Application Measurement Report

CA-311-13 BLF188XR 88-108MHz

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Document information

Info	Content
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Author Role	Application Engineer
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Abstract	Measurement results of a BLF188XR device at 88-108MHz with an output power of 1200W CW in an all planar application circuit.

founded by Philips

Revision History

Revision	Date	Description	Author
0.0	2013-Sept. 10	Initial version	Richard Keenan

Contents

1. Introduction

1.1 General Description

This document contains measurement results of a BLF188XR device from 88 to 108MHz tested with a CW signal. This demo has been optimized for maximum efficiency at an output power of 1000W CW and supply voltage of 45.5-47.5Vds but has also been measured up to1200W CW with 50Vds.The application board has been designed to manage the temperature of components and the PCB by using Chomerics Therma-A-Gap material to spread the heat under the output planar transmission line transformer and a high thermal conductivity PCB screwed to a copper base plate that is mounted to a water cooled heat sink for testing. Thermal measurements for this application board operating at 1200W CW are shown in Para.5.

1.2 Test object details

Transistor type:	BLF188XR (screwed down, thermal cond. compound, Bergquist TIC4000)
Production code:	M1328 WO
Package:	SOT539
Board:	30 mil thick, RF35TC.
Demo number:	2434

1.3 Test Setup

Test Signal: CW Load: Bird Tenuline 30dB Oil load Model 8327 S/N 94

88MHz 50.80+j.12 ohms 1.016:1

98MHz 50.85-j.16 ohms 1.017:1

108 MHz 50.89-j.51 ohms 1.021:1

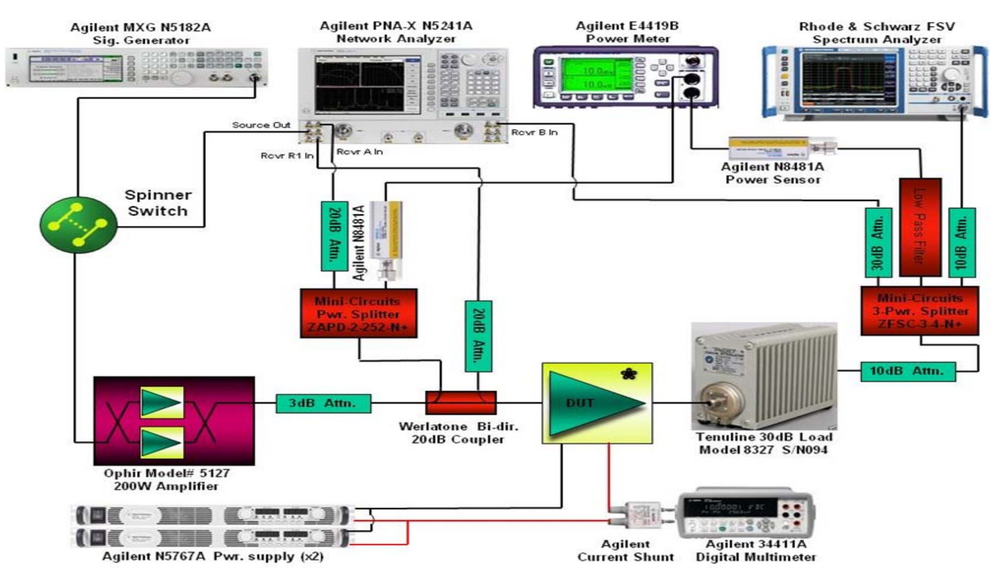


Fig 1. Test Setup → See Figure 12 for connections to DUT

1.4 Typical Performance BLF188XR

Symbol	Parameter	88 MHz	98 MHz	108 MHz	Unit
I_{Dq}	quiescent current	1000	1000	1000	mA
V_{DS}	power supply	47.5	45.5	47.5	V
Pout	Peak Output power	1000	1000	1000	W
$G_{@1000W}$	Gain at 1000W Pout	23.0	23.3	23.1	dB
$Gcomp_{@1000W}$	Gain compression at 1000W Pout	2.6	2.4	2.9	dB
$Eff_{@1000W}$	Efficiency at 1000W Pout	84.4	83.0	83.0	%
V_{DS}	power supply	50	50	50	V
Pout@ P_{3dB}	Peak Output power @ 3dB gain comp.	1123	1227	1107	W
$G_{@P3dB}$	Gain P3dB	22.8	22.9	23.0	dB
$Eff_{@P3dB}$	Efficiency at P3dB	84.6	83.3	82.8	%
2^{nd} H	2^{nd} Harmonic (100-1000W output pwr.)	-27.9	-31.3	-28.8	dBc
3^{rd} H	3^{rd} Harmonic (100-1000W output pwr.)	-30.7	-31.5	-31.1	dBc

2. Summary

This document contains measurement results of a BLF188XR device using NXP's XR process to provide maximum ruggedness capability in the most severe applications. Features of the XR process include high power and efficiency, extreme ruggedness, a typical thermal resistance R_{th} of 0.11 K/W, and enhanced double sided ESD diode protection.

As shown in this report the BLF188XR device can be used with a planar transmission line transformer on the input and output section to replace the more commonly used coaxial cable transformers. The output planar transmission line transformer was designed to manage the component and PCB temperature during maximum CW operation. A 5mm thick Chomerics Therm-A-Gap material is used in the area below the output planar transformer to improve spreading of the heat from the PCB to the copper base plate. To further improve the maximum temperature of the components and PCB, this amplifier uses a Taconic's RF35TC PCB dielectric material with 2 oz. copper which has approx. 4x better thermal conductivity than the standard RF35. This all planar application board, which eliminates coaxial cable transformers and has been optimized to limit the maximum temperature of the PCB and components, allows for simpler manufacturing, reduced cost, and more repeatable performance.

The measurement results show that the BLF188XR is an excellent choice for an application from 88 to108MHz with up to 1200W CW peak output power, >80% efficiency, and a maximum component/PCB temperature measuring 105ºC at 1200W CW output power. The results also show that the device passes ruggedness without any performance degradation or spurious with a 3:1 mismatch up to 1200W CW and a 5:1 mismatch up to 1000W CW.

