QRP TRANSCEIVERs

and P.A.s

from ACCESSIABLE

PARTS

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QRP TRANSCEIVERs and P.A.s from ACCESSIABLE PARTS is an English version of the Russian Book with the same name. The book was published by Igor Grigorov (UA3ZNW) in 1991 in Belgorod, Russia. From 1991 to 1996 were printed 2000 samples of the book. The book describes kits which company "Vibrissa" (lead by UA3ZNW) produced at the times.

Naturally, the book was the manual for the kits. Were produced 400 kits of TST (Tube- Semi- conductor- Transceiver) near 50 of them were assembled by UA3ZNW for customers, 200 kits SQT (Semi- conductor- Quartz- Transceiver), near 30 of them were assembled by UA3ZNW for customers, 200 kits of PA, near 60 were of them were assembled by UA3ZNW for customers.

Ever at the present time you may make the devices by using your junk- box-parts.

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Intro for Russian Edition

My Radio- Amateur practice began in the middle of 70-s. At the times the influence of the tube technique was very strong. Lots of hams designed tube RX, TX and TRCV. At present time you may find the tube only in the P.A. What a pity! It is possible to make a tube transmitter for one evening, a tube receiver – for two evenings. That is all! A beginner ham radio is ready. At the legendary times the beginner hams did exactly so.

Alas, now radio- amateur magazines practically do not print a reliable circuit of tube RX/TX/TRCV. Old ham magazines, where you may found such circuits, are hard to find.

Usual matter is when doing a modern semiconductor design a ham meets with many problems, such as ready PCB, expensive IC and power RF- transistors. Semiconductors TX/RX/TRCV as usual have poor frequency stability, TX often has not good tone due self-excitation stage(s). These shortages of semiconductors do not allow build simple and reliable ham equipment.

At the Book it was made an attempt to combine the advantages of tube design (ease to adjust, easy to get high level of RF- power, good repeatable of the design) with advantages of transistors (small dimensions). In the result a transceiver TST was designed.

With dimensions 150-140-70- millimeters (without PSU) it provides high sensitivity for RX (as usual not bad as 0.6-microV) and power near 10-Wtts.

Lack of the transceiver is high plate voltage 250-V for the P.A.s tube. However, with a converter (it may be a transistor converter) 12/250-V the transceiver may be used at a field conditions.

There is a simple transceiver for transistors fans. It is SQT- Semiconductor Quartz Transceiver. The transceiver with dimension 150-120-6- millimeters has 1-Wtt of output RF- power.

Of course, it may be not enough the 1 or 10-Wtts for success operation in the Air. So, a design of transistor power amplifier is included to the book. This power amplifier made without using of hard to find (or just expensive) ferrite cores. For the P.A. for low-HF- bands it is possible to use practically any modern power silicon transistors.

For all equipment, described at the book, there are design of the PCB (scale 1:1) and cabinet (with main sizes). It makes the equipment easy to repeat for other hams.

Regards, 73!

Igor Grigorov, UA3ZNW

June 1991, Belgorod, Russia

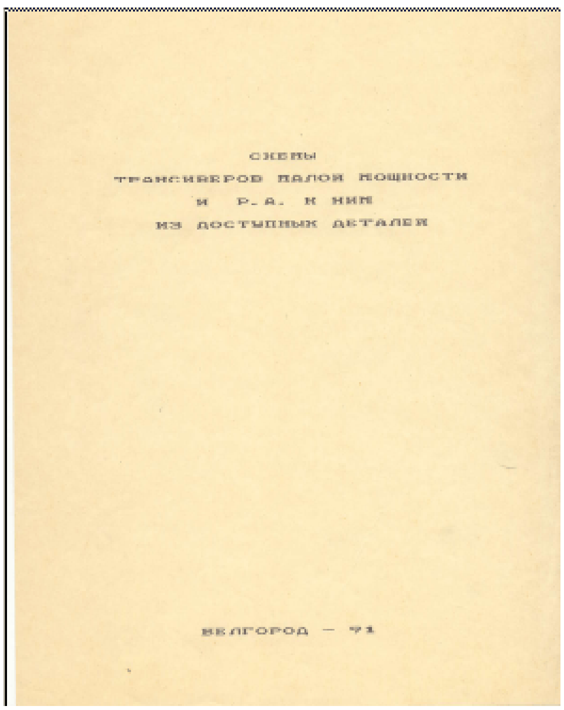
ua3znw and one of the clone of the SQT. Summer- 1993

Intro for English Edition

So, since 17 years after the Russian publication of “QRP Transceivers and PAs from Accessible Parts”, the book was translated to English and was pasted to pages of ANTENTOP- web-site. May be at the 21-century the design from the 20-century looks like very naïve.. It is. However, all of the design, described at the book, work fine up to ours days. Thoroughly look into your junk-box and shelves around- it is very possible to find parts for the designs.

English version of the book “QRP Transceivers and PAs from Accessible Parts” is very close to the Russian one. Drawings from the Russian book are used in the English version. Small corrections (that time requires to do) are added to the text for English version.

Regards, 73/72!
Igor Grigorov, VA3ZNW
February- 2008, Toronto, Canada



QRP Transceivers and PAs from Accessible Parts

Russia, 1991

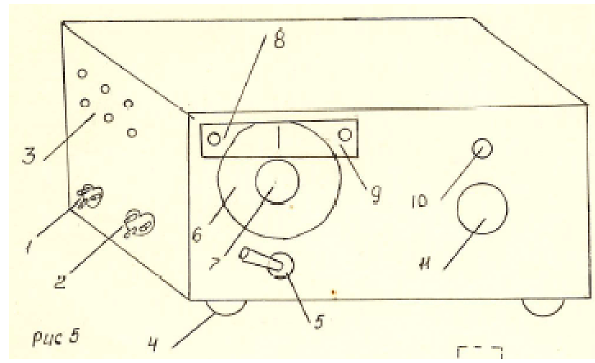
QRP Transceivers and PAs from Accessible Parts

CANADA, 2008

Tube-Semiconductor- Transceiver (TST)

Transceiver TST was published in my book- "QRP Transceivers and PAs from Accessible Parts "
The book was published by me (on my own expenses) in 1991, in Belgorod, Russia. I had printed 2000 samples of the book. The book describes kits which my own company ("Vibrissa") produced at the times. Fist such kit was transceiver TST. Were produced 400 kits of TST (Tube- Semi- conductor- Transceiver) near 50 of them were assembled by me for customers. Of course, may be some design of the transceiver seems to be old for the days, but what I can say, the transceiver works, and works not bad.

72/73! I.G.



Transceiver TST

Tube- Semiconductor- Transceiver (TST)

The transceiver consists of from two parts: there are RX part and TX part. Let's see how it is worked beginning from the TX part.

TX

Figure 1 shows the circuit of the tube's part of the transceiver TST.
VFO made on tube V1 (grid- cathode part). Zener diode VD1 (100V/ 20mA) provides the stable voltage to the tube. V1 works not only as VFO. L2C5 (switched in anode circuit) doubles the VFO frequency that depends on L1C2. Driver is assembled on V2, PA made on V3.

In my case the VFO worked very stable when Russian tube 6J2P was used in it. However, at 160- 20 meters pentode 6J1P works not bad. Inductor L1 is coiled on Russian resistor MLT-2 or WS-2 (it is depends on used band). The coil is uniformly spread on the form. The inductor should be coiled by wire that provides coiling turn to turn. To provide stability of the VFO the inductor coiled on the form firstly coated with neutral glue. I used Russian glue BF-2. Wire of the inductor is coiled (above the glue) with a small tension. After coiling the glued inductor is dried at + 150 C- degree while 2 hours. After that the inductor one more time is coated with the glue. After that the inductor is dried at room temperature for 24 hours. Remember, from the quality of the L1 depends the frequency stability of the TST. I had reached at 10- meters band the drift 200 HZ/hour with my home made inductors (and proper C2,C3).

Of course, if you managed use a ready- made inductor from an old VFO- use it. Tap to cathode goes from ¼ from the "cold end." (At my kit a special ceramic form for L1 was included)

If you can not get good air- dielectric Cn for the VFO - use a variable resistor that is switched on as the **Figure 2** shows. Resistor may have whole resistance in 1… 3-k. Tap to the resistor is taken from middle of the inductor. C* (27- 100-pF) is required picking to desire frequency range. The schematic provides less stability compare to air- variable capacitor. However, it is very possible to get a good stability just picking the capacitors (around L1) having different Temperature Coefficient of Capacity.

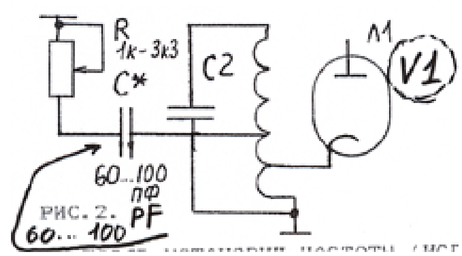
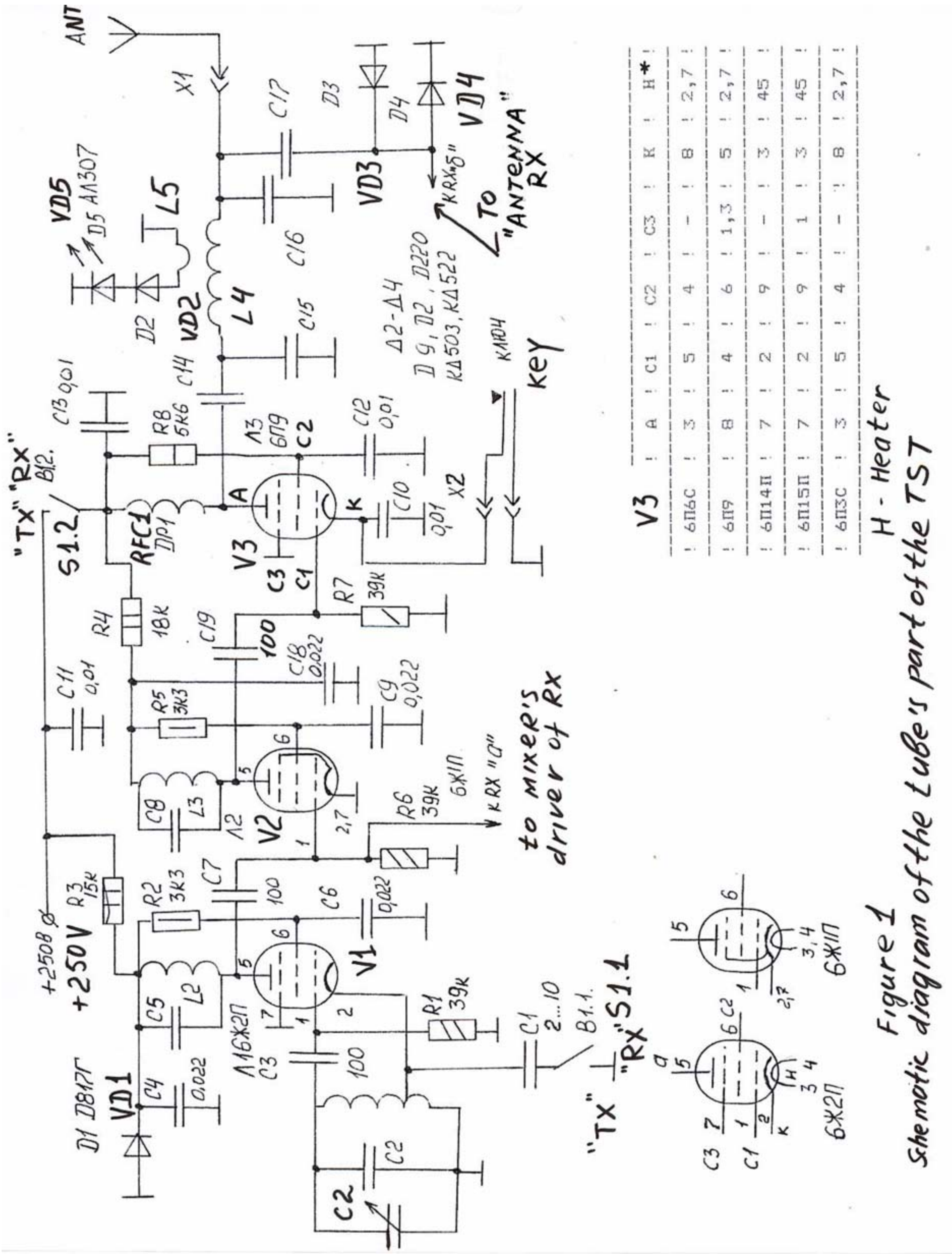


Figure 2 Variable Resistor instead Variable Capacitor

Adjusting and Tuning VFO

At first tune the tank L1C2 (with help a receiver or digital frequency meter) to needed frequency. Do not forget that the circuit is tuned to ½ or 1/3 frequency from used one. Then tune receiver to used frequency and tune L2C5 to maximum strength of the signal. Of course, you may use an RF voltmeter to do it. Then tune L3C8.



V3	A	C1	C2	C3	K	H*
6П6С	3	5	4	-	8	2,7
6П9	8	4	6	1,3	5	2,7
6П14П	7	2	9	-	3	45
6П15П	7	2	9	1	3	45
6П3С	3	5	4	-	8	2,7

H - Heater

Figure 1 Shemotic diagram of the tube's part of the TST

It is possible to do in two different ways. First, use a receiver and tune to maximum strength. Second, turn on an amperemeter between R4 and C18 and tune to minimum current. Current at resonance L3C8 fall but voltage across resistor R7 (it is measured by a high-ohms voltmeter, preferably electromechanical (not digital) is raised.

Note: V3 at the measurement the voltage across R7 should be in the socket, heater turn on but the voltage from anode and grid- 2 should be removed.

After the final tuning L3C8 turn on anode voltage to V3, turn on an antenna to X1, and tune the PA (with help of C15, C16) to maximum power going in to the antenna.

LED VD1 shows the power, the brighter it glows the more power is going in to the antenna. Coupling loop L5 should be placed at proper distance at L4, LED should not glow too bright that may cause fault for this one. As usual the circuit (L4,C15,C16) is being tuned at the center of an amateur band does not require to be retuning to the edges of the band. So, if only one antenna (or several antennas having the same input impedance, for example 50 Ohms) is used, it is possible use fixed capacitors C15, C16. At the PA a Russian tube 6P3S, 6P6S, 6P14P, 6P9, 6P15P works well. First three work well at 160 through 20 meters, the last two work well at 20- 10 meters. **Table 1** shows data for all inductors of the TX.

Table 1 Data for inductors of the TX

ТАБЛИЦА 1
ДАННЫЕ КОНТУРОВ ТХ

ДИА-ПАЗОН	1,8	3,5	7	10	14	18	21	24	28	
L1 *	–	–	28	18	15	13	14	11	11	МЛТ-2
	120/30	70/20	–	–	–	–	–	–	–	ВС-2
C2	1000	800	600	600	500	400	300	300	200	***
L2 *	–	–	25	19	15	14	11	10	10	МЛТ-2
	120/20	60/20	–	–	–	–	–	–	–	ВС-2
C5	200	200	180	150	120	100	100	90	60	
L3 *	–	–	25	19	15	14	11	10	10	МЛТ-2
	120/20	60/20	–	–	–	–	–	–	–	ВС-2
C8	200	200	180	150	120	100	100	90	60	
L4 *	53/45	27/45	14/40	10/45	8/45	7/45	7/45	6/45	6/45	**
C15	150	150	120	120	100	80	80	50	30	
C16	2000	2000	1500	1200	1000	600	600	500	300	
C14	1500	1000	1000	1000	470	470	390	300	300	

* First column- numbers of turns, second column- length of winding. Otherwise inductor is winded uniformly on to the form.

** Inductor L4 is coiled on a form in diameter 34 millimeter. For 160- 80 meters use wire 0.8 mm (20 AWG), for 40- 20 meters use wire in 1.0 mm (18 AWG), for 17- 10 meters use wire 1.0… 2.0 mm (18- 12 AWG).

diameter 0.1- 0.2 mm (37- 32 AWG), for 40- 30 meters may be wound by wire in 0.25- 0.5 mm (30-24 AWG), for 20- 10 meters may be wound by wire in diameter 0.5- 0.8 mm (24- 20 AWG).

