

Using GaN Devices for a 100 W SSPA on 3 Cm

ON7UN

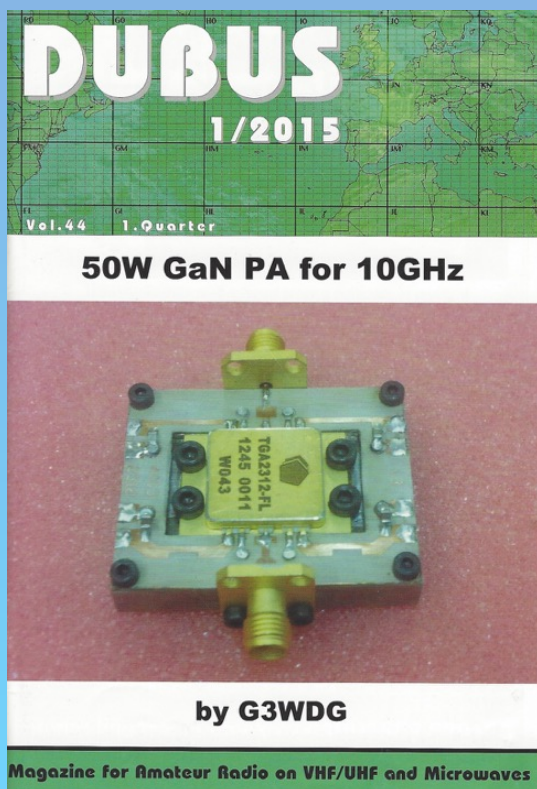
Örebro 2017

Looking for a SSPA for my 3,7m antenna




Dubus 1/2015

50W GaN PA for 10GHz by Charlie G3WDG



Triquint (Qorvo) TGA-2312-FL datasheet



TGA2312-FL
X-band 60W GaN Power Amplifier

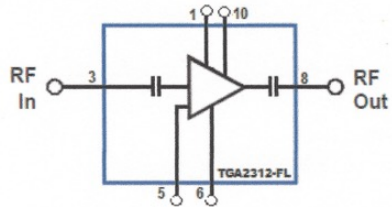
Applications

- Commercial and Military Radar
- Communications

Product Features

- Frequency Range: 9 – 10 GHz
- P_{SAT} : 48 dBm
- PAE: 38%
- Small Signal Gain: 13 dB
- Bias: $V_D = 24$ V, $I_{DQ} = 2.4$ A, $V_G = -2.6$ V Typical
- Pulsed: PW = 100us, DC = 10%
- Integrated Thermistor Temperature Monitor
- Package Dimensions: 17.4 x 24.0 x 3.9 mm

Functional Block Diagram



- Device designed for 9 – 10 GHz
- 24 VDC supply @ 6,4 A under full load
- Separate DC and RF connections
- 7 watt drive power needed for saturated output
- Build in thermistor for temperature measurement of the base
- PCB available from Charlie

Checking the Mouser website

The screenshot shows the Mouser Electronics website interface. The main product is the Qorvo TGA2312-FL, an RF amplifier. The page includes a search bar, navigation menu, and detailed product specifications. The specifications table is as follows:

Specificaties	Waarde
Productcategorie:	RF Versterker
Fabrikant:	Qorvo
RoHS:	<input checked="" type="checkbox"/> Details
Type:	Power Amplifier
Werkingsfrequentie:	9 GHz to 10 GHz
Versterking:	13 dB
NF - Ruisvorm:	-

Additional details include: Mouser-onderdeelnr: 772-TGA2312-FL, Fabrikantonderdeelnr: TGA2312-FL, Omschrijving: RF Versterker 9-10GHz Gain 13dB PAE 38% GaN 60W, and a price of 1.134,00 EUR.

The screenshot shows the Mouser Electronics website order summary page. It includes the Mouser logo, contact information for the customer service department, and a table of order details. The order summary is as follows:

Productdetail	Klantonderdeelnr.	Besteld aantal	Prijs (EUR)	Toestel (EUR)	Status	Datum	Factuurnr.
Mouser-nr. 772-TGA2312-FL Fabrikantnr:TGA2312-FL Omschr.: RF Versterker RF Versterker 9-10GHz Gain 13dB PAE 38% GaN 60W		2	994,35 €	1.988,70 €	2 Verzonden	31-03-15	37573277

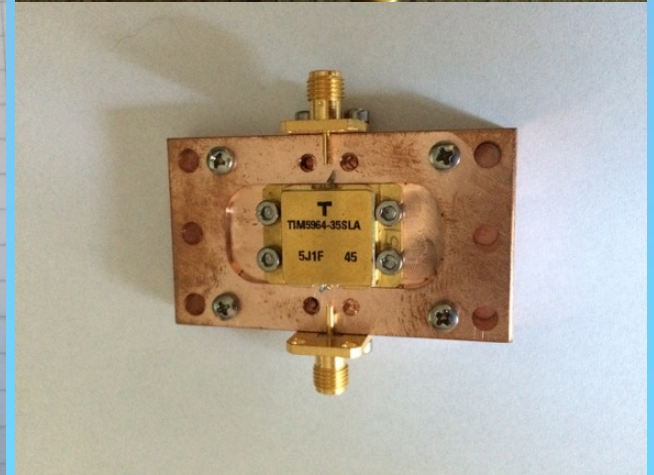
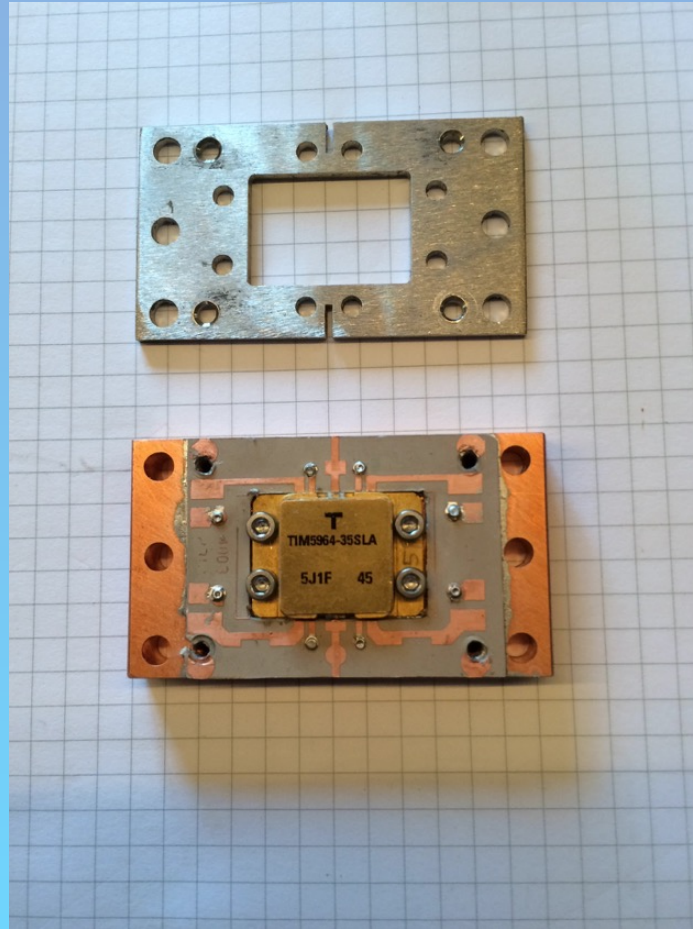
Additional information includes: Verkoopbestelnr. 233021563, Webbestelnr. 8577984, Besteldatum: 30-03-15, and Bestelstatus: VOLTOOID. The total order amount is 1.988,70 €.

In total 6 devices were purchased for myself, Dominique HB9BBD, Zdenek OK1DFC and Mirek OK2AQ .

Preparing construction of 50W amplifier

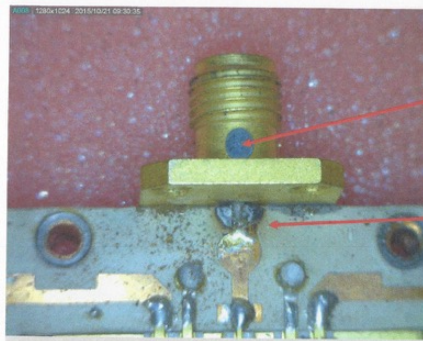
- Making the AutoCad drawing for the heat spreader
- Bert PE1RKI constructed the copper heatspreaders
- Charlie G3WDG supplied Rogers 4003 boards for the amplifier
- A bias supply with protection circuits got constructed
- Indium foil was used to transfer the heat out of the device to the heat spreader
- The Rogers PCB is soldered to the heat spreader with a heat plate

Preparing the board and spreaders



Charlie warned for over heated SMA connectors

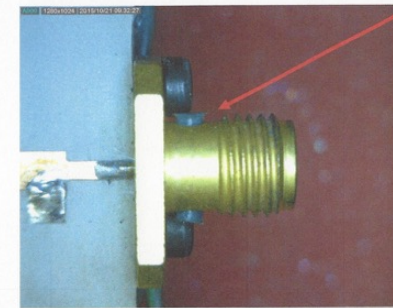
The problem – 50W of RF at 10GHz did this:



Epoxy plug is coming out of its hole

Solder joint has probably melted due to pin overheating leading to catastrophic failure

Epoxy plug movement



Epoxy plugs coming out

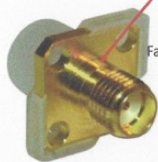
This has been seen on a number of Gigalane connectors now, on several different amplifiers with output powers of 50-90W at 10GHz. Usually both plugs are similarly affected. Hot smells have also been observed with the connector under power. Connectors also run hot to the touch.

Possible candidate

Candidate to replace Gigalane (2 tested)

Cannot see any evidence of epoxy retention, but DS does not specify pin retention method – RF connection is a 1.27mm wide tab, prefer the Gigalane pin. Tab trimmed with sidecutters to match 50 ohm line width on pcb.

