UPPSALA UNIVERSITET

LLRF for AWAKE run2c

13 Mar 2024

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Alireza M. Kasaei, Kristiaan Pelckmans

Outline

General tests

Solid state power amplifier

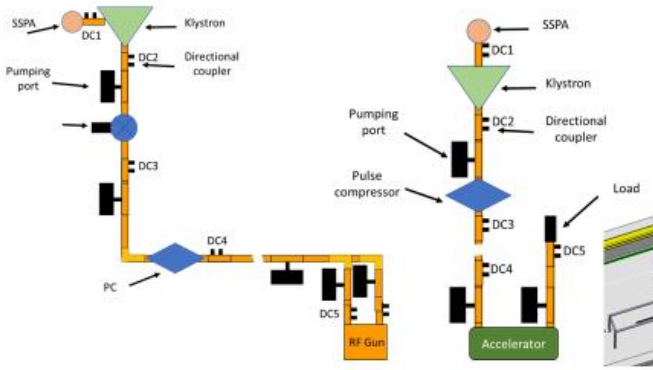
Low level RF mTCA

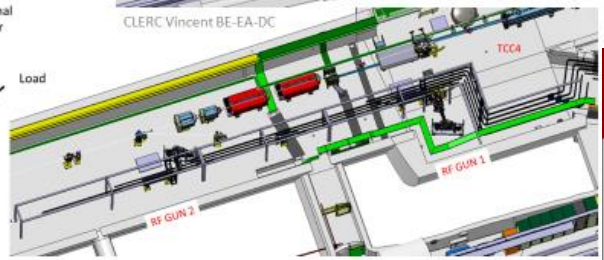
General tests

Layout to be updated

Modulators and klystrons – 1st line

2 Scandinova K100
2 Canon E37349 6 MW or E3779B 7.5 MW





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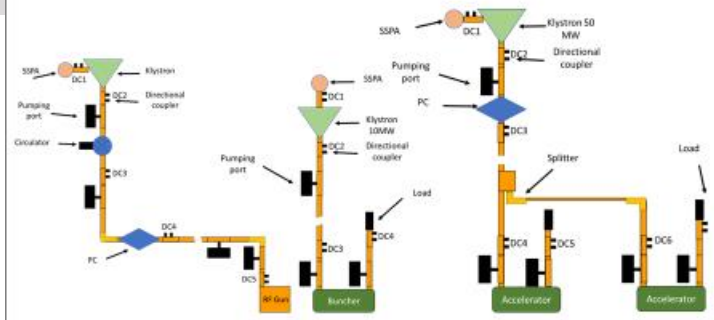
3 GHz

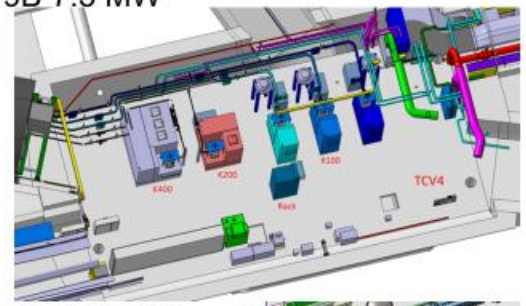
Work will start based on the new design for AWAKE Run2c

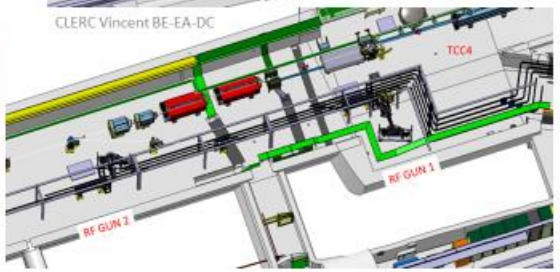
3 GHz and 12 GHz

Modulators and klystrons – 2nd line

1 Scandinova K100 - Canon E37349 6 MW or E3779B 7.5 MW
1 Scandinova K200 - Canon E37118 10 MW
1 Scandinova K400 - CPI VKX-8311 50 MW







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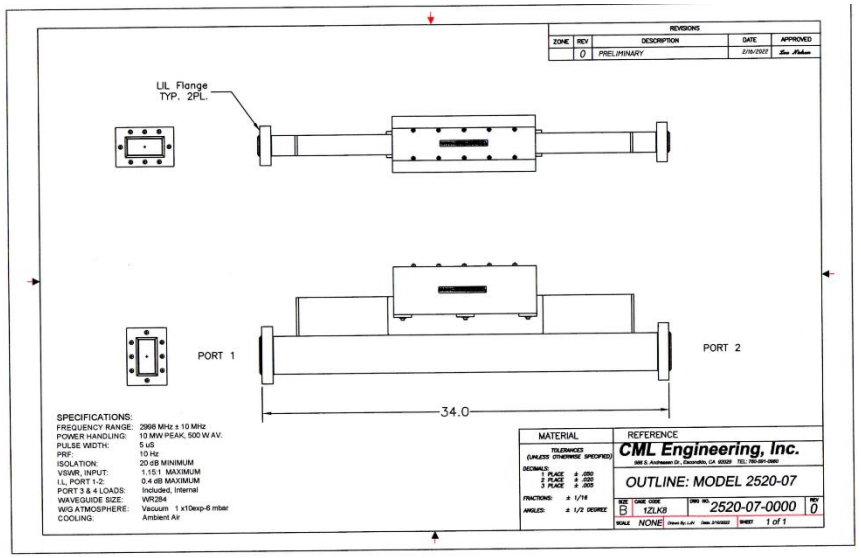
UHV circulator



SPECIFICATIONS: Model 2520-07 Vacuum Circulator

Frequency Range:	2998 MHz +/- 10 MHz
Peak Power:	10 MW maximum
Pulse Width:	5 uS
PRF:	10 Hz
Average Power:	500 Watts
Input VSWR:	1.15:1 maximum
Insertion Loss:	0.4 dB maximum
Isolation:	20 dB minimum
Waveguide Size:	WR284
Waveguide Flanges:	LIL
Waveguide Atmosphere:	< 1 x 10-6 Torr
Cooling:	Ambient Air
Materials:	OFHC Copper waveguide (0.173" wall) Stainless Steel, Alloy 316L, Ferrite
Outline:	Dwg. 2520-07-0000 Rev.0

Still no news !!!

Dear Kevin:

The machined parts have been received except for the LIL flanges and we are in the brazing process. It is looking like the brazing will not be complete by the scheduled date of August 18, as previously anticipated. After completion of the brazing we will proceed to test and tune the Circulator. At this time it looks like September 30 for delivery. We will keep you informed of progress.

Best regards,

LOUIS NIELSEN
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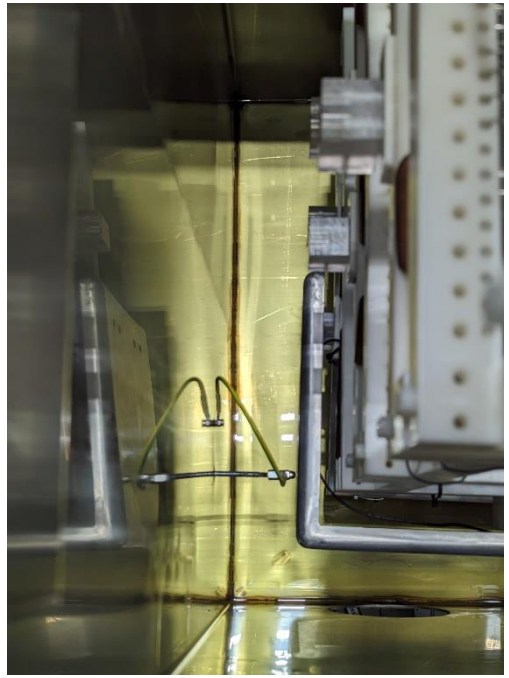
CML Engineering Sales, Inc.
T: 760-591-0980 x105
F: 760-591-0979
E: Louis@CMLengineering.com

CML Engineering

Testing will be done at low power using laboratory test equipment. High Power testing is not included in or contemplated by this quotation. Swept test data for all relevant parameters is included.