*** L1, L2, L3 are coiled on Russian resistors WS2 or MLT-2. Resistance for these ones should be more then100-k for L1 and L2. For inductor L3 the resistance should be more the 27-k.
L1 for 160- 80 meters may be wound by wire in

Note: Capacitors C1 and C5 may need be chosen to your implementation of the L1 and L2. Use a variable capacitor with a big marked limb to determinate the value of C1 and C5. Then install a fixed capacitor instead the variable.

L2 for 160- 80 meters may be wound by wire in diameter 0.1- 0.2 mm (37- 32 AWG), for 40- 30 meters may be wound by wire in diameter 0.25- 0.5 mm (30- 24 AWG), for 20- 10 meters may be wound by wire in diameter 0. 5- 0.8 mm (24- 20 AWG)

L3 for 160- 80 meters may be wound by wire in diameter 0.1- 0.2 mm (37- 32 AWG), for 40- 30 meters may be wound by wire in diameter 0.25- 0.5 mm (30- 24 AWG), for 20- 10 meters may be wound by wire in diameter 0.5- 0.8 mm (24- 20 AWG)

When TX is assembled and tuned, it is possible try to do QSOs using this one and separate receiver. At this case increase the capacity of the shift – frequency capacitor C1 to 100… 300-pF.It makes the shift of the VFO frequency far away from the amateur band. Solder the C1 to another end of the S1.1 (compare to shown in **Figure 1**) to shift the frequency in the low edge of the frequency band.

Note: Do not stay V3 at high voltage when the VFO or/and driver does not work properly. V3 gets the grid bias voltage from detecting an RF by the part- "1-grid- cathode." Without bias voltage (the same without an RF on the first grid) the tube may overheated (due huge anode current) and goe off operation. After tuning TX tune the RX part.

Part List TX

Tubes:

V1: Russian Tube 6J2P- small RF Pentode with short characteristic

V2: Russian Tube 6J1P- small RF Pentode with short characteristic

V3: Russian Tube 6P15P- RF Power Pentode

Resistors:

R1: 39 k/ 0.25 W* (27- 100 k)
R2: 3.3 k/ 0.5 W* (680 Ω – 5.6 k)
R3: 15 k/ 2 W* (12 – 18 k)
R4: 18 k/ 2 W* (12- 24 k)
R5: 3.3 k/ 0.5 W* ((680 Ω – 5.6 k)
R6: 39 k/ 0.25 W* (27- 68 k)
R7: 39 k/ 0.25 W* (27- 51 k)
R8: 5.6 k / 1 W* (3.3- 6.8 k)

*Recommended
() In brackets- may be used

Capacitors:

C1: 2… 10 pF*
C2: See Table 1
C3:100 pF**
C4: 0.022 uF***
C5: ***See Table 1***
C6: 0.022 uF***
C7: 100 pF**
C8: See Table 1
C9: 0.022 uF***
C10: 0.01 uF***
C11: 0.01 uF***
C12: 0.01 uF***
C13: 0.01 uF***
C14: See Table 1
C15: See Table 1
C16: See Table 1
C17: 27 pF**
C18: 0.022 uF ***
C19: 100 pF**
Cn: 10- 50 pF****

 * Depend on frequency shift
** Tolerance +100- 30%
*** Tolerance +200- 30 %
**** Depend on used band

Diodes

VD1: Zener Diode, 100 V/20 mA, should be placed on a small heater sink, I had used a coin having dimension of a 25 cents US coin.
VD2: Any small power RF diode
VD3: Any LED
VD4: Any small power RF diode
VD5: Any small power RF diode

Switches:

S1: Any DPDT switch that can be used at 250 V/ 100 mA

Connectors:

X1: Any RF Connector
X2: 5- PIN Audio Connector

RF- Choke:

RFC1: Wound on Russian Resistor WS-2 (sizes: diameter 9.7-mm, length 49-mm), resistance more than 51-k. ***Figure 3*** shows the RFC implemented for different bands.

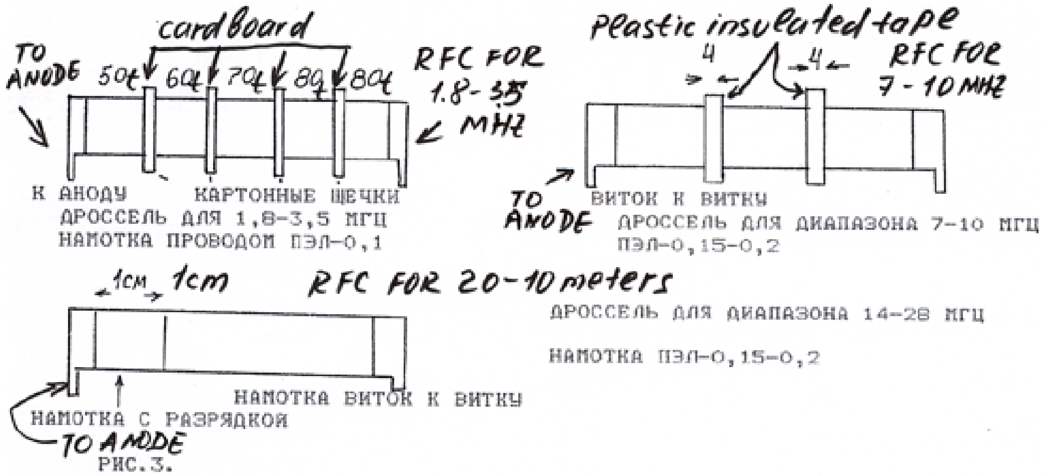


Figure 3. RFC for TST

A) 180- 80 meters: 50+60+70+80+80 turns by insulated wire 0.1-mm (38-AWG);
B) 40- 30 meters: 3 section wound turn to turn by insulated wire 0.2- mm (32- AWG);
C) 20- 10 meters: 1 section is wound with step 0.3 –mm, second section wound turn to turn by insulated wire 0.2-mm (32-AWG).

RX

A DC receiver is used at the TST. **Figure 4** shows schematic of the receiver.

Figure 4. Circuit diagram for DC receiver of the TST

RF Amplifier: It has active component T1 and T2. VD1… VD4 are protected the input RF Amplifier from an overload by own transmitter or power signals coming from the Air. The diodes allow use for the transceiver a separately antenna (sometimes it allows to avoid AC hum in the head phones). Adjusting the RF Amplifier is simple. With help of R3 install at emitter of T2 half voltage compare to collector T2. Check current of T2. It should be 5- 10-mA. If the current is higher – increase R1 then check again voltage at emitter T2. If the current is lower, decrease the R1, then again check voltage at emitter T2. L1C1 and L2C5 should be tuned on working frequency.

Driver for VFO: It is made on T3. Check drain current when signal from VFO is applied to the gate of the T3. It should be not more then 15-mA. If the current is more, play with R5 and C6. It is useful to play with R5 and C6 on to best reception.

RF Amplifier and Driver for low- bands: At 160- 40 meters you may use simplified RF amplifier made on 1 transistor and driver made on usual bipolar transistor. However, at such design the AC hum may come to head-phones.It may come difficulties with adjusting the driver to obtain an optimal RF voltage at mixer. Frequency between TX and RX may drift. **Figure 5** shows the schematic for simplified RF Amplifier (A) and Driver (B).

Quasi- Balanced Mixer: It is made on diodes VD5… VD9. RF is coming through L2.2 to the mixer. R6, R7 and C7, C8 provide quasi - balancing. No tuning and adjusting at right parts.

Audio Filter: It is made on C9, R8 and C10. Cutting frequency is near 3.5-kHz. If you have a commercial made Audio Filter (for example, from an old TRX) – use it. Turn on this one instead R8, C10 may be deleted. It is possible turn on instead R8 an old Universal Magnetic Head (from an old tape recorder), however, in some case an AC hum may come. No tuning and adjusting at right parts.

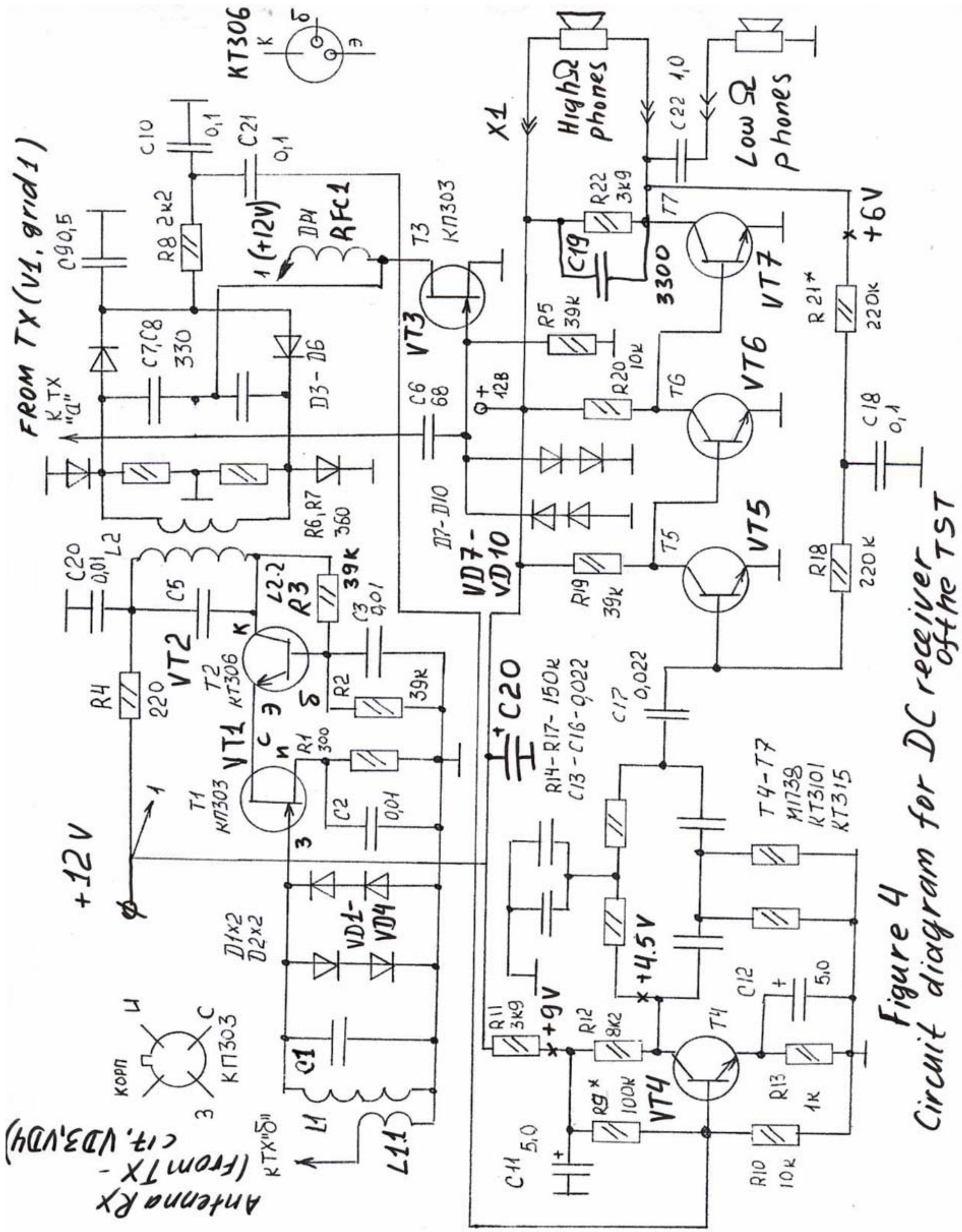


Figure 4
Circuit diagram for DC receiver of the TST

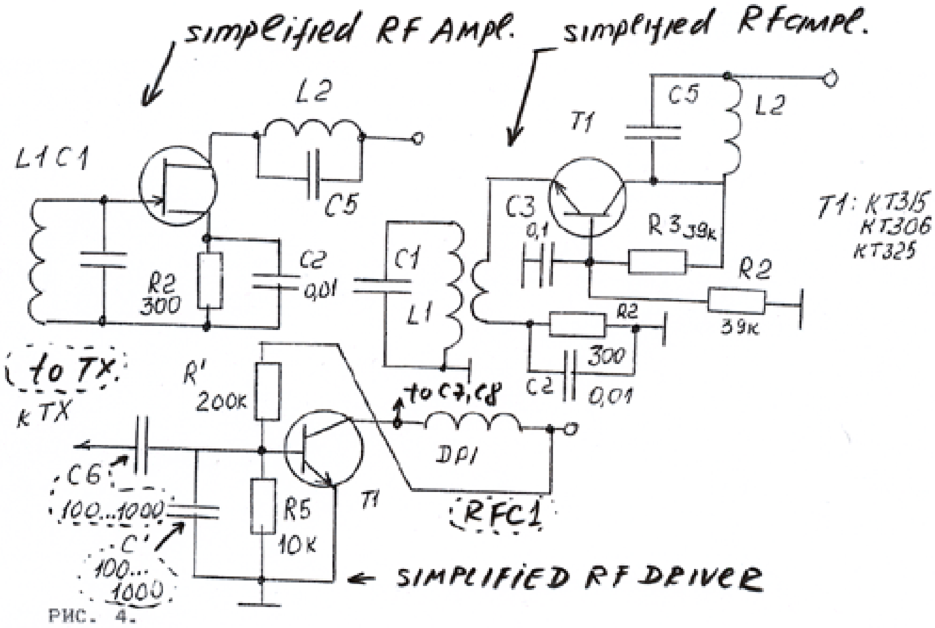


Figure 5 Circuit diagram for simplified RF Amplifier **(A)** and Driver **(B)**

Audio Amplifier: It is made on T4, T5, T6, T7. It is preferable to use a low noise high – gain transistors. It may be any low power old- made germanium or modern silicon transistors. Adjusting is a very easy. With help of R9 install at collector T4 the voltage 4.5-V. With help of R21 install at collector T4 the voltage 6.0-V. If audio amplifier has self-excitation, increase R11 (for example to 6.8-k or more).

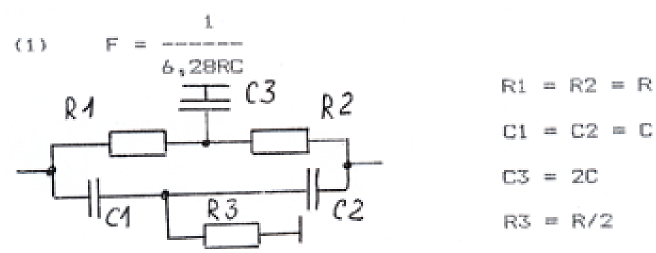


Figure 6 Bridge Wien

Bridge Wien: Bridge Wien (detailed shown on **Figure 6**) does rejection of the 50-Hz. The frequency is used at AC in Europe. It is possible re-count (using equation from the **Figure 6**) both as rejection frequency as parts for the bridge. Parts should have as possible small tolerance as can.

It is possible to use a precision potentiometer instead R3 (on **Figure 6**) to adjust the rejection frequency.

Figure 7 shows PCB (from side of the foil). PCB has sizes 100 x 70 mm. **Figure 8** shows view to montage of the RX. Board made by through- hole montage.

