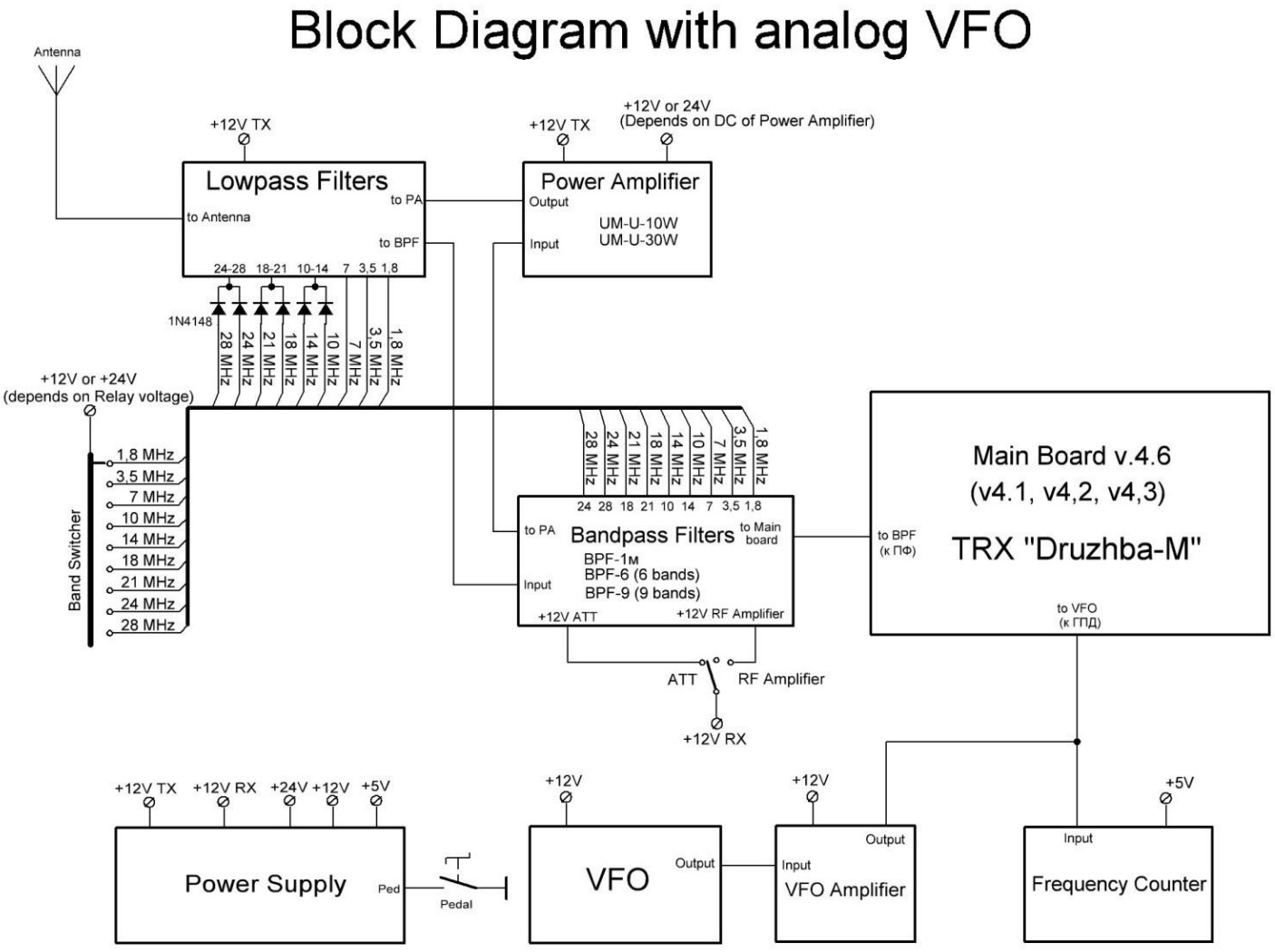
Amateur Transceiver “Druzhba-M”

