Assembly instructions PE1JPD 23cm NBFM transceiver V2.1

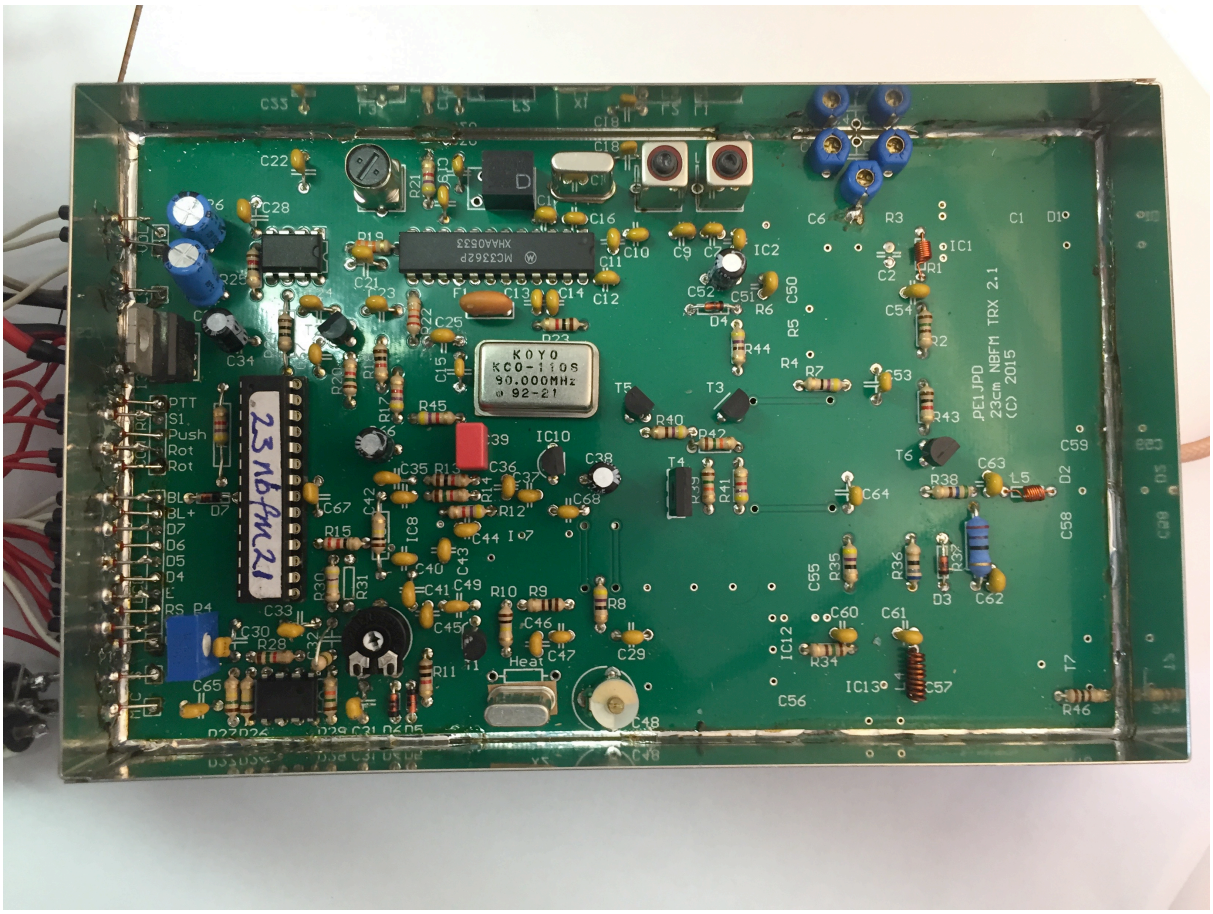


Figure 1 - Version v2.1 of the transceiver.

Introduction

Thank you for purchasing the PE1JPD 23cm FM transceiver kit. This kit is a complete transceiver for the 23cm amateur band, from 1240 to 1300 MHz. The supported modulation is (narrow band) FM, and the frequency step is 25 kHz. It is designed for simplex and repeater communication. For repeater usage, the shift is default -28 MHz, but any shift can be chosen via the menu. Normally in the EU, repeater transmit high in the band (1298-1299 MHz) and receive 28 MHz lower, so between 1270 and 1271 MHz. The noise figure of the transceiver is around 3dB, and the output power is up to 1W, more than enough for repeater usage if a proper antenna is used.