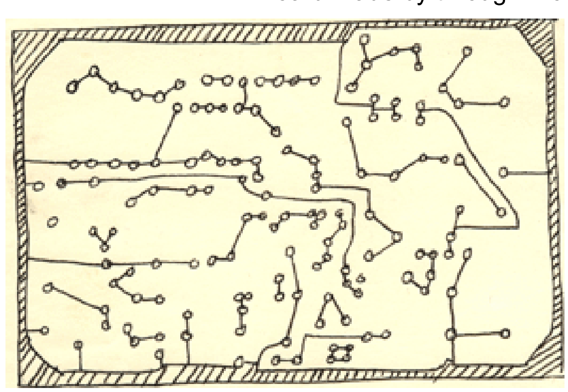


Figure 7 PCB of the RX

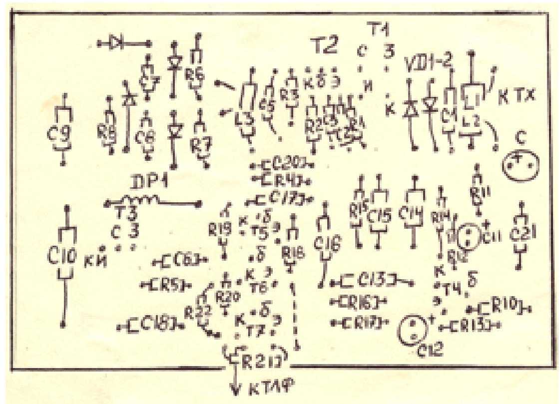


Figure 8 Montage of the RX
(Arrow shows to “Phones”)

Part List RX

Resistors:

R1: 300/0.25 W*
R2: 39 k/ 0.25 W*
R3: 39k/ 0.25 W*
R4: 220 /0.25 W* (200- 1000 Ω)
R5: 39k/0.25 W*
R6: 360/0.25 W* (470- 1000 Ω)
R7: 360/ 0.25 W* (470- 1000 Ω)
R8: 2.2k/0.25 W* (1k- 3.9k)
R9: 100k/0.25 W*
R10: 10k/0.25 W* (5.6k- 10k)
R11: 3.9k/0.25 W*
R12: 8.2k/ 0.25 W* (5.1k- 10k)
R13: 1k/0.25 W*
R14: 150k/0.25 W**
R15: 150k/0.25 W**
R16: 150k/0.25 W**
R17: 150k/0.25 W**
R18:220k/0.25 W* (39k- 300k)
R19: 39k/0.25 W*(27k- 51k)
R21: 10k/0.25 W* (8.2k- 12k)
R22: 3.9k/0.25 W* (3.9k- 6.8k)

*Recommended
** Tolerance 2%
() In brackets- may be used
R6 must be similar to R7

Capacitors:

C1: ***See Table 2***
C2: 0.01 uF*
C3: 0.01 uF*
C4: 68 pF
C5: ***See Table 2***
C6: 68 pF
C7: ***See Table 2***
C8: ***See Table 2***
C9: 0.5 uF
C10: 0.1 uF
C11: 5.0 uF**
C12: 5.0 uF**
C13: 0.022 uF***
C14: 0.022 uF***
C15: 0.022 uF***
C16: 0.022 uF***
C17: 0.022 uF***
C18: 0.1 uF *
C19: 3300 pF*
C20: 50.0 uFf**
C21: 0.1 uF *
C22: 1.0 uF *

* Tolerance +200- 30%
** Electrolytic
*** Tolerance 5%
C7 must be similar to C8

Diodes

VD1- VD10: Any small power RF diodes
VD5- VD8 must be similar

Connectors:

X1: 5- PIN Audio Connector

RF- Choke:

RFC1: Wound bulky by insulated wire 0.1-mm (38-AWG) on Russian Resistor WS- 0.5 (sizes: diameter 5.5-mm, length 26-mm), resistance more than 51-k. For quantity of turns see **Table 2.**

Semiconductors

VT1: Small power N- channel RF FET
VT2: Small power NPN bipolar RF transistor
VT3: Small power N- channel RF FET
VT4: Low noise high- gain PNP audio transistor
VT5: Low noise high- gain PNP audio transistor
VT6: Low noise high- gain PNP audio transistor
VT7: Low noise high- gain PNP audio transistor

Table 2. Data for inductors for the receiver

ТАБЛИЦА 2
ДАННЫЕ КОНТУРОВ RX

ДИА-ПАЗОН	1,8	3,5	7	10	14	18	21	24	28	
L1,L2	68	38	22	17	17	17	17	17	17	*
C1,C5	360	300	270	240	120	100	91	51	30	
C7,C8	1000	680	510	390	330	240	200	120	100	**
ДР1	300	250	200	180	120	120	120	80	80	***

* Inductors for 160- 80 meters is wound bulky by insulated wire 0.1-mm (38-AWG) on Russian Resistor MLT- 2 (sizes: diameter 8.6-mm, length 18.5-mm), resistance more than 51-k. For others bands (40- 10 meters) the inductors are wound uniformly by insulated wire 0. 5-mm (25-AWG) on Russian Resistor MLT- 1 (sizes: diameter 6.6-mm, length 13-mm), resistance more than 51-k.

** C7 and C8 may have tolerance -60 +100%, however, C7 must be similar to C8

Design TST

Experience shows that design in DC transceiver plays the same role as the schematic does. Perform the transceiver strictly to the draft and you obtain good result. **Figure 9** shows design of the TST.

*** RFC1: Wound bulky by insulated wire 0.1-mm (38-AWG) on Russian Resistor WS- 0.5 (sizes: diameter 5.5-mm, length 26-mm), resistance more than 51-k.
Figure 3. RFC for TST

Note: Capacitors C1 and C5 may need be chosen to your implementation of the L1 and L2. Use a variable capacitor with big marked limb to determinate the value of C1 and C5. Then install a fixed capacitor instead the variable.

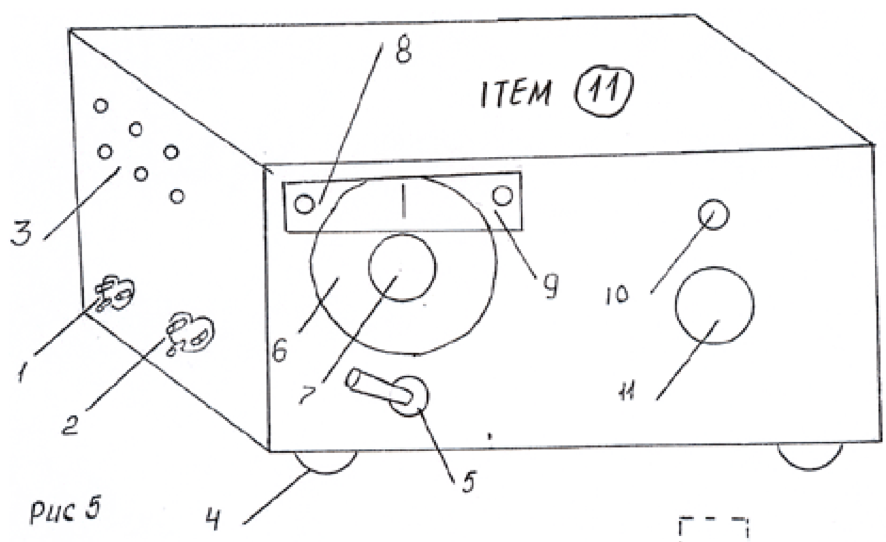


Figure 9 Design of the TST

According to **Figure 9**:

1. Connector + 250/+12/ AC 6.3V
2. Key
3. Ventilating holes
4. Stipes (may be made from a cap of toothpaste)
5. Toggle - Switch TX-RX
6. Tuning Dial, made from a PCB stuff
7. Tuning Knob (may be made from a cap from a plastic can), glued by “Crazy Glue” to item 6
8. Wide Strap (made from transparent Plexiglas)
9. Support Pole
10. LED TX
11. Tuning PA

Figure 10 shows the view upside to the montage of the TST. Montage must be done strictly to the figure.

Figure 11 shows view to inside of the TST. Drafts with sizes (in millimeter) for items 1- 11 are shown below. Leads of the TX’s parts are soldered to pad (the pad dimension on 4x4 mm are cutting on the PCB at parts position). L4 made from a heavy wire (for 20- 10 meters) may be just soldered by its leads to X1 and C15. L4 for 160- 30 meters wound on a form (plastic or cardboard) may be fastened to item 8. Holes intended the Tube Plastic Socket have sizes a bit less the sockets. So the sockets are hard inserted to the holes then grounding leads soldered to PCB.

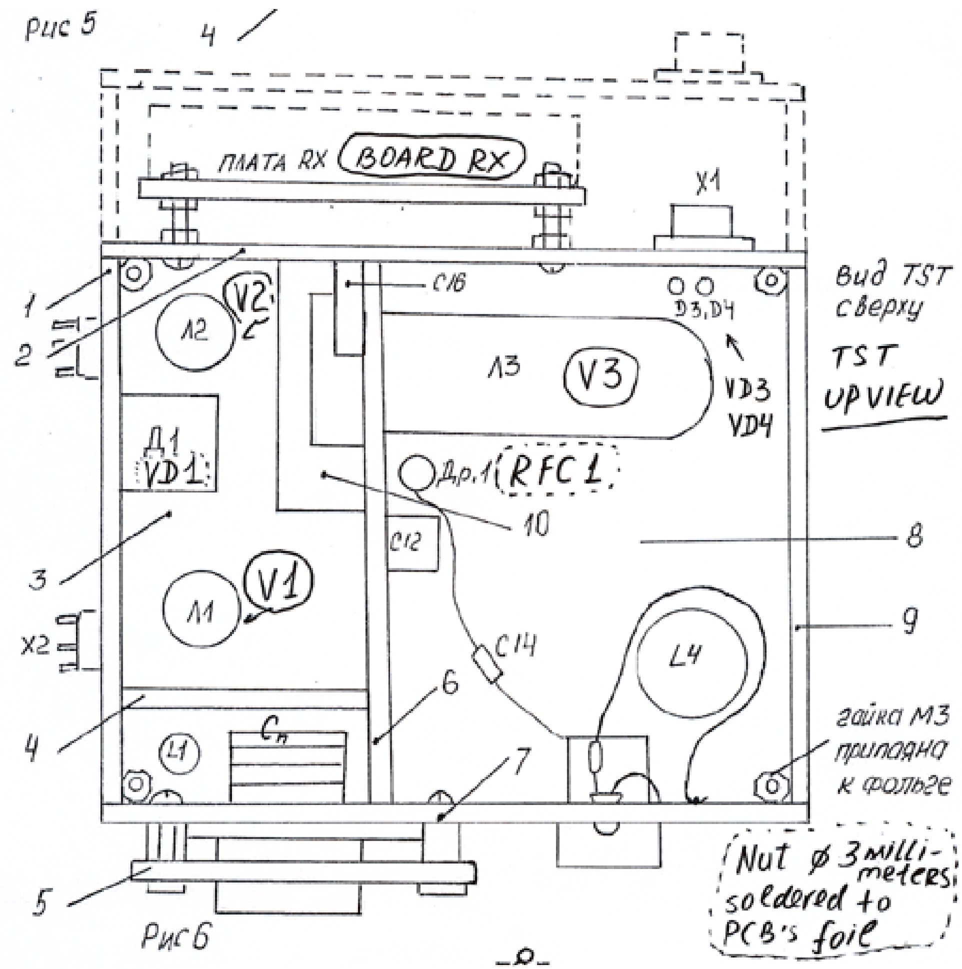


Figure 10. View upside to the montage of the TST

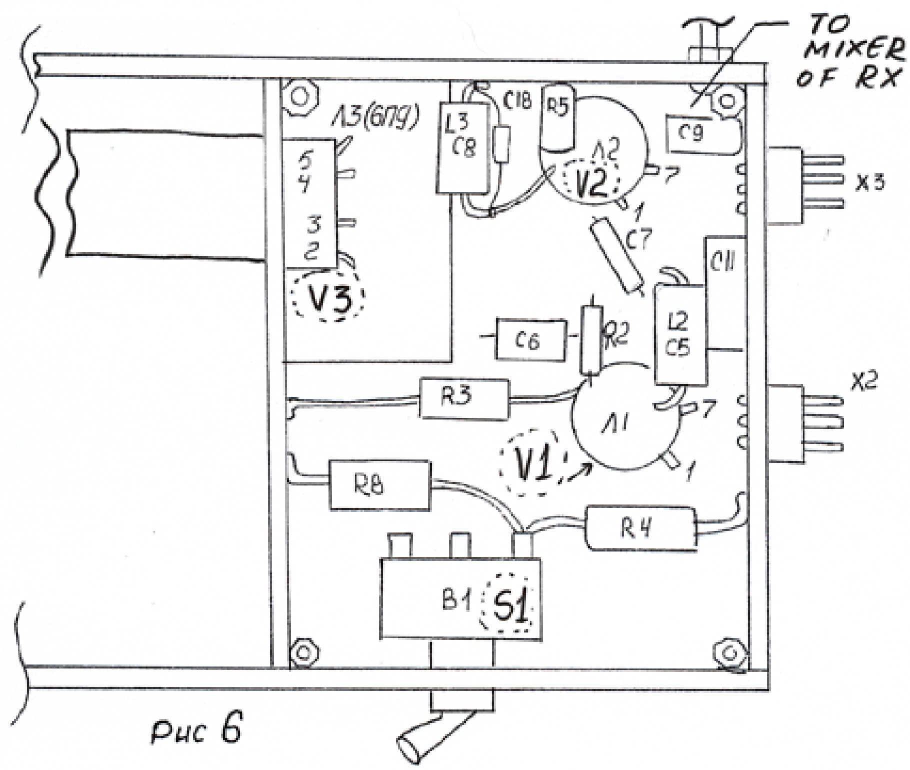
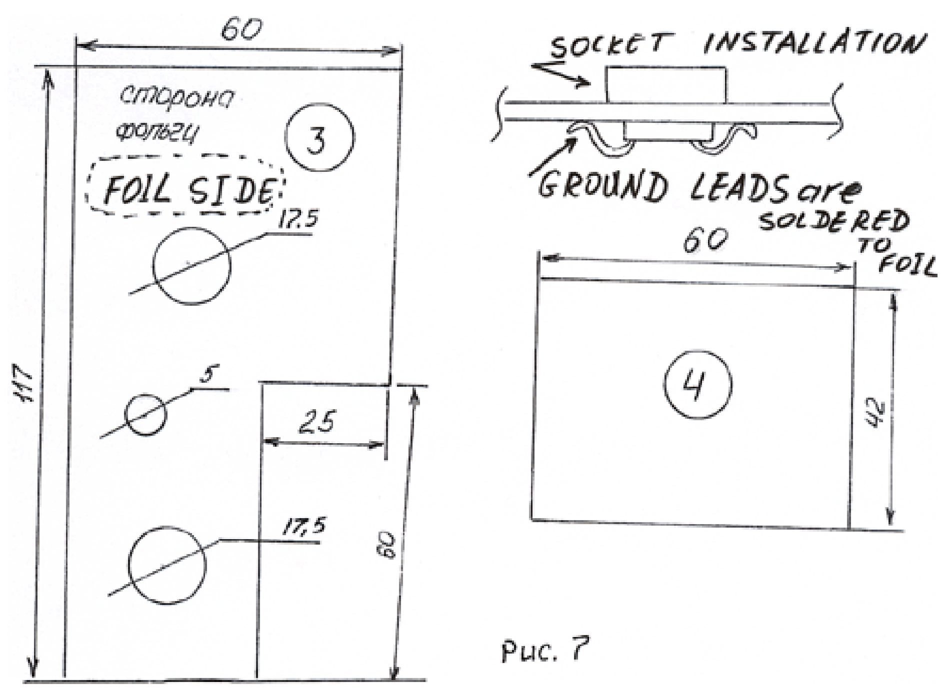


Figure 11. View inside of the TST

Steps to assembling TST:

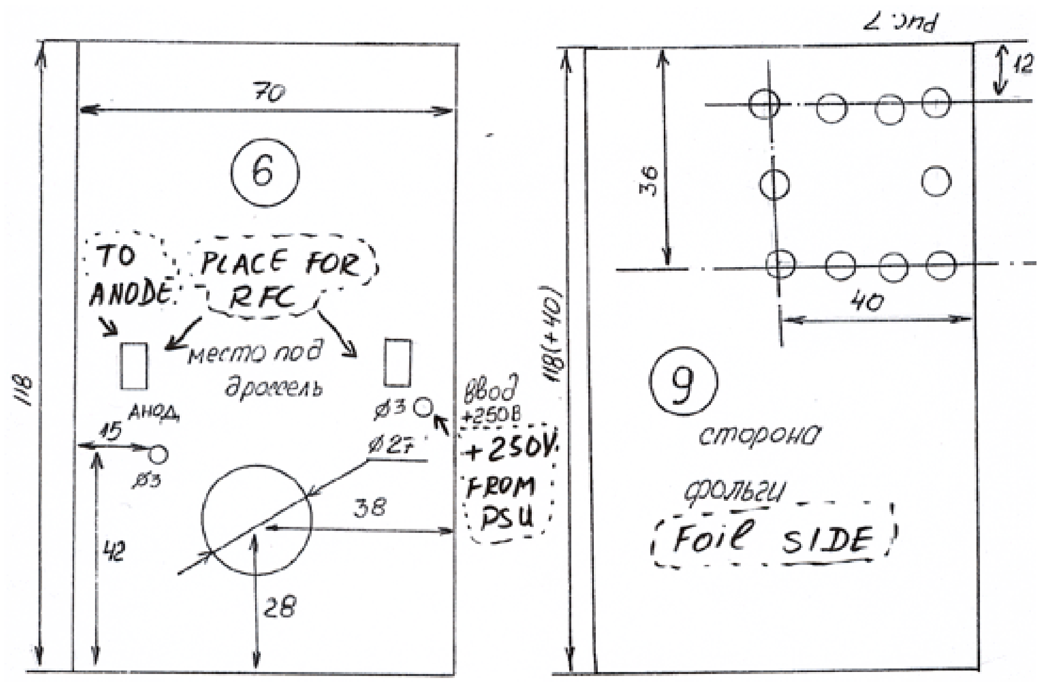
1. Have done ready items 1- 11 (do not forget that item 6 made from a double- sided PCB)
2. Have checked that all holes are made and made correctly
3. Install tubes' sockets
4. Solder edges at items 1- 9
5. Do fastened in several points item 1,2,7,9



