

Van idee tot ontwerp van een HF transceiver

PA0VRE

Uitgangspunten

- Modes: AM, USB, LSB, (CW)
- 9 HF banden
- Zoveel mogelijk uit de junk box gebruiken
- IF Tx en Rx naar buiten uitvoeren voor externe digitale IF Tx/Rx processing
- Selectie 10MHz Ext. Ref. van GPS of interne TCXO
- 4 maal DDS voor LO# 1,2 en 3 en AUX voor externe UHF SHF toepassingen
- Ca. 100W TX vermogen en SWR + temp. beveiliging
- Arduino Nano controller + SW van Martin, PE1BIW
- 13,5V DC externe voeding
- Compacte opbouw

Bedienings concept

- Frequentie gerelateerde instellingen m.b.v. microprocessor.
- Overige instellingen d.m.v. logica, b.v. mode (USB-LSB-AM-AMS) of filterkeuze bij AM synchroondetectie.
- analoge instellingen zoals IF gain, volume en RF power en een quasi analoge instelling voor Passbandtuning via de uP.
- CW wordt bij keying automatisch geactiveerd dmv logica.

GPSDO 10MHz reference

display

start

Sat=8 AT=0 10M=0
0XCO=1 AMSL=1

FILTER

AM LSB USB

M AMS

O AM

D SSB

E



HF Transceiver PA0VRE

TUNING STEP

A 7142.0000
1kHz RX S9+50

A/B/MEM

SELECT & STORE

MEM->A & RIT

IF gain

PBT

6dB

12dB

ATT

160

80

60

40

20

17

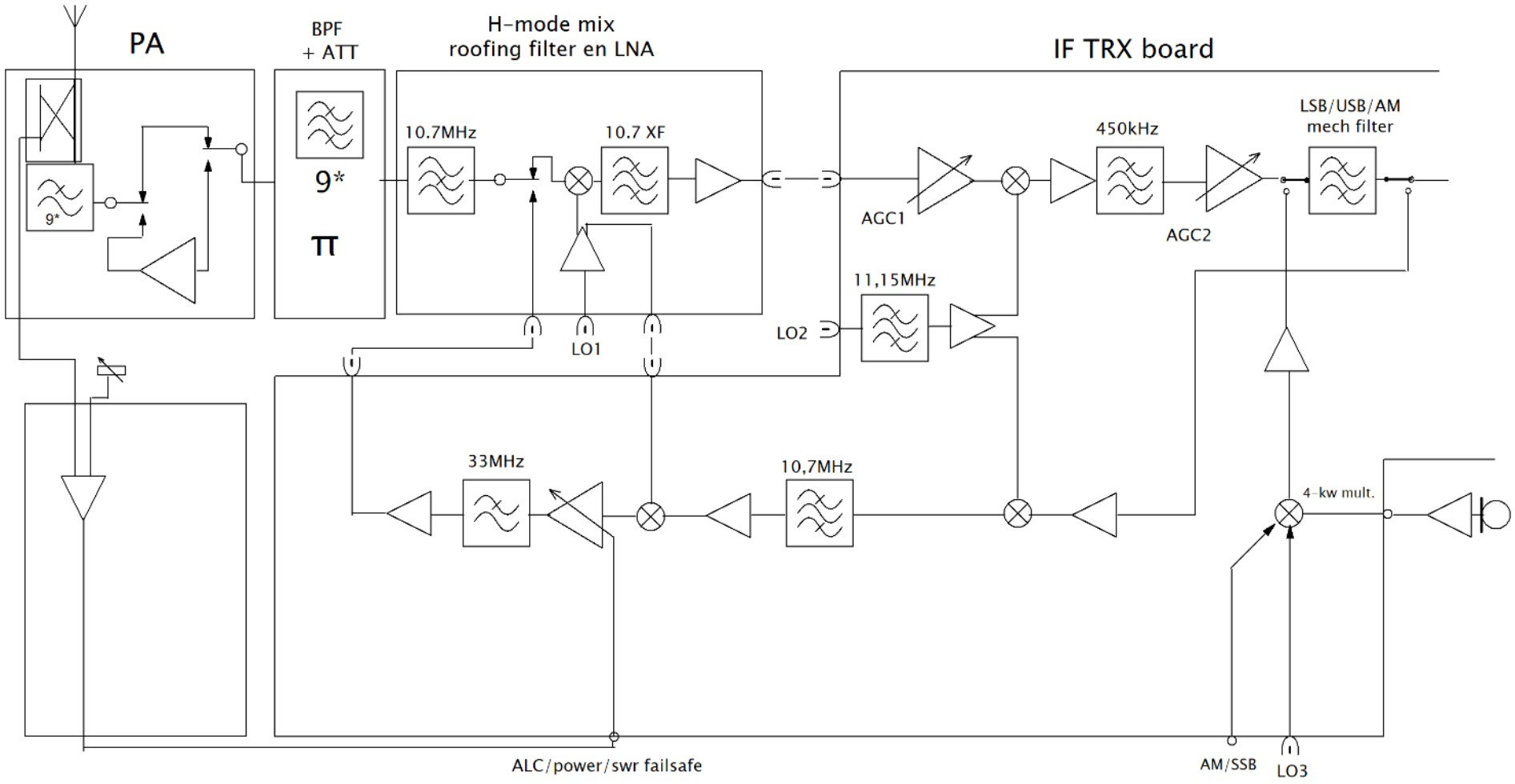
15

12

10

Vogel's

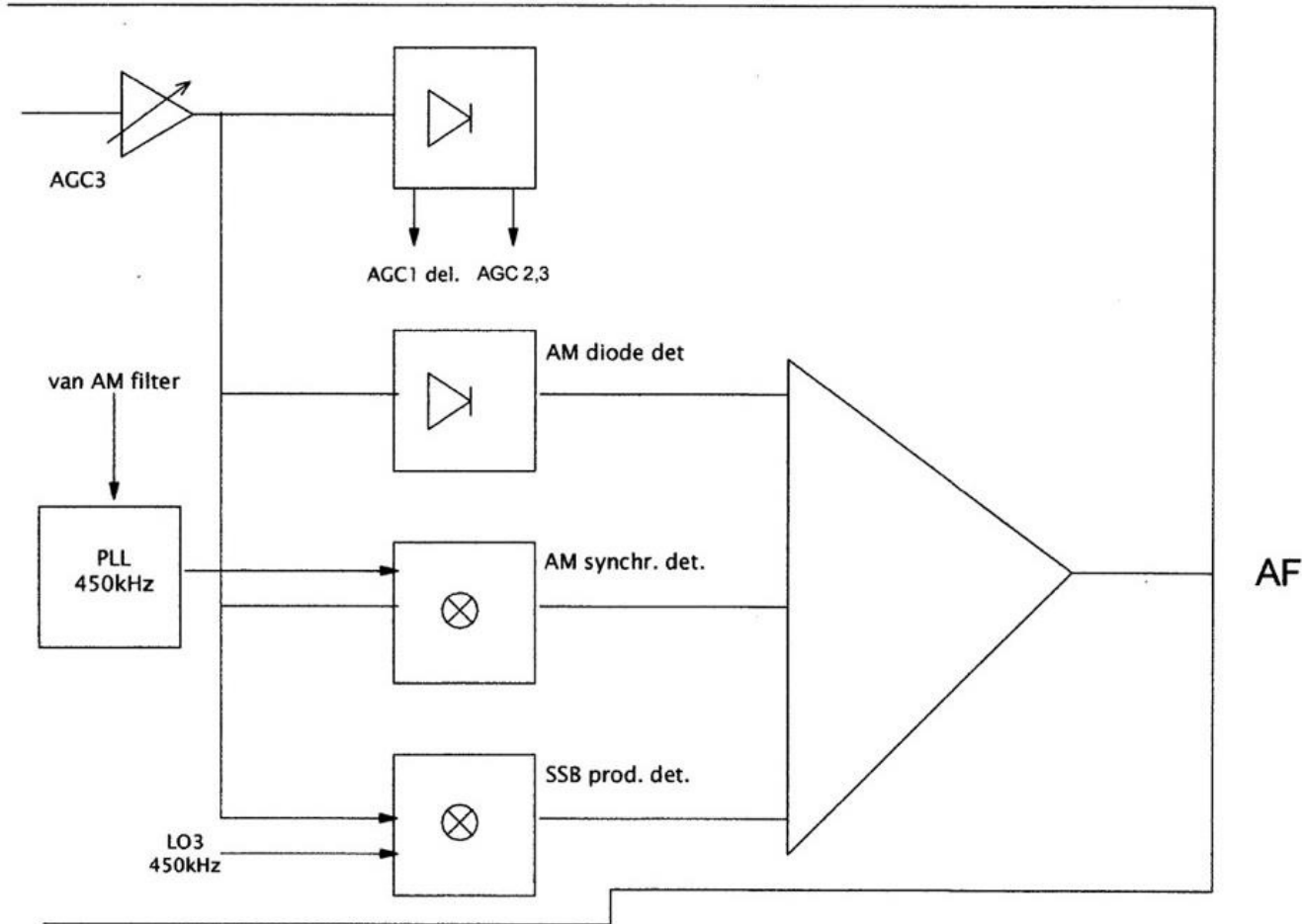
Concept keuze



concept HF TRX PA0VRE

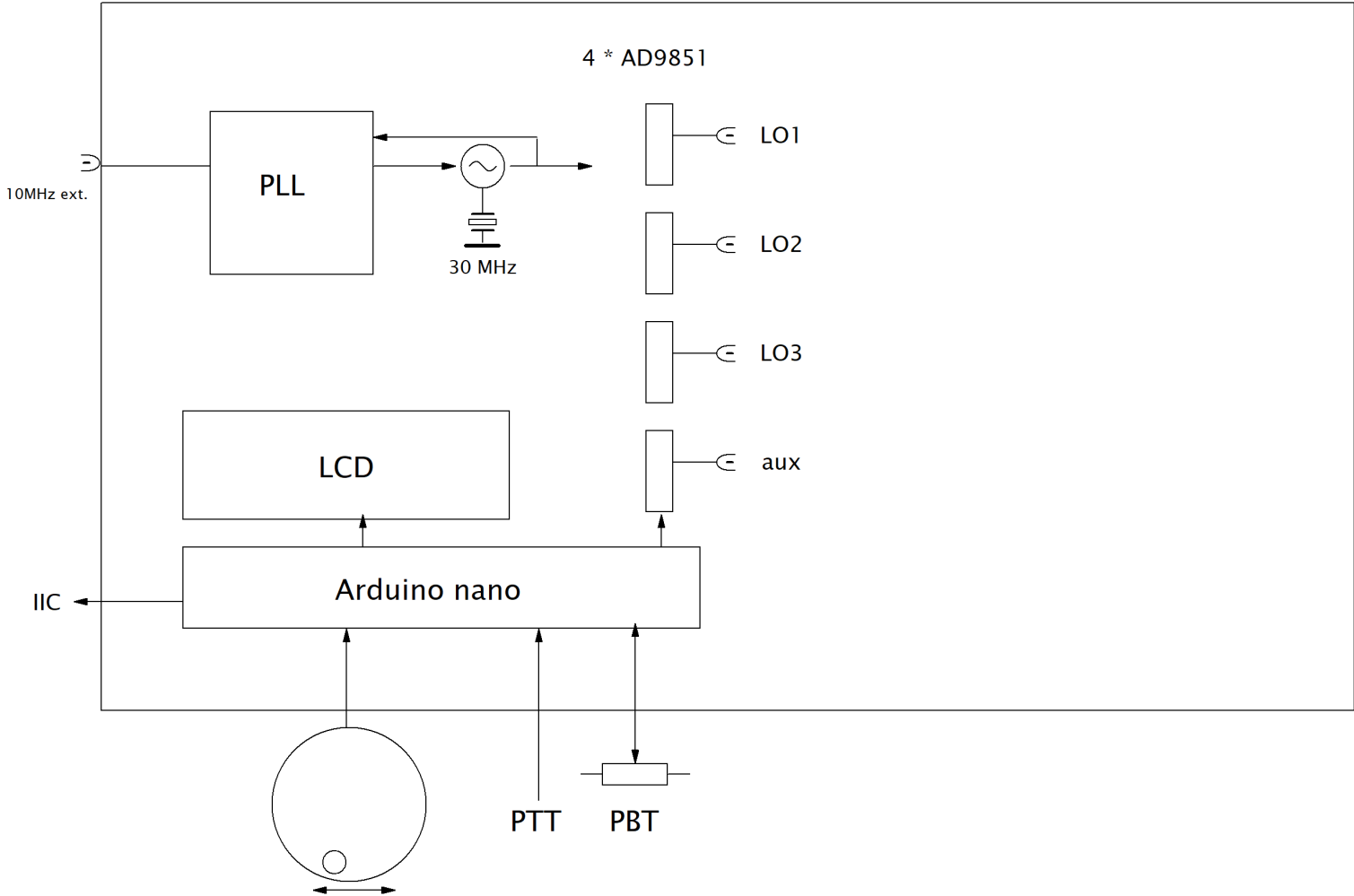
Concept keuze

IF TRX board



Concept keuze

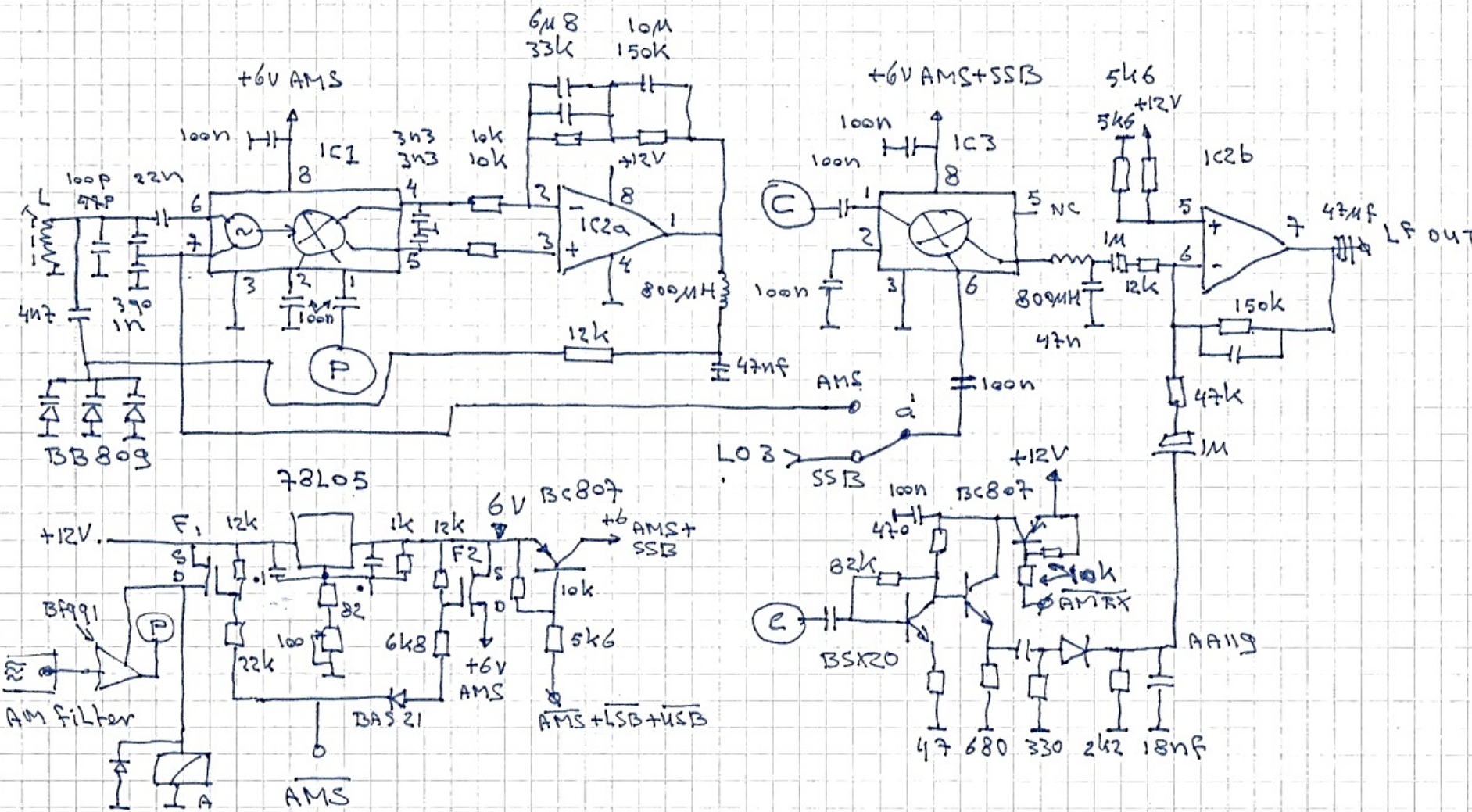
LO opwekking en besturing





Ontwerp volgorde

- Demodulatoren, benodigde IF spanning
- RF ingangssectie en mixer -> gevoeligheids eis
- Overall versterking volgt uit bovenstaande $1\mu\text{V} \rightarrow 30\text{mV}$ 89dB versterking tussen RF in en demodulator in
- IMA eisen RF en IF
- Bedieningsconcept



IC1 = IC3 = NE602
 IC2 = NE5532
 L = 280 - 330MH
 F1 = F2 = FDT434


AM detector
 SSB Product detector
 AM synchronous detector

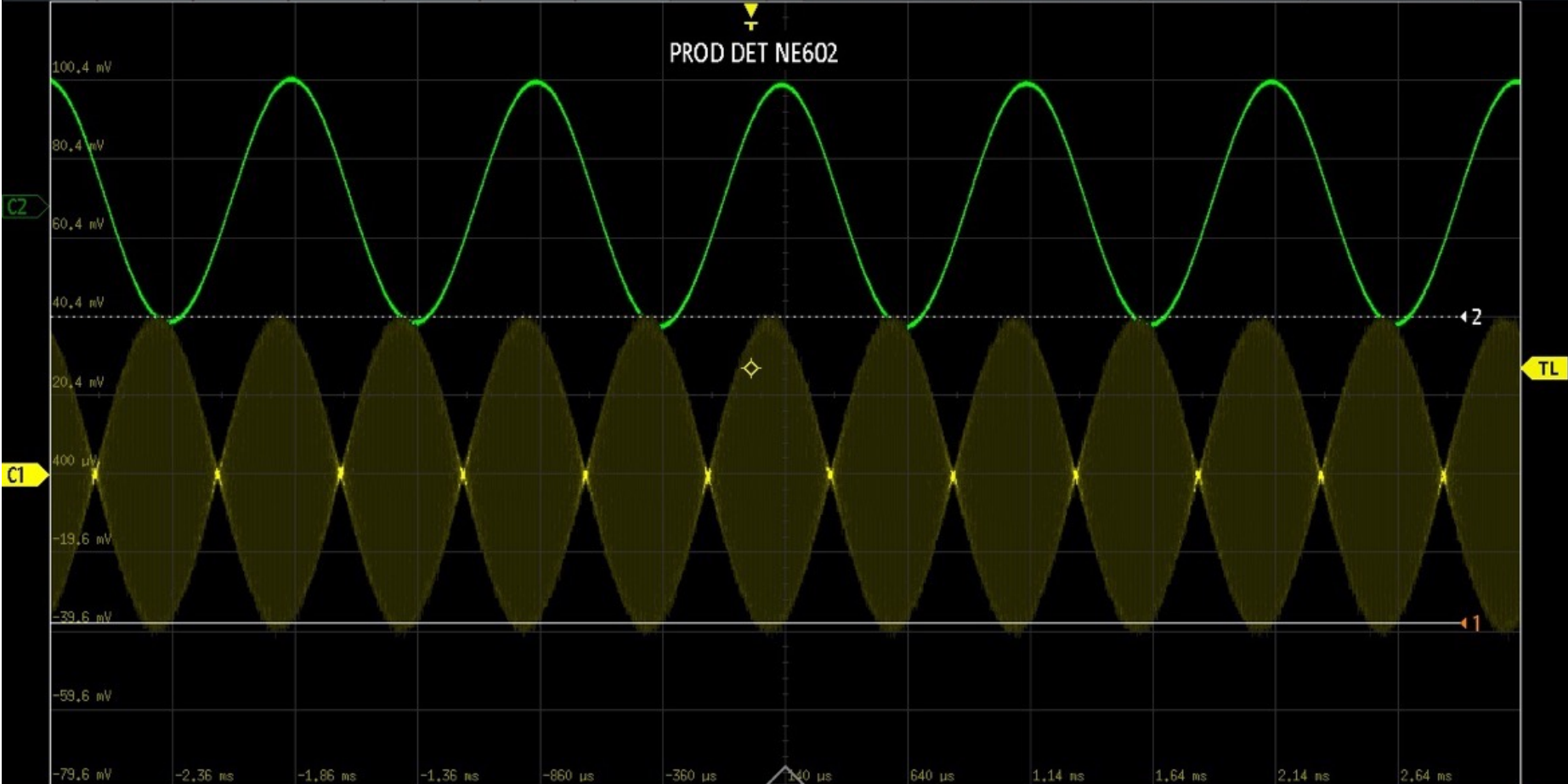
PA & VRE JUL-'22




1kHz gemoduleerd DSB-SC signaal demoduleren met NE602

RTB2004; 1333.1005K04; 101448 (02.202 2018-11-06)

Undo	Save Setup	Load Setup	Zoom	Meter	FFT	Annotation	<input checked="" type="checkbox"/> C1		Norm	500 μ s/	Complete	2022-07-08 17:38
							27.2 mV	1.25 GSa/s	140 μ s	Sample		