The kit includes all the parts for the transceiver. You only need a microphone, a loudspeaker and of course an antenna.

Controls

The frequency is set by a rotary encoder, which is also used to select menu items and to set values in the menu. The LCD-display shows the current frequency (RX or TX) and an R or T in the bottom right corner when receiving or transmitting. The rest of the bottom line is used for the S-meter. The menu has the following option (software v2.1):

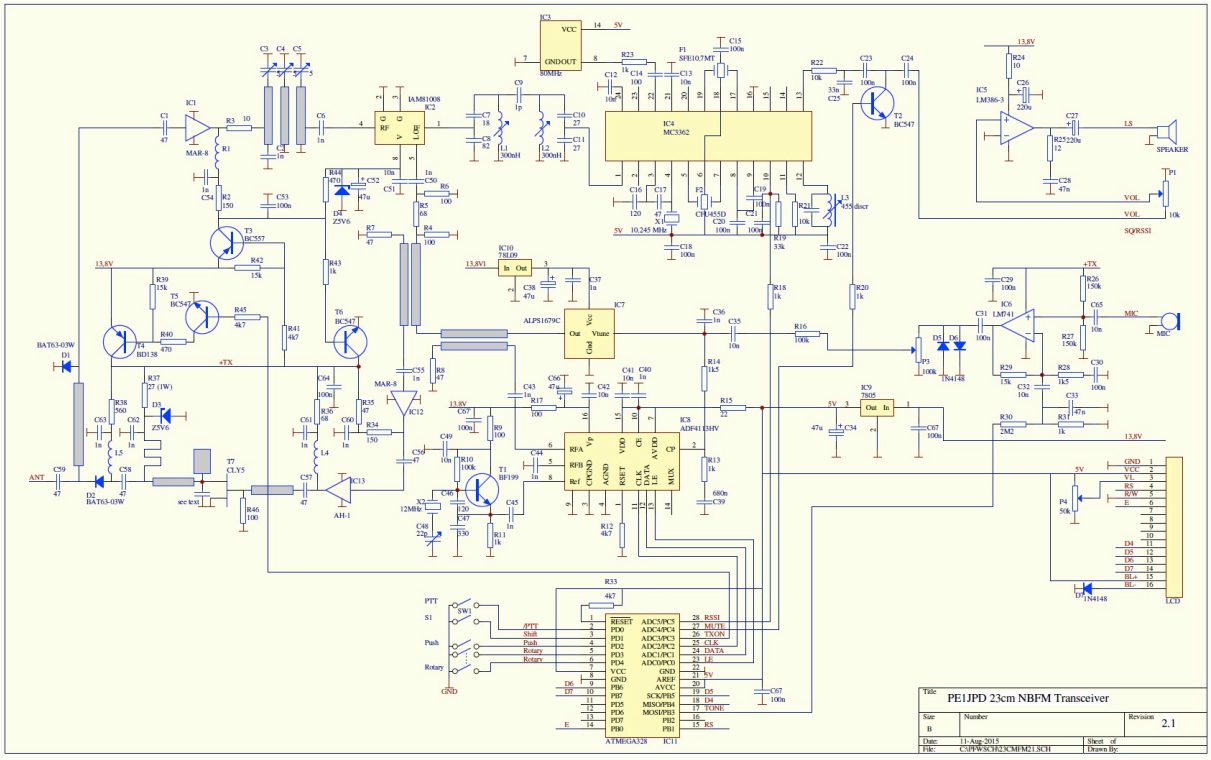
- set mute level (squelch)
- set frequency shift (-30 to +30 MHz)

- set CTCSS tone (65 - 200Hz, <65 Hz is off)

Pressing the rotary switch once enters the menu, and '>' is shown at the first line in the display in front of the menu item. When pressed again, the selected menu-item is chosen and the '>' jumps to the second line, where the value for the menu-item can be set. Pressing again, enters menu mode again, and after selecting back you return to normal usage.