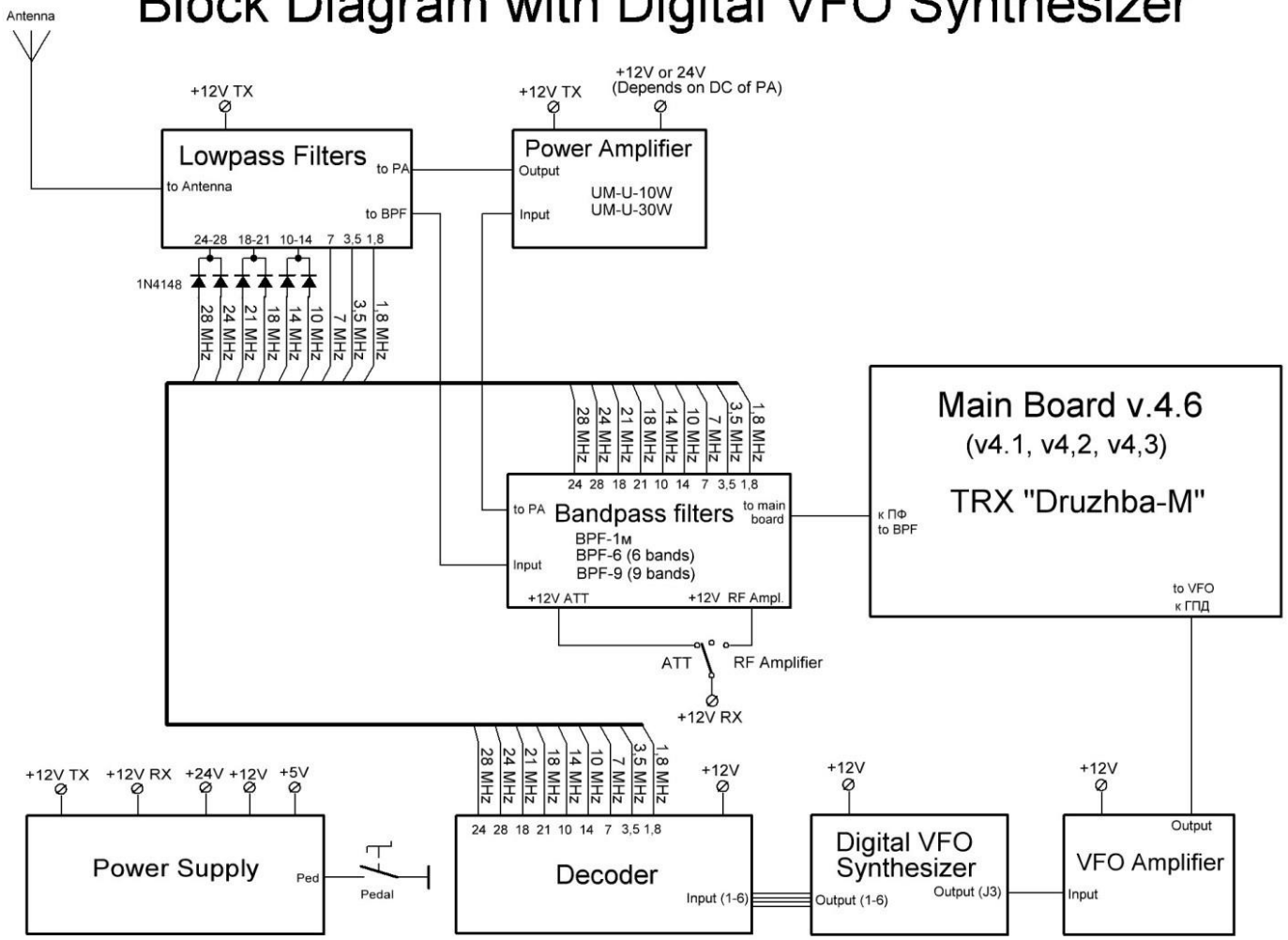
Shortwave transceiver "Druzhba-M" is designed for amateur radio communications SSB and CW on all nine HF bands from 160 to 10 meters. When designing the Druzhba-M transceiver, the task was to create an inexpensive device with acceptable electrical characteristics, high repeatability and an element base accessible to most radio amateurs. This design does not contain any original circuit solutions, it is a "hodgepodge" of nodes previously described by other authors and well-proven in mass repetition.

The transceiver has the following main technical characteristics:

- Sensitivity of the receiving path at a signal-to-noise ratio of 10 dB, not worse than 0.25 μV;
- Two-signal selectivity with signal detuning of 20 kHz not less than 80 dB;
- AGC adjustment range of at least 80 dB when the output voltage changes by 6 dB;
- The output power of the transmitting part of the transceiver is 10-30 W.



Block Diagram with Digital VFO Synthesizer



HF transceiver "Druzhba-M" is a transceiver with one frequency conversion and contains seven functionally complete blocks or boards:

- Motherboard
- Board of bandpass filters BPF-9 (nine bands) or BPF-6 (six bands) with attenuator and PRE amplifier;
- Druzhba power amplifier board (20-30W on IRF510) or power amplifier board on UM-U series boards (10 W or 30-40W);
- Board of low-pass filters LPF-2
- Frequency synthesizer or analog VFO;
- Numerical scale (TSS), if analog VFO is used;
- Power supply unit (PSU). Or factory-produced 20-24V PSU.
- Transformer 2A, 72W or equivalent.

Attention!

Before starting installation, please check the availability of all elements according to the list of equipment.

Claims for the complete set are accepted within 14 calendar days from the date of receipt of the order.

If you have any questions, feedback and suggestions, you can contact us by e-mail SALES@RV3YF.RU or through the contact window on our website WWW.RV3YF.STORE

Motherboard “Druzhba-M” (v4.61)

The main board of the Druzhba-M HF transceiver in terms of repeatability and ease of setup has proven itself perfectly and has been tested by serial production.