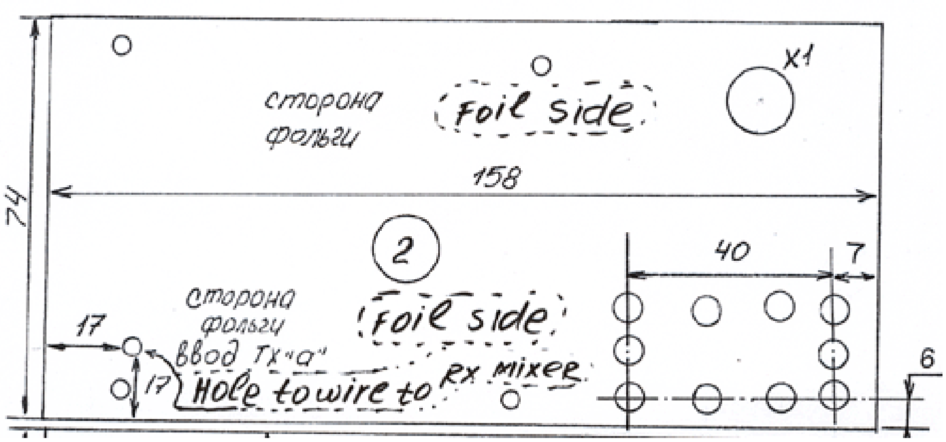
Items 3- 4

6. Do fastened in several points item 3,6,8
7. Do final soldering the (paragraph 5@6) items
8. Do montage TX
9. Tune the VFO to needed frequency range, then install item 4. VFO frequency may go down for a little.
10. Install a working board RX
11. Install item 5, do calibration of the transceiver
12. Install cover 10 and 11. Cover 11 is installed up the transceiver, cover 10 (consists from 2 parts) down the transceiver. Item 10a closes VFO, item 10b closes PA.

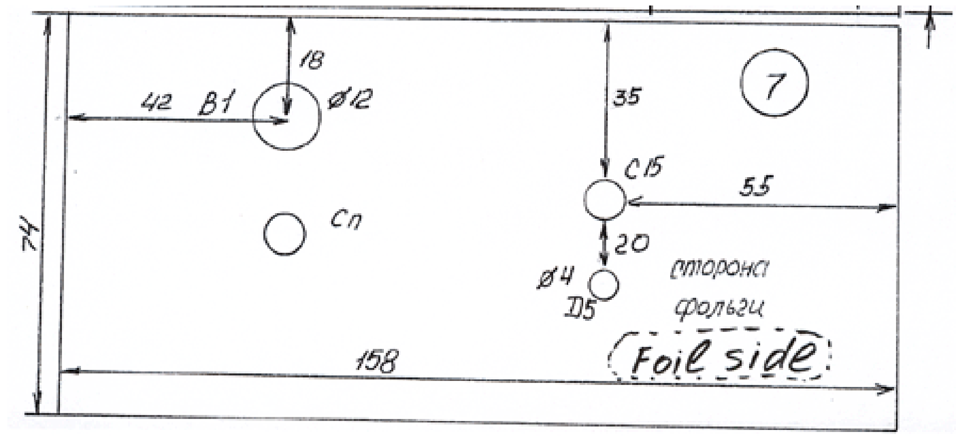
It is possible to do item 1, 9 10 and 11 a little bigger (shown in dashed line at **Figure 9**). In this case all sides of the transceiver will be closed. Transceiver will be work more stable at 20- 10 meters.



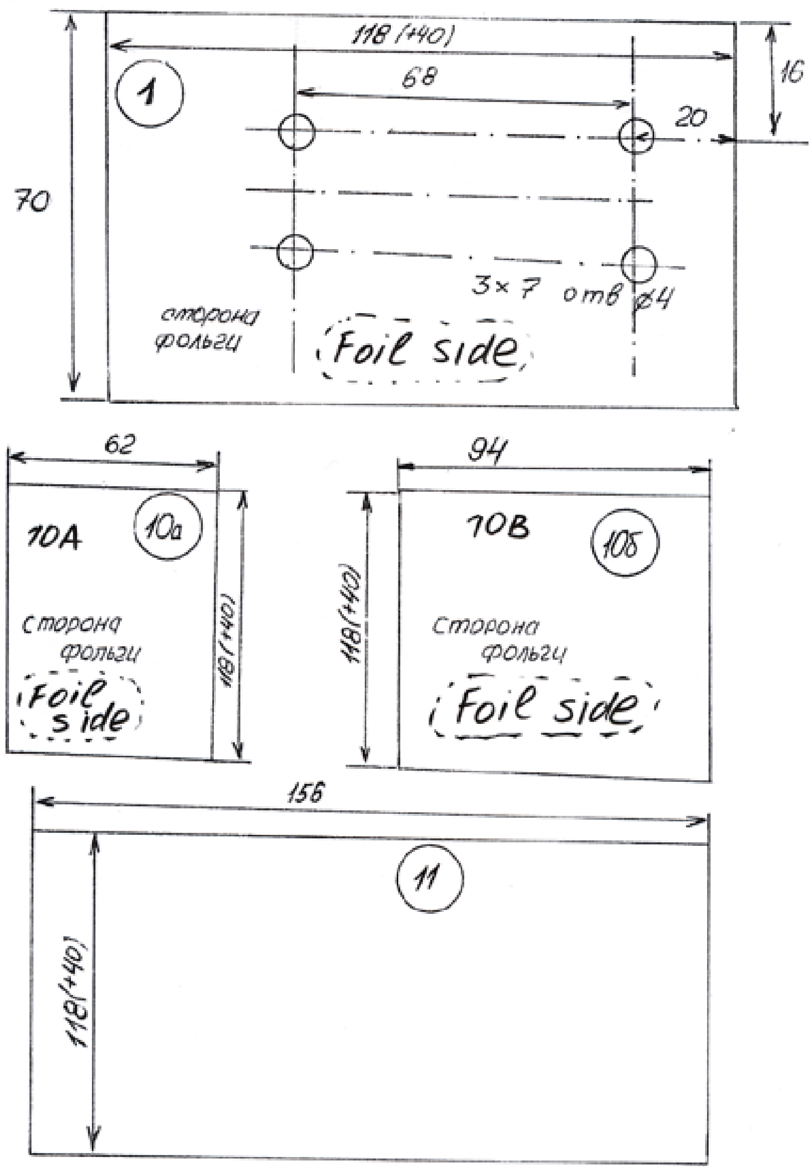
Item 6, 9



Item 2



Item 7



Item 1, 10, 11

Transceiver SQT

Igor Grigorov, UA3ZNW

Credit Line: **QRP Transceivers and PAs from Accessible Parts**

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Transceiver SQT differs from TST only by TX part, therefore main volume of the article will be devoted to the TX part. **Figure 1** shows the TX part of the SQT. Transceiver provides output RF power not less then 1 Wtts.

Transmitter consists of from a crystal oscillator (made on T1), PUSH- PULL amplifier (made on T2, T3). Transistor T4 provides keying of the Push- Pull amplifier. Crystal oscillator works both, in RX and TX mode. Through a coupling coil RF voltage going to capacitor C6 of RX (see article about TST). From value of R3 depends function of the RX. To much value is going to low sensitivity, too low value is going to bad reception (with spurious channels of reception). As usual, R3 should be near 100 – 1000-Ohms. Coupling coil has ¼ turns from L1. Data for L1C2 are the same like for L1C1 from RX of the TST (see Table 2 for TST article).

You know, that at RX/TX mode in the DC transceiver the generator should have shift 400- 800-Hz. Sometimes, when we down on the key of the SQT transceiver, we get the shift because changing mode of crystal oscillator. If we have not got reliable shift at the case, we may use circuit shown in **Figure 2**. The circuit is switched of instead jumper and turn on to the RF-amplifier. At TX mode a current going through inductor coiled above ferrite that is changed the permeability of the ferrite. So, we will have shift of the frequency at RX/TX. The shift is depend on quantity turns switched instead jumper (1- 5) and value of the resistor R*. It may be near 500- 5000-Ohms. Any ferrite with permeability 400- 2000 should be used in the circuit. For example, it may be ferrite ring with OD 7- 20-millimeter, ferrite road in 3- 8 mm diameter and 10-40 millimeter long. Wire in diameter of 0.1- 0.3-millimeter (38AWG- 28AWG) should be okey for both inductors. First winding (to point "2") is coiled turn to turn, the second one (to point "1") by pile-up.

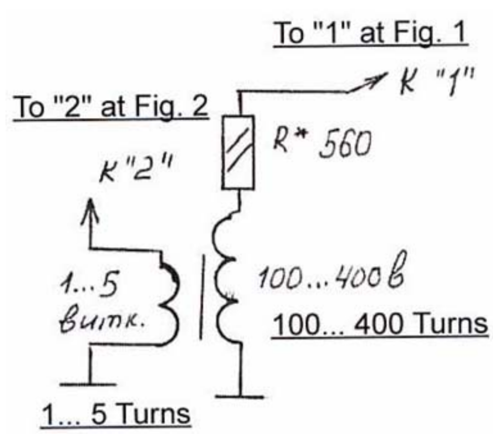


Figure 2 Frequency shift RX/TX circuit

If in serial with frequency- shift inductor an additional inductor plus capacitor is inserted, we will get circuit for frequency shift of the quartz in limit near 10-kHz plus circuit for frequency shift at RX/TX mode.

Figure 3 shows the circuit. **Table 1** shows data for L3, TR1, TR3, C3, L2C9, RFC1, RFC2. **Figure 4** shows design of transformer for frequency – shift circuit (**Figure 2**, **Figure 3**). **Figure 5** shows design L2.

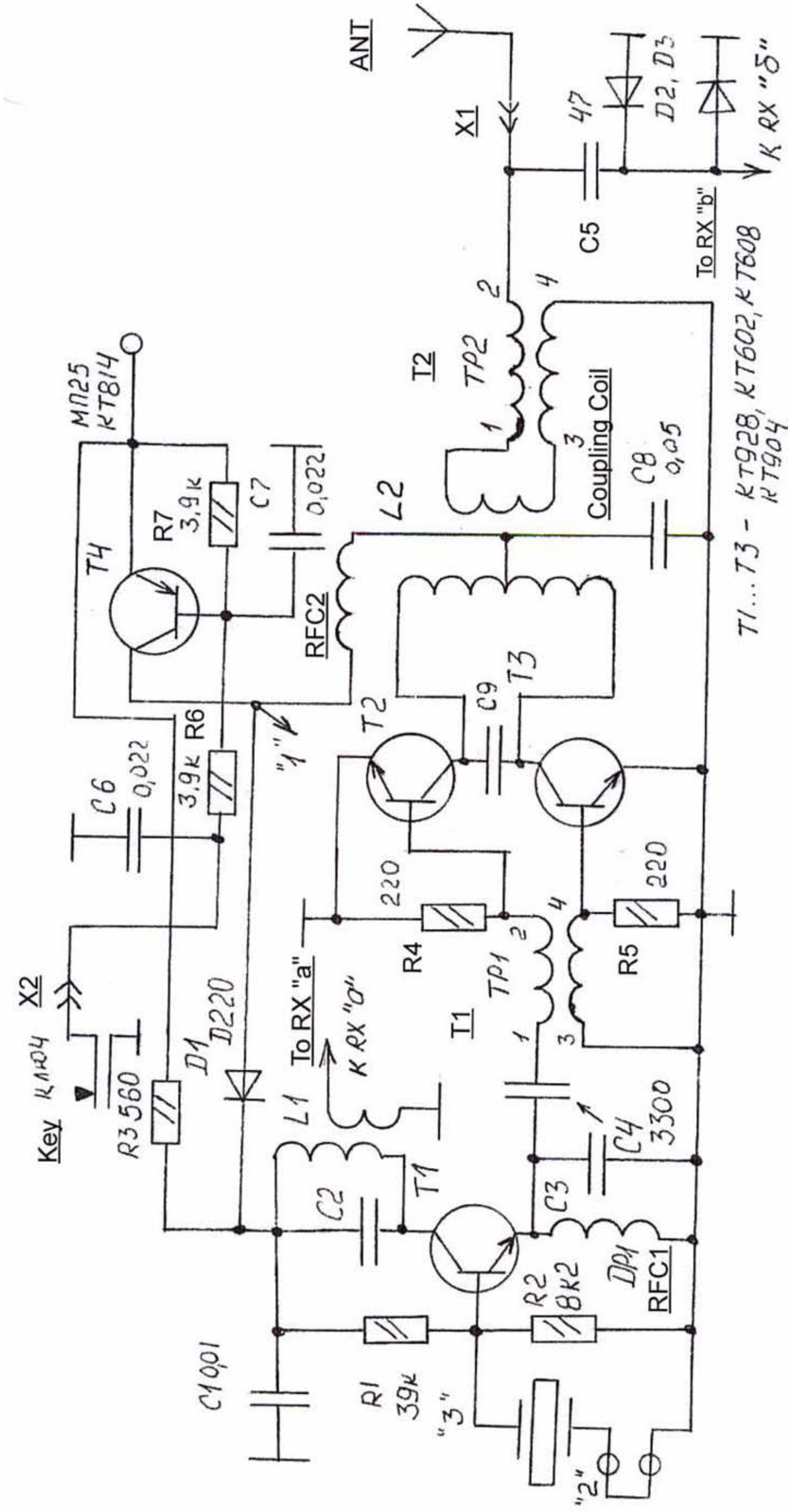


Figure 1 TX part of the SQT.