AMPHENOL RF 132166 RF/COAXIAL, SMA JACK, STRAIGHT, 50 OHM, SOLDER

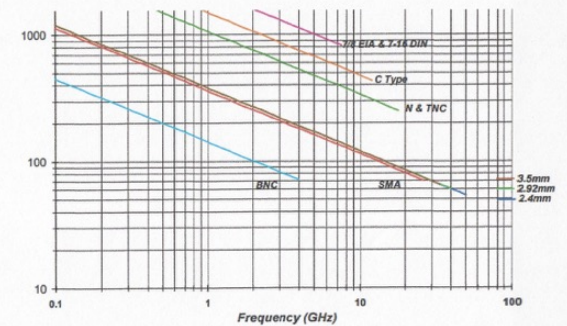
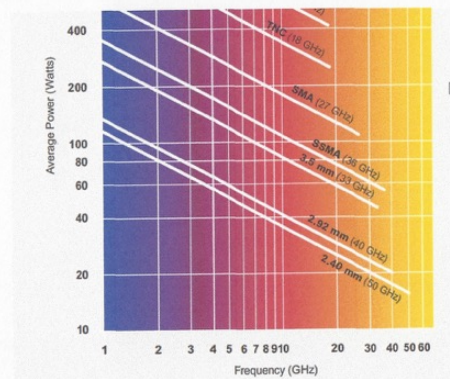


Amphenol® RF

Manufacturer: AMPHENOL RF
Farne|Order Code: 1791131
Manufacturer Part No 132166

Two PAs have been modified to use this connector at the output. They were run at 50W CW output for several minutes and the connector was only slightly warm, in comparison to the Gigalane that got hot to the touch.

Power handling

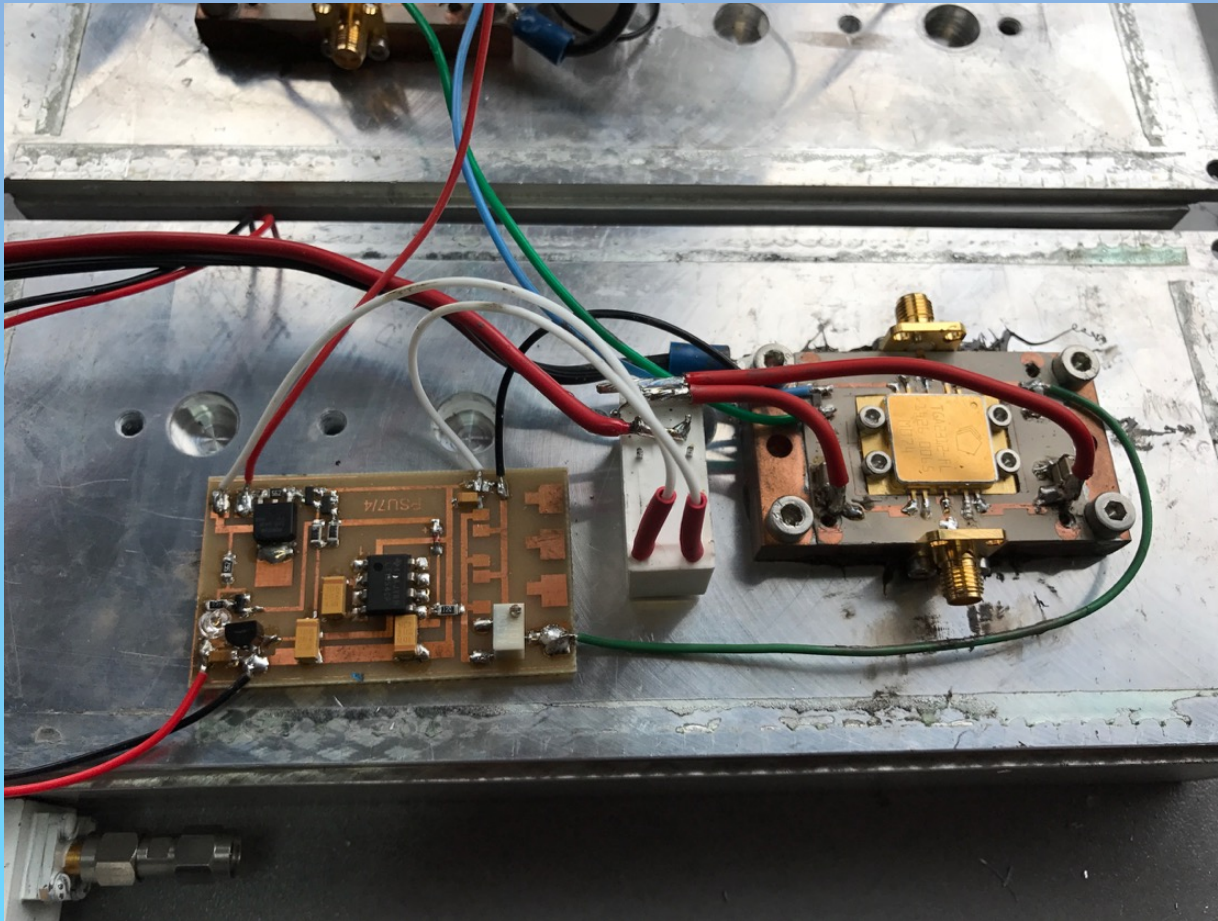


<http://f1chf.free.fr/fichiers/RF%20Connector%20Guide.pdf>

Info from South West Microwave

<http://mpd.southwestmicrowave.com/static/appendix.pdf>

First amplifier under test



- No RF input
- VD 24,0 V
- VG - 2,62 V
- IDQ 1,86 A

- Only a 4 watt driver available
- Pin +35,6 dBm
- Pout +44,0 dBm
- ID 3,6 A

Noticed high base temperature



TGA2312-FL X-band 60W GaN Power Amplifier

Typical Performance

A 100K Ω thermistor is assembled inside the TGA2312-FL package. Nominal resistance versus temperature is shown in the table below. The resistance measurement is taken between the Temp pin and ground pin to provide a useful indicator of the maximum package temperature.

deg C	R (Kohm)	deg C	R (Kohm)
0	378.80	65	17.89
5	284.71	70	14.84
10	216.16	75	12.37
15	165.70	80	10.37
20	128.17	85	8.74
25	100.00	90	7.40
30	78.66	95	6.29
35	62.36	100	5.37
40	49.81	105	4.61
45	40.06	110	3.96
50	32.44	115	3.43
55	26.44	120	2.97
60	21.68	125	2.59

- Reading 20 kohm after 3 min of quiescent current
- Meaning over 60° C of base temperature
- Found out the device was slightly larger than the datasheet specifications
- Device had no decent thermal connection to the heat spreader
- Filed off some material from the device to fit the heat spreader.
- Problem solved, device temperature with +44 dBm output did not reach 27 kohm or 55°C

Looking for a driver amplifier



Product Description

Qorvo's TGA2625-CP is a packaged high-power X-Band amplifier fabricated on Qorvo's QGaN25 0.25 um GaN on SiC process. Operating from 10 to 11 GHz, the TGA2625-CP achieves 42.5 dBm saturated output power, a power-added efficiency of > 40 %, and power gain of 28 dB.

The TGA2625-CP is packaged in a 10-lead 15x15 mm bolt-down package with a Cu base for superior thermal management. It can support a range of bias voltages and performs well under CW and pulsed conditions. Both RF ports are internally DC blocked and matched to 50 ohms allowing for simple system integration.

The TGA2625-CP is ideally suited for both commercial and defense applications.

Lead free and RoHS compliant.

Evaluation Boards are available upon request.

TGA2625-CP 10 – 11 GHz 20 W GaN Power Amplifier



Product Features

- Frequency Range: 10 – 11 GHz
- Pout: 42.5 dBm (at $P_{IN} = 15$ dBm)
- PAE: > 40 %
- Power Gain: 28 dB (at $P_{IN} = 15$ dBm)
- Bias: $V_D = 28$ V, $I_{DQ} = 365$ mA, $V_G = -2.6$ V typical, pulsed (PW = 100 μ s, DC = 10 %)
- Package Dimensions: 15.2 x 15.2 x 3.5 mm
- Package base is pure Cu offering superior thermal management

- Realized I need about 7 watt drive for the TGA2312-FL amplifier
- Want to combine two so need 14 watt
- Learn about the TGA2625CP, a GaN device to produce 20 watt with 28 dB gain

Checking the market



TGA00000CP 10–11 GHz 20 W GaN Power Amplifier

Absolute Maximum Ratings

Parameter	Value / Range
Drain Voltage (V_D)	40 V
Gate Voltage Range (V_G)	-8 to 0 V
Drain Current (I_D)	3 A
Gate Current (I_G)	-6 to 14 ⁽¹⁾ mA
Power Dissipation (P_{Diss}), 85 °C	53 W
Input Power, CW, 50 Ω , (P_{IN})	21 dBm
Input Power, CW, VSWR 6:1, $V_D = 28$ V, 85 °C, (P_{IN})	21 dBm
Channel Temperature (T_{CH})	275 °C
Mounting Temperature (30 Seconds)	260 °C
Storage Temperature	-55 to 150 °C

Operation of this device outside the parameter ranges given above may cause permanent damage. These are stress ratings only, and functional operation of the device at these conditions is not implied.

(1) Max rating for I_G is at Channel Temperature (T_{CH}) of 200 °C.

Recommended Operating Conditions

Parameter	Value / Range
Drain Voltage (V_D) pulsed: PW = 100 μ s, DC = 10 %	28 V
Drain Current (I_{DC})	365 mA
Drain Current Under RF Drive (I_{D_DRIVE})	See plots p. 6
Gate Voltage (V_G)	-2.6 V (Typ.)
Gate Current Under RF Drive (I_{G_DRIVE})	See plots p. 6
Temperature (T_{BASE})	-40 to 85 °C

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed over all recommended operating conditions.

