Freescale Semiconductor
Technical Data

Document Number: MRF6VP3091N
Rev. 1, 12/2011

RoHS

RF Power LDMOS Transistors

Enhancement-Mode Lateral MOSFETs

Designed for commercial and industrial broadband applications with frequencies from 470 to 860 MHz. Devices are suitable for use in broadcast applications.

- Typical Performance (Broadband Reference Circuit): V_{DD} = 50 Volts, I_{DQ} = 450 mA, 64 QAM, Input Signal PAR = 9.5 dB @ 0.01% Probability on CCDF.

Signal Type	P_{out} (W)	f (MHz)	G_{ps} (dB)	η_D (%)	Output Signal PAR (dB)	IMD Shoulder (dBc)
DVB-T (8k OFDM)	18 Avg.	470	21.8	31.0	7.9	-27.8
		650	21.6	26.4	8.4	-37.6
		860	21.7	27.6	7.1	-30.4

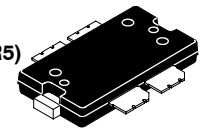
Features

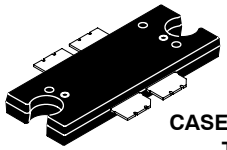
- Capable of Handling 10:1 VSWR, All Phase Angles, @ 50 Vdc, 860 MHz, 90 Watts CW Output Power
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Input Matched for Ease of Use
- Qualified Up to a Maximum of 50 V_{DD} Operation
- Excellent Thermal Stability
- Device can be used Single-Ended or in a Push-Pull Configuration
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- 225°C Capable Plastic Package
- In Tape and Reel. R1 Suffix = 500 Units, 44 mm Tape Width, 13 inch Reel. R5 Suffix = 50 Units, 56 mm Tape Width, 13 inch Reel.

MRF6VP3091NR1
MRF6VP3091NR5
MRF6VP3091NBR1
MRF6VP3091NBR5

470-860 MHz, 90 W, 50 V
BROADBAND
RF POWER LDMOS TRANSISTORS

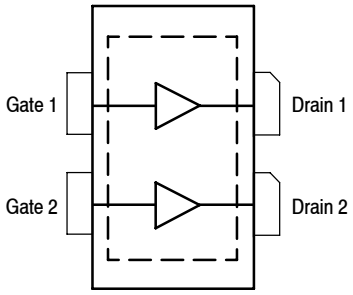
CASE 1486-03, STYLE 1
TO-270 WB-4
PLASTIC
MRF6VP3091NR1(NR5)





CASE 1484-04, STYLE 1
TO-272 WB-4
PLASTIC
MRF6VP3091NBR1(NBR5)

PARTS ARE PUSH-PULL



(Top View)

Note: Exposed 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_{DSS}	-0.5, +115	Vdc
Gate-Source Voltage	V_{GS}	-6.0, +10	Vdc
Storage Temperature Range	T_{stg}	-65 to +150	°C
Case Operating Temperature	T_C	150	°C
Operating Junction Temperature (1,2)	T_J	225	°C

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case Case Temperature 76°C, 18 W CW, 50 Vdc, I_{DQ} = 350 mA, 860 MHz Case Temperature 80°C, 90 W CW, 50 Vdc, I_{DQ} = 350 mA, 860 MHz	$R_{\theta JC}$	 0.79 0.82	°C/W

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

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Table 3. ESD Protection Characteristics

Test Methodology	Class
Human Body Model (per JESD22-A114)	2 (2001-4000 V)
Machine Model (per EIA/JESD22-A115)	B (201-400 V)
Charge Device Model (per JESD22-C101)	IV (>1000 V)

Table 4. Moisture Sensitivity Level

Test Methodology	Rating	Package Peak Temperature	Unit
Per JESD22-A113, IPC/JEDEC J-STD-020	3	260	°C

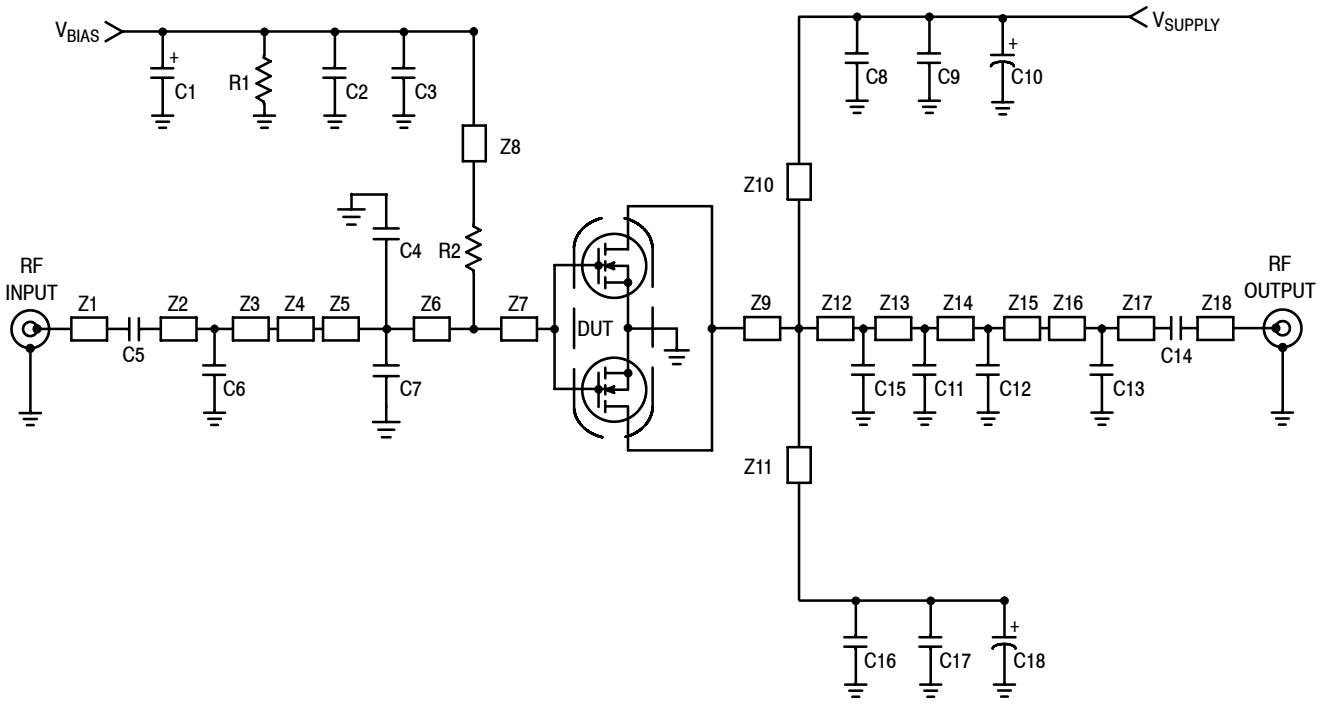
Table 5. Electrical Characteristics (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Off Characteristics (1)					
Gate-Source Leakage Current (V_{GS} = 5 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	0.5	μAdc
Drain-Source Breakdown Voltage (I_D = 50 mA, V_{GS} = 0 Vdc)	$V_{(BR)DSS}$	115	—	—	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 (1) (V_{DS} = 10 Vdc, I_D = 100 μAdc)	$V_{GS(th)}$	0.9	1.6	2.4	Vdc
Gate Quiescent Voltage (V_{DD} = 50 Vdc, I_D = 350 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	2.0	2.7	3.5	Vdc
Drain-Source On-Voltage (1) (V_{GS} = 10 Vdc, I_D = 0.25 Adc)	$V_{DS(on)}$	—	0.2	—	Vdc
Dynamic Characteristics					
Reverse Transfer Capacitance (2) (V_{DS} = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	41	—	pF
Output Capacitance (2) (V_{DS} = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	65.4	—	pF
Input Capacitance (2) (V_{DS} = 50 Vdc, V_{GS} = 0 Vdc ± 30 mV(rms)ac @ 1 MHz)	C_{iss}	—	591	—	pF

Functional Tests (In Freescale Single-Ended Narrowband Test Fixture, 50 ohm system) V_{DD} = 50 Vdc, I_{DQ} = 350 mA, P_{out} = 18 W Avg., f = 860 MHz, DVB-T (8k OFDM) Single Channel. ACPR measured in 7.61 MHz Channel Bandwidth @ ±4 MHz Offset @ 4 kHz Bandwidth.

