AR211050

ART1K6FH, 88-108MHz

v1.3 — 18-March-2021

AMPLEON

Application Report

Document information	
Status	Company Public
Author(s)	Ampleon
Abstract	Measurement results of a Class AB design for the 88-108MHz band with the ART1K6FH

1. Revision History

Table 1: Report revisions

Revision	Date	Description	Author
1.0	18-March-2021	Initial document	Harrie Rahangmetan
1.1	29-March-2021	Corrected several typos	Harrie Rahangmetan
1.2	06-December-2021	Value C23 corrected	Harrie Rahangmetan
1.3	03-January-2023	Corrected typo in the BOM.	Harrie Rahangmetan

2. Contents

3. List of figures

4. List of tables

5. Introduction

5.1 General description

This report presents the measurement results of the Class AB amplifier demo AR211050. The device ART1K6FH used is a 1600 W advanced ruggedness LDMOS power transistor for industrial, scientific and medical applications in the HF to 400 MHz band, 9th generation LDMOS in a SOT539 package. ART1K6FH is a symmetrical push-pull power transistor. The presented demo is tuned for the frequency band 88-108MHz.

5.2 Test object details

Transistor type:	ART1K6FH (Soldered down)
Production code :	m2030-0001
Package :	SOT539
Board:	ART1K6FH_input_output_rev4.3
Demo number:	AR211050

5.3 Used Test signals

CW:	CW (Vds=48V - 52V)

5.4 Test circuit

A description of this circuit can be found in Appendix A.

Start with a supply voltage (drain-source) of 50V. The total Idq should be 100mA (2x50mA).

Start with Vgs1=1.5V and increase until Idq1=50mA.

Then Vgs2=1.5V and increase until Idq2=50mA.

Leave the Vgs as it is, and you can vary Vds from 48V till 52V.

6. Measurement Results

6.1 Summary CW Power Sweeps (Vds=48V, results @ 1200W)

Freq [MHz]	MaxGain [dB]	MaxEff [%]	G@MxEff [dB]	P1dB [dBm]*	P1dB [W]*	G@P1dB [dB]*	Eff@P1dB [%]*	P3dB [dBm]*	P3dB [W]*	G@P3dB [dB]*	Eff@P3dB [%]*
88.00	27.1	84.5	23.9	60.4	1101.15	26.1	80.7	60.9	1238.57	24.1	84.3
93.00	27.1	83.6	24.1	60.4	1108.63	26.1	78.3	61.2	1315.58	24.1	83.6
98.00	27.2	83.1	24.0	60.6	1150.90	26.2	77.2	61.4	1375.44	24.2	83.0
103.00	27.1	82.8	24.0	60.8	1203.85	26.1	77.6	61.4	1383.01	24.1	82.7
108.00	27.1	82.8	23.9	60.8	1209.41	26.1	78.6	61.2	1315.84	24.1	82.7

Freq [MHz]	Gain [dB] @ 1200W	Eff [%] @ 1200W	Compr [dB] @ 1200W	IRL [dB] @ 1200W
88.00	25.0	83.4	-2.10	10.4
93.00	25.6	80.8	-1.55	12.3
98.00	25.9	78.6	-1.24	14.4
103.00	26.1	77.5	-0.98	16.8
108.00	26.1	78.2	-0.94	18.9

6.2 Gain & Efficiency @ Frequency=88-108MHz CW, Vds=48V

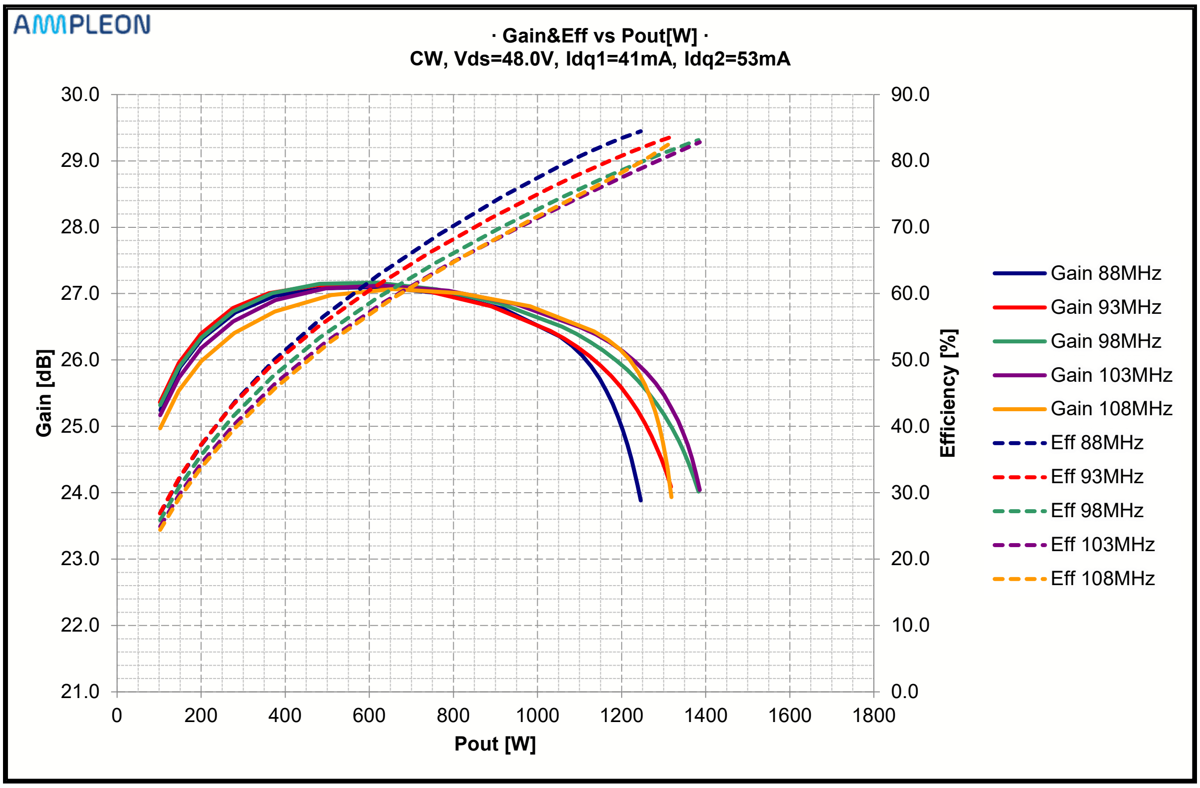


Figure 1 CW (Vds=48V) Gain and Efficiency vs Pout [W]

