50 W SSPA 10 GHz

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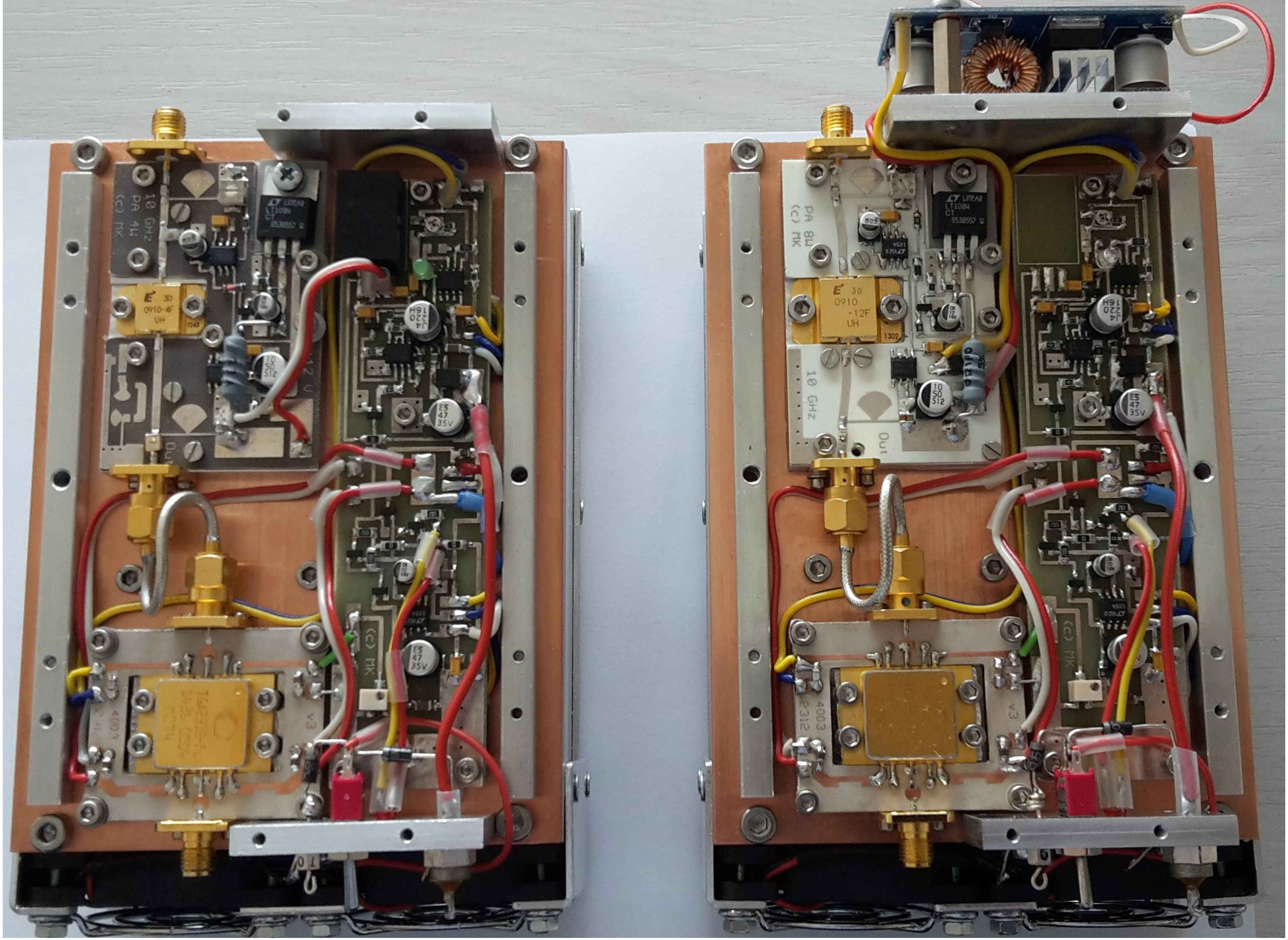
http://www.urel.feec.vutbr.cz/esl/files/EME/EME.htm

Gajów, June 9-11, 2017



Gajów, June 9-11, 2017

Outline

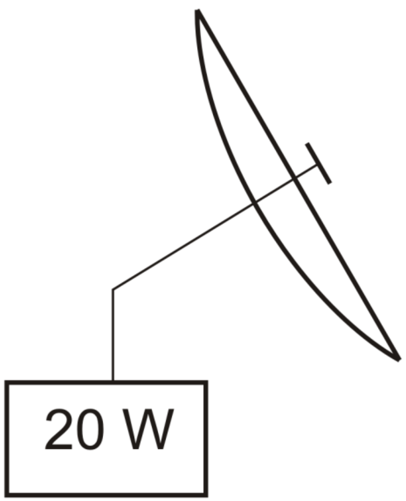
1. Why such high power? And why SSPA ?
2. New technology
3. TGA 2312FL and similar MMIC
4. Construction of the PA end stage
5. Driver
6. Supply and control circuits

OK2AQ

d1 = 1,8 m
A1 = 2,5 m^2
G1 = 43,6 dBi
EiRP1 = 56,6 dBi(W)
= 457 kW

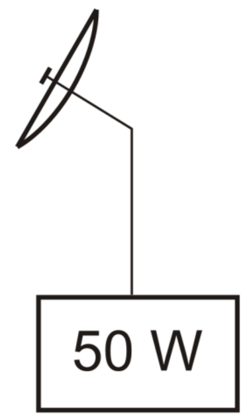
VK7MO

d2 = 0,77 m
A2 = 0,5 m^2
G2 = 36,2 dBi
EiRP2 = 53,2 dBi(W)
= 209 kW



$$S2/N = \frac{P_2 G_2 L_0 G_1}{k T_s B_n}$$

$$S1/N = \frac{P_1 G_1 L_0 G_2}{k T_s B_n}$$



S2/N

$$\frac{S_2}{S_1} = \frac{P_2}{P_1} => 10\log\frac{50}{20} = 4\text{ dB}$$

S1/N = S2/N - 4 dB

GaAs FET – 12 V, X A

$\eta \sim 25\%$

SSPA

GaN FET – 24 V, <X/2 A

$\eta \sim 40\%$

Higher gain,

Better thermal stability,

MMIC

TWT

High voltage in outdoor environment

TriQuint SEMICONDUCTOR

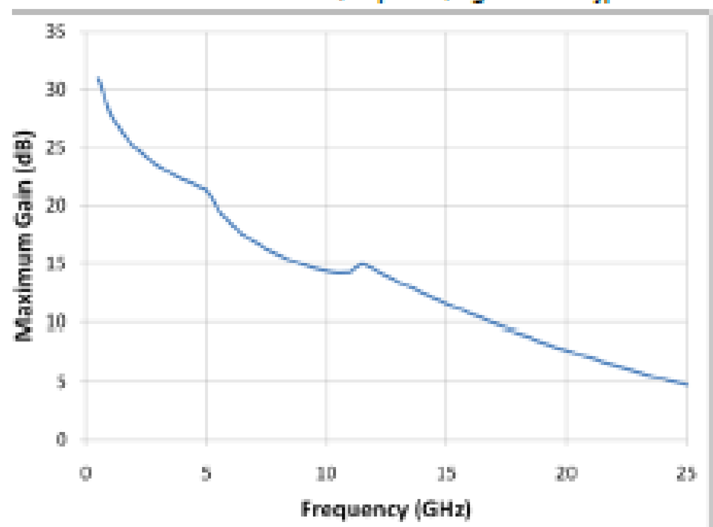
TGF2023-20

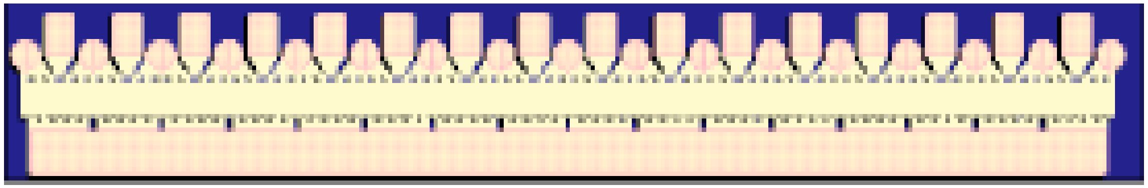
90 Watt Discrete Power GaN on SiC HEMT

Key Features

- Frequency Range: DC - 18 GHz
- 49.6 dBm Nominal Psat at 3 GHz
- 52% Maximum PAE
- 17.5 dB Nominal Power Gain
- Bias: Vd = 28 - 32 V, Idq = 2 A, Vg = -3.6 V Typical
- Technology: 0.25 um Power GaN on SiC
- Chip Dimensions: 0.82 x 4.56 x 0.10 mm

Bias conditions: Vd = 28 V, Idq = 2 A, Vg = -3.6 V Typical



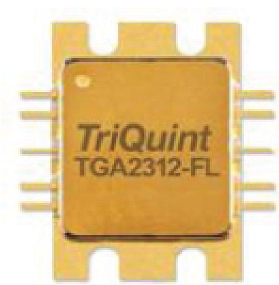


Now TriQuint + RFMD = Qorvo

Frequency (GHz)	Power (dBm)	Gain (dB)	NF (dB)	PAE (%)	Voltage (V)	IQ (mA)
8 to 11	43.5	25	-	>25	14	3,600

Product Features

- Frequency range: 8 - 11 GHz
- Saturated output power: 43.5 dBm
- Small signal gain: 25 dB
- Bias: Vd = 14 V, Idq = 3.6 A, Vg = -0.6 V typical



Zvětšit obrázek

Č. části Mouser:	772-TGA2312-FL
Číslo části výrobce:	TGA2312-FL
Výrobce:	TriQuint Semiconductor
Popis:	VF zesilovač 9-10GHz Gain 13dB PAE 38% GaN 60W

Další informace o TriQuint Semiconductor TGA2312-FL

Technické informace

Obrázky jsou pouze pro referenční účely
Viz specifikace produktu

Přidat do seznamu pro srovnání

Share | g+1 0 G+1 0

Specifikace | **Dokumenty (1)** | **Mé poznámky**

Výrobce:	TriQuint	✔

Dostupnost v reálném čase

Na skladě:	0
Na objednávce:	0
Dodací lhůta výrobce	16 týdny/týdnů

Zadejte množství:

Koupit

Minimum: 1
Vícenásobné: 1

Stanovení ceny (EUR)

1: 871,50 €
25: Nabídka

Chcete-li doplnit projekt, prosím Přihlásit se.

EAR Pro vývoz ze Spojených států může být u tohoto zboží vyžadována další dokumentace.

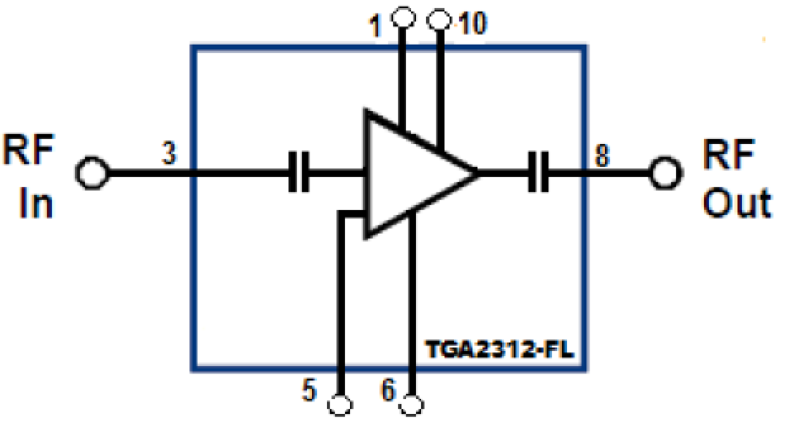
Stanovení ceny (CZK)

1: 30 674,70 Kč

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



Electrical Specifications

Test conditions unless otherwise noted: 25 °C, V_D = 24 V, I_{DQ} = 2400 mA , Pulsed: PW = 100us, DC = 10%, V_G = -2.6 V

Parameter	Min	Typical	Max	Units
Operational Frequency Range	9		10	GHz
Small Signal Gain		13		dB
Input Return Loss		15		dB
Output Return Loss		14		dB
Output Power at Saturation (Pin = 38dBm)		48		dBm
Power-Added Efficiency (Pin = 38dBm)		38		%
Output TOI		49		dBm
Gain Temperature Coefficient		-0.02		dB/°C
Power Temperature Coefficient		-0.001		dBm/°C
TOI Temperature Coefficient		-0.001		dBm/°C