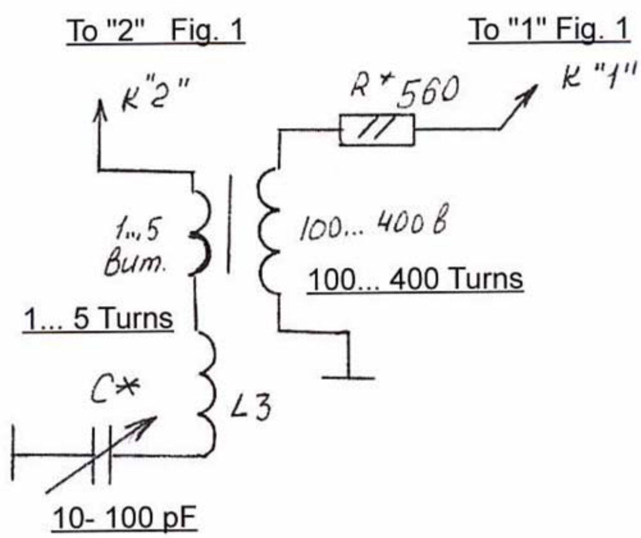


Figure 3 Circuit for shift quartz frequency plus frequency sift RX/TX

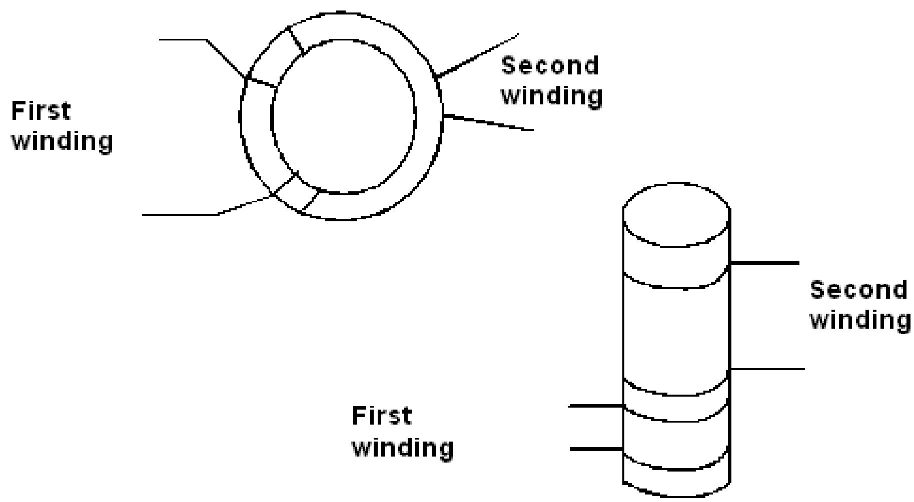


Figure 4 Design of transformer for frequency – shift circuit

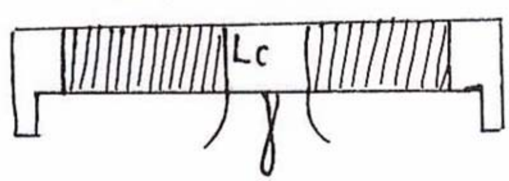


Figure 5 Design L2

Table 1 Data for inductors of the SQT

Band, MHz	1,8	3,5	7	10	14	18	21	24	28	Note
L2	32/120	10/60	3,5/36	2,5/30	1,5/22	0,9/18	0,9/18	0,9/18	0,9/18	*
L3	50/150	30/100	20/80	15/60	12/50	10/46	9/42	9/42	8/40	**
RFC1, RFC2	300	250	200	180	150	150	120	120	100	***
C9, pF	250	200	150	110	91	68	51	30	30	
C3, pF	1000	1000	560	470	470	300	100	56	56	
T1, T2	20	17	14	12	11	10	10	8	8	****

Note

* L2: First column is inductance in microHenry, the numbers of turns. Tap from center of the inductor. Inductor must be made symmetrically. L2 for 160- 80 meters may be wound by wire in diameter 0.1- 0.2 mm (37- 32 AWG), for 40- 30 meters may be wound by wire in 0.25- 0.5 mm (30- 24 AWG), for 20- 10 meters may be wound by wire in diameter 0.5- 0.8 mm (24- 20 AWG). L2 for bands 1.8- 3.5 – MHz is wound on Russian Resistor WS-2, for 7- 28 –MHz is wound on Russian Resistor WS1. Resistance for the resistors should be more than 51-k

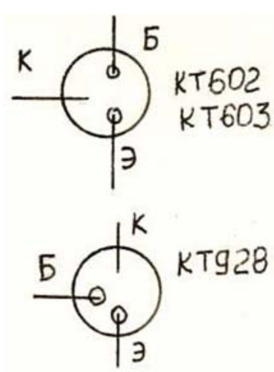
WS-2 (sizes: diameter 9.7-mm, length 49-mm)
WS-1 (sizes: diameter 7.6-mm, length 31-mm)

**L3: First column is inductance in microHenry, the numbers of turns. L3 for 160- 80 meters may be wound by wire in diameter 0.1- 0.2 mm (37- 32 AWG), for 40- 10 meters may be wound by wire in 0.25- 0.5 mm (30- 24 AWG). L3 for bands 1.8- 3.5 – MHz is wound on Russian Resistor MLT-2, for 7- 28 –MHz is wound on Russian Resistor MLT-1. Resistance for the resistors should be more than 27-k

MLT-2 (sizes: diameter 8.6-mm, length 18.5-mm)
MLT-1 (sizes: diameter 6.6-mm, length 13-mm)

***RFC1, RFC2: Coiled by pile- up on Russian Resistor WS- 0.5 by wire in diameter 0.1- 0.2 mm (37- 32 AWG).
WS- 0.5 (sizes: diameter 5.5-mm, length 26-mm)

****T1, T2: Coiled by two twisted wires (1 turn to 1 centimeter) by wire in diameter 0.25- mm (30- AWG). Core – ferrite ring with OD 7… 20-millimeters (not critical), with permeability 100- 1000 (not critical). **Figure 6** shows the design of the transformer.



Pins for Soviet/Russian transistors KT602 and KT928

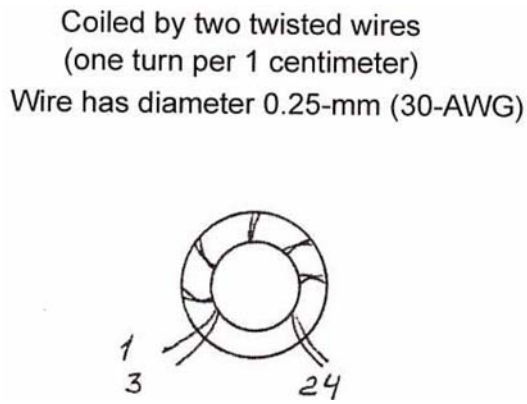


Figure 6 Design of the T1, T2

Part List TX

Resistors:

R1: 39 k/ 0.25 W* (27- 100 k)
R2: 8.2 k/ 0.25 W* (5.1- 10 k)
R3: 560 Ohm/ 0.25 W* (100-Ohms-1k)
R4, R5: 220 Ohm/ 0.25 W* (51- 300-Ohms-1k)
R6, R7: 3.9 k/ 0.25 W* (2.2 - 10 k)

*Recommended
() In brackets- may be used

Capacitors:

C1: 1000- pF 0.1 uF
C2: ***See Table 1 article TST trcv***
C3: ***See Table 1***
C4: 1000- pF 0.1 uF
C5: 47 pF
C6, C7, C8: 0.022- 0.1-uF
C9: ***See Table 1***

Do not down the key too long because VT2, VT3 may be overheated. If quartz is too active, switch in serial with it a resistor in 15-100 Ohm.

The capacity for C3 is given (at **Table 1**) for active quartz. If quartz is low- active the capacity of C3 should be pick- up. As usual it needs a little reduce the capacity compare to **Table 1**.

Caution: Moving frequency for quartz described below suits for OLD QUARTZ made in 30- 60s years of 20 century, which installed in the socket on holders (i.e., has not wires soldered to the quartz plate). Moving frequency by the methods may destroy modern tiny quartz plate. Only experienced ham have to use the Procedure that described below.

Semiconductors

Transistors

VT1: Small power NPN bipolar RF transistor (250-mWtts/250-MHz)
VT2, VT3: Middle power NPN bipolar RF transistor (1-Wtts/250-MHz) *
VT4: Middle power Switch PNP transistor (Ic not less the 0.2-A)

" Small heater is must or VT2, VT3. It may be a little length of a copper tube that is sitting on the case of the transistors.

Diodes

VD1: Any small power diode 50-mA/50-V
VD2, VD3: Any small power RF diodes

Connectors:

X1: Any RF Connector
X2: 5- PIN Audio Connector

Old Crystal

If you have quartz with frequency a bit high what you need – you may move the frequency a little down. Mark the quartz with smooth pencil, measure the frequency, mark again (if frequency not low enough) or remove line carefully with rubber (if frequency is too low). Depend on quartz you may move the frequency up to 20 kHz down

To move the frequency up follows next steps.

1. To take out quartz from the holder.

2. Remove silver plating (if it is) from the quartz. I did it with fresh solution of iron chloride.

3. Make the holder for quartz shown on **Figure 7**.

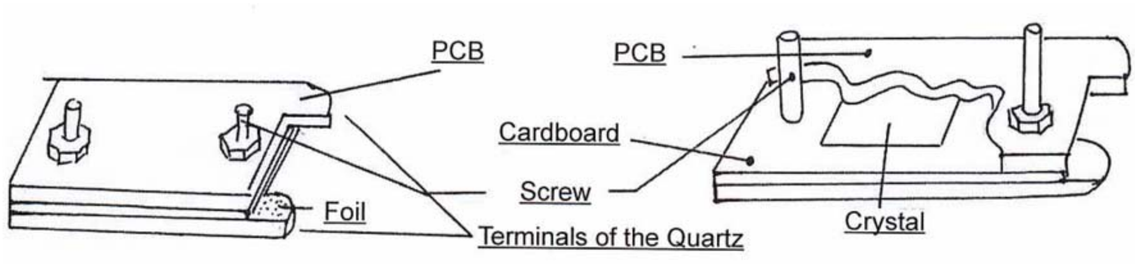


Figure 7 Home made holder for quartz plate

4. Put the quartz plate in to the holder.
5. Measure the frequency of the quartz.
6. If the frequency is lower the needed one, carefully rub the quartz plate on very tiny glass-paper. It is possible to rub quartz with some kind of abrasive paste.
7. Measure the frequency of the quartz.
8. Repeat item 6 if the frequency of the quartz is lower the needed one
9. When the needed frequency is got, put the quartz into holder, make little cavity (with help of a small broach file) on the side of the holder, then put epoxy into the cavity. **Figure 8** shows the closed holder.

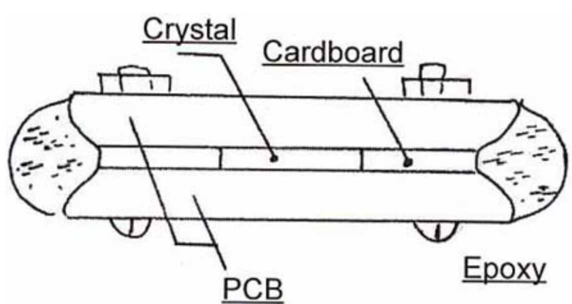


Figure 8 *Closed holder*

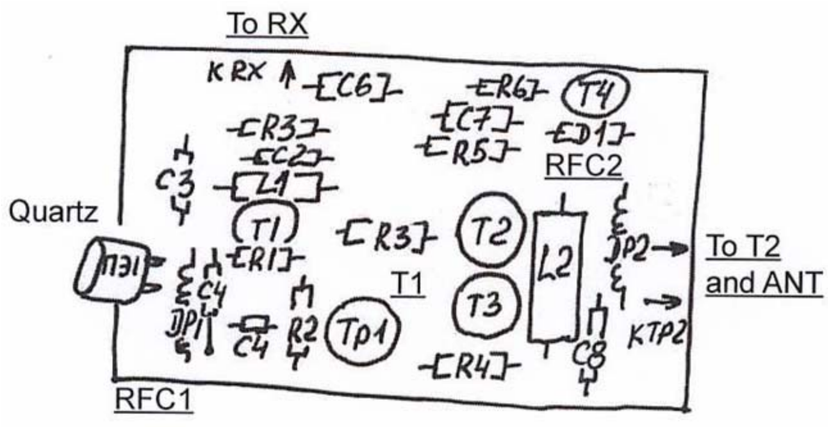
Note: Be careful when work with quartz plate. Quartz plate is fragile, it may be broken at fall down or at too high tightened of the screw in the holder. Quartz may go off generation when the screw in the holder tight too much. Do not worry if the quartz plate is split up on several pieces.

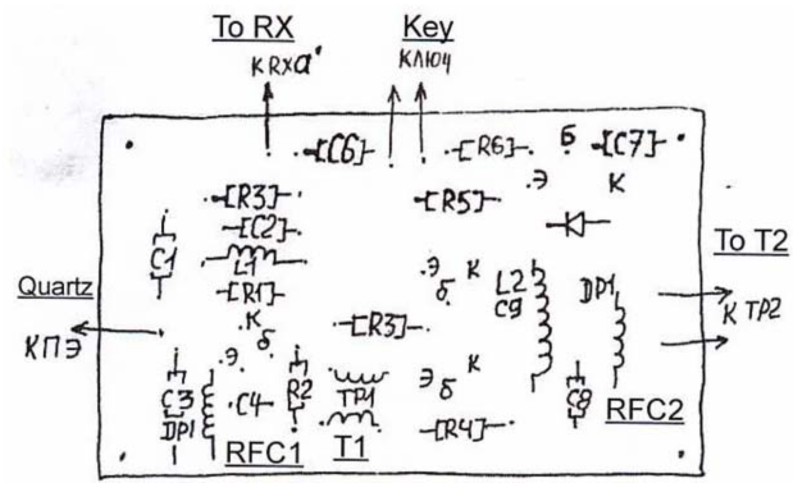
You will be surprised when find off that each pieces of the quartz plate may be used in quartz generator. Having some experience you may cut big quartz plate (I have used for this sharp broach file, good result are obtain with diamond glazier) on to 4-6 and ever 8 working crystals!

Design SQT

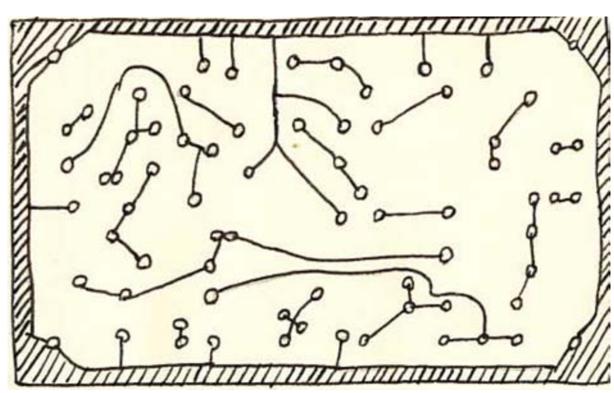
Transceiver made right to the drawing works well and is easy to tuning. **Figure 9 (page 24)** shows the design of the Transceiver SQT. Cabinet made from PCB-stuff.

Figure 10 (page 25- 26) shows the parts of the cabinet with recommended sizes. **Figure 11** shows PCB for TX part of the SQT. Assembly and Tuning SQT is similar to those ones for TST