Oil tests



AWAKE special seminar: Green alternatives to transformer mineral oils

mercredi 22 févr. 2023, 14:00 → 15:30 Europe/Zurich

18/3-008 - CLIC Meeting room (CERN)

Videoconférence CLIC_Module_Zoom_Room Rejoindre

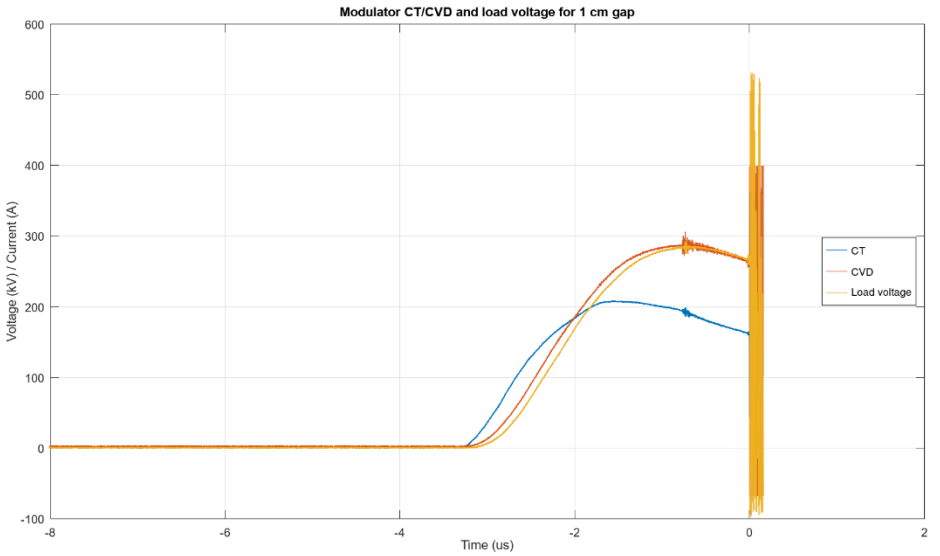
14:00 → 15:00 **Green alternatives to transformer mineral oils** 1h

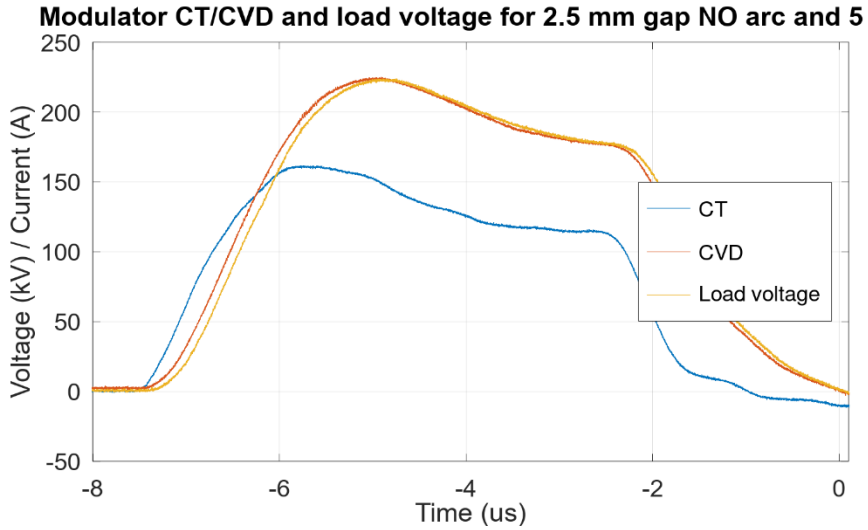
Uppsala University studied alternative high voltage oils for modulators in the framework of the AWAKE collaboration.

Mineral oil manufactured from fossil fuels is the most widespread type of oil used for electrical insulation in transformers. Although a very capable insulator, its source materials and poor biodegradability mean that finding more environmentally friendly alternatives, such as vegetable oils, is highly desirable. In this study, a number of popular high-quality mineral oils were compared to a selection of ester-based oils by means of breakdown voltage and complex permittivity measurements. The results show that some of these greener alternatives can potentially replace mineral oil in transformer applications without compromising on electrical performance.

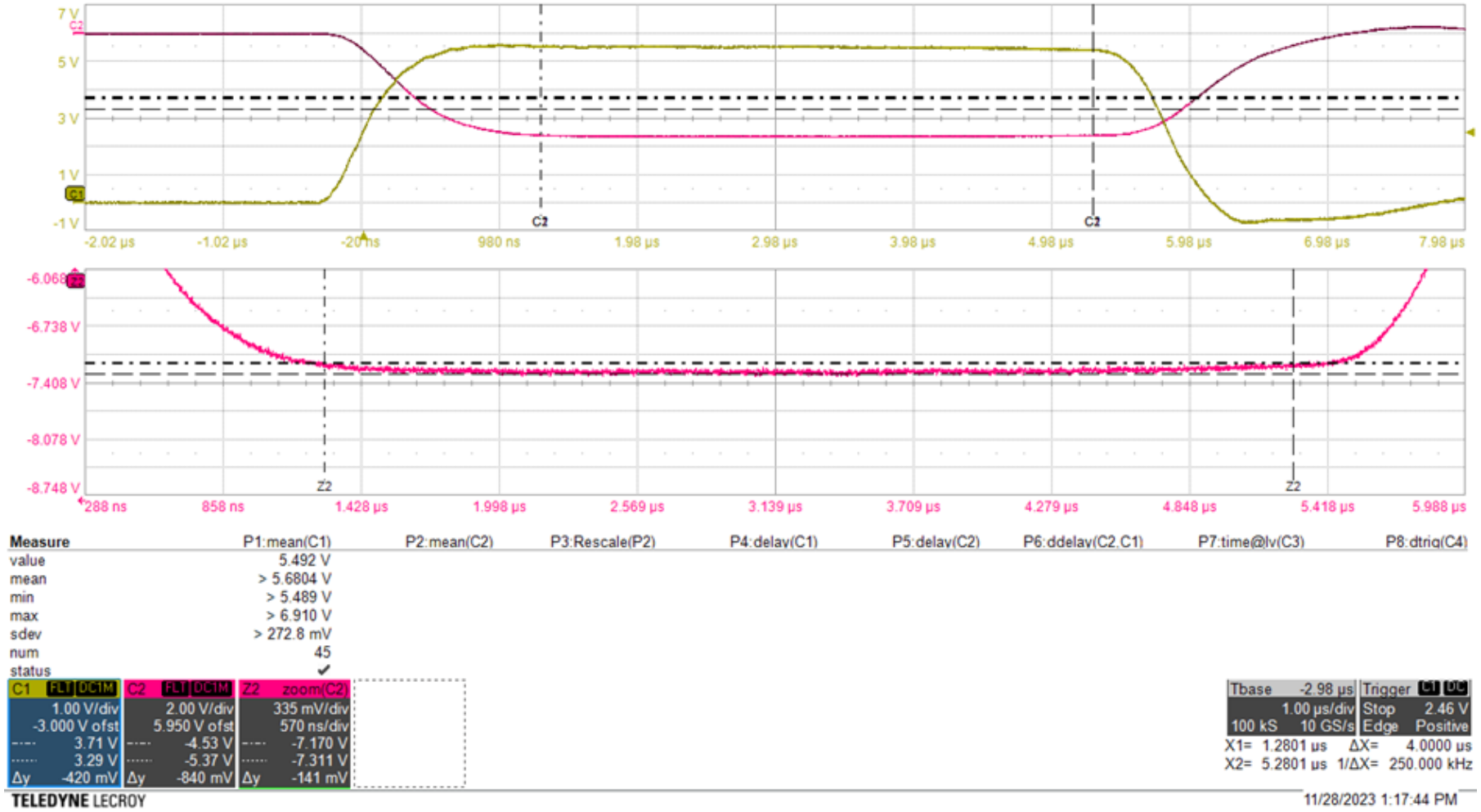
Orateurs: Steffen Doebert (CERN), Dr Piotr Szaniawski (Uppsala University)

2023-02-22 - Piotr S...