Electrical Specifications

Parameter	Min	Typ	Max	Units
Operational Frequency Range	10		11	GHz
Small Signal Gain		36		dB
Input Return Loss		13.5		dB
Output Return Loss		10		dB
Output Power (at $P_{IN} = 15$ dBm)		42.5		dBm
Power Added Efficiency (at $P_{IN} = 15$ dBm)		40		%
Power Gain (at $P_{IN} = 15$ dBm)		28		dB
Output Power Temperature Coefficient (25 °C to 85 °C only)		-0.003 -0.01		dBm/°C
Recommended Operating Voltage	25	28	32	V

Test conditions unless otherwise noted: 25 °C, $V_D = 28$ V (PW = 100 μ s, DC = 10 %), $I_{DC} = 365$ mA, $V_G = -2.6$ V typical.

- Device designed for 10 – 11 GHz internally matched
- Drain voltage +28 VDC
- Power gain 28 dB !
- Output power +42,5 dBm
- Price less than 400 us\$

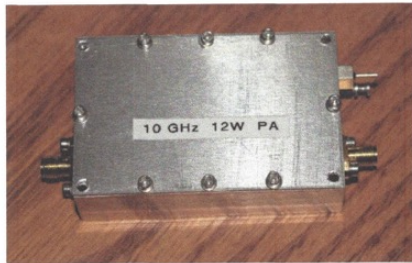
TOM K5TRA had a project with the TGA-2625-CP

RMG Meeting

June 4, 2016

10 GHz PA

PHOTOS & RESULTS



K5TRA

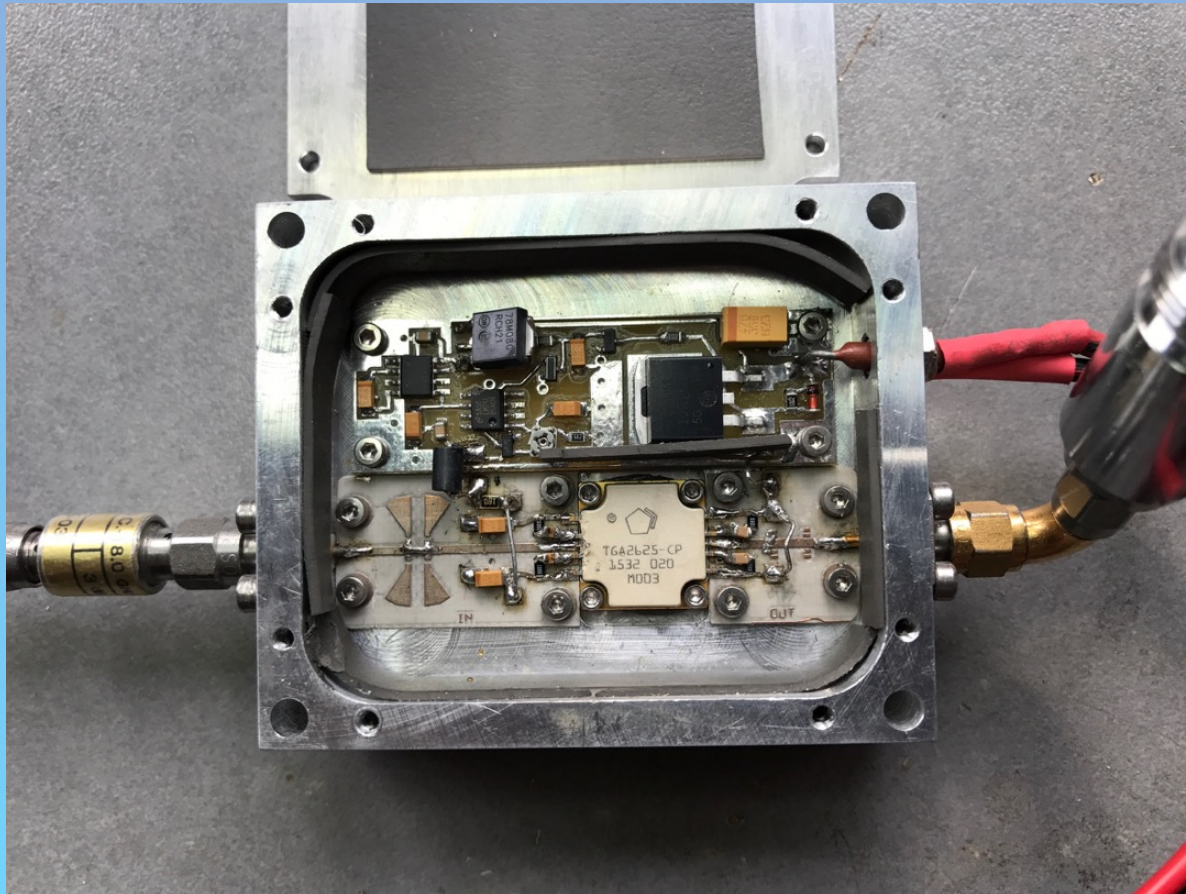


T.Apel

1

- Unfortunately the PCB's where already sold out
- Constructed the RF board on Rogers 4003 using my LPKF plotter
- Commercially produced the bias boards
- Made and Autocad drawing for the aluminum enclosure
- Bert PE1RKI produced the aluminum box

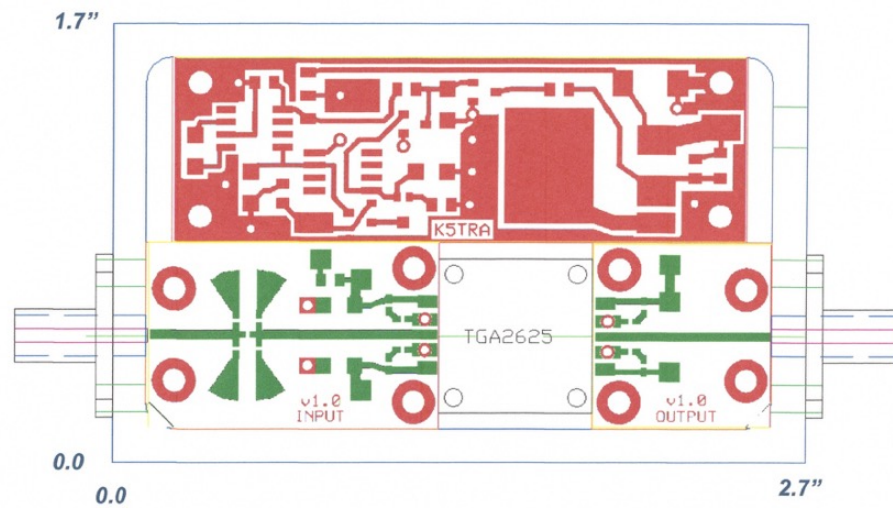
Driver amplifier



- Oscillating like hell (28 dB gain)
- Needed enough absorb material on the lid and inside the box to keep the amplifier stable.
- 15 watt output power with +17 dBm input (50 mW)
- Sequenced drain supply (design K5TRA)

K5TRA design details

PA Module Floor Plan

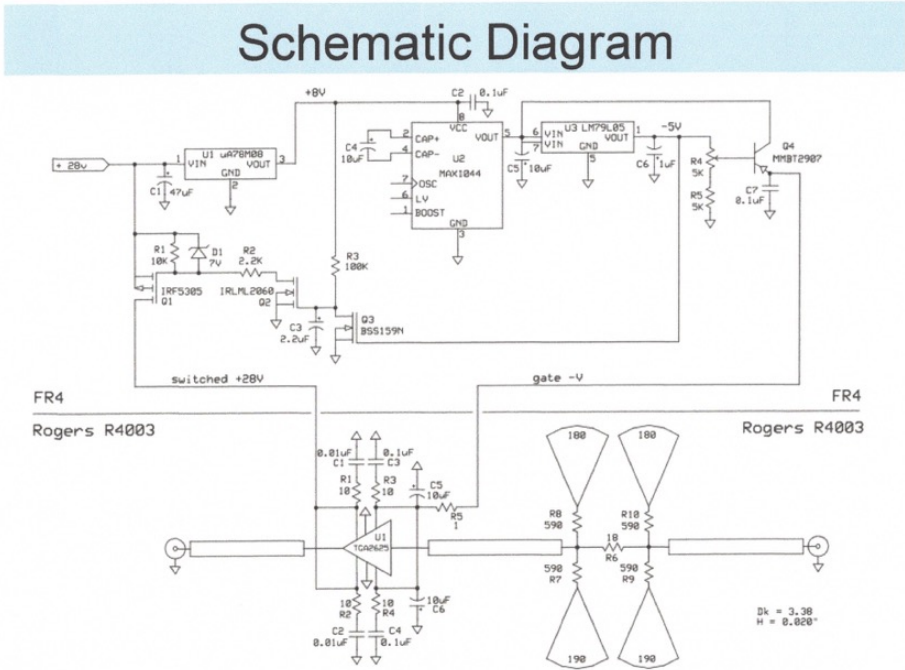


K5TRA

T.Apel

3

Schematics of the driver

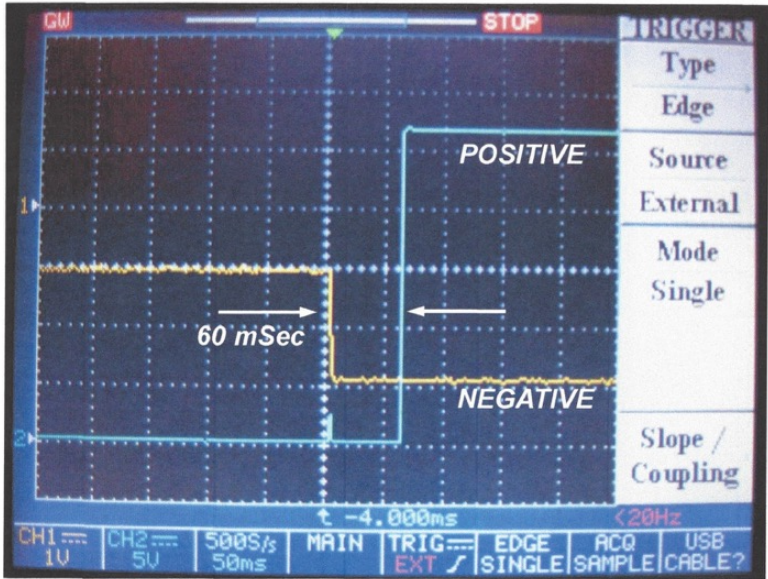


K5TRA

T.Apel

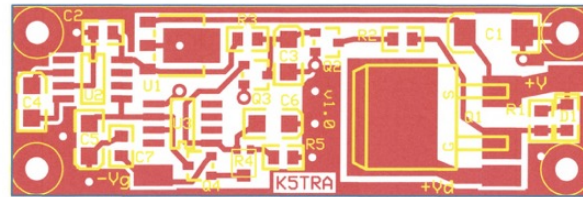
Sequenced Bias / Drain power supply

Bias Sequencer Test



K5TRA boards

Bias Board Top Layer



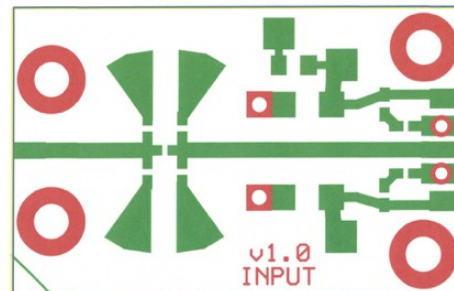
2.250" x 0.725"