Power Gain	G_{ps}	21.0	22.0	24.0	dB
Drain Efficiency	η_D	27.5	28.5	—	%
Adjacent Channel Power Ratio	ACPR	—	-62.0	-60.0	dBc
Input Return Loss	IRL	—	-14	-9	dB

1. Each side of device measured separately.
2. Part internally input matched.



Z1	0.266″ × 0.067″ Microstrip	Z10, Z11	1.292″ × 0.079″ Microstrip
Z2	0.331″ × 0.067″ Microstrip	Z12	0.680″ × 0.571″ Microstrip
Z3	0.598″ × 0.067″ Microstrip	Z13	0.132″ × 0.117″ Microstrip
Z4	0.315″ × 0.276″ Microstrip	Z14	0.705″ × 0.117″ Microstrip
Z5	0.054″ × 0.669″ Microstrip	Z15	0.159″ × 0.117″ Microstrip
Z6	0.419″ × 0.669″ Microstrip	Z16	0.140″ × 0.067″ Microstrip
Z7	0.256″ × 0.669″ Microstrip	Z17	0.077″ × 0.067″ Microstrip
Z8	0.986″ × 0.071″ Microstrip	Z18	0.163″ × 0.067″ Microstrip
Z9	0.201″ × 0.571″ Microstrip		

Figure 2. MRF6VP3091NR1(NBR1) 860 MHz Single-Ended Narrowband Test Circuit Schematic

Table 6. MRF6VP3091NR1(NBR1) 860 MHz Single-Ended Narrowband Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1	22 μF, 35 V Tantalum Capacitor	T491X226K035AT	Kermet
C2, C9, C17	10 μF, 50 V Chip Capacitors	GRM55DR61H106KA88L	Murata
C3, C5, C8, C14, C16	43 pF Chip Capacitors	ATC100B430JT500XT	ATC
C4	6.2 pF Chip Capacitor	ATC100B6R2BT500XT	ATC
C6	2.2 pF Chip Capacitor	ATC100B2R2JT500XT	ATC
C7	9.1 pF Chip Capacitor	ATC100B9R1CT500XT	ATC
C10, C18	220 μF, 100 V Electrolytic Capacitors	EEVFK2A221M	Panasonic-ECG
C11, C15	7.5 pF Chip Capacitors	ATC100B7R5CT500XT	ATC
C12	3.0 pF Chip Capacitor	ATC100B3R0CT500XT	ATC
C13	0.7 pF Chip Capacitor	ATC100B0R7BT500XT	ATC
R1	10 kΩ, 1/4 W Chip Resistor	CRCW120610KOJNEA	Vishay
R2	10 Ω, 1/4 W Chip Resistor	CRCW120610ROJNEA	Vishay
PCB	0.030″, ε_r = 3.5	RF-35	Taconic

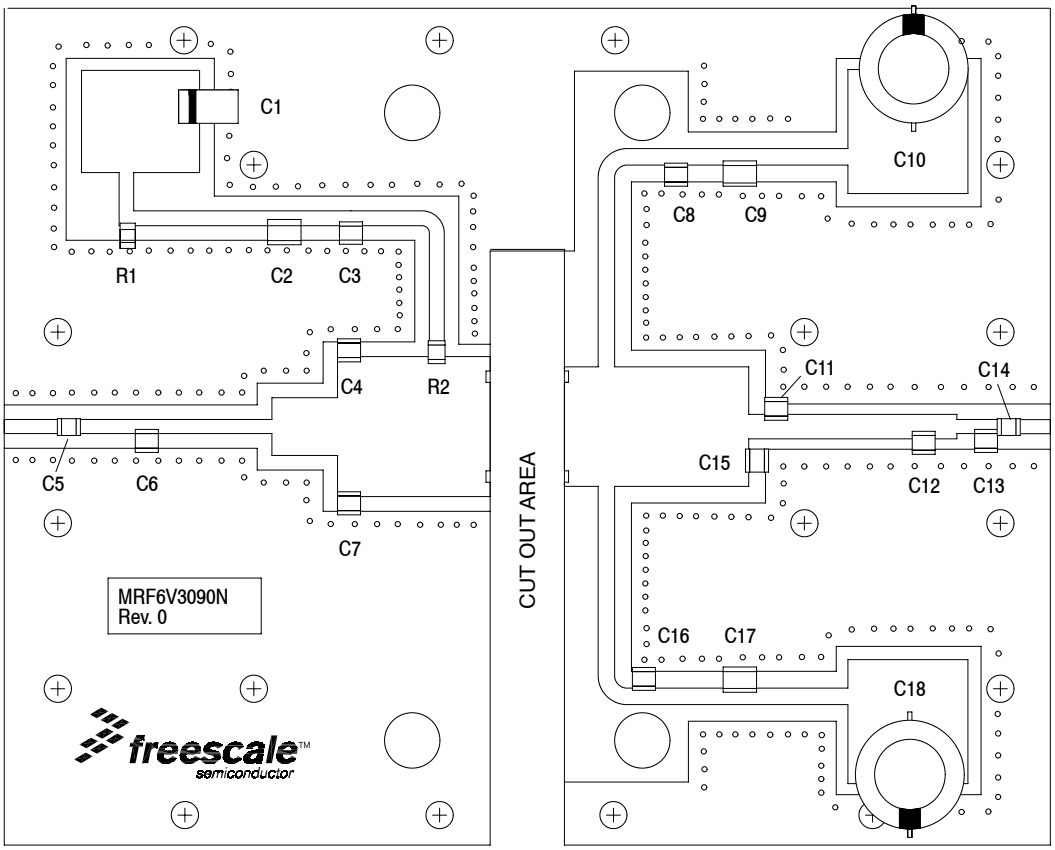


Figure 3. MRF6VP3091NR1(NBR1) 860 MHz Single-Ended Narrowband Test Circuit Component Layout

TYPICAL CHARACTERISTICS

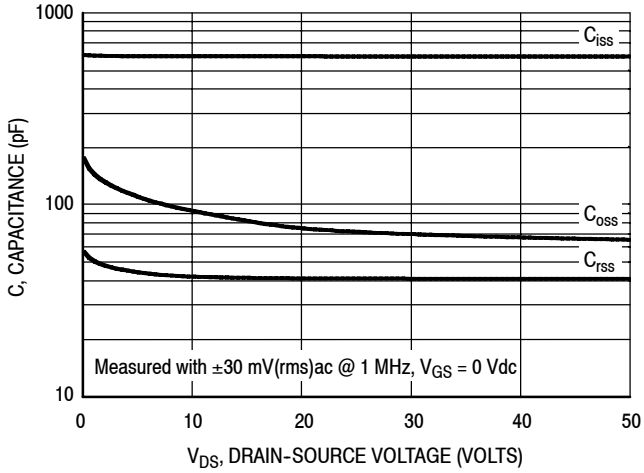


Figure 4. Capacitance versus Drain-Source Voltage

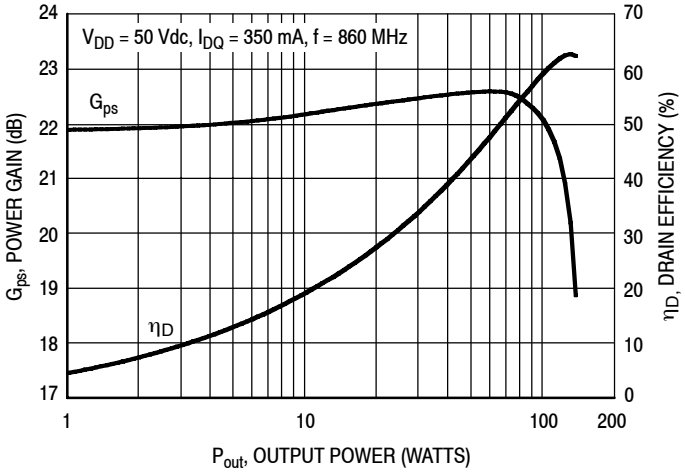


Figure 5. CW Power Gain and Drain Efficiency versus Output Power (Single-Ended Narrowband Test Circuit)