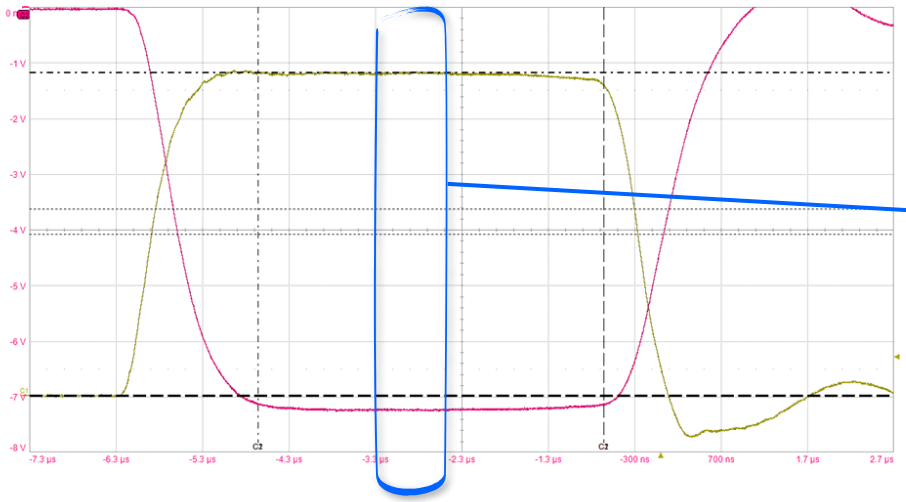


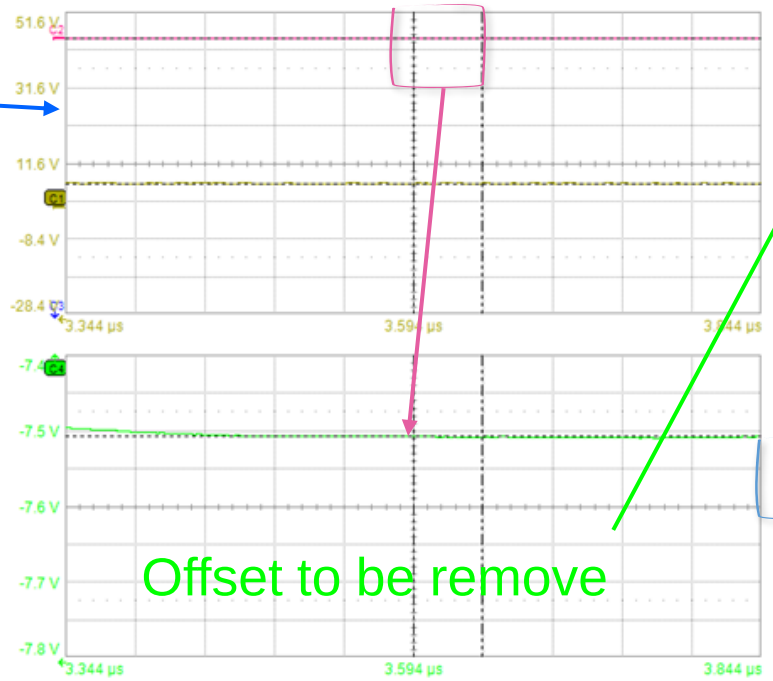
Pulse flatness

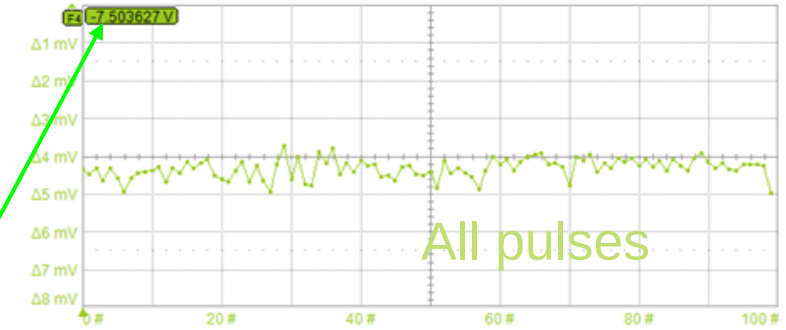


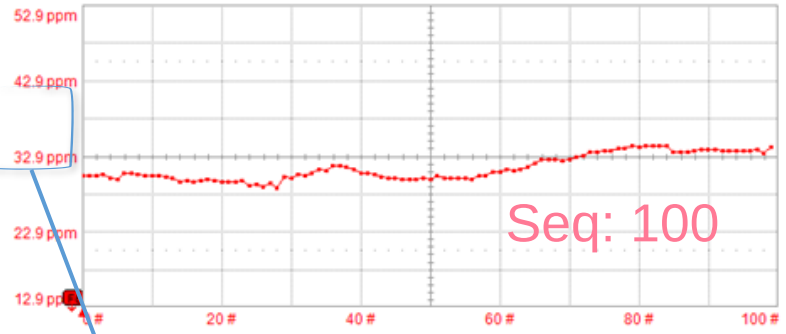
This example has a flatness of +- 0.97%, better can be achieved over 4 us

Pulse 2 pulse stability









For this example the p2p stability is 33 ppm

What does it mean

Let's consider a driving voltage V = 155 kV, which has a traveling tube of L = 0.5 m and operates at a constant temperature and at f = 3 GHz

- We obtain that

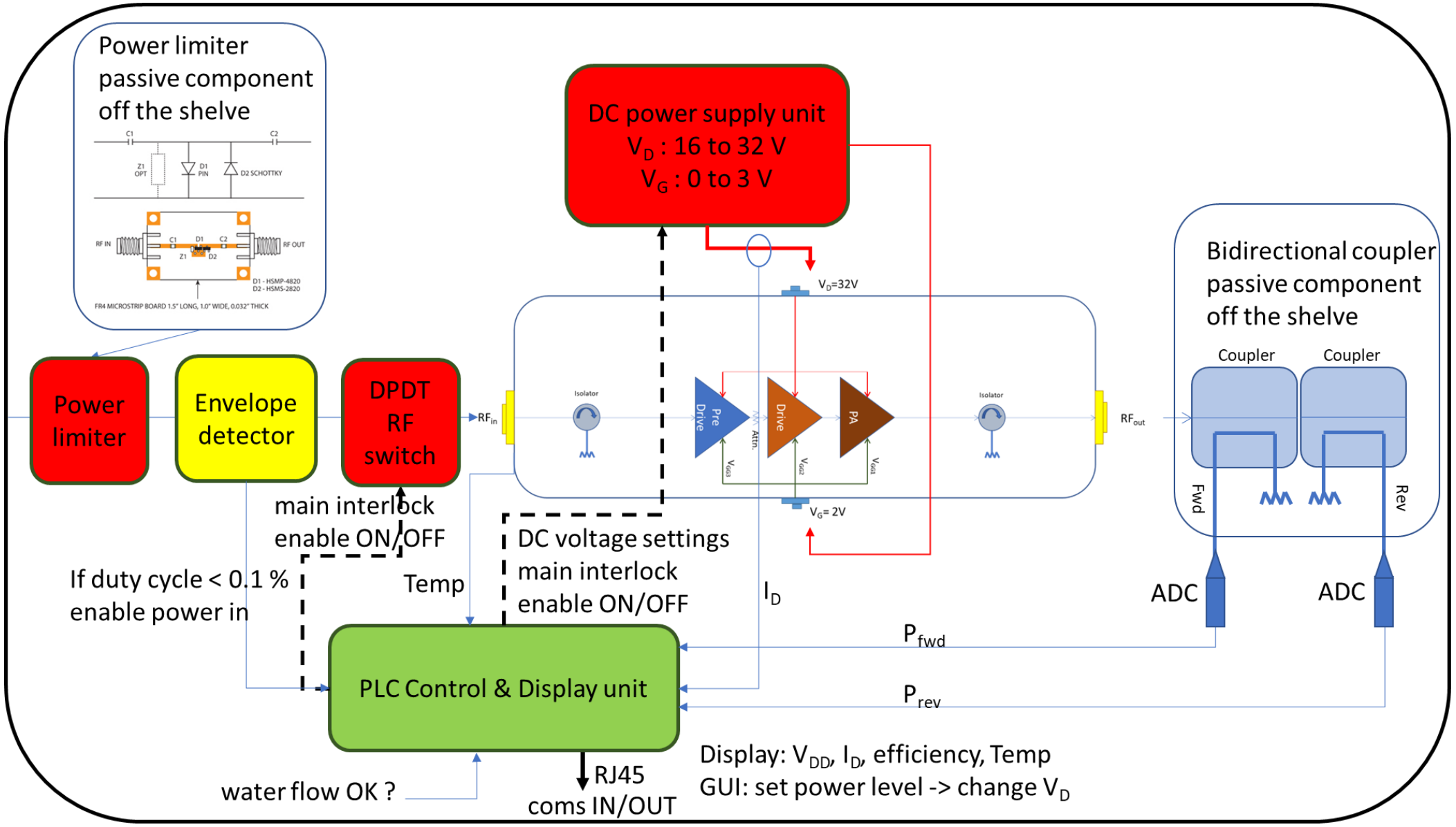
  The traveling time of the electrons is $t = 2.60057$ ns

- Now let's consider variation of the driving voltage

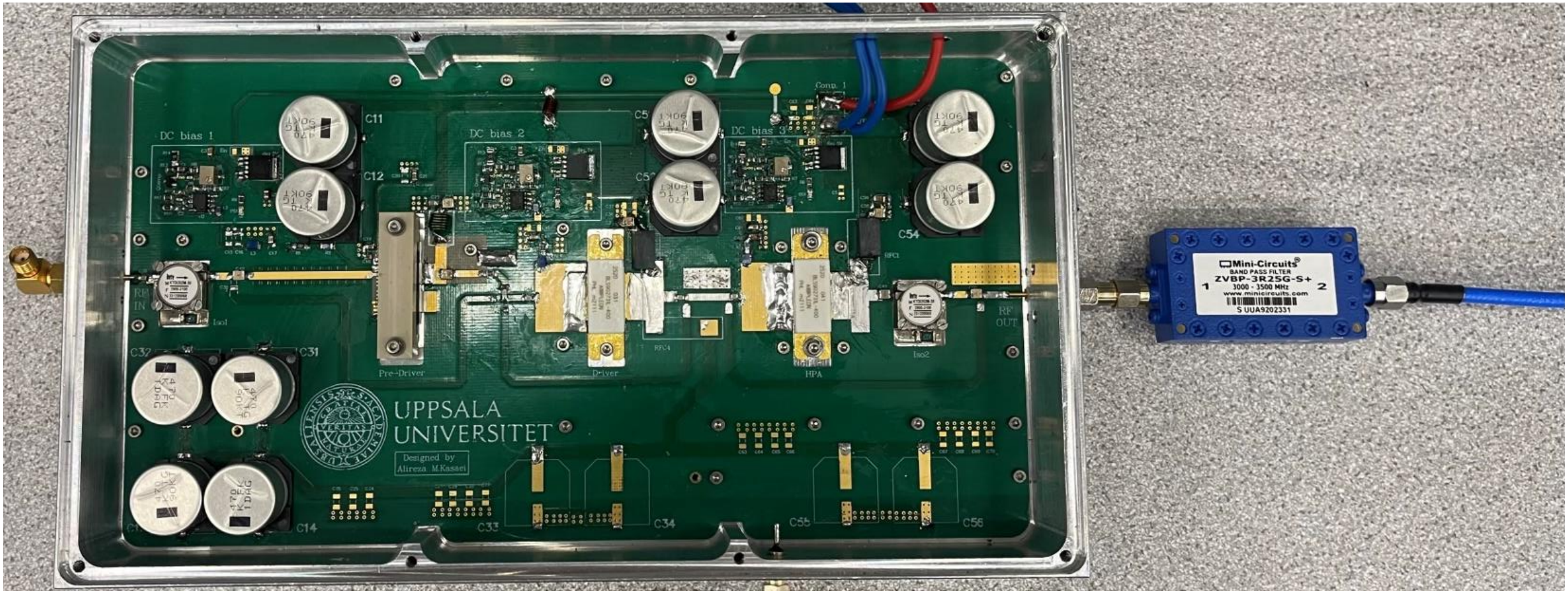
Pulse to pulse stability (ppm)	Voltage difference (V)	Traveling time (ns)	Traveling time difference (ps)	Phase stability (°)
1000	155.00	2.59971	0.8655	0.9348
500	77.50	2.60014	0.4330	0.4676
100	**15.50**	**2.60049**	**0.0866**	**0.0936**
70	**10.85**	**2.60051**	**0.0606**	**0.0655**
33	**5.11**	**2.60055**	**0.0286**	**0.0309**
10	**1.55**	**2.60056**	**0.0087**	**0.0094**
8	**1.24**	**2.60057**	**0.0069**	**0.0075**