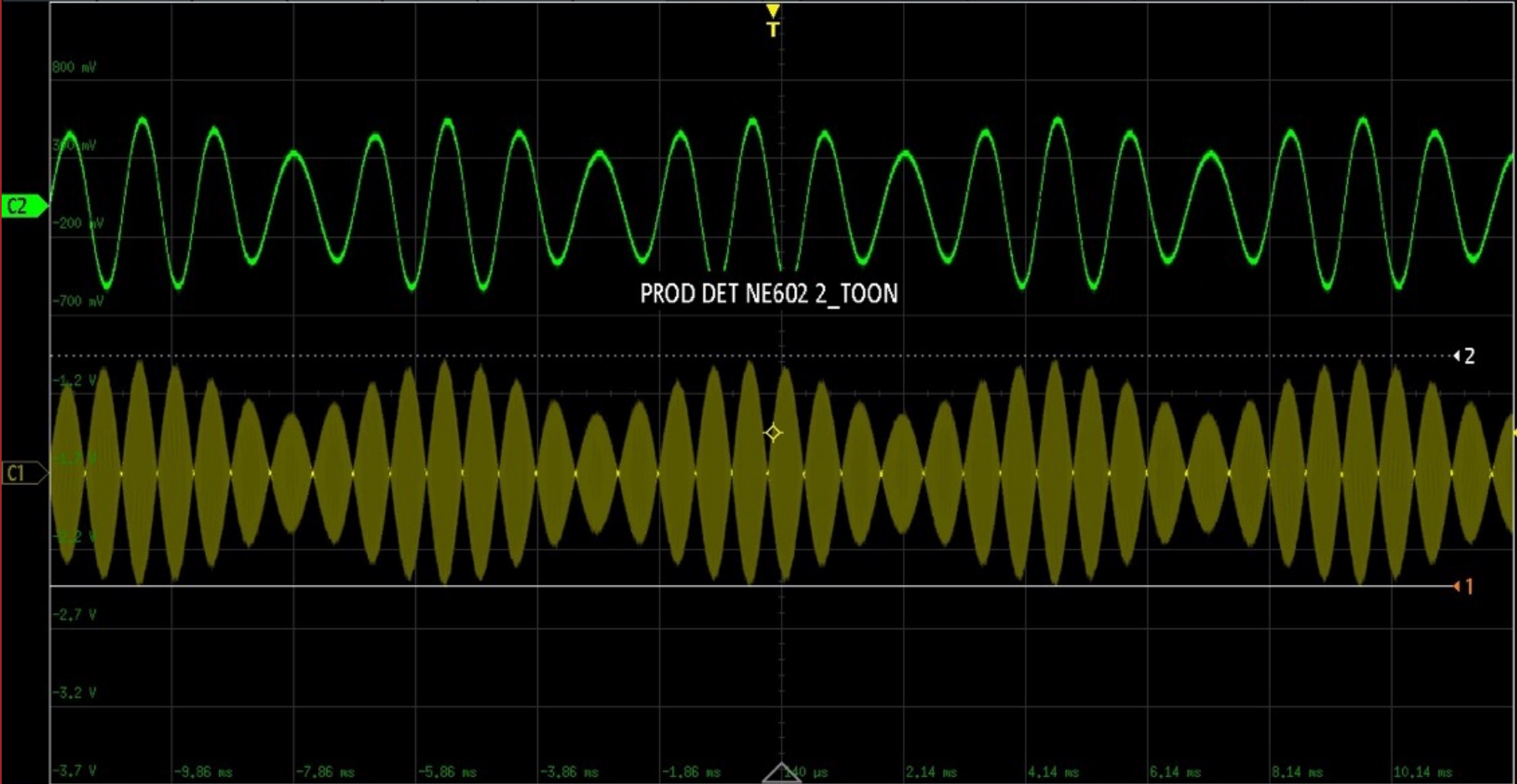
C1 RMS-Cyc: 24.87 mV
 V1: -37.42 mV
V2: 40.355 mV
 Δ V: 77.774 mV

<input checked="" type="checkbox"/> C1	20 mV/	AC 1:1	<input checked="" type="checkbox"/> C2	200 mV/	AC 10:1	C3	C4		Menu
--	--------	--------	--	---------	---------	----	----	---	------

2-toon DSB-SC demodulatie met NE602

RTB2004; 1333.1005K04; 101448 (02.202 2018-11-06)

Undo	Save Setup	Load Setup	Zoom	Meter	FFT	Annotation	C1	Norm	2 ms/	Complete	2022-07-08 17:45
							26 mV	312 MSa/s	140 μ s	Sample	



C1 RMS-Cyc: 25.081 mV C1 V1: -71.926 mV V2: 75.591 mV Δ V: 147.52 mV

AM synchronon detector

RTB2004; 1333.1005K04; 101448 (02.202 2018-11-06)

Undo Save Setup Load Setup Screenshot Zoom Meter FFT Annotation **C1** 50 mV Auto 1.25 GSa/s 500 μ s/ 4 ms Complete Sample 2021-04-02 14:09



C1 V1: -44.839 mV V2: 43.282 mV Δ V: 88.121 mV

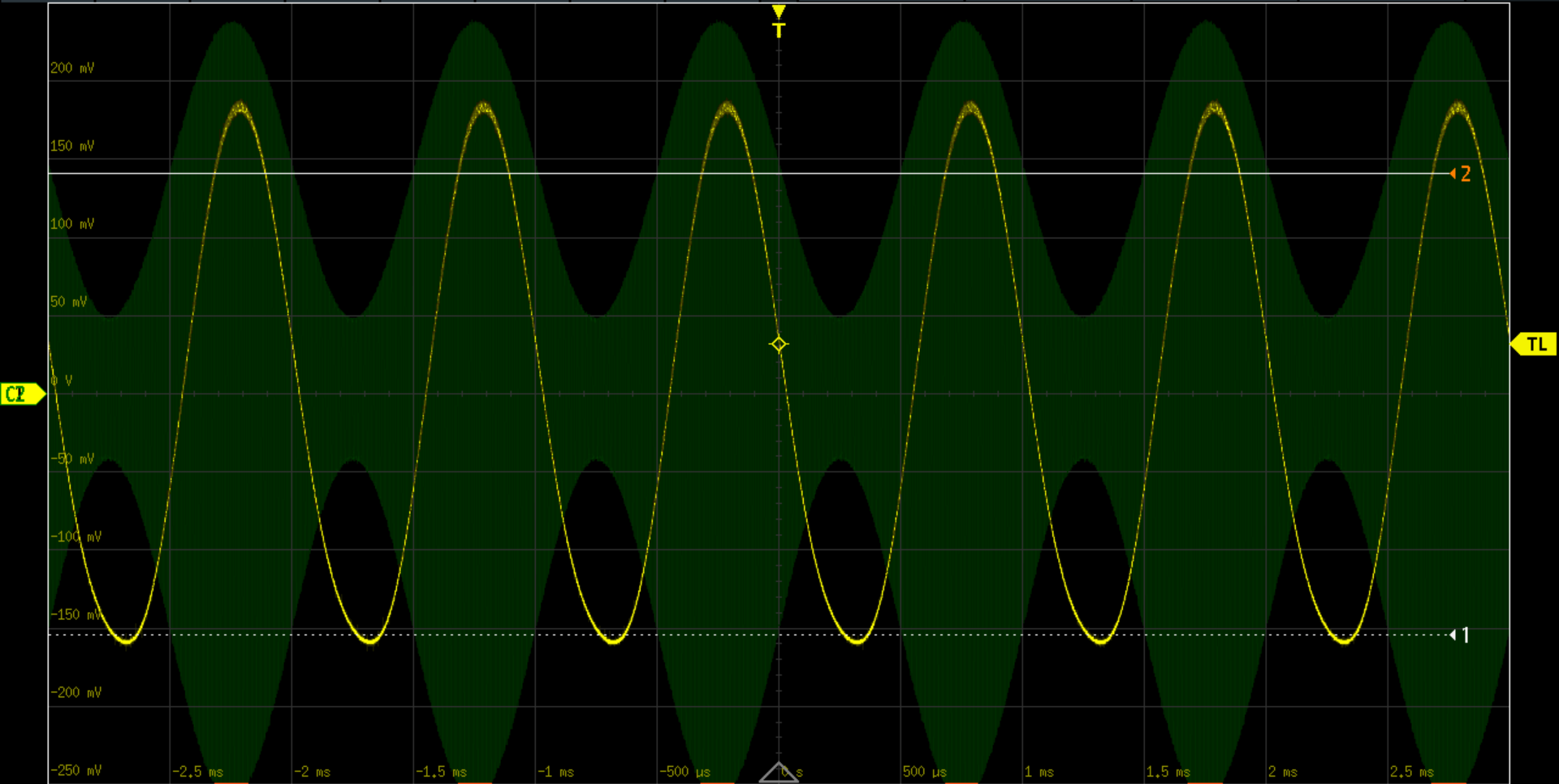
C1 20 mV/ B_w AC 1:1 **C2** 20 mV/ B_w AC 1:1 C3 C4



Diode omhullende detector

RTB2004; 1333.1005K04; 101448 (02.202 2018-11-06)

Undo	Save Setup	Load Setup	Screenshot	Zoom	Meter	FFT	Annotation	C1	Auto	500 μ s/	Run	2021-04-05 19:04
								32 mV	1.25 GSa/s	0 s	Sample	

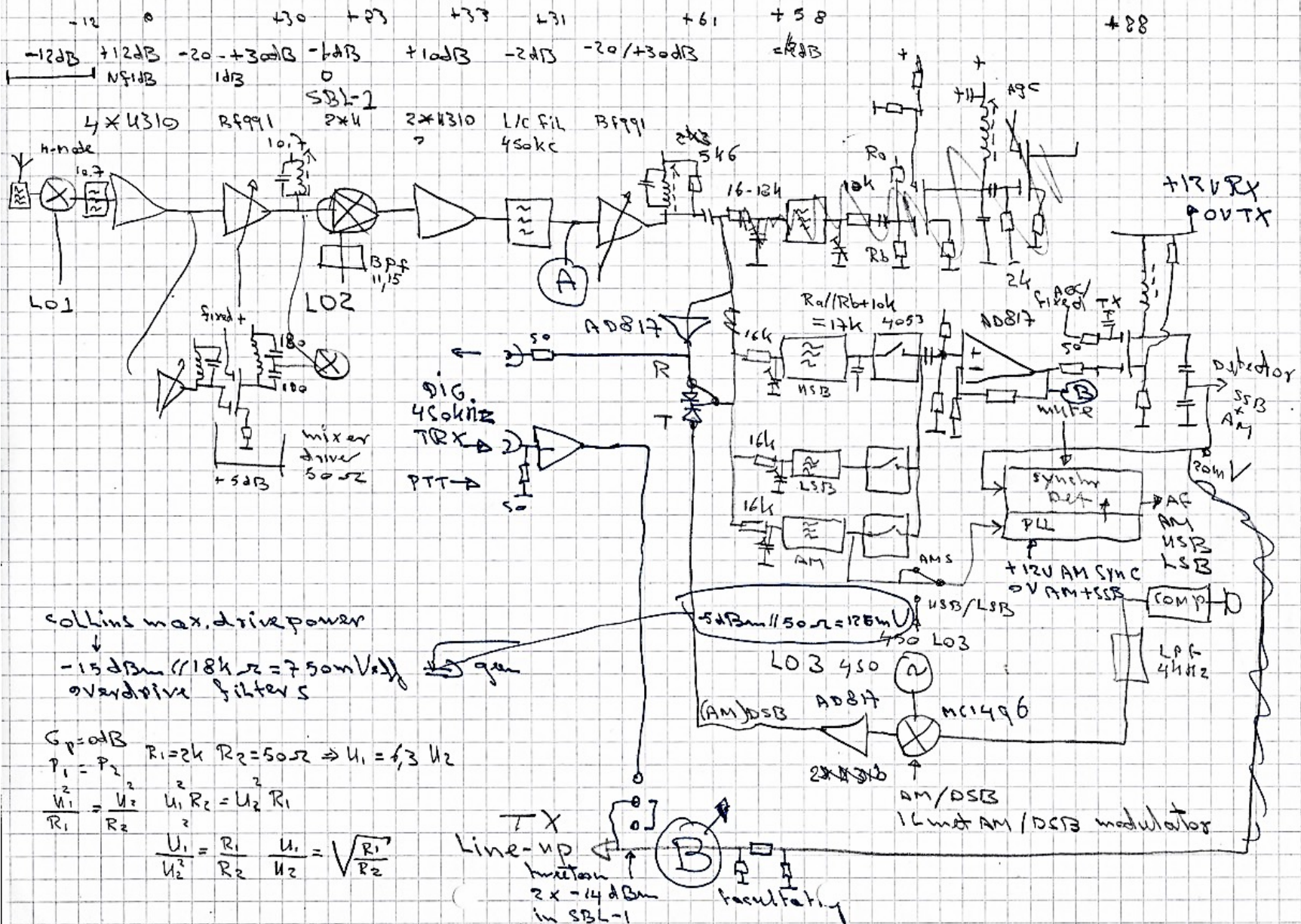


C1	V1: -154.3 mV	V2: 140.62 mV	Δ V: 294.92 mV										
C1	50 mV/	AC 1:1	C2	20 mV/	BW AC 1:1	C3		C4					



Menu

Ruwe schets RX opzet en niveau's

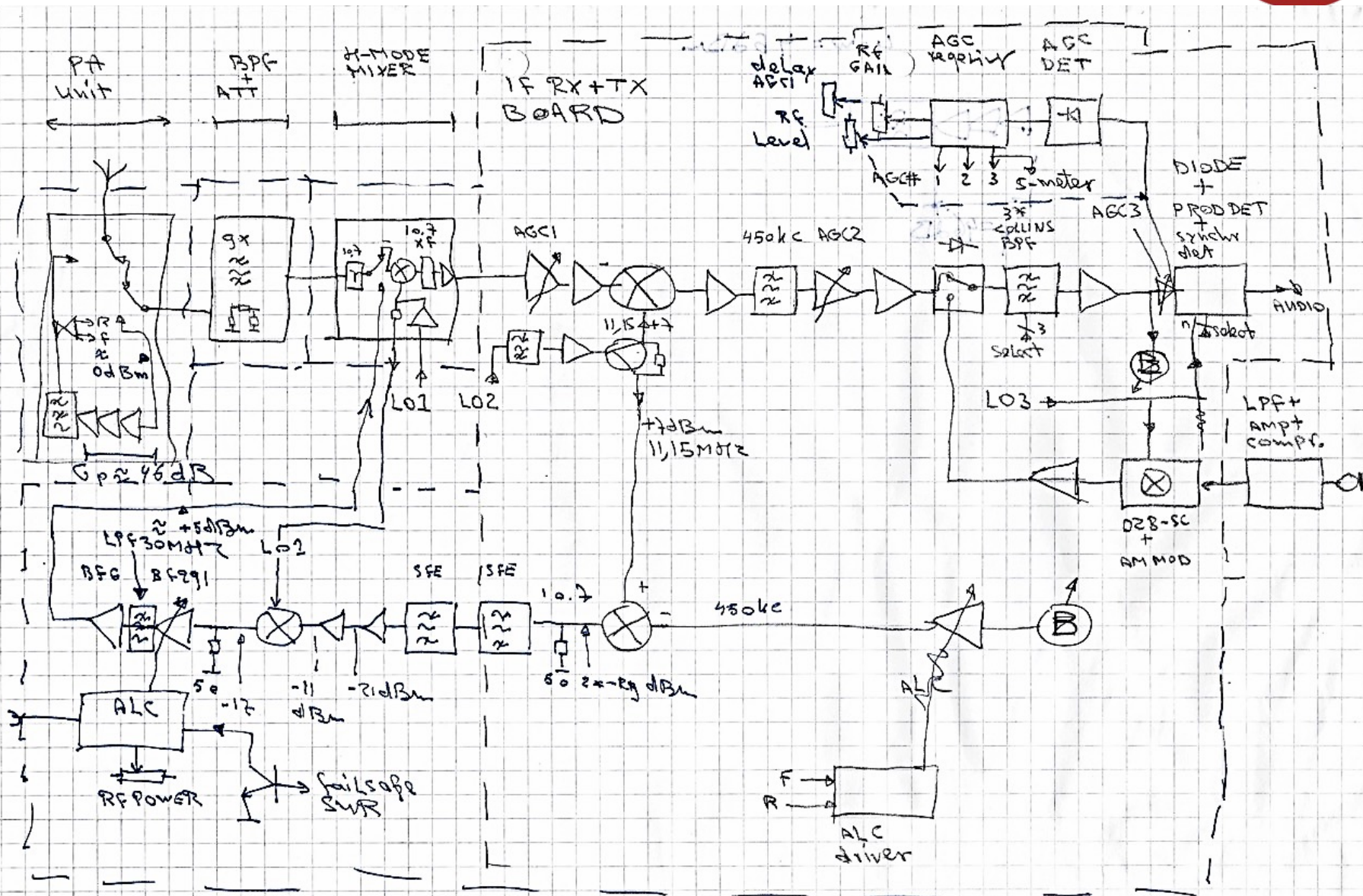


collins max. drive power
 $\rightarrow -15\text{dBm} / 18\text{k}\Omega = 750\text{mV}_{\text{eff}}$
 overdriev filter's

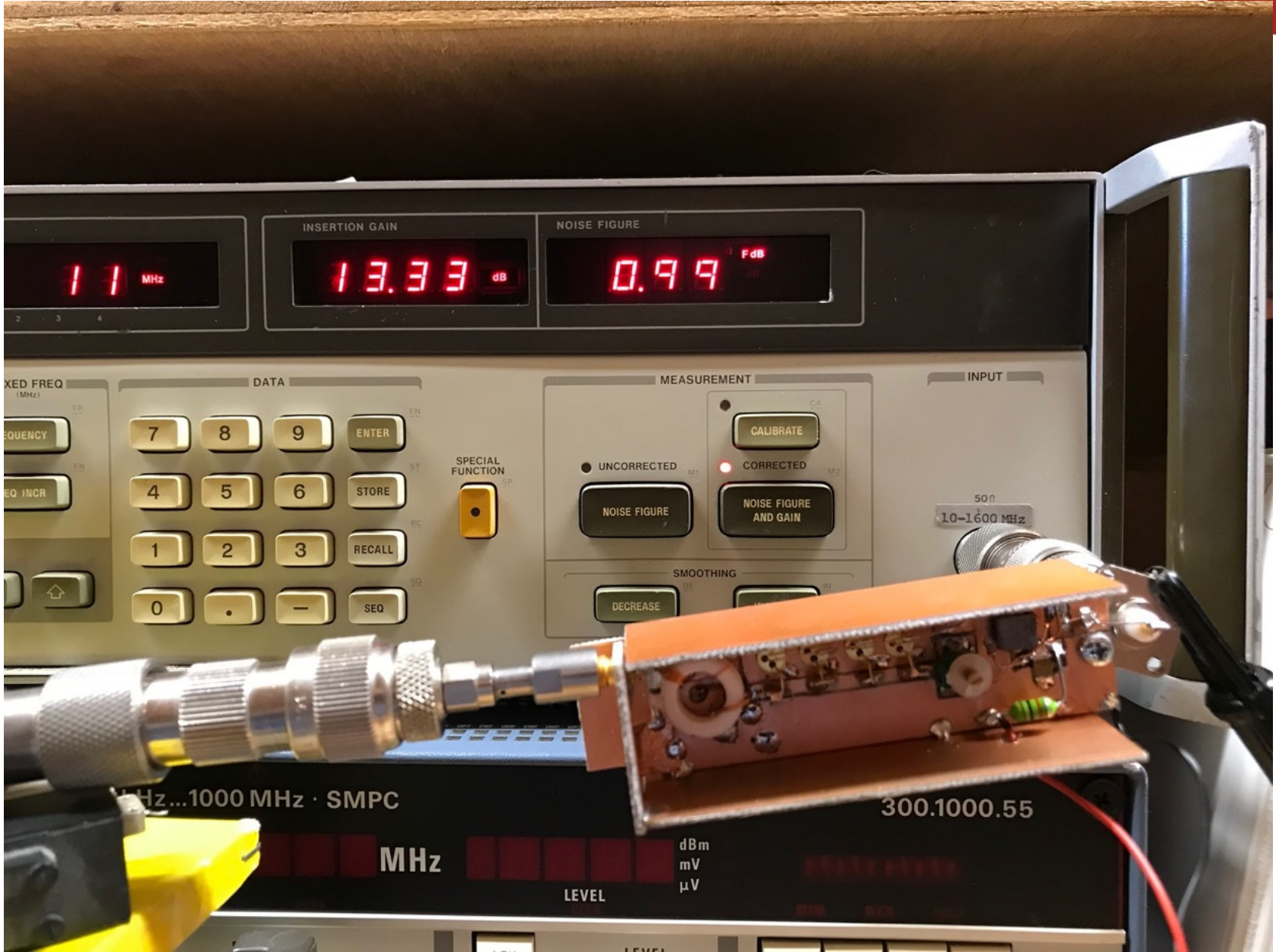
$G_p = 0\text{dB}$
 $P_1 = P_2$
 $\frac{U_1^2}{R_1} = \frac{U_2^2}{R_2}$
 $U_1 R_2 = U_2 R_1$
 $\frac{U_1}{U_2} = \frac{R_1}{R_2}$
 $\frac{U_1}{U_2} = \sqrt{\frac{R_1}{R_2}}$

Line-up
 hueten
 2x -14dB
 in SBL-1
 facultatief

Vervolgschetsontwerp

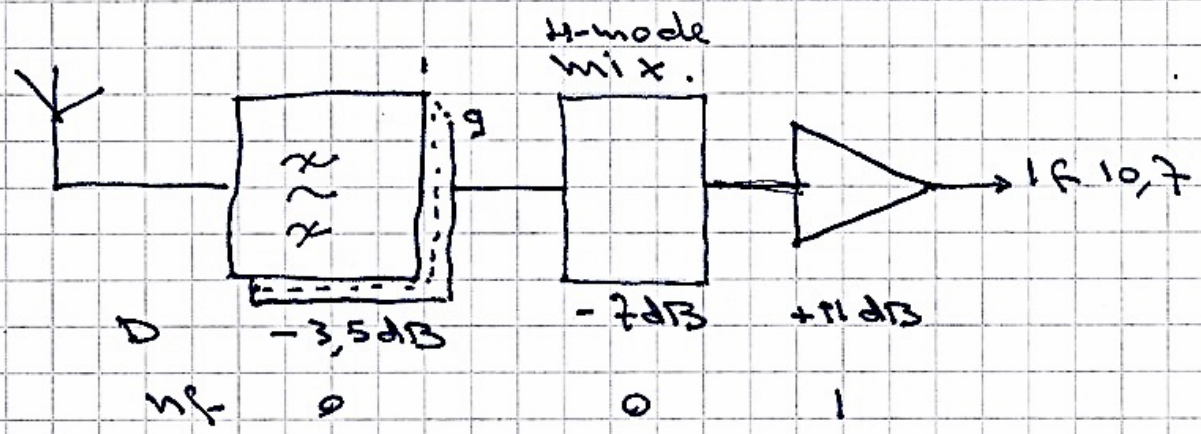


Postmix amplifier met 4 maal U310 van W7AAZ



Benadering gevoeligheid

Gevoeligheid HF ontvanger ovr:



$N_f \text{ totaal} = 11 \text{ dB}$

$B = 2,5 \text{ kHz} \rightarrow 10 \log(2500) = +34 \text{ dB}$ voor $B = 1 \text{ Hz}$