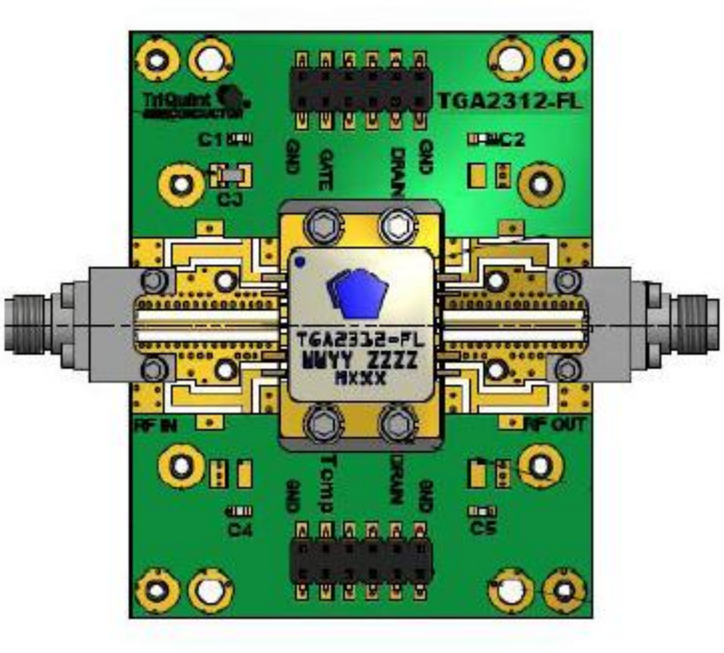
ACKNOWLEDGEMENT

THANKS to Dominique HB9BBD and Eddy ON7UN for help with TGA2312FL provision

THANKS to Charlie G3WDG for help and support with TGA2312FL bearing and PCB

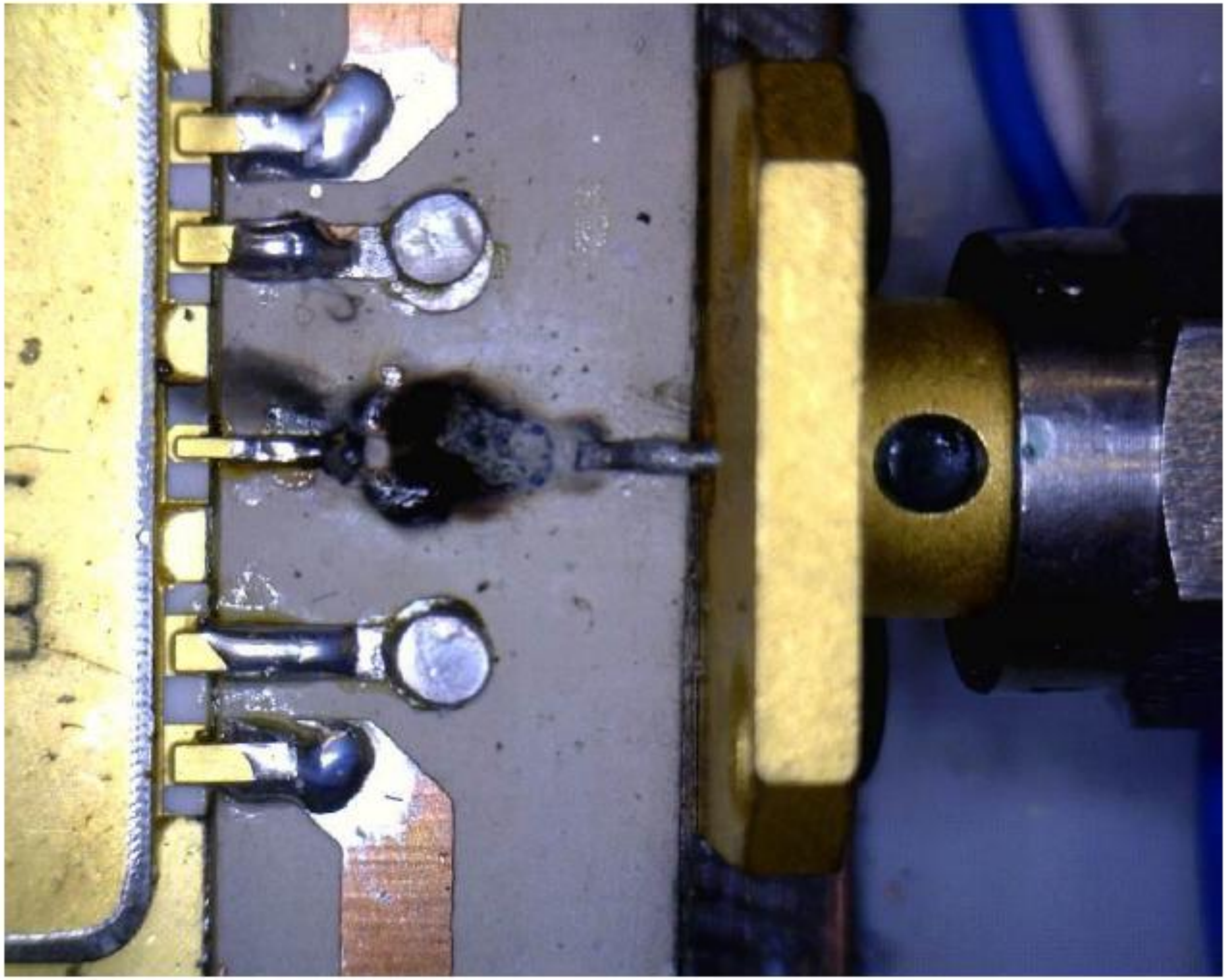
Substrate

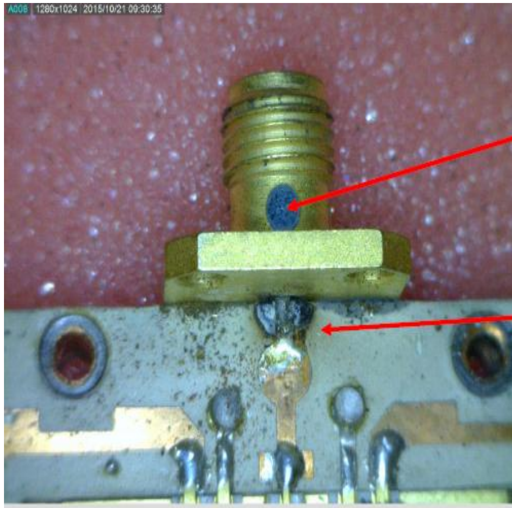
Top dielectric material is RO4350 0.020 inch thickness with 0.5 oz. copper.



With 4003 20 mil predicted rise above ambient is 71 C and on **6035HTC** it is only 25 C

0.635mm Rogers 3210



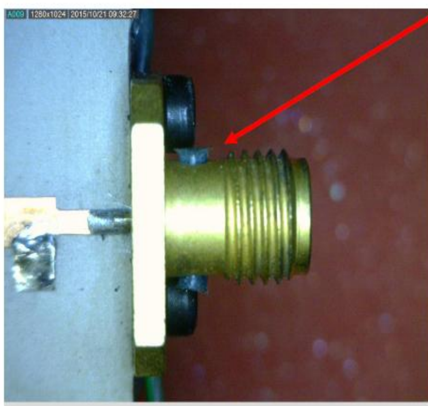


Epoxy plug is coming out of its hole

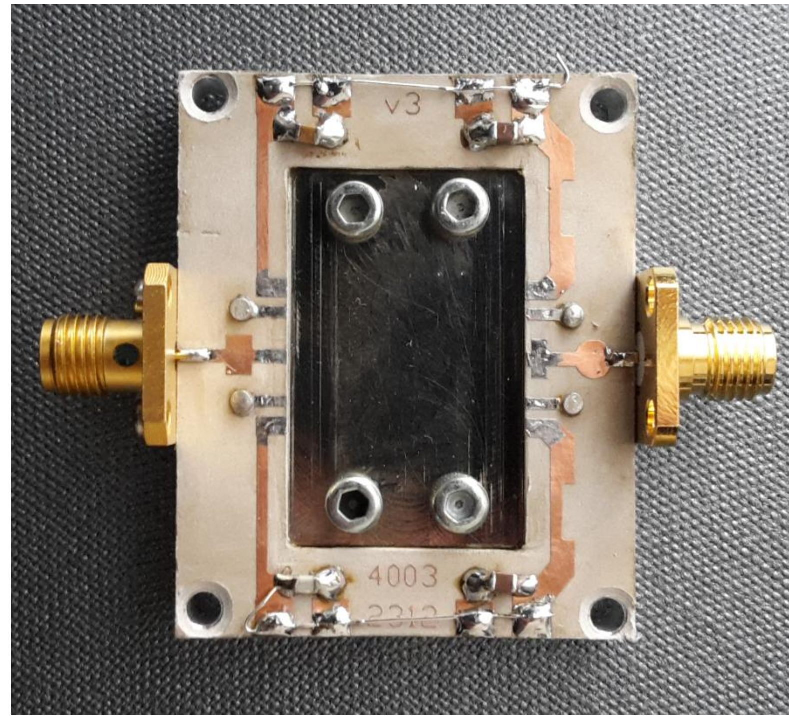
Solder joint has probably melted due to pin overheating leading to catastrophic failure

Epoxy plug movement

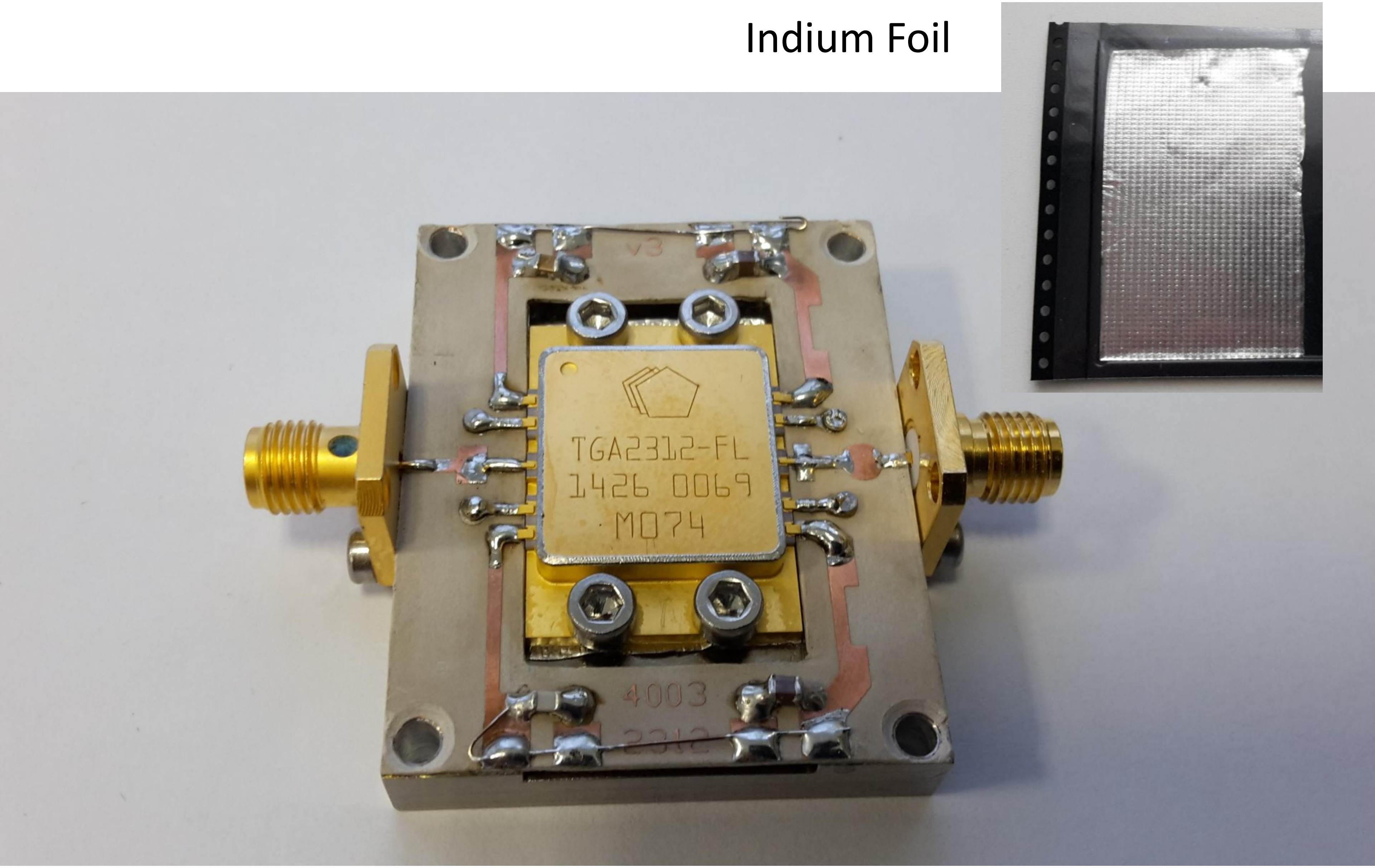
Epoxy plugs coming out

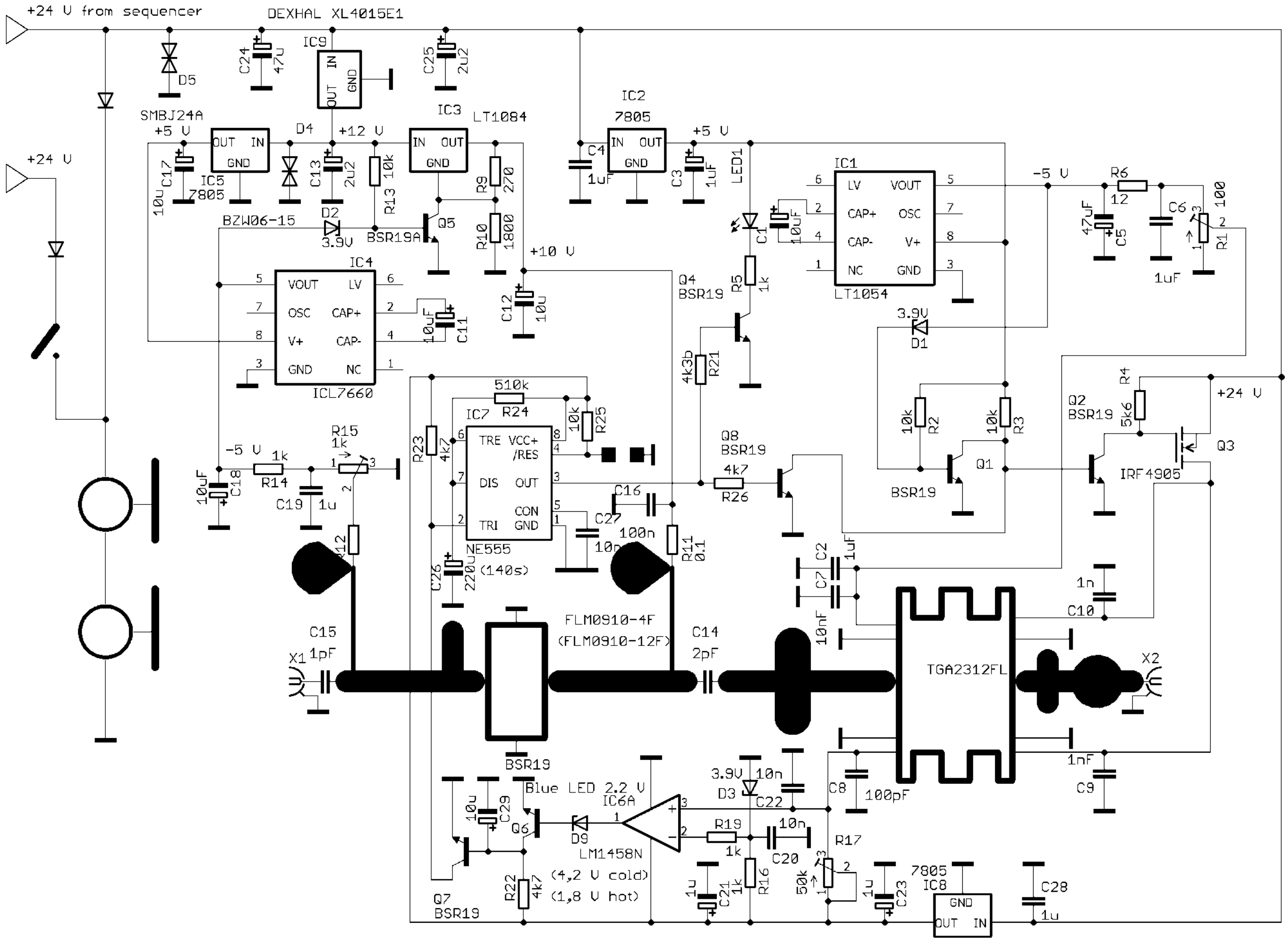


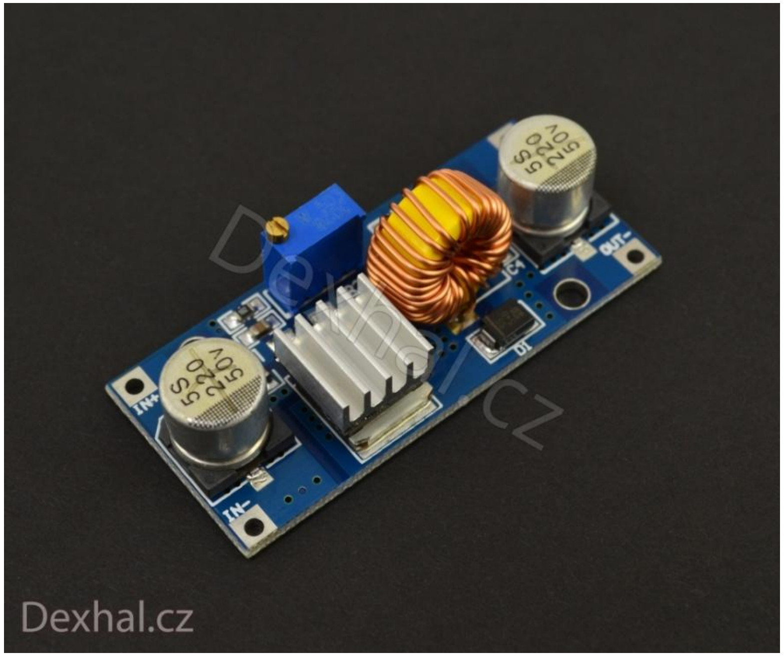
This has been seen on a number of Gigalane connectors now, on several different amplifiers with output powers of 50-90W at 10GHz. Usually both plugs are similarly affected. Hot smells have also been observed with the connector under power. Connectors also run hot to the touch.