K5TRA

T.Apel

15

RF Input

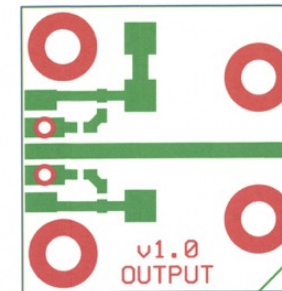


K5TRA

T.Apel

18

RF Output



K5TRA

T.Apel

19

Obtaining GaN devices in Europe

- Mouser did not ask questions in 2015 to obtain the TGA-2312-FL
- Their sales policy changed in 2016 , GaN devices where no longer available in Europe
- I ordered TGA-2625CP from Richardson RFPD with 'some' paperwork
- Richardson RFPD send me an email in march 2017 telling they no longer support or sell Qorvo products
- Checked with RF MD, they seem to have stock and will ship to Europe, but ask you ' some ' questions
- Mouser seems to sell GaN devices again in Europe, but have some restrictions

Questions asked :

(PLACE ON COMPANY LETTERHEAD OF PURCHASER OR PROVIDE CHOP/STAMP)

Sales order/Purchase Order/Quote: _____ Part Number: _____ Quantity: _____

Purchasing user of the above product obtained (Please provide full address and country)

Company Name: _____

Company nature of business: _____

Address 1: _____

Address 2: _____

City / Province / Country: _____

Ultimate end user of the above product obtained (Please provide full address and country of end user):

Company Name: _____

Company nature of business: _____

Address 1: _____

Address 2: _____

City / Province / Country: _____

The above product will be used as follows:
(Explain in detail the precise purpose for which the part is to be used – for example, if the part is being used for testing purposes specify what type of application is being tested.)

Will this part number be used for the following market type: (please mark X in all appropriate boxes)

Telecommunications Radar Aerospace Automotive Other: _____
(please specify)

Will this part number be used for: (please mark X in all appropriate boxes)

Military use Commercial (civil) use Government use

Will this part be used in nuclear/chemical/biological weapons and/or missile related items? (please mark X in the appropriate box)

NO YES

If you marked yes above, please explain: _____

We acknowledge that these commodities, technology or software may be subject to the Export Administration Regulations of the United States and that diversion contrary to U.S. law is prohibited.

We also confirm that any re-export, sale or transfer to a third party is carried out in compliance with the originating/supplying and receiving countries' export control laws. If the product is subject to the U.S. encryption control regulation, we agree to obtain approval or license from U.S. government for resale or transfer to a government end user outside U.S. even when it's within the country we are located.

Furthermore, we acknowledge that products referenced above will not be sold, transferred or diverted during shipment to the following countries or regions: **Crimea (Ukraine) Region, Cuba, Donetsk (Ukraine) Region, Iran, Libya, Lugansk (Ukraine) Region, North Korea, Sudan, Syria, or Iraq, or to a military end-user or for military end-use in China, Russia, Venezuela or any country referenced in part 744.17 of the U.S. Export Administration Regulations.**

We acknowledge that, based on the end-use information provided above, additional information/clarification may be required.
(To be filled out by the purchaser)

Signature: _____ email: _____ Date: _____

Printed Name: _____ web-site: _____ Title/ Department: _____

- Need an end user statement
- Need a description of your ' project '
- Need approval from their export dept
- Takes around 2 weeks

New supplier ?

From: **Bernard Feltin** bernard.feltin@rfmw.com
Subject: TR: Qorvo TGA-2625-CP TGA-2312-FL
Date: 17 May 2017 17:41
To: ejespers@telenet.be

BF

M Jespers

Yes this product is available for the European market .
What is your final application ?

Regards

Bernard FELTIN
RFMW France
Sales Manager / Responsable des Ventes

Tel : + 33 (0) 1 83 64 53 97



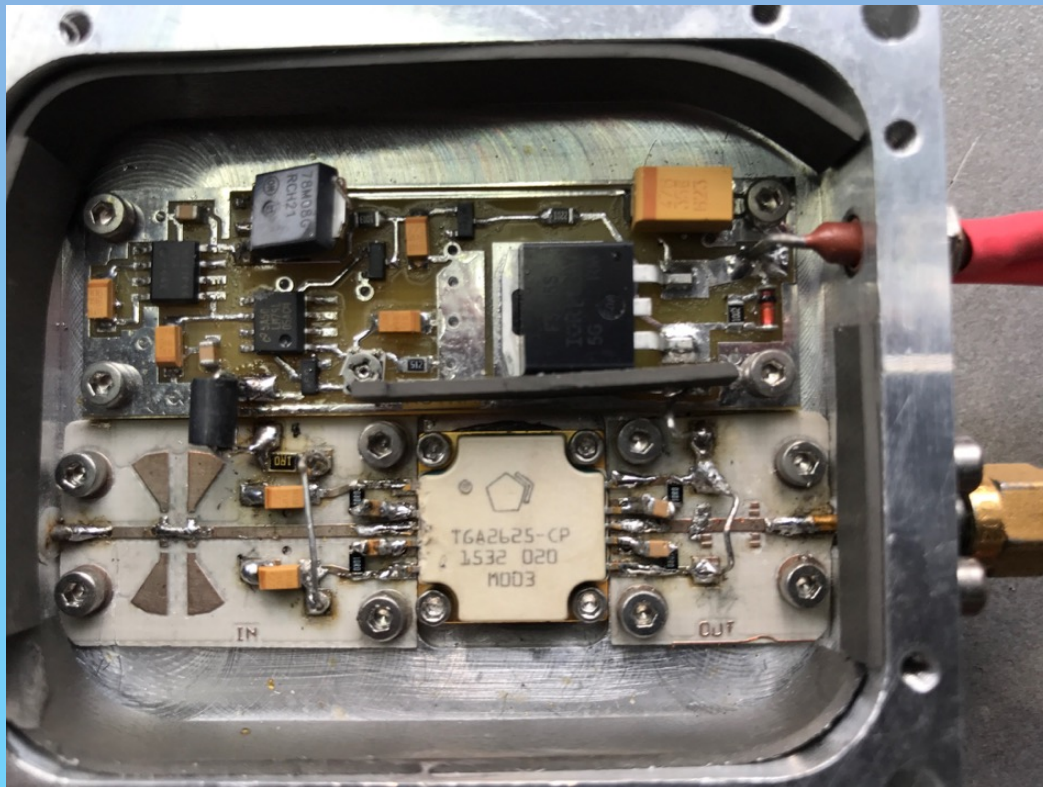
Site web : www.rfmw.com

RFMW distribue : Ampleon (RF Power ex NXP) et Qorvo (issue de TriQuint SC et de RFMD)

Ampleon , ASC Amplifier Solutions , API Technologies , API / Inmet , API / Weinschel , Aviacomm , Carlisle Interconnect , Delta Electronics , DiTom , EMC Technology - Florida RF Labs , Frontier Electronics , Isolink (filiale de Skyworks Solutions) , Johanson Technology , Johanson Dielectrics , MACOM Metelics , MAST Technologies , Meca Electronics , MiniRF , MWT Inc. , P1dB , ParkerVision , Peregrine Semiconductor , RFAxis , RF Circulator Isolator , RF Industries , Rosenberger , Shoulder Electronics , Skyworks Circulators and Isolators , Southwest Antennas , Sunny Electronics , Telemakus , XMA Corp , XSYSTOR .