B. Positions of parts



A. Layout

Figure 11 PCB for TX part of the SQT
Different views

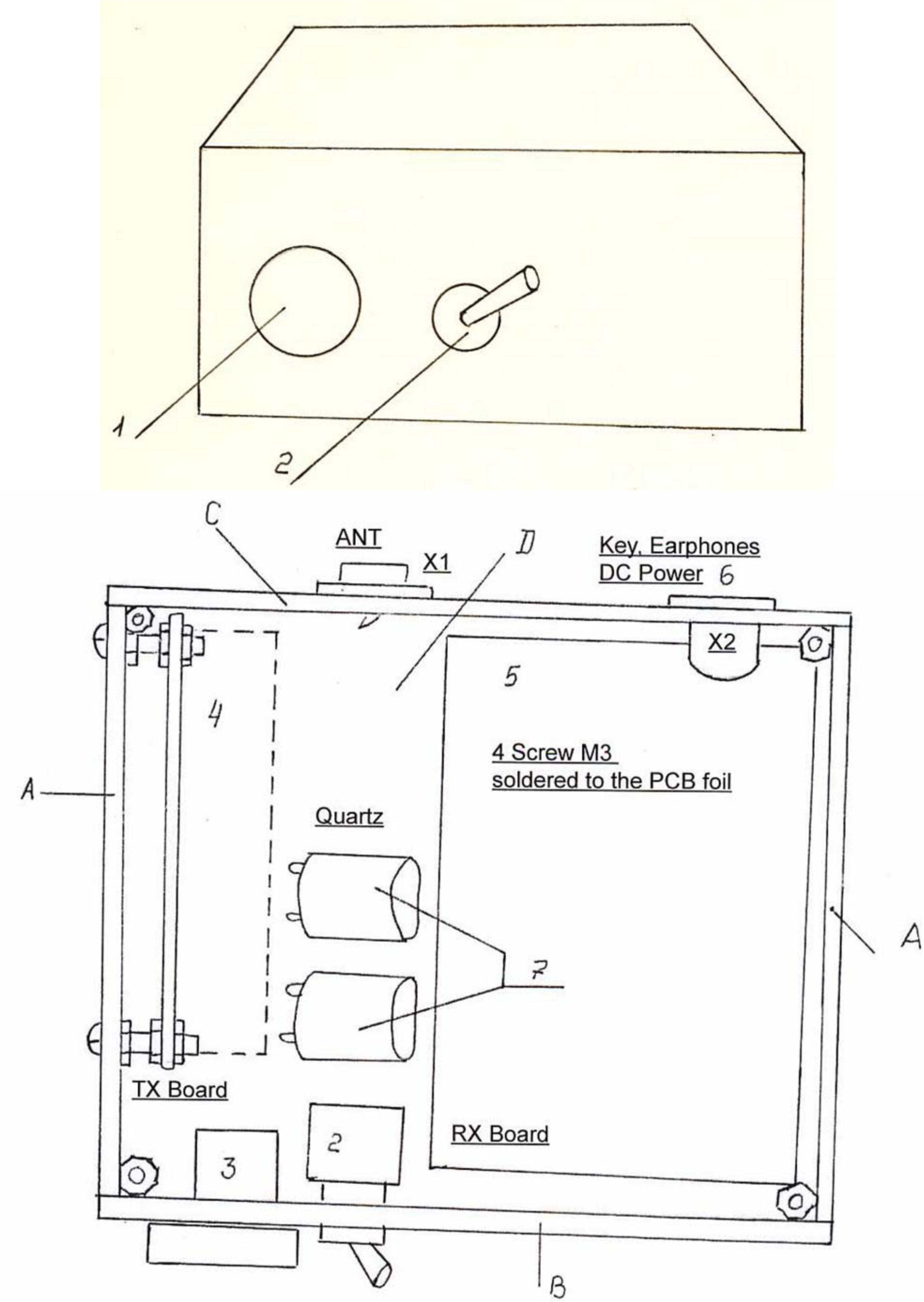


Figure 9 Transceiver SQT

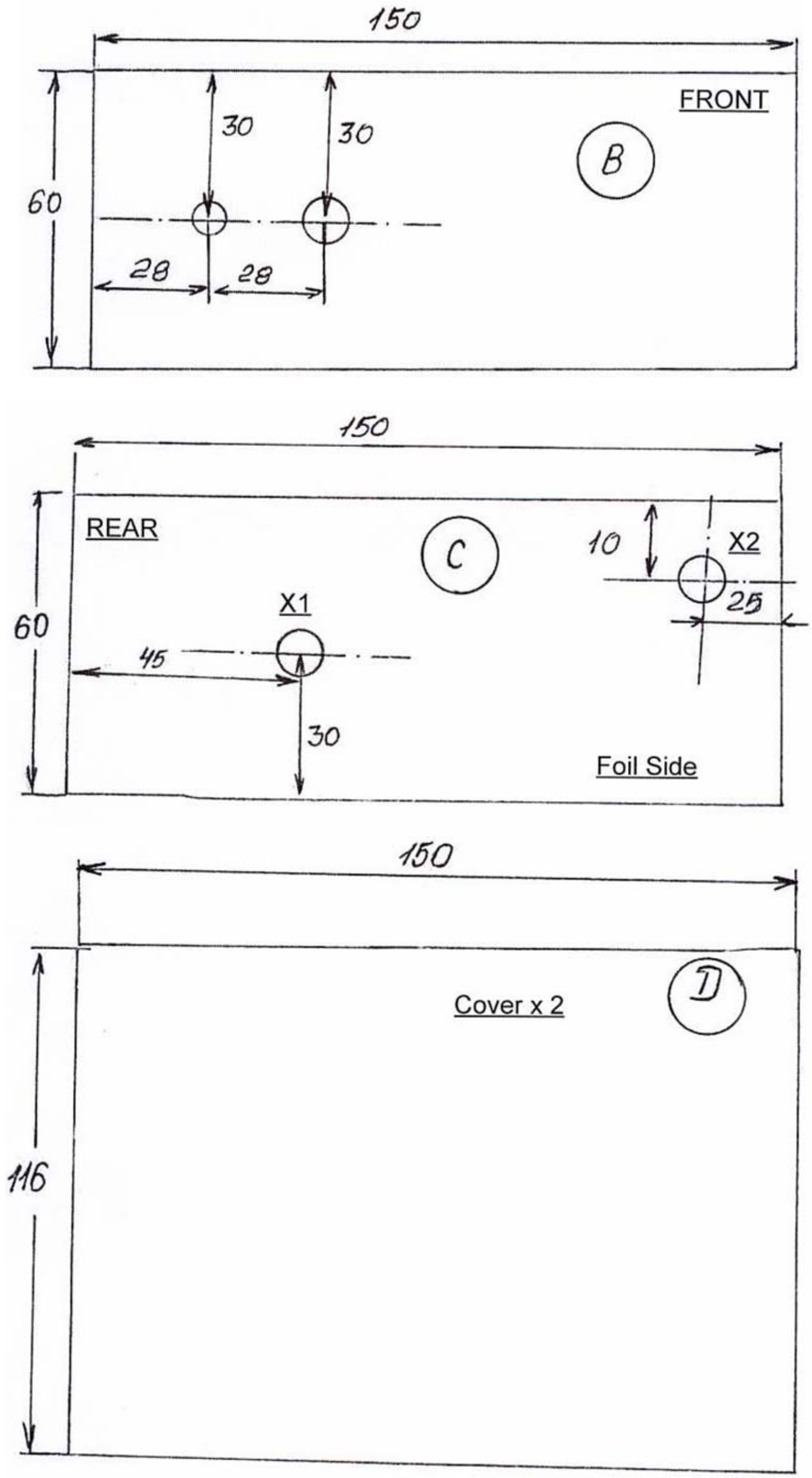


Figure 10 Parts of the cabinet

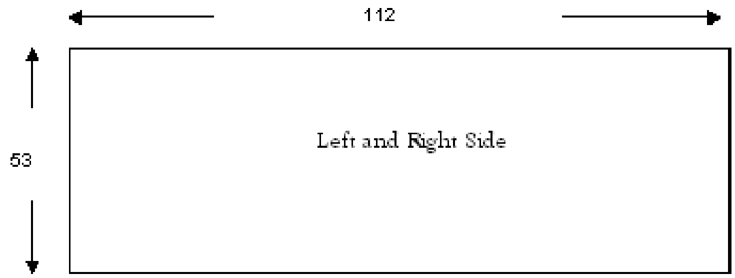


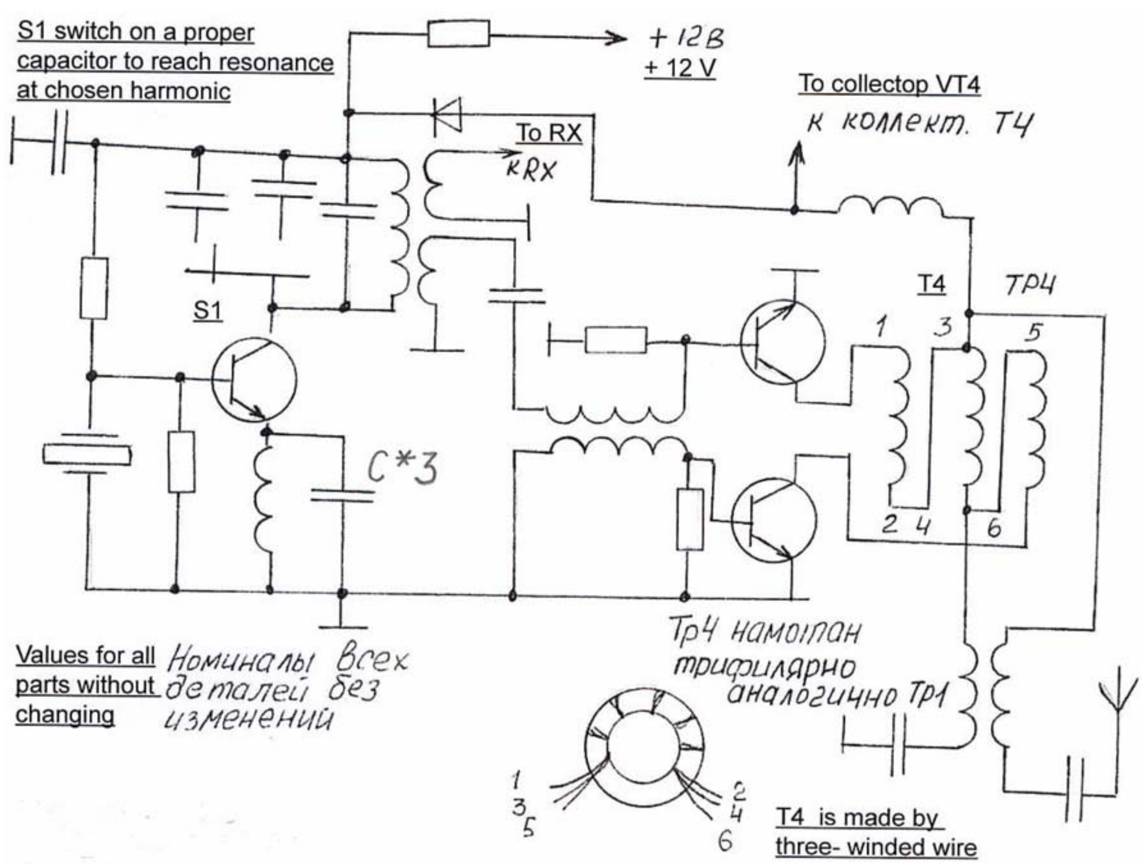
Figure 10 Parts of the cabinet

To **Figure 9**:

1. Knob for frequency shift
2. Toggle - switch for a choice of quartz
3. Capacitor C1 from **Figure 3**
4. PCB TX
5. PCB RX
6. X2 from **Figure 1**
7. Two switched quartzes.

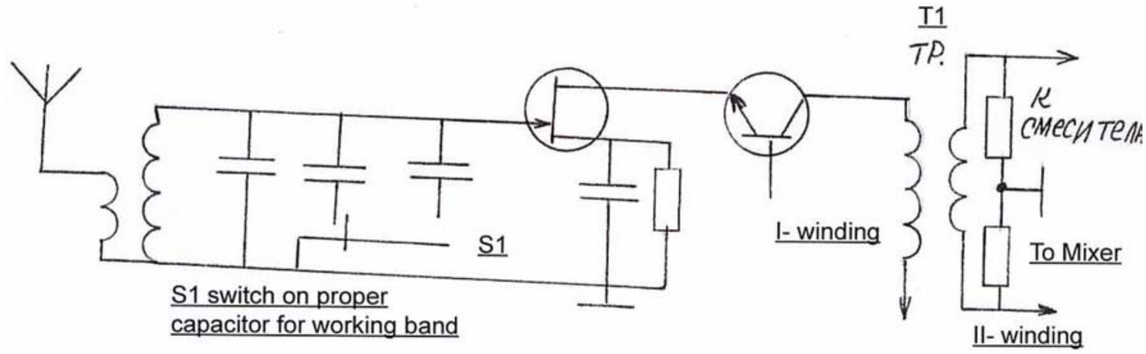
Two/Three Bands SQT

If a crystal used at SQT transmitter is enough active, it is possible to build the SQT for two and ever for three radio- amateurs bands. **Figure 12** shows corrections needed to make work the SQT at 2 or 3 Bands.



A. TX - part

Figure 12 Two/Three Bands SQT



B. TX - part

Figure 12 Two/Three Bands SQT

Corrections at TX board:

L1C1 is tuned to higher frequency. C3 is chosen for stable oscillation of the crystal at main, second and (if it is possible) third harmonic. Switch S1 takes capacitor for tuning L1C1 to resonance. Coupling coil to PA has the same numbers of turns as coupling coil to RX. Transformers T1 and T2 have turns for middle or high band of the multi-band TST. For example, for SQT working on 40-20-15 meter, there are used T1 and T2 for 20 meters. For SQT working on 40-20 meter, there are used T1 and T2 for 20 meters.

Broadband transformer T4 (instead resonance tank L2C9) is installed at the PA. T4 has numbers of turns and coiled wire equal to T1/T2 of the TST. However, the transformer made by three- winded wire, 1 turn per 1 centimeter. PCB for the version is without changing, the new parts are installed by common sense.

Some quartz may not work well at second harmonic but work well at third. RF power at multi- range variant on the high harmonics as usual less in 2- 5 times compare to one- band transceiver. RF power at main harmonic may be less in two times compare to one- band transceiver.

Corrections at RX board:

L1C1 is tuned to higher frequency. Switch S1 takes capacitor for tuning L1C1 to resonance. RF amplifier has broad-band output. Transformer T1 has the same numbers of turn in the first winding as transformer T1 in multi- band SQT. The second winding has in twice less turn compare to the first winding. Core for T1 (used in multi- band RX) is the same as for T1 used in SQT. PCB for the version is without changing, the new parts are installed by common sense.

Figure 13 shows design of the multi-band SQT. The design differs from one- band SQT only by new-installed miniature switch (item 8).

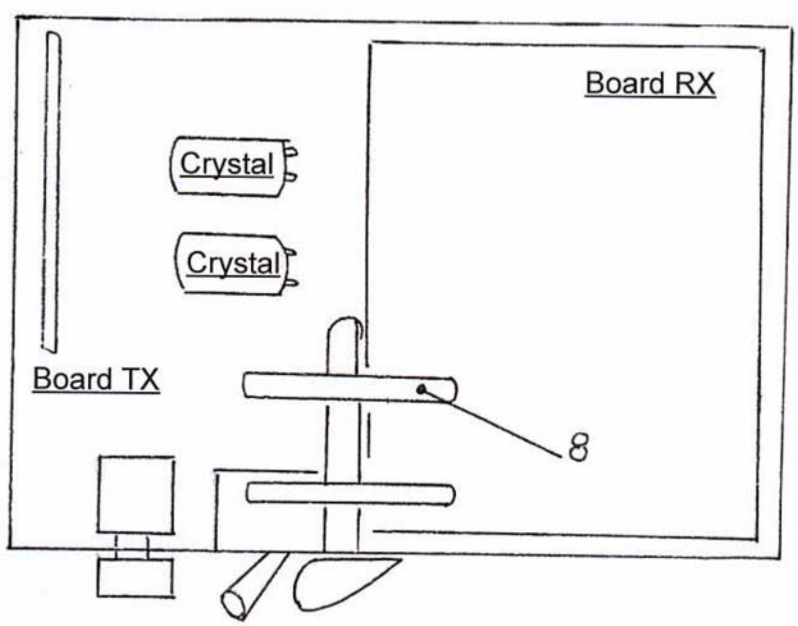


Figure 13 Design of the multi-band SQT

Two Bands SQT with PA for second harmonic

It is necessary to notice that tuning the two/three bands SQT (described above) is not a piece of pie. An oscilloscope plus experience are required for this deal. However, if you have a ready one band SQT, you may turn it to the two bands SQT described below. Figure 14 (page 29) shows schematic for two bands SQT.

Figure 14 Schematic for two bands SQT.

It is wise to build 7/14-MHz SQT. So, there are described such SQT. You may design you own SQT for another bands using the description.

7/14 –MHz SQT consists of (see Figure 14):

1. TX for 7- MHz that was described above (**SQT**).
2. Doubler 7/14-MHz. The doubler is made on T5, VD1, VD2. Transformer T5 is similar to T4 (Figure 12). VD1, VD2- any high speed diodes that can stand 50-mA/50-V. Resonator tank L1C1is tuned to 14-MHz, data for the circuit may be taken from one- band SQT. Coupling coils for RX and TX are contained ¼ numbers of turn from main coil L1.

The coils may be placed close to the "cold end" of the L1. Tap from L1 may be taken from 1/5-1/3 turns from the "cold end."
Serial tanks L2C2 (tuned to 14-MHz) and L3C3 (tuned to 7-MHz) may considerable to clean output signal on 14-MHz. However, the circuits should be used only if you can see the shape of the signal at input/output item 3. Inappropriate tuning of the two circuit may make worse the shape of the output signal at 14-MHz. Data for the circuit may be taken from one band SQT.

Value of the resistors R*1 and R*2 should be pick up at real design of the transceiver. R*1 is influenced on to RX- sensitivity and noise level, R*2 is influenced on to power at TX mode. The adjusting are depended so you mat need to try different nominal for both resistors several times. However the tuning is not hard to do.

3. PA for 14-MHz. It is board for 14-MHz without a crystal. Signal from the 7/14-MHz doubler goes to the transistor VT1 base.

RX for the transceiver is to similar of 7/14-MHz RX from previous paragraph (**Two/Three Bands SQT**).

Figure 15 shows view of the two bands SQT.

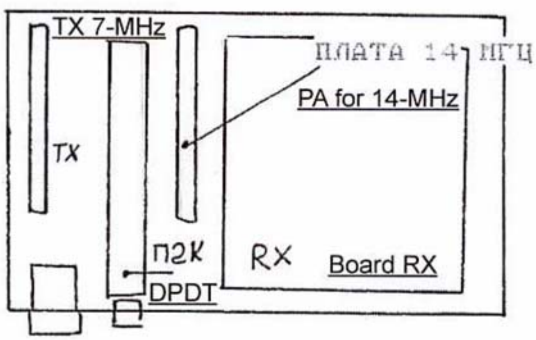


Figure 15 View of the two bands SQT.