Solid state amplifiers

Layout of the RF amplifier

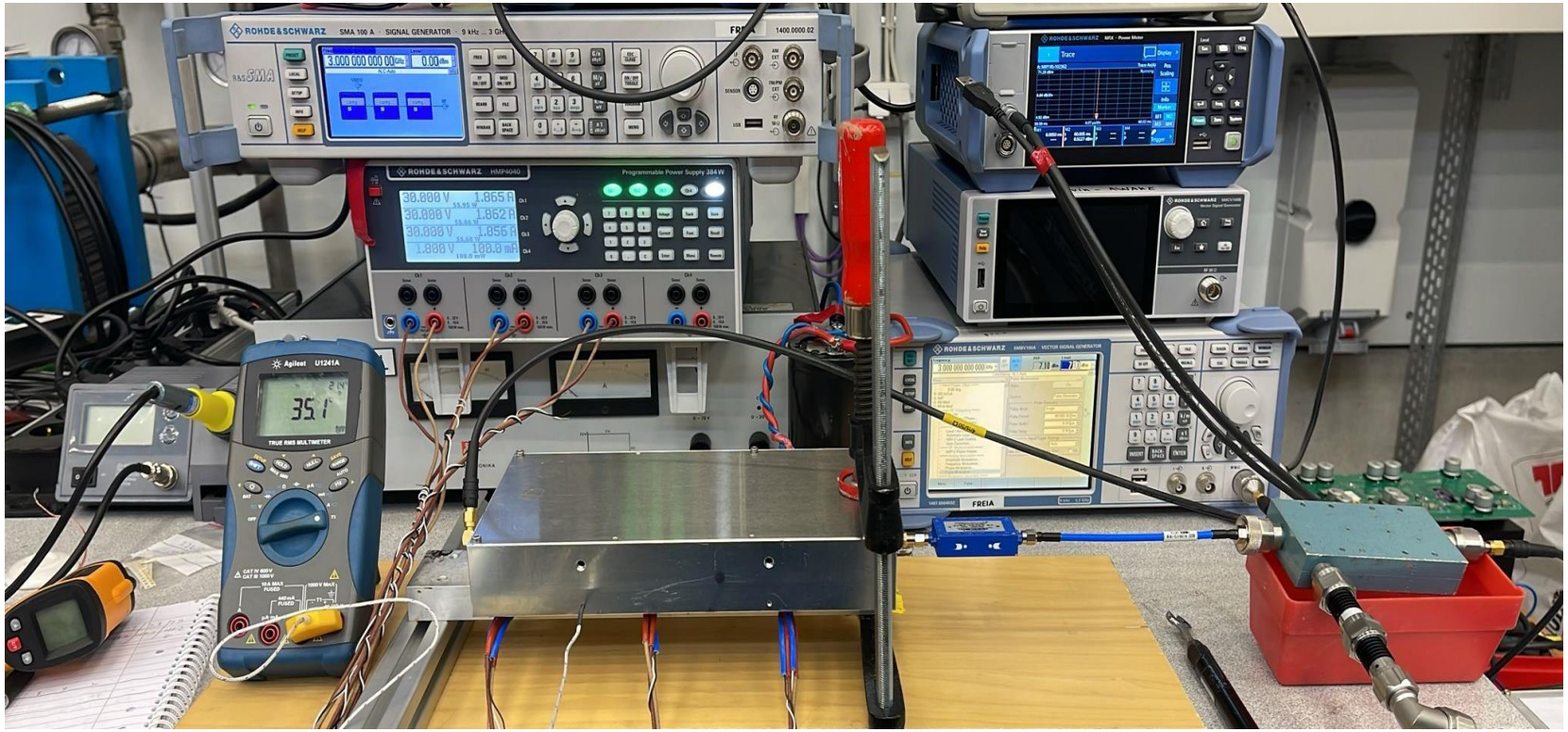


Architecture of the power amplifier



Alireza M. Kasaei

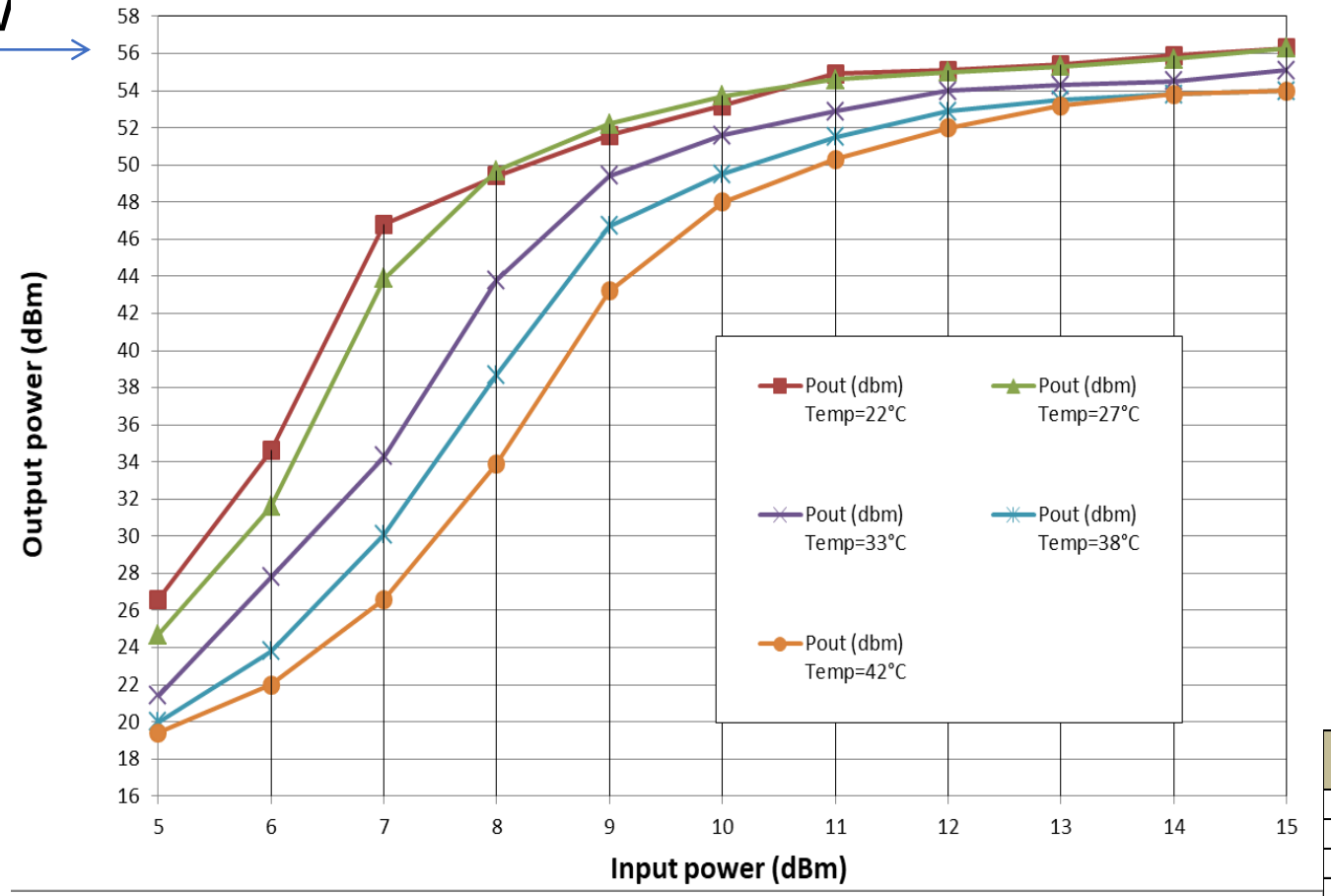
Test setup including thermal measurements