3. Measurement Results

3.1 CW – Power Sweeps

3.1.1 Gain & Efficiency (optimized for max. efficiency @ 1000W CW output power)

Table 1: Gain & Efficiency

Frequency [MHz]	Vds (V)	Pout [W]	Gain [dB]	Gain Compression [dB]	Efficiency [%]
88	47.5	1000	23.0	2.6	84.4
98	45.5	1000	23.3	2.4	83.0
108	47.5	1000	23.1	2.9	83.0

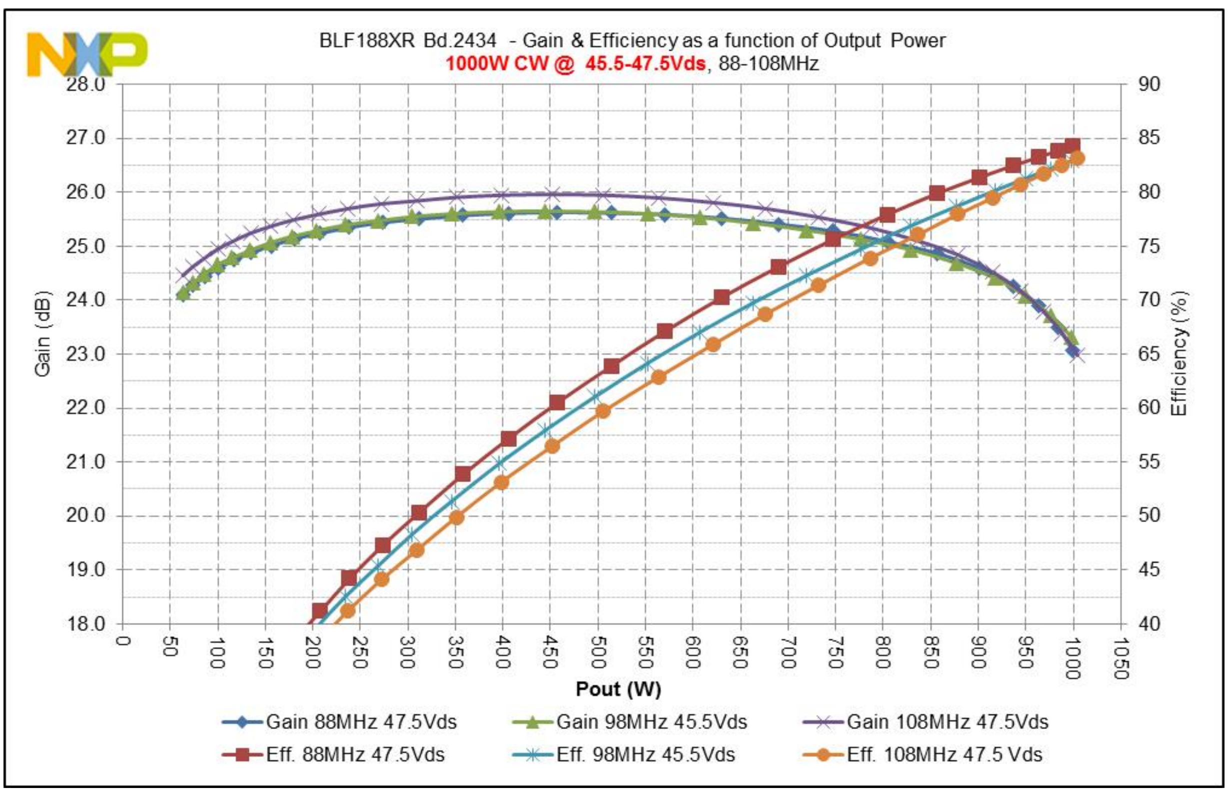


Fig 2. Gain and Efficiency as a function of Output Power for a CW signal, 45.5-47.5Vds.

3.1.2 CW Output Power, Gain & Efficiency @ 3dB Gain Compression

Table 2: CW Output Power, Gain & Efficiency

Frequency [MHz]	Vds (V)	Pout [W]	Gain [dB]	Efficiency [%]
88	50	1123	22.8	84.6
98	50	1227	22.9	83.3
108	50	1107	23.0	82.8

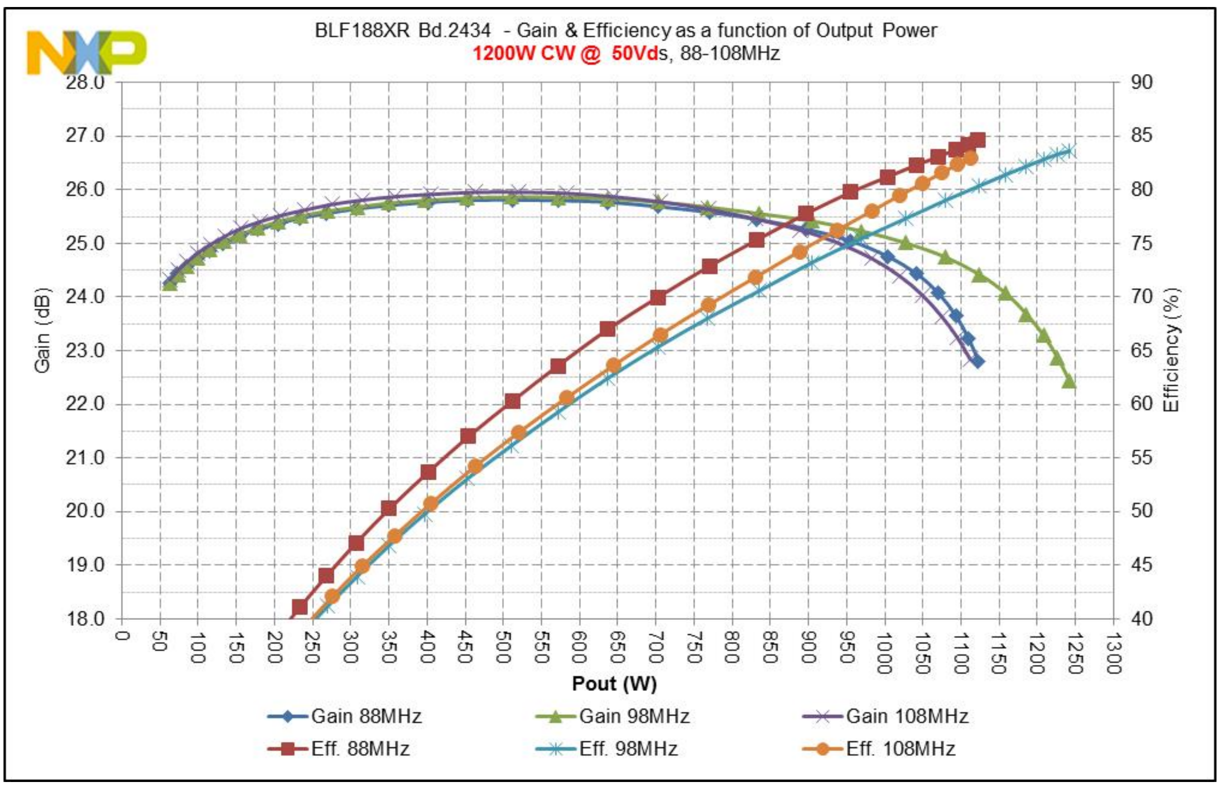


Fig 3. Gain and Efficiency as a function of Output Power for a CW signal, 50Vds.