Schematic Diagram

Figure 2: schematic diagram



Central part in the design is the vco (IC7) which oscillates from 1150 tot 1350 MHz. It is locked in a PLL using a ADF4113HV, a modern PLL from Analog Devices. The reference for the PLL is 12MHz, which is generated by a simple crystal oscillator around T1. The PLL is programmed by a microcontroller from Atmel, a ATMEGA328 which also performs various other functions. The output of the vco is 5dBm, which is attenuated by 10 dB befor it is fed into the receive mixer IC2, an IAM81008. This mixer has a gain of 8.5 dB and a noise figure of 17 dB.

The received signal is passed via a PIN-diode antenna switch to the RF preamplifier IC1, a mar-8 which gives around 25 dB gain. The amplified signal is passed via a bandpass filter on 23cm to the receive mixer. The bandpass filter has a antenuation of around 4 dB. The IF signal from the mixer is filter in a bandpass filter at 69.3 MHz and fed into an integrated IF (IC4), an MC3362. In this IF IC, the signal is converted first to 10.7 MHz, by mixing it with 80 MHz from a standard computer crystal oscillator. After filtering in a SFE10.7 (50kHz wide) and amplified, the signal is mixed to 455 kHz and filtered again in a CDU455D (20 kHz wide), or CFU455E (15 kHz wide) and demodulated to audio. The audio is amplified by IC5, an LM386-3 up to 0.5W or so. On pin 10 of the MC3362, a RSSI signal is available and led into the microcontroller where it is used to calculate the S-meter signal and muting. When RSSI is less than the preset mute level (in the menu), the atmel shuts off the audio by shorting it via T2 to ground. Of course, when transmitting, the audio is also muted.

For TX, the 5dB output of the vco (which oscillates now directly on the transmit frequency), is coupled via a -20 dB stripline coupler to the first amplifier IC12 (mar-8), which again amplifies it by 25 dB giving ca. 10dBm output. The second amplifier (IC13, an AH-1) amplifies 12dB followed by the fet CLY5 (+8dB) giving up to 30dBm output (1W).