Alireza M. Kasaei

Test results

400 W

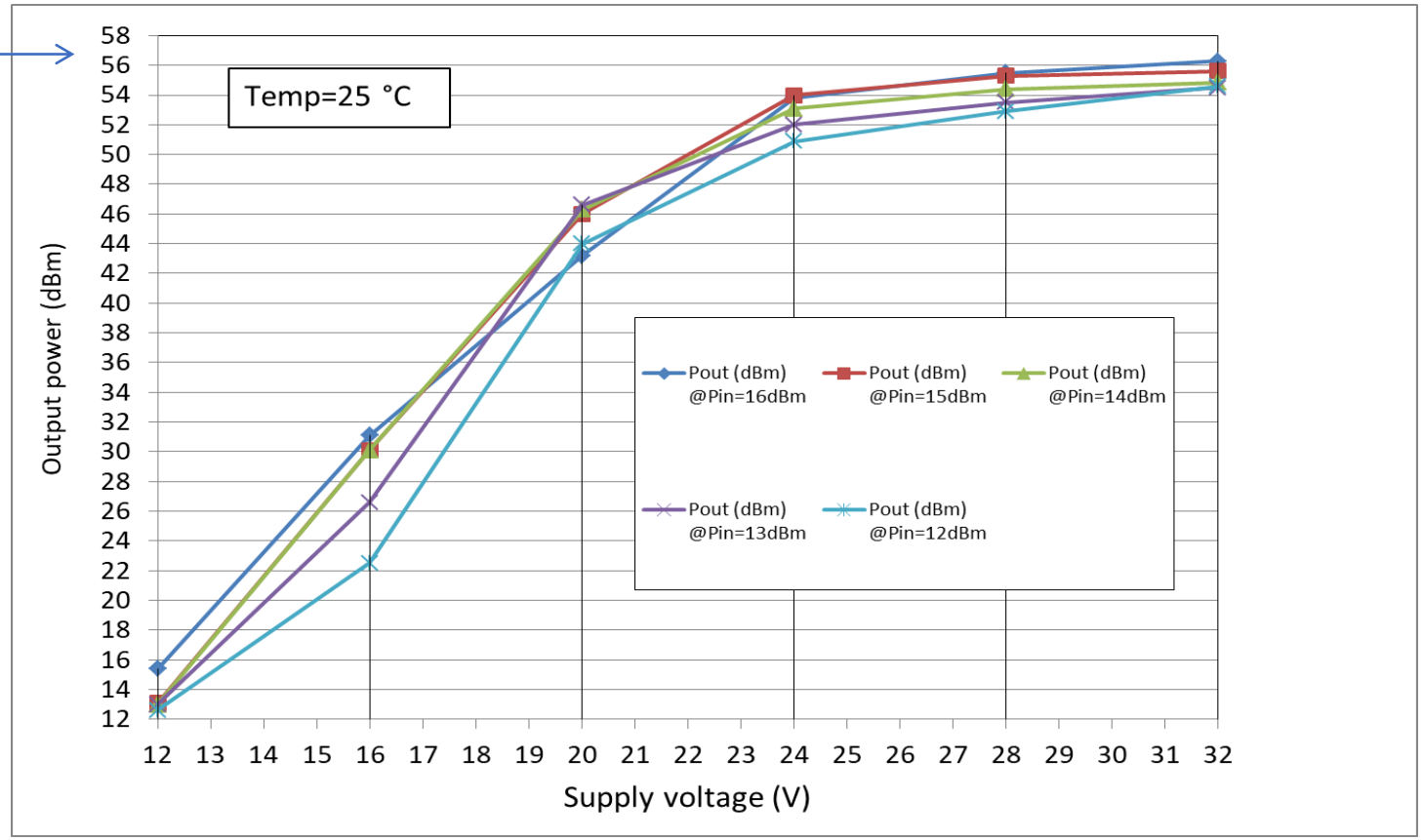


Pin (dBm)	Pout (dbm) Temp=22°C	Pout (dbm) Temp=27°C	Pout (dbm) Temp=33°C	Pout (dbm) Temp=38°C	Pout (dbm) Temp=42°C
5	26.6	24.7	21.4	20	19.4
6	34.6	31.6	27.8	23.8	22
7	46.8	43.9	34.3	30.1	26.6
8	49.4	49.7	43.8	38.7	33.9
9	51.6	52.2	49.4	46.7	43.2
10	53.2	53.7	51.6	49.5	48
11	54.9	54.6	52.9	51.5	50.3
12	55.1	55	54	52.9	52
13	55.4	55.3	54.3	53.5	53.2
14	55.9	55.7	54.5	53.8	53.8
15	56.3	56.3	55.1	54	54

Alireza M. Kasaei

Test setup including thermal measurements

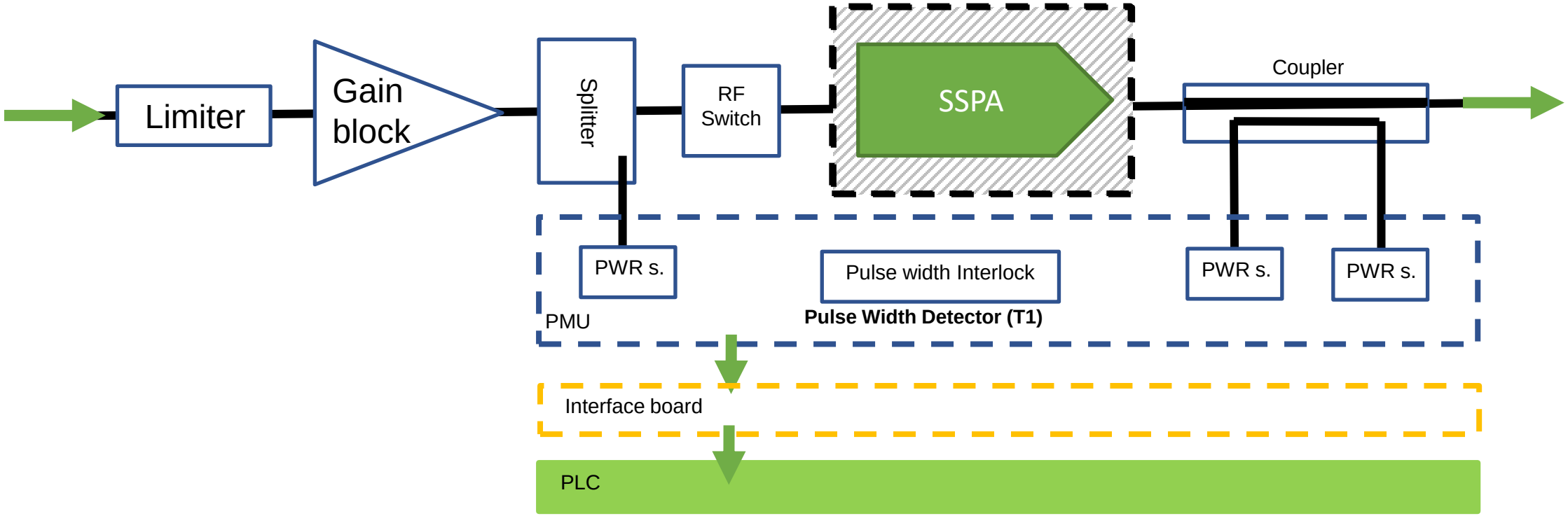
400 W →



Vdd	Pout (dBm) @Pin=16dBm	Pout (dBm) @Pin=15dBm	Pout (dBm) @Pin=14dBm	Pout (dBm) @Pin=13dBm	Pout (dBm) @Pin=12dBm
12	15.4	13.1	13	13	12.6
16	31.1	30.1	30.1	26.6	22.5
20	43.2	46	46.3	46.6	44
24	53.8	54	53.1	52	50.9
28	55.5	55.3	54.4	53.5	52.9
32	56.3	55.6	54.85	54.5	54.6