3.2 CW – Network Analyzer Sweep

3.2.1 Gain & Input Return Loss at approx. 1000W CW, 50Vds

Table 3: Gain & Input Return Loss

Frequency [MHz]	Gain [dB]	Input Return Loss (dB)
108	24.9	-11.1
113	25.0	-12.0
118	24.8	-11.8

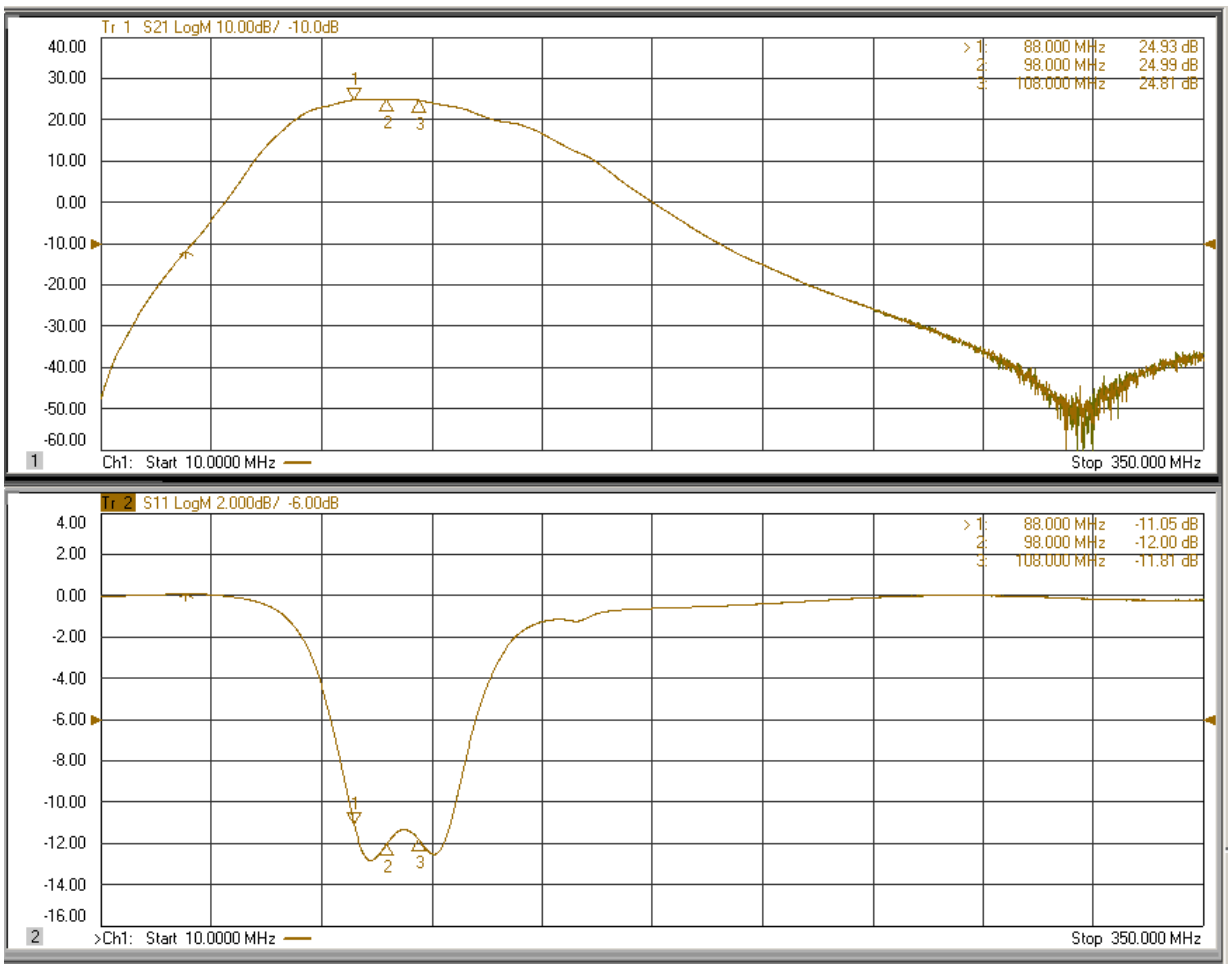
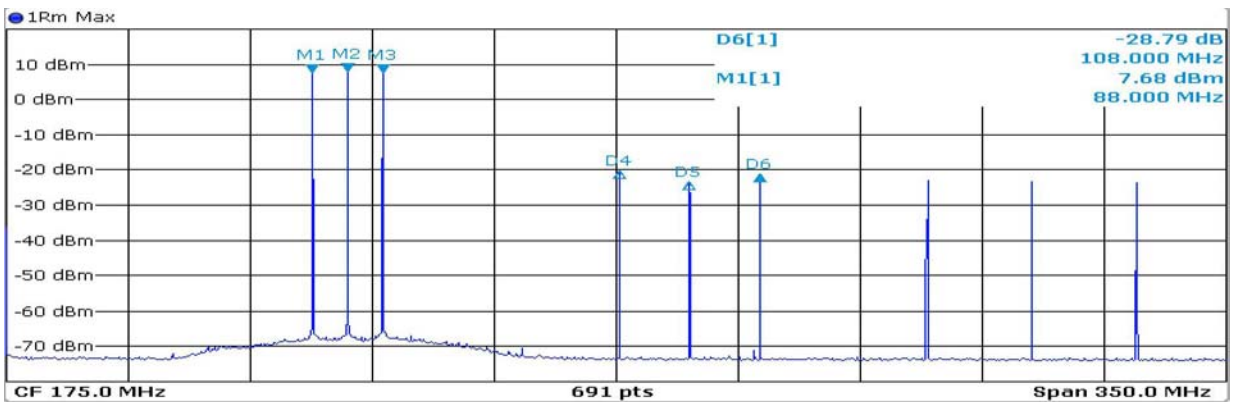