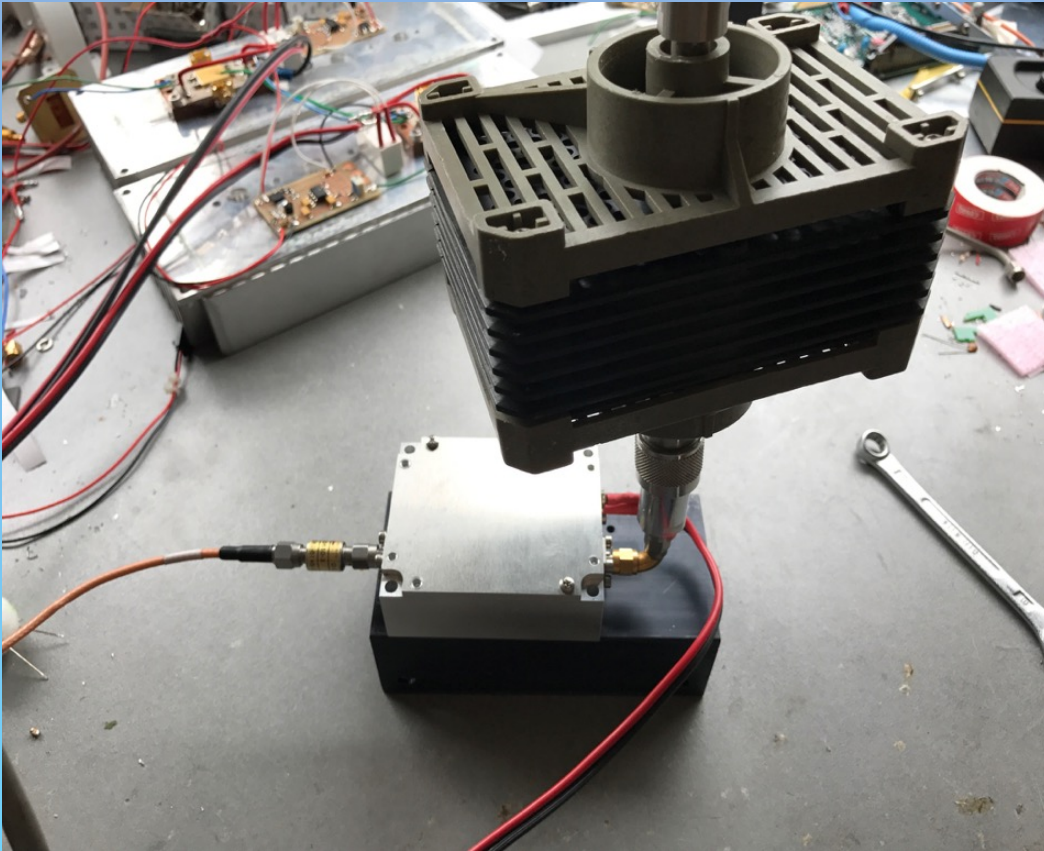
- RFMW seems to have stock and is ready to supply
- Questions are asked about the application

TGA-2625-CP failed ☹️

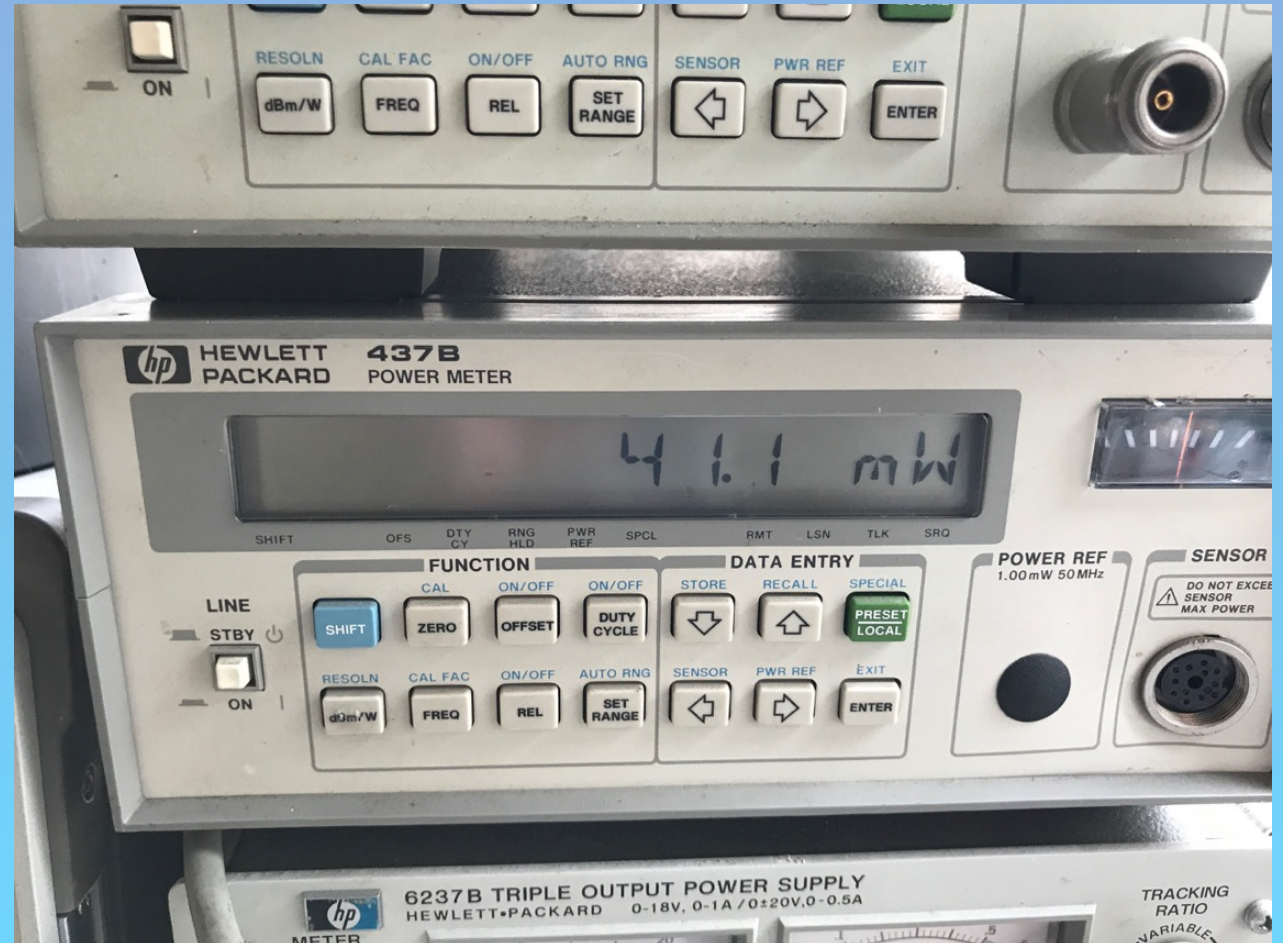
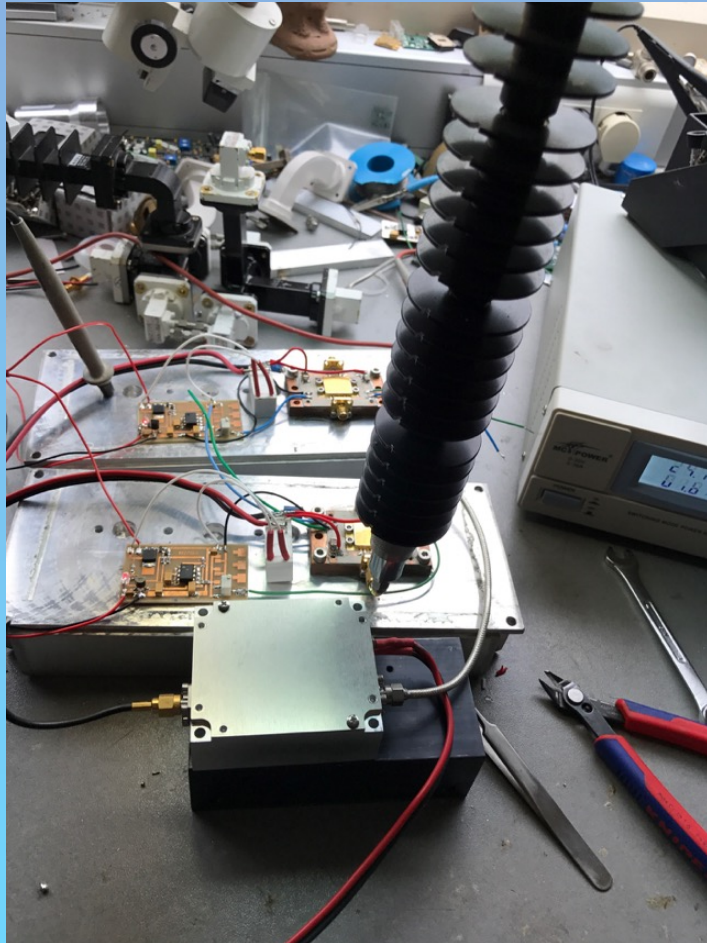


- One of the Veropins to ground negative bias failed.
- Tantalum capacitors at the gate where installed in wrong polarity
- Device died
- New TGA-2625-CP is ordered and took again the same procedure to obtain (3 weeks)