Indium Foil

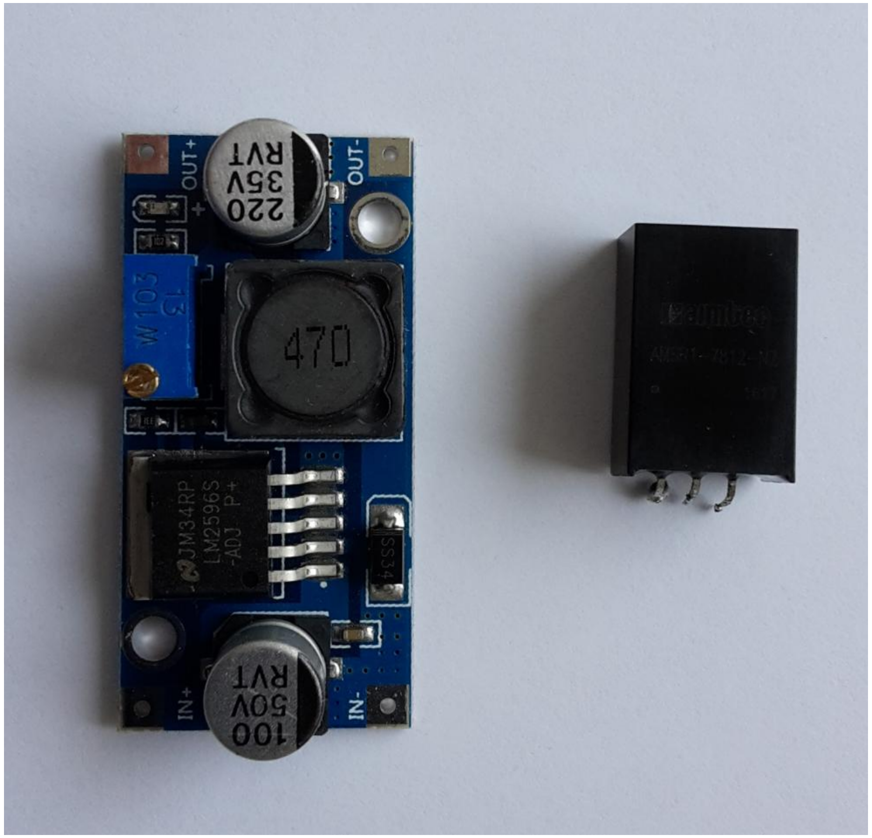



+24 V from sequencer
DEXHAL XL4015E1
IC9
IN
OUT
GND
C24
47u
C25
2u2
D5
SMBJ24A
+5 V
OUT IN
GND
IC5
7805
C17
10u
D4
+12 V
C13
2u2
R13
10k
IC3
LT1084
IN OUT
GND
R9
270
R10
1800
Q5
BSR19A
D2
3.9V
BZW06-15
+10 V
C12
10u
IC4
VOUT LV
OSC CAP+
V+ CAP-
GND NC
ICL7660
C11
10uF
IC2
7805
IN OUT
GND
C4
1uF
+5 V
C3
1uF
LED1
C1
10uF
R5
1k
Q4
BSR19
R21
4k3b
IC1
LV VOUT
CAP+ OSC
CAP- V+
NC GND
LT1054
-5 V
R6
12
C5
47uF
C6
1uF
R1
100
3.9V
D1
R2
10k
R3
10k
Q1
BSR19
R4
5k6
Q2
BSR19
+24 V
Q3
IRF4905
+24 V
-5 V
R14
1k
R15
1k
C18
10uF
C19
1u
R12
510k
R24
IC7
R23
4k7
TRE VCC+
/RES
DIS OUT
CON
TRI GND
NE555
(140s)
C26
220u
R25
10k
C16
100n
C27
10n
R11
0.1
Q8
BSR19
R26
4k7
C2
1uF
C7
10nF
C10
1n
FLM0910-4F
(FLM0910-12F)
C15
1pF
X1
C14
2pF
TGA2312FL
X2
BSR19
1nF
C9
C8
100pF
Blue LED 2.2 V
IC6A
LM1458N
(4,2 V cold)
(1,8 V hot)
D9
Q6
C29
10u
Q7
BSR19
R22
4k7
3.9V
D3
C22
10n
R19
1k
R16
1k
C20
10n
C21
1u
R17
50k
C23
1u
7805
IC8
GND
OUT IN
C28
1u