6.3 Summary CW Power Sweeps (Vds=50V, results @ 1300W)

Freq [MHz]	MaxGain [dB]	MaxEff [%]	G@MxEff [dB]	P1dB [dBm]*	P1dB [W]*	G@P1dB [dB]*	Eff@P1dB [%]*	P3dB [dBm]*	P3dB [W]*	G@P3dB [dB]*	Eff@P3dB [%]*
88.00	27.2	84.2	24.0	60.7	1187.86	26.2	80.2	61.3	1344.01	24.2	84.0
93.00	27.2	83.3	24.2	60.8	1193.66	26.2	77.7	61.5	1427.52	24.2	83.2
98.00	27.2	82.8	24.1	60.9	1235.39	26.2	76.6	61.7	1489.91	24.2	82.6
103.00	27.2	82.7	24.0	61.1	1293.65	26.2	77.0	61.8	1498.00	24.2	82.4
108.00	27.1	82.4	24.0	61.2	1306.97	26.1	78.1	61.5	1424.51	24.1	82.4

Freq [MHz]	Gain [dB] @ 1300W	Eff [%] @ 1300W	Compr [dB] @ 1300W	IRL [dB] @ 1300W
88.00	25.1	83.1	-2.08	10.3
93.00	25.6	80.4	-1.57	12.2
98.00	26.0	78.2	-1.29	14.3
103.00	26.2	77.2	-1.03	16.8
108.00	26.1	77.9	-0.96	18.9

6.4 Gain & Efficiency @ Frequency=88-108MHz CW Vds=50V

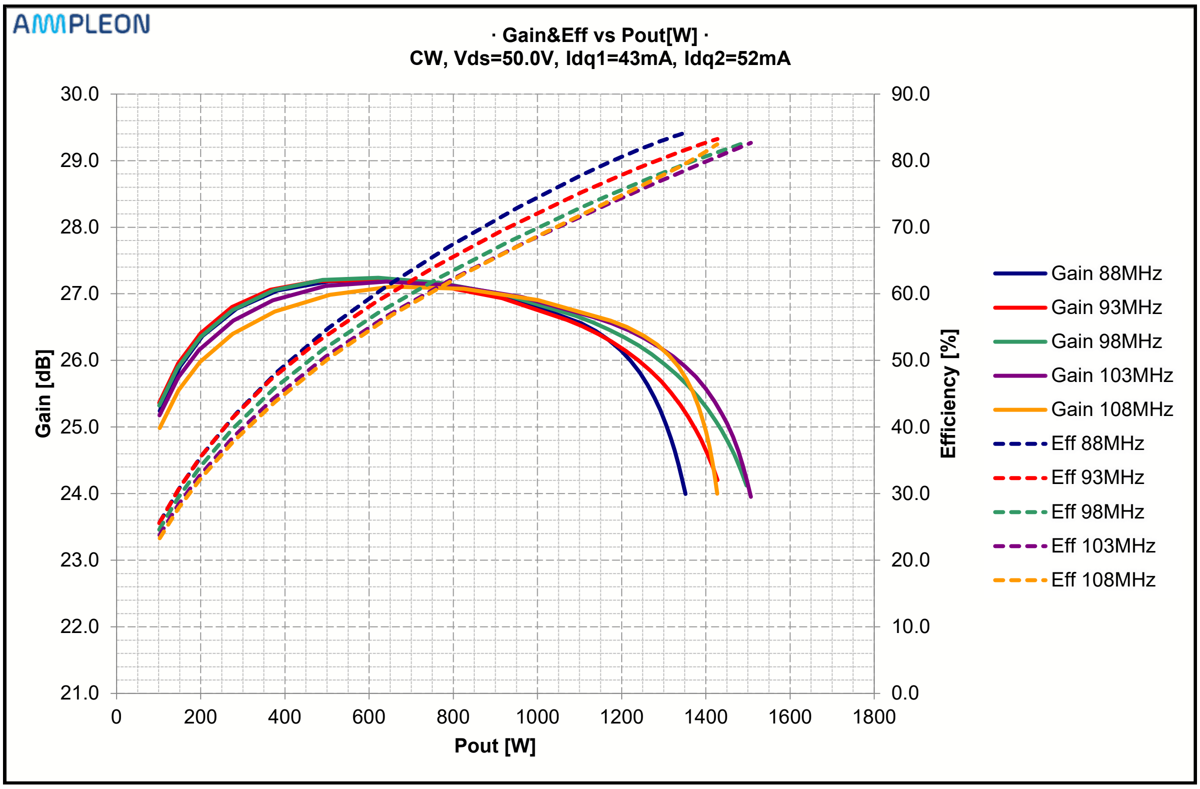


Figure 2 CW (Vds=50V) Gain and Efficiency vs Pout [W]

6.5 Second & third harmonic @ Frequency=88-108MHz CW Vds=50V

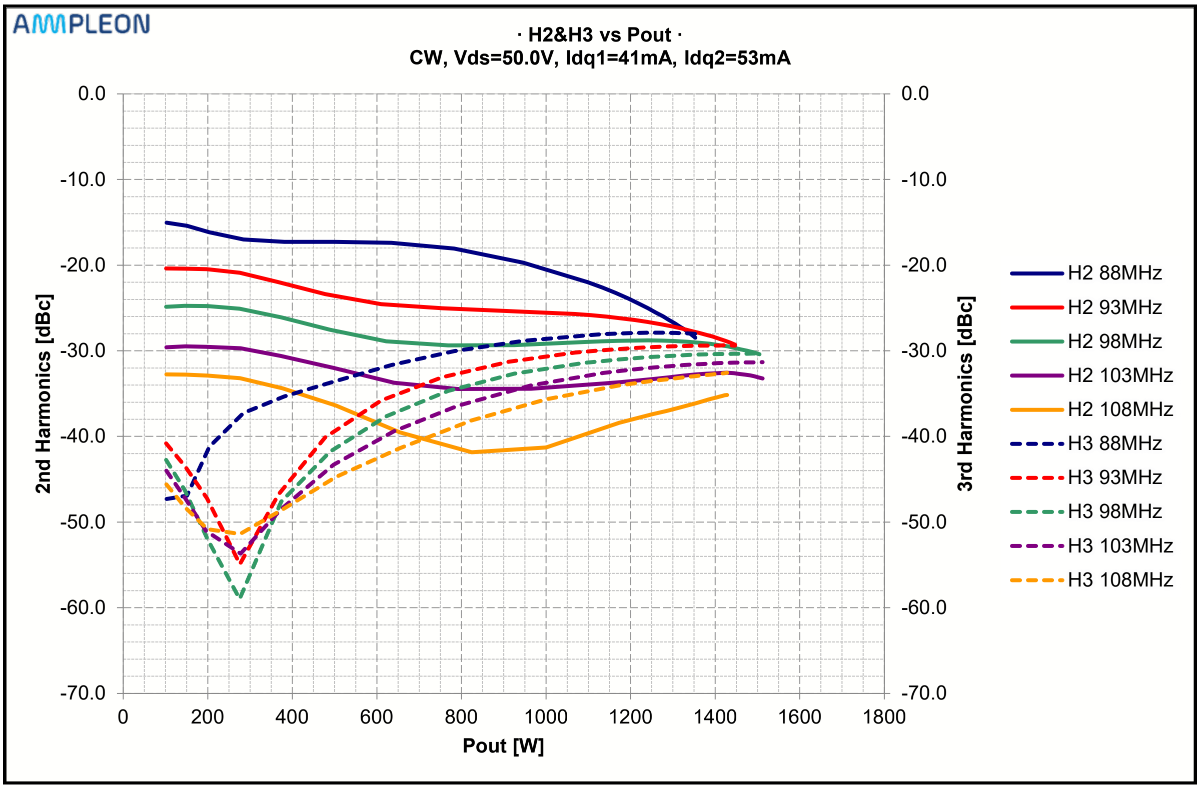


Figure 3 CW (Vds=50V) H2 & H3 vs Pout [W]