Fig 4. Gain and R.Loss as a function frequency. (@ approx. 1000W)

3.3 Harmonics

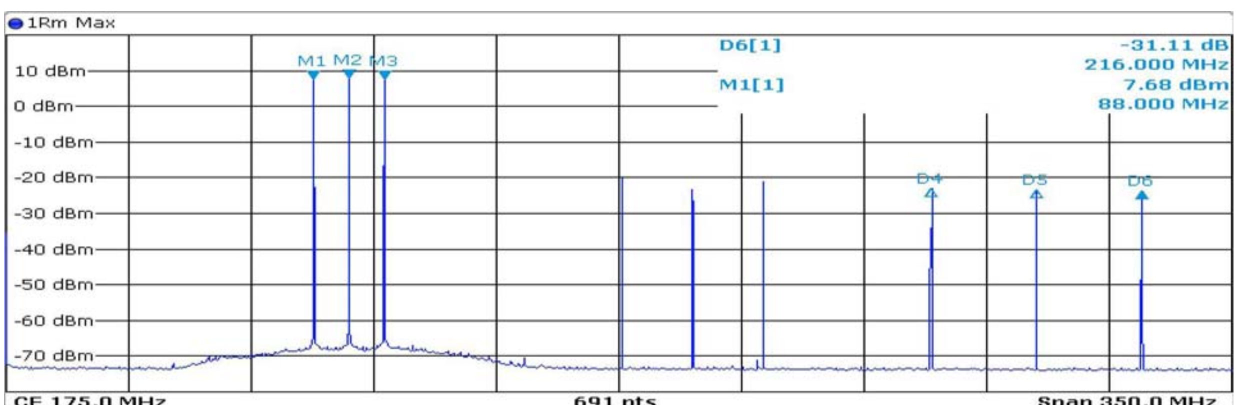
3.3.1 BLF188XR Harmonics (Meas. Max. old up to 1200W CW)



Marker

Type	Ref	Trc	Stimulus	Response	Function	Function Result
N1		1	88.0 MHz	7.68 dBm		
N2		1	98.0 MHz	8.03 dBm		
N3		1	108.0 MHz	7.55 dBm		
D4	N1	1	88.0 MHz	-27.91 dB		
D5	N2	1	98.0 MHz	-31.27 dB		
D6	N3	1	108.0 MHz	-28.79 dB		

Fig 5. 2nd Harmonics, 50 to 1200W CW output power



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Type	Ref	Trc	Stimulus	Response	Function	Function Result
N1		1	88.0 MHz	7.68 dBm		
N2		1	98.0 MHz	8.03 dBm		
N3		1	108.0 MHz	7.55 dBm		
D4	N1	1	176.0 MHz	-30.67 dB		
D5	N2	1	196.0 MHz	-31.51 dB		
D6	N3	1	216.0 MHz	-31.11 dB		

Fig 6. 3rd Harmonics, 50 to 1200W CW output power

4. Ruggedness Testing

4.1 Ruggedness Test with a CW signal

Ruggedness testing is done using a length of H&S Sucoform250 cable terminated in variable capacitor to rotate thru all phases. The loss of the length of line at 98MHz determines the mismatch presented to the application board. The input power is recorded for an output power of 1000W and 1200W CW when terminated into a 50 ohm load. This input power is then set during ruggedness testing when a mismatch of 3:1 (1200W CW) and 5:1 (1000W CW) is presented at the output of the application board.

Spurious emissions were also monitored using a 10K ohm resistor probe on one drain of the output device during ruggedness testing. The cancelation or reduction of the harmonics from the push pull configuration is not seen because only one drain lead is being probed. Therefore the harmonics in this measurement is very high compared to the harmonics at the output connector.

4.1.1 3:1 Mismatch @ 1200W CW – Passed thru all phases. (spurious <-70dBc)

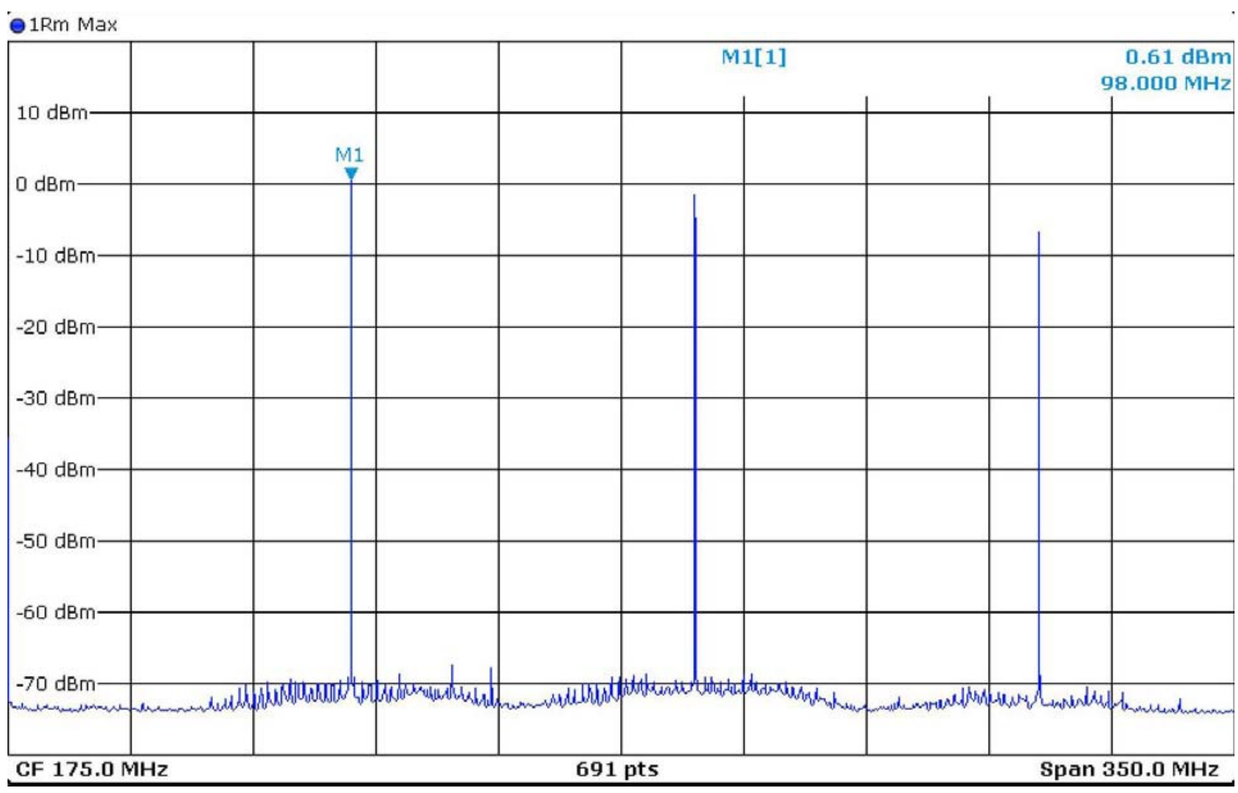


Fig 7. Spurious emissions with 3:1 mismatch and 1200W CW output power.