The first stages of the main board of the HF transceiver "Druzhba-M":

- High level double balanced ring mixer
- Broadband amplifier of VFO (frequency synthesizer)
- Cascade matching mixer and eight crystal quartz filter using a powerful field effect transistor КП903 (VT1). The cascades assembled on КП327 (VT2) and KT315 (VT11) are circuit solutions that have long been known to everyone and have proven themselves.
- Two cascades of IF are made on two-gate low-noise field-effect transistors КП327 (VT3 and VT4). Between them, a four-crystal clearing quartz filter is included with a change in bandwidth (only for reception in CW mode) using КВ127 varicaps, which are energized from a KT315 (VT18) transistor. At a voltage of 12V, the stripping filter bandwidth is 2.7 kHz. In the absence of voltage, the band for the telegraph is 1 kHz. Both stages of the IF are covered by AGC (automatic volume control).
- The modulator-demodulator (it is also the second mixer) is a ring mixer based on KD514 diodes, in the circuit of which, to simplify balancing, a tuning resistor R67 is introduced.
- Preliminary two-stage AF amplifier is made on low-noise transistors KT3102E (VT15, VT16) with a gain of about 600 - 800.
- After sufficient amplification of the signal by preliminary AF amplifier, it became possible to use the available TDA2003 (DD2) chip in the final amplifier, as radio amateurs say - in easy mode.
- The transceiver uses the simplest and most well-proven AGC circuit made on transistors of the KT3102E series (VT13 and VT12), an AGC amplifier is assembled on VT14, the signal to which is supplied from the second stage of the AF amplifier as a result of which the dependence of the AGC circuit on the position of the variable resistor “IF gain”.
    - The level of AGC operation is set by trimming resistor R106
    - The AGC is turned off by shorting the base of the VT13 transistor to the “case”, but not directly, but through a resistance of 3.3k, which makes it possible to protect you from your “beloved” neighbor who “approached” the few kW to say hello. In this case, AGC will work.
- Voltage is supplied to the base of the VT12 transistor through a decoupling diode from the manual IF gain controller, and an S-meter device (100-250 μA) is connected to the emitter through a tuning resistor.
- On transistors KT315 (VT19) and KT646 (VT20) a quartz reference oscillator (BFO) and a broadband amplifier are made according to standard, long-established schemes.
- The microphone amplifier is made on transistors of the KT3102E (VT6, VT7) type with a gain of 600 - 800. Its input circuits are selected to work with dynamic microphones of the MD-66, MD80, MD382 types. The cascade on KT815 (VT5) is an emitter follower. Power is supplied to the first stage of the microphone amplifier from the SSB / CW switch through an electronic key to the transistor KT361 (VT8), in the "transfer" mode, power is connected to the second stage from the "+ TX" bus.
- The telegraph generator is assembled on the transistor KT315 (VT10) according to the capacitive three-point scheme. The CW generator is controlled by a key on a KT361 (VT17) transistor. Self-control in CW mode is implemented on the K561LA7 (DD1) microcircuit - this is an RC generator (800-1000 Hz), which is triggered by a high logic level supplied to pin 6 from the collector of the VT17 transistor, and from output 10 an audio signal is already fed to the input of the TDA2003 microcircuit (DD2). The desired signal level is set by the tuning resistor R57.
- The choice of the intermediate frequency of the transceiver depends on the applied crystal filter. In the literature, schemes and methods for manufacturing home-made filters for various frequencies have been repeatedly described. The main board of the Druzhba-M transceiver is designed for the eight-crystal main and four-crystal cleaning quartz filters "Desna" or a small-sized version of KF-8m and PKF-4m (fc = 8.865 MHz). These CFs are assembled on the basis of quartz resonators from PAL/SECAM set-top boxes. As measurements have shown, these quartzes have a high quality factor, the resonant gap is from 14 to 20 kHz. An eight-crystal quartz filter made of such resonators has the following parameters:
    - squareness coefficient for levels 6 and 60 dB – 1.5 – 1.7;
    - attenuation beyond the passband more than 80 dB;

- unevenness in the passband - 1.5 - 2 dB;
- 6 dB bandwidth – 2.4 kHz;
- input and output impedance 200 - 270 Ohm.

- The RX/TX mode formation circuit is made on the RES-49 (REK-23) relay with a response voltage of not more than 12 volts. All external connections from the main board are made through two connectors X1 and X2.

Building

The main board has dimensions of 215x98 mm and is made of double-sided f/glass-textolite 1.5 mm thick. When mounting the board, it is necessary to take into account that some circuits are connected through jumpers, and for some p / elements, the "ground" is supplied through the case terminals of quartz filters, which must be carefully soldered.

On the main board apply:
o high-frequency chokes - type DM, DPM or imported analogues with a rated current of at least 0.1A.
o Connectors X1, X2, X3, X4 and X5 are single-row PLS type (BLS counterpart).
o Fixed resistors 1/4W,
o Trimmer Resistors - Multiturn 3296W,
o Capacitors type K10-17 or equivalent.
o Relay type RES-49 for operating voltage 12-18V.

Attention! For installation, it is convenient to use the specification for matching the labels on the board. The list of denominations and their correspondence is supplied in printed form with the kit. This greatly speeds up installation without errors.