6.6 Summary CW Power Sweeps (Vds=52V, results @ 1450W)

Freq [MHz]	MaxGain [dB]	MaxEff [%]	G@MxEff [dB]	P1dB [dBm]*	P1dB [W]*	G@P1dB [dB]*	Eff@P1dB [%]*	P3dB [dBm]*	P3dB [W]*	G@P3dB [dB]*	Eff@P3dB [%]*
88.00	27.3	83.9	24.3	61.0	1273.01	26.3	79.8	61.6	1452.98	24.3	83.9
93.00	27.3	83.0	24.3	61.1	1277.21	26.3	77.1	61.9	1544.14	24.3	83.0
98.00	27.3	82.4	24.2	61.2	1316.83	26.3	75.9	62.1	1607.70	24.3	82.3
103.00	27.2	82.3	24.0	61.4	1380.40	26.2	76.3	62.1	1613.68	24.2	82.1
108.00	27.1	82.1	24.1	61.5	1401.80	26.1	77.6	61.9	1534.35	24.1	82.1

Freq [MHz]	Gain [dB] @ 1450W	Eff [%] @ 1450W	Compr [dB] @ 1450W	IRL [dB] @ 1450W
88.00	24.4	83.8	-2.93	10.5
93.00	25.4	81.1	-1.92	12.3
98.00	25.7	79.0	-1.57	14.4
103.00	25.9	78.0	-1.29	16.8
108.00	25.8	79.1	-1.34	18.9

6.7 Gain & Efficiency @ Frequency=88-108MHz CW Vds=52V

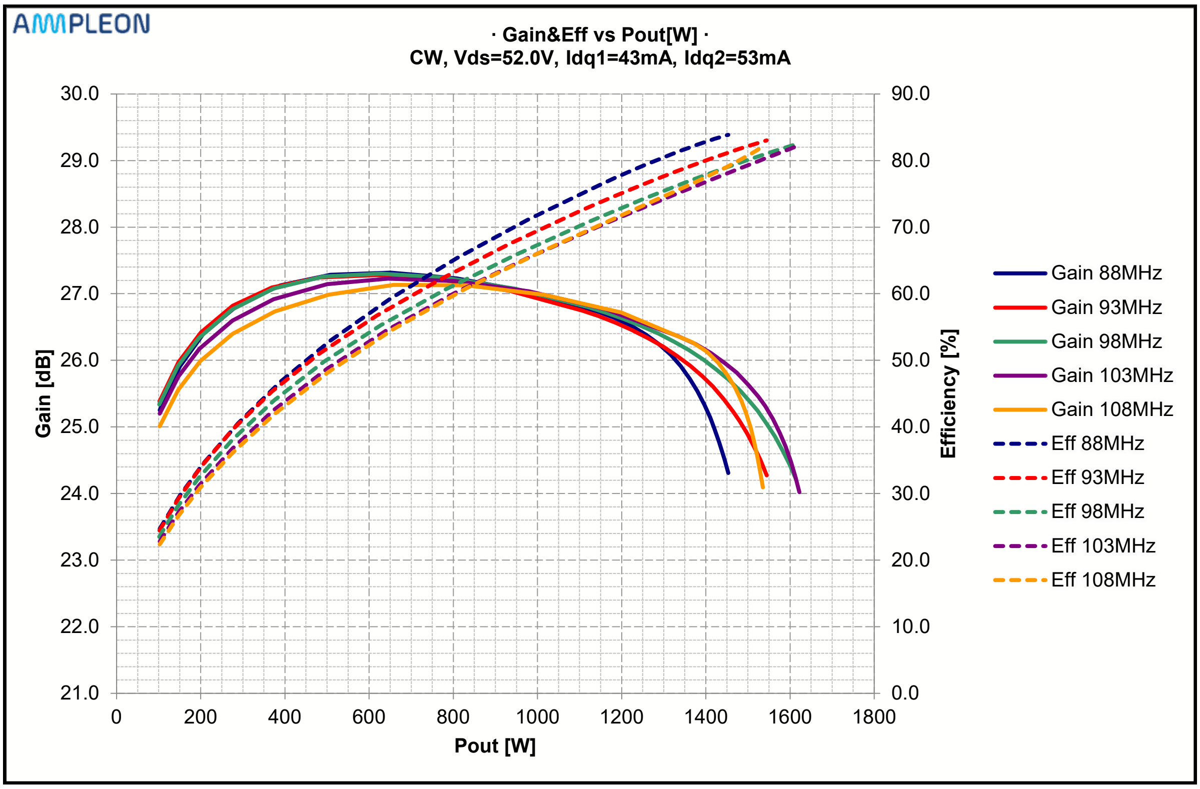


Figure 4 CW (Vds=52V) Gain and Efficiency vs Pout [W]

6.8 Summary CW P3dB and Efficiency at Vds=48V-52V

Vds -->	48V		49V		50V		51V		52V	
Freq	P3dB @	Eff @	P3dB @	Eff @	P3dB @	Eff @	P3dB @	Eff @	P3dB @	Eff @
(MHz)	(W)	(%)	(W)	(%)	(W)	(%)	(W)	(%)	(W)	(%)
88	1237.1	84.8	1291	84.65	1345.6	84.66	1395.9	84.25	1451.5	84.17
93	1312.2	84.07	1369.2	83.85	1427.9	83.83	1481.9	83.5	1541.2	83.36
98	1376.5	83.32	1435.5	83.13	1494.7	83.05	1550.8	82.73	1608.9	82.52
103	1393.7	83.03	1451.3	82.84	1509.2	82.75	1567.4	82.44	1625	82.22
108	1327.5	82.92	1380.8	82.7	1435.2	82.62	1491.4	82.3	1545.5	82.07

