2P3 Superheterodyne MW Radio Receiver Kit Manual

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Rev. C

Covering the paper based manual 2014.3 VER. 4 “Green PCB”

In the mid 1960's, with the population of transistors, radio amateurs of China were passionate to build their own radio receivers. It was a dream to have a good looking case for their homebrew radio receiver, so 2P3 case appeared.

2P3 was compact and beautiful. Once it hit the street, it was welcomed. Many people saved money for buying one, and built various radios from single transistor to six transistor superheterodyne with it, and the dream of building a transistor radio with a case came true.

Half a century has passed, but those senior radio amateurs still can remember 2P3. Once talking about

transistor radios, 2P3 is always a hot topic. People smile if they were lucky to have built one, and regret if they failed. However, 2P3 is seldom found these days, and it becomes a product for collection. So, it becomes a new dream to own 2P3 again!

We reproduced 2P3 case, and designed and produced a superheterodyne radio receiver kit based on the current component characteristics. Hopefully it can fulfill the senior radio amateurs' dream, inspire the interest of the new generation and help improve their hands-on capabilities.

CRKITS is now proudly introducing the kit to the worldwide. The kit manual translation is dedicated for our customers, to match our standard of service.

“2P3” Superheterodyne MW Radio Theory of Operation

“2P3” is a tiny superheterodyne MW radio receiver.

Performance:
Frequency Range: 530 kHz ~ 1620 kHz
Power Supply: 3 V (2x AA size battery)
Sensitivity: < 1 mV/m
Max Audio Output: 120 mW
Quiescent Current: 7 mA

Fig. 1 and Fig. 2 are the outline, Fig. 3 is the internal structure of 2P3, Fig. 4 is the circuit block diagram of 2P3, and

Fig. 5 is the circuit diagram.

Theory of Operation

1. Frequency Conversion: Frequency conversion circuit consists of frequency selection, local oscillation (LO) and mixer three parts.

The magnetic rod antenna senses the incoming radio signal, after the selection of frequency selection circuit including VC4 and L1, (ideally) only one resonant frequency will be induced to the two ends of L2. This is so called "tuning". The signal induced by L2 will be fed to the base of the frequency conversion transistor Q1 (S9018);

The frequency conversion transistor Q1 has two functions:

1) Local Oscillation. By working with VC3, C2 and T1, Q1 generates a RF CW signal with frequency 455 kHz higher than the incoming signal;

2) Mixer. Q1 mixes the induced signal of L2 with the LO signal to generate an IF signal of 455 kHz (that is, LO frequency – incoming signal frequency = 455 kHz). In fact, the mixer product is more than one signal of 455 kHz, so a frequency selection circuit (IFT T2) is used to filter the unwanted signal, and couple the IF signal to the IF amplifiers;

2. IF amplification: To achieve big enough IF gain, 2P3 has two IF amplifier stages including Q2 (S9018), Q3 (S9018) and the surrounding components. The outgoing 455 kHz IF signal from T2 goes to Q2 for the first amplification, and coupled by 455 kHz ceramic filter (CF1) to Q3 for the second amplification. The amplified IF signal goes to IFT T3 for frequency selection

to filter the unwanted signals and then goes to detector stage;

3. Detector: The frequency conversion only converts the carrier frequency, but not the audio carried on the frequency. The IF signal is not able to be heard by human ears. The detector is to “unload” the carried audio signal from the IF frequency. The detector mainly consists of detector diode D1 (1N60).

4. Automatic Gain Control (AGC): The output from D1 is IF pulses. It is filtered by the filter including C7 and R11. Part of it goes through C6, R9 and C4 to reduce voltage and filter, to provide negative bias voltage for the base of Q2. The stronger is the incoming signal, the higher is the negative bias voltage, and the lower is the gain of the first IF amplifier, or vice versa. It keeps the volume of the radio relatively stable even the incoming signal is changing. That's the theory of the AGC of this radio.

5. Audio Power Amplification: The other part of the output from the detector is coupled by C8 to audio power amplifier IC1 (CD7368) for amplification. The amplified signal is converted to audio by the speaker. The potentiometer VR is used for volume control and power switch.