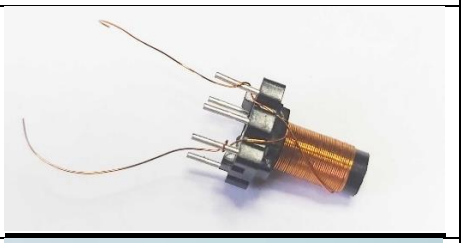
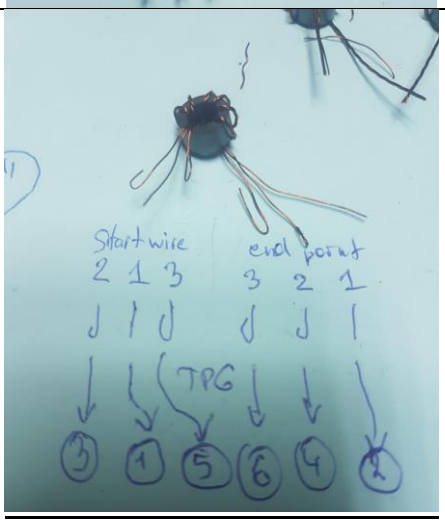
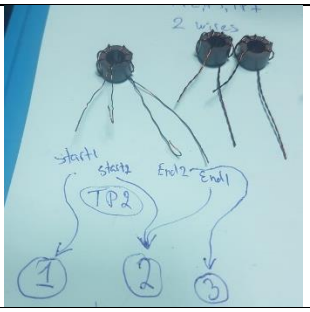
Shields of quartz resonators and a quartz filter must be connected to the case to eliminate the background of alternating current and the microphone effect.

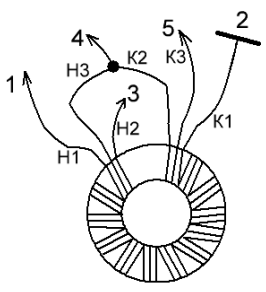
Inductors are made with 0.16mm wire on frames 6 mm in diameter with trimming cores. The frames are enclosed in a screen.

Coils L1, L4, L6 contain 28 turns each, winding turn to turn, communication coils L2, L5, L7 contain 5-6 turns, over L1, L4, L6 closer to the middle and are fixed by glue. Coils L3, L8 contain 25-35 turns each (selected during setup), winding turn to turn.

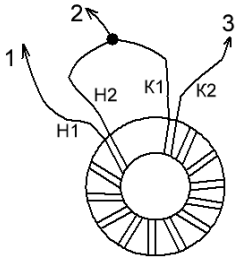
Broadband transformers are made on toroid 10x6x5 with 0.28 mm wire. Transformers Tr1, Tr5, Tr6 contain 7 turns in three twisted wires, Tr4 contains 7 turns in four twisted wires, Tr2, Tr3, Tr7 contain 7 turns in two twisted wires.

ATTENTION! I pay additional attention to the correct and high-quality manufacture of broadband transformers, especially the observance of polarity when connecting the windings.

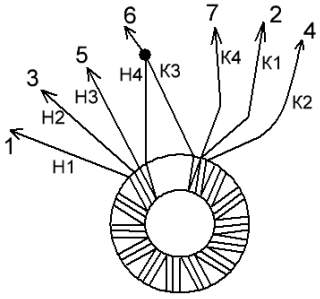
Element	Building	Pictures
L1, L4, L6	28 turns by 0.16mm wire. Turn to turn.	
L2, L5, L7 (over L1,L4,L6)	5-6 turns over L1,L4,L6 (in the middle). Fix by glue	
L3, L8	25-35 turns of 0.16mm (selected during tuning). We recommend 28 turns initially, then adjust if necessary.	
Transformers Tp1, Tp5, Tp6	They are made on toroid 10x6x5 and contain 7 turns in three twisted wires, i.e. We cut off three identical segments from the wire - 0.28mm, 25-30 cm long. We twist three wires in increments of 2-3 turns per centimeter. In everyday life, it is most convenient and practical to use a manual screwdriver or drill: Both ends are temporarily tied. We hook one end into the drill chuck, the other for some object. Slowly turn the drill and control the pitch of the turns per centimeter. It turns out nice and fast. Next, we clean the ends, identify the wires (where, which end), and install on the board according to the illustration below.	
Tp4	Contains 7 turns in **four** twisted wires 0.28mm	
Tp2, Tp3, Tp7	Contains 7 turns in **two** twisted wires 0.28mm	



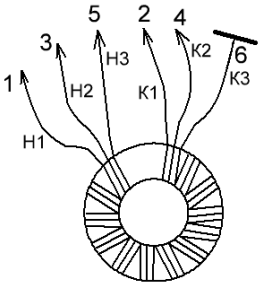
Tp1, Tp5



Tp2-Tp3-Tp7

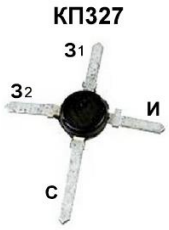


Tp4



Tp6

Mounting of two-gate transistors КП327

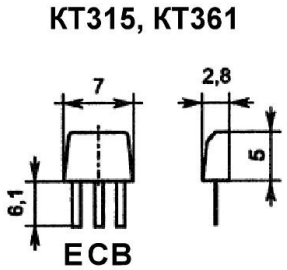


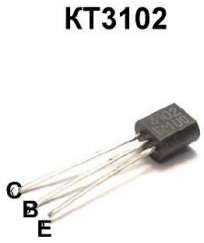
- Transistors are not installed in the same way, so at the request of radio amateurs, we add a photo of the correct installation for each transistor. Pay attention to the pinout of the transistor on the right. There is a marking on the transistor (one or two white dots). Please note that the transistor in the illustration is turned “dot” down (that is, away from us). Unfortunately, this is a very common installation error. Be careful. Below is a photo of each transistor on the board.