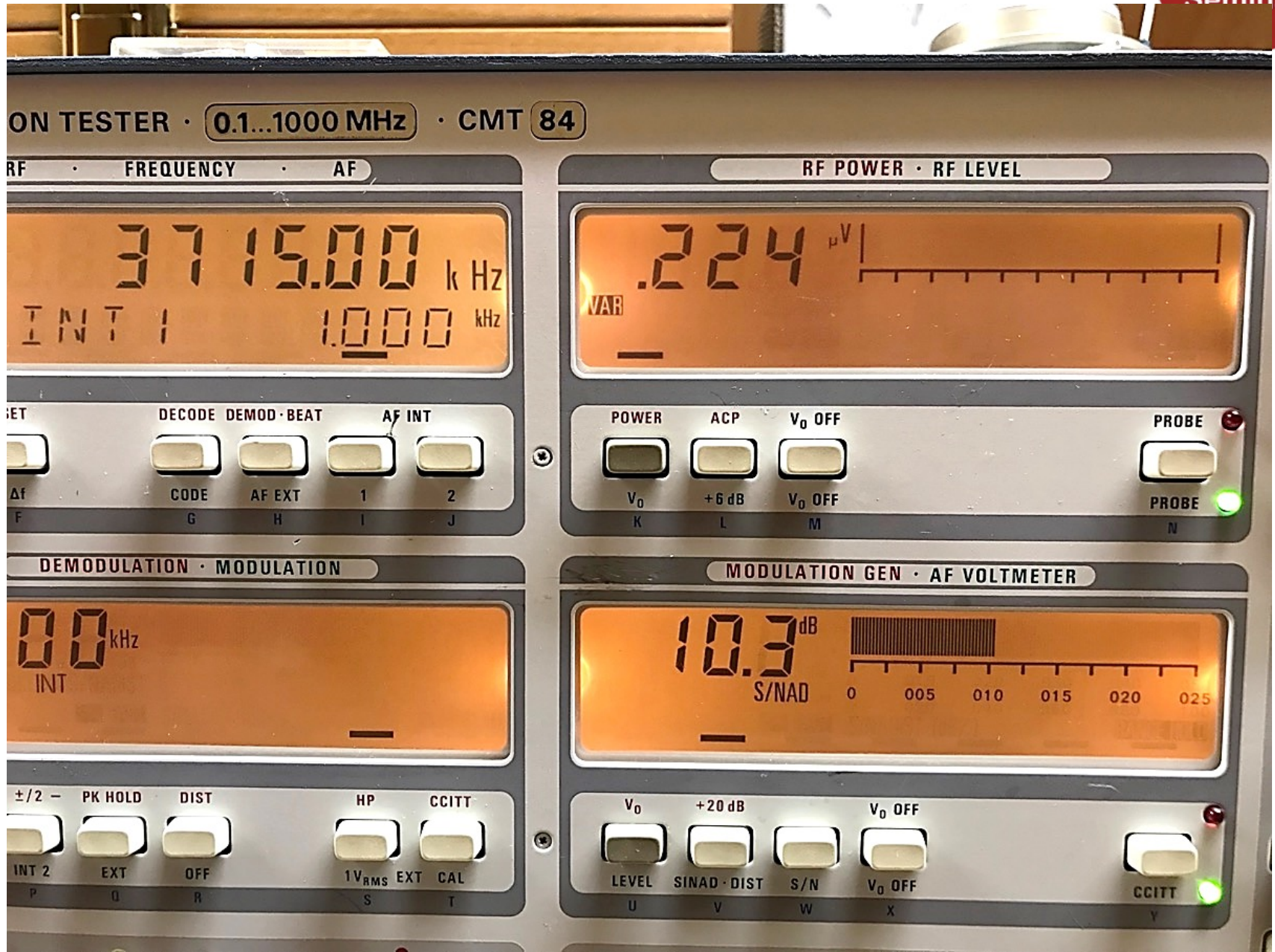
$P_{\text{ruis}} = -174 + 34 + 11 = -129 \text{ dBm} \hat{=} 1,259 \cdot 10^{-16} \text{ W}$

in $Z = 50 \Omega$ is de ruis spanning $\sqrt{P \cdot Z} = \sqrt{1,259 \cdot 10^{-16} \cdot 50} =$

$7,9 \text{ nV}$ of $0,08 \mu\text{V}$ 10 dB bovengerois vereist $U_{\text{in}} =$

$0,08 \mu\text{V} \cdot 10^{\frac{10}{20}} = 0,25 \mu\text{V}$

Meting gevoeligheid



ON TESTER · 0.1...1000 MHz · CMT 84

RF · FREQUENCY · AF

3715.00 kHz
INT 1 1000 kHz

RF POWER · RF LEVEL

224 μ V
VAR

DECODE DEMOD · BEAT AF INT
CODE AF EXT 1 2
G H I J

POWER ACP V₀ OFF PROBE
V₀ +6 dB V₀ OFF PROBE
K L M N

DEMODULATION · MODULATION

00 kHz
INT

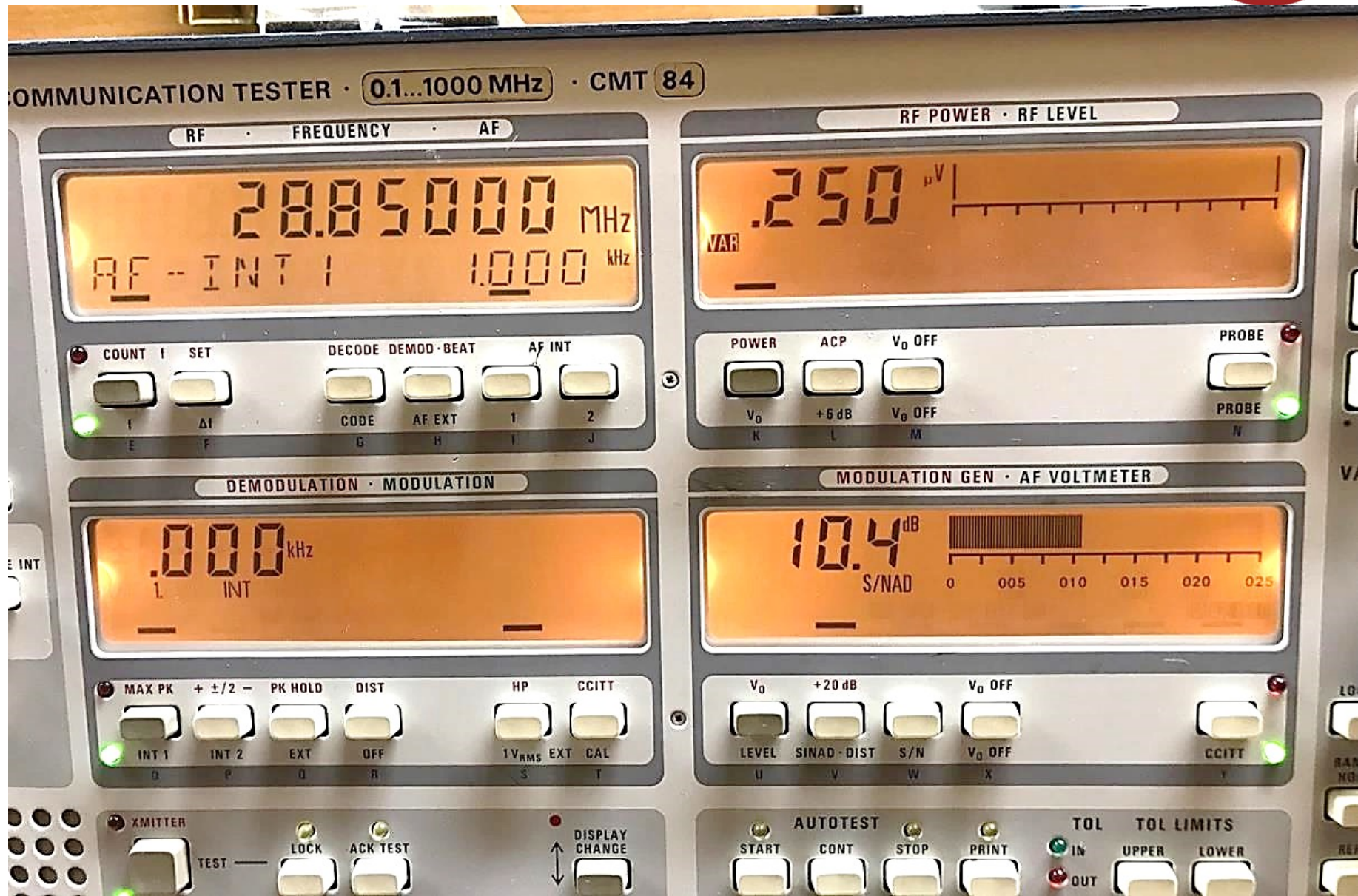
MODULATION GEN · AF VOLTMETER

10.3 dB
S/NAD 0 005 010 015 020 025

±/2 - PK HOLD DIST HP CCITT
INT 2 EXT OFF 1V_{RMS} EXT CAL
P Q R S T

V₀ +20 dB V₀ OFF CCITT
LEVEL SINAD · DIST S/N V₀ OFF
U V W X Y

En op 10 meter...



COMMUNICATION TESTER · 0.1...1000 MHz · CMT 84

RF · FREQUENCY · AF

28.85000 MHz
AF - INT 1 1000 kHz

RF POWER · RF LEVEL

250 μ V
VAR

DEMODULATION · MODULATION

0.000 kHz
INT

MODULATION GEN · AF VOLTMETER

10.4 dB
S/NAD

COUNT I SET
I Δ
E F
DECODE DEMOD-BEAT AF INT
CODE AF EXT 1 2
G H I J

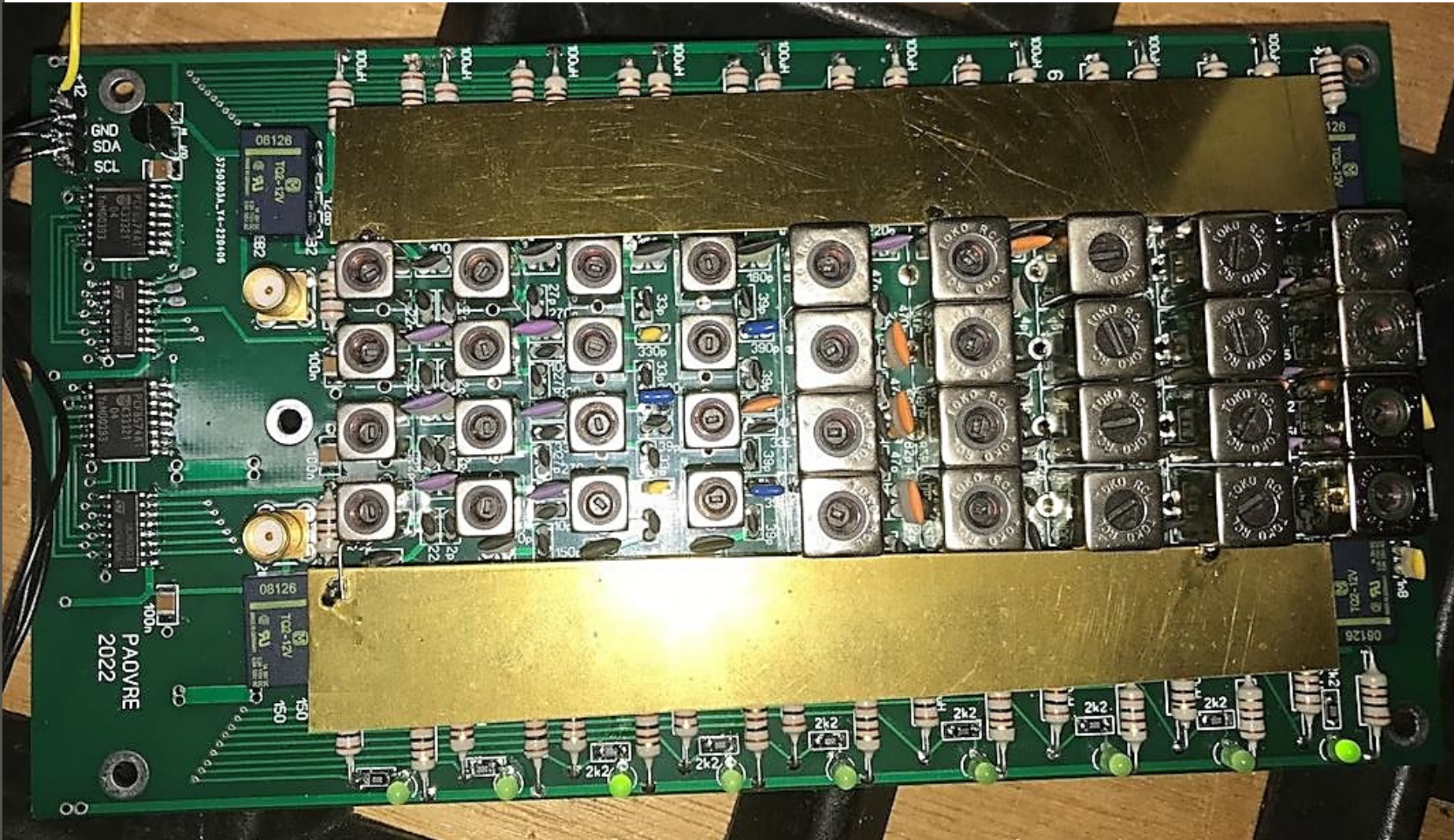
POWER ACP V₀ OFF PROBE
V₀ +6 dB V₀ OFF
K L M N

MAX PK + \pm /2 - PK HOLD DIST HP CCITT
INT 1 INT 2 EXT OFF 1V_{RMS} EXT CAL
O P Q R S T

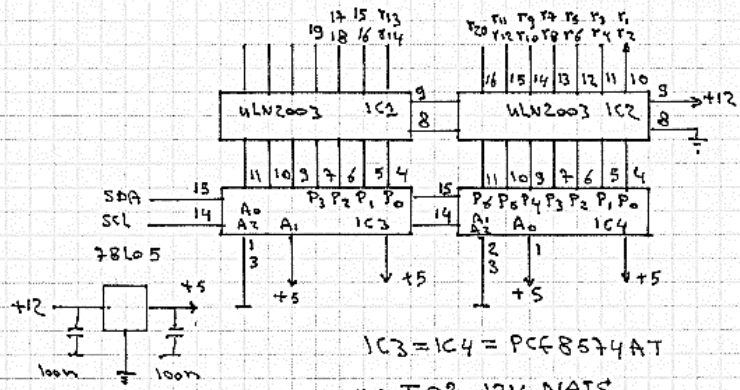
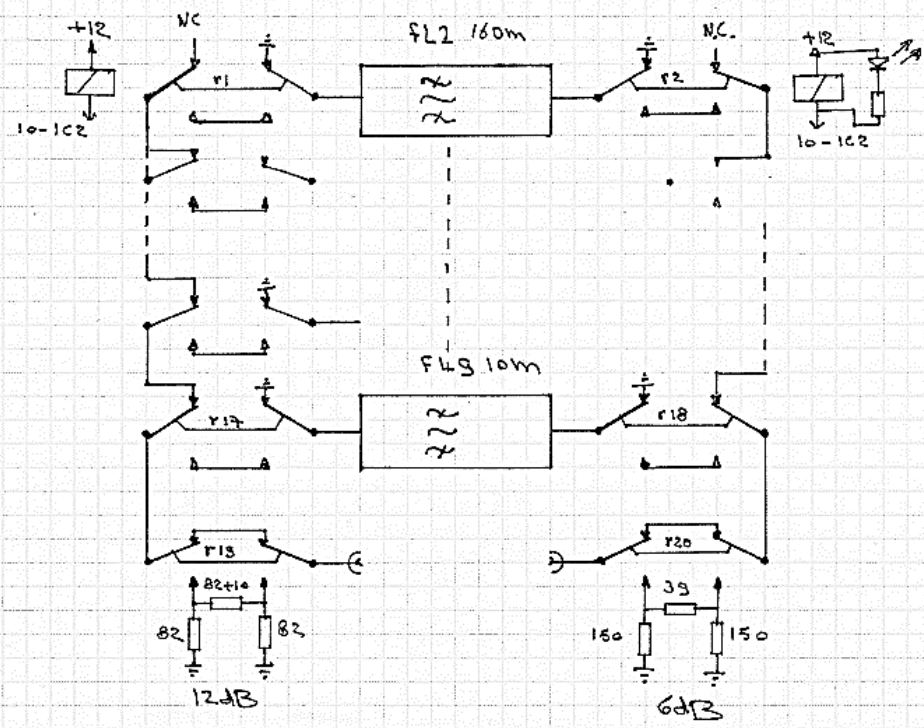
V₀ +20 dB V₀ OFF
LEVEL SINAD-DIST S/N V₀ OFF CCITT
U V W X Y