Part List

Bag	Designator	Name	Value	Remarks
1	C1, C5,	Ceramic	203 (0.02 µF)	Add C7 from

	C6, C7, C15	Capacitor		2014.3 VER. 4
	C2	Polyester Film Capacitor	223 (0.022 µF)	
	C3	Ceramic Capacitor	3 pF	
	C4	Electrolytic Capacitor	10 µF/ 16 V	Note polarity
	~~C7~~	~~Ceramic Capacitor~~	~~103 (0.01 µF)~~	Remove C7 from 2014.3 VER. 4
	C8	Electrolytic Capacitor	1 µF/ 50 V	Note polarity
	C9	Polyester Film Capacitor	152 (1500 pF)	
	C10, C11, C14, C16	Electrolytic Capacitor	100 µF/ 10 V	Note polarity
	C12	Electrolytic Capacitor	220 µF/ 6.3 V	Note polarity
	C13	Electrolytic Capacitor	470 µF/ 10 V	Note polarity
	SFU	Ceramic Filter	SFU455	
2	R1	Resistor	120 kΩ	BRN-RED-YEL-GLD

	R2, R3	Resistor	1.8 kΩ	BRN-GRY-RED-GLD
	R4	Resistor	220 kΩ	RED-RED-YEL-GLD
	R5	Resistor	18 kΩ	BRN-GRY-ORG-GLD
	R6	Resistor	2 kΩ	RED-BLK-RED-GLD
	R7, R10, R12	Resistor	100 Ω (R7 ONLY 51 Ω from 2013.12 VER. 3)	BRN-BLK-BRN-GLD (R7 ONLY GRN-BRN-BLK-GLD from VER. 3)
	R8	Resistor	150 kΩ	BRN-GRN-YEL-GLD
	R9	Resistor	12 kΩ (10 kΩ from 2013.12 VER. 3)	BRN-RED-ORG-GLD (BRN-BLK-ORG-GLD from VER. 3)
	R11	Resistor	1.5 kΩ	BRN-GRN-RED-GLD
	D1	Detector Diode	1N60	Note polarity
	D2, D3, D4	Diode	1N4148	Note polarity
	Q1, Q2, Q3	Transistor	S9018	Note each pins

		Speaker Wire	Black, White	
3		Self-tapping screw	Φ2*6PA x3	To fix PCB
		Self-tapping screw	Φ2*6PWA x6	To fix speaker mask and magnetic rod
		Screw	Φ1.7*4PM x1	To fix volume knob
		Screw	Φ2.5*5PM x1	To fix tuning knob connecting part
		Screw	Φ2.5*4PM x2	To fix variable capacitor
		Screw and nut	Φ3*5PM x2	To fix battery cabinet
		Hexagon standoff (including washer, screw and nut)	1 set	To fix rear cover
	~~J1, J2, J3, J4~~	~~Jumper~~		~~Use the clipped extra leads.~~ Remove from 2014.3 VER. 4

		Shielding	10 x 10	Add from 2014.3 VER. 4
		Case		
	SP	Speaker	4 Ω/ 1 W	Note polarity. With mask.
	EJ1	Headphone jack	Φ3.5 mm	
	VR	Potentiometer with switch	5 k	
	VC3/ VC4	Two-gang variable capacitor	59 p/ 140 p	
	IC1	Audio power amplifier IC	CD7368	Note each pin and orientation
	T1	MW oscillation coil	YD2P302	Red cap
	T2	IFT	YD2P301	Yellow cap
	T3	IFT	YD2P303	Black cap
	L1, L2	MW magnetic rod	Magnetic rod: Φ8x100mm Coil: primary ~~113~~ 93+45 turns: secondary ~~20~~ 15 turns	Note primary and secondary coils. ~~Ends are colored. Primay ends 1 – original~~

				~~color, 2 – black; Secondary ends 3 – red, 4 – green.~~ Change from 2014.3 VER. 4
		3V battery cabinet	5# (AA type) x2	Note positive and negative polarity
		Plastic strap		To fix magnetic rod
		Magnetic rod holder		
		Badge		
		PCB		
		Tuning knob and connecting part		
		Volume knob		
		Mini dual head non-inductive screw driver		To adjust IFT and trimmer capacitor
		User manual		Add from 2014.3 VER. 4

		and gift box for finish goods		

Assembly Instructions

1. Components check. Classify the components first, by referring to the circuit diagram and part list, check components model and value. It is recommended that you test all the components by a multimeter before you actually start building.

2. Building. To facilitate the check and debug during assembly, it is recommended to follow this turn to solder: Audio amplifier – detector - 2nd IF amplifier - 1st IF amplifier – frequency conversion. Check each stage after you complete the building.