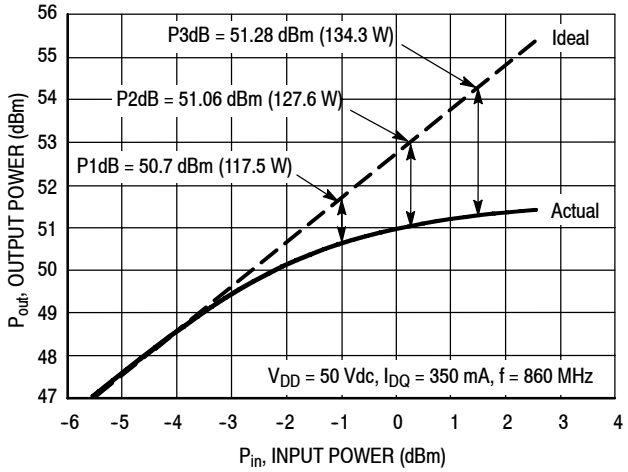


Figure 6. CW Output Power versus Input Power (Single-Ended Narrowband Test Circuit)

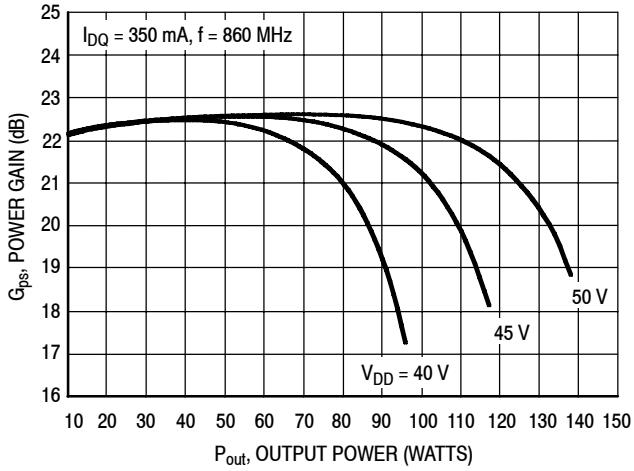


Figure 7. CW Power Gain versus Output Power (Single-Ended Narrowband Test Circuit)

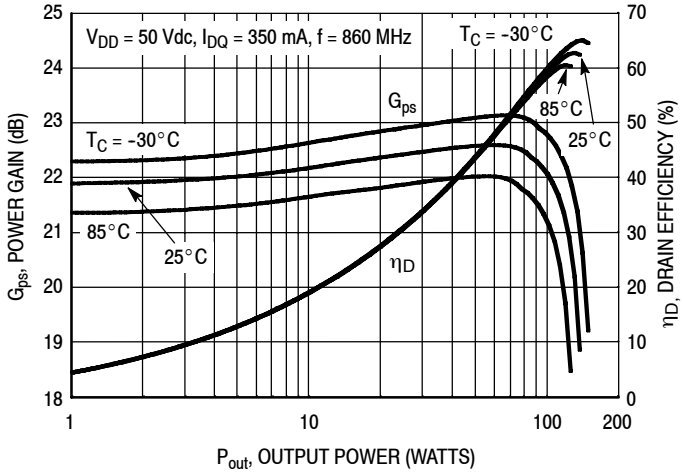


Figure 8. CW Power Gain and Drain Efficiency versus Output Power versus Temperature (Single-Ended Narrowband Test Circuit)

TYPICAL CHARACTERISTICS — TWO-TONE (SINGLE-ENDED NARROWBAND TEST CIRCUIT)

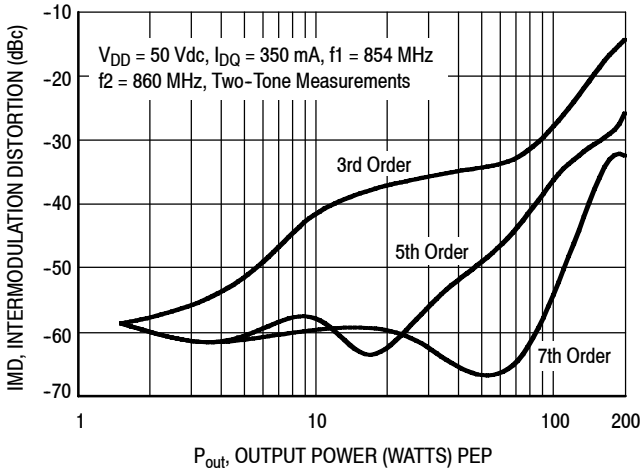


Figure 9. Intermodulation Distortion Products versus Output Power

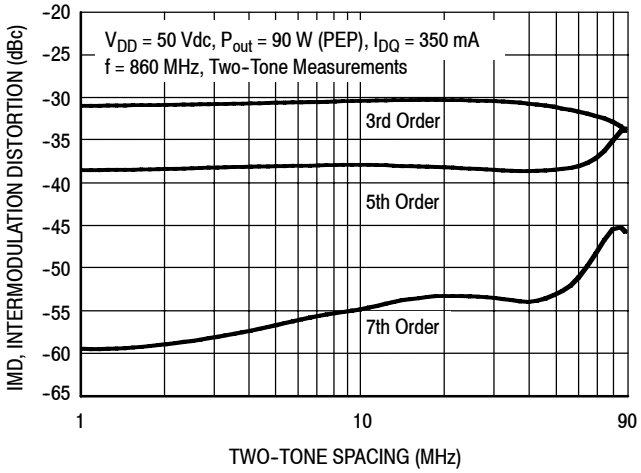


Figure 10. Intermodulation Distortion Products versus Two-Tone Spacing

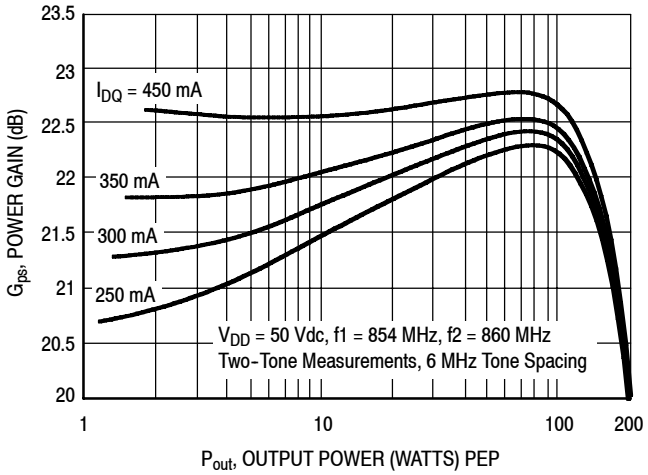


Figure 11. Two-Tone Power Gain versus Output Power

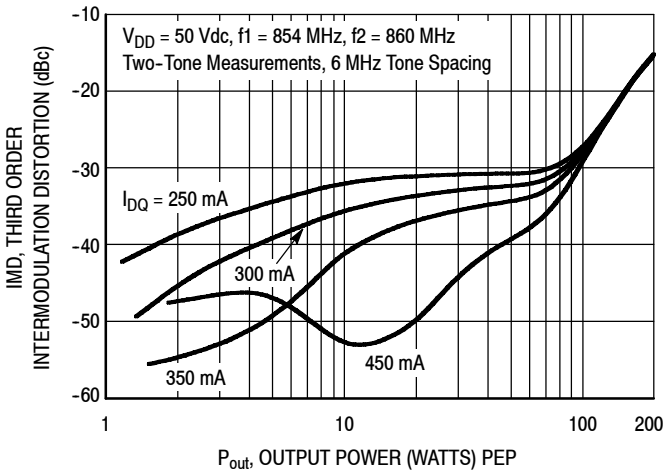


Figure 12. Third Order Intermodulation Distortion versus Output Power

TYPICAL CHARACTERISTICS — DVB-T (8k OFDM)