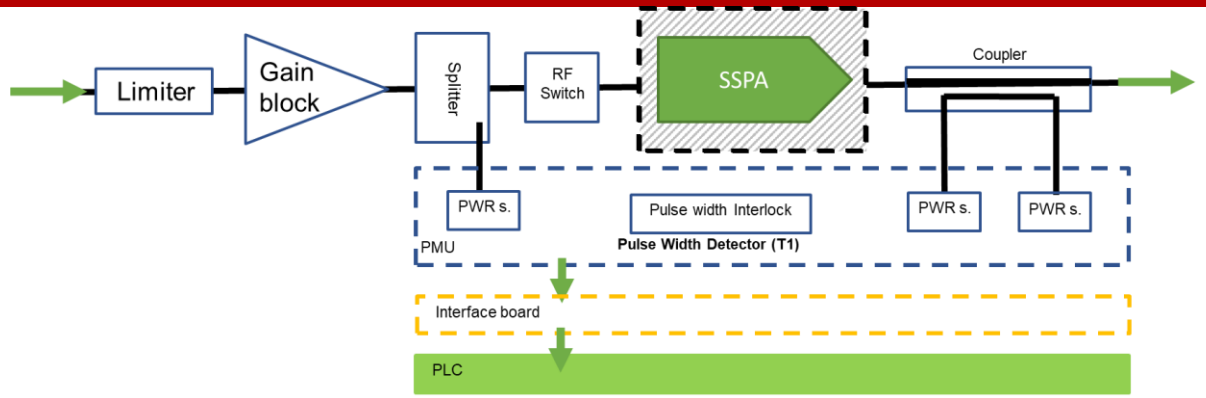
Alireza M. Kasai

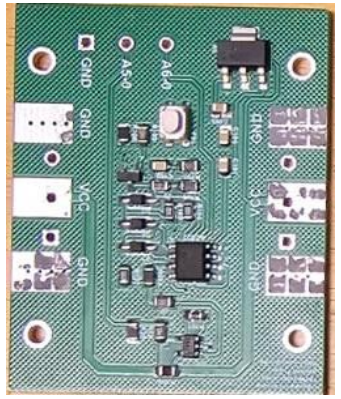
Final RF integration



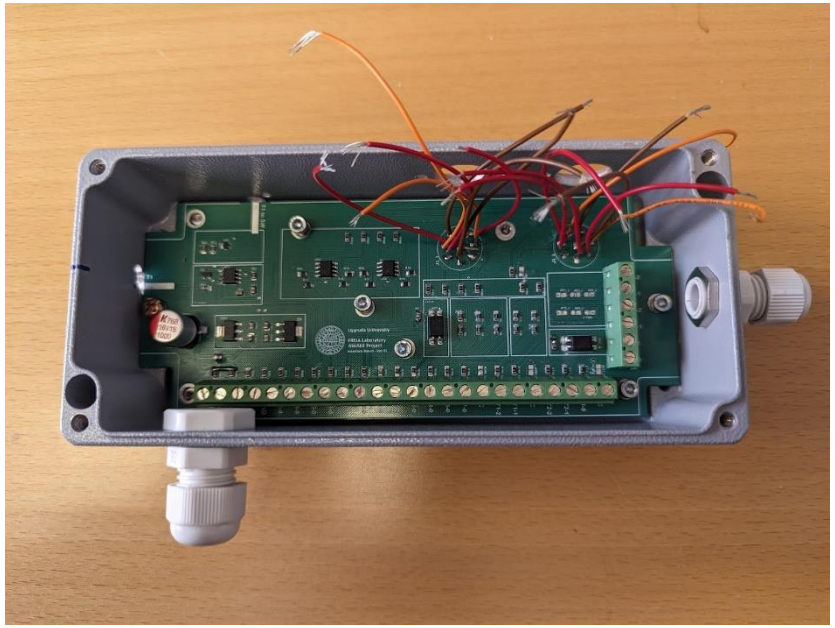
Yasin Alekajbaf

Final RF integration PMU and current / voltage Sensor

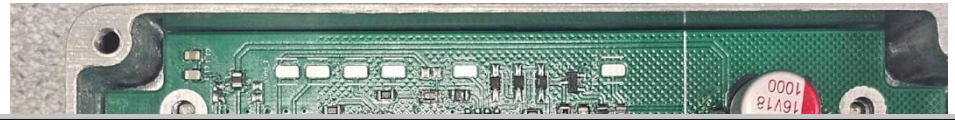


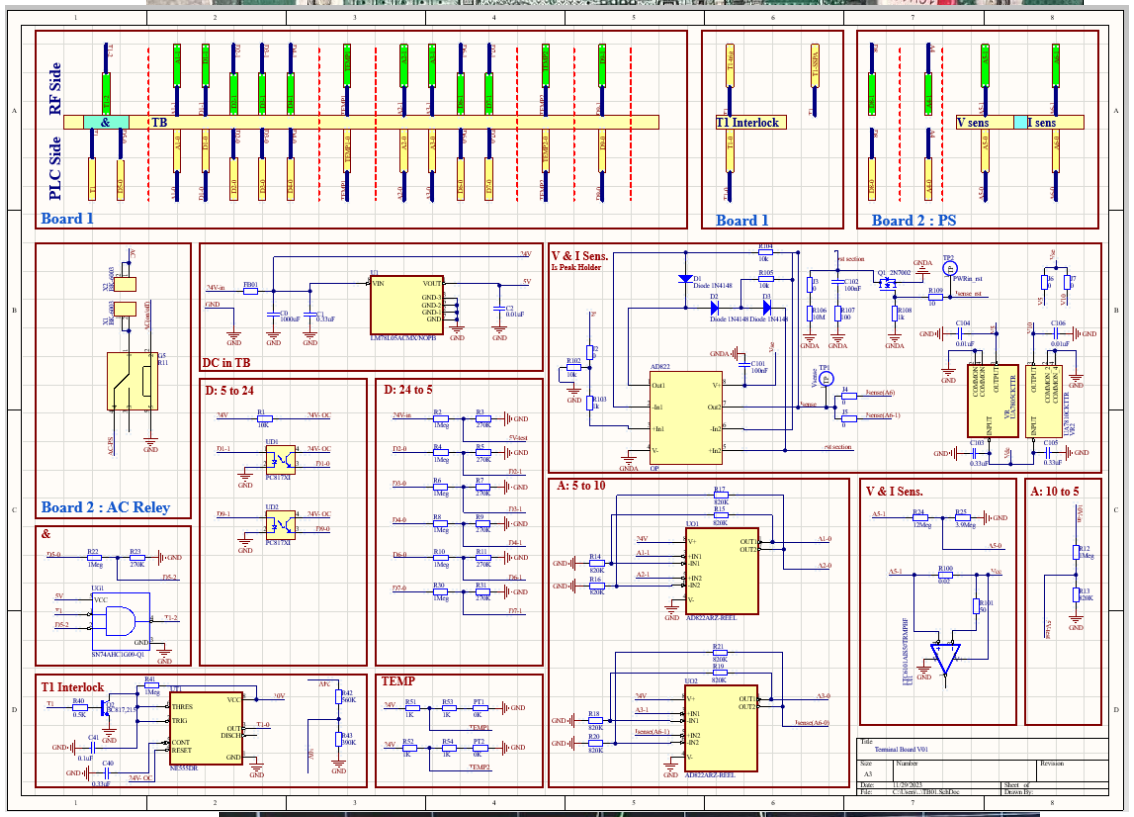


IV sensor



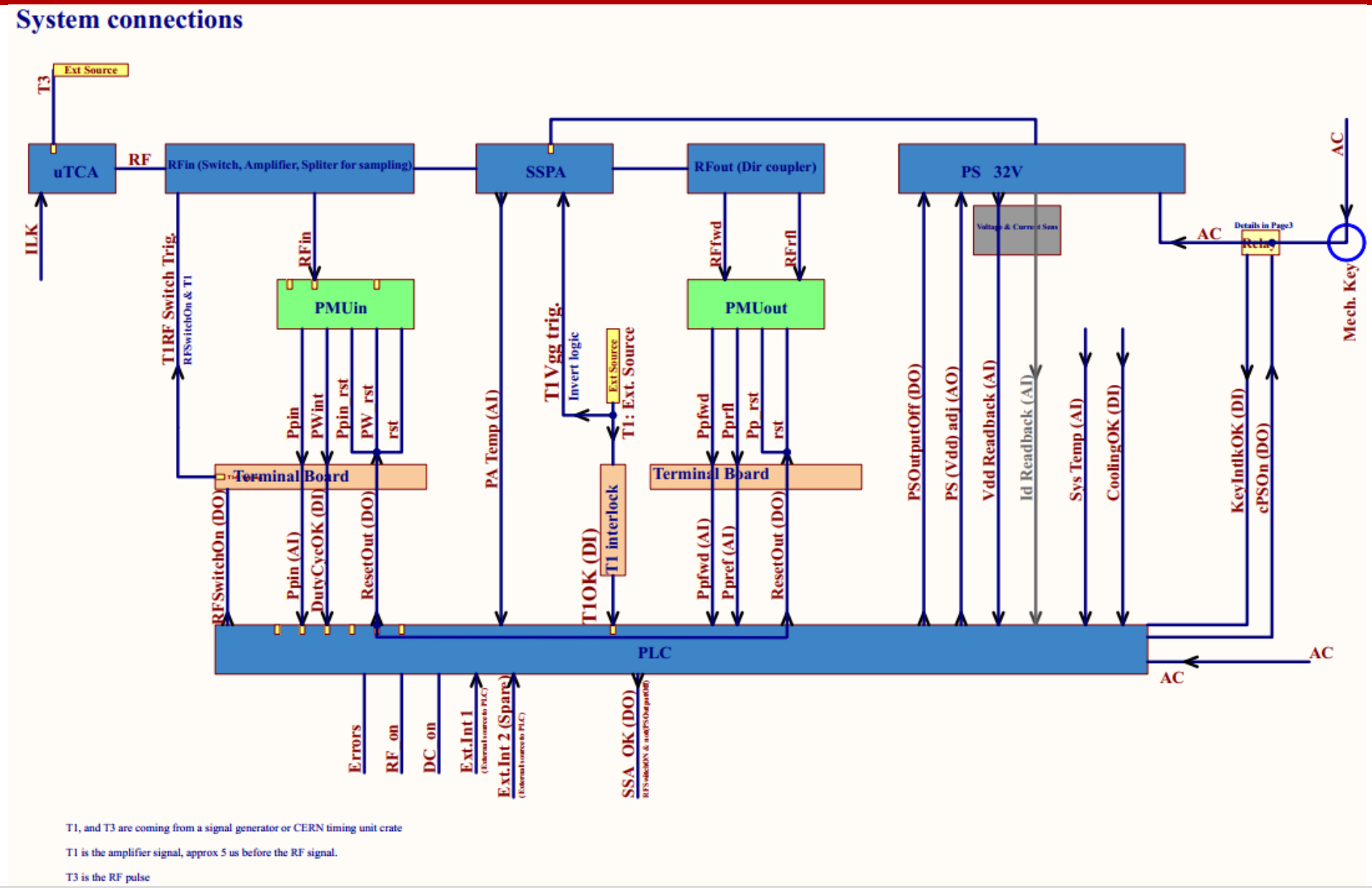
Interface board





Yasin Alekajbaf

System integration