Assembly instructions

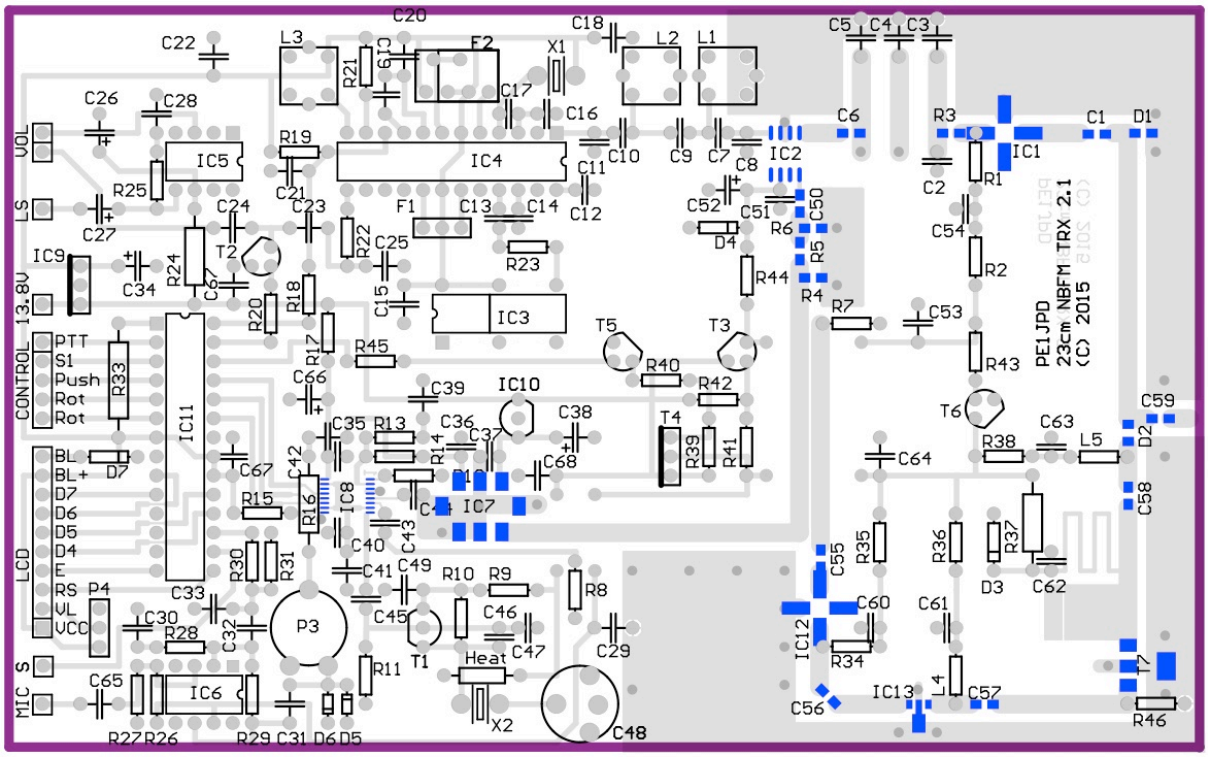


figure 3: top view of the board

1. The ADF4113 is the smallest part of this kit. It is soldered at the bottom side of the PCB, where pin 1 is marked. There are different ways to solder this part:
    a. tin the pads on the board, solder the chip with 1 leg and check that it sits fine. Then solder all pin with more than enough tin. After that, you remove the surplus tin with solder wick.
    b. tin the pads and fix the chip as in option 1. With a fine point solder every pin by itself.
    c. use flux. Tin the pads, add some flux and fit the chip with 1 pin. Then use a hot air soldering device to solder

    (I use the first method myself).
2. Solder IC2 on the board. Pin 1 is the IF output, so pin 4 at the side of C6.
3. The two mar-8 IC1 and IC12 have the dot at the input pin. This is for IC1 at the side of C1, and for IC12 at C55.
4. Pin-diode D1 has its marking (K) at ground side, and D2 at the side of C59.
5. Now solder the rest of the SMD part at the bottom side.
6. Not on the board is an extra 100p-1n smd C in parallel of C2, at the underside to improve the performance of the bandpassfilter.
7. On the top side, only the Atmel has a socket (28 pins). The other IC's are soldered directly on the board.
8. Take care for IC3 and X1 and X2 that the pins are not shorted against ground. You could keep them a fraction above the print.

9. The trimmers have their 'flatted' side at the 'hot' end. And C4 does not fit between its neighbors, so turn it around. Remove the green mask on the board to be able to solder the lead of C4 to ground. Bend it 90 degrees out and cut it to 1 mm to see where is should be mounted.
10. Prepare the tin box by drilling at 12 mm from the bottom the 21 holes for the feed through C's. Drill these at 2mm, which enables you you press the C's in the hole with your thumbs, or with a pair of tweezers. At the other end, drill a hole of 3mm at 8mm from the bottom for the antenna connection.
11. Now fit the board in the tin box at a height of 8mm from the bottom/solder side. Put the two sides of the box in one lid for this. Now the feed through C's should be approx. 2mm above the pcb, and the hole for the antenna fits to the pad at the bottom side. File at the two opposite corners a fraction of the board to fit it between the bend corners. If necessary, file the other two corners a little bit round. Now solder the board on a few spots in the tin box, and check that it is fitted all right and that the box does not wiggle when set flat on the table.
12. Now solder the box to the board. Especially at the antenna side and around IC13 and T7, on both sides. At the other ends of the board solder it to the box where there is room to do this.
13. Finally, connect the feed through C's to the pads on the board and fix a (SMA) chassis connector (not included) or thin coax.
14. Tip: use 3mm thin PFTE coax. Free 1.5-2 cm of the outer plastic and than tin the braid. Then carve at approx. 7-10mm from the end the tinned braid, after which you can break it and remove it. Now free the inner conductor of the coax and solder it on the board and to the box.