4.1.2 5:1 Mismatch @ 1000W CW – Passed thru all phases. (spurious <-60dBc)

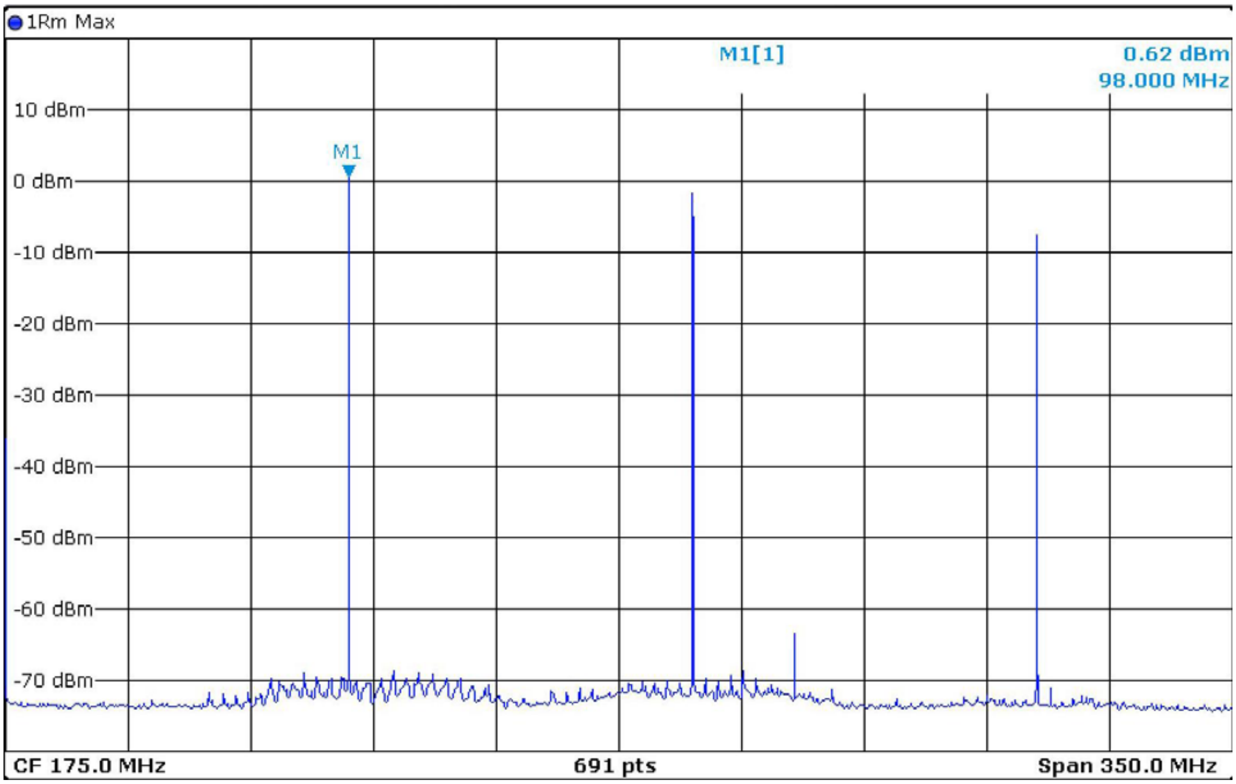


Fig 8. Spurious emissions with 5:1 mismatch and 1000W CW output power.

5. Thermal Measurements

5.1 Thermal measurements

Thermal measurements were performed on this application board at 98MHz and 1200W CW output power. The temperature of the output PCB and components were measured using a FLIR IR camera. The output circuit was painted black so there would be a uniform emissivity and accurate IR measurements. The temperatures shown below were measured with the BLF188XR off and operating at 50Vds and 1200W CW output power.

The BLF188XR application circuit is on a copper base plate (non-water cooled) which is then mounted to a brass water cooled heat sink with the water at approx. 18-20 ºC. The application board uses an electrically insulating and thermally conductive Chomerics Therm-A-Gap material under the output planar transmission line transformer to improve heat spreading from the PCB and components to copper base plate. To further improve the maximum temperature of the components and PCB, this amplifier uses a Taconic's RF35**TC** PCB dielectric material with 2 oz. copper which has approx. 4x better thermal conductivity than the standard RF35.

The maximum component and PCB temperature measured was **105ºC at 1200W CW** output power.