6.9 P3dB & Efficiency @ Frequency=88-108MHz CW

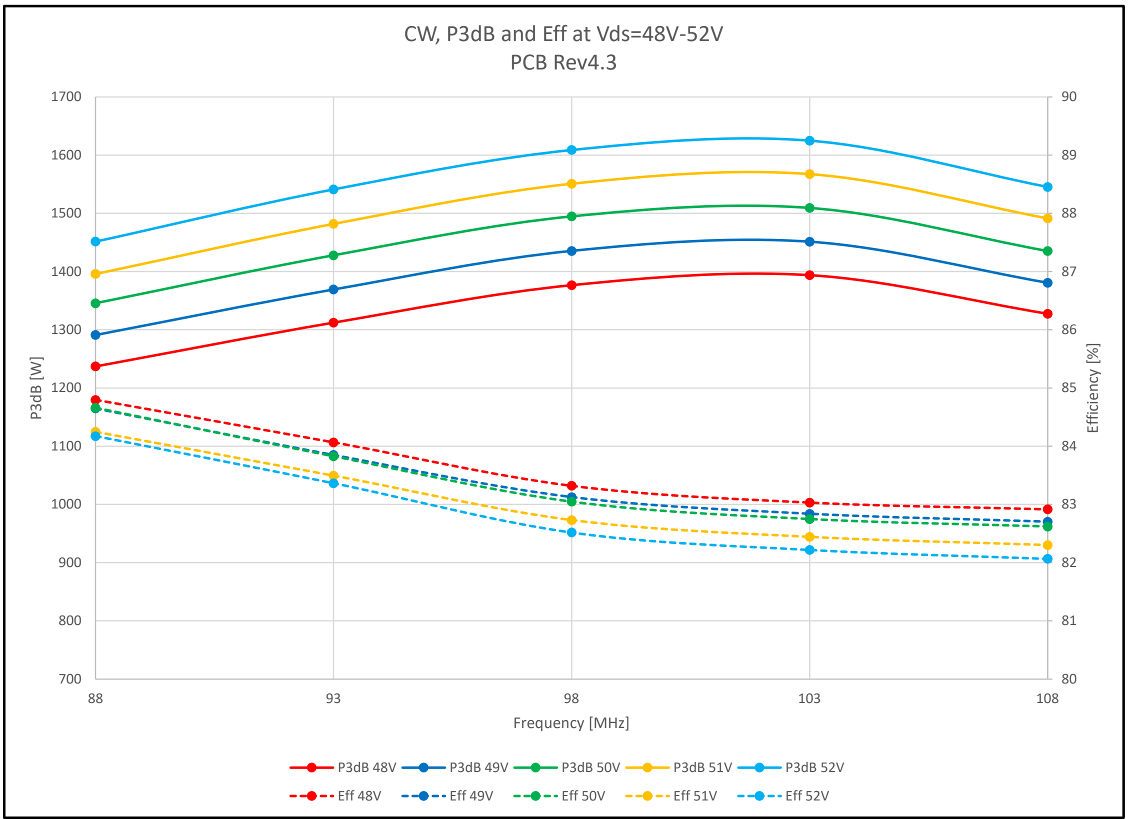


Figure 5 P3dB & Efficiency @ Frequency=88-108MHz Vds=48V-52V

6.10 Tuning C35 and C36 for different performance

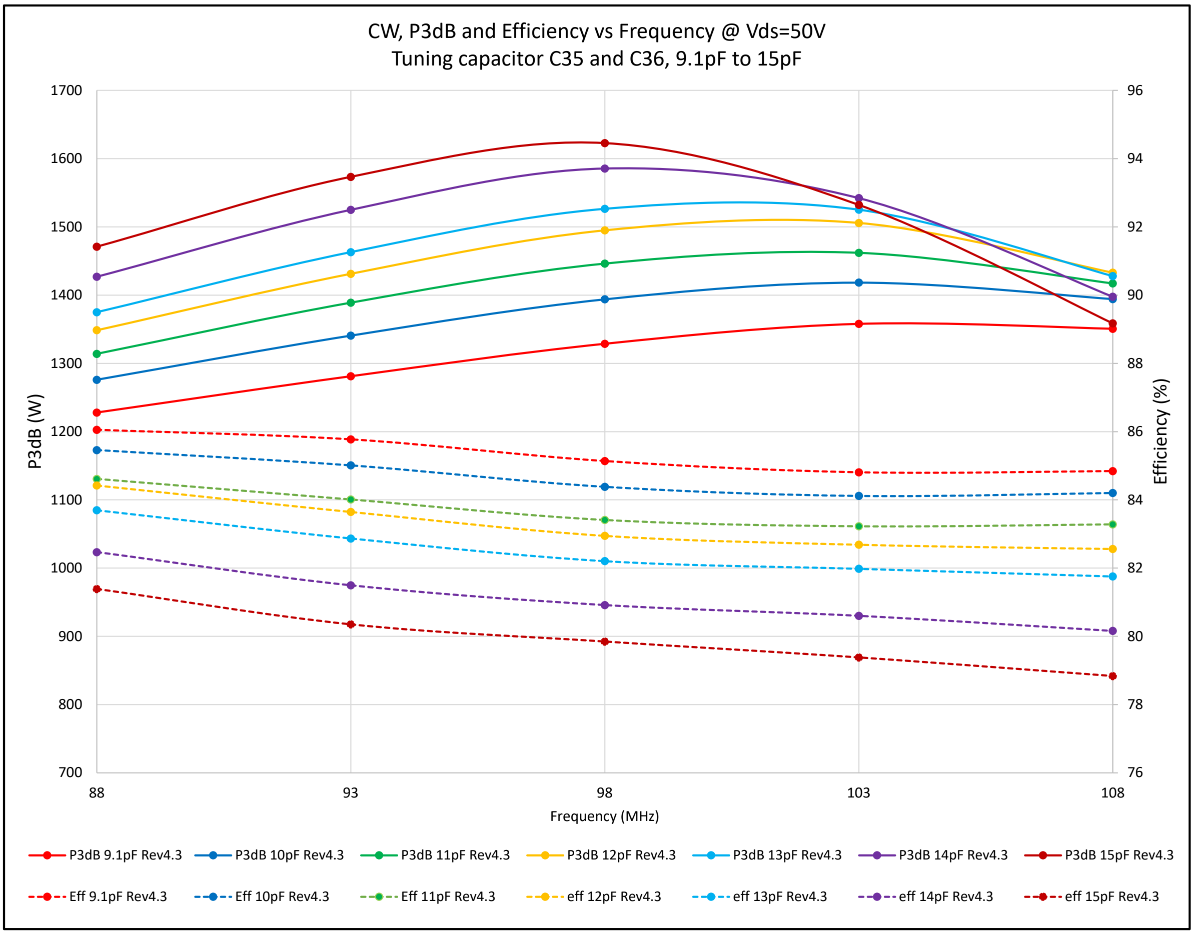
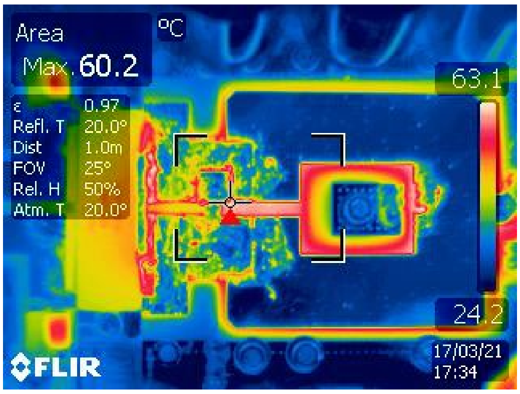