Test and tuning

Be sure to verify specifically the pins of the PLL chip. You can do this with a multimeter with short (beep) function. Be absolutely sure that pin 15 and 16 do not short, because this is fatal for your chip.
After the connections all seem ok, power the transceiver up. You should hear noise and the display shows VFO 1298.375 MHz and 'R' in the lower right. To see this you will have to adjust the contrast potmeter on the board (P4). When you press PTT, a 'T' should show in the lower right of the display. When the frequency changes to 1270.375, you have shift switched on.

When the vco is on frequency, the receiver can be tuned. This can be done with a rather strong signal at 23cm, or stage by stage. The first IF can be tuned this way with 69.3 MHz. The dicriminator is set to give optimal audio. With a scope connected to pin 13 of the MC3362, the noise can be tuned symmetrical and with a carrier on frequency, the line should be in the middle of this noiselevel on the scope. With the discriminator, you can tune the dc-level on pin 13.

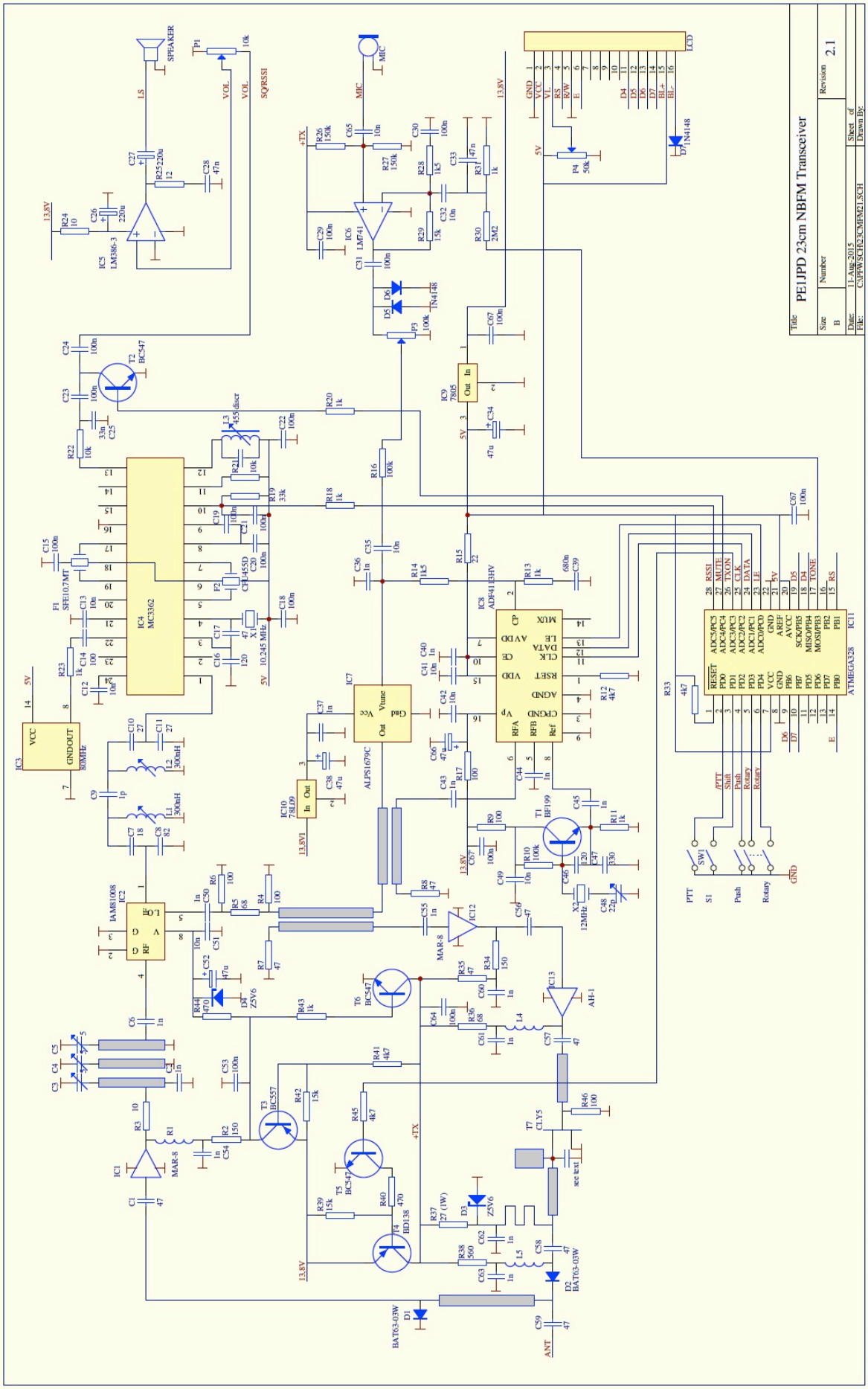
The 3 Murata trimmers should be set to maximum sensitivity. These trimmers need careful adjustment.