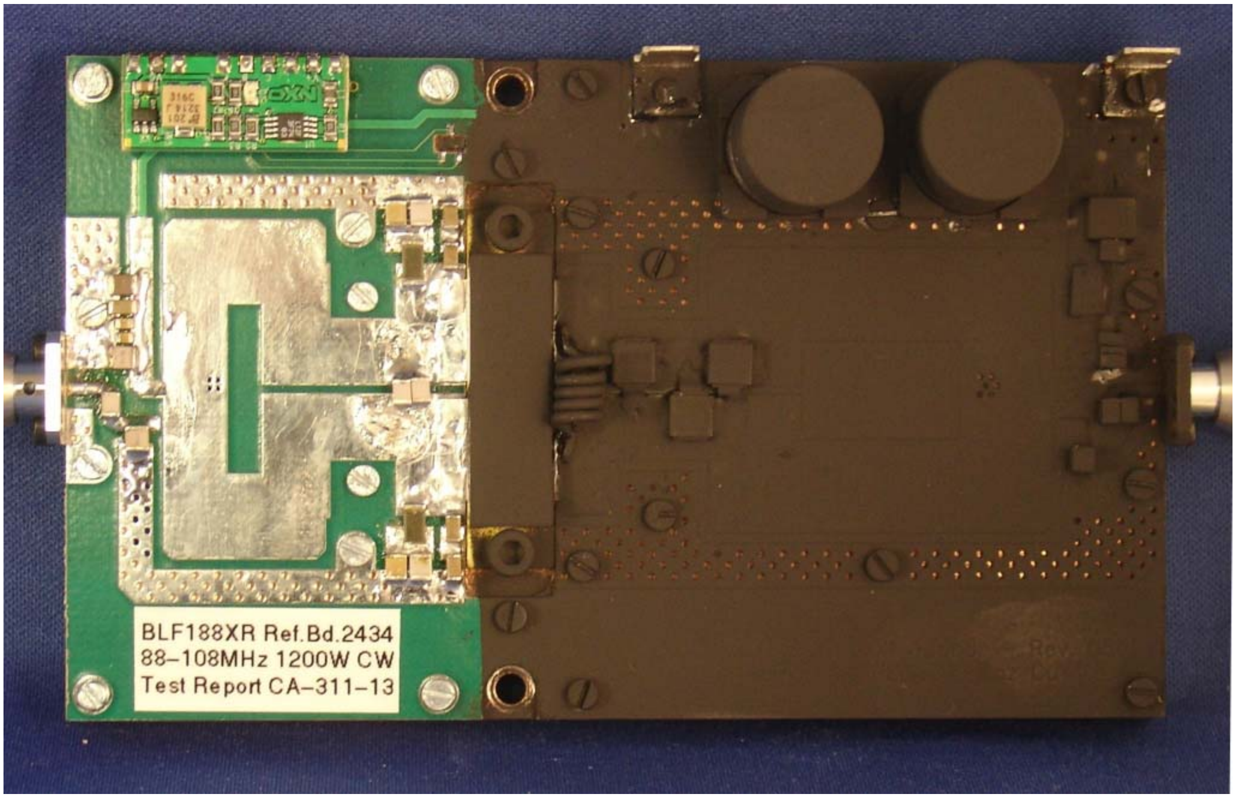


Fig 9. BLF188XR Bd.2434 Thermal Measurements

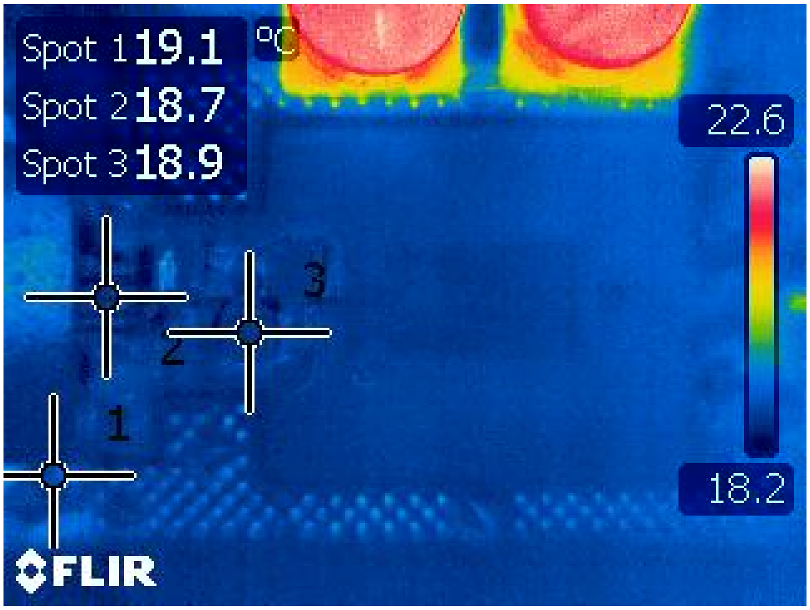


Fig 10. No DC or RF power

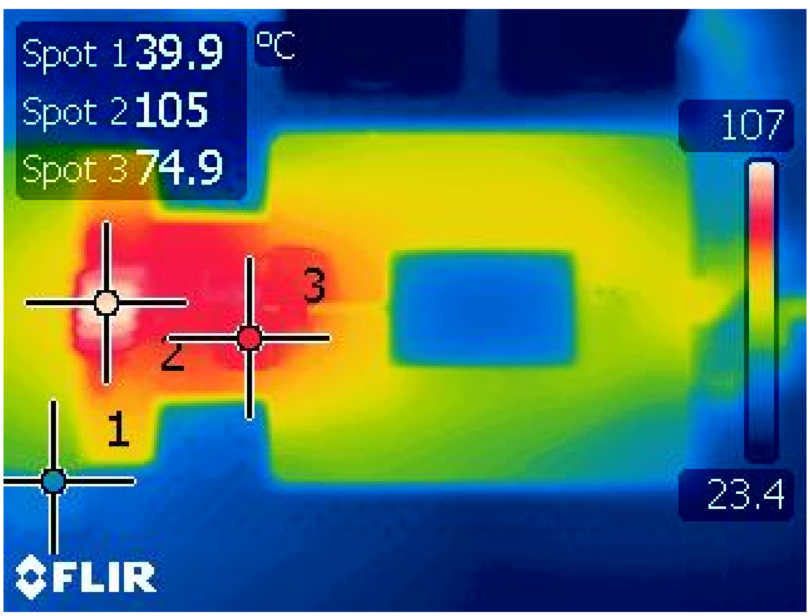
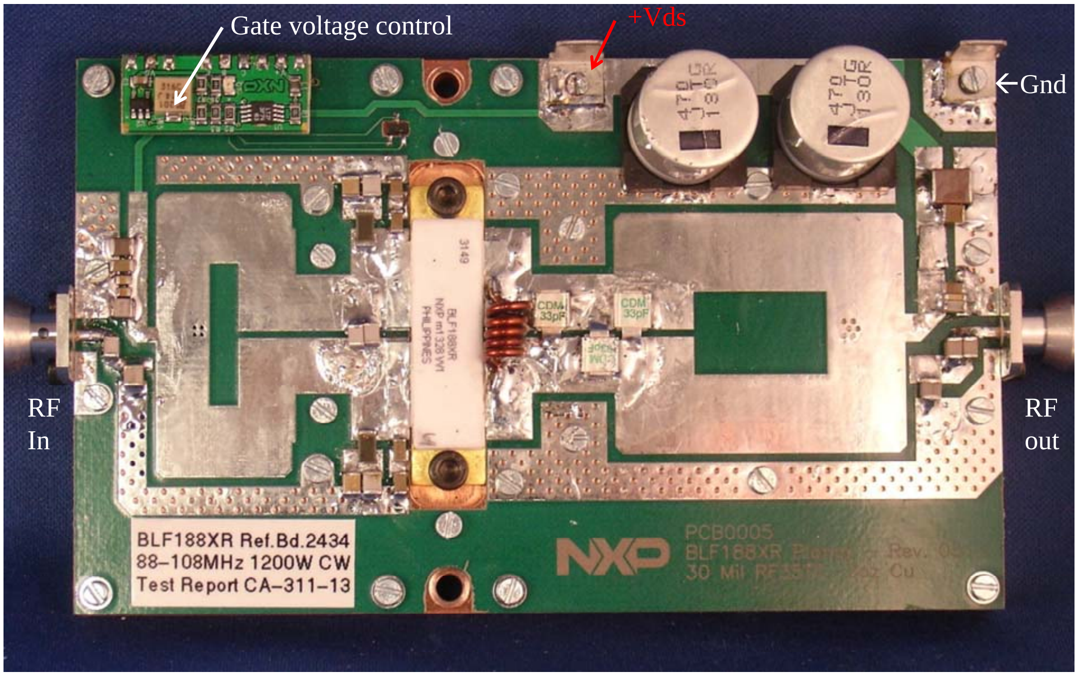