Figure 6 P3dB & Efficiency @ Frequency=88-108MHz C35, C36=9.1-15pF

7. Thermal images CDE capacitor C23, C37+C38 output circuit

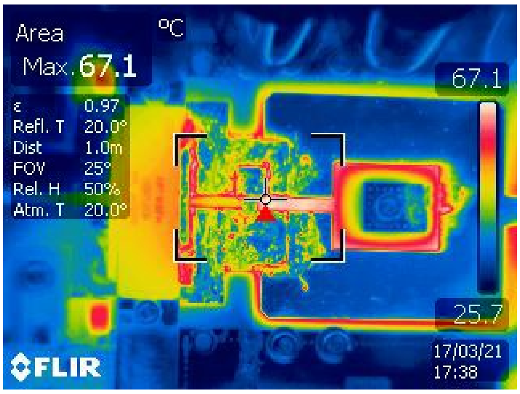
7.1 Vds=50V, 88-98-108MHz @ P3dB

C23, 88MHz, 50V, P3dB=1341W:



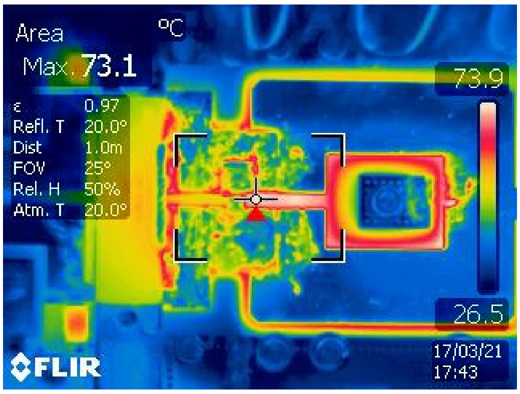
C37+C38, 88MHz, 50V, P3dB=1341W:

C23, 98MHz, 50V, P3dB=1485W:

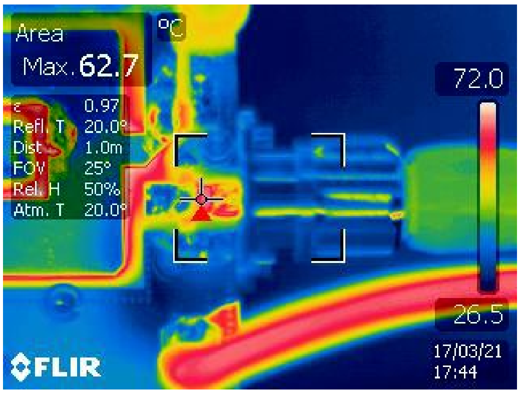


C37+C38, 98MHz, 50V, P3dB=1485W:

C23, 108MHz, 50V, P3dB=1418W:



C37+C38, 108MHz, 50V, P3dB=1418W:



Note: Pictures show the temperature of the PCB board close to the CDE capacitor (C23) and show the temperature of C37+C38 at the output connector.

