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Medium wave receiver with a synchronous detector
Radio, 1991, 2

This receiver was designed as a simple, suitable construction to be repeated by rookie radio amateurs, as an introducing to the techniques of synchronous reception.

Synchronous receivers are known to have high selectivity and they provide a linear detection of AM signal. The name itself tells us that the receiver can receive the signals when a frequency of its local oscillator is synchronized with the frequency of a signal, i.e., the frequency of the local oscillator is equal to the signal frequency. The local oscillator can be synchronized by using a phase-locked loop (PLL) or by method of locking a frequency of the local oscillator with the input signal. In this circuit is used the second method as the most simple method of synchronization.

Let's consider the circuit diagram of the receiver (Fig. 1).

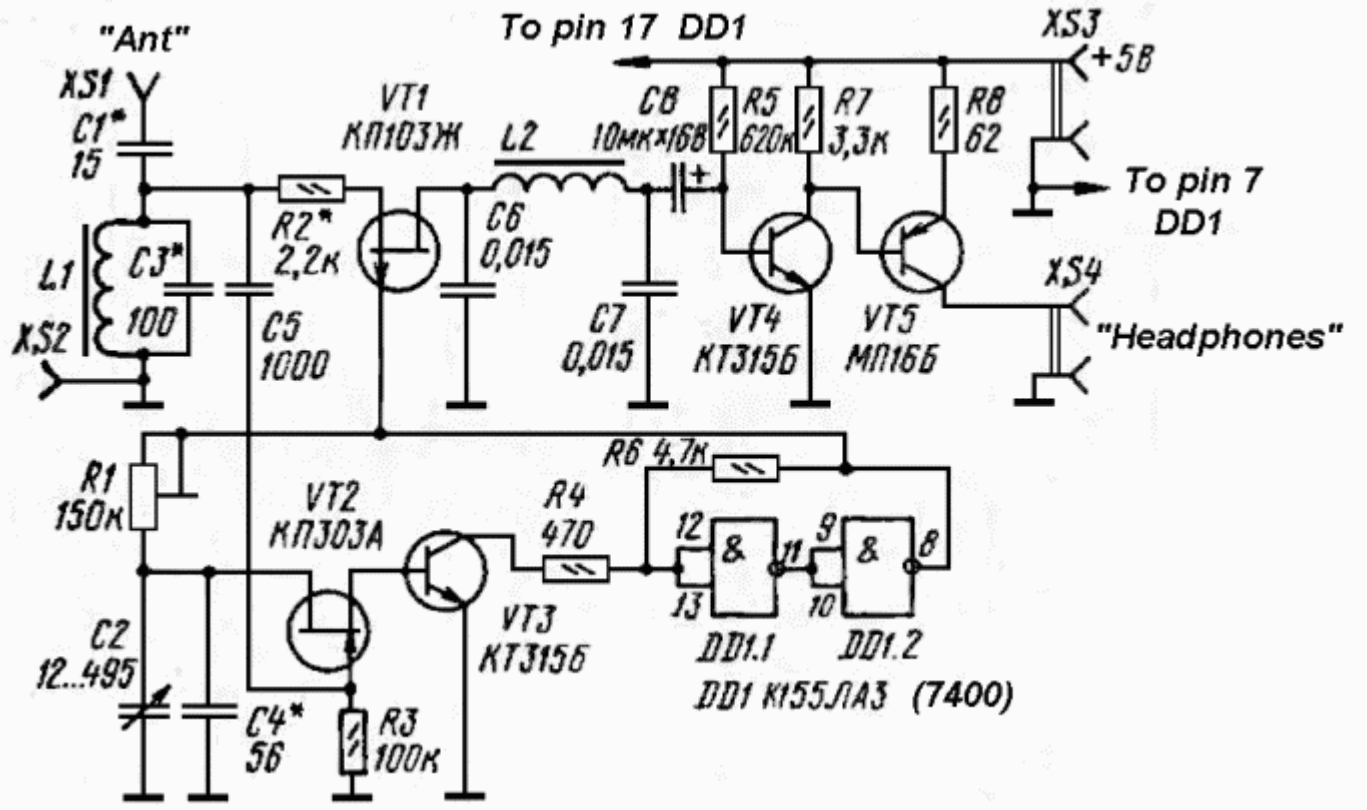

Fig. 1.