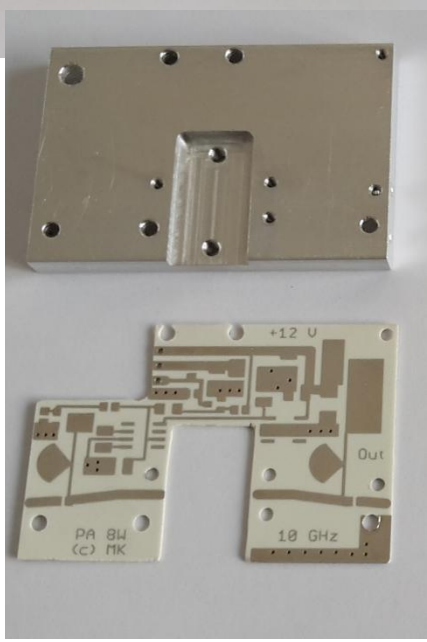


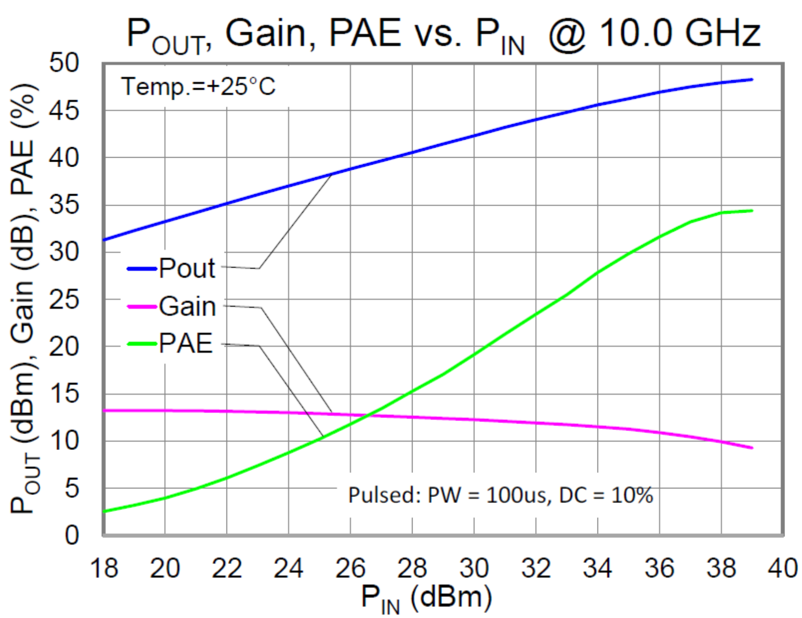
XL4015E1 – 5A

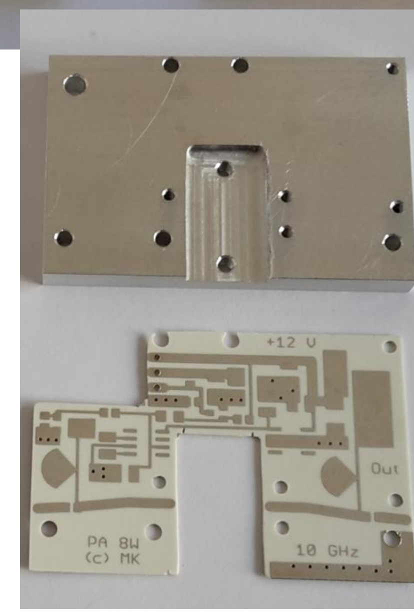
AMSR1-7812-NZ

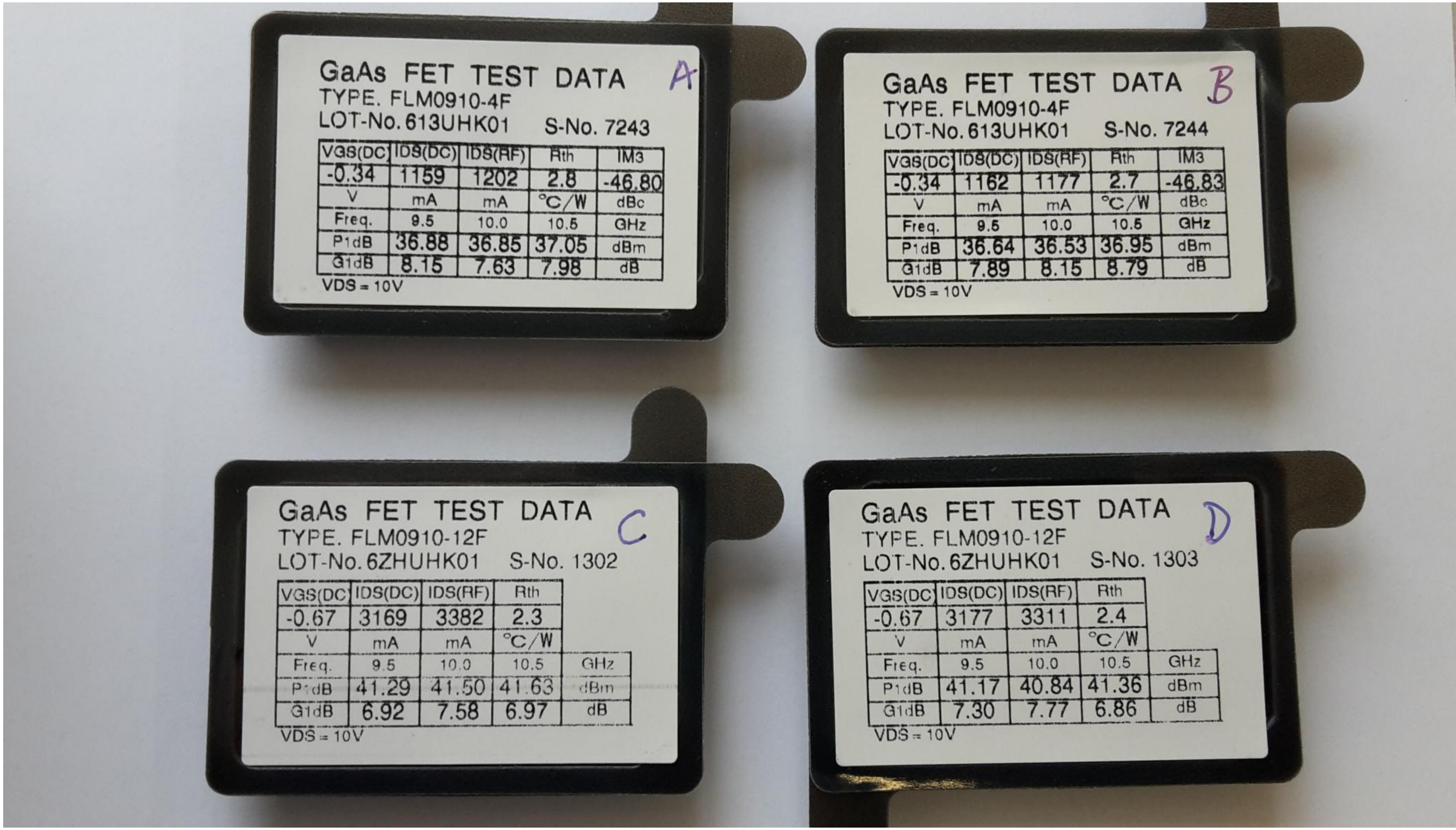



+12 V
Out
10 GHz
PA 4W
(c) MK
(c) MK

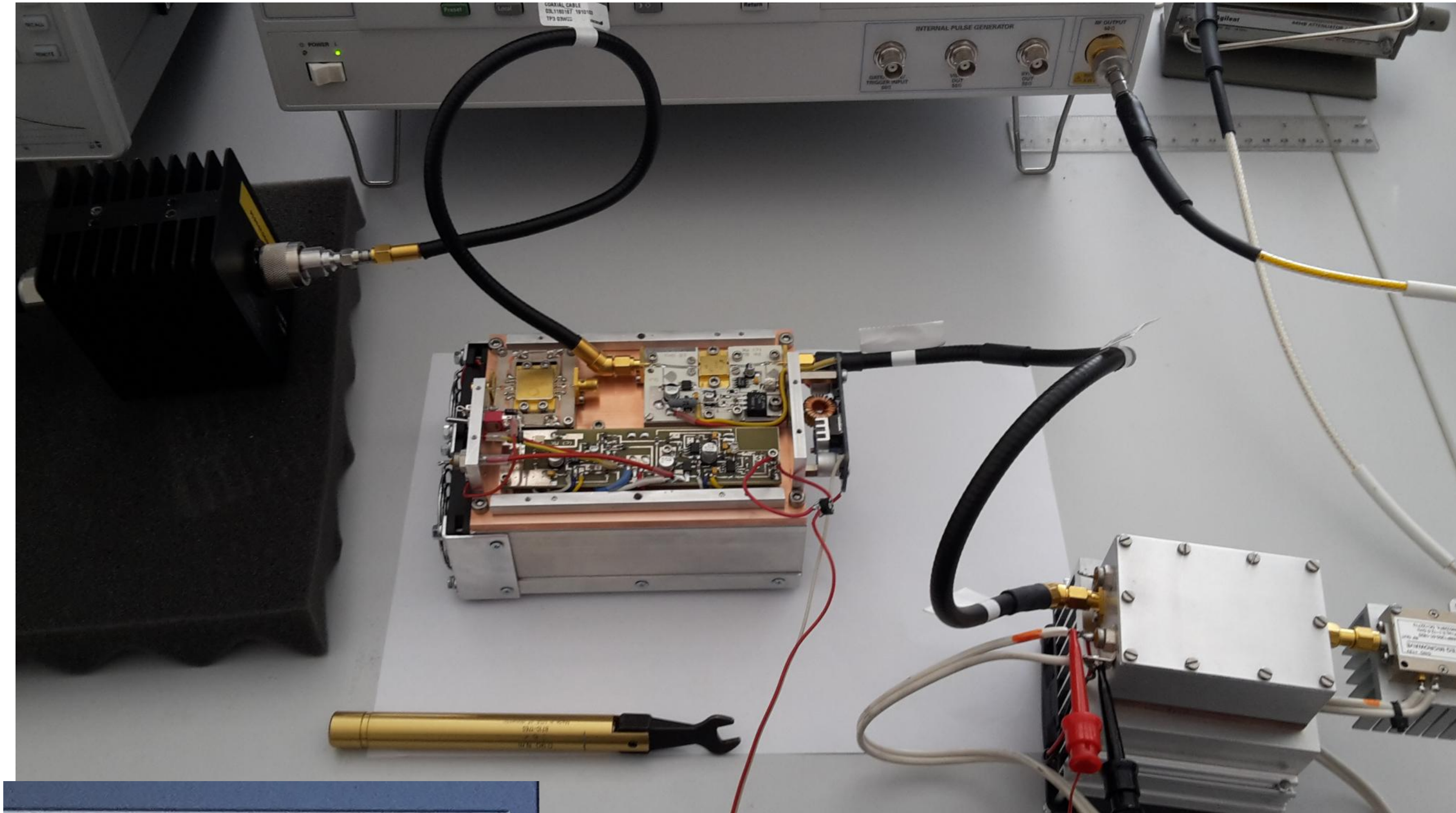

+12 V
Out
PA 8W
(c) MK
10 GHz

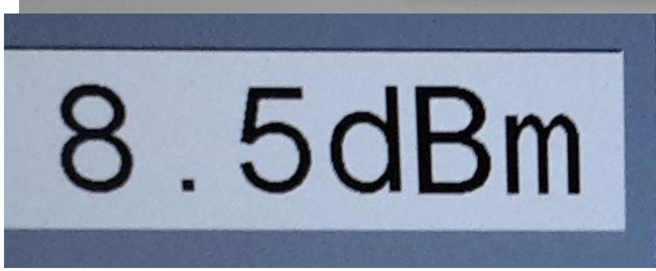

P_{OUT}, Gain, PAE vs. P_{IN} @ 10.0 GHz
Temp.=+25°C
Pout
Gain
PAE
Pulsed: PW = 100us, DC = 10%
P_{OUT} (dBm), Gain (dB), PAE (%)
P_{IN} (dBm)
0
5
10
15
20
25
30
35
40
45
50
18
20
22
24
26
28
30
32
34
36
38
40


+12 V
Out
PA 8W
(c) MK
10 GHz


GaAs FET TEST DATA
A
TYPE. FLM0910-4F
LOT-No. 613UHK01 S-No. 7243
VGS(DC) IDS(DC) IDS(RF) Rth IM3
-0.34 1159 1202 2.8 -46.80
V mA mA °C/W dBc
Freq. 9.5 10.0 10.5 GHz
P1dB 36.88 36.85 37.05 dBm
G1dB 8.15 7.63 7.98 dB
VDS = 10V
GaAs FET TEST DATA
B
TYPE. FLM0910-4F
LOT-No. 613UHK01 S-No. 7244
VGS(DC) IDS(DC) IDS(RF) Rth IM3
-0.34 1162 1177 2.7 -46.83
V mA mA °C/W dBc
Freq. 9.5 10.0 10.5 GHz
P1dB 36.64 36.53 36.95 dBm
G1dB 7.89 8.15 8.79 dB
VDS = 10V
GaAs FET TEST DATA
C
TYPE. FLM0910-12F
LOT-No. 6ZHUHK01 S-No. 1302
VGS(DC) IDS(DC) IDS(RF) Rth
-0.67 3169 3382 2.3
V mA mA °C/W
Freq. 9.5 10.0 10.5 GHz
P1dB 41.29 41.50 41.63 dBm
G1dB 6.92 7.58 6.97 dB
VDS = 10V
GaAs FET TEST DATA
D
TYPE. FLM0910-12F
LOT-No. 6ZHUHK01 S-No. 1303
VGS(DC) IDS(DC) IDS(RF) Rth
-0.67 3177 3311 2.4
V mA mA °C/W
Freq. 9.5 10.0 10.5 GHz
P1dB 41.17 40.84 41.36 dBm
G1dB 7.30 7.77 6.86 dB
VDS = 10V

8 W Driver





$$+30.6\,\text{dBm} = 39.1\,\text{dBm} \Rightarrow 8.1\,\text{W}$$

(Input 2 W, I_{dq}= 3A)

Power level measurement

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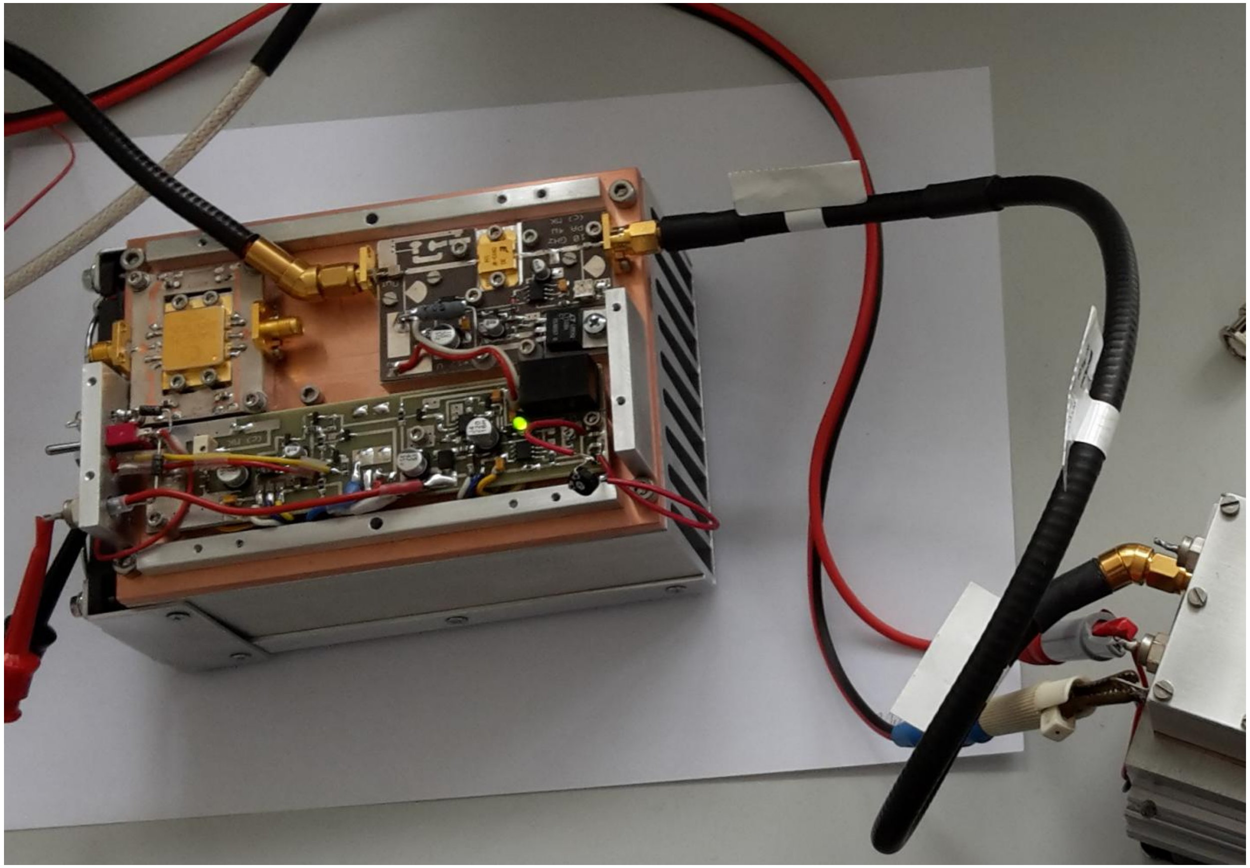
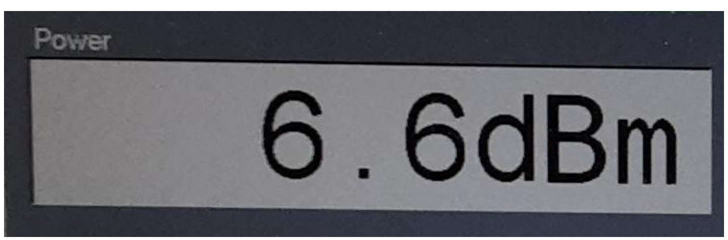
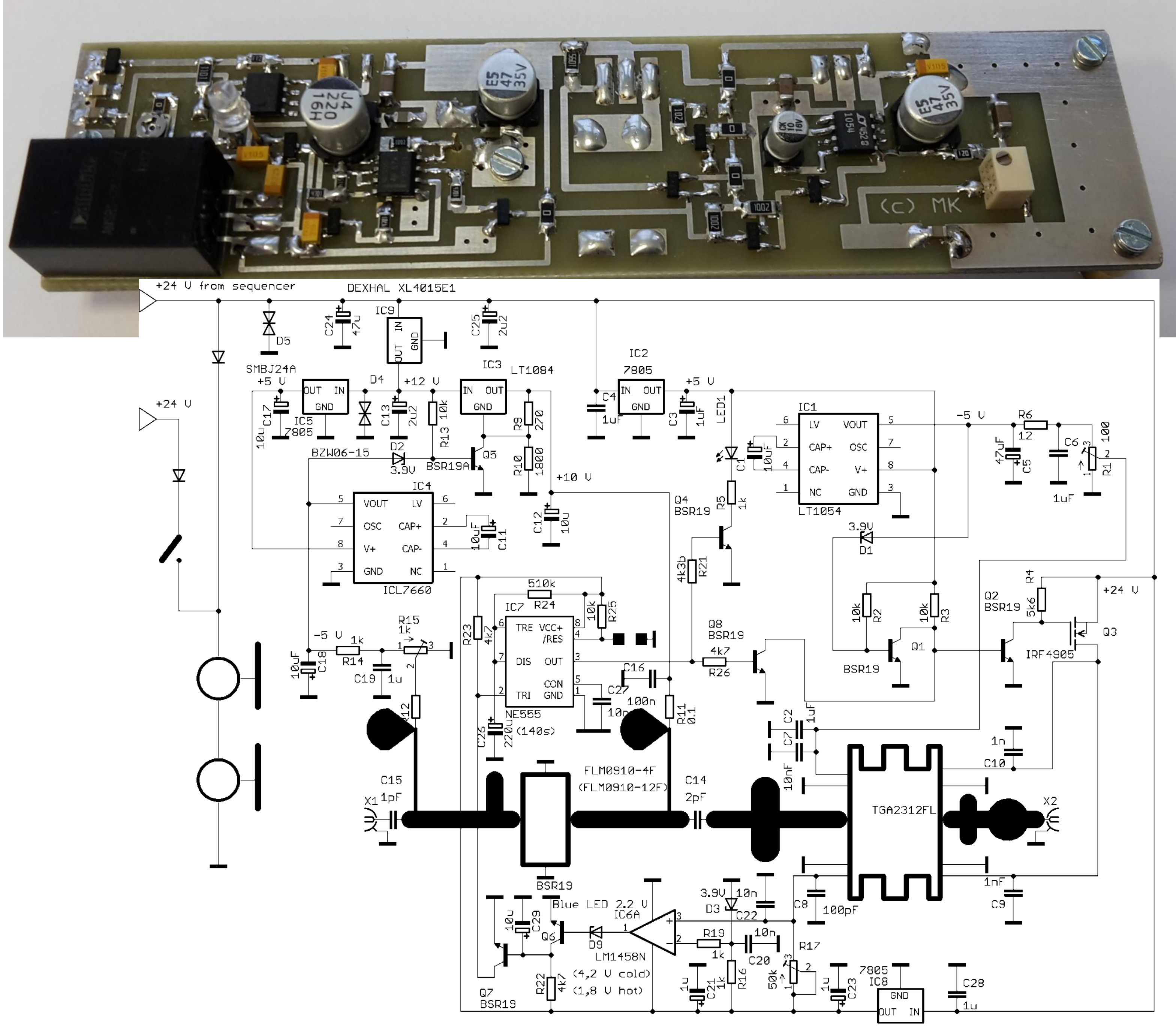