8. Appendix A

8.1 PCB Layout Drawing top and bottom

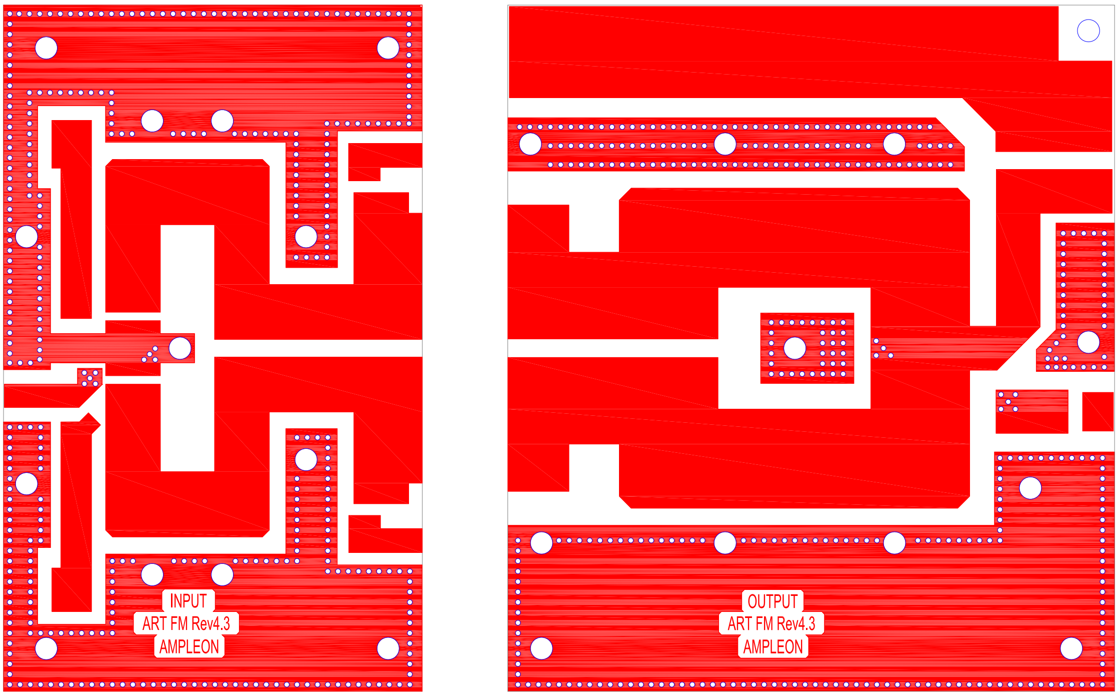


Figure 7 PCB layout top layer

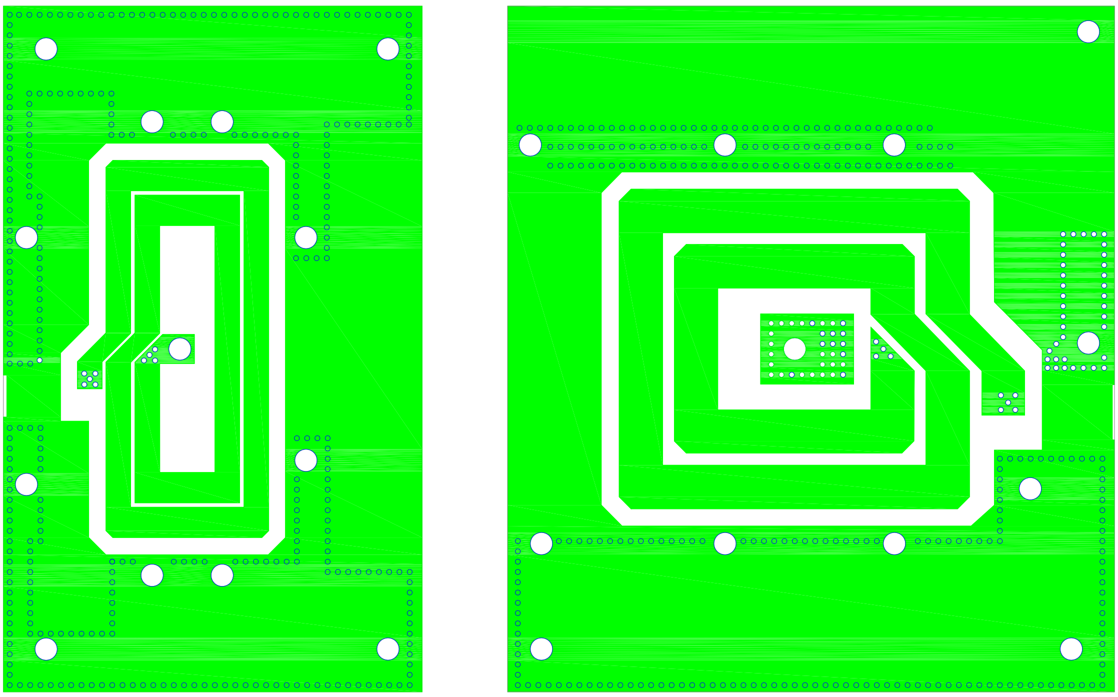


Figure 8 PCB layout bottom layer

8.2 PCB Layout Drawing + Components

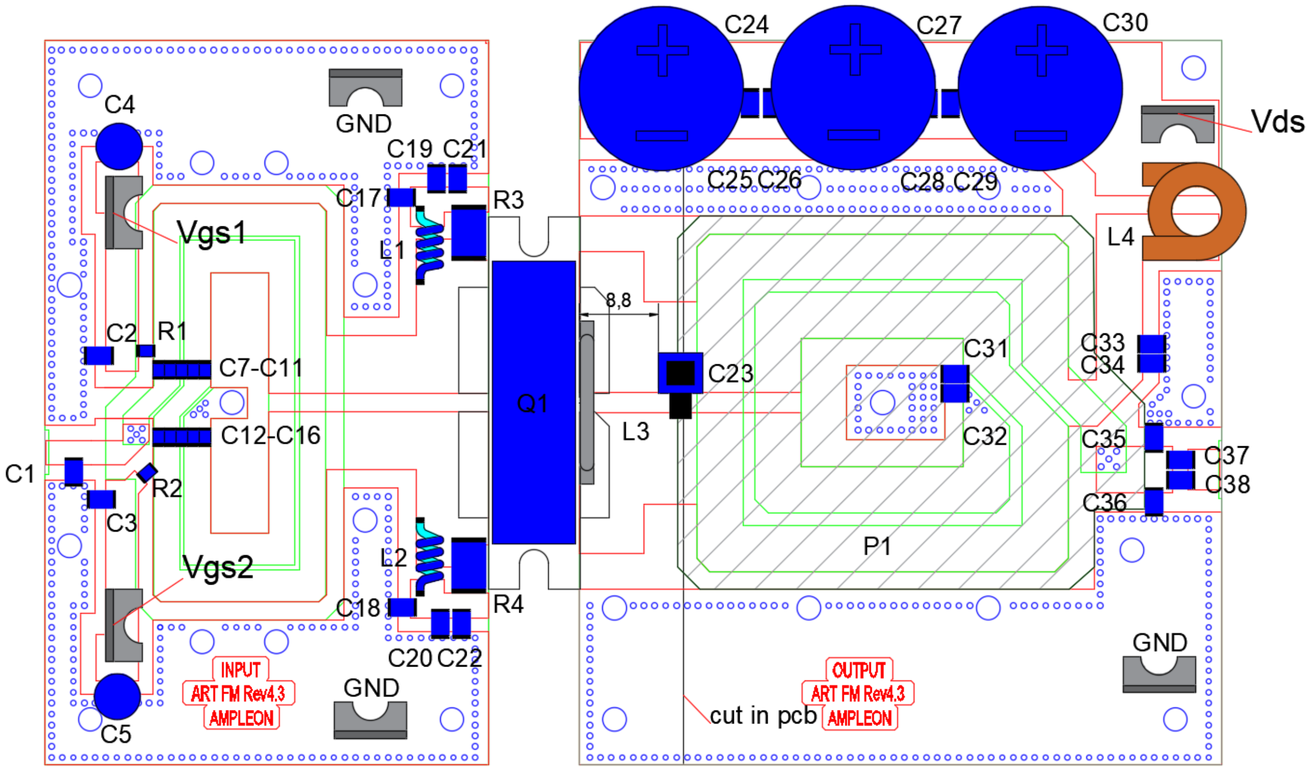


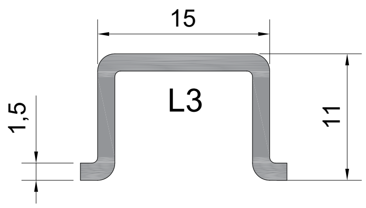
Figure 9 PCB Layout Drawing + Components

Note:

The output pcb is cut in two. The part close to the drain of the transistor and the transistor itself is soldered to the base plate. The other part of the pcb at the output connector side is screwed down. The input pcb is screwed down to the base plate. The cavity in the base plate under the input pcb is not filled. Air only. The cavity in the base plate under the output pcb is filled with Thermipad (blue).

See section 8.6 Building Sequence Demo board.

8.3 L3 dimensions



Silver plated copper wire
diameter = 1.5mm

Figure 10 L3 Dimensions .