XMITTER TEST LOCK ACK TEST DISPLAY CHANGE

AUTOTEST TOL TOL LIMITS
START CONT STOP PRINT IN UPPER LOWER
OUT



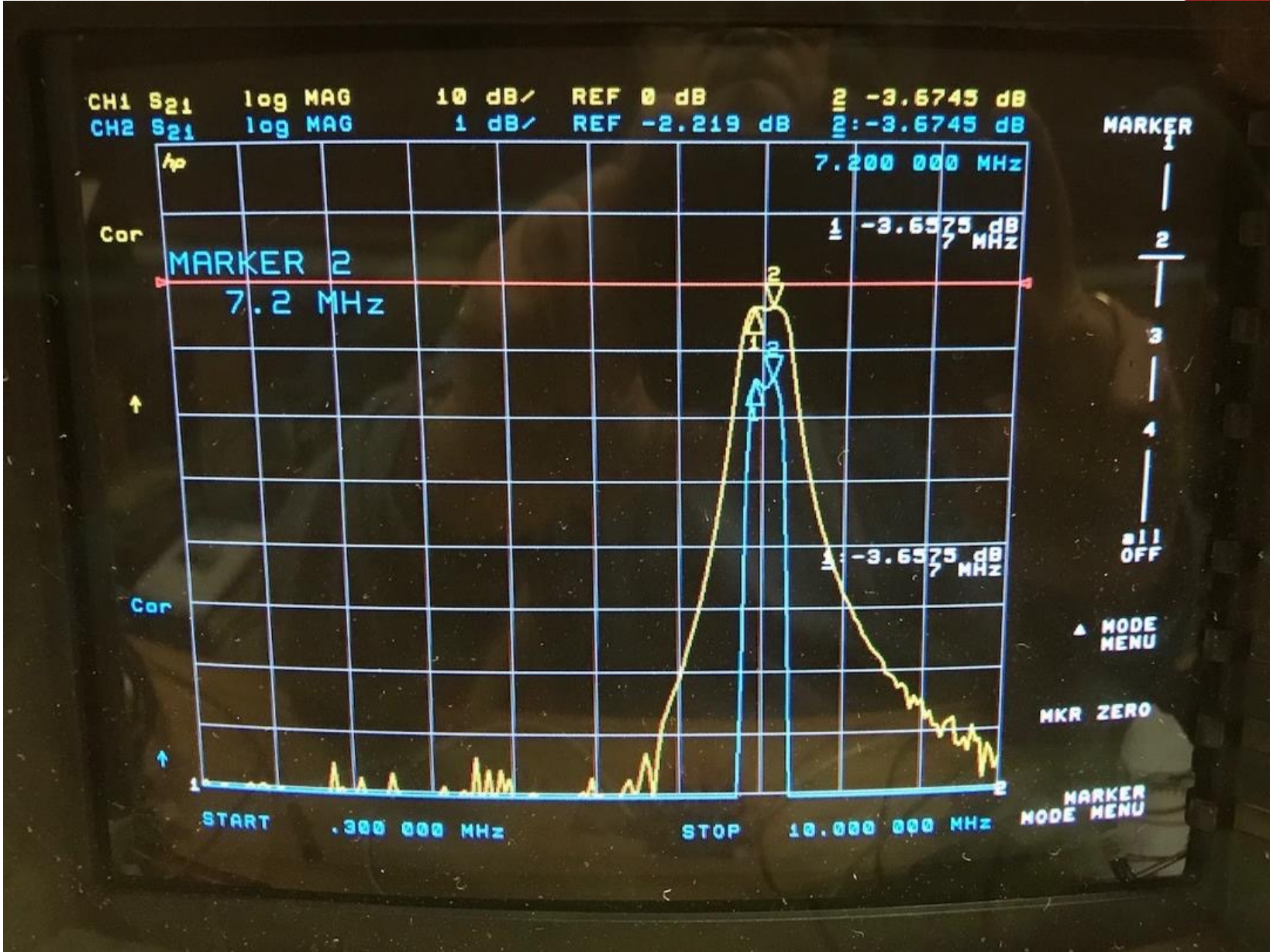
Preselectie opzet



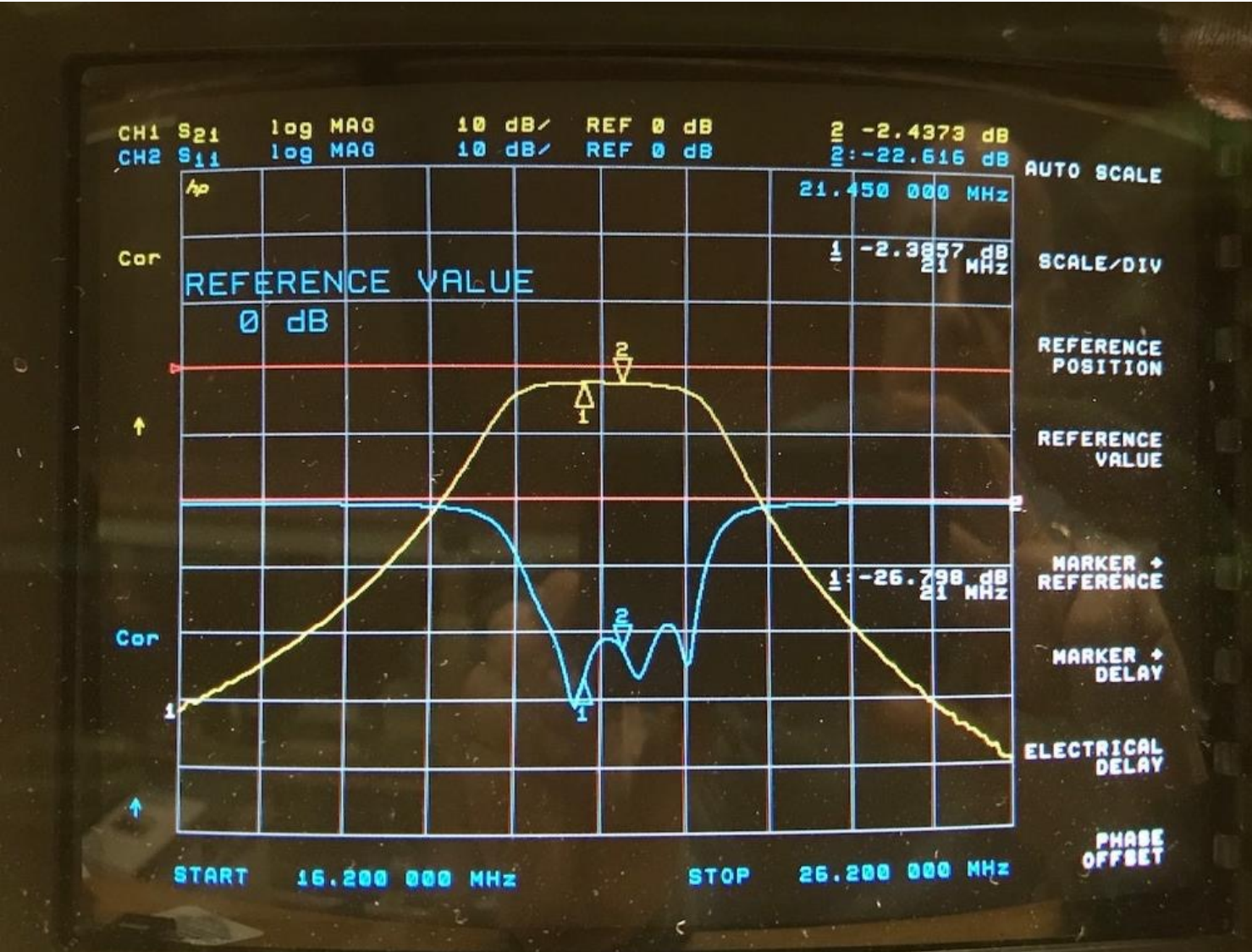
IC3 = IC4 = PC8574A
r = TQ2 - 12V NALS

Preselectie
PA OUVRE
mt 122
100 x 185 mm

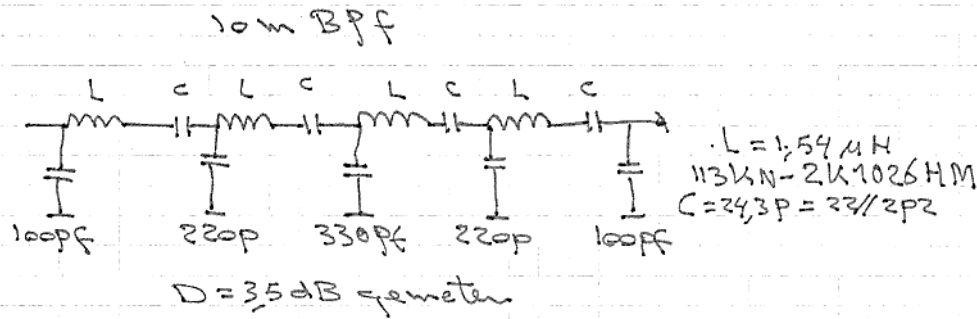
40m bandpass filter



15m bandpass filter



Topologie mesh capacitor filter en simulatie-optimalisatie



22-FEB-122

COMPACT SOFTWARE - ARRL Radio Designer 1.0
 File: c:\arrl\bpf15.clt

211

Simulatie 10m preselectie

- * bpf 28MHz
- * $Z=50$ ohm in en uit

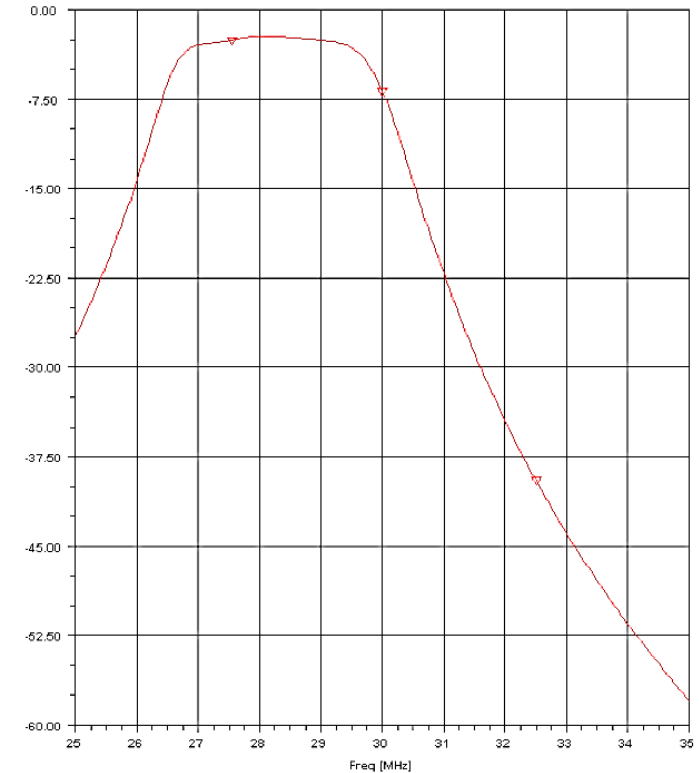
blk

- cap 1 $c=110pF$
- slc 1 2 $l=1.54\mu H$ $Q=100$ $F=28MHz$ $c=24.3pF$
- cap 2 $C=243pF$
- slc 2 3 $l=1.54\mu H$ $Q=100$ $F=28MHz$ $c=24.3pF$
- cap 3 $c=317pF$
- slc 3 4 $l=1.54\mu H$ $Q=100$ $F=28MHz$ $c=24.3pF$
- cap 4 $c=243pF$
- slc 4 5 $l=1.54\mu H$ $Q=100$ $F=28MHz$ $c=24.3pF$
- cap 5 $C=110pF$

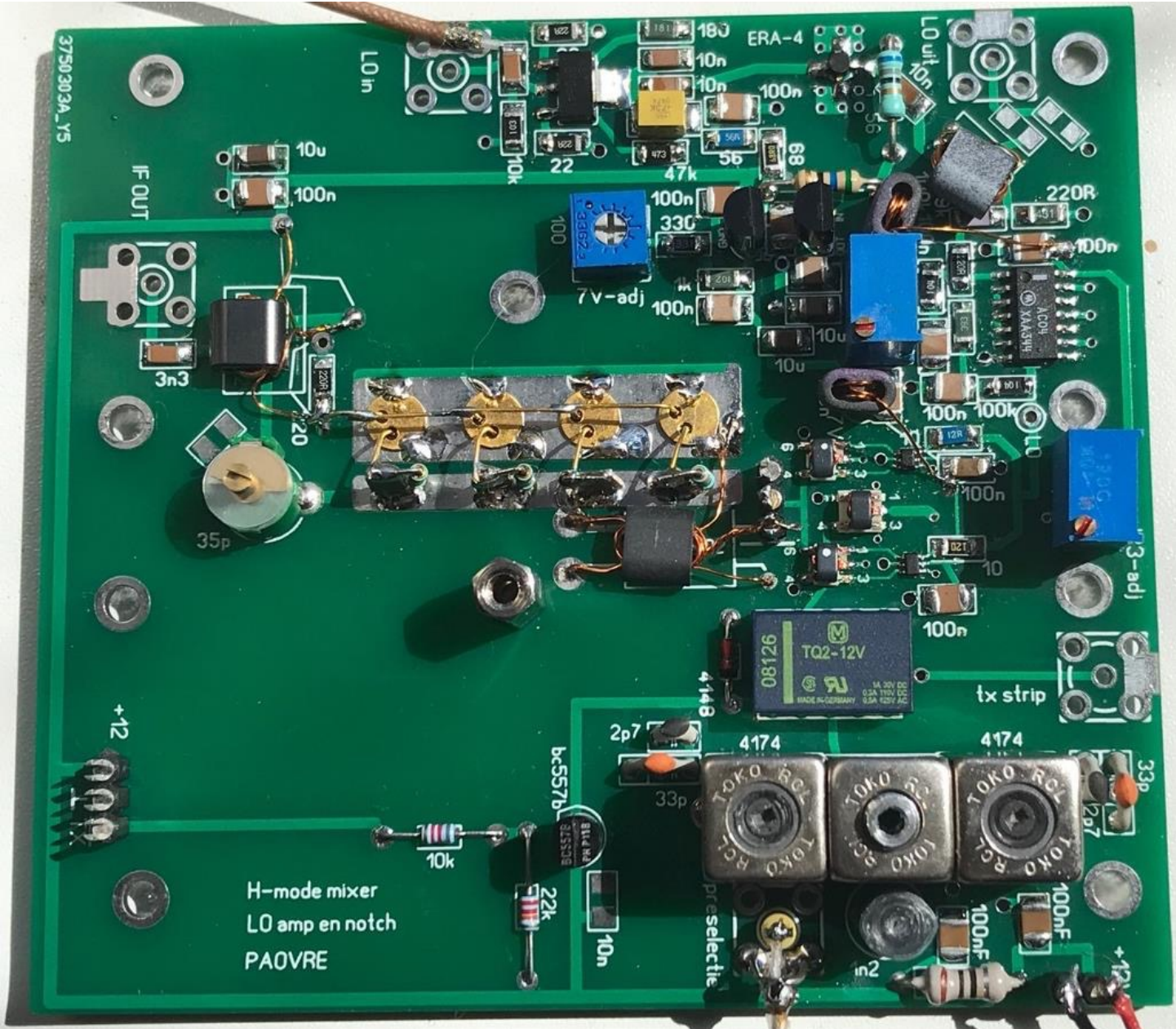
bpf10M:2POR 1 5
 END

FREQ
 STEP 25MHz 35MHz .05MHz
 END

MS21 [dB] BPF10M



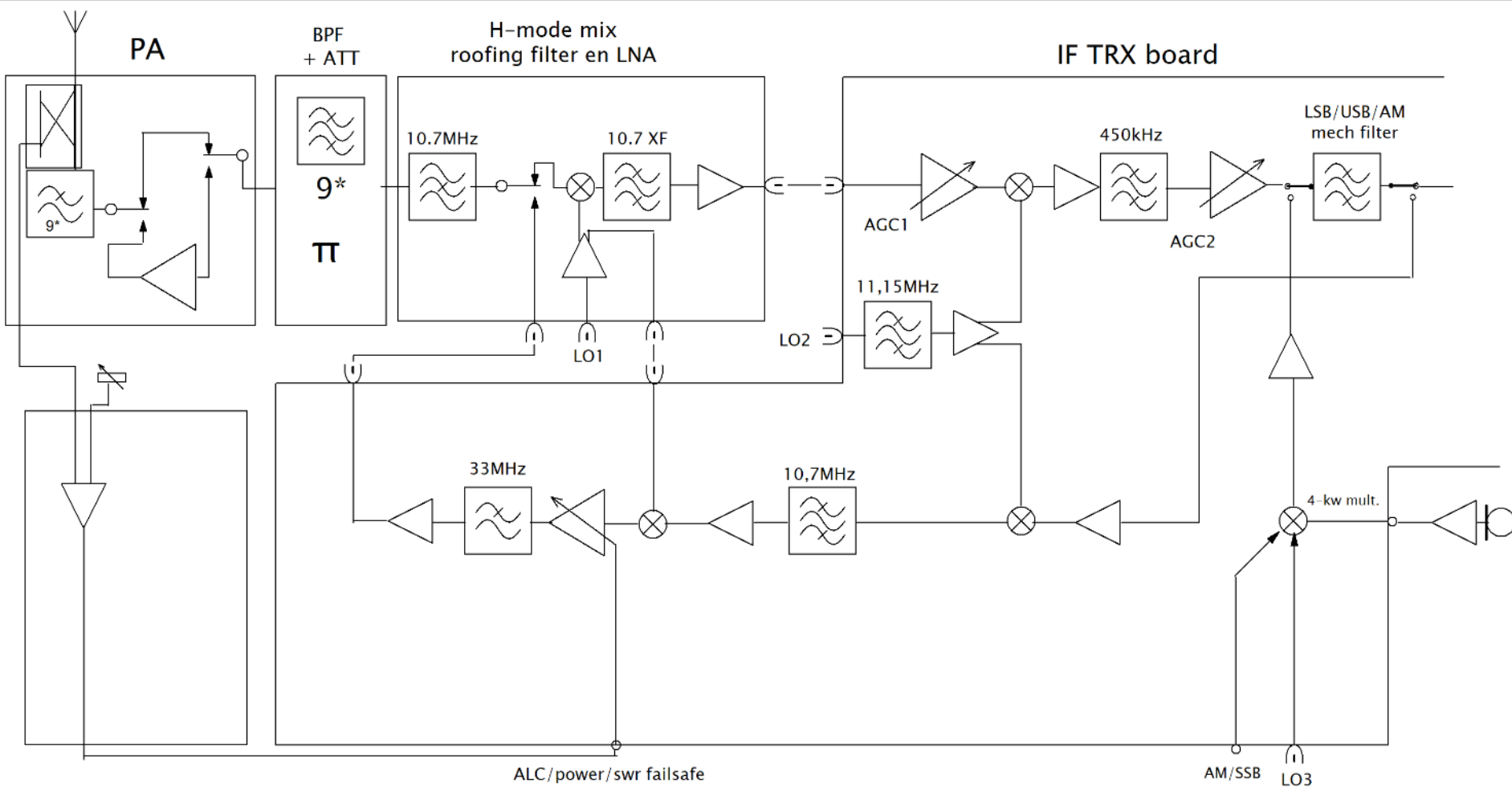
H-mode mixer + 10.7 notch + LNA



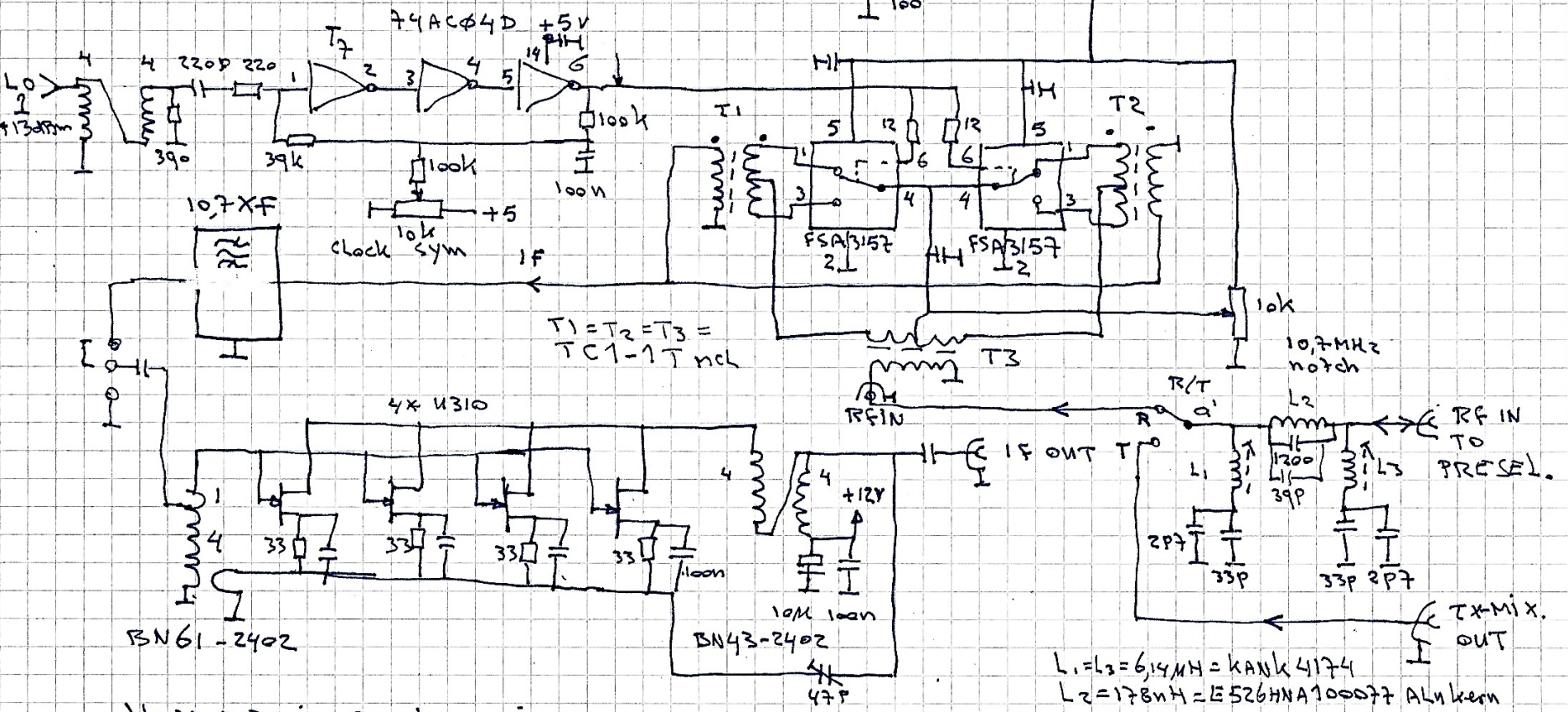
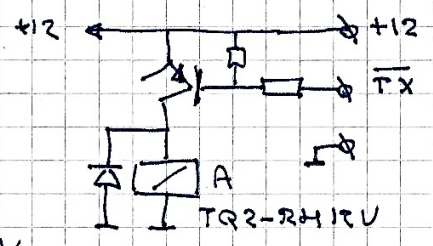
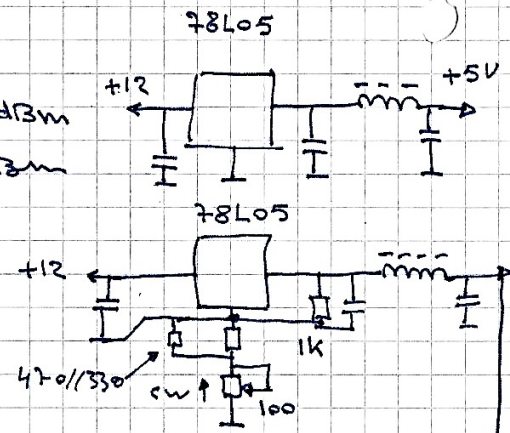
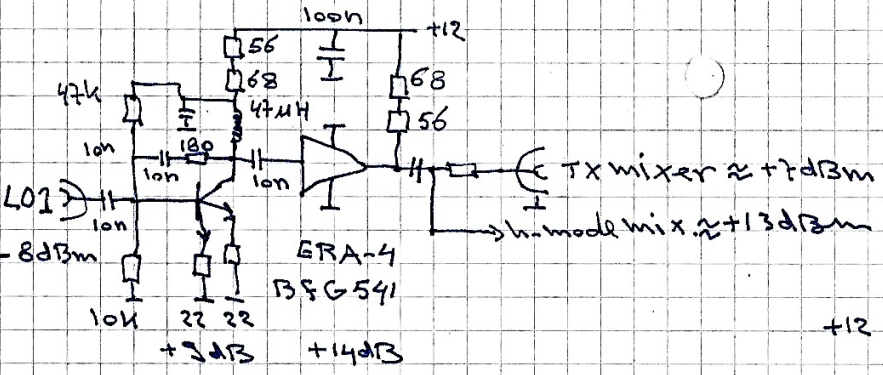
H-mode mixer
LO amp en notch
PAOVRE