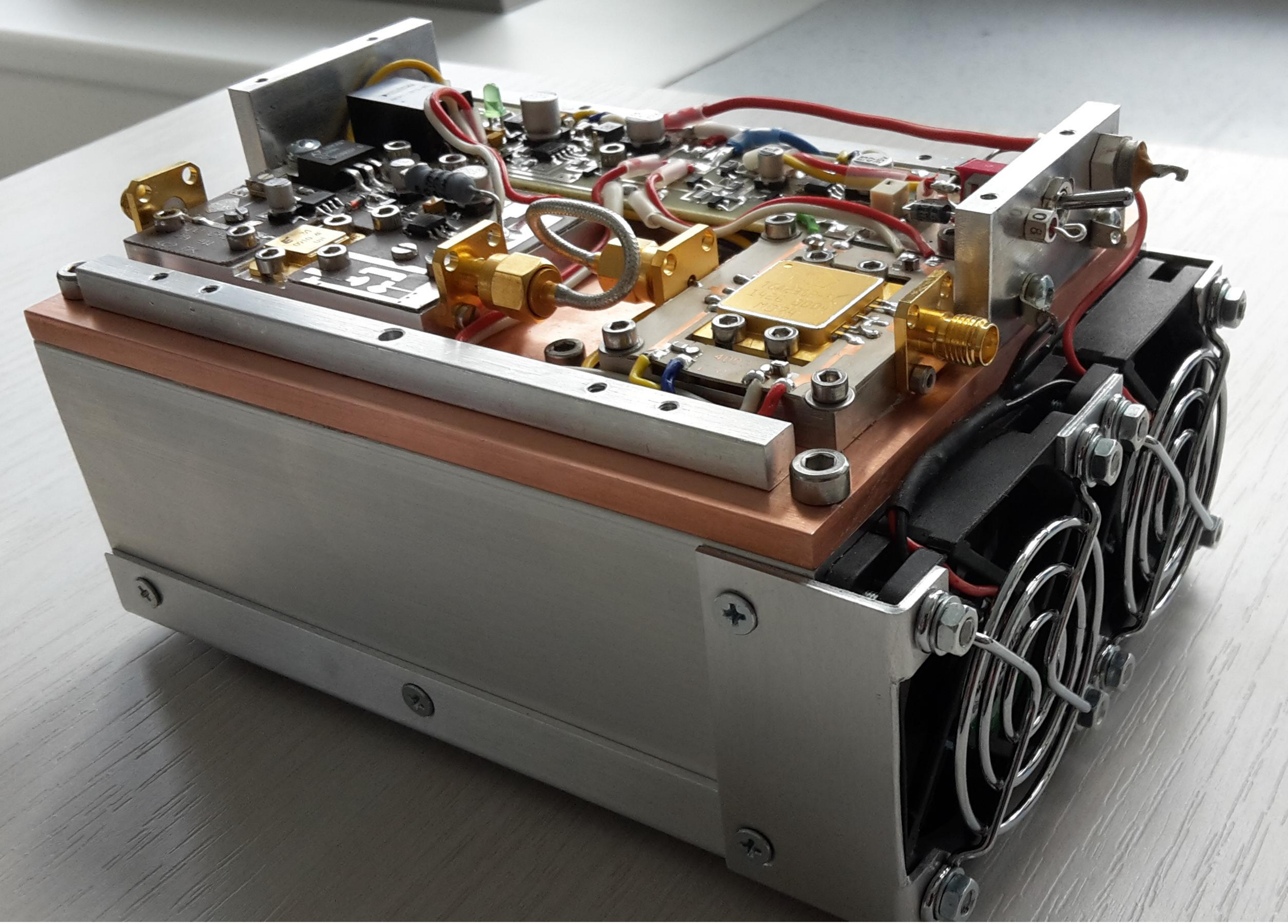


$$+30.6\,\mathrm{dBm} = 37.2\,\mathrm{dBm} \Rightarrow 5.2\,\mathrm{W}$$

(Input 1,4 W, I_{dq}= 1A)



(c) MK
+24 V from sequencer
DEXHAL XL4015E1
IC9
IN
OUT
GND
C24
47u
D5
SMBJ24A
C25
2u2
IC3
LT1084
+12 V
IC2
7805
+5 V
C4
1uF
C3
1uF
LED1
IC1
LV
VOUT
CAP+
OSC
CAP-
V+
NC
GND
LT1054
-5 V
R6
12
C6
1uF
C5
47uF
R1
100
+24 V
C17
10u
IC5
7805
D4
C13
2u2
R13
10k
R9
270
R10
1800
Q5
BSR19A
D2
3.9V
BZW06-15
IC4
ICL7660
C11
10uF
C12
10u
+10 V
Q4
BSR19
R5
1k
C1
10uF
3.9V
D1
R21
4k3b
R2
10k
R3
10k
Q1
BSR19
Q2
BSR19
R4
5k6
Q3
IRF4905
510k
R24
IC7
R25
10k
TRE
VCC+
/RES
DIS
OUT
CON
TRI
GND
NE555
(140s)
R23
4k7
C26
220u
C16
C27
100n
10n
R11
0.1
Q8
BSR19
4k7
R26
-5 V
1k
R14
R15
1k
C18
10uF
C19
1u
R12
C2
1uF
C7
10nF
1n
C10
FLM0910-4F
(FLM0910-12F)
C15
1pF
X1
C14
2pF
TGA2312FL
X2
BSR19
Blue LED 2.2 V
IC6A
LM1458N
(4,2 V cold)
(1,8 V hot)
D9
Q6
C29
10u
Q7
BSR19
R22
4k7
3.9V
D3
10n
C22
C8
100pF
1nF
C9
R19
1k
10n
C20
R17
50k
R16
1k
C21
1u
C23
1u
7805
IC8
GND
OUT
IN
C28
1u



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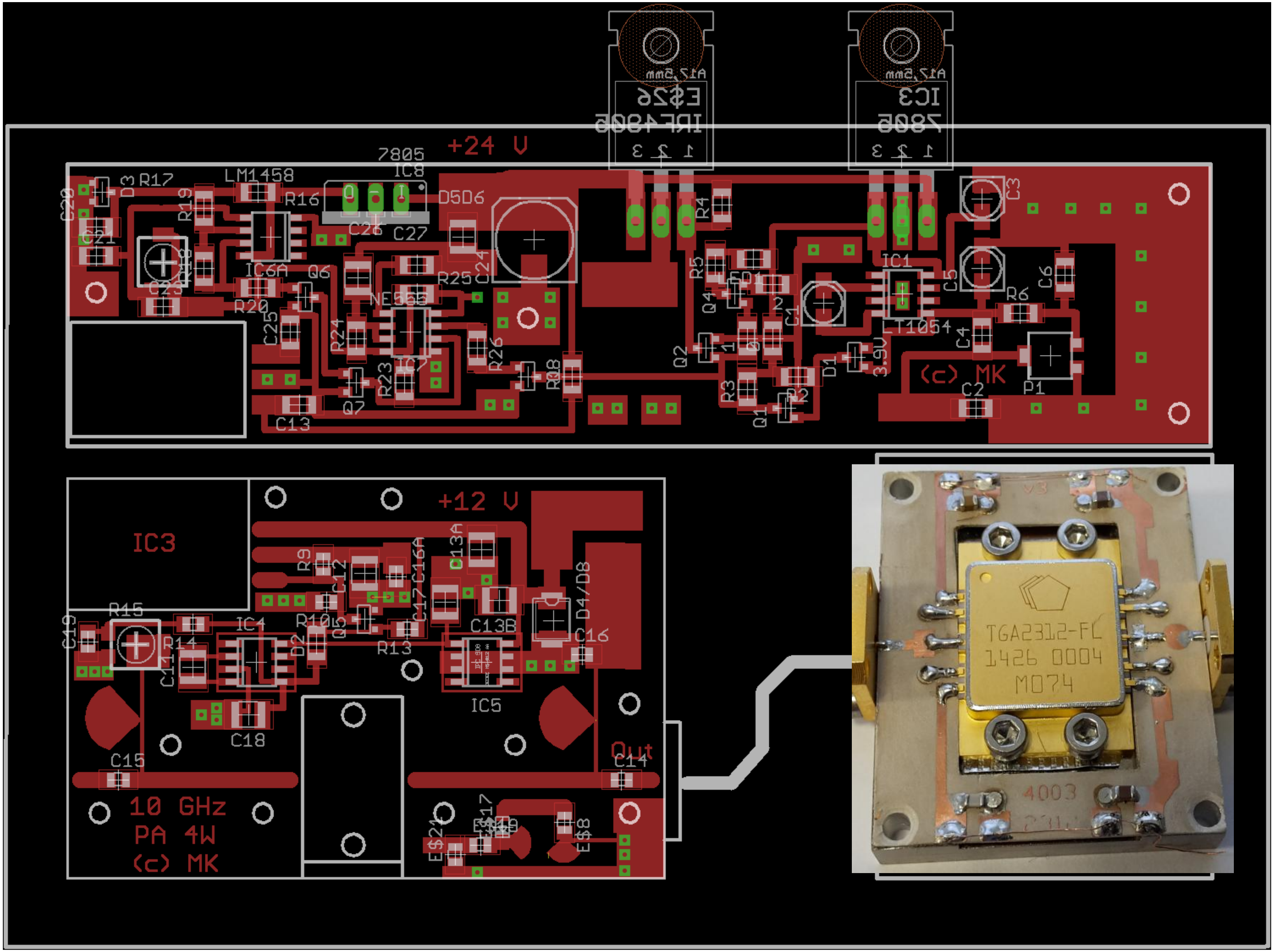
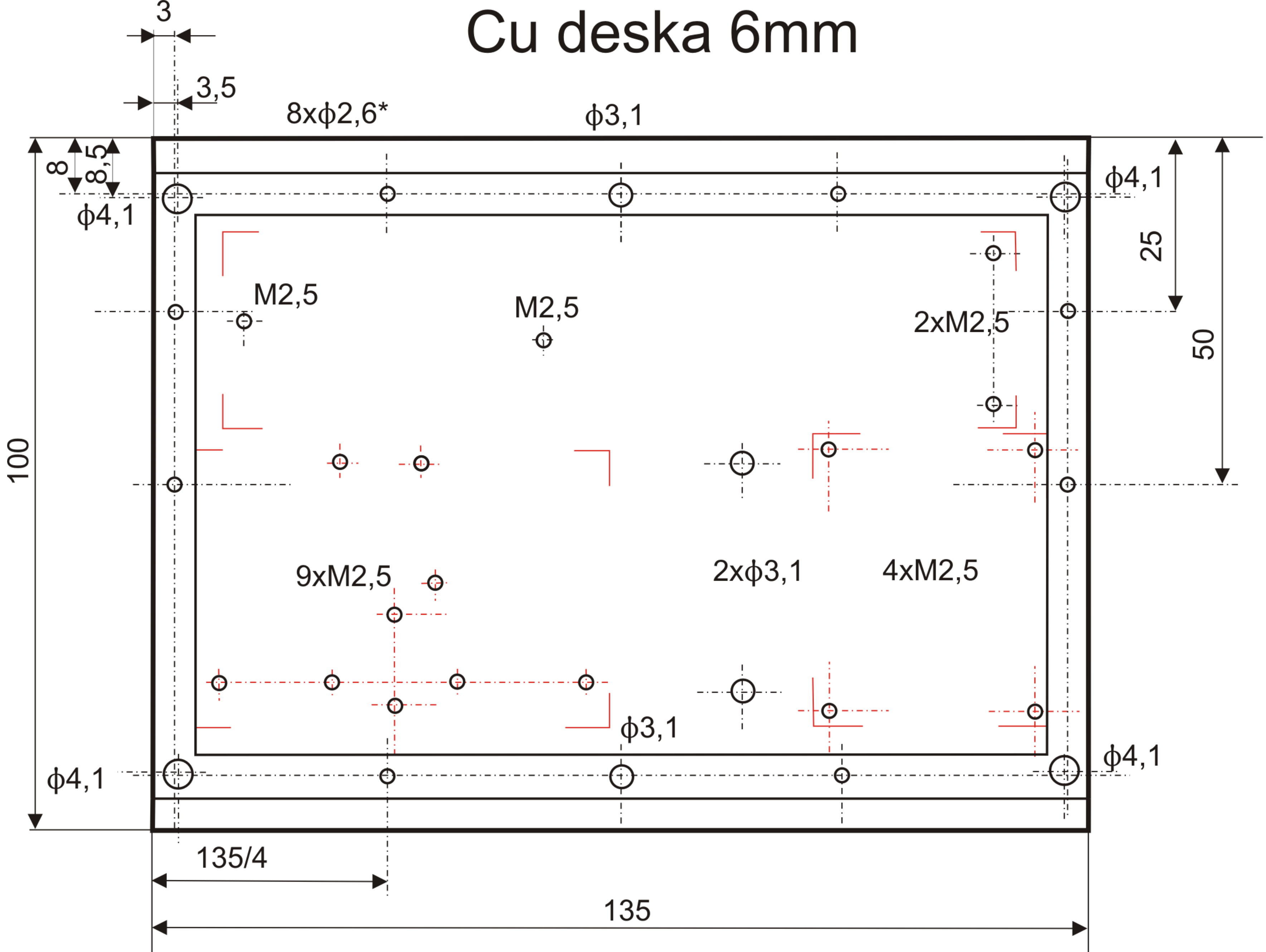

+24 V
7805
IC8
LM1458
NE555
LT1054
(c) MK
+12 V
IC3
IC4
IC5
Out
10 GHz
PA 4W
(c) MK
TGA2312-FL
1426 0004
M074

Cu deska 6mm



* ze spodní strany zapustit

PA cooling design

Thermal and Reliability Information

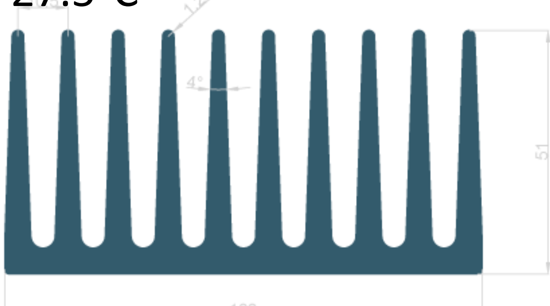
Parameter	Test Conditions	Value	Units
Thermal Resistance, θ_{JC} (Note 1)	Tbaseplate = 85 °C	0.85	°C/W
Channel Temperature, T_{CH} (Without RF Drive)	Tbaseplate = 85 °C, **V_D = 24 V**, I_{DQ} = 2400 mA, P_{DISS} = 58 W, Pulsed: PW = 100us, DC = 10%	135	°C
Median Lifetime, T_M (Without RF Drive)		9.75 x 10^10	Hrs
Channel Temperature, T_{CH} (Under RF Drive)	Tbaseplate = 85 °C, **V_D = 24 V**, $I_{D\ Drive}$ = 6360 mA, P_{OUT} = 48 dBm, P_{DISS} = 87 W, Pulsed: PW = 100us, DC = 10%	158	°C
Median Lifetime, T_M (Under RF Drive)		7.38 x 10^9	Hrs
Channel Temperature, T_{CH} (Under RF Drive)	Tbaseplate = 85 °C, **V_D = 30 V**, $I_{D\ Drive}$ = 6670 mA, P_{OUT} = 48.8 dBm, P_{DISS} = 124 W, Pulsed: PW = 100us, DC = 10%	190	°C
Median Lifetime, T_M (Under RF Drive)		3.12 x 10^8	Hrs

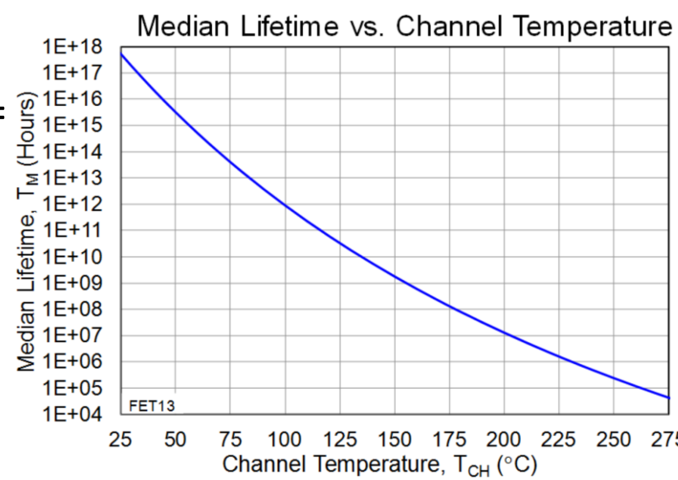
Notes: (1) Thermal resistance measured at back of the package.