DD1 - 7400;
VT1 - KP103J (U_{cutoff} = 0.5...2.2 V at U_{ds}=10 V and I_d=0.01 mA);
VT2 - KP303A (U_{cutoff} = 0.5...3.0 V at U_{ds}=10 V and I_d=0.01 mA);;
VT3, VT4 - KT315B (h_{fe} = 50...350 at U_{ke}=10 V and I_k=1 mA), (h_{fe} = 2.5 at U_{ke}=10 V and I_k=1 mA and F=100 mHz);
VT5 - MP16B (germanium, h_{fe} = 45...100 at U_{ke}=1 V and I_k=10 mA; f_T = 2 mHz);
C1 - 15 pF; C2 - 12...495 pF; C3 - 100 pF; C4 - 56 pF; C5 - 1 nF; C6, C7 - 0.015 uF; C8 - 10 uF x 16 V;

A broadband resonant circuit L1C3 is tuned to the middle of the MW band by matching a capacitor C3. A set of capacitors and a switch can be used instead of the capacitor C3. The mixer is based on a transistor VT1, the input signal is fed to the mixer through a resistor R2, which is used as an attenuator.

The attenuator is used to reduce a crosstalk. The crosstalk is usually caused by the direct detection of a strong signals due to the nonlinearity of the channel of a FET transistor. The resistance of the attenuator is selected according to the specific conditions of reception.

The voltage of local oscillator goes directly to the gate of the transistor VT1, this transistor operates as a switch. A controlled RC-oscillator is used as the local oscillator. The controlled RC-oscillator is based on a Schmitt trigger (IC DD1). The oscillation is provided by a positive feedback in the RC-network of the voltage-controlled frequency-dependent oscillator. The oscillator frequency is determined by the resistor R1, the capacitors C2, C4 and the resistance of the channel of the transistor VT2. The input clock signal is fed to the gate of the transistor VT2 through the capacitor C5. With the value of the components used in this circuit, the tuning range of the local oscillator is about 300 kHz. A middle of the band is adjusted by the potentiometer R1. The variable capacitor C2 is used to set the desired frequency of the local oscillator. When the local oscillator frequency is near to the frequency of the input signal then the frequency locking occurs, so the frequency of the local oscillator is equal to the frequency of the input signal. In this condition the mixer performs synchronous detection of the input signal.

After the mixer, the audio signal is filtered by a filter L2C6C7 with a cutoff frequency of 5 kHz. The audio amplifier of the receiver is made with directly coupled transistors VT4, VT5. The operation mode of both transistors is set by resistors R5, R7. The last stage of the amplifier is loaded by a low-impedance headphones TA-56M (Soviet military headphones) with the DC resistance of 50 ohms. Resistor R8 limits the current consumed by the last stage of the audio amplifier, and provides a negative feedback by AC, its improves the linearity of the amplification.

To power up the receiver it is better to use a stabilized power supply, but you can use a fresh battery 3R12 or a battery, composed of several cells to provide the required supply voltage. The current consumed by the receiver is about 30 mA. The receiver works good until voltage drops to about 4 V. The receiver is built on a printed circuit board made of tho sided copper clad laminate (Fig. 2). The assembled PCB is placed in a housing, made of the same copper clad laminate or in any suitable housing. The size of the housing can vary, it depends on the size of PCB and the size of the variable capacitor C2. A jacks for power supply, headset, antenna and ground is mounted on the sides of the housing.