8.4 Component list

Table 1: Component list

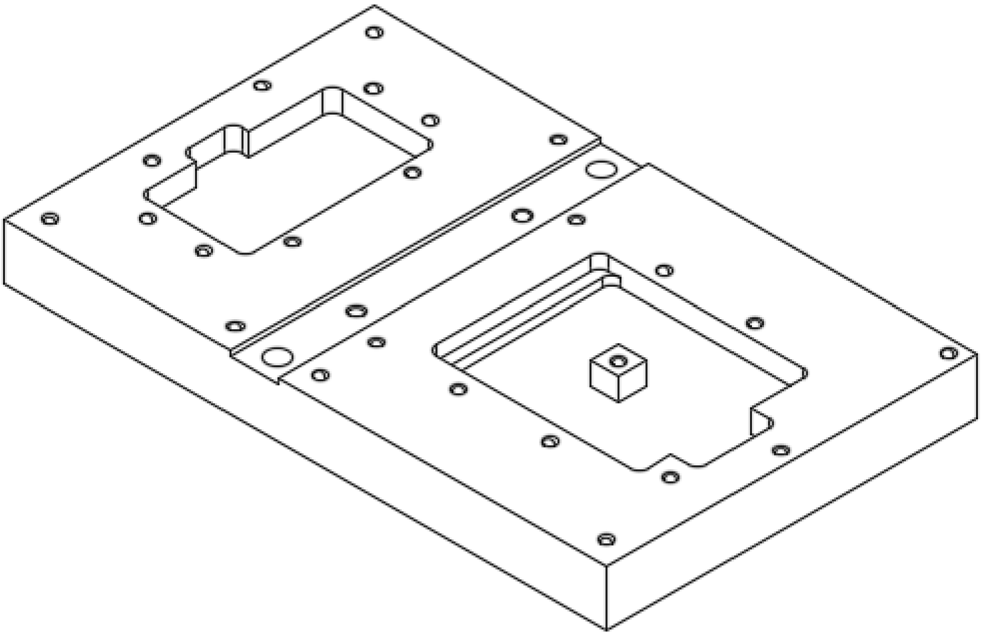
Designator	Description	Manufacturer	Part #
C1	18pF	ATC	100B
C2, C3, C17, C18	10nF	AVX	12101C1033KAT2A
C4, C5	22uF electrolytic capacitor		
C7-C11, C12-C16	4.7nF	Murata	GRM2165C1H472JA01D
C19, C20	1nF	ATC	100B
C21, C22	470pF	ATC	100B
C23	68pF	CDE	MIN-002
C24, C27, C30	1000uF electrolytic capacitor	PHILIPS	
C25, C26, C28, C29	910pF	ATC	100B
C31, C32, C33, C34	1nF	PPI	1111N
C35, C36	12pF	ATC	100B
C37, C38	470pF	ATC	100B
R1, R2	10 Ohm		1206
R3, R4	33 Ohm, 2W	TE CONN	CRGP2512F33R
L1, L2	17.5nH	COILCRAFT	B06TGLC
L3	Figure 16, silver plated wire		1.5mm diameter
L4	22nH	COILCRAFT	1212VS-22NM EB
Q1	ART1K6FH	AMPLEON	
Base plate	Copper with water cooling channel		Cavity for coplanar baluns are 5mm deep
P1	Thermal conductor under the output balun in the cavity of the base plate	Mueller Ahlhorn	Thermipad TP22626 Er=6.7
PCB Material: Arlon TC350, thickness 0.762 mm (30 mil), Er = 3.5, Cu = 2x70 micron			

8.5 Baseplate

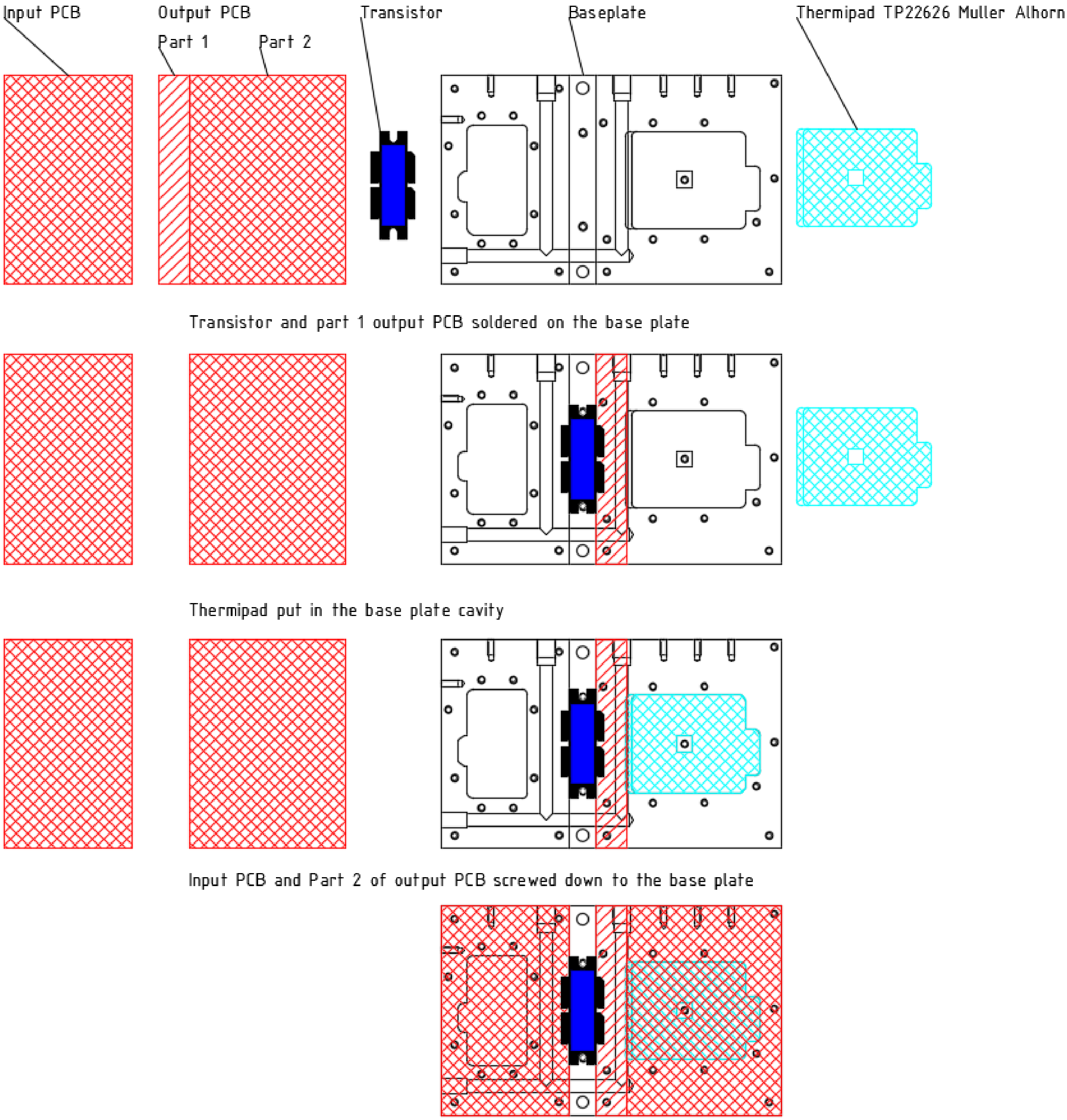
Please note that this drawing is the standard base plate. This baseplate for the demo AR211050 needed some rework so this drawing is just for illustration.

The demo amplifier pcb boards are mounted on a full copper base plate. The base plate contains a water channel to supply the amplifier with enough cooling.

The base plate contains two cavities for the coplanar baluns. The input balun cavity is air filled. The output balun cavity is filled with a thermal conductive material that has good electrical properties. The material is conducting the heat from the balun, generated because of RF losses, to the baseplate. The thermal conductive material is necessary to cool the coplanar output balun.