For **DC = 100%** is Θ_{JC} is 2 times higher – it is **1.7°C/W**. Dissipated heat is 5A*24V + 8W – - 52W = 76W. T_{CH} = 50°C + 27.5°C + 76W *1.7°C/W = 207°C -> **lifetime** > 5E+06 hours

Θ_H = 1.4°C/W => 0.24°C/W (V)

ΔTH = (1.6A*24V+76W)*0.24 = = 27.5°C





Driver 8W (C)

For **DC = 50%** is Θ_{JC} = **1.7°C/W**. Dissipated heat is (5A*24V + 8W – 52W)/2 = 38W.
T_{CH} = 50°C +13.7°C + 38W *1.7°C/W = 129°C -> **lifetime > 1E+10 hodin**

Θ_H = 1.4°C/W => 0.24°C/W (V) ΔTH = 0.24°C/W*(1.6A*24V+76W)/2 = 13.7°C

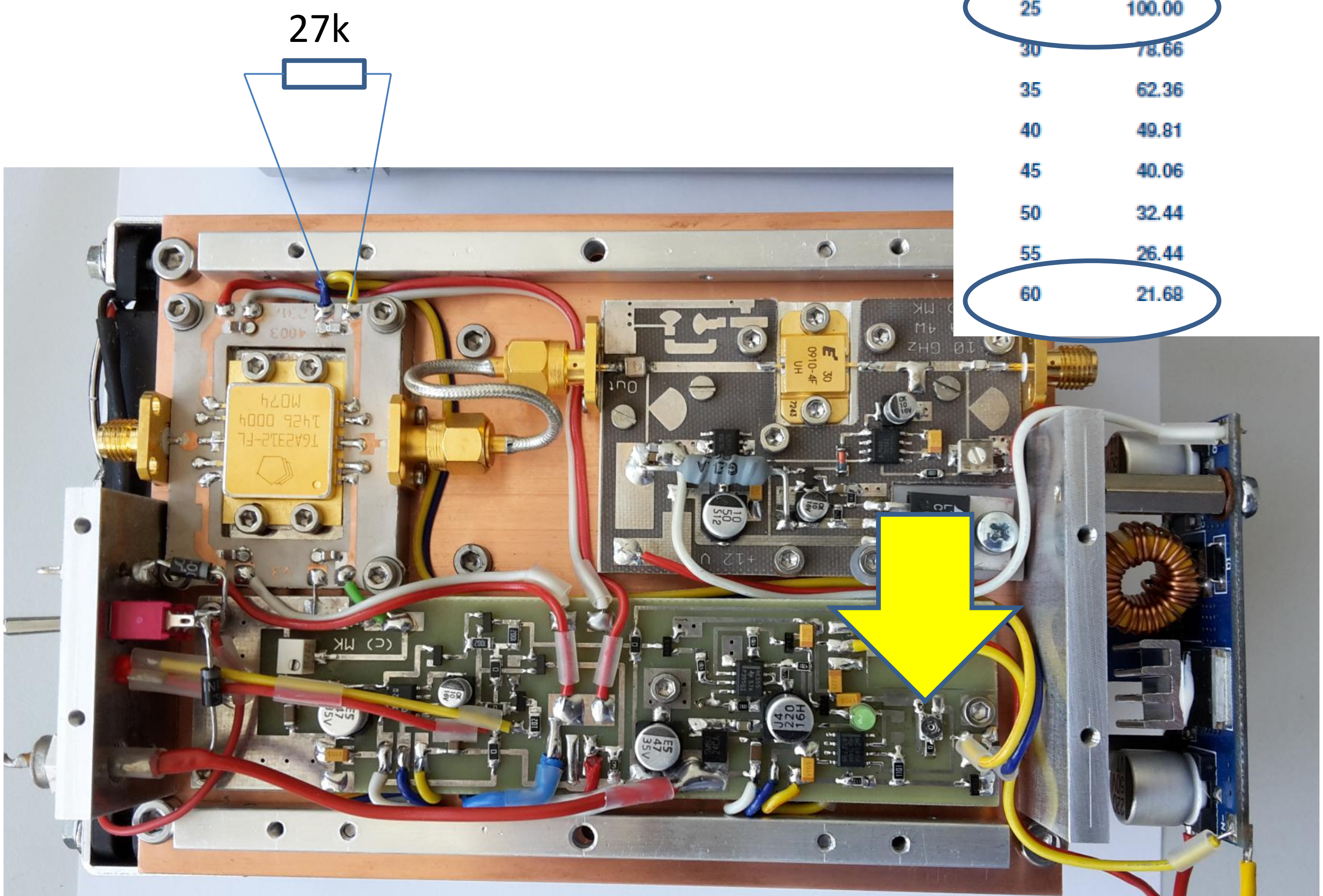
Driver 5W (A)

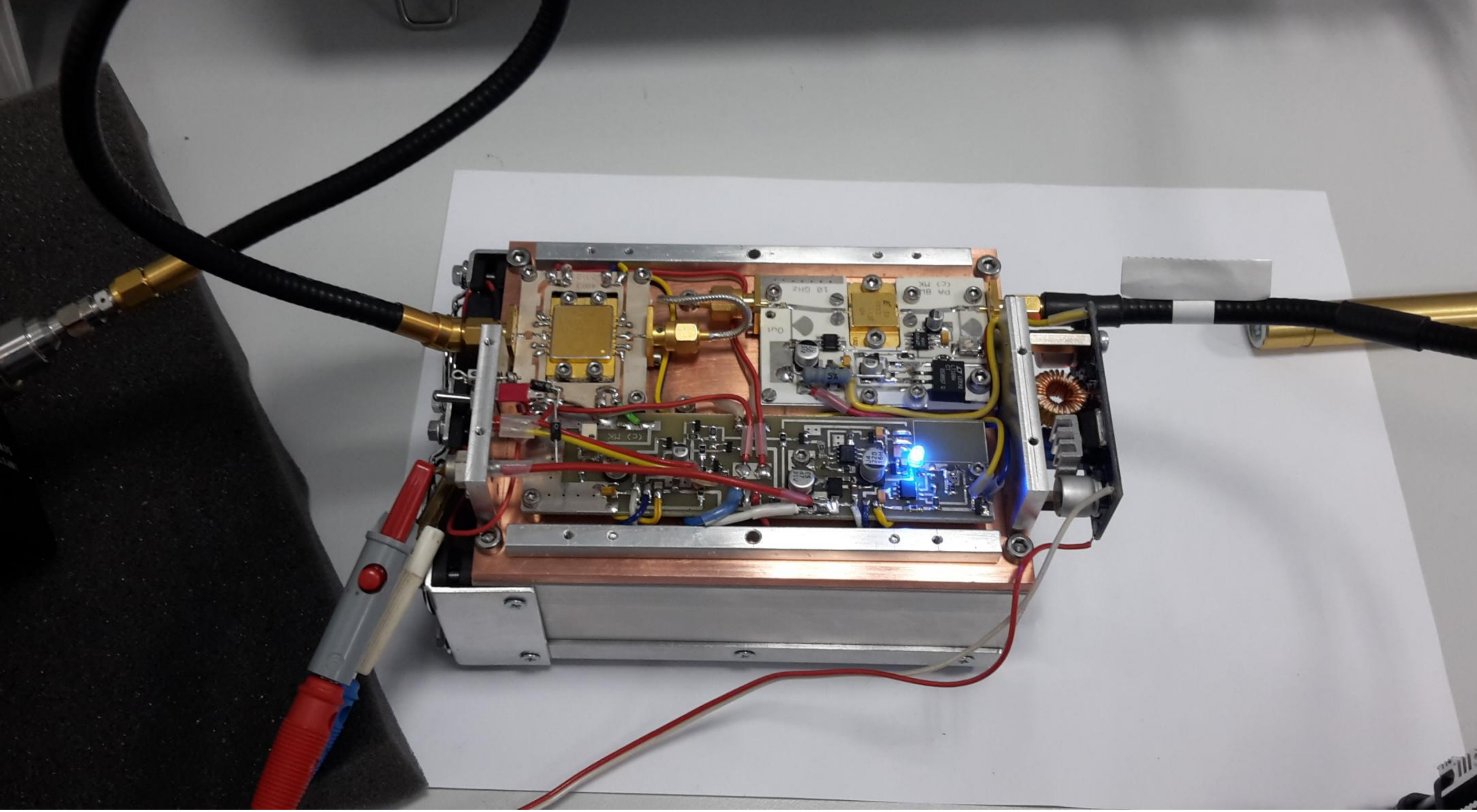
For **DC = 50%** is Θ_{JC} = **1.7°C/W**. Dissipated heat is (4.3A*24V + 5W – 42W) = 66W.
T_{CH} = 50°C +19.3°C + 66W *1.7°C/W = 182°C -> **lifetime > 5E+07 hodin**

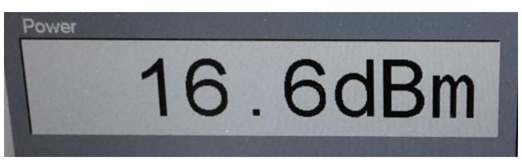
Θ_H = 1.4°C/W => 0.24°C/W (V) ΔTH = 0.24°C/W*(0.6A*24V+66W) = 19.3°C

Overheating protection adjustment

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







$$+30.6\,\text{dBm} = 47.2\,\text{dBm} \Rightarrow 52.5\,\text{W}$$

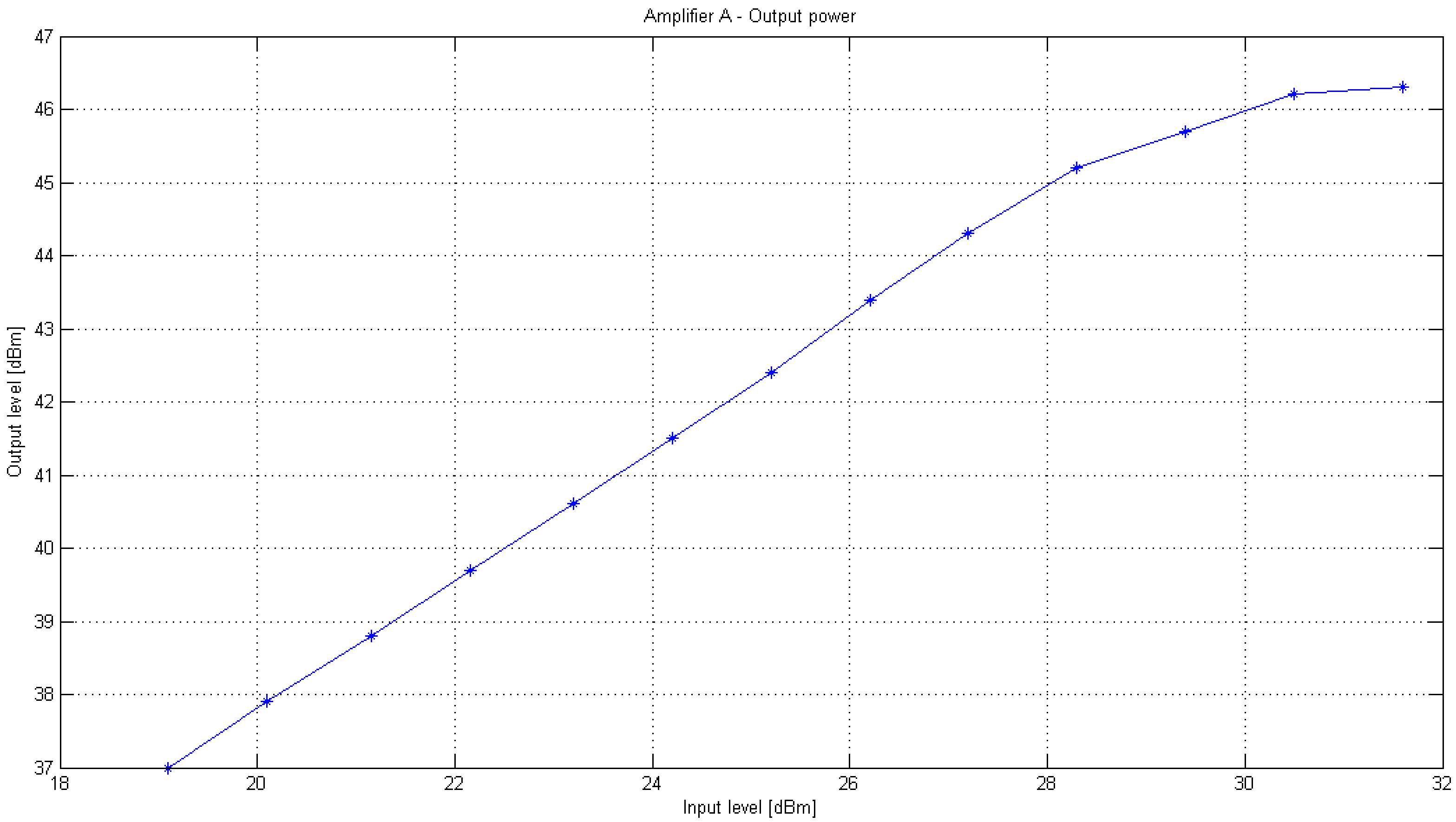
(Input 2 W, I_{dq}= 2.3A, I_d= 4.9A)

Amplifier A (5 W)