All parts of the two bands SQT is switched by a 3-block DPDT. If you have not so long 3-block- DPDT you may make it by itself. Homebrew DPDT is shown on **Figure 16**. The DPDT is made from of three separately DPDT.

These ones are soldered on to PCB. It takes some experience (but not so much) to do the thing. First DPDT has lock. Last two are unlocked. It is possible to use unlocked switch or remove from lockable DPDT a fixating clamp.

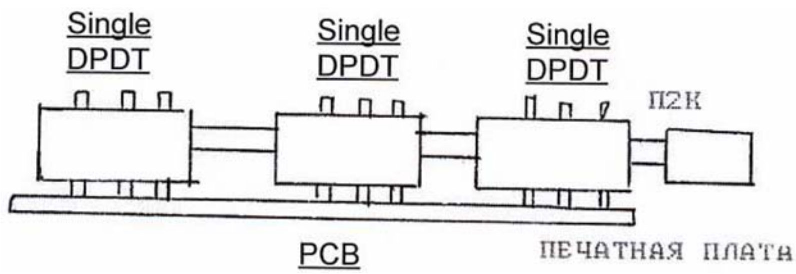


Figure 16 Home made 5- block DPDT

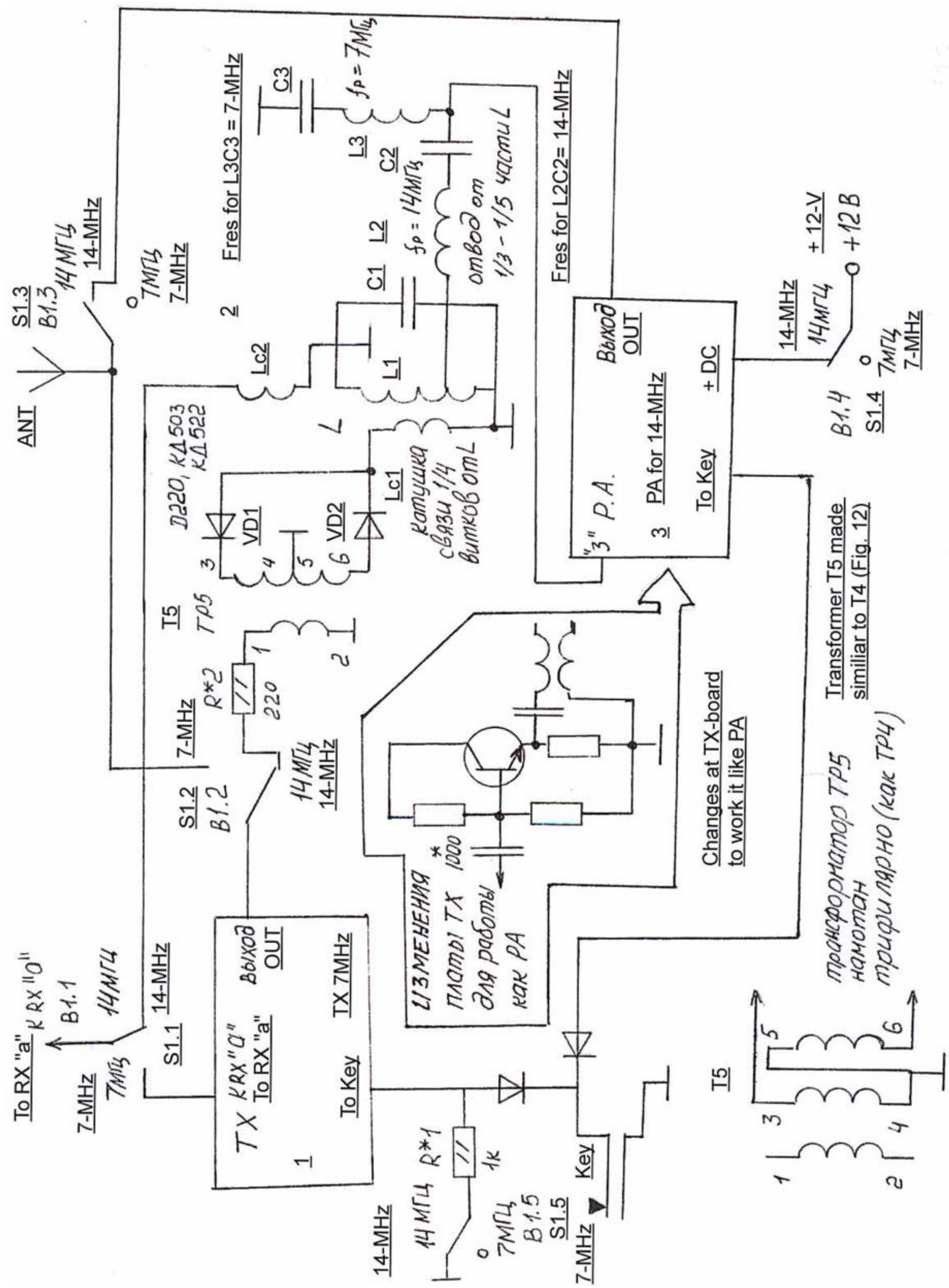


Figure 14 Schematic for two bands SQT.

Commutation of the parts

Switch S1.1:

Position 7-MHz: RF frequency (7-MHz clock) from TX-board 7-MHz goes to the mixer of the receiver board.
Position 14-MHz: RF frequency (7-MHz clock) from doubler 7/14-MHz goes to the mixer of the receiver board.

Switch S1.2

Position 7-MHz: RF power from TX-board 7-MHz goes to antenna.
Position 14-MHz: RF power from TX-board 7-MHz goes to the doubler 7/14-MHz. R*2 is influenced on to power at TX mode

Switch S1.3

Position 7-MHz: Antenna is turned off from PA-board 14-MHz.
Position 14-MHz: RF power from PA-board 14-MHz goes to antenna.

Switch S1.4

Position 7-MHz: DC power turn off from PA-board 14-MHz
Position 14-MHz: DC power turn on to PA-board 14-MHz

Switch S1.5:

Position 7-MHz: Resistor R*1 is turned off.
Position 14-MHz: Resistor R*1 is turned on so it allows TX board 7-MHz to be switch on at working two band SQT at 14-MHz. R*1 is limited the power of the TX board 7-MHz. R*1 is influenced on to RX-sensitivity and noise level

Switch S1.6 (Not shown at the **Figure 12**):

Position 7-MHz: Additional capacitor is switched on at input filter at RX- board (**Figure 14**).
Position 14-MHz: Opened Switch.

Figure 17 shows the position of the switches at DPDT.

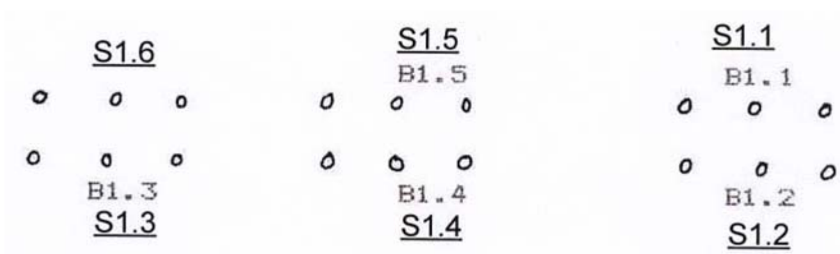


Figure 17 Position of the switches at DPDT

The two bands transceiver is easy tuned and adjusted. Sometimes especially for two band transceiver 3,5/7-MHz and 7/14-MHz output power 1-Watts may be reached without on VT1 on the board "PA." However, it needs to pick up the R*1 and R*2 thoroughly. Broadband PA on 10 watts may be used with the transceiver. So you get compact radio that well work at field and home. Several such transceivers were used at my radio station UA3ZNW at the already late 90s.

At the article were used pictures from the Book:

QRP Transceivers and PAs from
Accessible Parts

Some pictures is not in scale compare to original book.

English commentaries were included. The commentaries are underlined.

73/72! I.G.

BEWARE!

Simple Broadband P.A.

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Credit Line:

"QRP Transceivers and PAs from Accessible Parts ": by Igor Grigorov, UA3ZNW

The P.A. is very simple. It is usual push- pull (made on VT1, VT2) with some tricks which allows to make the P.A. in easy style.

How it is work: Transformer Tp1 provides matching 50-Ohm input of the P.A. with low resistance input impedance of the and makes symmetrical of the unsymmetrical50-Ohm input with the symmetrical push-pull input. Transformer Tp2 works something like RF-Choke plus Push- pull transformer. Transformer Tp3 provides matching "balance" push- pull output with unbalance output 50-Ohm. If you use to a symmetrical antenna (for example dipole, quad, delta) which is connected to the P.A. by a short length of a coaxial cable you may do not ground the pin "4" at the transformer Tp3. **Figure 1** shows the schematic diagram of the P.A.

(***Note I.G.:*** Generally speaking it is not correct description, but I leave it as is for some reason. The schematic is only first step for ham to the miracle world of the P.A. I would like to leave "academic" description for next steps…)

Correctly assembled (using right parts) amplifier requires a minimal adjustment. At first it needs to install collector current. It is equal 50-mA/ at power 20-Wtts, 100-mA/ at power 40-Wtts, 150-mA/ at power 60-Wtts. It is desirable to use a low- frequency (or resonated) filter before the P.A. and antenna.

For example, you may use filters from **References 1**. If a high impedance antenna will be used with the P.A., it is possible to install transformer 50/300-Ohm or 50/450-Ohm at the output of the transformer and feed the antenna through a two-wire line. At radio-amateurs source it is possible to find lots different designs for such transformers, for example in **Reference 2**.

Matched pair of the RF-power transistors should be used in the amplifier. Best way is to buy such matched transistors from supplier. However, if you have a stock of 10- 20 RF- power transistors, you may to find a matched pair from these ones. To provide this it is necessary to measure some parameters of the transistors. Transistor is switched on in the circuit shown in **Figure 2**. Install with help R2 collector's current equal to 50/100/200/500/1000-mA. Do measuring fast enough while the transistor should not be warm too much. Better way is to use a heat sink for the transistor. Transistors which plots are mostly close are the matched pair. Remember, that collector current divide to base current is amplification factor (gain). Matched pair should consist of from transistors with gain that do not differ more then 20% at different currents.

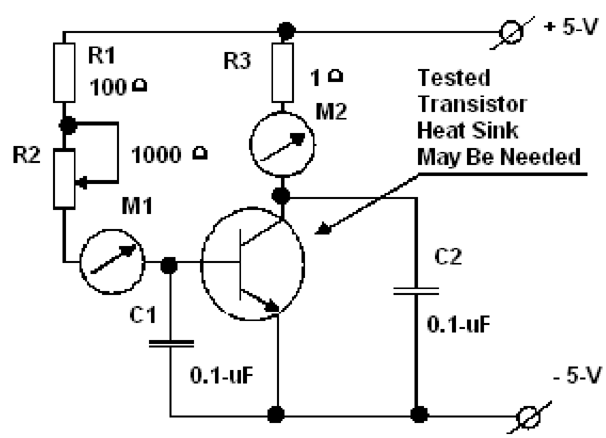


Figure 2 Circuit for finding of matched pair of the RF power transistor

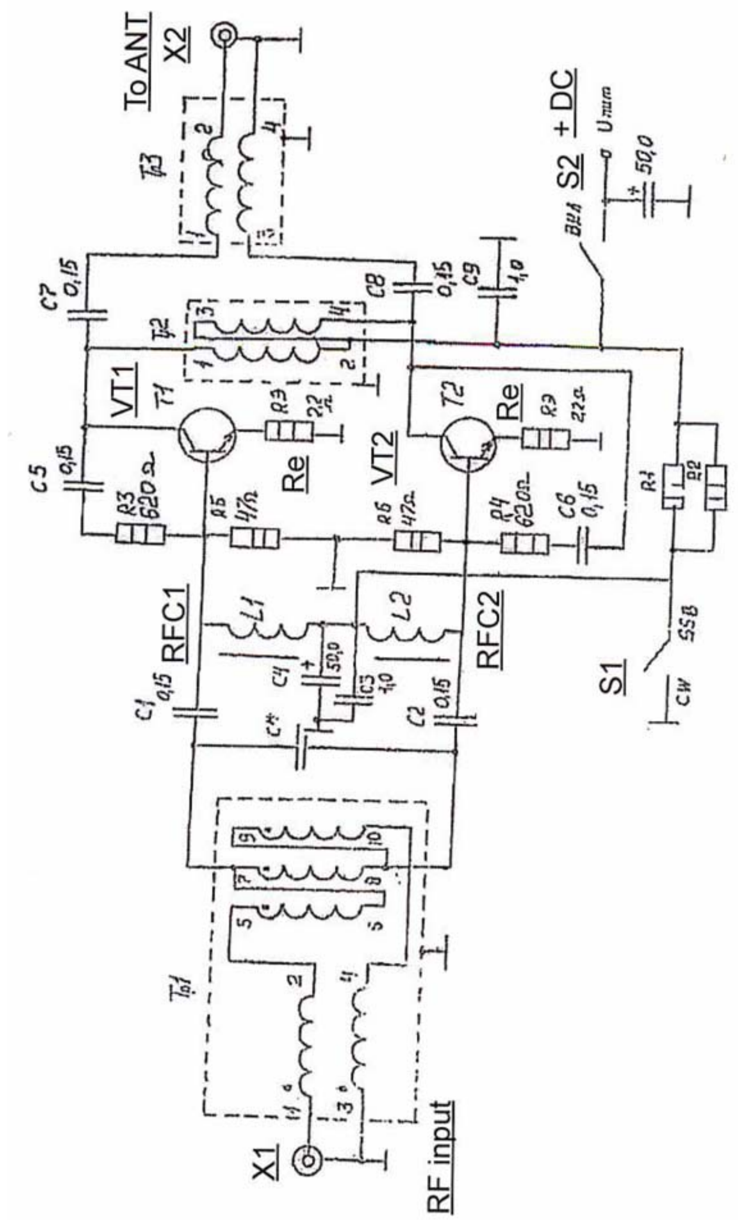


Figure 1 schematic diagram of the P.A.

(***Note I.G.:*** Generally speaking, 5 points it is not enough for normal selection of matched pair of transistors. It is desirable to do the selection using 7-10 points, thus the tolerance at amplification factor should be not more the 10%. I do not speak about selection of a matched pair using measuring of the transistor parameters at different frequencies because it goes away from the radio- amateur technology.)

It is possible to use non matched transistors but it needs install individual for each transistor biasing. To do this cut jumper between L1 and L2. A capacitor 50-micro- farads is soldered in bridge with C3. A capacitor 1-micro- farads is soldered in bridge with C4. With help of additional base resistors install equal current for each of the transistors. Turn RF power to the input of the P.A. With help of an oscillograph check the shape of RF- voltage on the Dummy Load and on the collector of each of the transistors.

Do the check at different frequencies. Adjust biasing on to minimum distortions. Capacitor C* (200- 600-pF) may help to illuminate distortions. However the method required some experience. Sometimes (when the transistors are too different) satisfied result is not possible.

Resistors Re have nominal from 1to 4 –Ohms, depend on output power. Less at high power and more at low power. Sometimes, when not matched transistor pair is used to the P.A. the resistors may have different nominal, it is possible to fond right value with help of oscillograph on to minimum distortions.

P.A. has two modes: SSB and CW. At CW mode the transistors work in mode "B'- the bases closed to ground (with help of S1) through RFC1 and RFC2.

Practically any RF transistors can be used at the P.A.

RFC1 and RFC2 are wound on a ferrite core 8-millimeter OD and 10 millimeter in length. The ferrite core is cut off from a ferrite rod using in "magnet antenna" for a transistor radio. RFC1 and RFC2 have 80 turns each wound by copper wire in 0.1- millimeter (38-AWG). Transformers Tp1, Tp2 and Tp3 are wound on a ferrite core. As usual for the P.A. I use to a ferrite from TV Flyback. Not bad work a ferrite core from a monitor Flyback. It is possible to use ferrite core from T.V. yoke. Transformer Tp3 works well when it is wound on a ferrite from yoke. All transformers are wound by insulated copper wire in diameter 0.5- millimeter. Transformer Tp1 is wound by twisted and tripled wires, one turn to one centimeter of the length. Transformers Tp2 and Tp3 are wound by twisted wires, one turn to one centimeter of the length. Design of the transformers is shown on **Figure 3**.