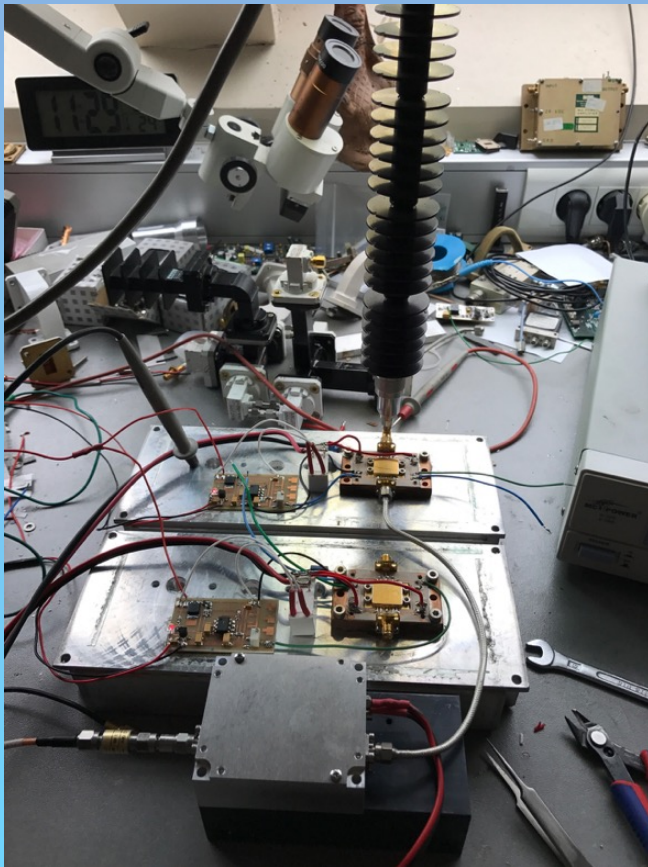
Output power measurement of the driver



Testing the TGA-2312-FL amplifier A



Testing the TGA-2312-FL amplifier B



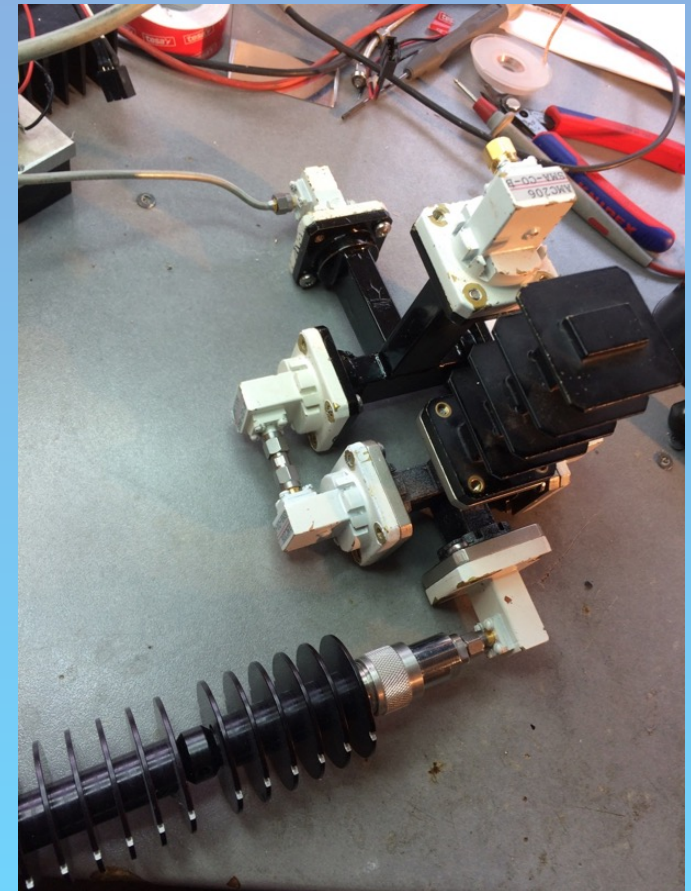
Preparing the combiner network



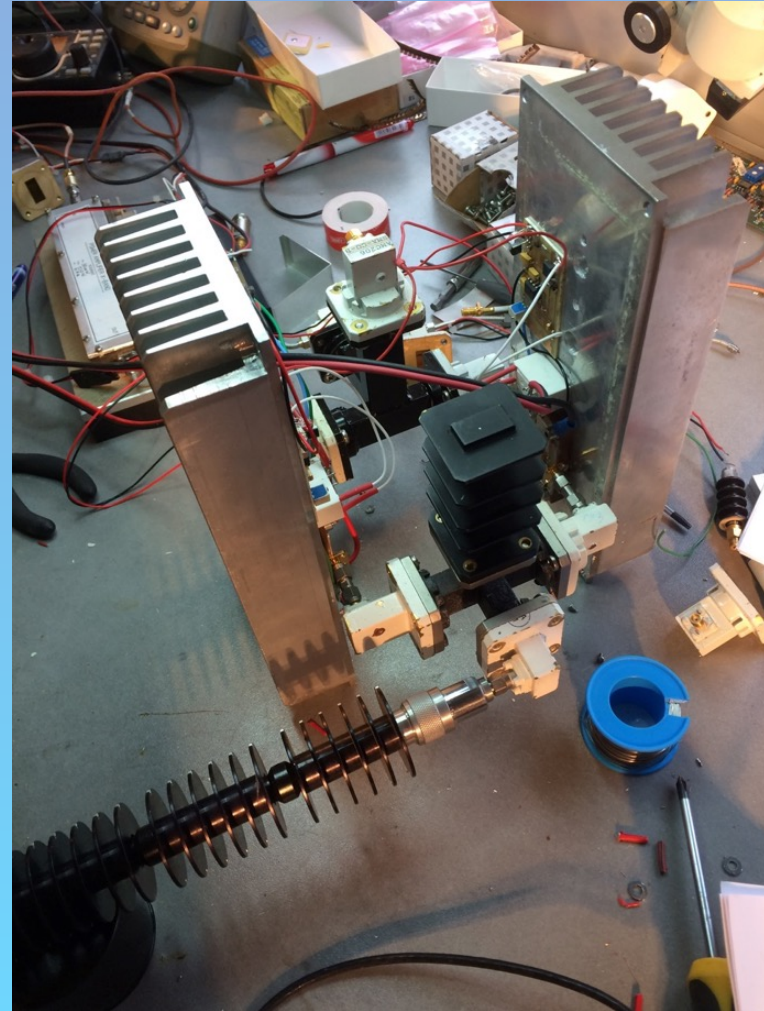
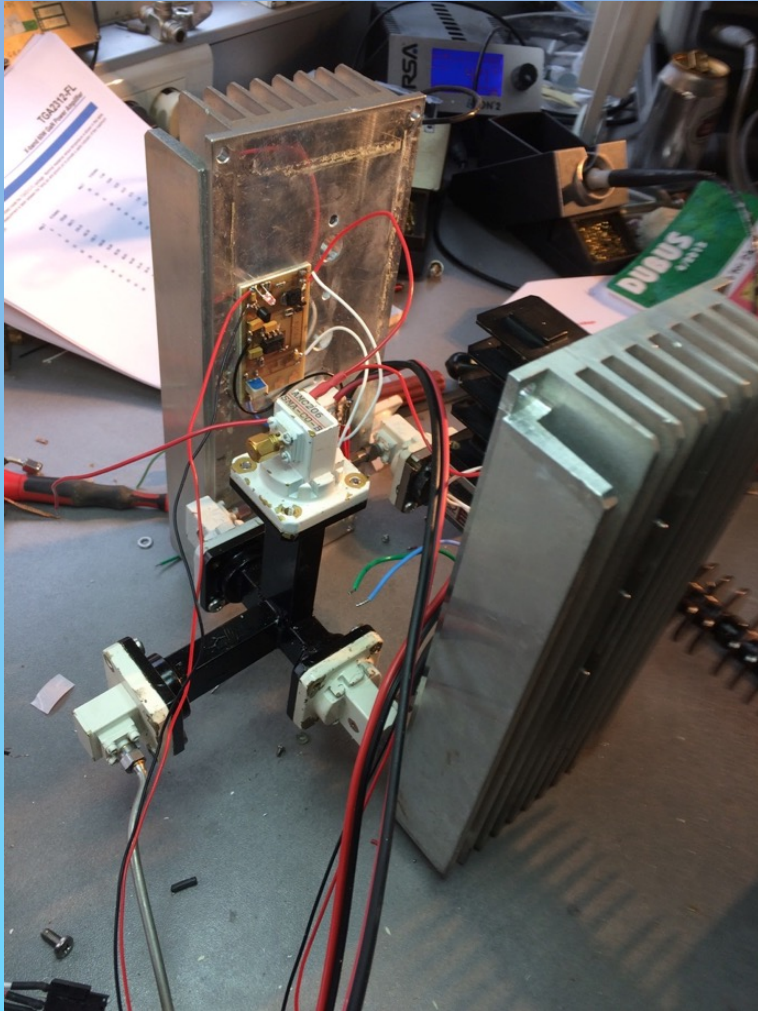
Magic T in WR-75



- Found one MagicTee on ebay
- Constructed a second with obsolete WR-75 waveguide components
- Measured loss 0,2 dB
- Needing tuning screws for best phase correction



Combining the two amplifiers



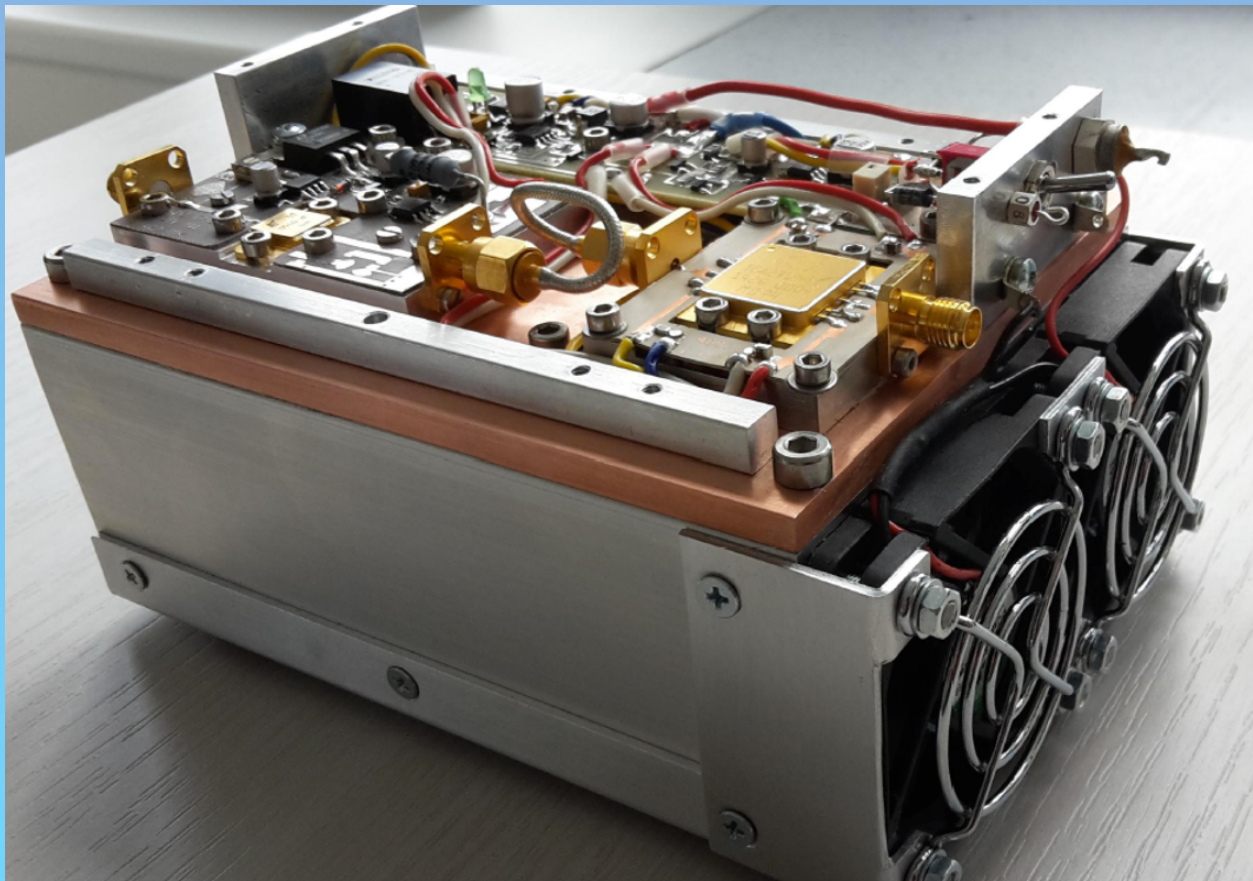
Need some more fine tuning of the combiner