pre selective

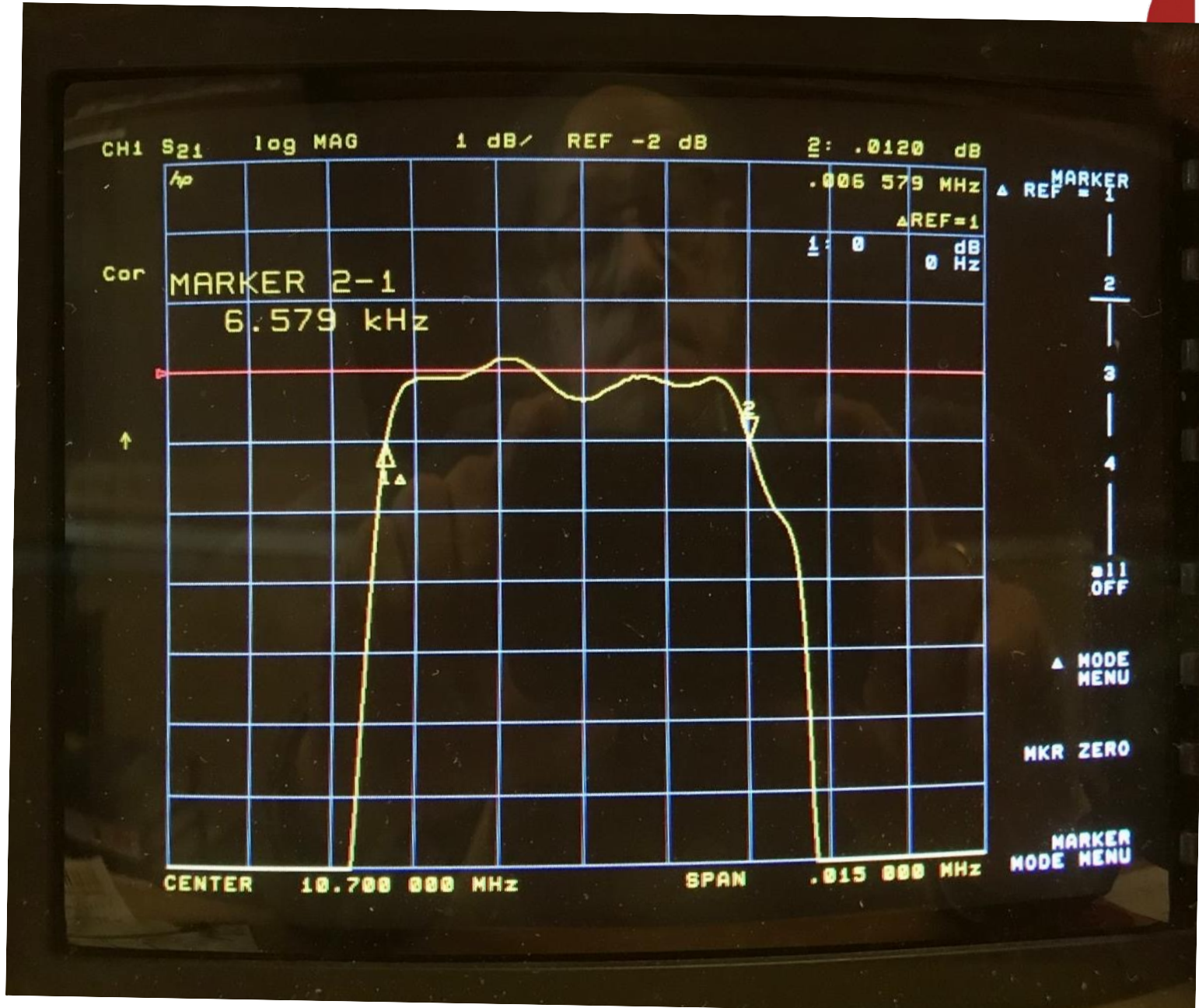
tx strip



concept HF TRX PA0VRE

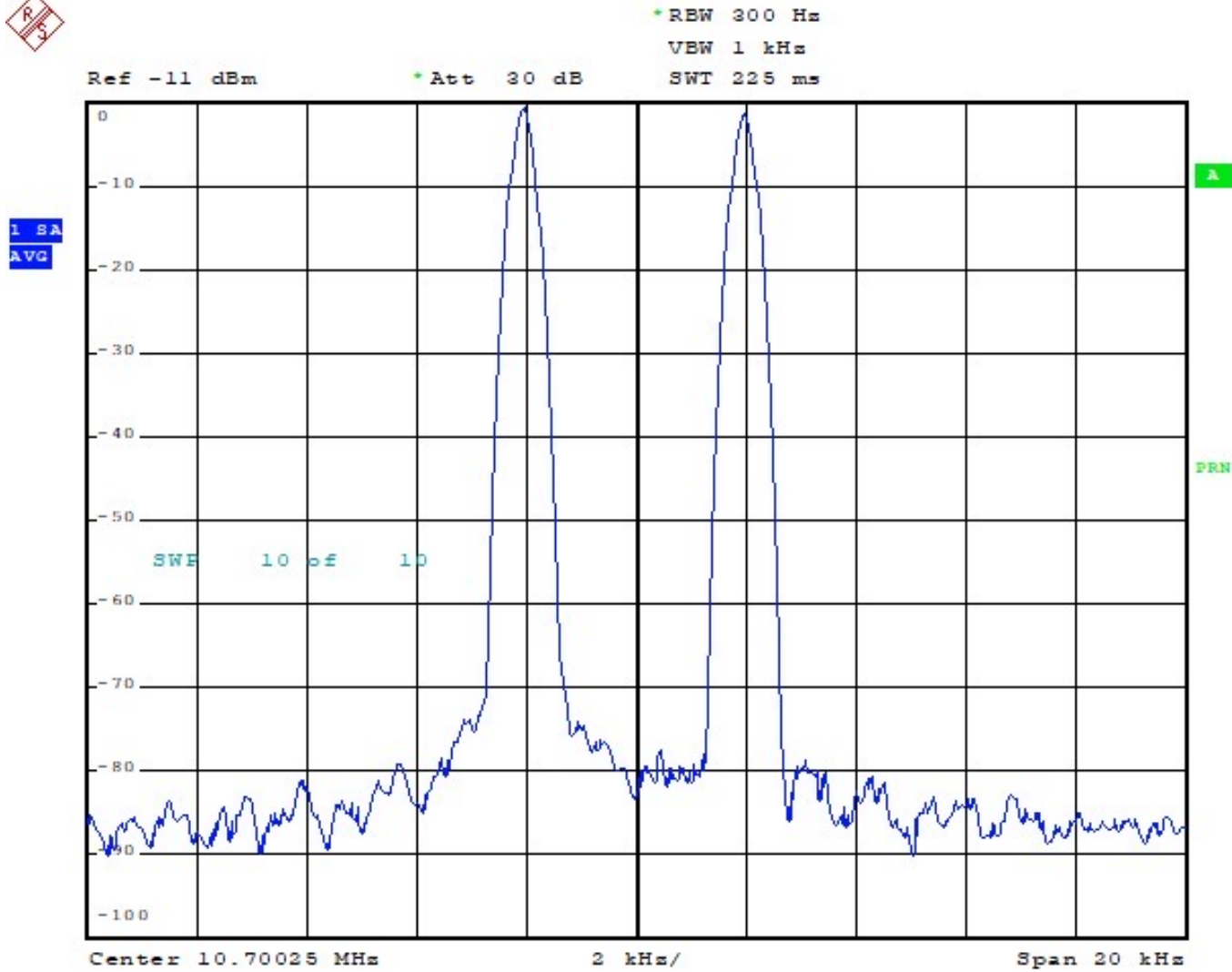


H-MODE MIXER \approx Low noise amp.
 PA ØVRE 2022



IMA₃ H-mode mixer

IP_{3 in} > 37dBm, 45 wordt gespecificeerd



Comment: ref 70

Date: 17.MAY.2022 13:35:04

2 carriers van -11dBm aan de uitgang van de h-mode mixer (vóór het roofing filter) betekent 2 maal -1dBm aan de antenne ingang.

Dat komt overeen met 2 signalen van elk $S9 + 72\text{dB}$ of $2 * 1585 = 3170$ carriers van $S9 + 40$ waarbij de IMA_3 dezelfde afstand heeft als in getoonde meting!

(signaal energie hetzelfde, $10^{\exp(3,2 * 2)} = 3170$)

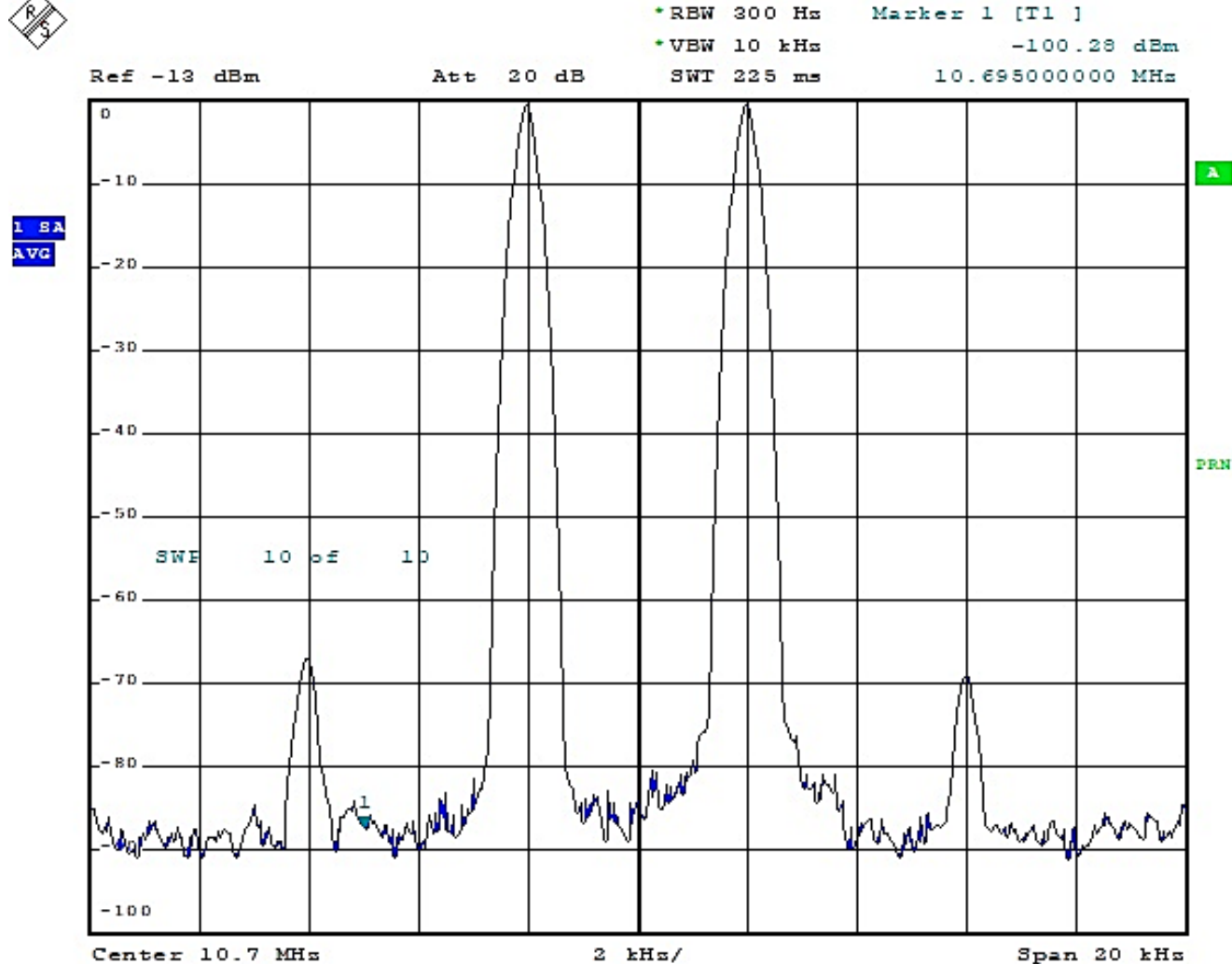
Zoveel passen er niet in de bandbreedte van een amateurband, die is gemiddeld 500kHz of minder breed en dan is er ruimte voor $500/4=125$ SSB signalen, het bandplan buiten beschouwing gelaten.

Dus IM problemen zijn niet te verwachten.

AGC regelbereik ruim kiezen om dynamisch bereik te ondersteunen

BF991 AGC versterker IMA₃

-19dBm (30mV) is max. Signaal niveau in laatste IF trap, eerdere secties veel lager



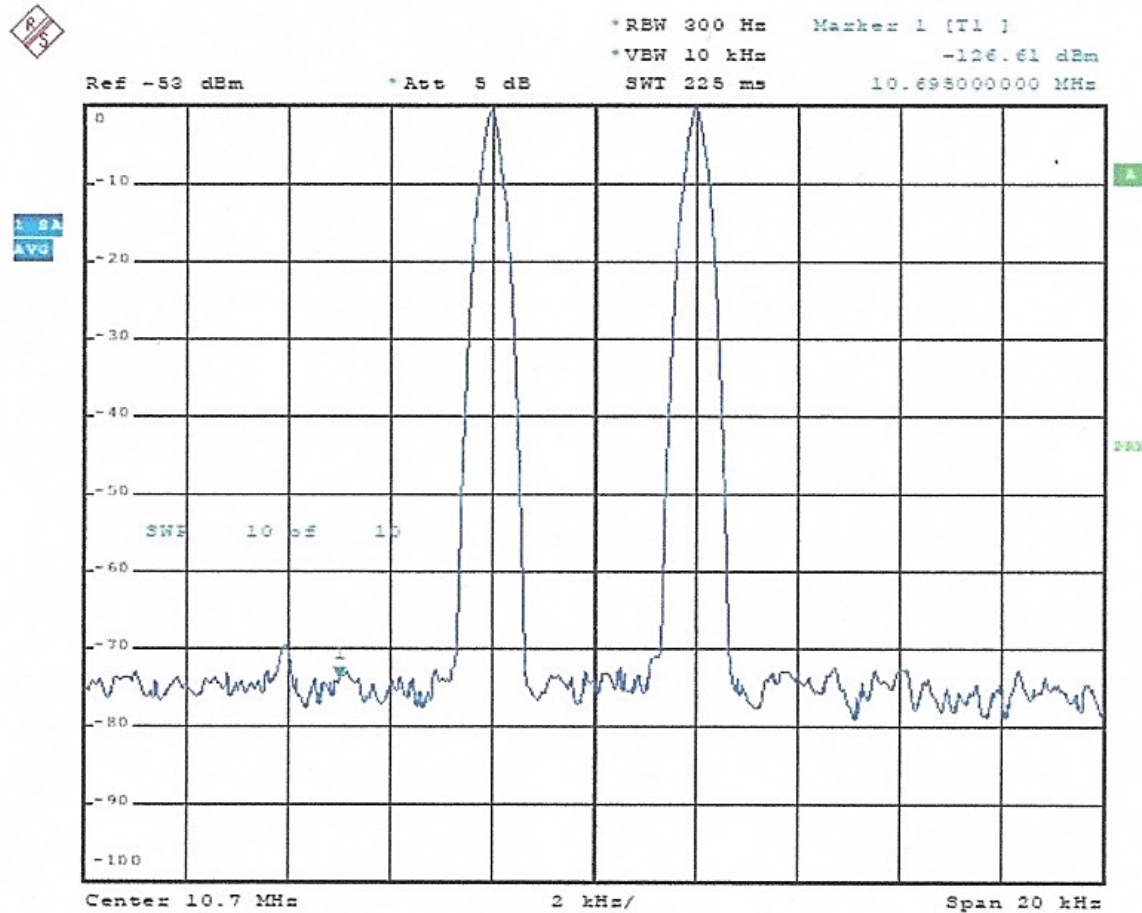
Comment: ref 70

Date: 14.MAY.2022 16:20:30

Regelbereik BF991

AGC regelbereik: $S9+60$ in=50mV dat resulteert in ca.50mV @10,7MHz $20 \cdot \text{LOG}[30\text{mV}/50\text{mV}] = -4,5\text{dB}^*$;
 van -4,5 tot 89 dB= 93,5 dB dus regelbereik minimaal 94dB.*)

30mV is demodulator aansturing.
 3 stuks BF991 regelt meer dan 120dB

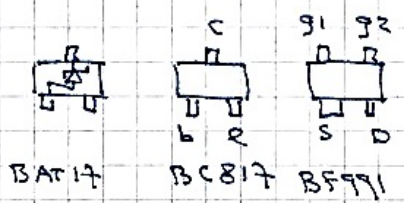
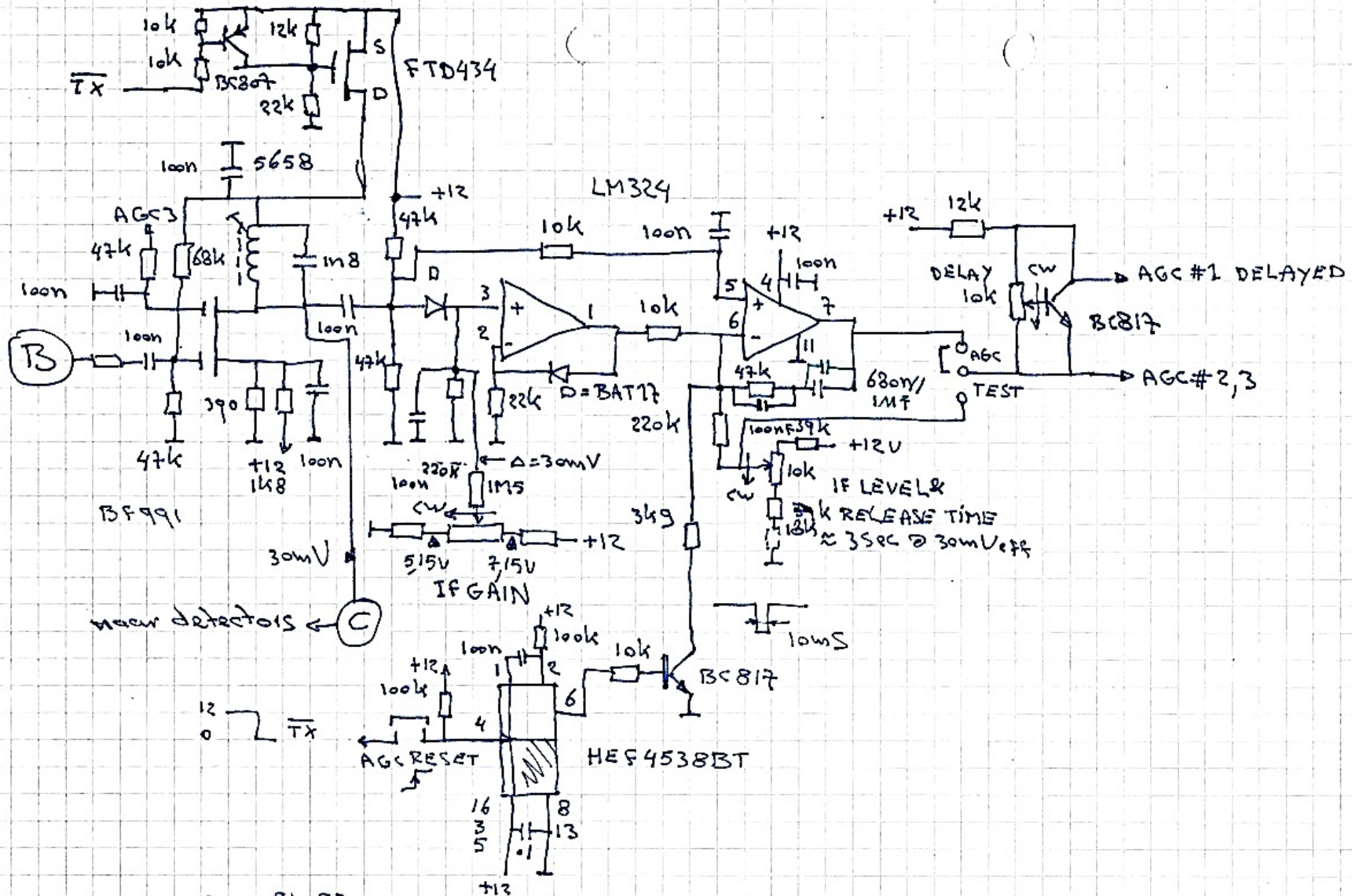


Comment: ref 70
 Date: 14.MAY.2022 16:35:34

2 maal -53dBm (AGC -40dB t.o.v. maxgain)