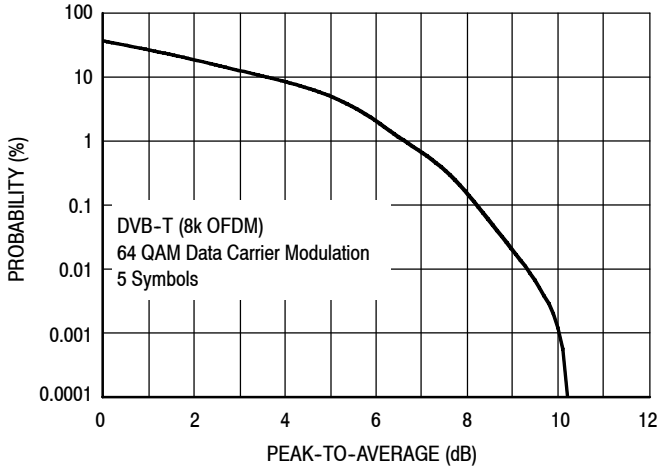


Figure 13. Single-Carrier DVB-T (8k OFDM)

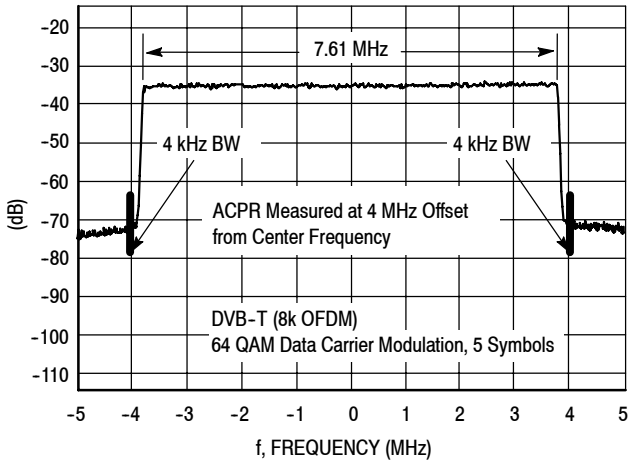


Figure 14. DVB-T (8k OFDM) Spectrum

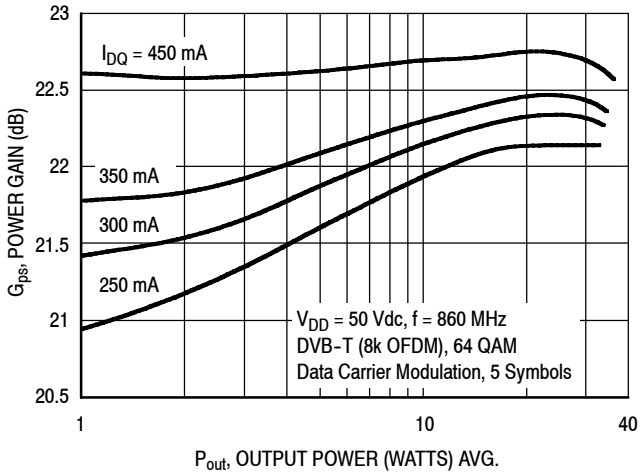


Figure 15. Single-Carrier DVB-T (8k OFDM) Power Gain versus Output Power (Single-Ended Narrowband Test Circuit)

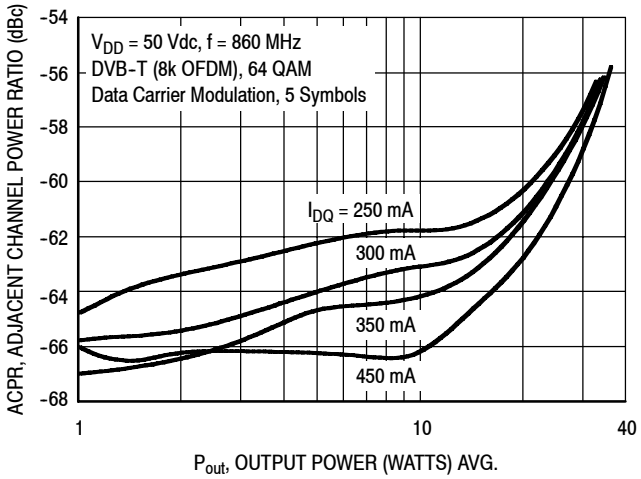


Figure 16. Single-Carrier DVB-T (8k OFDM) ACPR versus Output Power (Single-Ended Narrowband Test Circuit)

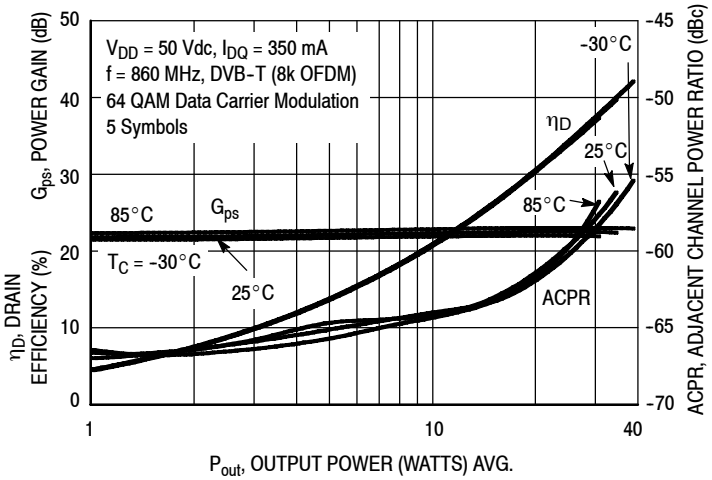
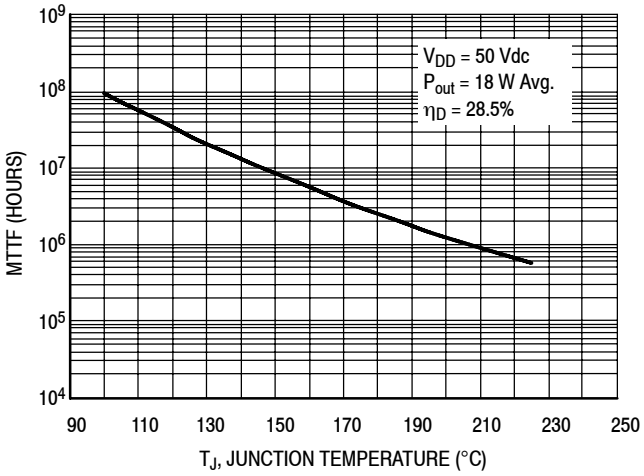


Figure 17. Single-Carrier DVB-T (8k OFDM) Drain Efficiency, Power Gain and ACPR versus Output Power versus Temperature (Single-Ended Narrowband Test Circuit)