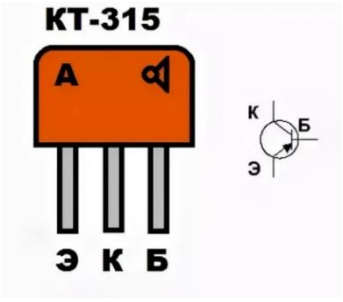
The "key" of the transistor is on the "Source". A key is drawn on the board for convenience.

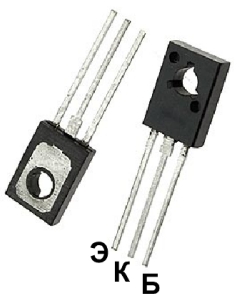
VT4 – “dot” is not visible	VT3 “dot” is not visible	VT2 “dot” is visible
		

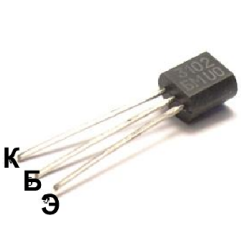
The pinout of other transistors should not cause any particular difficulties. The pinout for KT315 and KT361 is the same. Illustrations below.











Quartx Fitlers “Desna”

The assembly of quartz filters is carried out on separate boards, which are attached to the main board by the first and last output from the quartz resonators - pay attention to this, and do not cut them off during the installation of quartz. It is also necessary to leave the leads on the clean-up quartz filter for subsequent connection to the main board (see the circuit diagram of the 4-crystal filter below).

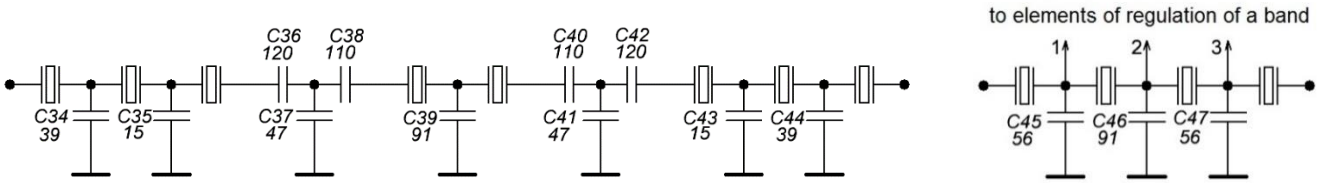
All quartz resonators are selected to one frequency from a very large batch, and do not require additional selection. Capacitors are selected according to the ratings for the filters. In the kit, we divide the resonators into three packages: 8 quartz and 4 quartz, respectively, for filters, and two reference quartz, which are installed separately on the main board.

Quartz is installed on the board through a gasket. The body of each quartz is grounded using separate pads. When installing quartz filters on the main board, it is necessary to connect all the leads (along the edges of the filter boards) using small segments (it is convenient to use the remnants of mounting resistors)

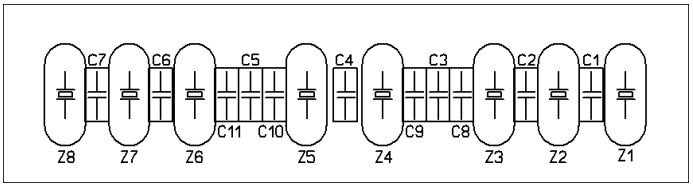
The quartz filter assembled from the kit corresponds to the specified characteristics and does not need to be adjusted. If necessary, increase or decrease the width in a small range, you can slightly adjust the extreme values of the capacitors (C1 and C7; and C1 and C3, respectively).

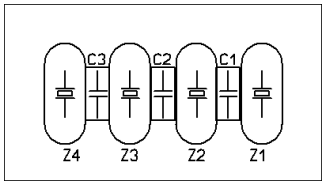
When connecting to a frequency response tester, remember to match the filter to the filter specifications, since the outputs of frequency response meters are usually set to a load of 50 ohms. In this case, the frequency response will be displayed incorrectly, which may mislead you.

ATTENTION! In the case of buying of set of completed quartz filters KF-8m and PKF-4m, it is necessary to close the jumpers K1 and K2 on the board, and in the clearing quartz filter circuit, the elements VD27, VD28, VD29, C35, C36, C37, R42, R43, R44 are not installed on the board , because this circuit has already been assembled on the PKF-4m board.



Монтажная схема Кварцевых фильтров





Adjustment

The main board is configured separately from the rest of the transceiver units. Before turning on the power, the board must be washed from flux and rosin residues, visually check the correct installation of all elements.

Remember! The installed components on the board are 30% of the assembled board. The board is considered 100% collected at the moment when it is fully configured. Therefore, the setup phase must be treated with the utmost care and endurance. Sometimes the setup process takes longer than the actual installation of the components. We recommend taking a short pause between the end of the soldering of the elements and the setup phase; clean up the desktop after installation, carefully remove all scraps from resistors and other elements from the table. In no case do not need to rush to connect. Often the rush, fatigue from editing and the desire to hear the air as soon as possible lead to fatal consequences when setting up.