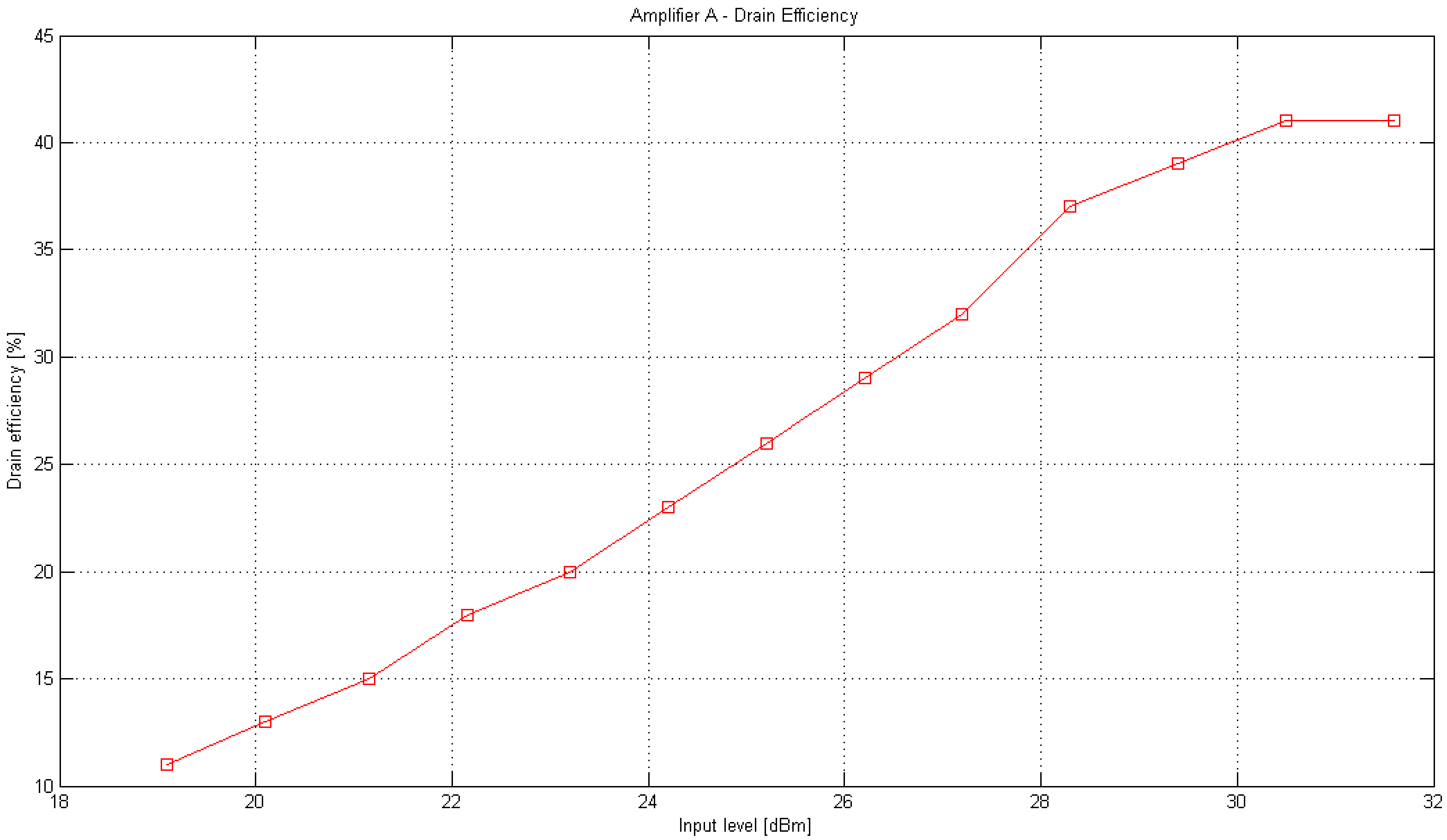
Gen Level [dBm]	Inp Level [dBm]	Inp Level [W]	Measur Level [dBm]	Id [A]	Input Power [W]	Output Power [dBm]	Output Power [W]	Drain Efficiency [%]	Total Efficiency [%]	Gain [dB]
-14	19.10	0.081	6.40	1.90	45.6	37.00	5.01	11	9	17.9
-13	20.10	0.102	7.30	2.00	48.0	37.90	6.17	13	10	17.8
-12	21.15	0.130	8.20	2.10	50.4	38.80	7.59	15	12	17.7
-11	22.15	0.164	9.10	2.20	52.8	39.70	9.33	18	14	17.6
-10	23.20	0.209	10.00	2.40	57.6	40.60	11.48	20	16	17.4
-9	24.20	0.263	10.90	2.60	62.4	41.50	14.13	23	19	17.3
-8	25.20	0.331	11.80	2.80	67.2	42.40	17.38	26	22	17.2
-7	26.20	0.417	12.80	3.10	74.4	43.40	21.88	29	25	17.2
-6	27.20	0.525	13.70	3.50	84.0	44.30	26.92	32	28	17.1
-5	28.30	0.676	14.60	3.70	88.8	45.20	33.11	37	33	16.9
-4	29.40	0.871	15.10	3.97	95.3	45.70	37.15	39	35	16.3
-3	30.50	1.122	15.60	4.24	101.8	46.20	41.69	41	37	15.7
-2	31.60	1.445	15.70	4.31	103.4	46.30	42.66	41	37	14.7
-1	32.70	1.862								
0	33.80	2.399								
1	34.70	2.951								
2	35.50	3.548								
3	36.30	4.266								
4	37.00	5.012								

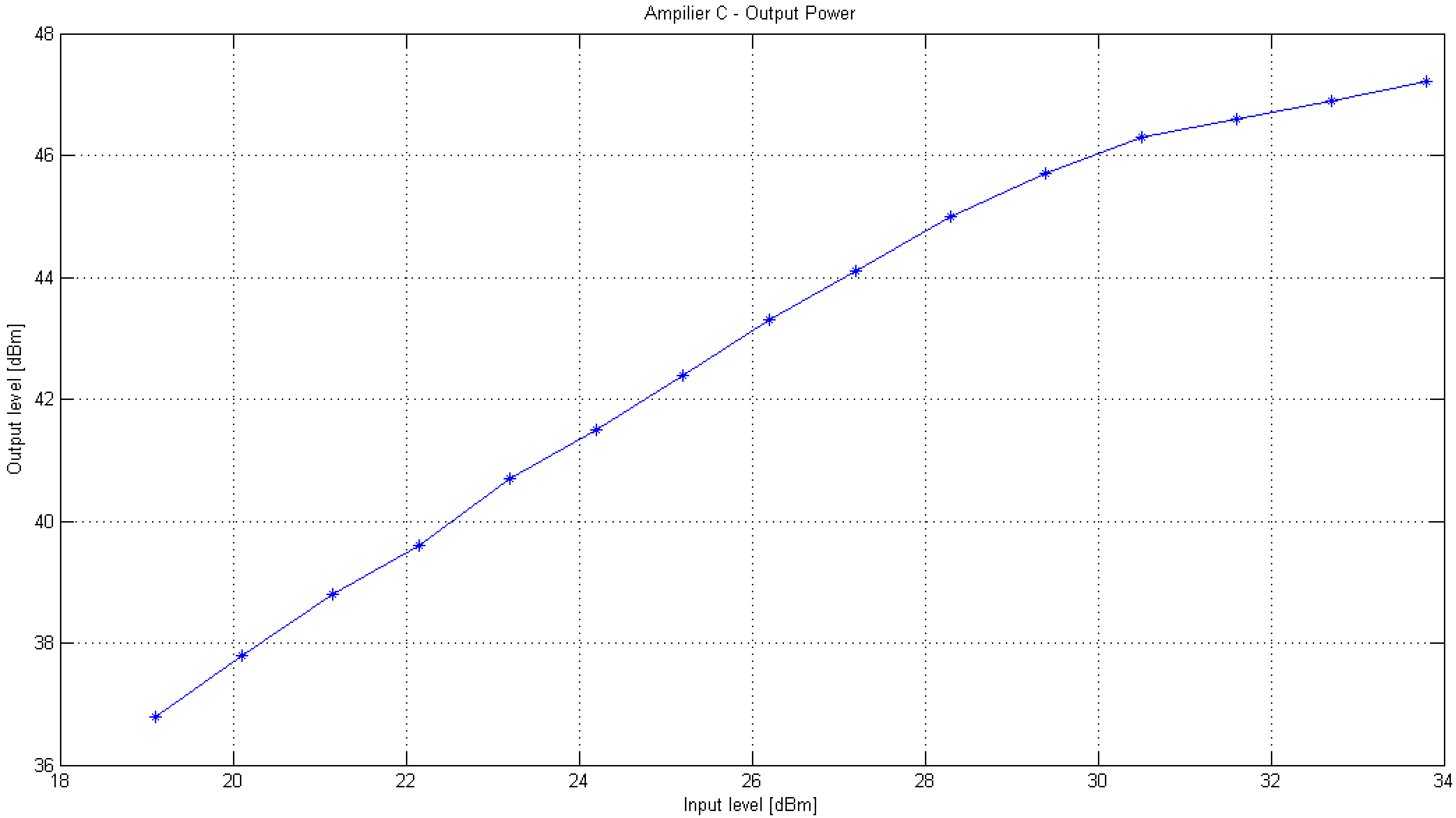
Amplifier C (8 W)

Gen Level [dBm]	Inp Level [dBm]	Inp Level [W]	Measur Level [dBm]	Id [A]	Input Power [W]	Output Power [dBm]	Output Power [W]	Drain Efficiency [%]	Total Efficiency [%]	Gain [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

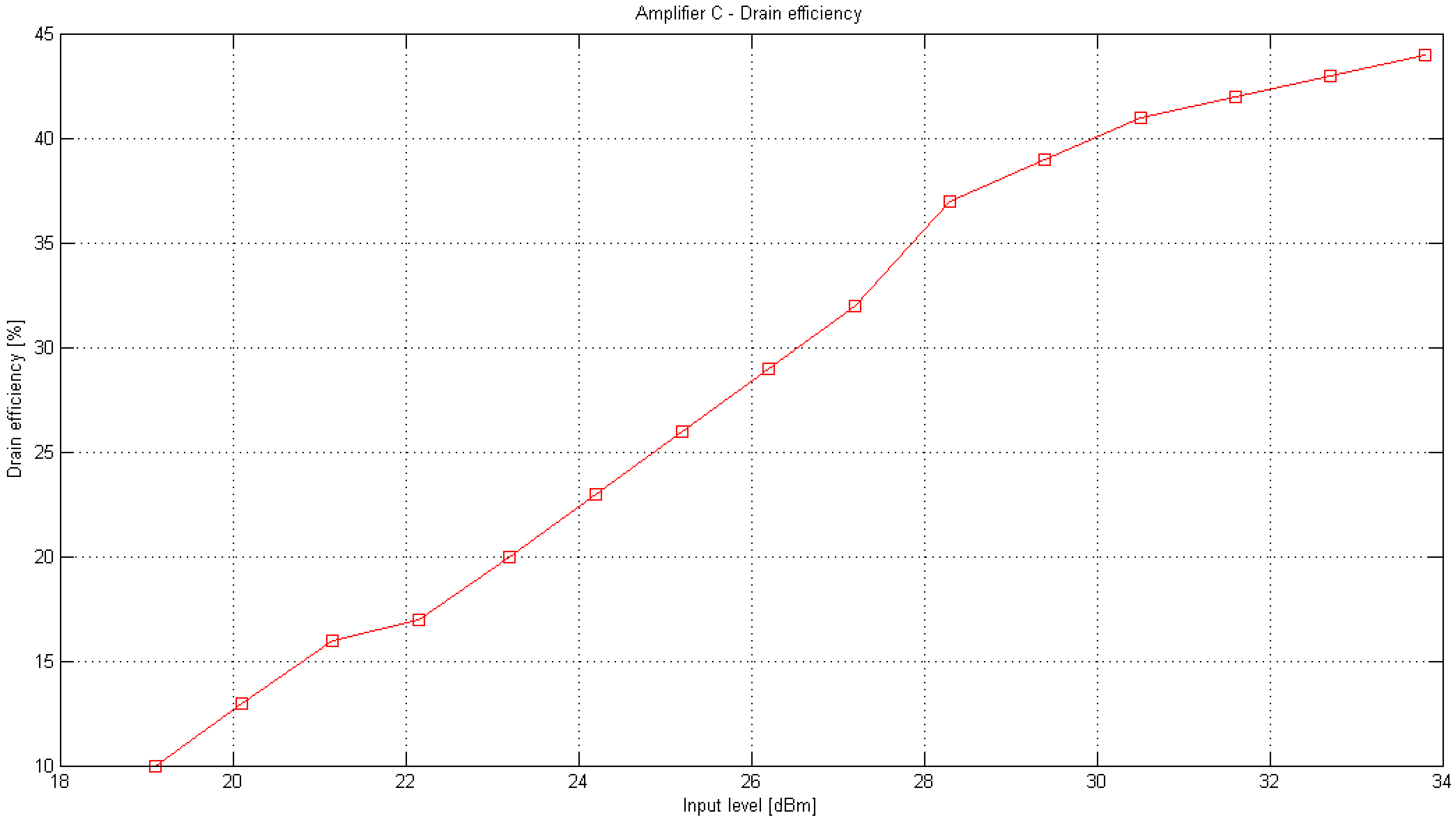


Amplifier A - Output power
Output level [dBm]
Input level [dBm]
47
46
45
44
43
42
41
40
39
38
37
18
20
22
24
26
28
30
32


Amplifier A - Drain Efficiency
Drain efficiency [%]
Input level [dBm]
45
40
35
30
25
20
15
10
18
20
22
24
26
28
30
32



Ampilier C - Output Power
48
46
44
42
40
38
36
Output level [dBm]
18
20
22
24
26
28
30
32
34
Input level [dBm]


Amplifier C - Drain efficiency
Drain efficiency [%]
Input level [dBm]
45
40
35
30
25
20
15
10
18
20
22
24
26
28
30
32
34