8.6 Building sequence Demo board



9. Photo’s Demo Board

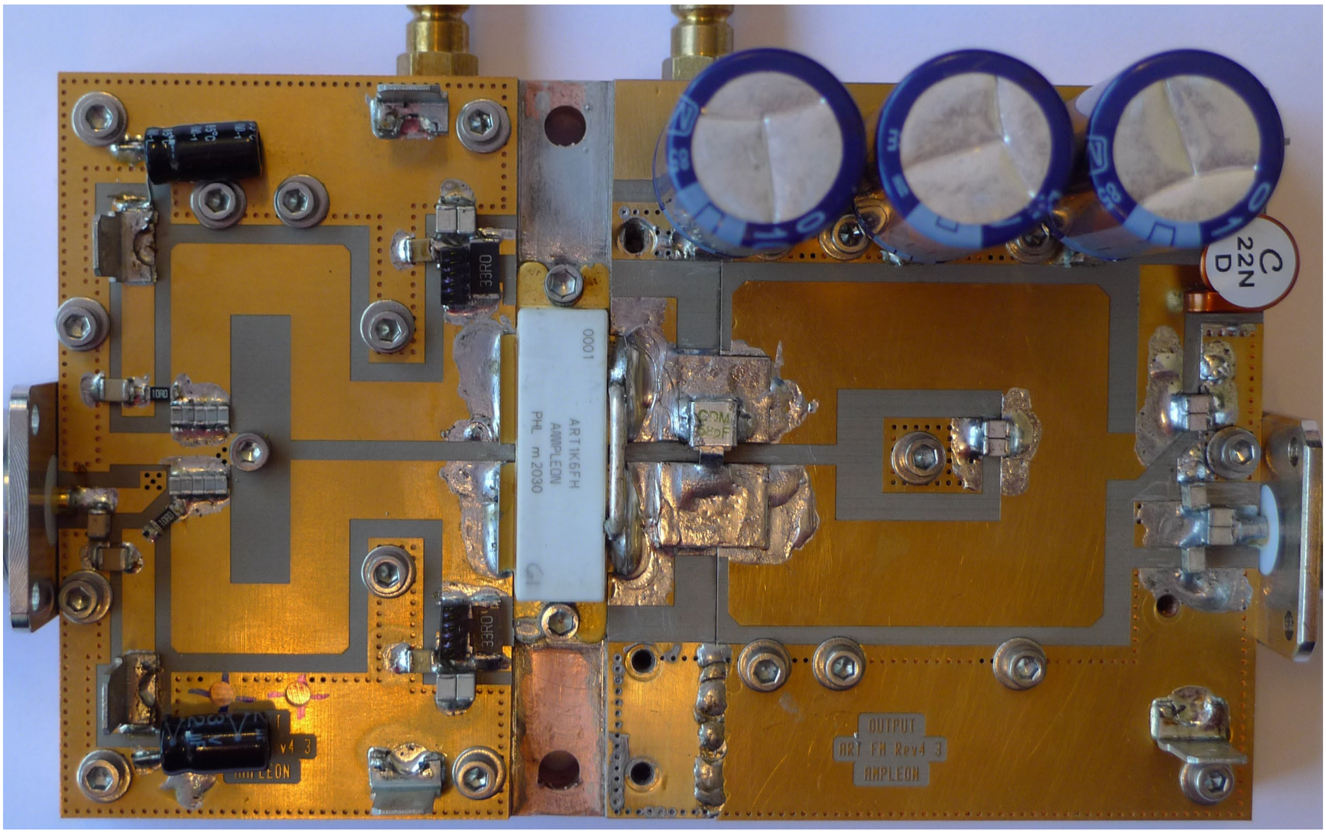


Figure 11 Picture Top View Demo Board

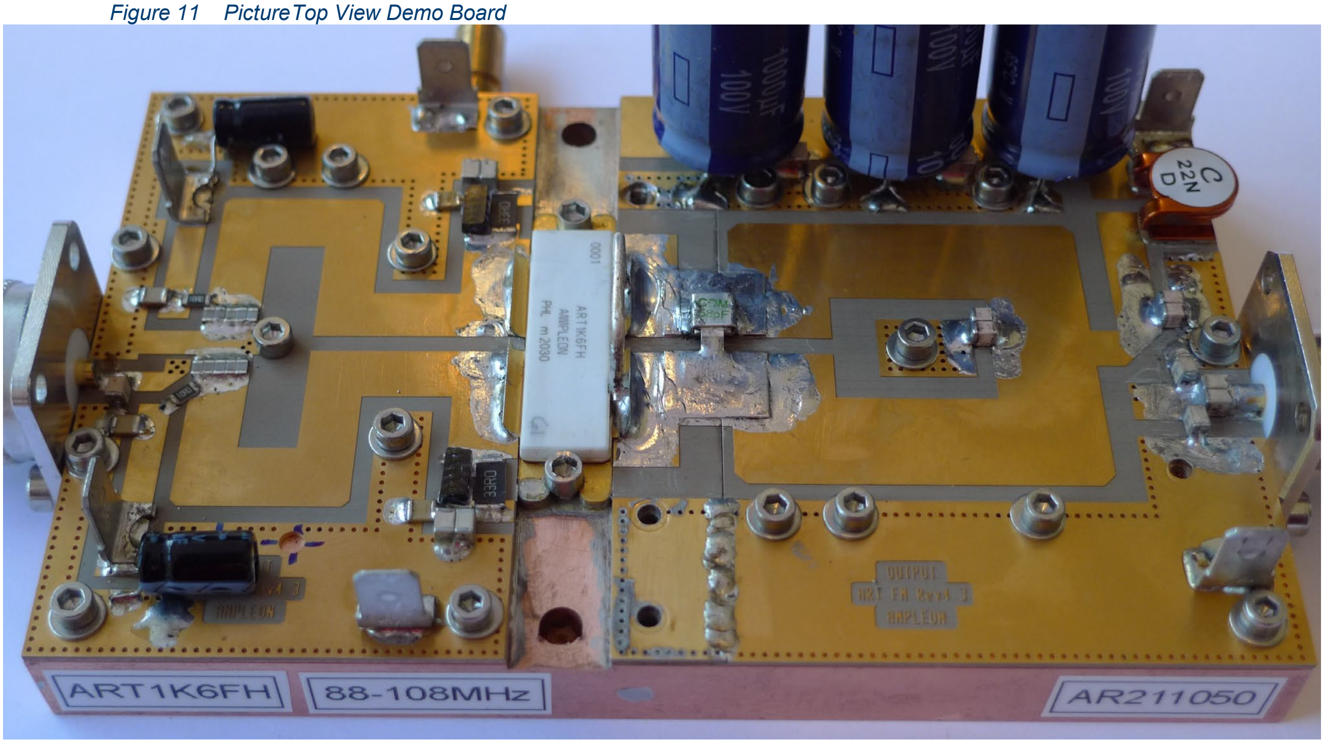


Figure 12 Picture Side View Demo Board

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