TYPICAL CHARACTERISTICS



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

Figure 18. MTTF versus Junction Temperature – CW

V_{DD} = 50 Vdc, I_{DQ} = 350 mA, P_{out} = 18 W Average

f MHz	Z_{source} Ω	Z_{load} Ω
860	1.58 – j0.89	3.51 – j3.98

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

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

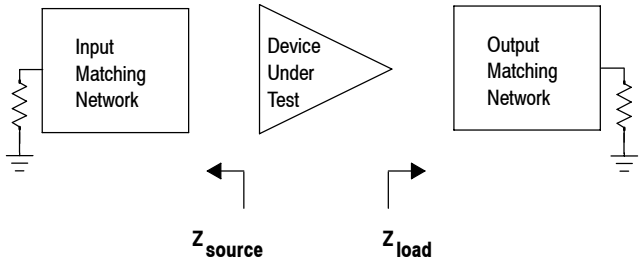
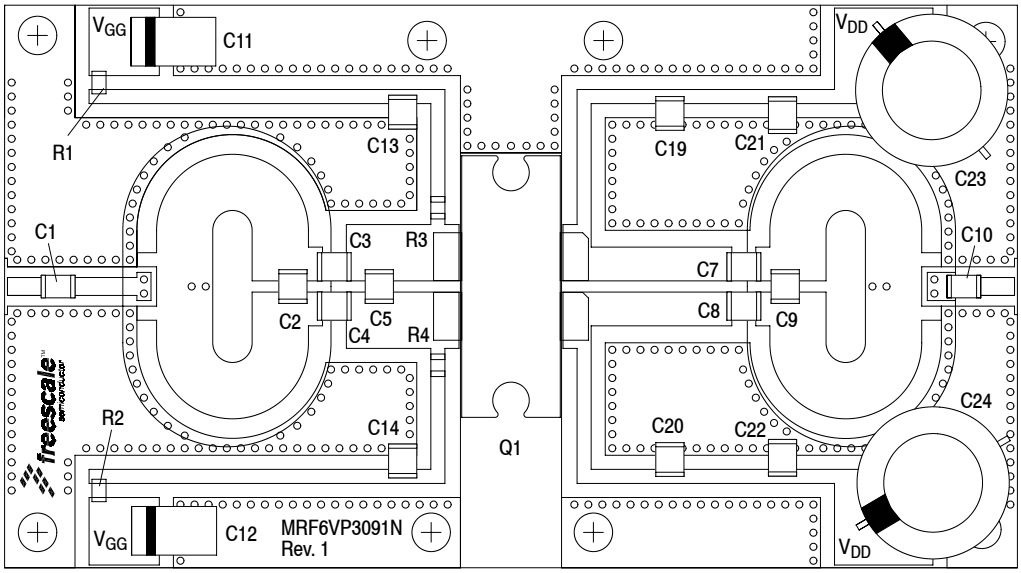


Figure 19. Series Equivalent Source and Load Impedance (Single-Ended Narrowband Test Circuit)

470–860 MHz BROADBAND REFERENCE CIRCUIT

V_{DD} = 50 Volts, I_{DQ} = 450 mA, Channel Bandwidth = 8 MHz, Input Signal PAR = 9.5 dB @ 0.01% Probability on CCDF.

Signal Type	P_{out} (W)	f (MHz)	G_{ps} (dB)	η_D (%)	Output Signal PAR (dB)	IMD Shoulder (dBc)
DVB–T (8k OFDM)	4.5 Avg.	470	21.7	12.6	10.1	–40.1
		650	21.5	11.2	10.1	–43.1
		860	21.9	11.6	9.8	–46.0
	9 Avg.	470	21.8	20.3	9.9	–35.9
		650	21.6	17.5	9.9	–40.9
		860	21.9	18.5	9.1	–41.7
	18 Avg.	470	21.8	31.0	7.9	–27.8
		650	21.6	26.4	8.4	–37.6
		860	21.7	27.6	7.1	–30.4



Note: Component numbers C6, C15, C16, C17 and C18 are not used.

Figure 20. MRF6VP3091NR1(NBR1) 470–860 MHz Broadband 2″ × 3.6″ Compact Reference Circuit Component Layout

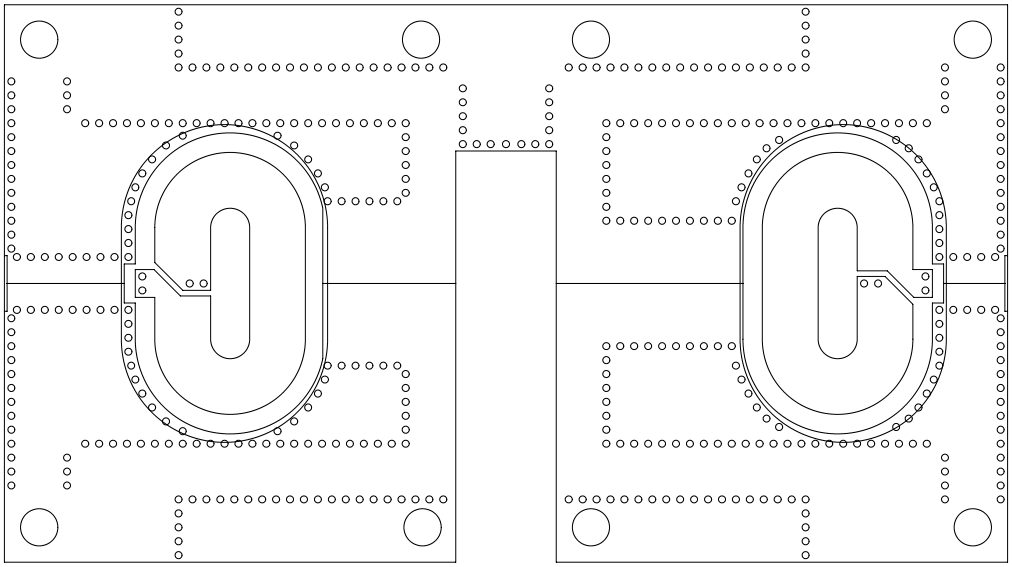
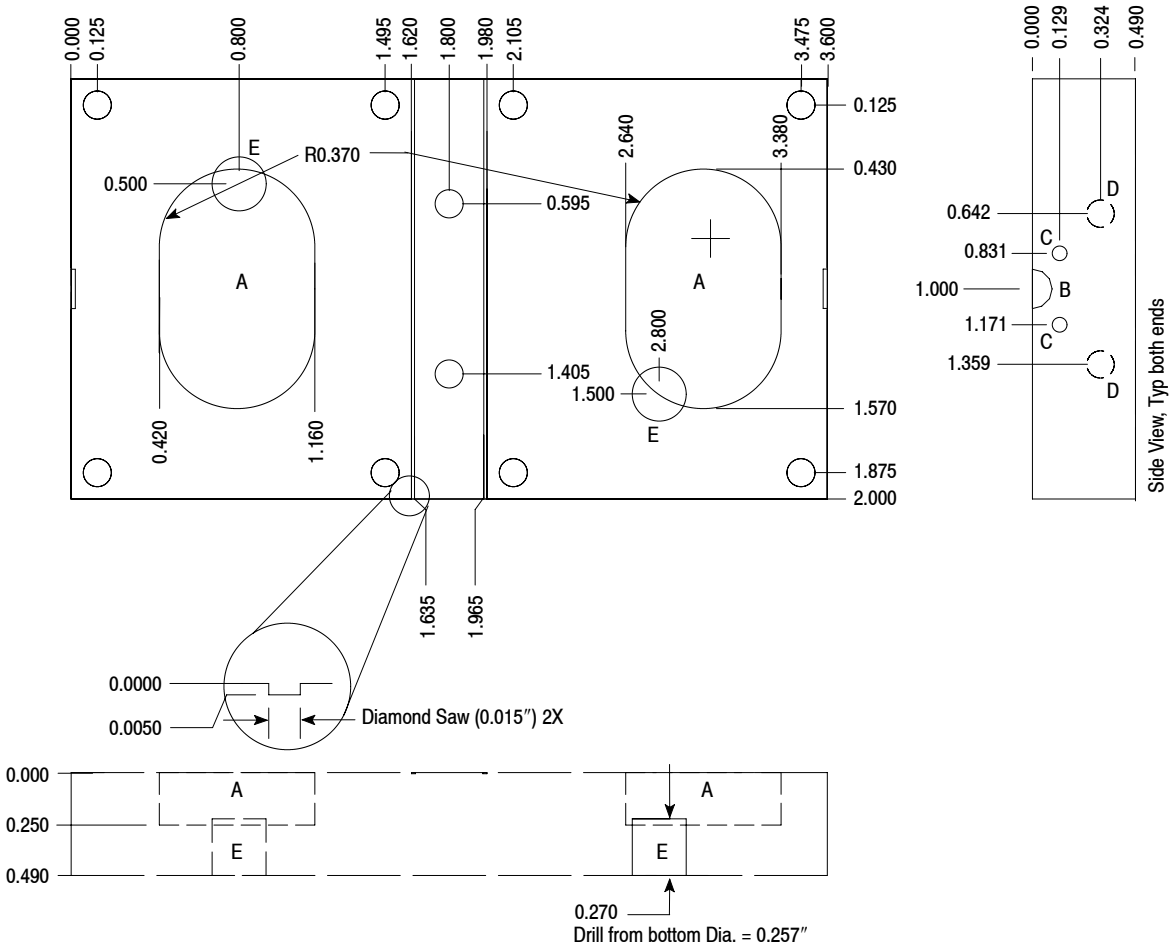


Figure 21. MRF6VP3091NR1(NBR1) 470–860 MHz Broadband 2″ × 3.6″ Compact Reference Circuit Component Layout — Bottom