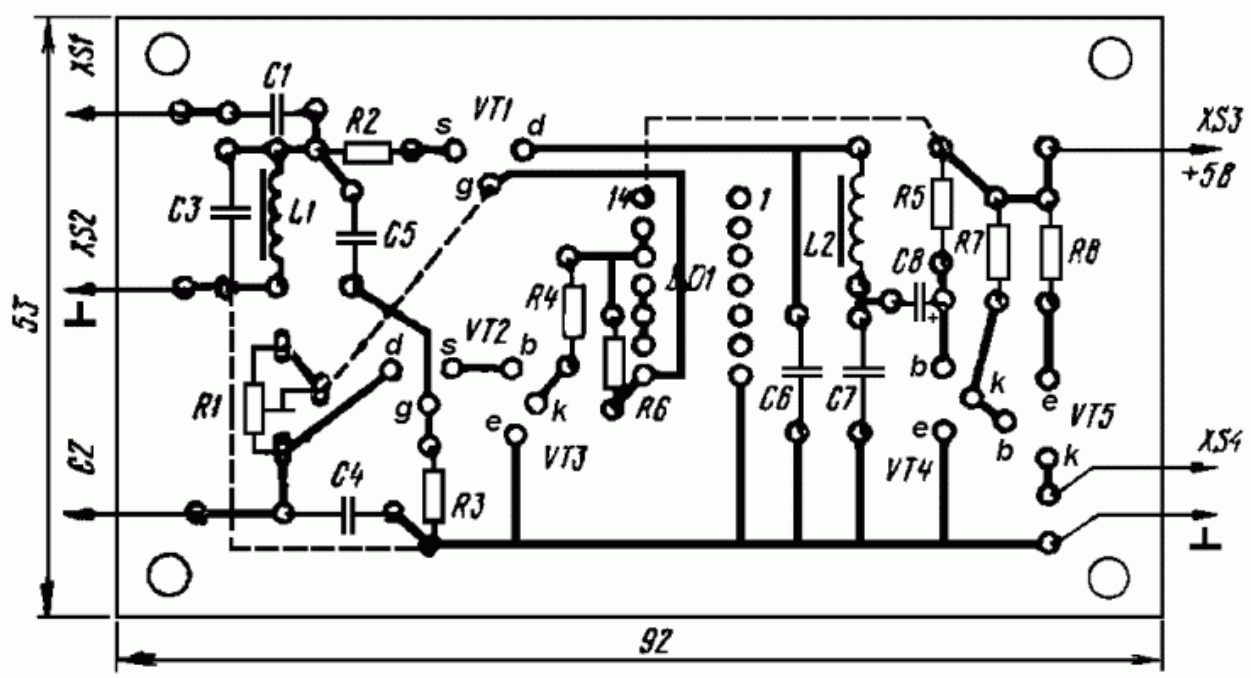

Fig. 2.

In the high-frequency networks of the receivers is used a ceramic capacitors. The variable capacitor can be used from a portable radio receiver. Capacitors C6, C7 and C8 can be of any type. The coil L1 is wound on a ferrite ring core K7x4x2 600NN (the magnetic permeability is 600) and contains 30 turns of enameled copper wire of 0.2 mm (AWG 32). The resonant frequency of the input resonant tank is about 1250 kHz. The coil L2 is wound on a ferrite core ring K18x9x5 2000NN and contains 260 turns of enameled copper wire of 0.2 mm (AWG 32).

The adjustment of the receiver starts from the audio amplifier. When you touch with a screwdriver the input of the audio amplifier (the base of the transistor VT4), you could hear the AC humming sound in the headphones, it indicates the normal operation of the audio amplifier. Any other MW receiver can receive the signal of the local oscillator, it can help to adjust the tuning range. Adjusting the potentiometer R1 to setup the tuning range. After that, match the capacitor C3 to tune the resonant circuit L1C3 to the middle of the MW band.

It should be noted that the bandwidth of the resonant circuit L1C3 is wide because of the significant shunting effect of the resistir R2 and the mixer. This allows to receive a few stations without tuning the input resonant circuit.

Despite its simplicity, the receiver has a high sensitivity and allows to receive very distant radio stations using a wire of 1 m length as antenna and a ground connection.

The disadvantage of this receiver is the low frequency stability of its local oscillator, it is common to all RC-oscillators. Therefore, while the receiving, especially the weak signals, due to the destabilizing factors the synchronization can be lost and it takes to retune the receiver.

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