TX/RX MF, AGC, AM/SSB modulator en demodulatoren





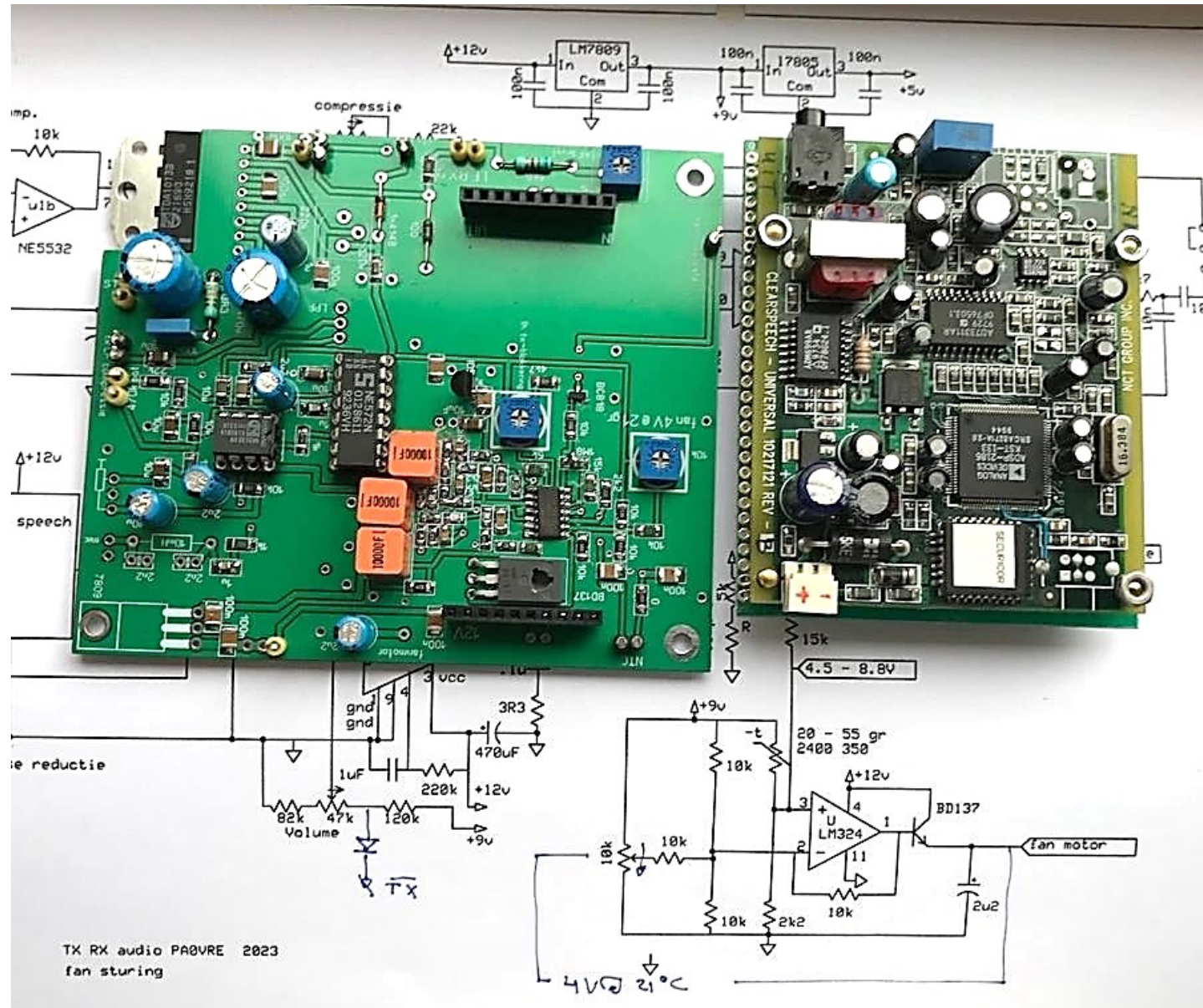
AGC SYSTEM

JUN '22
PAΦVRE

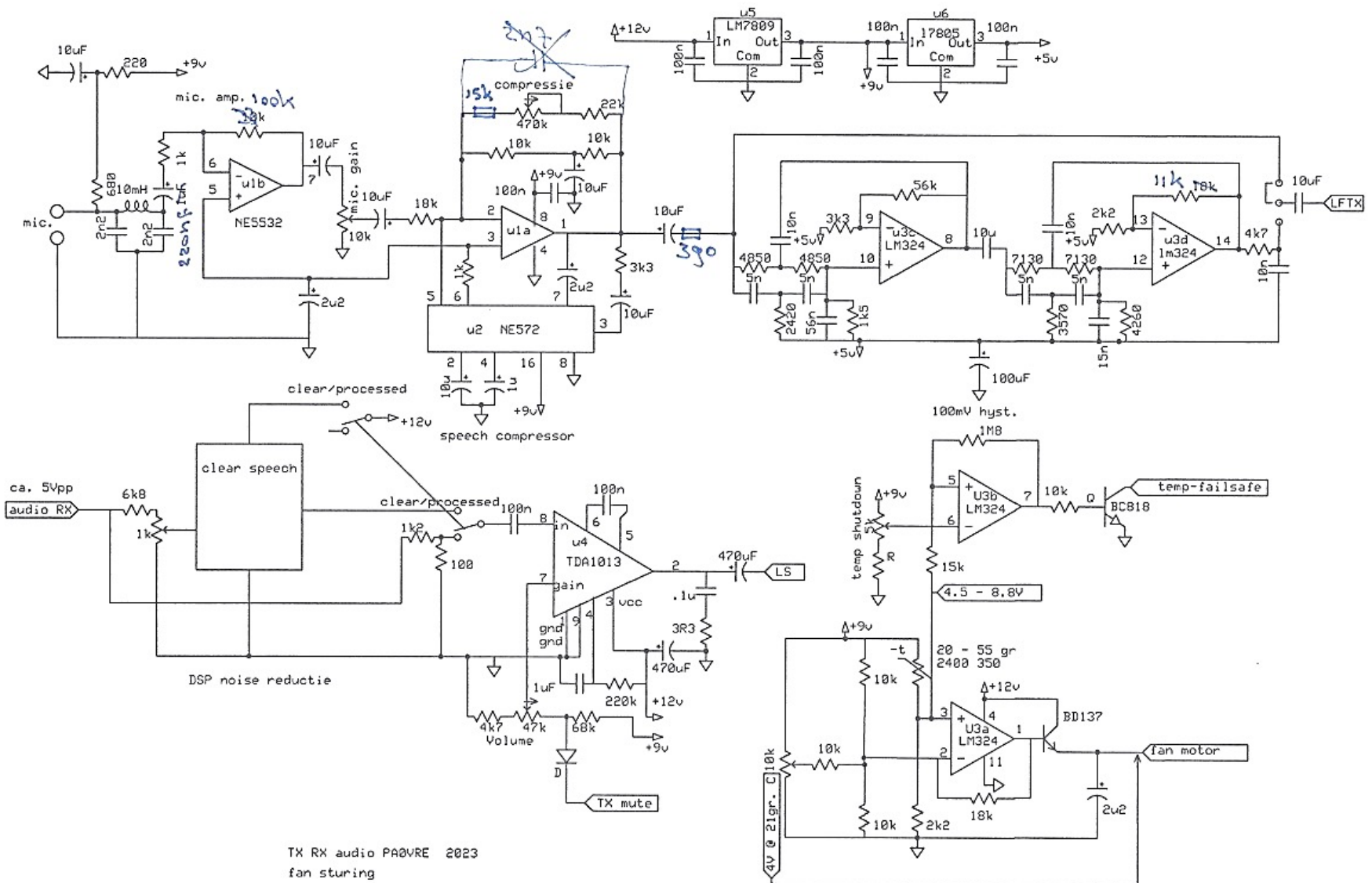
Attack en release time AGC



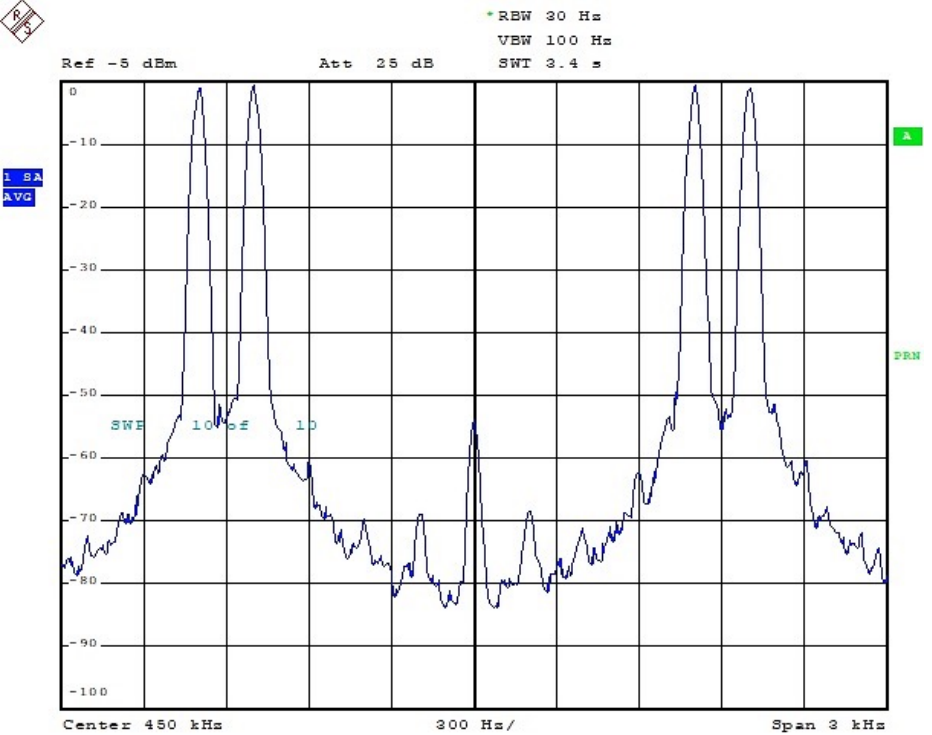
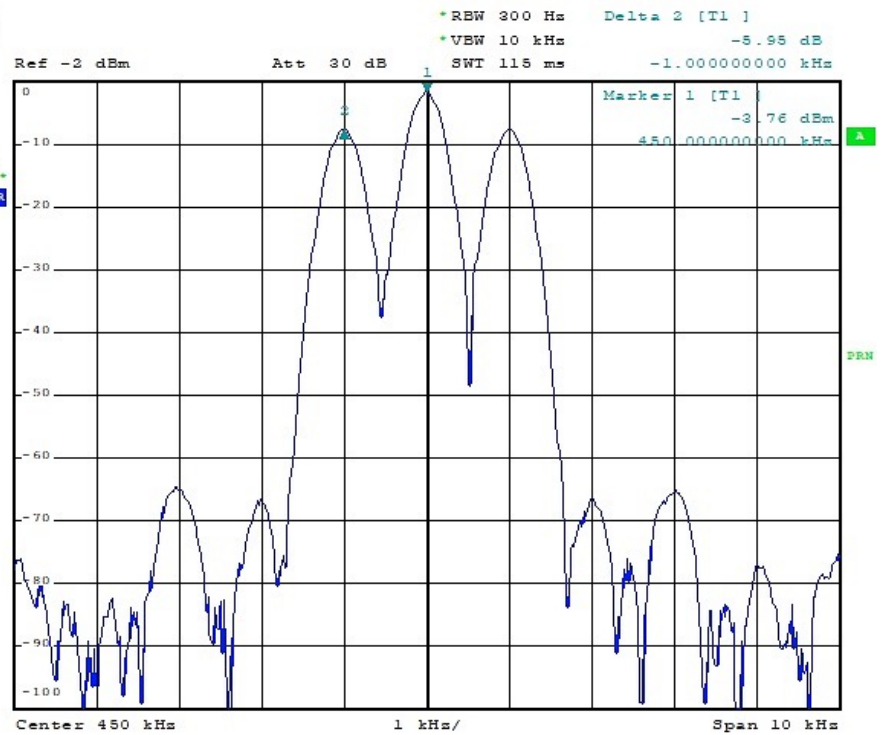
Audio TX + RX sectie



Audio RX en TX



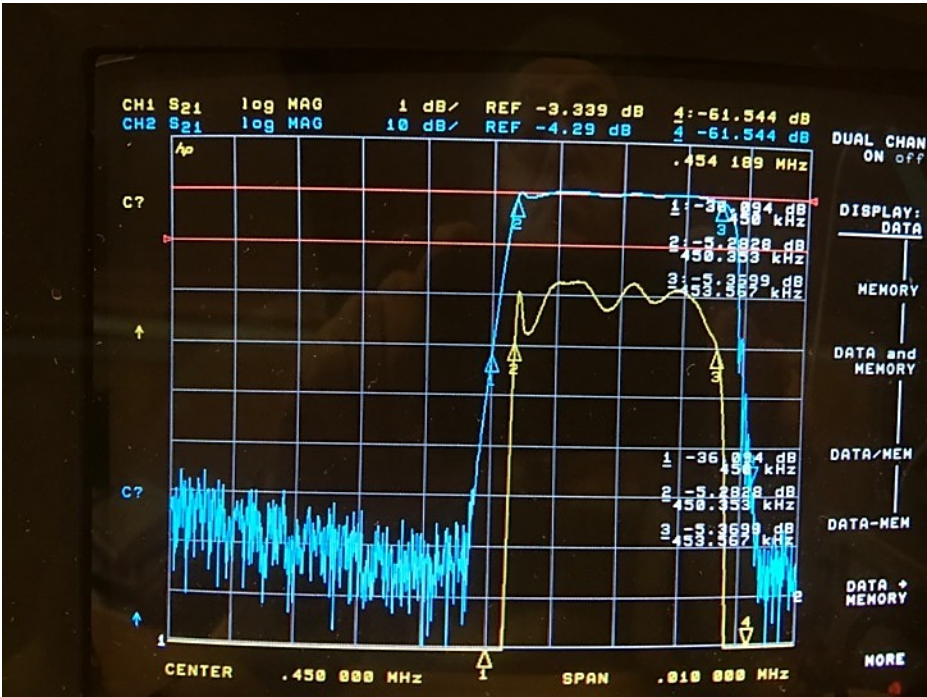
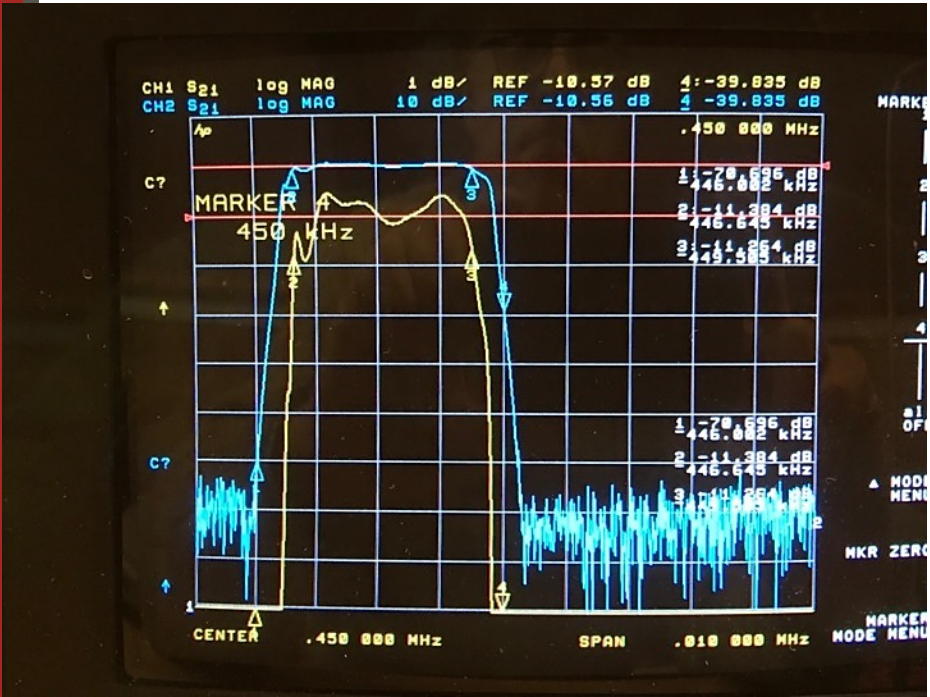
AM, CW en DSB-SC modulator



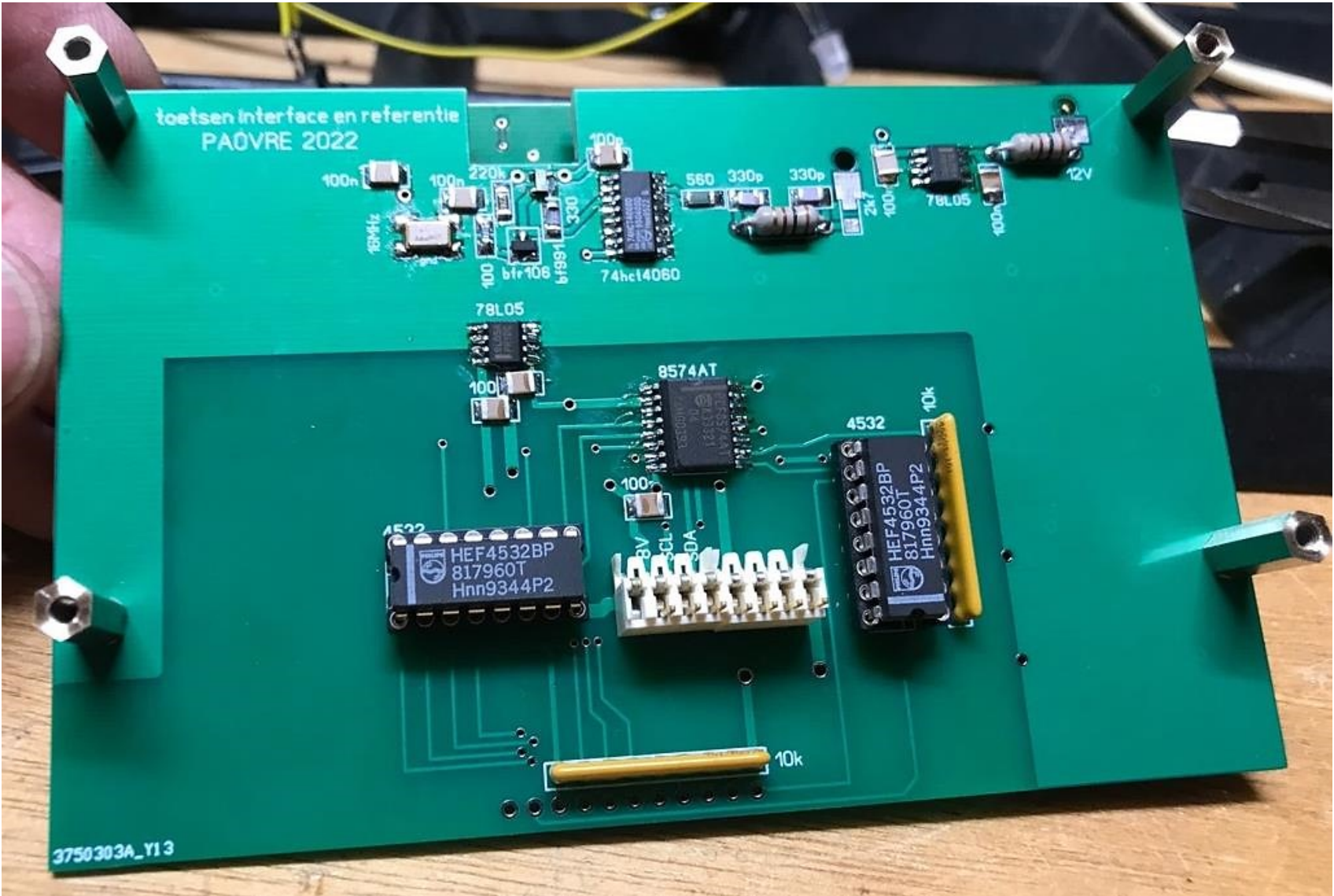
Comment: ref 70
 Date: 17.JUN.2022 15:38:27

Comment: ref 70
 Date: 17.JUN.2022 13:27:22

LSB en USB selectiviteit na modulatie



Int. Ref. en bandkeuze



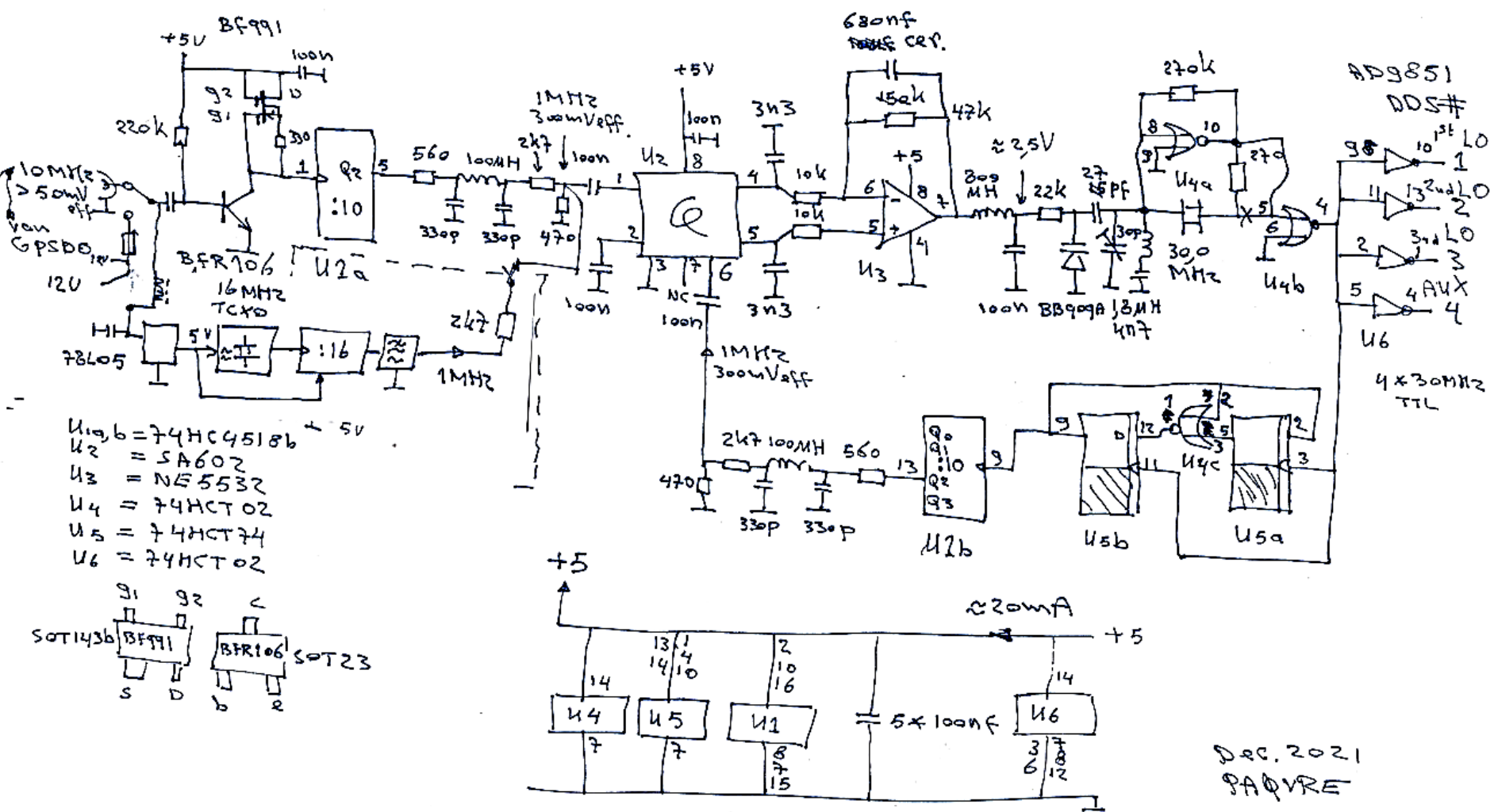
10->30MHz PLL & 4 maal DDS



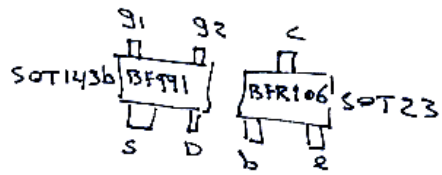
10->30MHz PLL- 4*DDS



GPS Locked 30 MHz DDS Clockgen.