T0-272 0.490″ Copper Heatsink (for 30 mil 1 oz/1 oz PCB)

Designators	Details
A	2 places, mill down cavity 0.250″
B	2 places, on sides, 0.1875 diameter notch 0.020″ deep (N connector notch)
C	4 places, side, drill & tap #2-56 screw 0.500″ deep (SMA holes)
D	4 places, side, drill & tap #4-40 screw 0.500″ deep (N conn holes)
E	2 places drill diameter = 0.257″, from bottom depth = 0.270″
All others, drill through & tap for #4-40 screw	

Figure 22. MRF6VP3091NR1(NBR1) 470-860 MHz Broadband 2″ × 3.6″ Compact Reference Circuit Component Layout — Heatsink

Table 7. MRF6VP3091NR1(NBR1) 470–860 MHz Broadband 2″ × 3.6″ Compact Reference Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1, C3, C4, C7, C8, C10	51 pF Chip Capacitors	ATC100B510GT500XT	ATC
C2	7.5 pF Chip Capacitor	ATC100B7R5CT500XT	ATC
C5	4.7 pF Chip Capacitor	ATC100B4R7CT500XT	ATC
C9	5.6 pF Chip Capacitor	ATC100B5R6CT500XT	ATC
C11, C12	47 μF, 16 V Tantalum Capacitors	T491D476K016AT	Kemet
C13, C14, C19, C20	200 pF Chip Capacitors	ATC100B201JT300XT	ATC
C21, C22	2.2 μF, 100 V Chip Capacitors	C3225X7R2A225KT	TDK
C23, C24	470 μF, 63 V Electrolytic Capacitors	MCGPR63V477M13X26–RH	Multicomp
Q1	RF High Power Transistor	MRF6VP3091NBR1	Freescale
R1, R2	10 Ω Chip Resistors	CRCW120610R0JNEA	Vishay
R3, R4	56 Ω Chip Resistors	CRCW120656R0FKEA	Vishay
PCB	0.030″, ε_r = 3.5	RO4350B	Rogers

TYPICAL CHARACTERISTICS — 470–860 MHz BROADBAND REFERENCE CIRCUIT

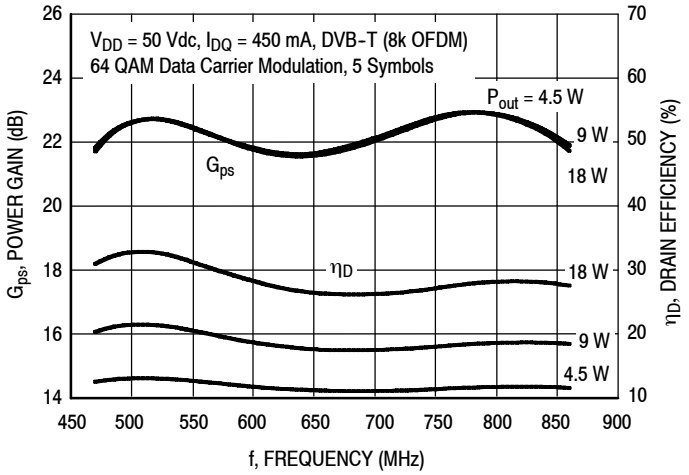
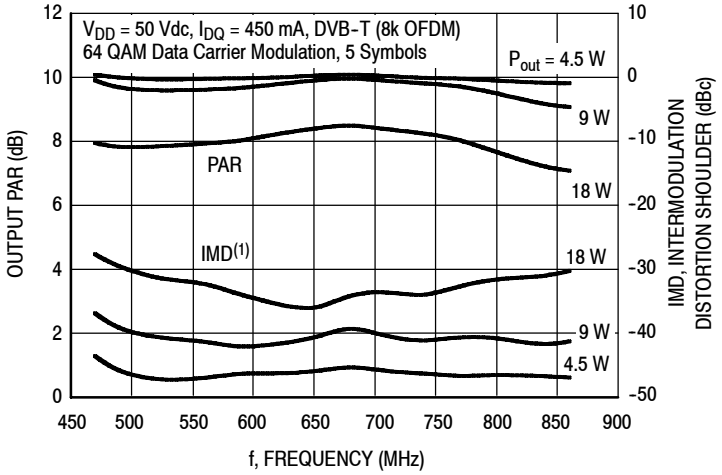


Figure 23. Single-Carrier DVB-T (8k OFDM) Power Gain and Drain Efficiency versus Frequency (Broadband Reference Circuit)



(1) Intermodulation distortion shoulder measurement made using delta marker at 4.2 MHz offset from center frequency.

Figure 24. Single-Carrier DVB-T (8k OFDM) Output PAR and IMD Shoulder versus Frequency (Broadband Reference Circuit)

