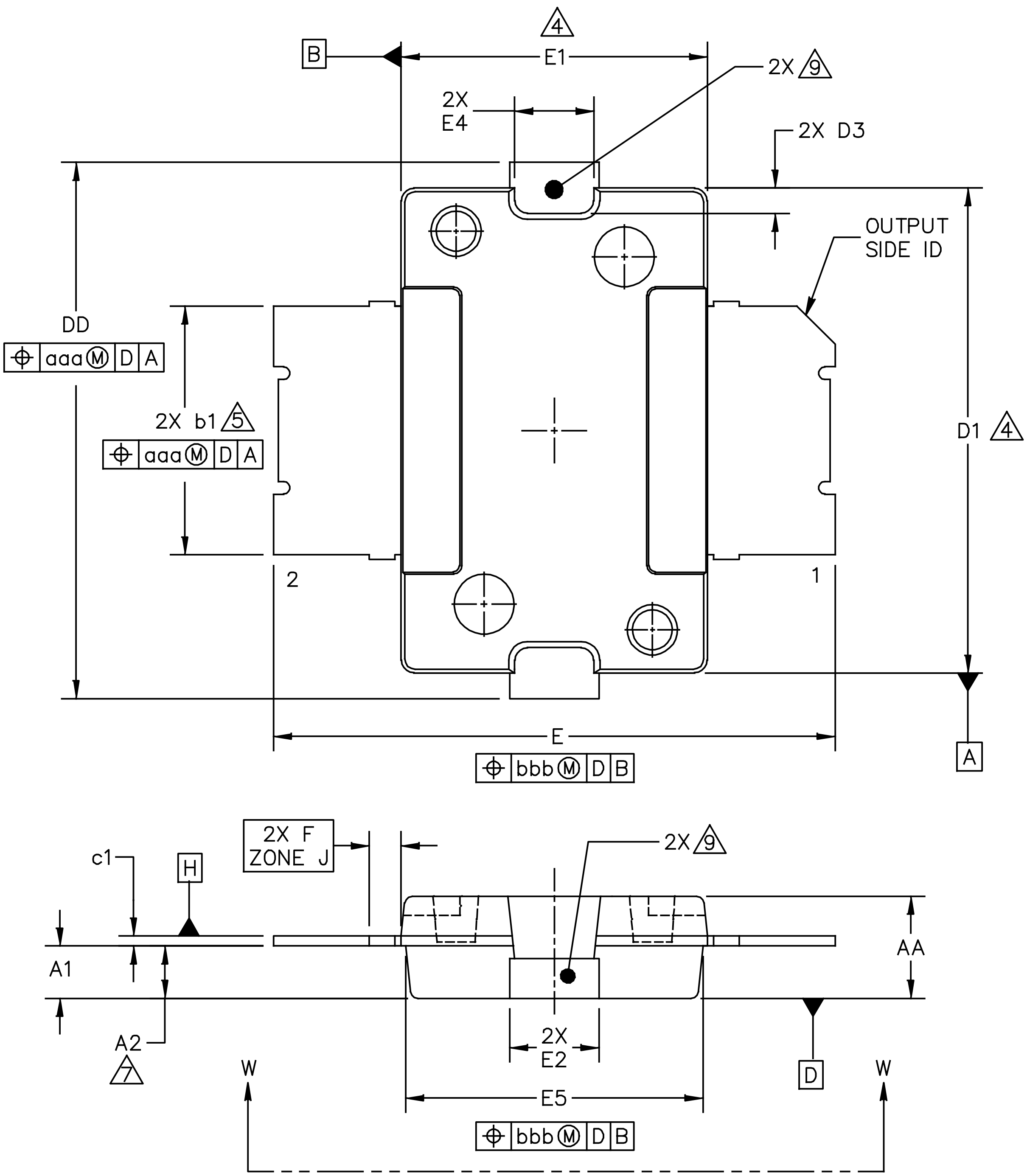


Figure 9. Product Marking

PACKAGE DIMENSIONS



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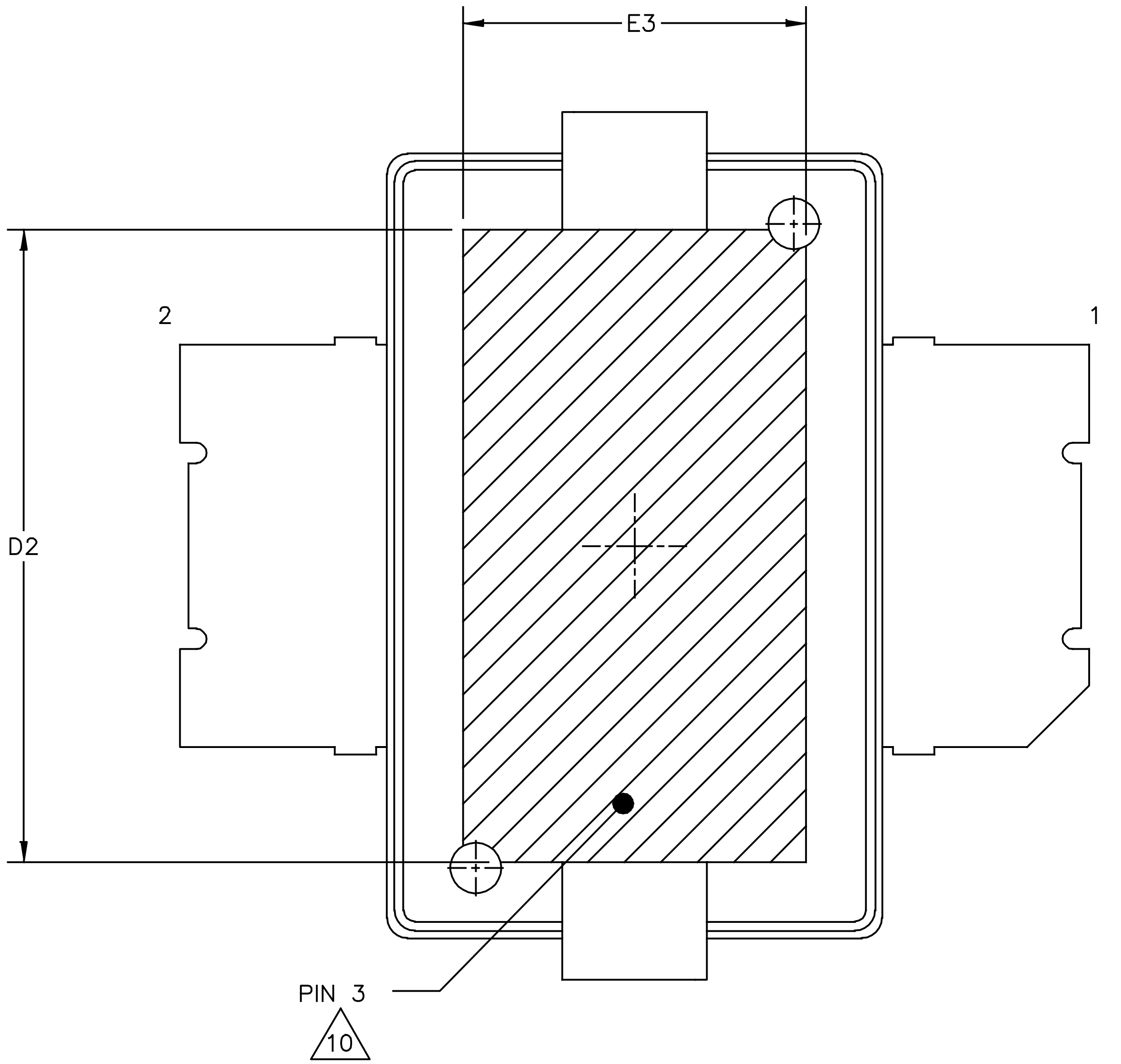

VIEW W–W
BOTTOM VIEW

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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 D1 AND E1 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 INCH (0.15 MM) PER SIDE. DIMENSIONS D1 AND E1 DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H.

5. DIMENSION b1 DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 INCH (0.13 MM) TOTAL IN EXCESS OF THE b1 DIMENSION AT MAXIMUM MATERIAL CONDITION.

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

7. DIMENSION A2 APPLIES WITHIN ZONE J ONLY.

8. DIMENSIONS DD AND E2 DO NOT INCLUDE MOLD PROTRUSION. OVERALL LENGTH INCLUDING MOLD PROTRUSION SHOULD NOT EXCEED 0.430 INCH (10.92 MM) FOR DIMENSION DD AND 0.080 INCH (2.03 MM) FOR DIMENSION E2. DIMENSIONS DD AND E2 DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE D.

9. THESE SURFACES OF THE HEAT SLUG ARE NOT PART OF THE SOLDERABLE SURFACES AND MAY REMAIN UNPLATED.

10. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG. DIMENSIONS D2 AND E3 REPRESENT THE VALUES BETWEEN THE TWO OPPOSITE POINTS ALONG THE EDGES OF EXPOSED AREA OF THE HEAT SLUG.

	INCH		MILLIMETER			INCH		MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
AA	.078	.082	1.98	2.08	E4	.058	.066	1.47	1.68
A1	.039	.043	0.99	1.09	E5	.231	.235	5.87	5.97
A2	.040	.042	1.02	1.07	F	.025 BSC		0.64 BSC	
DD	.416	.424	10.57	10.77	b1	.193	.199	4.90	5.06
D1	.378	.382	9.60	9.70	c1	.007	.011	0.18	0.28
D2	.290	----	7.37	----	aaa	.004		0.10	
D3	.016	.024	0.41	0.61	bbb	.008		0.20	
E	.436	.444	11.07	11.28					
E1	.238	.242	6.04	6.15					
E2	.066	.074	1.68	1.88					
E3	.150	----	3.81	----					

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PRODUCT DOCUMENTATION AND TOOLS

Refer to the following resources to aid your design process.

Application Notes

- AN1955: Thermal Measurement Methodology of RF Power Amplifiers

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	Sept. 2015	• Initial Release of Data Sheet

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Document Number: MMRF5015N
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