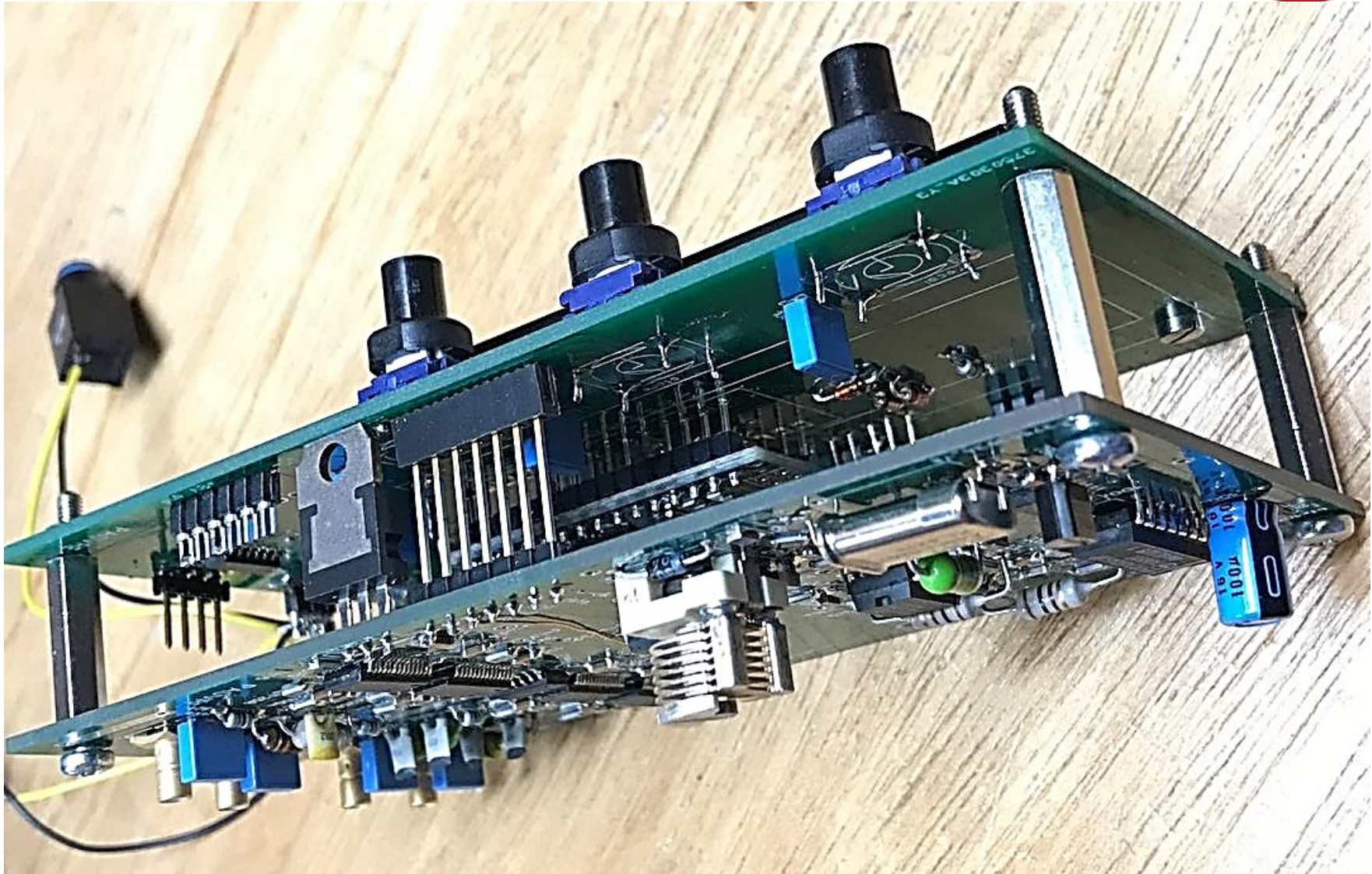


- U1a,b = 74HC4518b + 5V
- U2 = 5A602
- U3 = NE5532
- U4 = 74HCT02
- U5 = 74HCT74
- U6 = 74HCT02

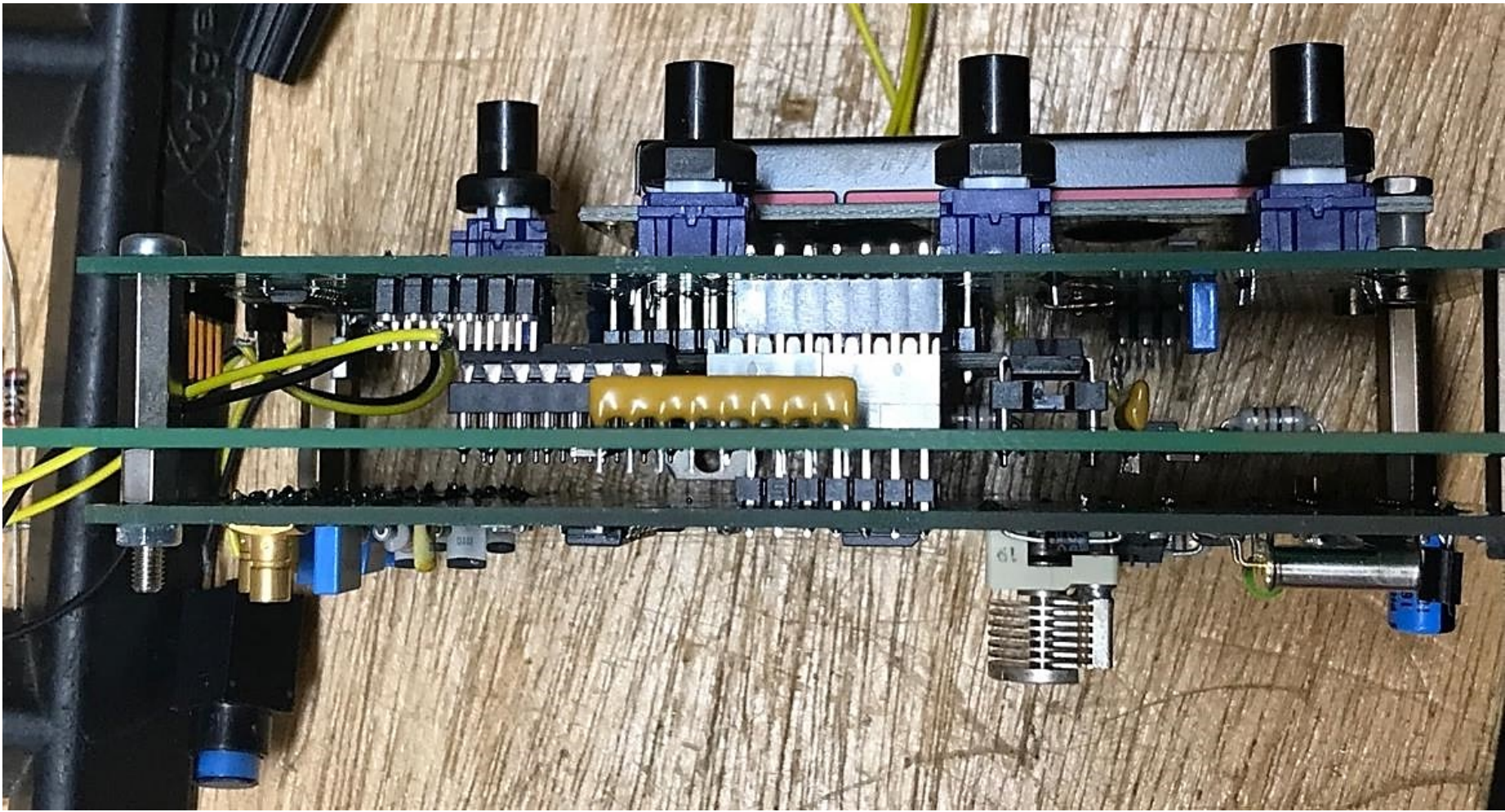


Dec. 2021
PAQVRE

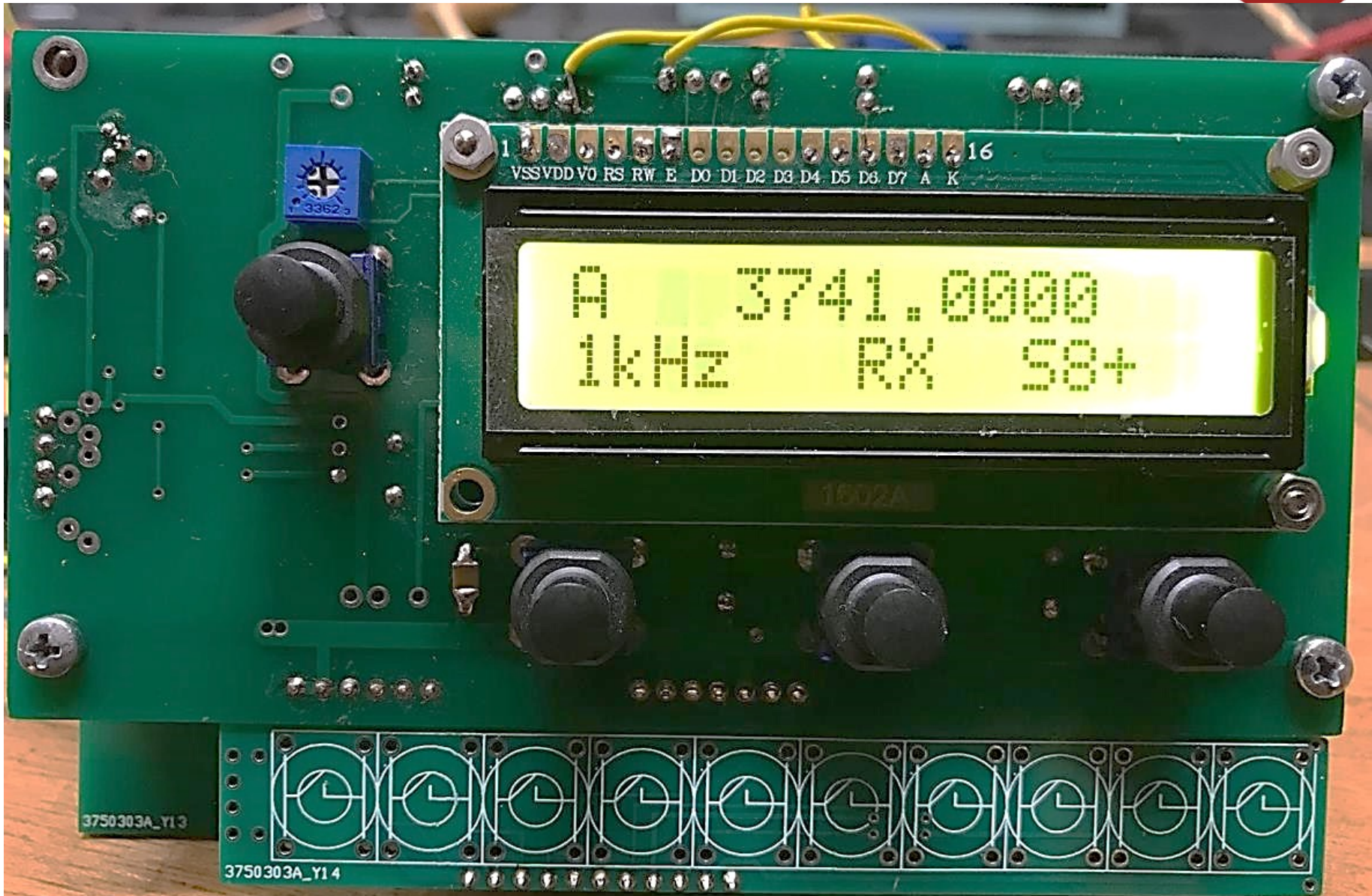
Arduino nano controller +DDS pcb



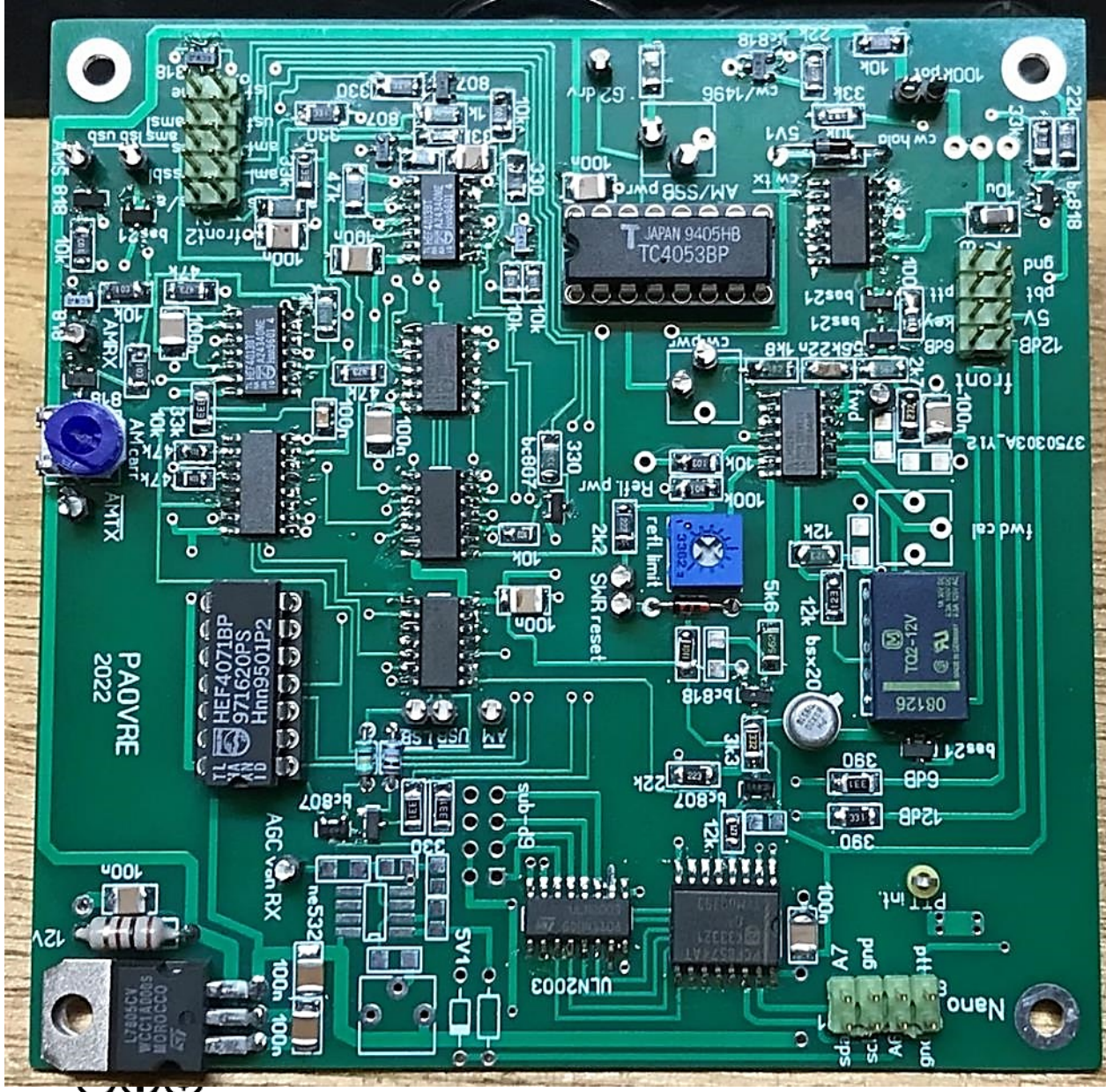
De bandkeuze + int. Referentie ertussen geplaatst



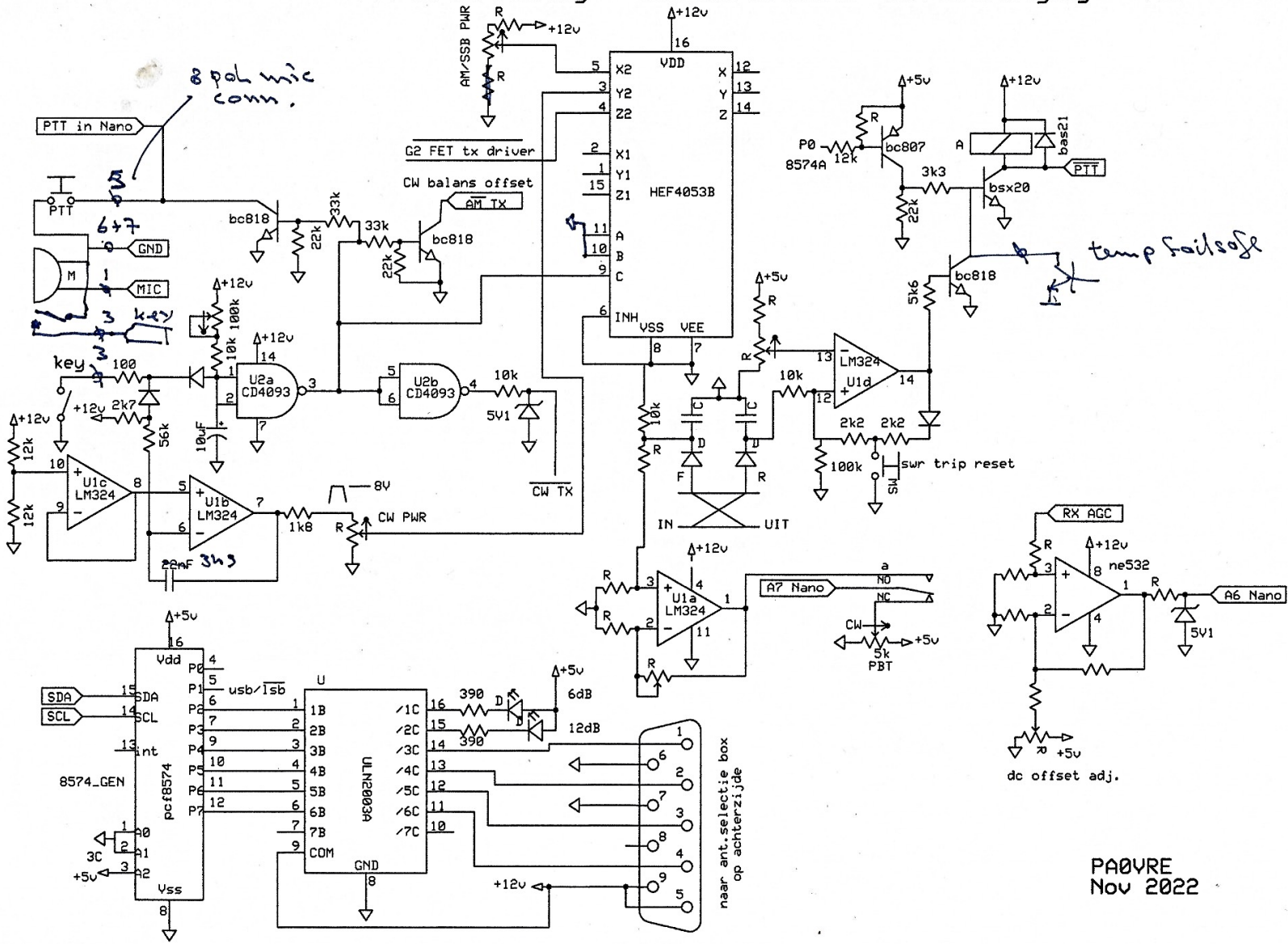
Resultaat:



Logica tbv overige functies buiten uP om



PTT en CW sturing antenne selectie SWR beveiliging PBT

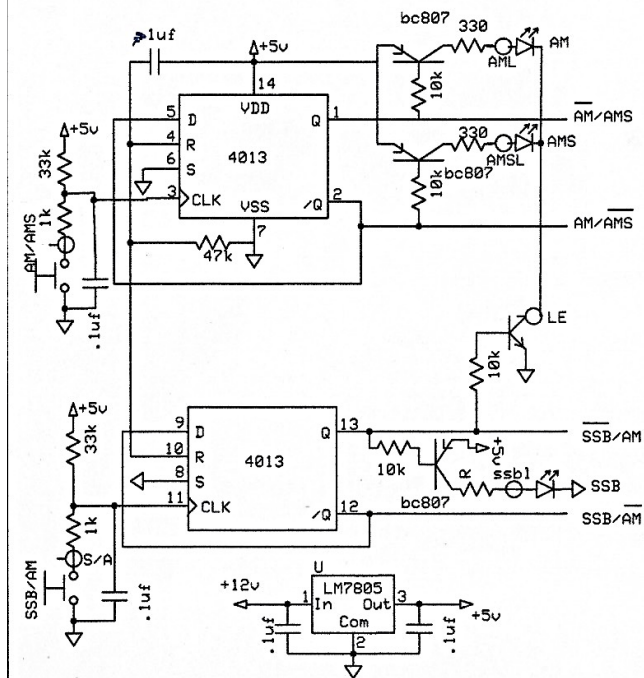
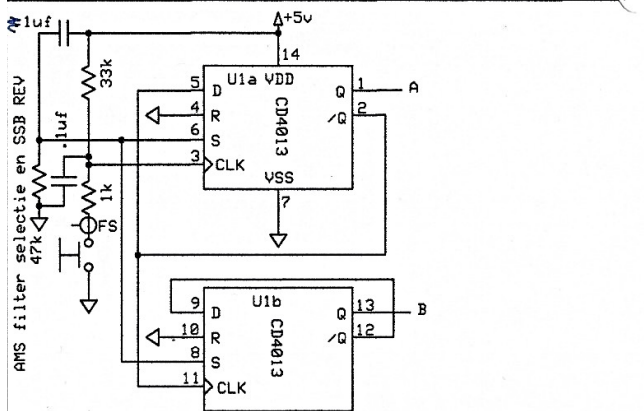
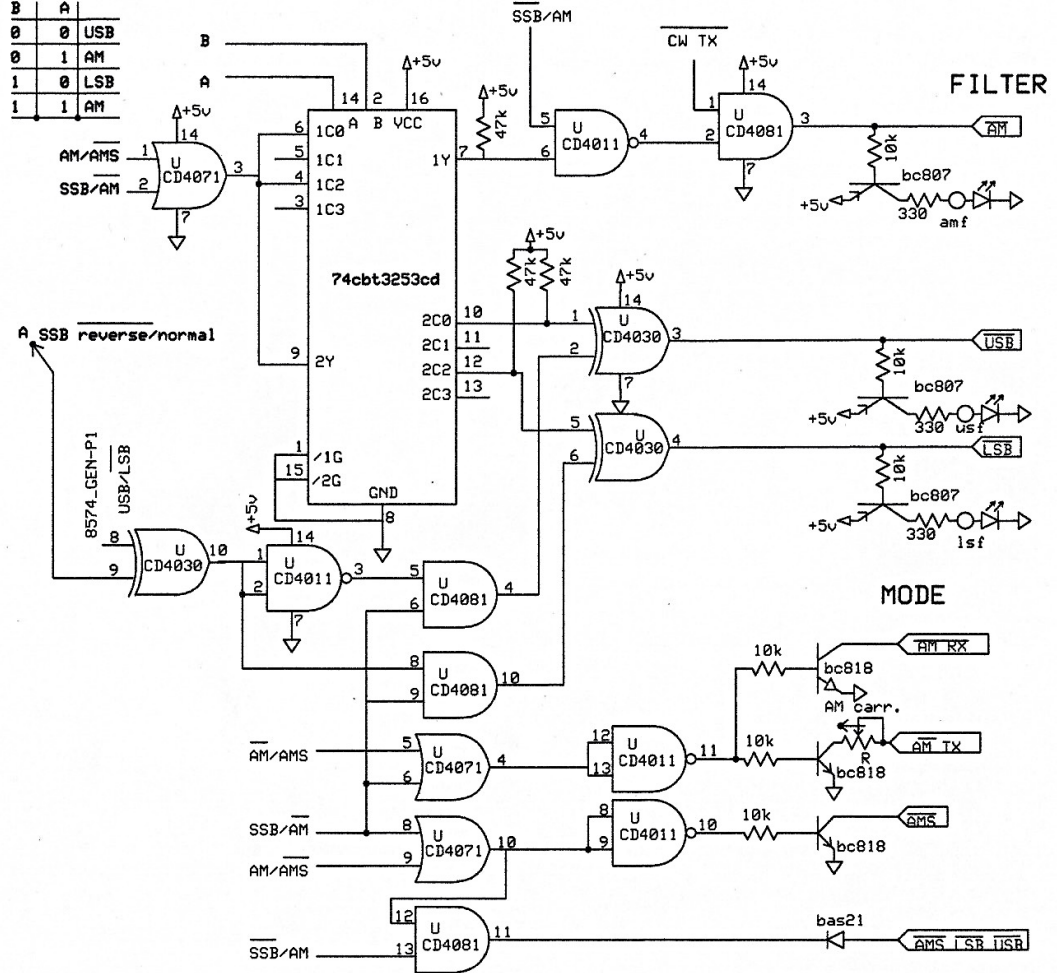


PA0VRE
Nov 2022

MODE EN FILTER SELECTIE

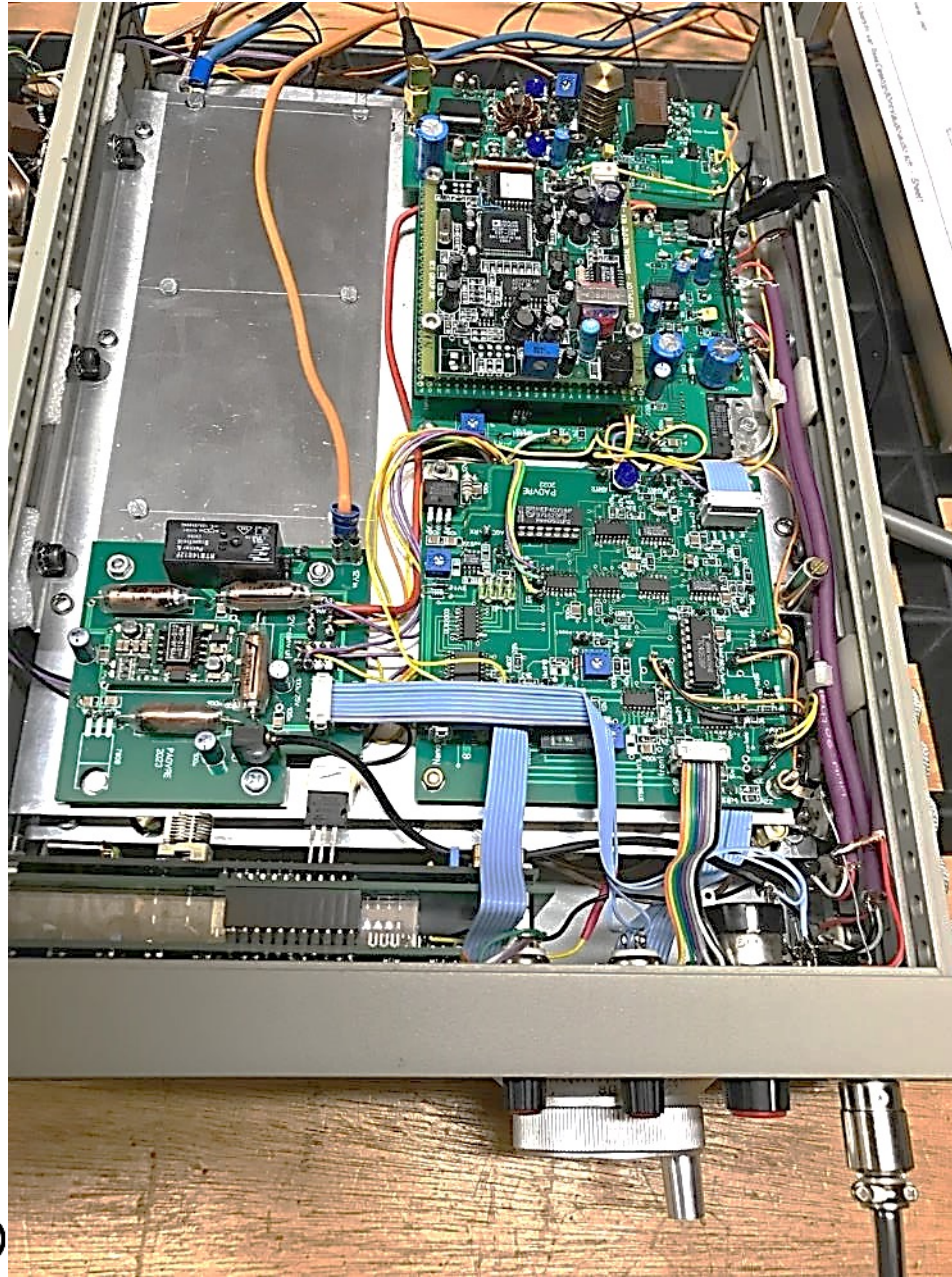
AMS
filtersel.