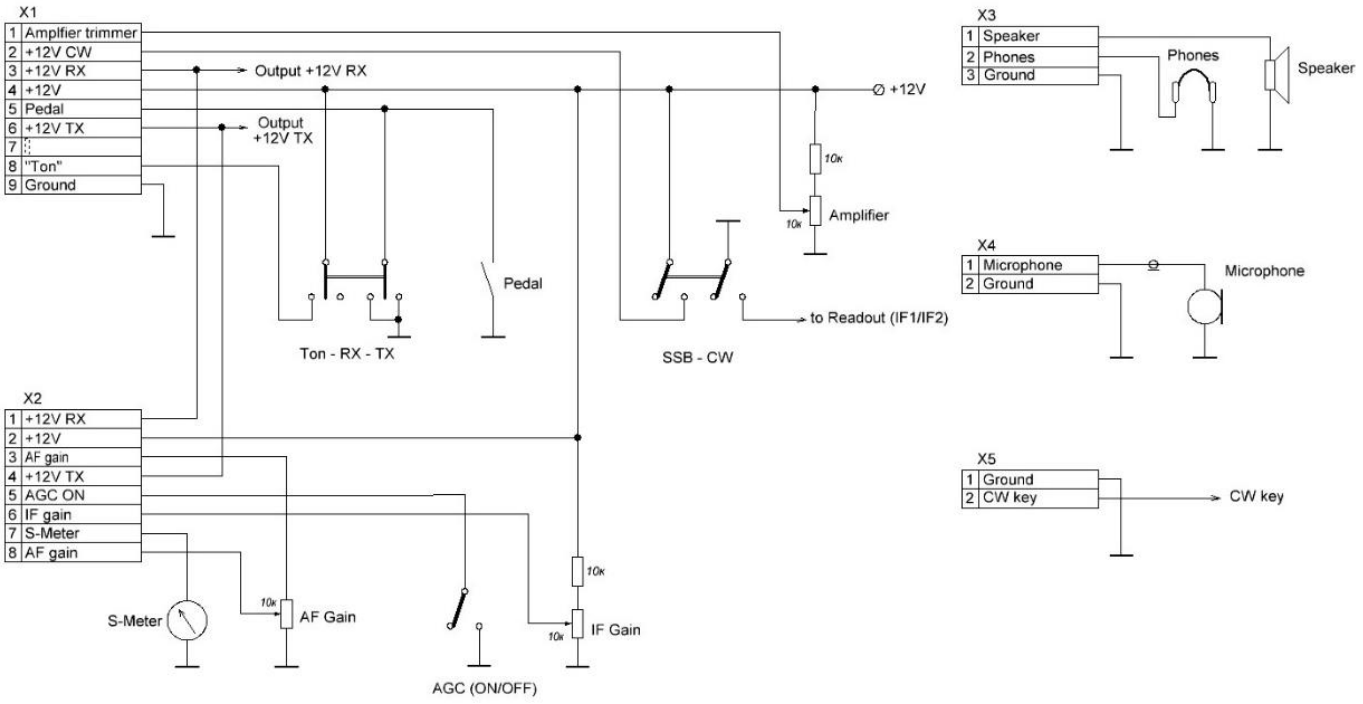
Upon completion of the main installation check, they begin to assemble the hinged part of the elements: variable resistors, switches, headphones (speaker), S-meter device (if exists) according to the connection diagram. Of the features of the connection scheme, it is necessary to note the SSB-CW switch - in the illustration, an output to the readout (Makeyevskaya digital scale) is added. When using a synthesizer, this output is not used, and a switch with one switching section can be used.

Further, it should be noted that jumpers must be installed between the following connectors:

- X1.3 and X2.1 (+12V RX)
- X1.4 and X2.2 (+12V)
- X1.6 and X2.4 (+12V TX)

(It is convenient to use any wire for mounting jumpers)