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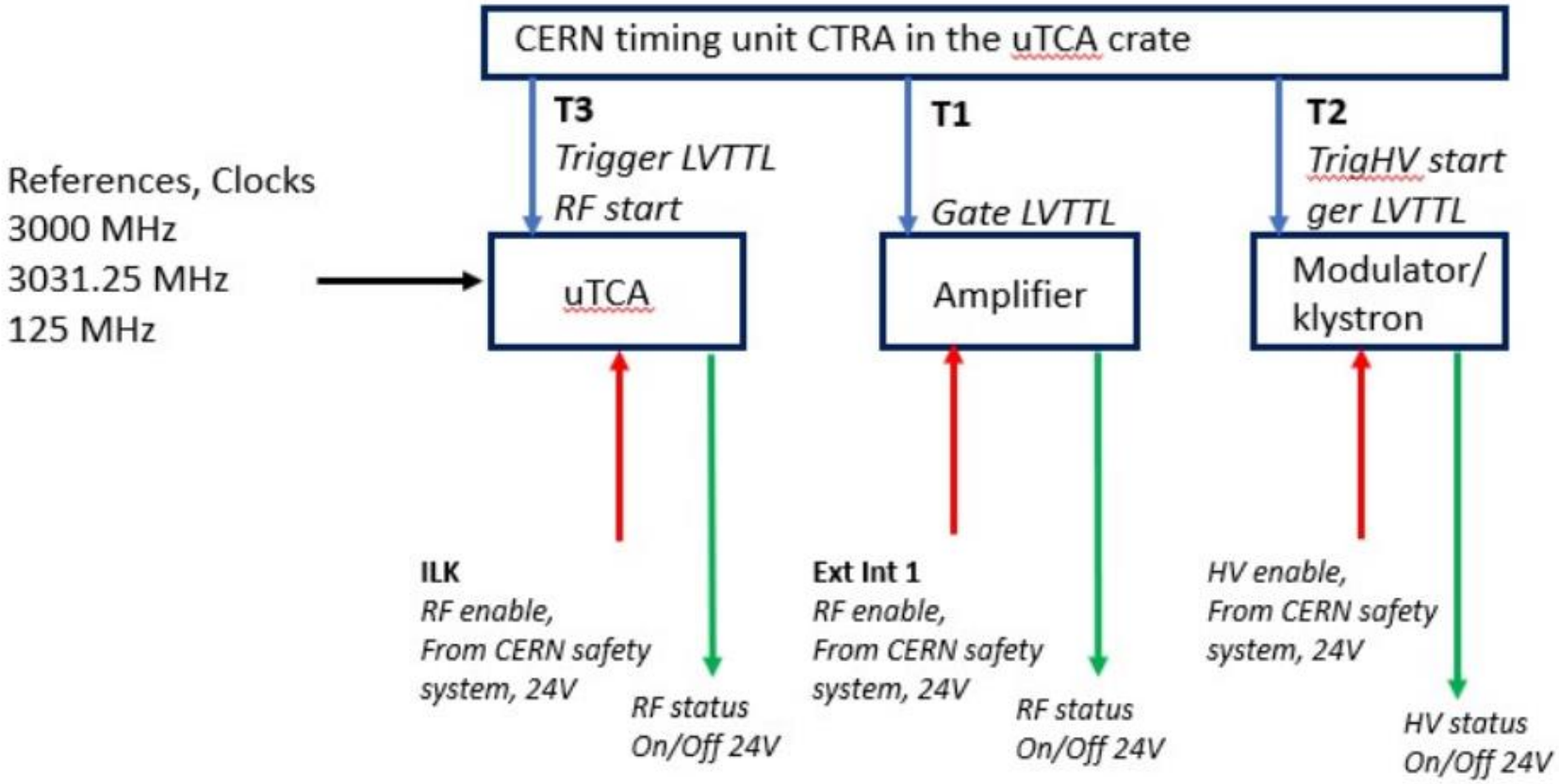
Signal connections

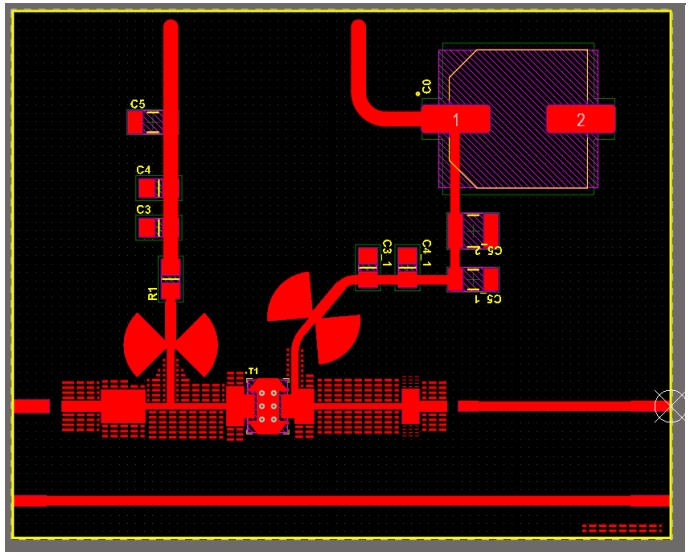


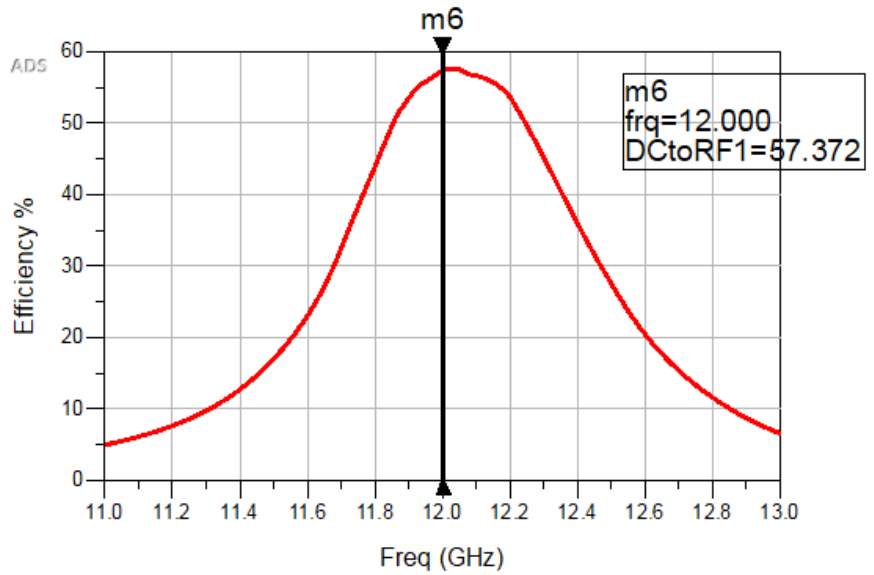
T1, and T3 are coming from a signal generator or CERN timing unit crate

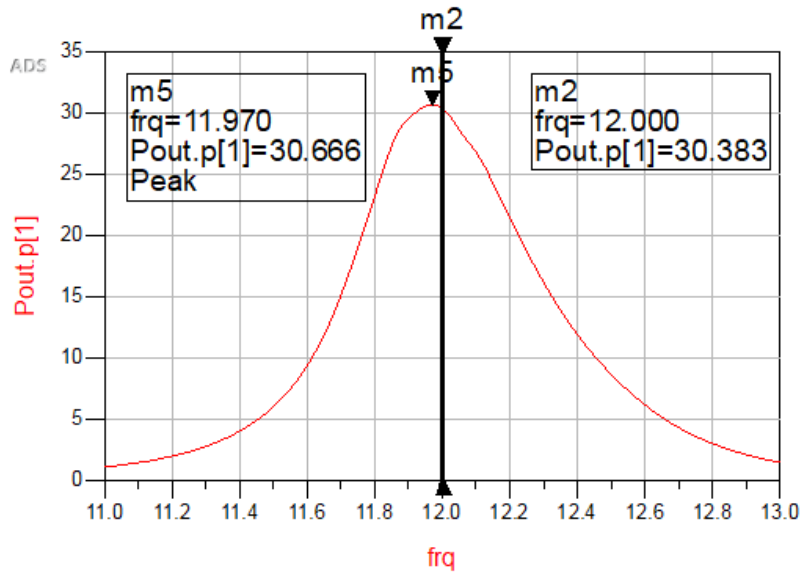
T1 is the amplifier signal, approx 5 us before the RF signal. It opens the input RF switch (logic AND with PLC:RFSwitchOn) and warms up the SSPA