Fig 11. 1200W CW – 105 °C Max. temperature

6. Photo

6.1 Application Circuit Connections



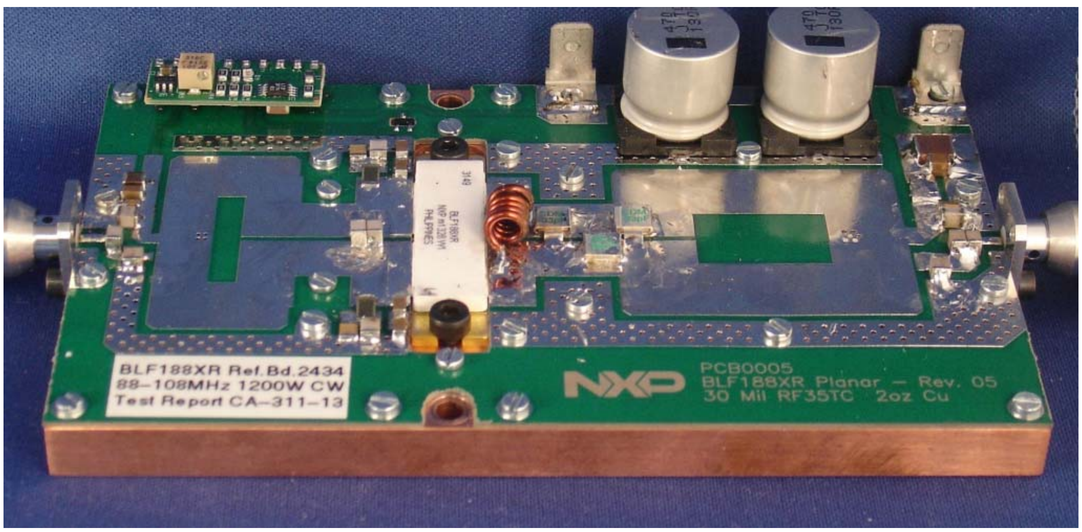


Fig 12. BLF188XR Bd.#2434

This amplifier requires a 45.5-50V DC power supply connected to the Vds input shown above. This power supply is used for both the drain supply and for our LDMOS bias circuit which supplies the gate voltage. Details of the LDMOS bias circuit are in the attached report CA-330-11. RF input is connected to the N-type connector on the left and the amplifier load is connected to the RF output N-type connector on the right.

7. Layout and Material List

7.1 Layout

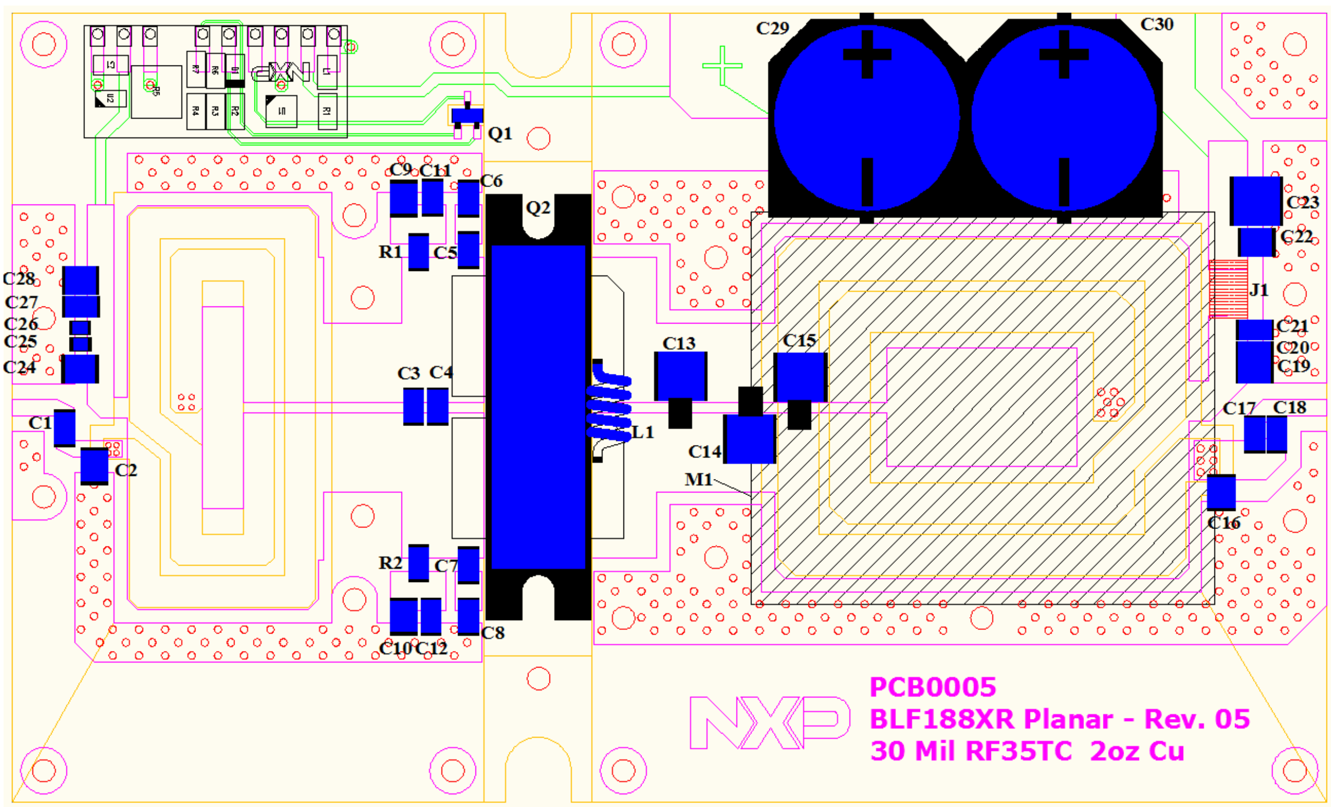


Fig 13. Layout (AutoCAD dxf file attached)