New focus box construction for my antenna

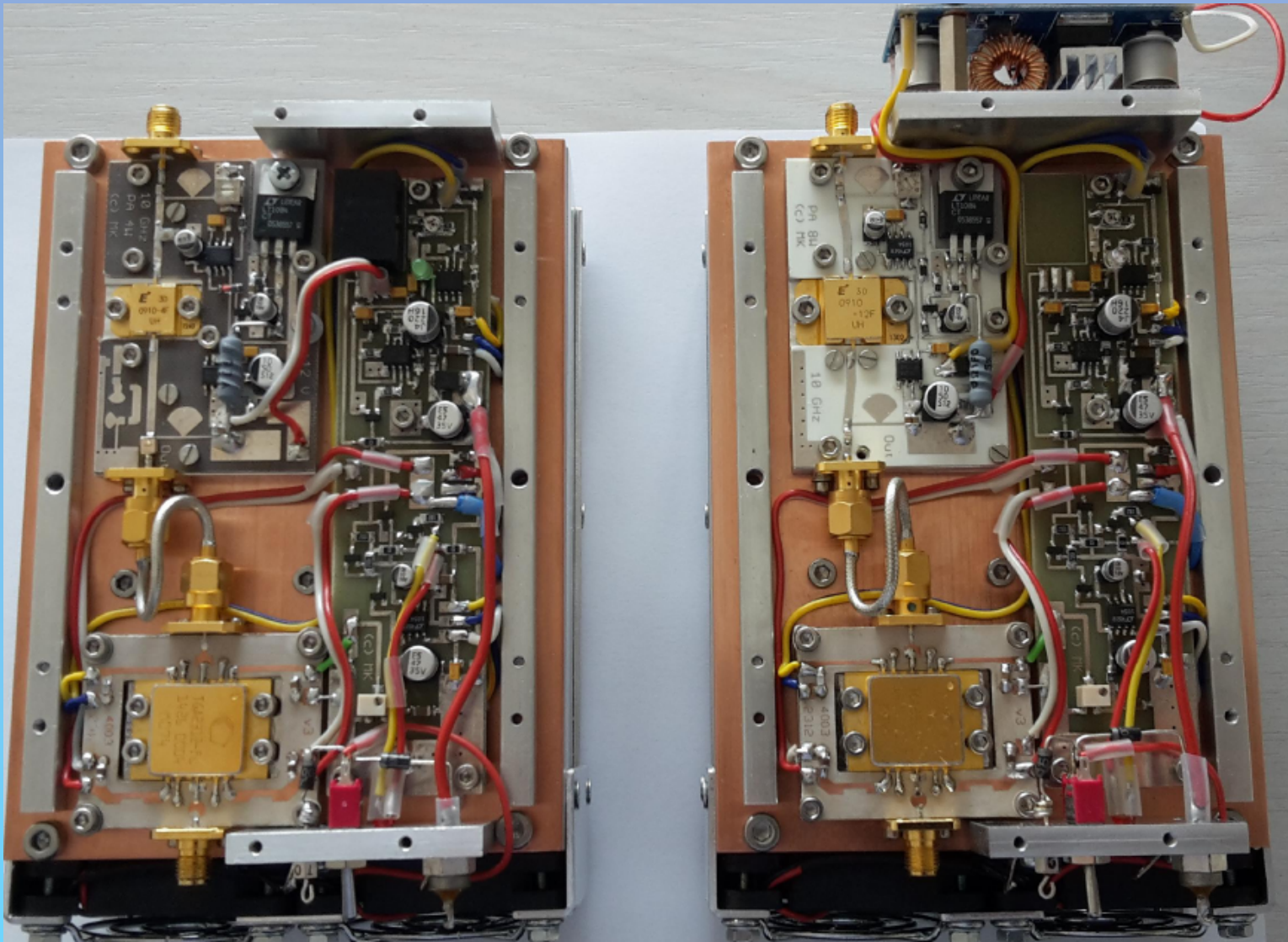


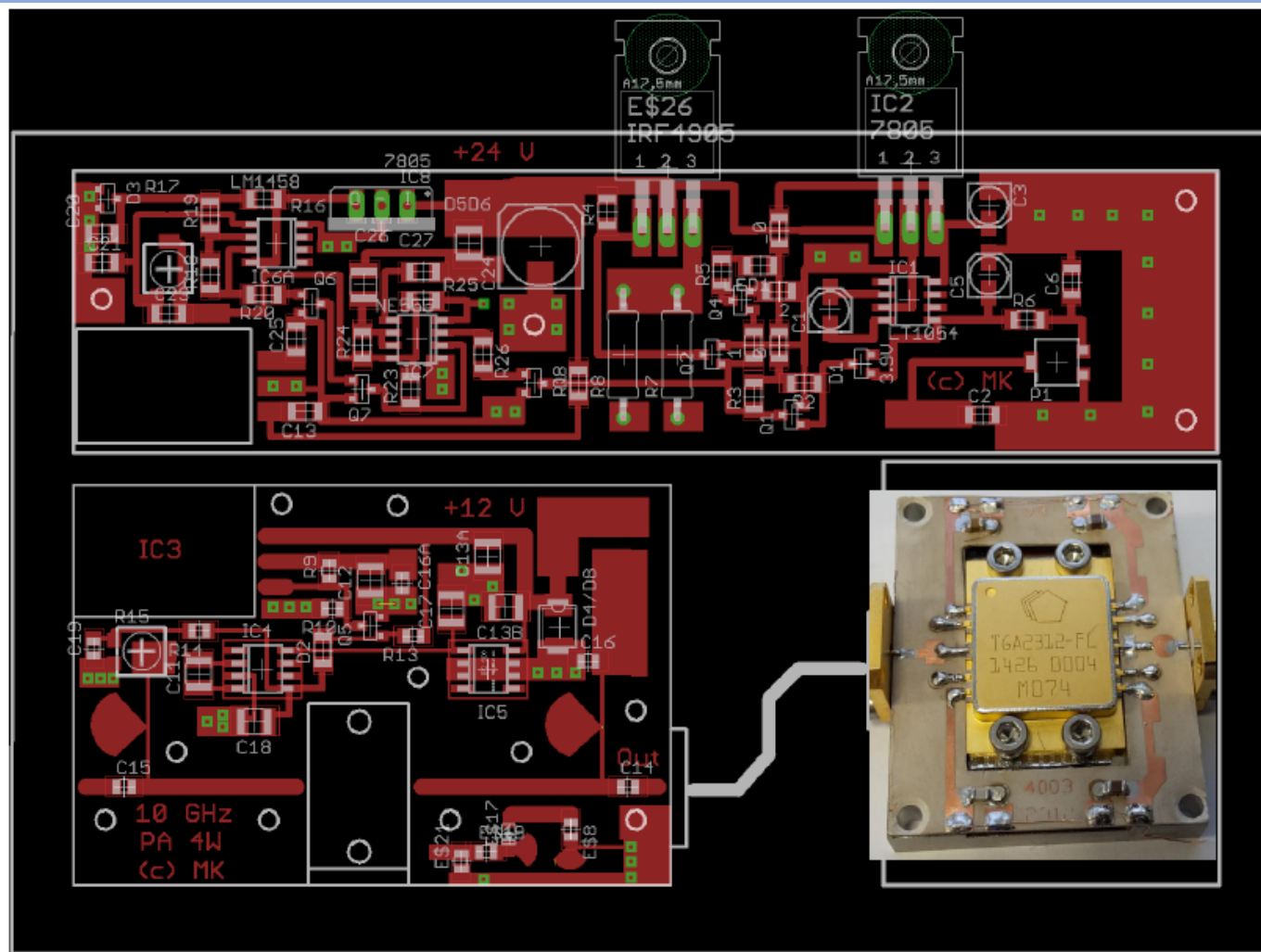
Mirek OK2AQ produced a very nice and compact version with the TGA-2312-FL