T3 is the RF pulse

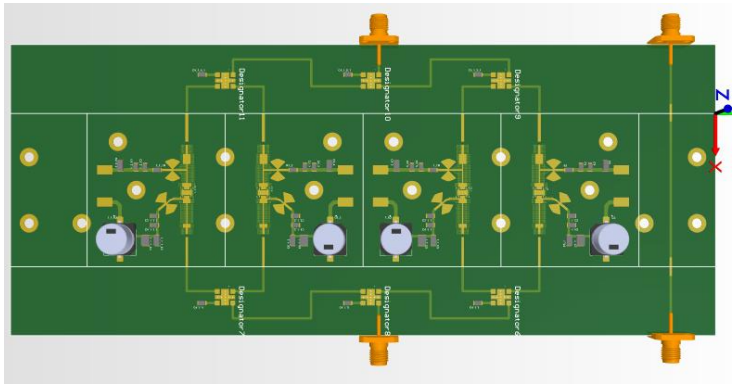
25W PA: PCB of initial design – 12 GHz

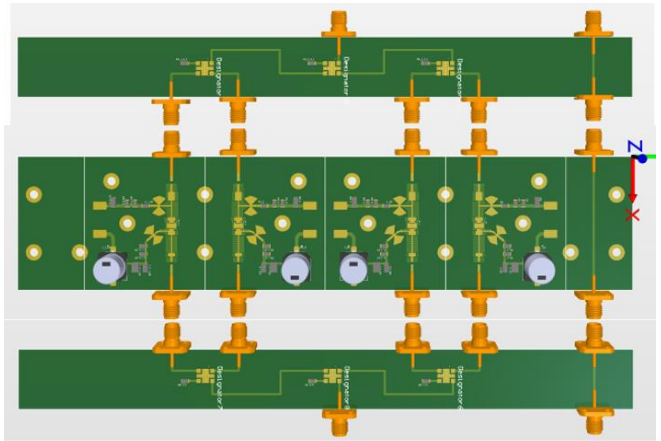






- PCB and results review
- Order PCB





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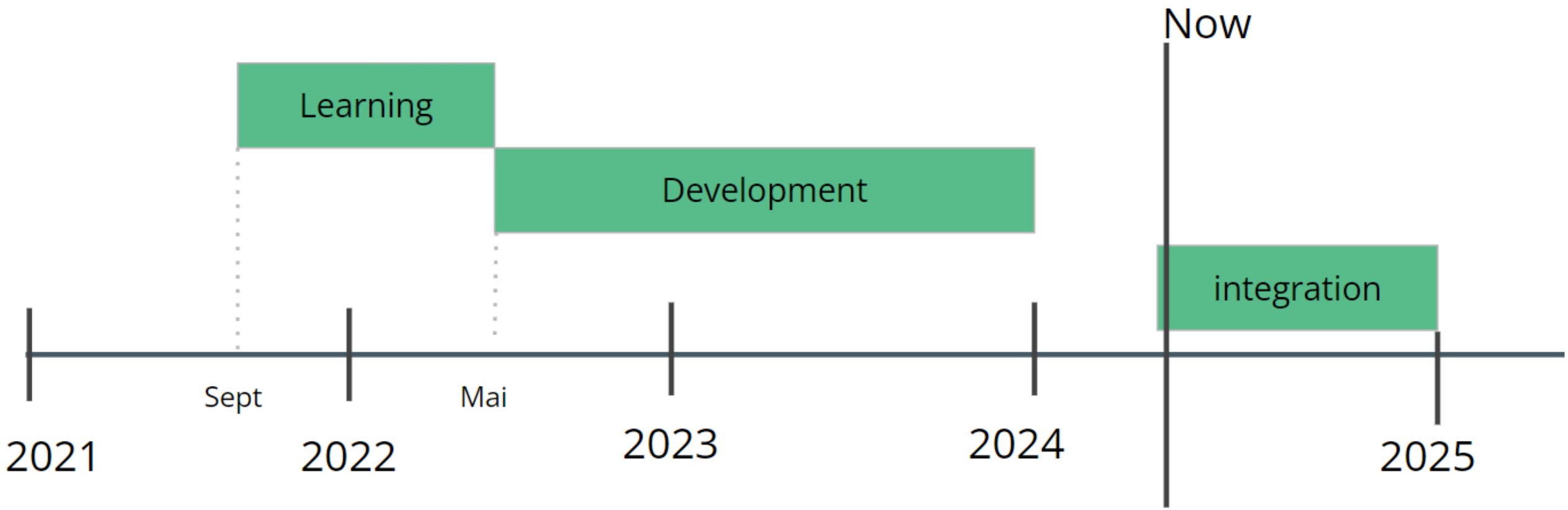
Low level RF - mTCA

Timeline

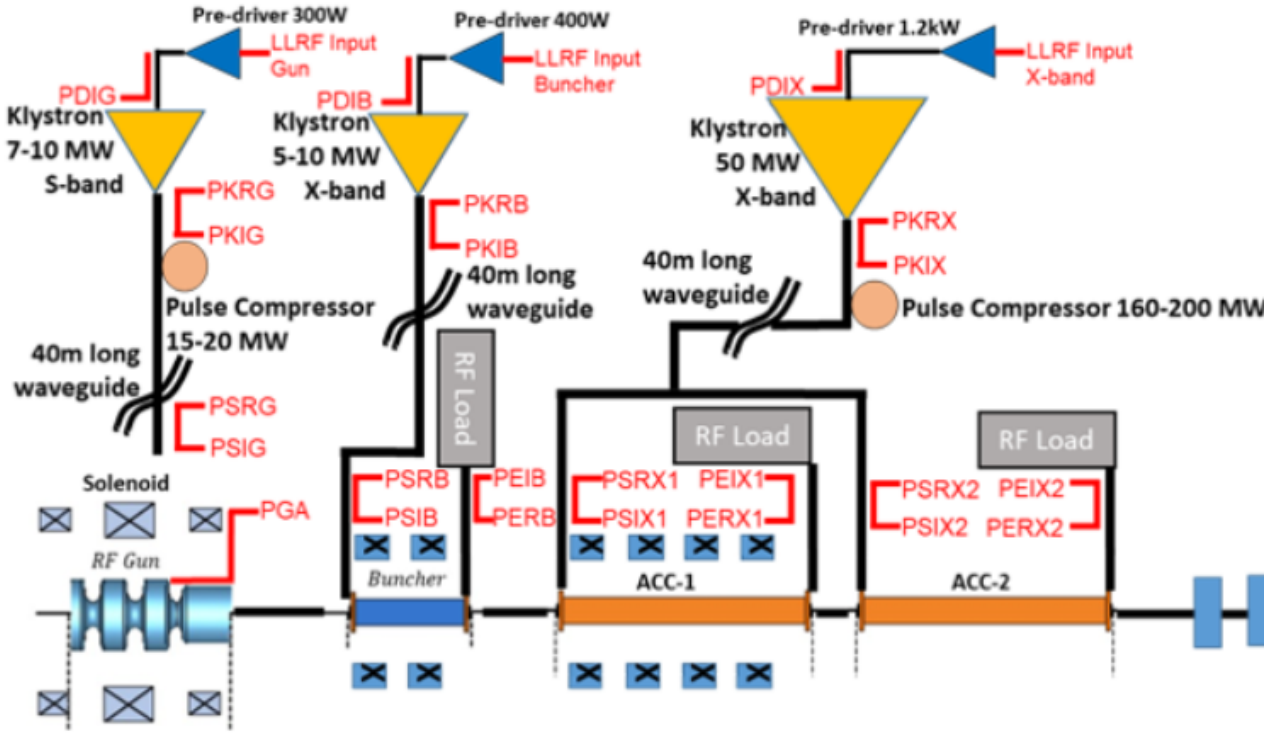


Kristiaan Pelckmans

Development in Uppsala

1. Based on DESY's mTCA tools (desy-RDL, BSP, …).
2. Closed loop (based on FFWD/FB control) on FPGA (Xilinx-US).
3. Software (DAQ -> xDMA -> CPU): and GUI.
4. Calibration.
5. Manual.

Second e-injector line



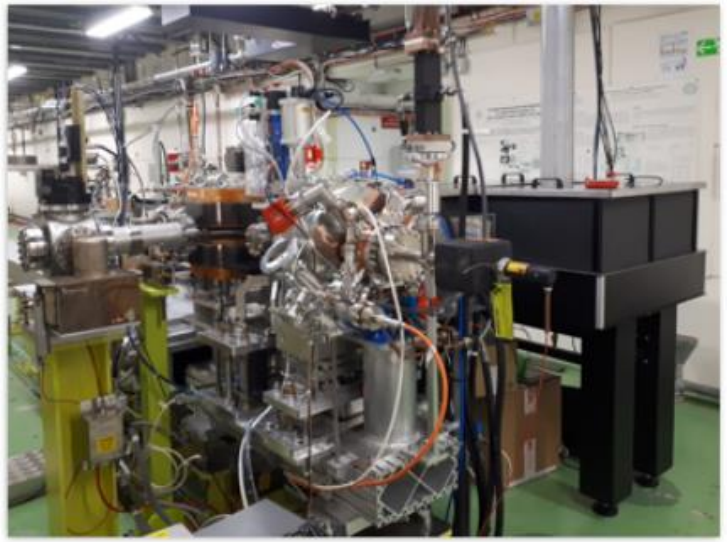
Kristiaan Pelckmans

mTCA at CERN (sept 2023)

Kristiaan Pelckmans

Integration in CERN (next steps)

1. **Memory Map** integration (DesyRDL <-> Cheby/FESA).
2. Integration of **UI** in AWAKE's (calibration!).
3. **DeRTM-Log** still under development by KVG/Desy. Expected delivery in April 2024, so all LO/REF/clk signals distributed via RF-backplane
4. Integration of **interlocks**/alarm/permit.
5. Assembly of **5** card pairs (now 2 AMC-RTM card pairs in operation, only for S-band)
6. **Measurement** campaign (1-2 weeks in juni 2024): "closing all loops".



Kristiaan Pelckmans

Thank you for your attention