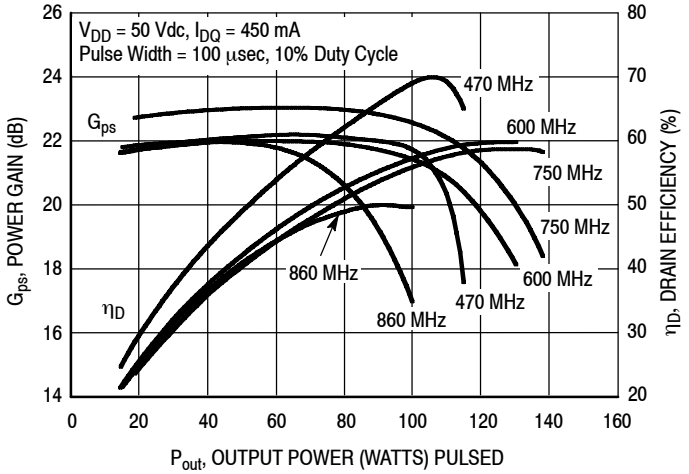
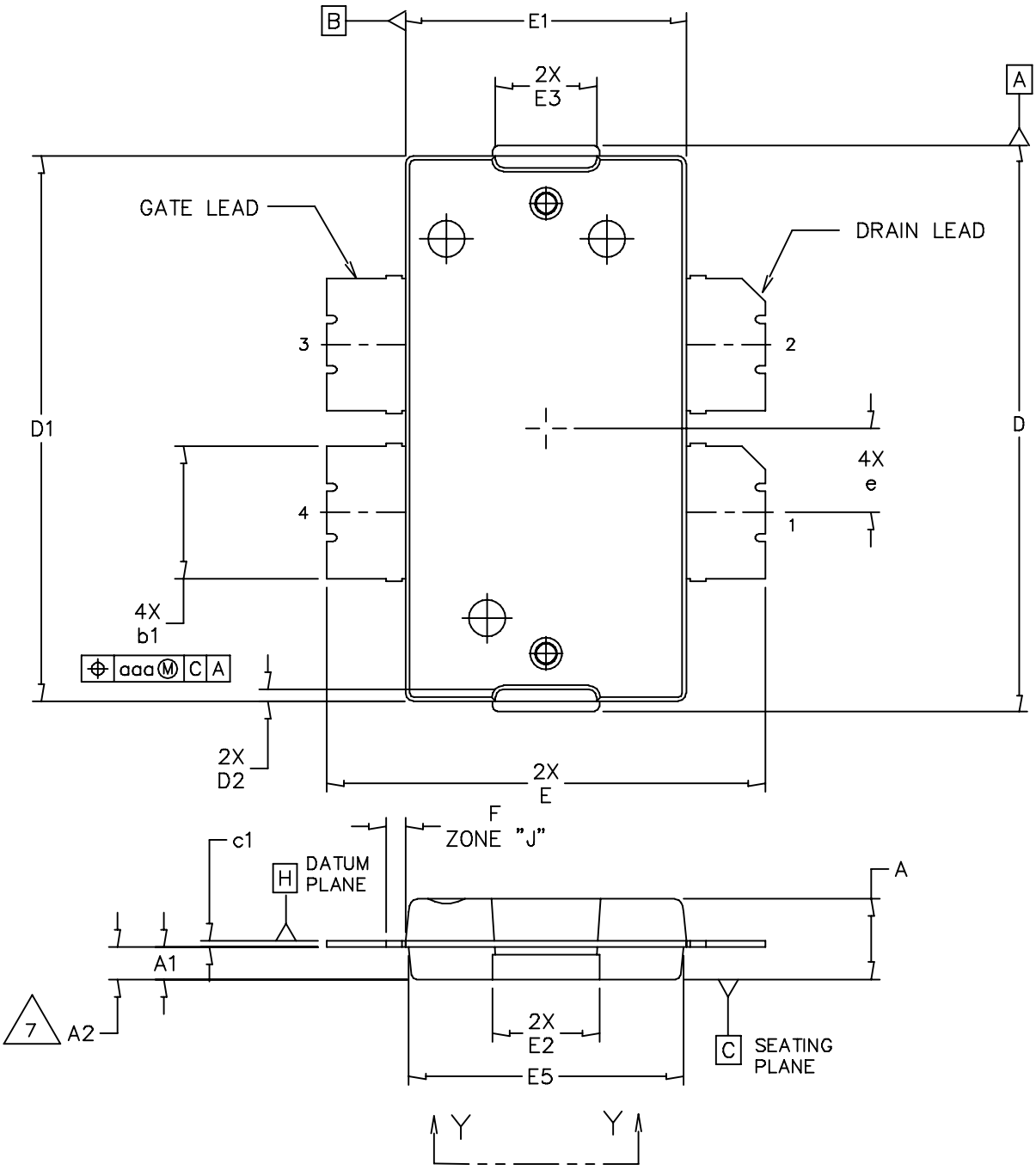
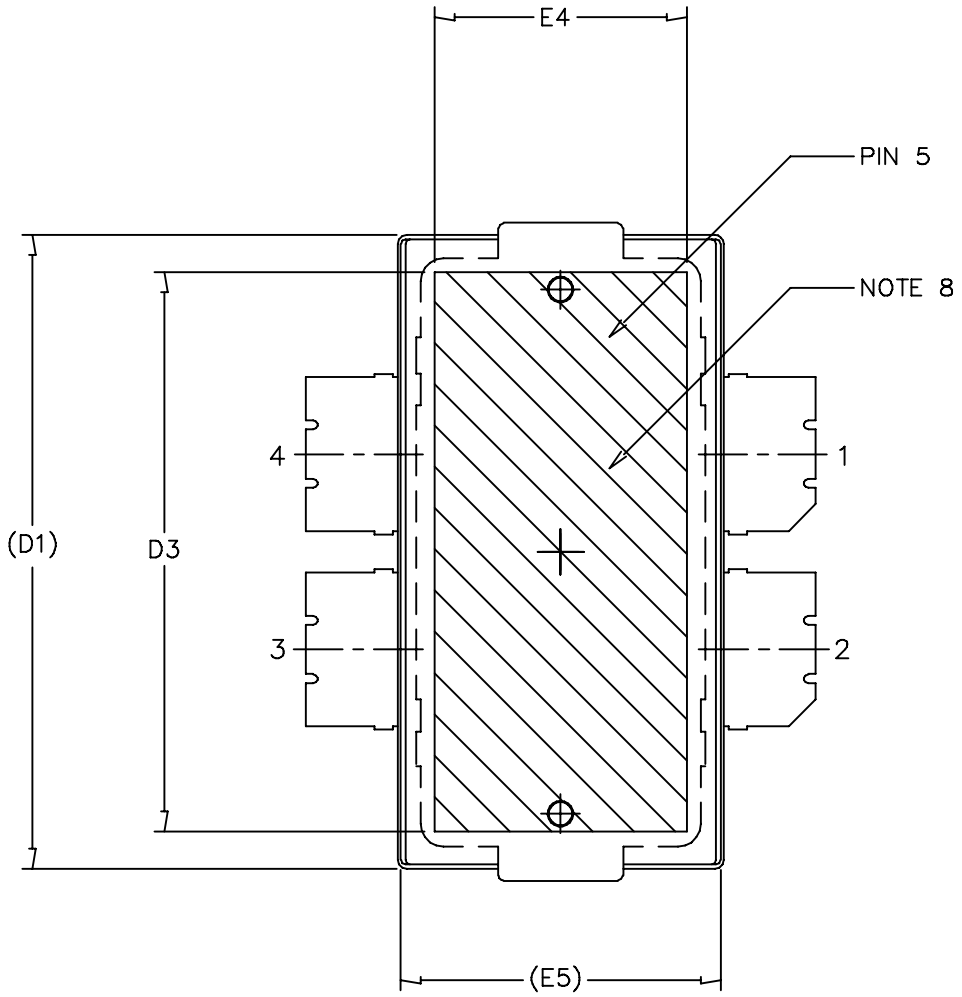


Figure 25. Pulsed Power Gain and Drain Efficiency versus Output Power (Broadband Reference Circuit)

PACKAGE DIMENSIONS



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	CASE NUMBER: 1486−03	13 AUG 2007
	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 THE 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. DIMENSIONS "b1" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 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. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG.

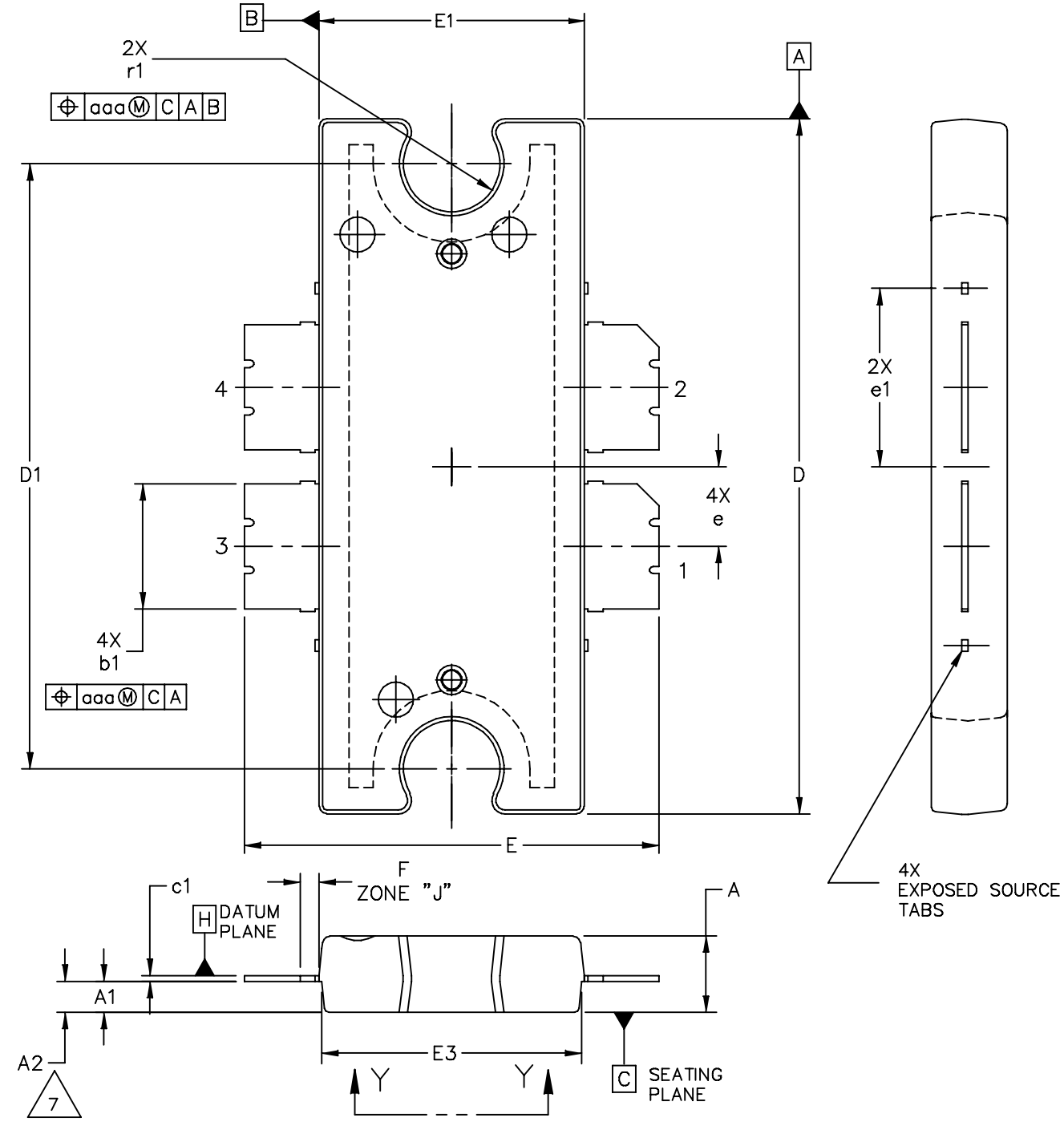
STYLE 1:
PIN 1 – DRAIN PIN 2 – DRAIN
PIN 3 – GATE PIN 4 – GATE
PIN 5 – SOURCE

DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX
A	.100	.104	2.54	2.64	F	.025 BSC		0.64 BSC	
A1	.039	.043	0.99	1.09	b1	.164	.170	4.17	4.32
A2	.040	.042	1.02	1.07	c1	.007	.011	.18	.28
D	.712	.720	18.08	18.29	e	.106 BSC		2.69 BSC	
D1	.688	.692	17.48	17.58	aaa	.004		.10	
D2	.011	.019	0.28	0.48					
D3	.600	---	15.24	---					
E	.551	.559	14	14.2					
E1	.353	.357	8.97	9.07					
E2	.132	.140	3.35	3.56					
E3	.124	.132	3.15	3.35					
E4	.270	---	6.86	---					
E5	.346	.350	8.79	8.89					

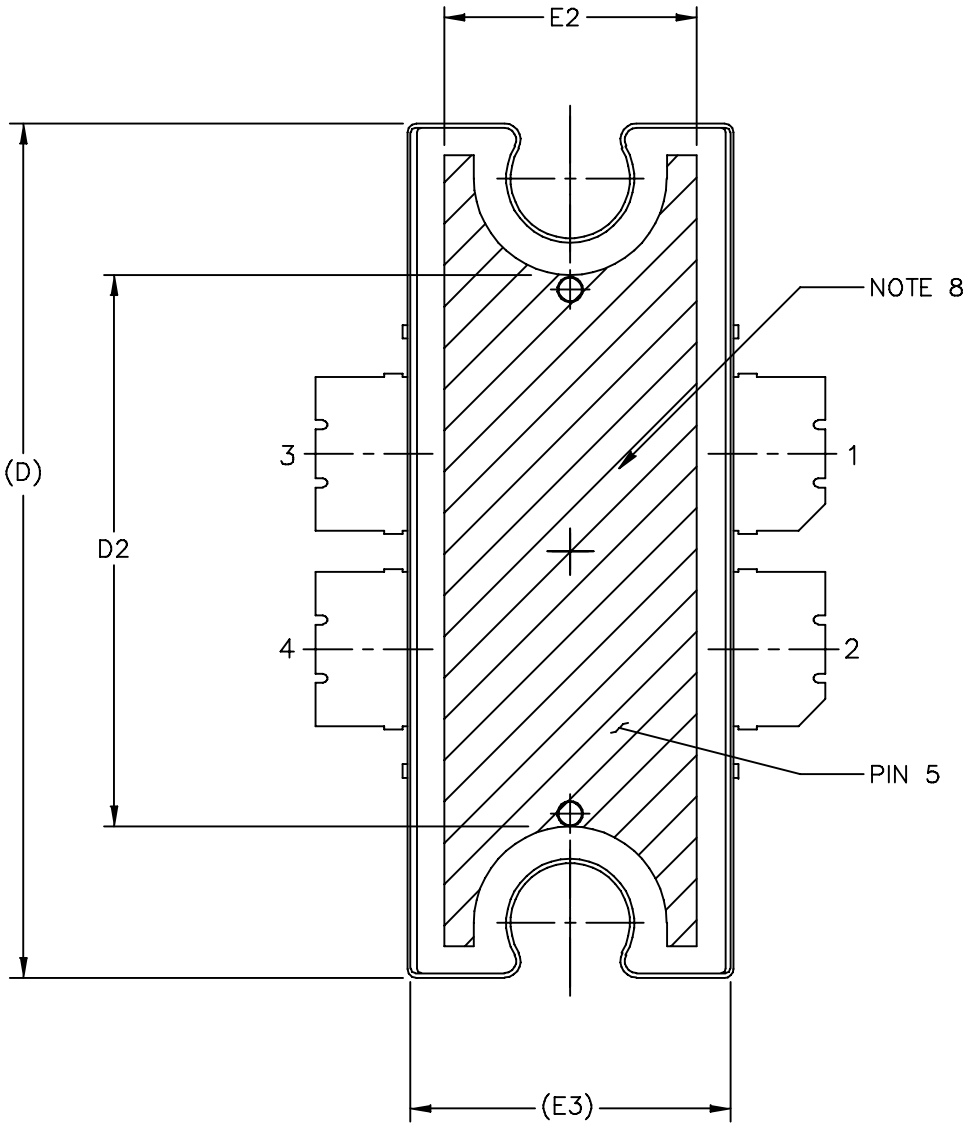
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	CASE NUMBER: 1484−04	31 AUG 2007
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TITLE: TO−272 4 LEAD, WIDE BODY	DOCUMENT NO: 98ASA10575D	REV: E
	CASE NUMBER: 1484−04	31 AUG 2007
	STANDARD: NON−JEDEC	

NOTES:

1. CONTROLLING DIMENSION: INCH
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M–1994.
3. DATUM PLANE H IS LOCATED AT THE 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. DIMENSIONS "b1" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE "b1" DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUM A AND B TO BE DETERMINED AT DATUM PLANE H.
7. DIMENSION A2 APPLIES WITHIN ZONE "J" ONLY.
8. HATCHING REPRESENTS EXPOSED AREA OF THE HEAT SLUG. HATCHED AREA SHOWN IS ON THE SAME PLANE.

STYLE 1:
PIN 1 – DRAIN PIN 2 – DRAIN
PIN 3 – GATE PIN 4 – GATE
PIN 5 – SOURCE

DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX
A	.100	.104	2.54	2.64	b1	.164	.170	4.17	4.32
A1	.039	.043	0.99	1.09	c1	.007	.011	.18	.28
A2	.040	.042	1.02	1.07	r1	.063	.068	1.60	1.73
D	.928	.932	23.57	23.67	e	.106 BSC		2.69 BSC	
D1	.810 BSC		20.57 BSC		e1	.239 INFO ONLY		6.07 INFO ONLY	
D2	.600	---	15.24	---	aaa	.004		.10	
E	.551	.559	14	14.2					
E1	.353	.357	8.97	9.07					
E2	.270	---	6.86	---					
E3	.346	.350	8.79	8.89					
F	.025 BSC		0.64 BSC						

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TO–272 4 LEAD WIDE BODY	CASE NUMBER: 1484–04	31 AUG 2007
	STANDARD: NON–JEDEC	

PRODUCT DOCUMENTATION, TOOLS AND SOFTWARE

Refer to the following documents, tools and software 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
- AN3263: Bolt Down Mounting Method for High Power RF Transistors and RFICs in Over-Molded Plastic Packages
- AN3789: Clamping of High Power RF Transistors and RFICs in Over-Molded Plastic Packages

Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

Software

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

For Software and Tools, 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	Sept. 2011	• Initial Release of Data Sheet
1	Dec. 2011	• Added R5 part numbers MRF6VP3091NR5 and MRF6VP3091NBR5, p. 1 • Fig. 7, CW Power Gain versus Output Power (Single-Ended Narrowband Test Circuit): adjusted x-axis scale from 0 to 140 watts to 10 to 150 watts, p. 5 • Fig. 10, Intermodulation Distortion Products versus Two-Tone Spacing: added f = 860 MHz to graph callouts, p. 6 • Added Fig. 21, 470-860 MHz Broadband 2″ × 3.6″ Compact Reference Circuit Component Layout - 470-860 MHz - Bottom, p. 10 • Added Fig. 22, 470-860 MHz Broadband 2″ × 3.6″ Compact Reference Circuit Component Layout - 470-860 MHz - Heatsink, p. 10

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