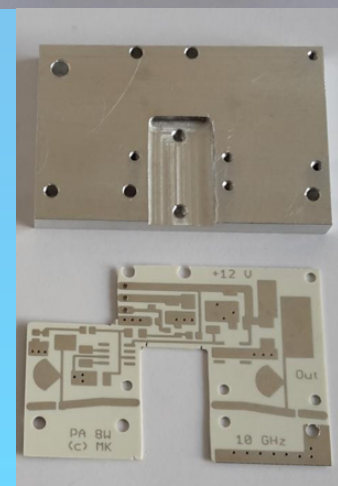
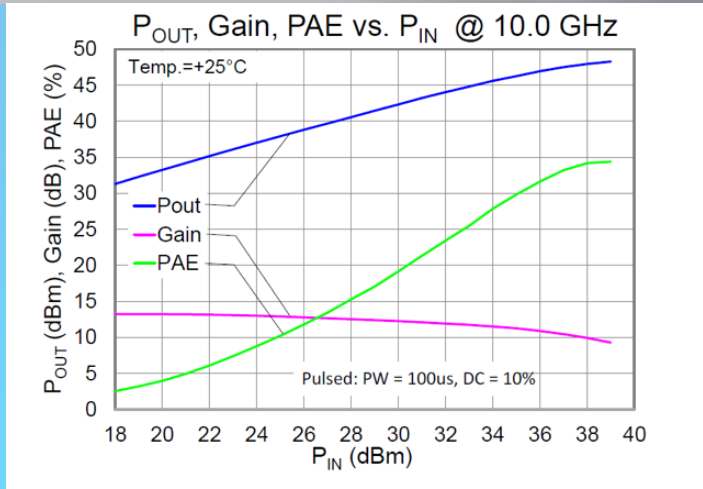
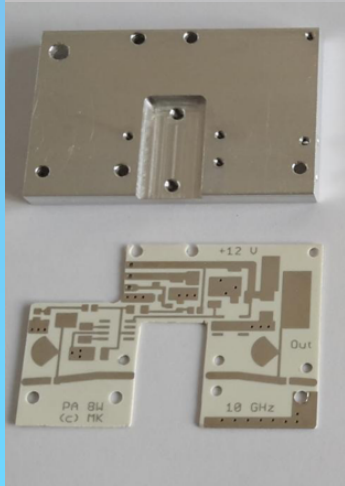
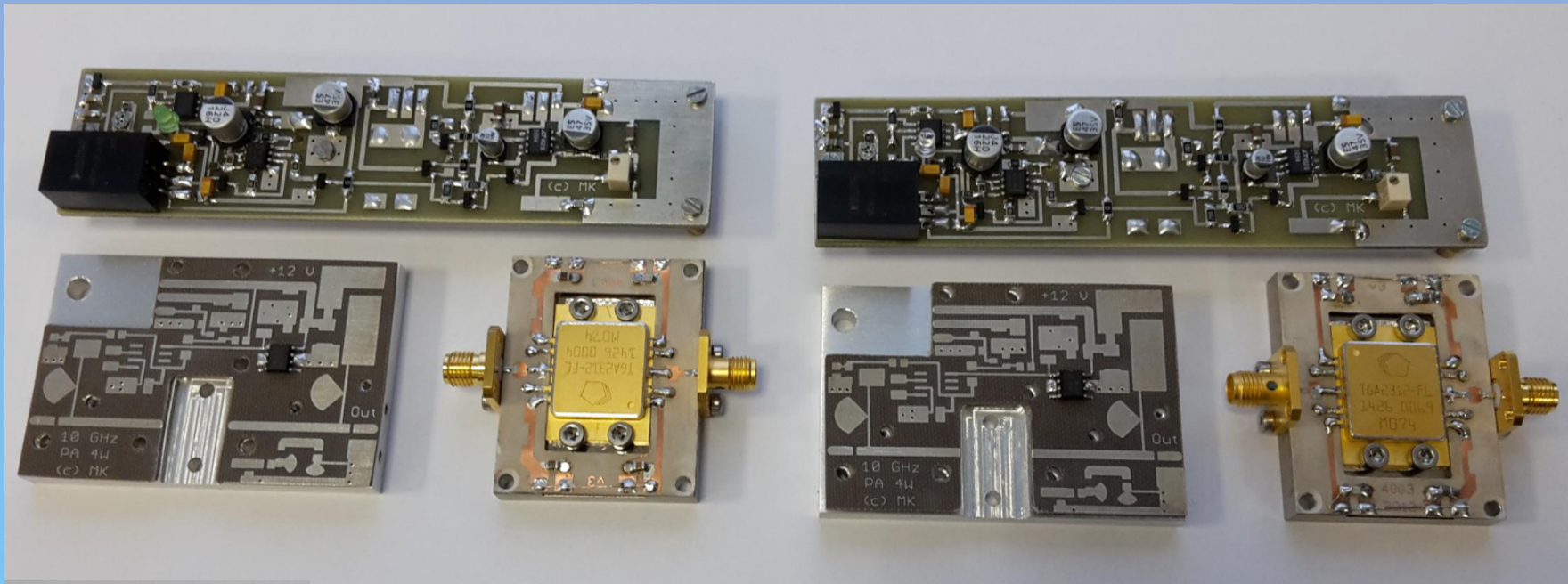
OK2AQ design







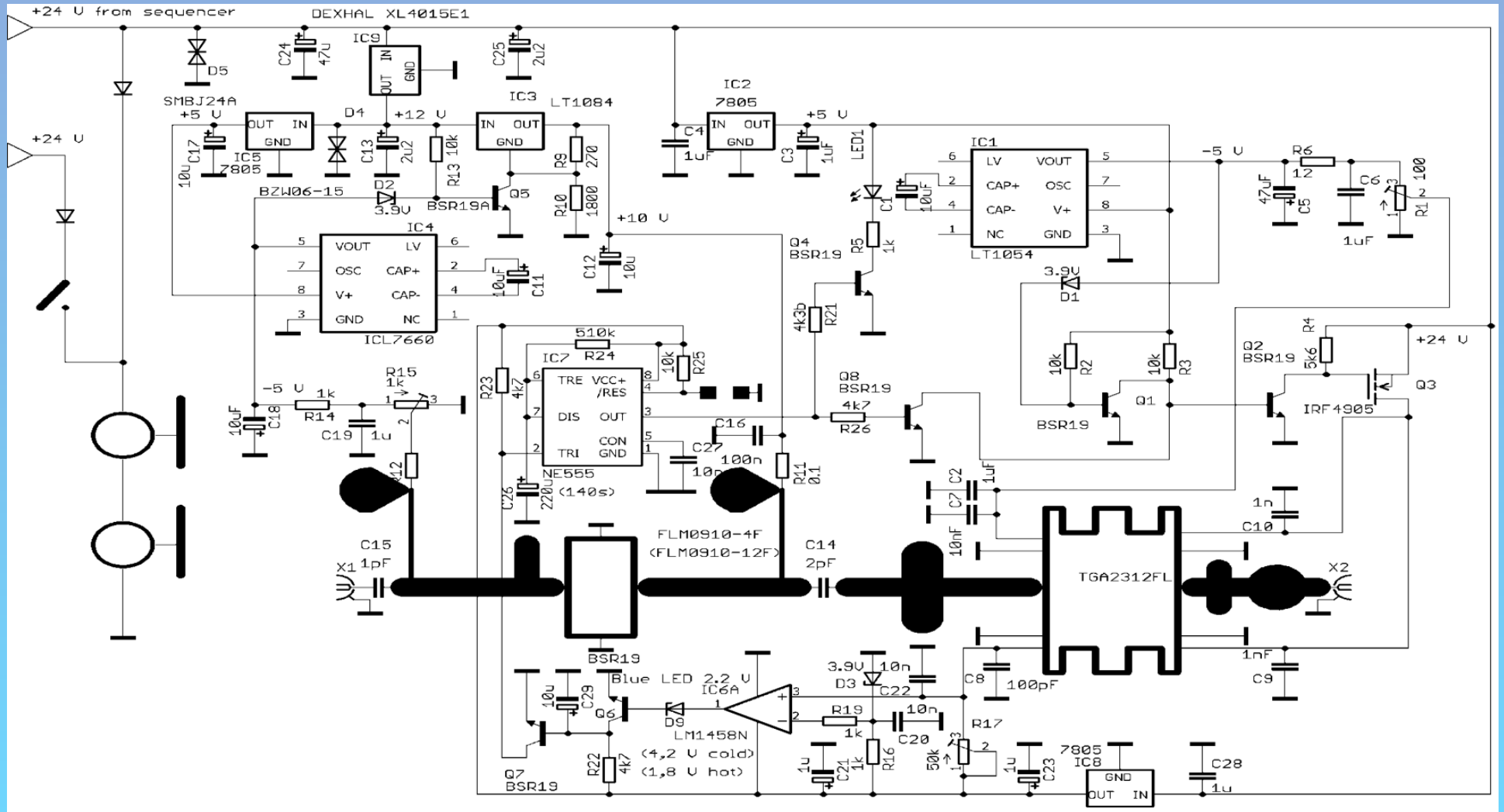
EME a MW seminář, Tři Studně, Březen 24-26, 2017



OK2AQ design

- - Including driver amplifier with TIM-0910-4 and/or TIM-0910-12
- - Thermistor output of the TGA2312-FL is used to measure base plate temperature and to shut off PA when temperature is too high (starting a timer with auto recovery after 2 minutes
- Protection system when gate voltage fails
- Build in step down DC/DC supply to supply TIM-0910-x from the same power supply

Schematic



Amplifier data with 8 watt driver

Amplifier C (8 W)

Gen	Inp	Inp	Measur		Input	Output	Output	Drain	Total	
Level	Level	Level	Level	Id	Power	Power	Power	Efficienc	Efficienc	Gain
[dBm]	[dBm]	[W]	[dBm]	[A]	[W]	[dBm]	[W]	[%]	[%]	[dB]
-14	19.10	0.081	6.20	1.90	45.6	36.80	4.79	10	6	17.7
-13	20.10	0.102	7.20	1.90	45.6	37.80	6.03	13	7	17.7
-12	21.15	0.130	8.20	2.00	48.0	38.80	7.59	16	9	17.7
-11	22.15	0.164	9.00	2.20	52.8	39.60	9.12	17	10	17.5
-10	23.20	0.209	10.10	2.40	57.6	40.70	11.75	20	13	17.5
-9	24.20	0.263	10.90	2.60	62.4	41.50	14.13	23	14	17.3
-8	25.20	0.331	11.80	2.80	67.2	42.40	17.38	26	17	17.2
-7	26.20	0.417	12.70	3.10	74.4	43.30	21.38	29	19	17.1
-6	27.20	0.525	13.50	3.30	79.2	44.10	25.70	32	22	16.9
-5	28.30	0.676	14.40	3.60	86.4	45.00	31.62	37	26	16.7
-4	29.40	0.871	15.10	4.00	96.0	45.70	37.15	39	28	16.3
-3	30.50	1.122	15.70	4.30	103.2	46.30	42.66	41	31	15.8
-2	31.60	1.445	16.00	4.50	108.0	46.60	45.71	42	32	15.0
-1	32.70	1.862	16.30	4.80	115.2	46.90	48.98	43	32	14.2
0	33.80	2.399	16.60	4.99	119.8	47.20	52.48	44	34	13.4

Thanks you for your attention !

- Questions ?