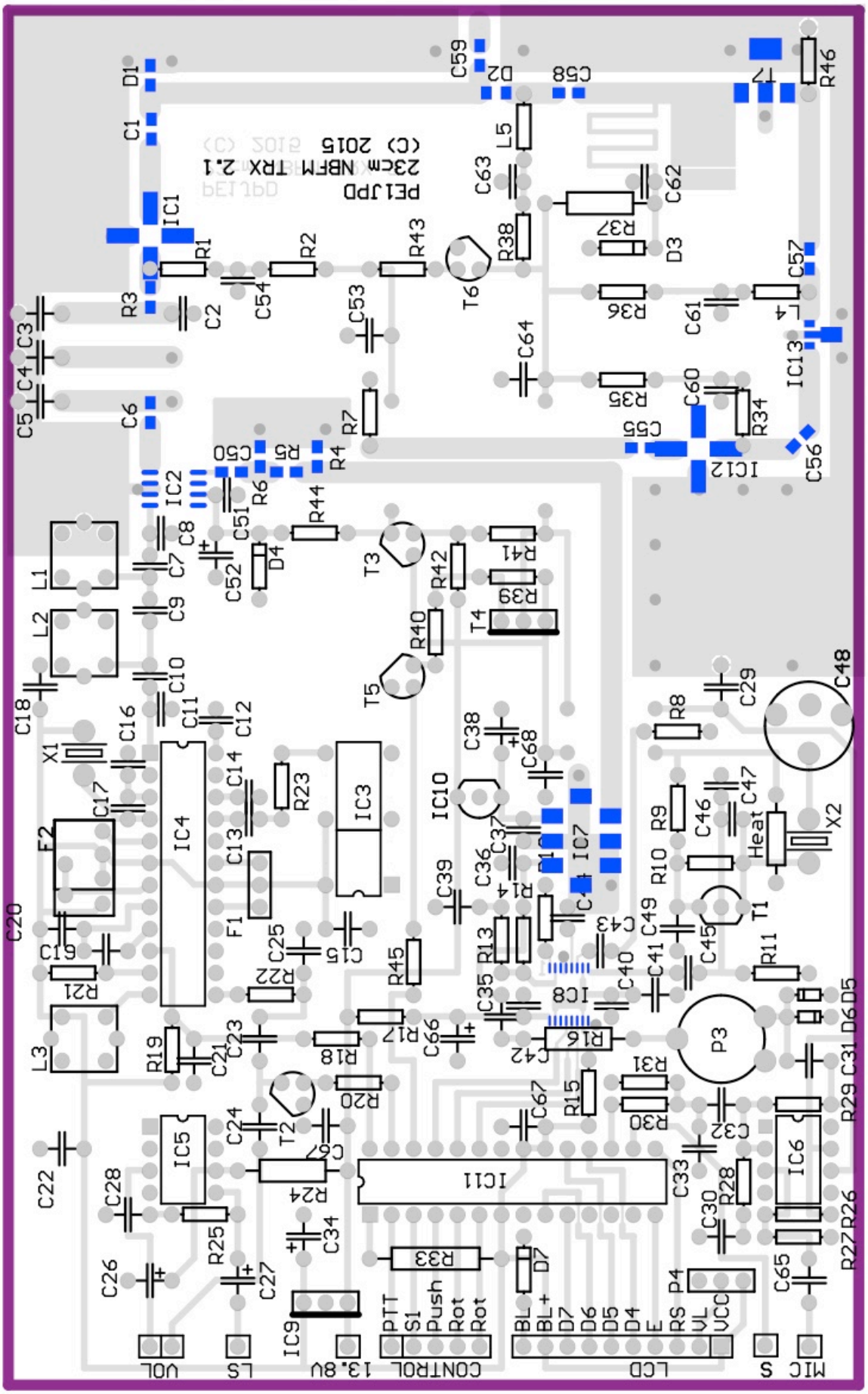
With a spectrum analyzer or frequency counter the output of the vco is checked which should oscillate at 1298.375 MHz when PTT is pushed. Without any tuning, you should have 400 mW output and when a small C of 0p68 is added between drain and source of T7 this should increase to 700mW. Also, the stub at the drain of the fet could be increased with a piece of 8x8 mm copper foil to get up to 1W output.