Connections diagram

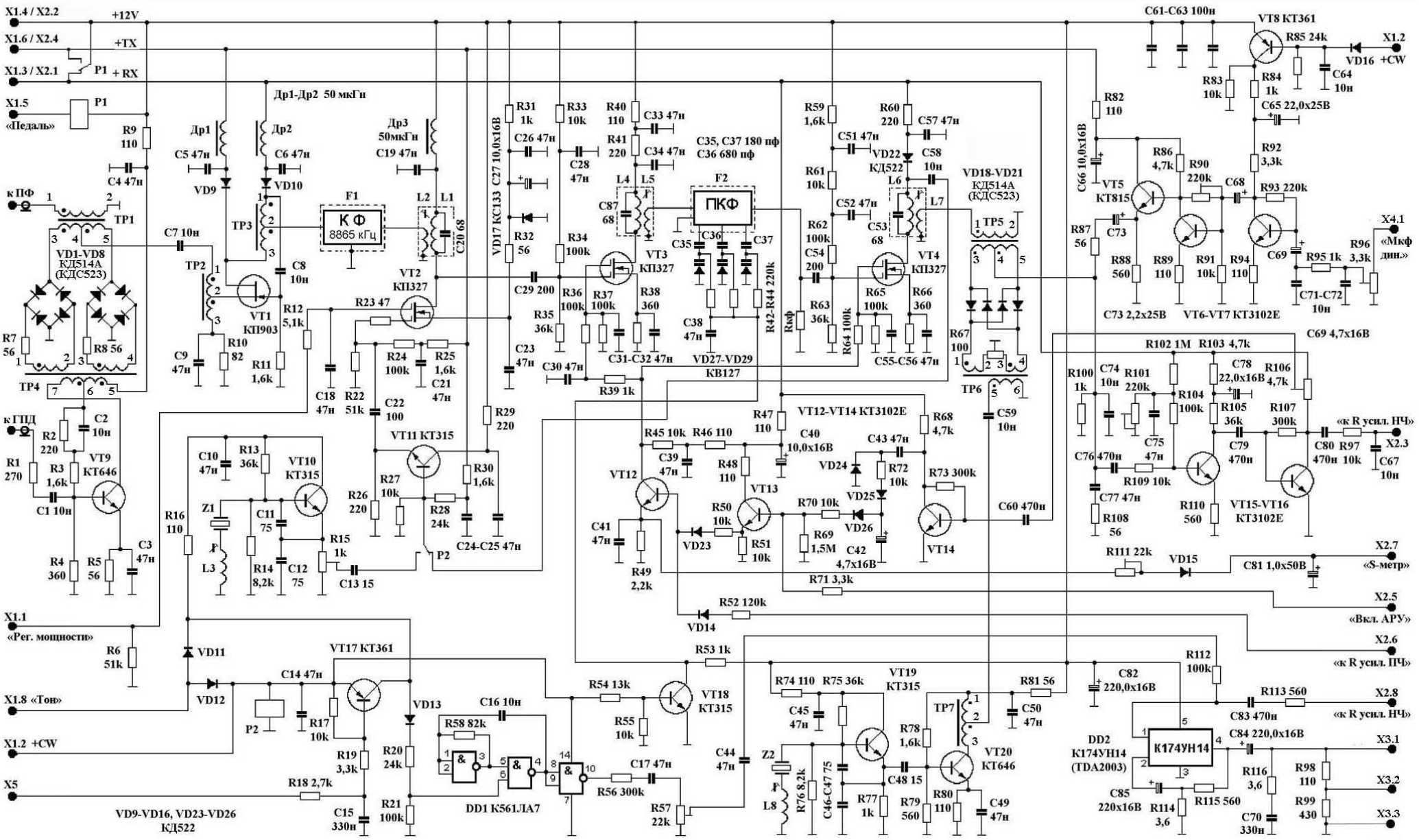


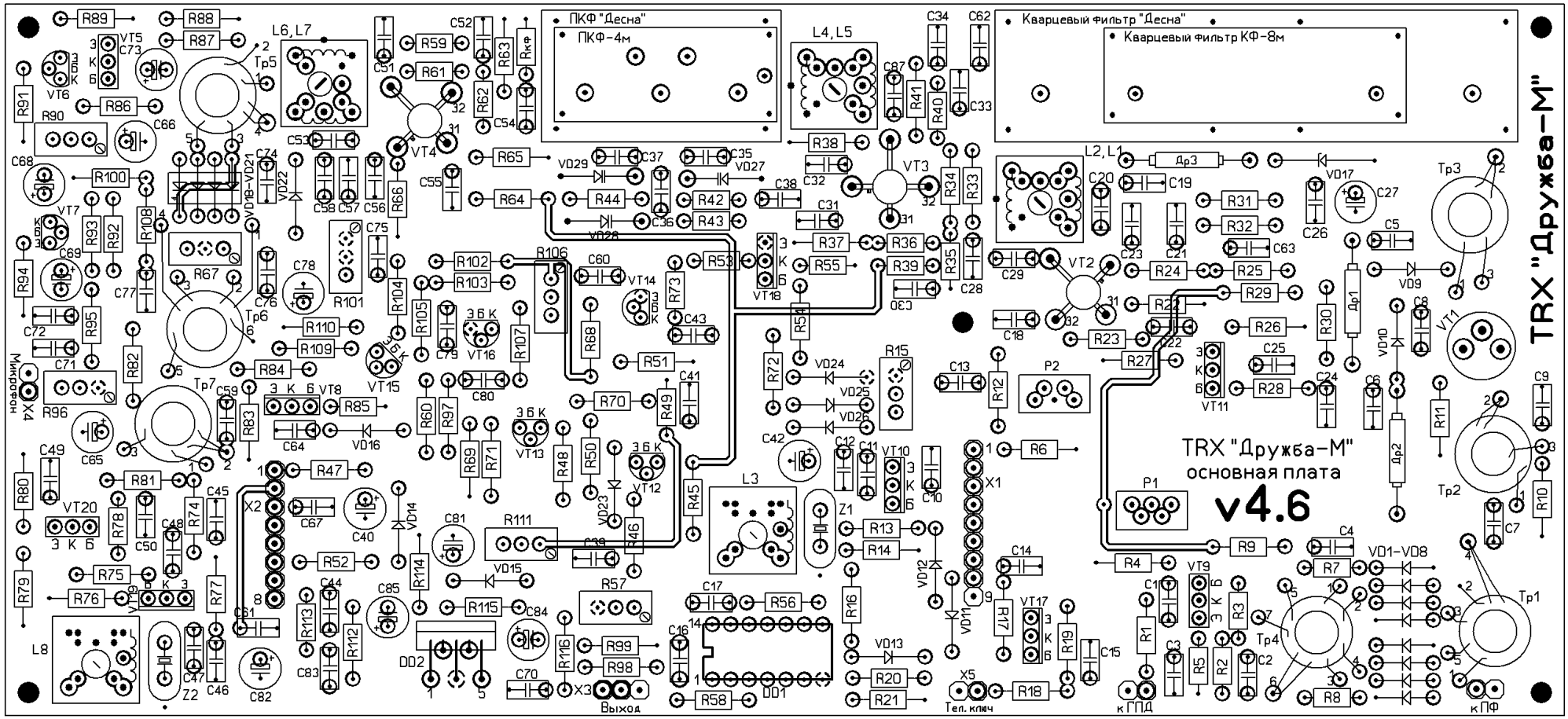
After checking the installation of attachments, only the +12V power supply and the frequency synthesizer (or analog VFO) are connected to the board to the VFO input («ГПД»). After turning on the power source, the first check is the receiving-transmitting switching node, when the “RX” mode is on, the voltage on the “TX” bus should be 0 and vice versa, in the “TX” mode, the voltage on the “RX” bus should be 0.