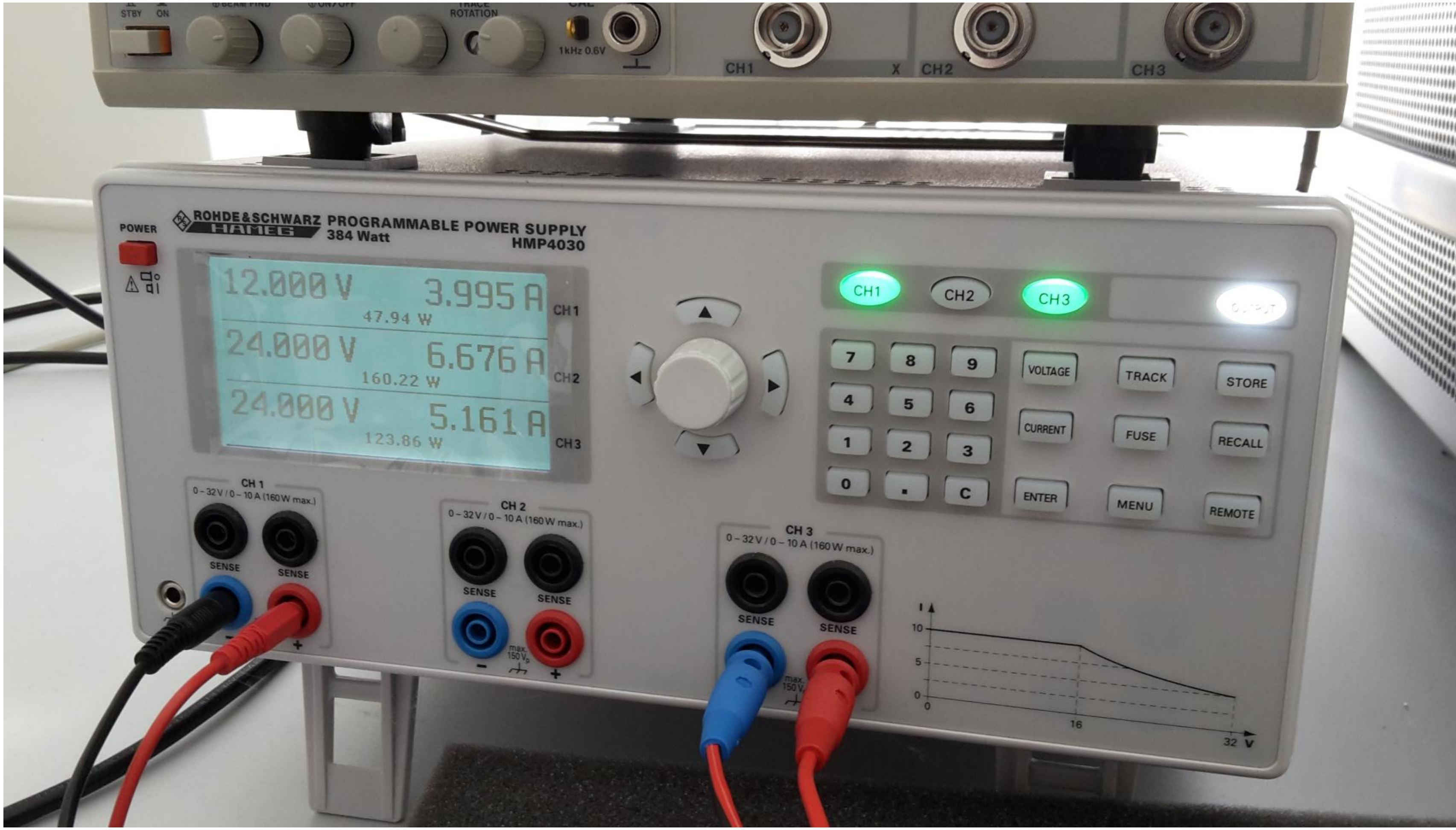
10 GHz PA by OK2AQ

Figure 1. Two 10 GHz power amplifiers with TGA2312FL

Both PA are identical except drivers. TGA2312FL internal thermistor is used for a protection agains overheating. A 24V/12V step down converter is used for the drivers supply. The TGA2312FL bearing including PCB with tuned microstrip structure were designed and produced by G3WDG.

The left one developed for OK1DFC has bigger driver – 8 W and gives 52 W output power at 2.4 W at the input. The total efficiency is a little bit worse due bigger driver.

The right one developed for OK2AQ has driver 4.5 W and gives 42 W output power at 1.4 W at the input. Very good total efficiency results in slightly warm cooler after long time operation.

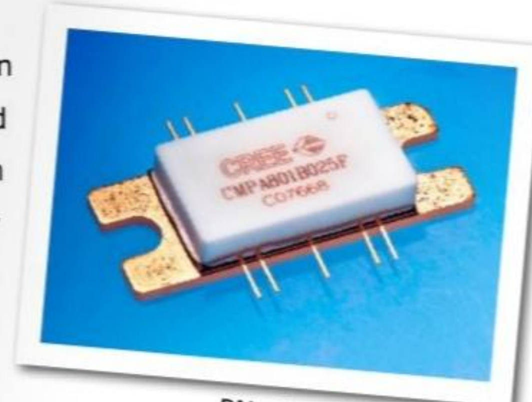

ROHDE&SCHWARZ
HAMEG
PROGRAMMABLE POWER SUPPLY
384 Watt
HMP4030
POWER
12.000 V 3.995 A
47.94 W
CH1
24.000 V 6.676 A
160.22 W
CH2
24.000 V 5.161 A
123.86 W
CH3
CH1
CH2
CH3
VOLTAGE
TRACK
STORE
CURRENT
FUSE
RECALL
ENTER
MENU
REMOTE
CH 1
0 – 32 V / 0 – 10 A (160 W max.)
SENSE
CH 2
0 – 32 V / 0 – 10 A (160 W max.)
CH 3
0 – 32 V / 0 – 10 A (160 W max.)
CH1
CH2
CH3

CREE

CMPA801B025F

25 W, 8.0 - 11.0 GHz, GaN MMIC, Power Amplifier

Cree's CMPA801B025F is a gallium nitride (GaN) High Electron Mobility Transistor (HEMT) based monolithic microwave integrated circuit (MMIC). GaN has superior properties compared to silicon or gallium arsenide, including higher breakdown voltage, higher saturated electron drift velocity and higher thermal conductivity. GaN HEMTs also offer greater power density and wider bandwidths compared to Si and GaAs transistors. This MMIC is available in a 10 lead metal/ceramic flanged package for optimal electrical and thermal performance.



PN: CMPA801B025F
Package Type: 440208

Typical Performance Over 8.5-11.0 GHz ($T_c = 25\,^{\circ}C$)

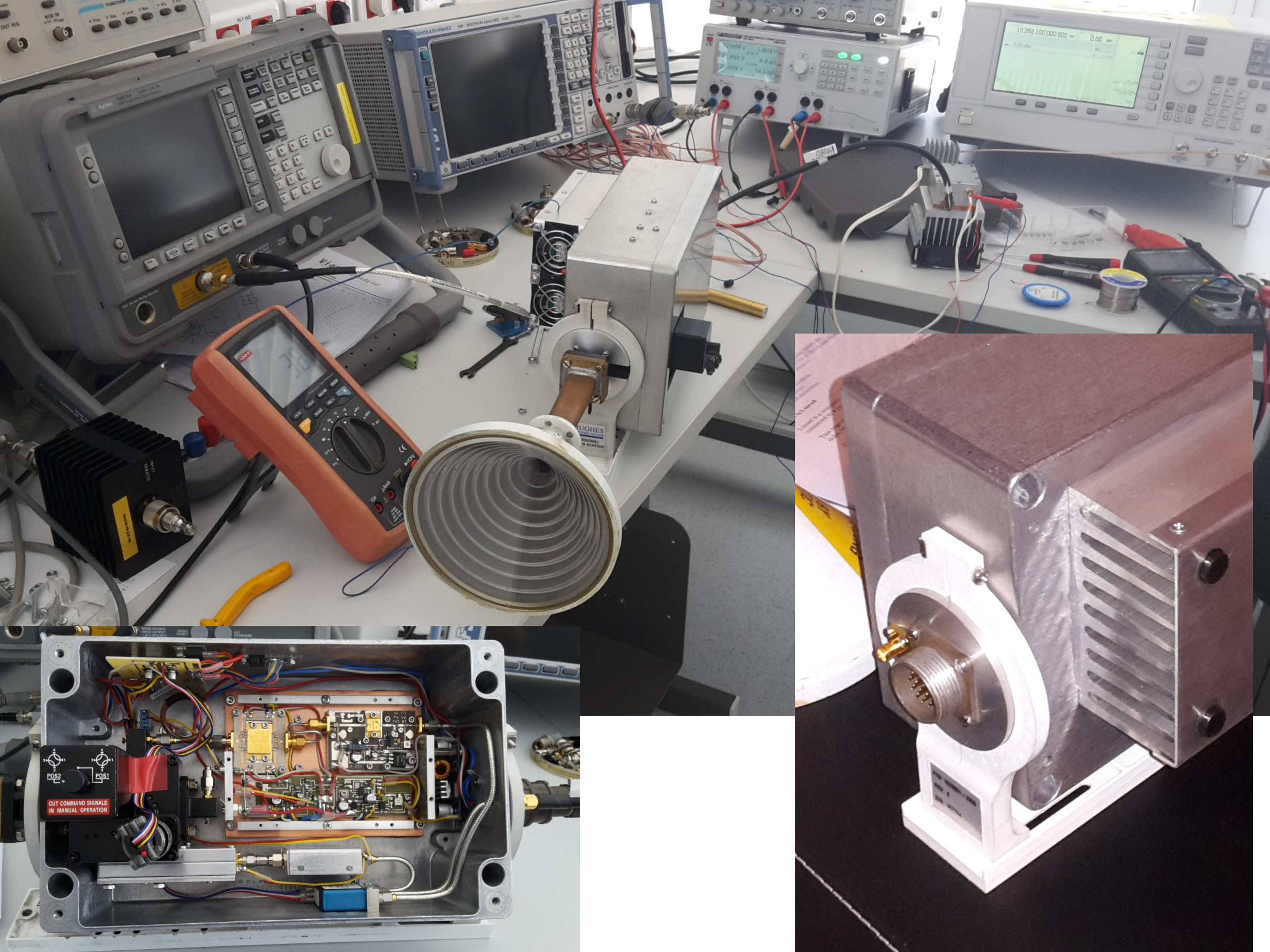
Parameter	8.5 GHz	10.0 GHz	11.0 GHz	Units
Output Power[1]	38.0	37.0	35.5	W
Output Power[1]	45.8	45.7	45.5	dBm
Power Added Efficiency[1]	37.0	36.0	35.0	%

Wolfspeed

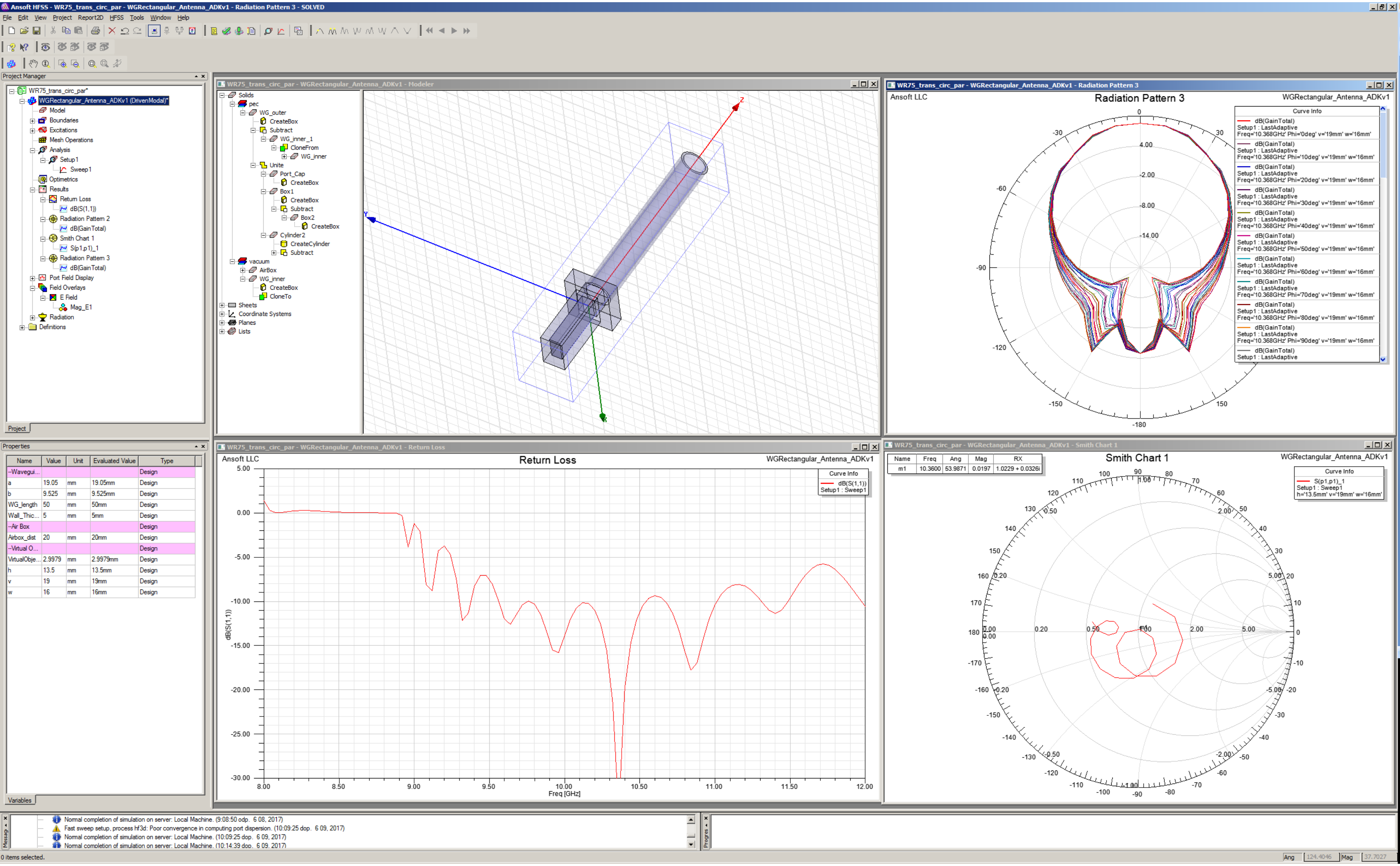
Pol	Označení dodávky	Množství	J.cena	Cena	%DPH	DPH	Celkem
1.	**CMPA801B025F** ▪ 25-W, 8.0 – 11.0-GHz, GaN MMIC Power Amplifier	**2 ks**	10 399,71	20 799,42	21%	4 367,88	25 167,30 CZK
	Součet položek			20 799,42		4 367,88	25 167,30 CZK
	Zaokrouhlení						0,70
	CELKEM K ÚHRADĚ						**25 168,00 CZK**

Ceny jsou uvedeny v CZK a jsou stanoveny pro kurz ČNB 1USD = 25,434 Kč

DB6NT: 1 W costs ~ 67 EUR => 50 W ~ 3300 EUR
60 W ~ 4000 EUR



10.368 100 000 000
HUGHES
POS2
POS1
CUT COMMAND SIGNALS
IN MANUAL OPERATION



Gajów, June 9-11, 2017

Děkuji Vám za pozornost

Thanks for your attention