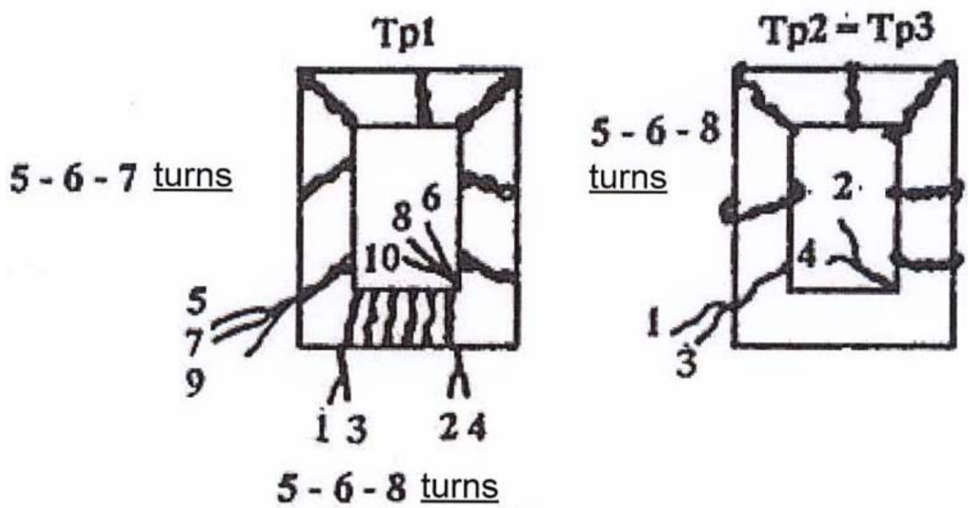


Figure 3 Design of the transformers Tp1, Tp2- Tp3

Ferrite core is wound by soft plastic insulation tape. After winding the coils also are wound by soft plastic insulation tape. Transformer is installed on the main PCB. Two PCB square are installed at the sides of the transformer. With help bare copper wire (1-millimeter or 18-AWG diameter) the squares are soldered between each other and soldered to the main PCB. Installation of the transformers is shown on **Figure 4**.

The heat sink for the P.A.'s transistors made from aluminum H- stuff. It is possible to by such stuff at a household shop (such like Home Depot). **Figure 5** shows the installation of RF-power transistor to the H-stuff. **Figure 6** shows PCB for the P.A.

The adjusted PCB is installed inside a cabinet made from two- sided PCB. Jointing of the PCB-stuff is carefully soldered. P.A.'s PCB may be soldered to the PCB – stuff of the cabinet. At four corners (up and down) of the cabinet a nuts M4 are soldered. To the nuts upper and low cover is fastened. Near the heat sink of the transistors (at cabinet and at covers) are drilled ventilation holes (3-4 millimeter in diameter). RF connector "Input" and toggle switches "SSB/CW" and "OFF/ON" are installed at front panel. Connector "Antenna" and DC power supply terminals are installed at back panel. **Figure 7** shows the design of the P.A.

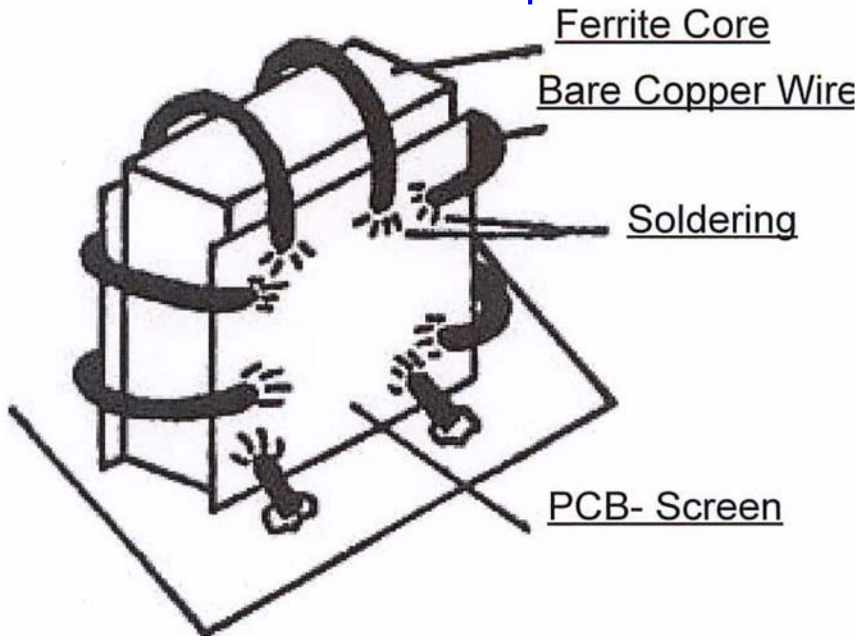


Figure 4 Installation of the transformers Tp1, Tp2- Tp3

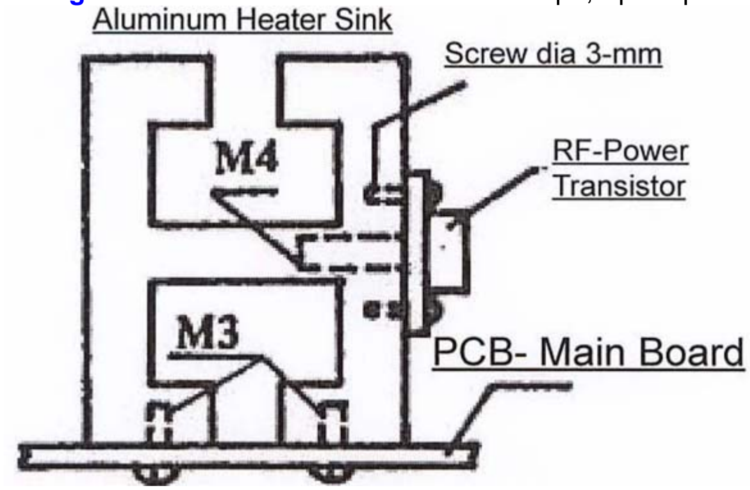


Figure 5 Installations of an RF-power transistor to a heat sink

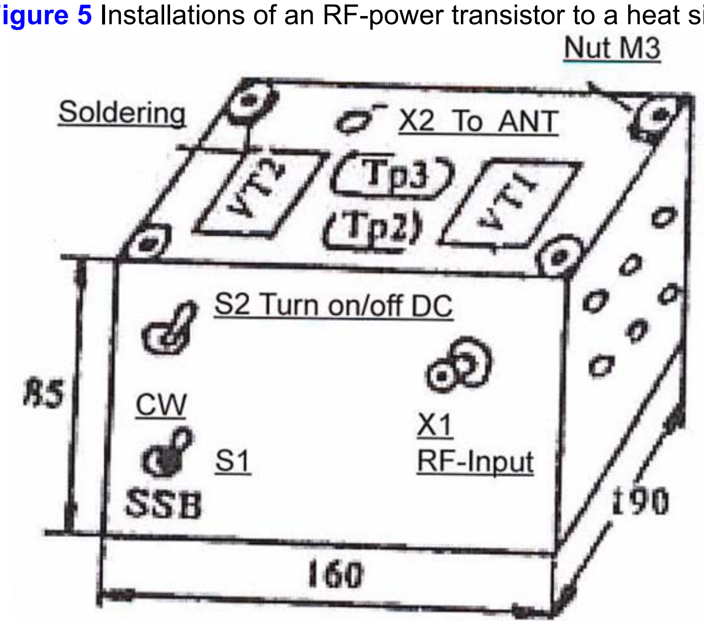


Figure 7 Design of the P.A.

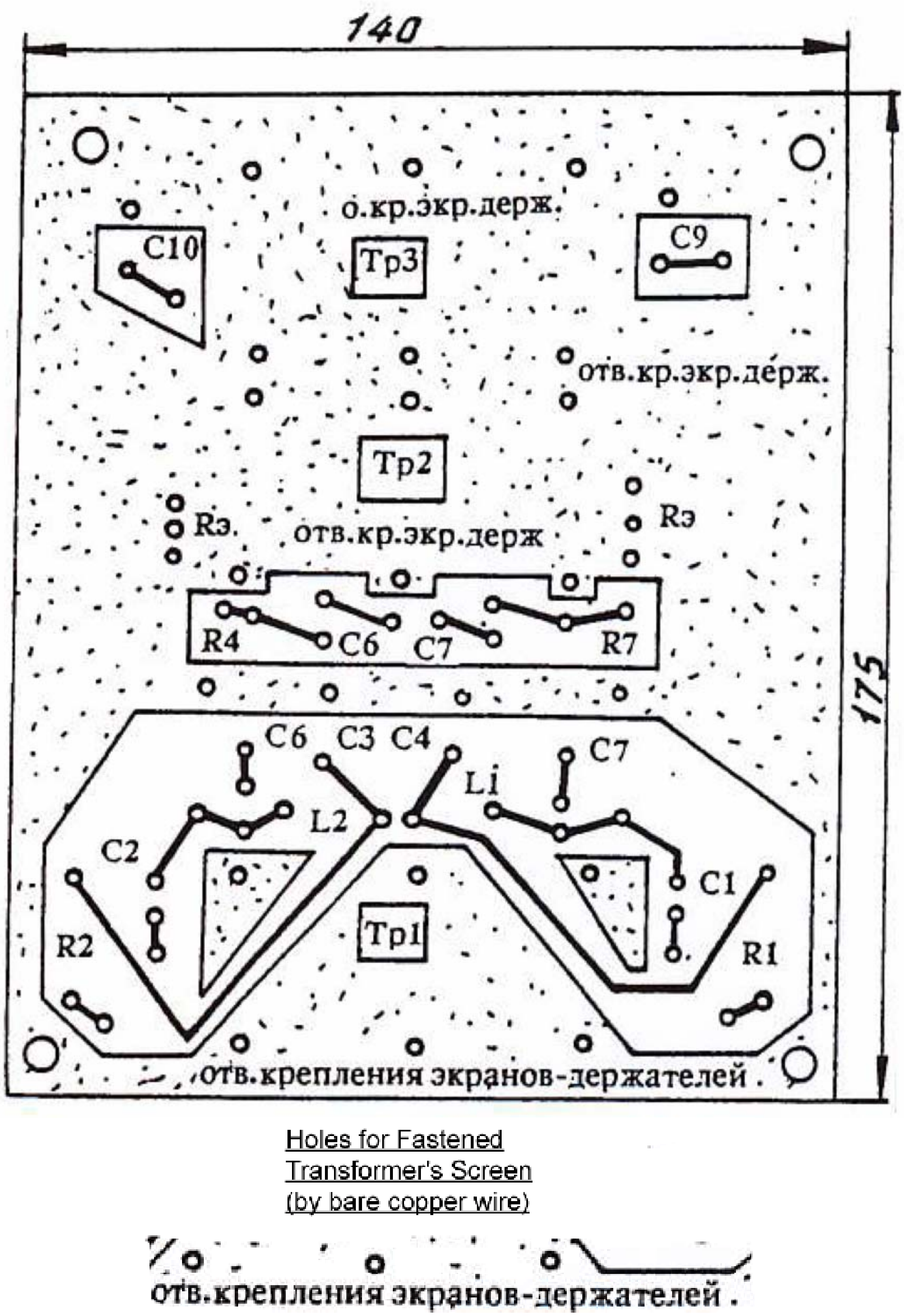


Figure 6 PCB for the P.A.

Home ferrite core made from a flat ferrite

The good results give transformers (Tp1, Tp2 and Tp3) wound on a home made ferrite core made from a flat ferrite. Such flat ferrite is used at some transistor LW/MW radio.

To make all three transformers it needs several such flat ferrites. I have bought a pile of the ferrites at a scrap-radio shop by very nice price.

Flat ferrite is cut on to pieces then the pieces are glued on to needed shape. It is possible to cut the ferrite with help a device shown on **Figure 8**. I cut ferrites having different shape (flat, round rod, toroid) with help of the device.

The device is very simple. It is an incandescent 40-Watts bulb (or simple soldering iron) that is turn on into the main. Any main -110 or 220-V works good, however, main on 220-V works better the 110-V. Two probes with hard steels sewing needle are inserting in one wire. To cut a ferrite it needs to mark the ferrite on to cutting line by a lead pencil.

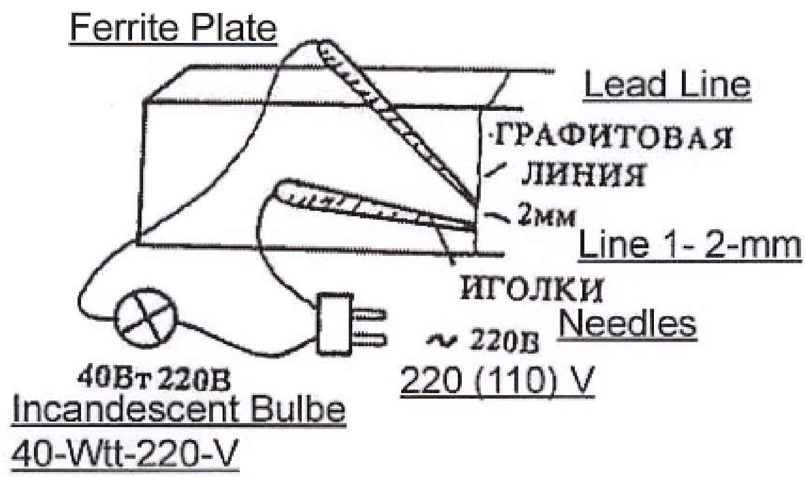


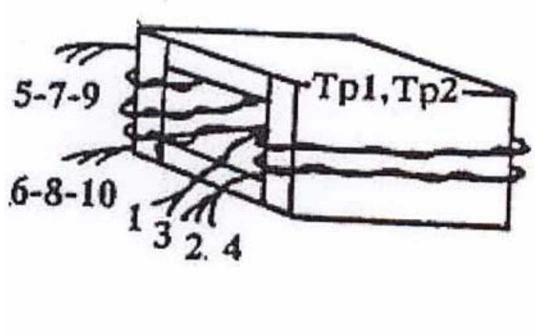
Figure 8 Cutter for ferrite core

(***Note I.G.:*** Lead pencil is very important at the process. Try several pencils at a scrap ferrite to find the pencil that helps cut the ferrite in the best way.) Turn on the cutting device in to the main. Touch by the needles the graphite line. Gap between the needles should be 1-2 millimeters. An arc going onto the graphite line will appear. The arc leaves a cavity on to the line. Move the probes and do the cavity on to all mark line. Then break the ferrite on to the line. It needs some experiences, it needs very quick to break this ferrite.)

(***Note I.G.:*** Be very careful because the PROBE IS SWITCH ON IN TO MAIN. Use good insulator for the probes and be very careful.)

The needles are heat up at the process, so, use heat-resistant stuff for the probes. After cutting several ferrites the needle's point should be sharpened or the needles should be changed.

As usual a flat ferrite used at "magnetic antenna" of a transistor radio has length in 90… 12- millimeters. At the case length for Tp1 is 1/3 from the length of the ferrite. Length for Tp2 is 1/2 from the length of the ferrite. Tp3 made like a double Tp2 or has the same design like a Tp2. **Figure 9** shows design of the transformers.



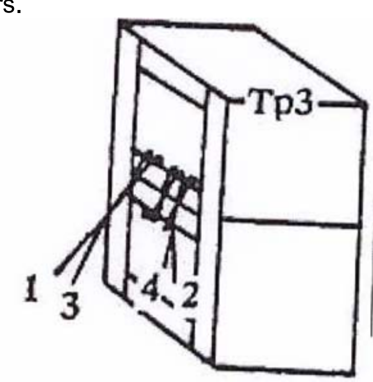


Figure 9 Design of the P.A. transformers

References:

1. S.G. Bunin, L. P. Yajlenko. Reference Book for Amateur Radio,- Kiev, Publishing House "Tehnika". 1978. (in Russian)

2. Igor Grigorov . Antennas: Tuning and Adjusting.- Moscow, Publishing House "RadioSoft", 2002, ISBN: 5- 93037-087-7 (in Russian)

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