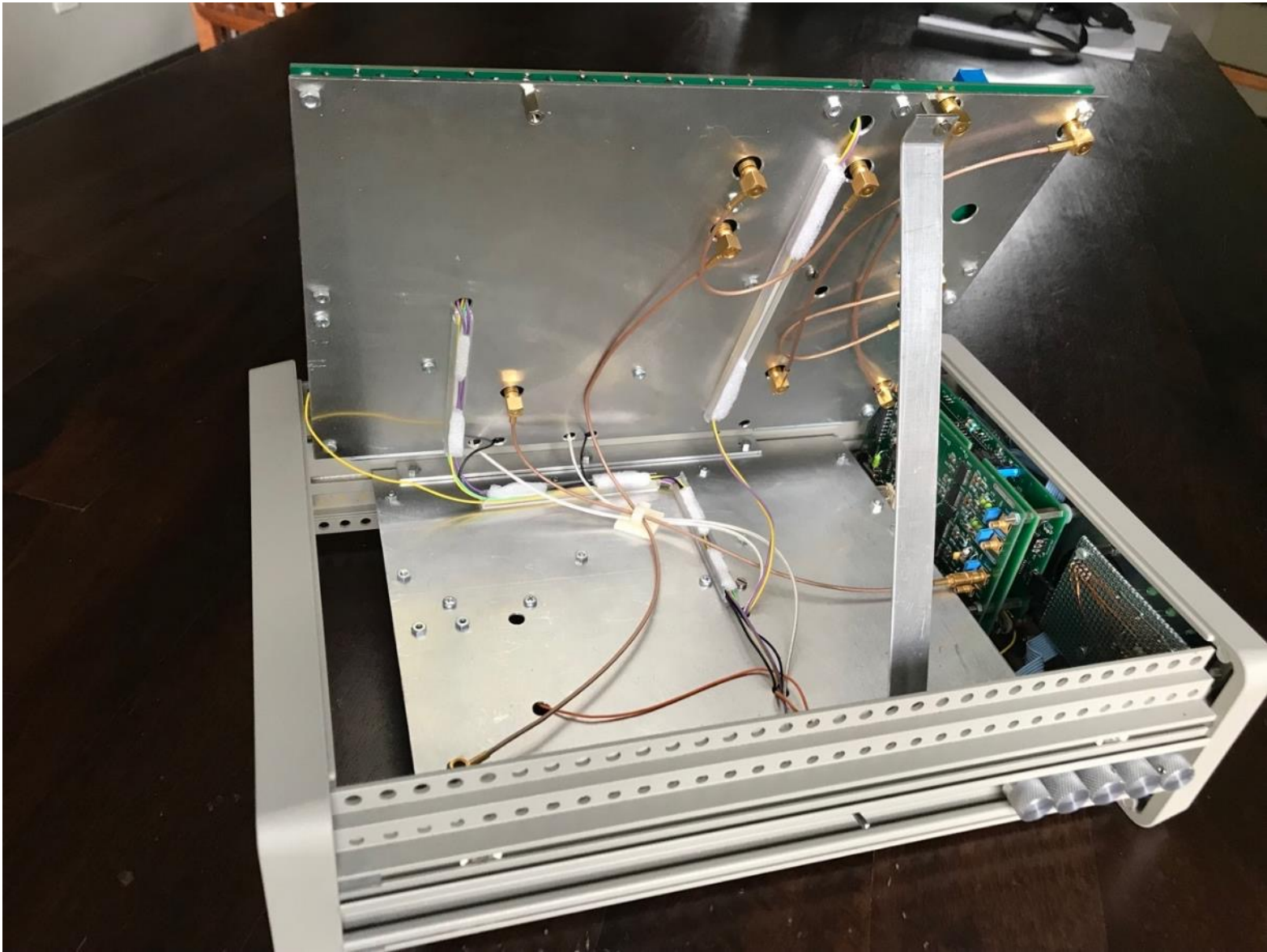
B	A	
0	0	USB
0	1	AM
1	0	LSB
1	1	AM





Onderkant per eind augustus-23



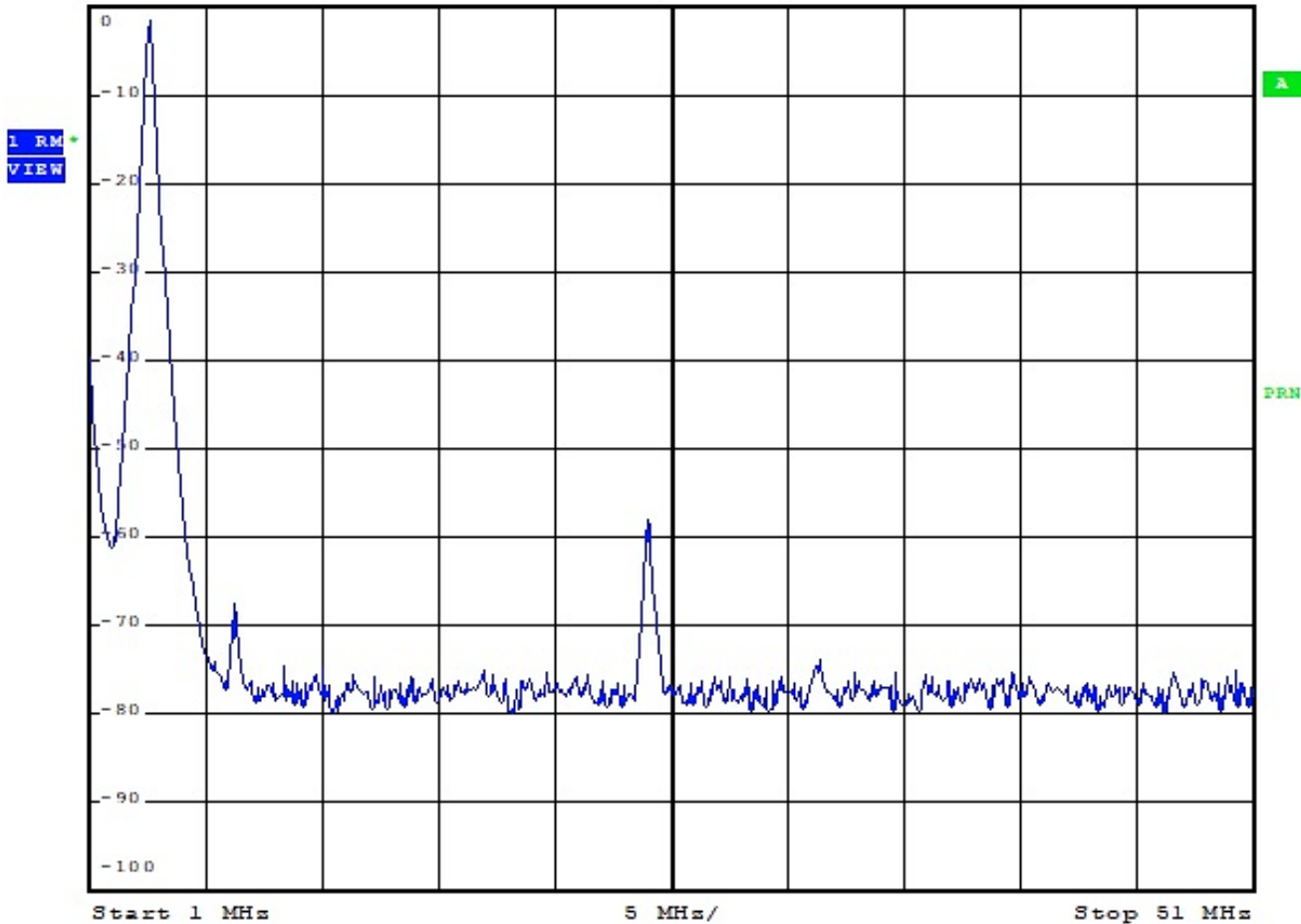


Uitgangsspectrum 3,6MHz@ 0dBm niveau filterprint



*RBW 300 kHz
*VBW 30 kHz

Ref 1 dBm *Att 25 dB SWT 15 ms

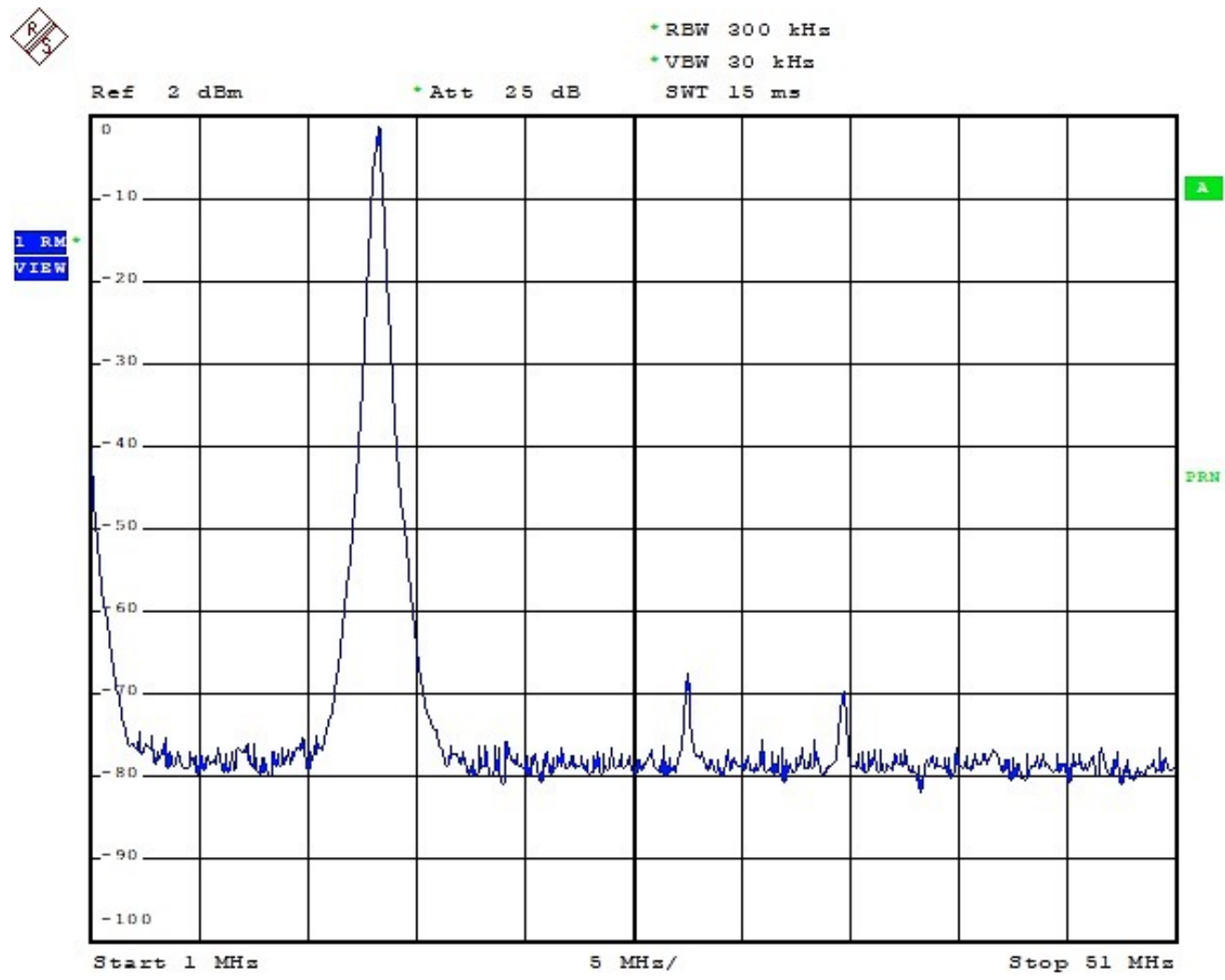


Comment: ref 70

Date: 3.OCT.2022 16:30:13



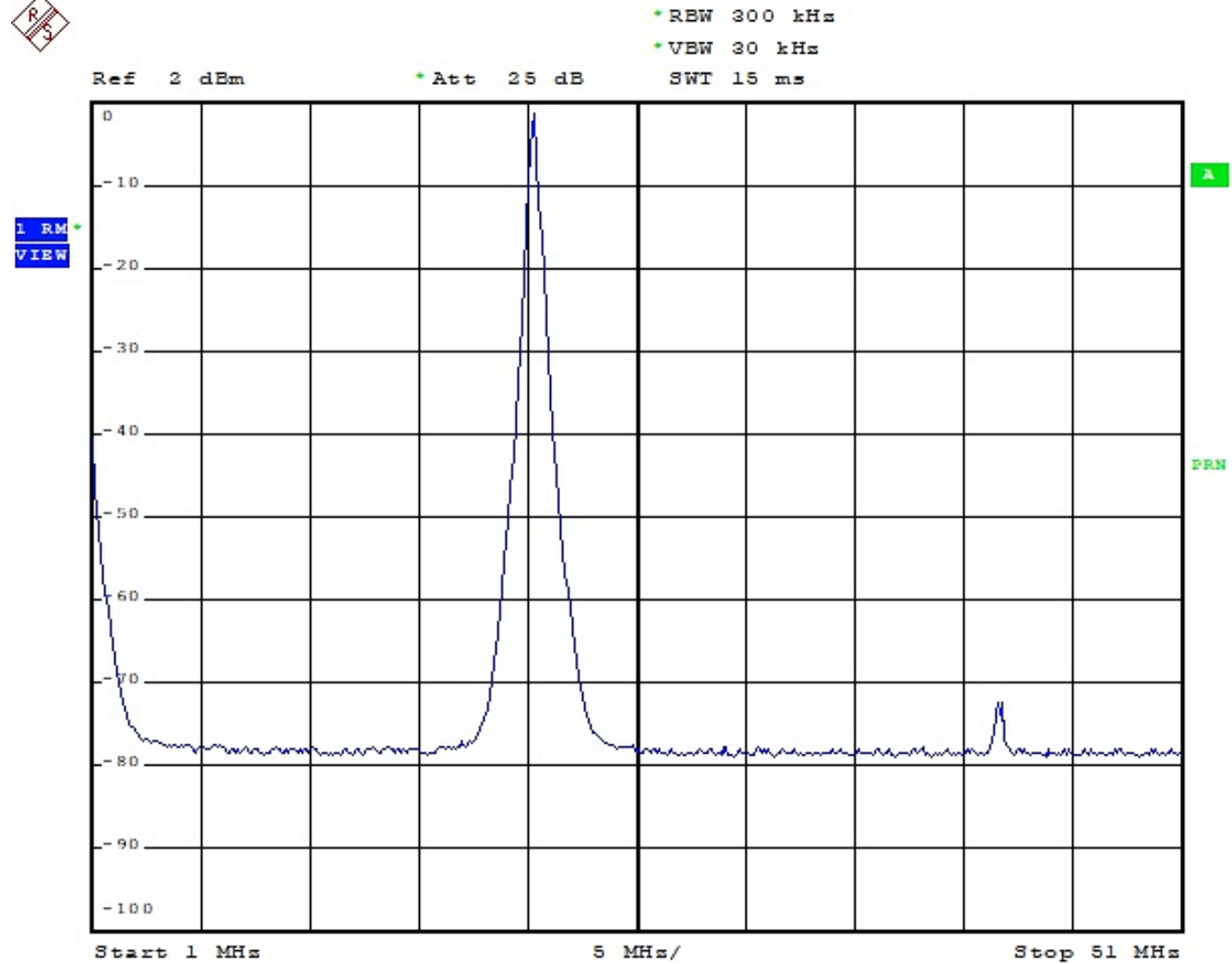
Uitgangsspectrum 14MHz@ 0dBm niveau van MF trx print



Comment: ref 70
Date: 3.OCT.2022 16:28:22



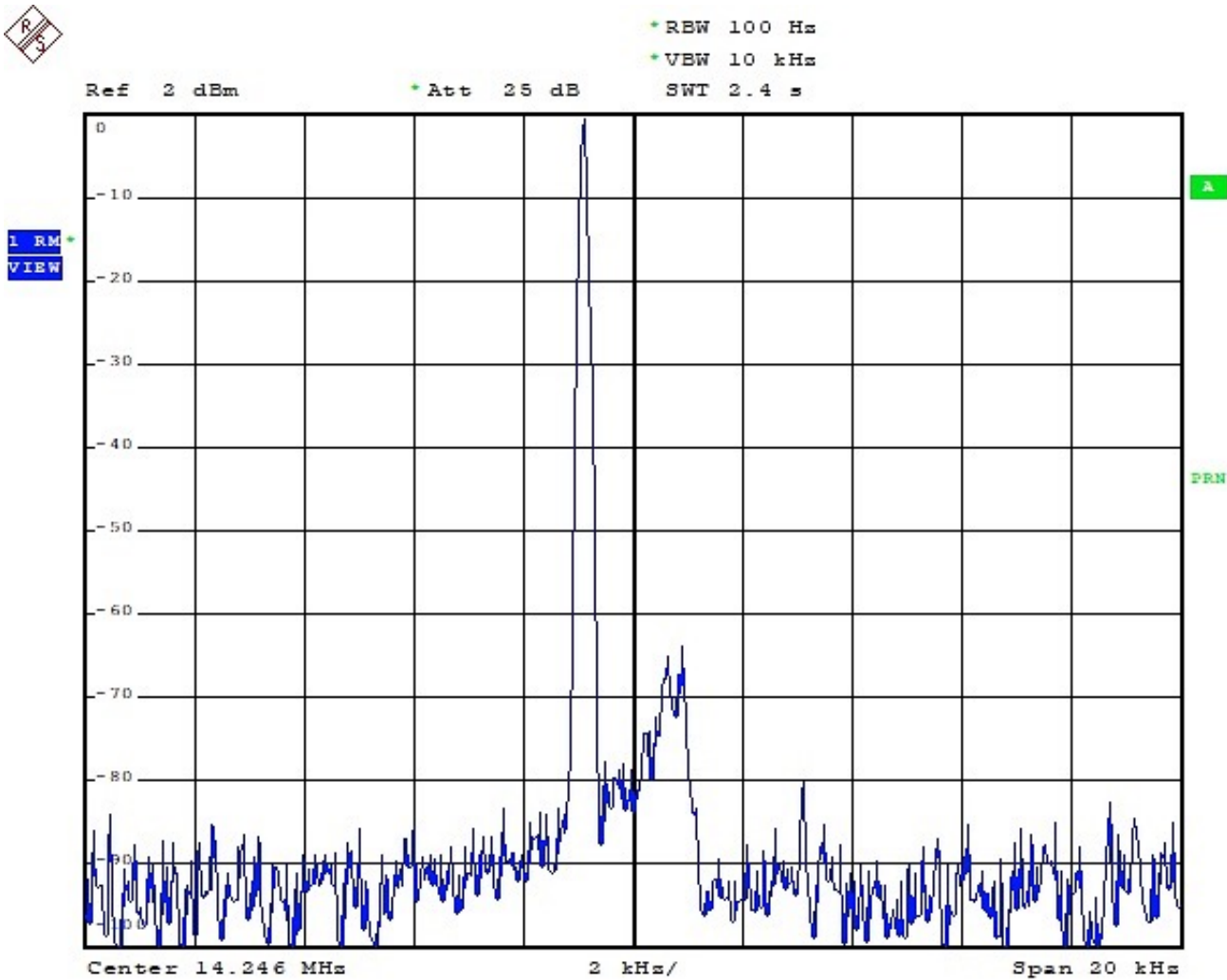
Uitgangsspectrum 21MHz@ 0dBm niveau van MF trx print



Comment: ref 70
Date: 3.OCT.2022 16:27:34



Uitgangsspectrum 14,2MHz @ 0dBm met 2000Hz modulatie



Comment: ref 70
Date: 3.OCT.2022 16:50:24