7.2 Material List

Designator	Description	Manufacturer	Part #
PCB	Input PCB 30 mil thk. RF35TC	Avanti Circuits	PCB0005_BLF188XR_Planar_PCBfab_Rev05
Q1	2N2222 NPN Transistor	Fairchild	MMBT2222
Q2	BLF188XR	NXP	BLF188XR
R1, R2	5Ω, ALN50W	IMS	NG3-2010WA5R0J
L1	5T, 16 AWG, .125 inner dia.		
J1	Copper or Brass Jumper		
C1	43 pF	Passive Plus	1111N
C2	27 pF	Passive Plus	1111N
C3	20pF	Passive Plus	1111N
C4	330pF	Passive Plus	1111N
C5, C6, C7, C8, C21	1uF	Murata	GRM31CR72A105KA01L
C9,C10	100nF	AVX	12101C104KAT2A
C11,C12	10 nF	TDK	C3225C0G2E103J
C13, C14, C15	33 pF MICA	Cornell Dubilier CDE	MIN02-002E700J
C16	33 pF	Passive Plus	1111N
C17 C18	1000 pF	Passive Plus	1111N
C19	10 nF	TDK	C3225C0G2E103J
C20	100 nF	Murata	GRM31CR72E104KW03L
C22	2.2 uF	Murata	GRM32ER72A225KA35L
C23	10uF	TDK	C5750X7R1H106M
C24	820 pF	Passive Plus	1111N
C25	10nF	Multicomp	U0805R103KCT
C26	100 nF	Multicomp	S0805W104K1HRN-P4
C27	1 uF	Murata	GRM31CR72A105KA01L
C28	10 uF	Murata	GRM32DF51H106ZA01L
C29, C30	470 uF, Electrolytic	Panasonic	PCE3667CT-ND
M1**	0.2 in. thick Chomerics Terma-A-Gap 976	Chomerics	Therma-A-Grip 976

PC-board Material: 30 mil thk. RF35TC ,2oz copper each side. ** M1 is in machined pocket in base plate under PCB.

Fig 14. BLF188XR Material List

8. Copper Base Plate

8.1 Base plate

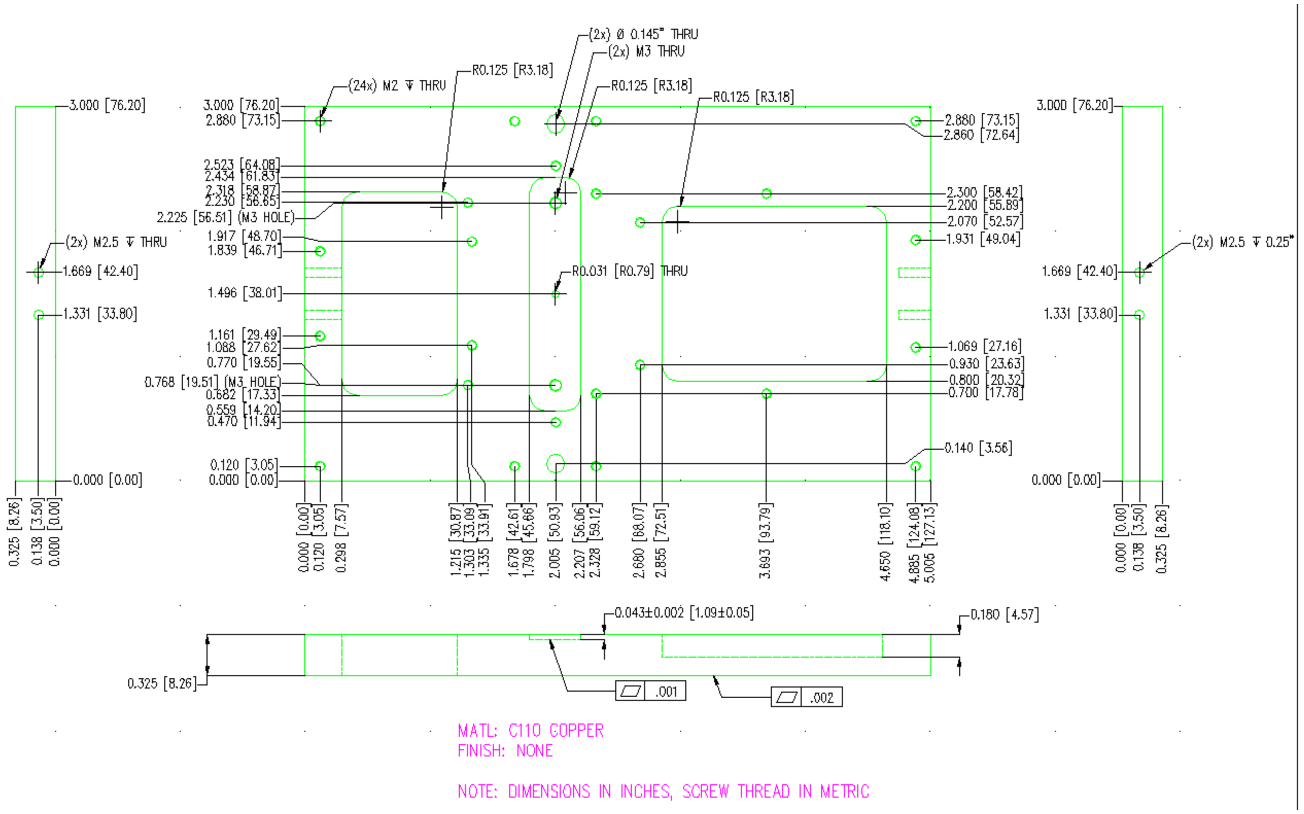


Fig 15. Base Plate drawing (AutoCAD dxf file attached)

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