- Using a frequency meter, we check the operation of the quartz reference oscillator at the output of TP7. The core of the coil L8 is temporarily fixed in the middle position. It would not be superfluous to check the passage of the VFO signal after the amplifier on VT9.
- On the varicaps of the VD27-VD29 quartz filter in SSB mode, there should be a voltage of 12V. This means that the filter bandwidth is about 2.7KHz. When switching to the CW telegraph, the voltage from the KT315 transistor should be equal to "0", and the filter bandwidth will drop to 1 kHz.

- Then, using a low-frequency generator and an oscilloscope, they check the passage of an undistorted signal (1000 Hz) in the stages of the low-frequency path of the transceiver. To check the low frequencies of the receiving path, a generator with a frequency of 1000 Hz is connected to R87 from the side of the TP5 transformer. The oscilloscope probe is connected to X2.3 (at the output of the preliminary AF amplifier). The oscilloscope screen should have a "pure sine" without any distortion. It is not the maximum level of signal transmission that is important here, but its “purity”. The setting is made by a tuning resistor R101.
- After tuning the IF gain, they begin to adjust the microphone amplifier. The same 1000Hz generator is connected to the X4.1 microphone input, and the oscilloscope probe to R87. By adjusting the trimmers R90 (gain control) and R96 (microphone signal level control), a “clean” sinusoidal signal is achieved.
- We connect an antenna to the “ПФ” input, or a frequency generator with a level not exceeding 20-30mV. Further, the level must be reduced in the process of adjusting the contours.
- The next step: using an RF generator and a voltmeter, tune the IF circuit to resonance. In principle, with the correct installation of the IF circuits and with the core twisted by about half, the circuits can be tuned without instruments - by ear at the maximum level.
- Most often, the nuances in starting the main board arise in the correct inclusion of the TP4 transformer in the circuit. It is easy to check if, for example, the output 1 of the transformer TP4 is disconnected from the resistors R7, the signal level at the output of the main board decreases, then TP4 is turned on correctly, if it increases, then it is necessary to swap pins 1 and 2. The same operation is carried out with pins 3 and 4 of the same transformer.
- Next, let's go back to setting up the reference oscillator. At this stage, the main board is already able to receive the air. It is necessary to find a loud, and preferably constantly working station. At this stage, it is not necessary to achieve even frequency values on the synthesizer on the synthesizer screen, since the IF frequency is unknown to us with great accuracy. By the way, do not forget at this stage to check the settings of the IF values on the synthesizer, otherwise the output of the synthesizer will be incorrect values, and you will not hear the ether. After tuning to a loud station by tuning the L8 circuit, as well as adjusting the frequency with a synthesizer with a small step, a clear intelligibility of the operator's speech is achieved. Actually, with the L8 coil, we set the desired reception band from 1 kHz to 2.7-3.0 kHz (depending on the maximum width of the quartz filter).
- Upon completion of the reference oscillator tuning, it is convenient to tune the L3 coil of the telegraph oscillator, as well as check the operation of the tone signal. When the self-monitoring unit is running, there should be a loud tone in the speakers. The level is adjusted by resistor R15 and R57.
- The next step is to adjust the level of operation of the Automatic Gain Control (AGC). Often, with standard factory values of tuning resistors, when listening to the air, it is impossible to set the maximum volume on the speaker - there is a sharp “excitation” and an increase in the current consumed! Be careful. Do not overload this node to avoid destroying the TDA2003 chip. This defect is eliminated by adjusting the AGC using the tuning resistor R106.
- Balancing the TP5 modulator to suppress the "carrier" is performed using the trimmer resistor R67.
- Lastly, you can adjust the level of operation of the S-meter using R111.
- Upon completion of the main board setup, it is necessary to check the level and "purity" of the output signal in the transmit mode, as well as to make sure that the modulator balancing configuration is correct.
- Upon completion, you can gradually connect the rest of the transceiver units in the following order: add the tuned band-pass filters, set up switching between the bands using a decoder (or biscuit switching, if you use a VFO), and lastly, the tuned power amplifier boards and low-pass filter are connected.

Принципиальная схема основной платы v4.3 трансивера «Дружба-М».




TRX "Дружба-М"
основная плата
v4.6
ПКФ "Десна"
ПКФ-4м
Кварцевый фильтр "Десна"
Кварцевый фильтр КФ-8м
Микрофон
Выход
Тел. ключ
к ГПД
к ПФ