Troubleshooting

- When the display doesn't show anything first check all connections. Also check the contrast potmeter.
- When the PLL refuses to lock, check all connections and C's around it.
- When R37 heats up and start to smell you probably don't have RF input for T7. At R46 you should measure a small negative voltage (-0.5 to -1 V). If not, check the mar-8 (IC12) and AH-1 (IC13). In case you could experiment with the 100 ohms resistor at the gate of the fet. The higher this R, the higher the negative voltage you measure at the gate and the more the fet is cut off and the less current it consumes.

Schematic diagram




PE1JPD
23cm NBFM TRX 2.1
(C) 2015
VOL
LS
13.8V
CONTROL
PTT
S1
Push
Rot
Rot
LCD
BL
BL+
D7
D6
D5
D4
E
RS
VL
VCC
S
MIC

Part list

Reference	Part	#
IC1,12	MAR8	2
IC2	IAM81008	1
IC3	80MHz oscillator	1
IC4	MC3362	1
IC5	LM386-1/2/3	1
IC6	LM741	1
IC7	ALPS 1679C	1
IC8	ADF4113HV	1
IC9	7805	1
IC10	78L09	1
IC11	ATMEGA328	1
IC13	AH1	1
D1,2	BAR63-03W	2
D5,6,7	1N4148	3
D3,4	5V6 zener	2
T1	BF199	1
T2,5,6	BC547	3
T3	BC557	1
T4	BD138	1
T7	CLY5	1
F1	SFE10.7MT 50kHz	1
F2	CFU455D2	1
X1	10.245 MHz crystal	1
X2	12 MHz crystal	1
L1,2	300nH adjustable coil (TOKO)	2
L3	455 discriminator	1
L4,5	RFC 8w 1.5mm	2
R1	RFC 8w 1.5mm	1
R2,34	150	2
R3	10 (0805 SMD)	1
R4,6	100 (0805 SMD)	2
R5	68 (0805 SMD)	1
R7,8,35	47	3
R9,17,46	100	3
R10,16	100k	2
R11,13,18,20,23,31,43	1k	7
R12,33,41,45	4k7	4
R14,28	1k5	2
R15	22	1

R19	33k	1
R21,22	10k	2
R24	10	1
R25	12	1
R26,27	150k	2
R29,39,42	15k	3
R30	2M2	1
R36	68	1
R37	27 1W	1
R38	560	1
R40,R44	470	2
P1	potmeter 100k log	1
P2	-	
P3	100k small	1
P4	50k small standing	1
C1,56,57,58,59	47p (0805 SMD)	5
C2,36,37,40,43,44,45,54,60,61,62,63	1n	12
C3,4,5	5p trimmer sky or murata	3
C6,50,55	1n (0805 SMD)	3
C7	18p	1
C8	82p	1
C9	1p0	1
C10,11	27p	2
C12,13,32,35,41,42,49,51,65	10n	9
C14	100p	1
C15,18,19,20,21,22,23,24,29,30,31,53,64,67,67'	100n	15
C16,46	120p	2
C17	47p	1
C25	33n	1
C47	330p	1
C28,33	47n	2
C39	680n	1
C34,38,52,66	47u elco	4
C26,27	220u elco	2
C48	22p trimmer	1
-	feed through C's 1n	21
-	LCD 2x16	1
-	rotary-encoder	1
-	switch	1
-	IC-socket 28p narrow	1
-	PCB	1
-	1 tin box 100*160*30 mm	1