3. Following the symbols on the PCB to insert the components to the corresponding locations (Fig. 6), double confirm then solder and clip the extra leads. The components used in this radio kit has small size and not good at heat dissipation, so it is preferred that you solder with solder iron of 25 W~ 40 W and the solder time does not exceed 3 sec each time. The solder applied to the pad needs to be controlled to appropriate amount. The solder quality standard is: The soldering spot is durable, reliable, bright and smooth. There is no cold soldering or solder bridge.

4. When you solder the battery cabinet wires, speaker, electrolytic capacitors, diodes, transistors, please pay attention to the polarity. When you solder the magnetic rod coils, please differ each of the wires on the primary and secondary coils.

The following diagram shows the soldering of the potentiometer:

A, Separate the potentiometer daughter board from the main board (by hand);

B, Insert the potentiometer to the holes in place to make sure the potentiometer is in parallel to the PCB.

Solder these 3 pads first;

Don't solder these 2 pads for switch now.

This is the slot on the main board to install the potentiometer board.

* This jumper is to fixing the copper foil to prevent the peel off due to over heat.

C, Insert the potentiometer board to the slot from the components layer of the main board, and make sure the potentiometer board is vertical to the main board.

Main board solder layer.

D, Solder the potentiometer switch pads, and 5 interconnecting pads on the potentiometer board to the main board.

Fixing the magnetic rod:

As shown in the following diagram, fix the magnetic rod to the holder by a plastic strap.

(Top to down) Magnetic rod, strap, holder, PCB, screw for fixing the holder

5. After assembly, double check based on the circuit diagram and assembly diagram. After the check, you can proceed to the following instruction (good for beginners without test equipment) to align the radio.

2P3 Alignment

Alignment tools: multimeter, non-inductive (non-metal) screwdriver

1. Bias adjustment

Install new batteries into the battery cabinet, and power on the radio. Put the multimeter to DC measurement, and measure A, B, C three points (Ic1, Ic2, Ic3) on the PCB respectively to see if they are in normal range (if the deviation is too much, please check R1, R5 and R8 first if they are not properly installed). Adjusting R1, R5 and R8 can adjust Ic1, Ic2 and Ic3 to appropriate values. After adjustment, bridge A, B, C points respectively by solder. Install the hexagon standoff, frequency dial, potentiometer dial, install the PCB assembly into the case (see Fig. 7), solder speaker wires, and fix the PCB assembly by screws (temporarily not to cover rear cover).

The following steps can be conducted preferably in night time when more MW stations can be received.

2. IF adjustment

IF amplifiers are the crucial stage to determine the

sensitivity and selectivity of a superhederodyne radio. Although IF transformers (IFT) are pre-tuned in factory, but they can be de-tuned when they are connected into the circuit, so re-adjustment is required.

1) Tune to a station, then use a wire to short circuit the LO part of the variable capacitor (VC3). If the signal from the speaker immediately disappear or significantly lower, it means that the mixer and LO stages are working okay. If there is no change after shorting circuit the variable capacitor, it means the signal passing the IF stage is not the product of the mixer. If you adjust IFT in this situation, it will mess up the whole thing. If the latter happens, you will need to check if the LO is not oscillating first, before you tune the IFT.

2) Tune to a weak signal distant station (or change the orientation of the magnetic rod to reduce the incoming signal)

A, Use the noninductive screw driver to slowly adjust the magnetic cap of T3 (black) until the signal is the most loud and clear. Please note not to adjust too hard, or the magnetic cap will crack.

B, Use the noninductive screw driver to slowly adjust the magnetic cap of T2 (yellow) until the signal is the most loud and clear.

C, Repeat steps A and B until the signal has no longer change.

To make the adjustment more accurate, you can put the multimeter to DC voltage measurement, and measure the two ends of volume potentiometer VR (contact the black probe to F1 point in Fig. 5, and contact the red probe to F2 point in Fig. 5), repeat the adjustment of T3 and T2 until the voltage reading is maximized.

3. Frequency dial calibration

1) Adjust the low end frequency

Search for an available signal at the low end frequency (say 639 kHz):

A, If the frequency dial reading is higher than 639 kHz, use the noninductive screw driver to slowly turn the magnetic cap of T1 (red) counter-clockwise (to reduce inductance).

B, If the frequency dial reading is lower than 639 kHz, use the noninductive screw driver to slowly turn the magnetic cap of T1 (red) clockwise (to increase inductance).

Until you can receive 639 kHz signal when the frequency dial reading is exactly 639 kHz. Please note not to adjust too hard, or the magnetic cap will crack.

2) Adjust the high end frequency

Search for an available signal at the high end frequency (say 1377 kHz):

Use the noninductive screw driver to adjust “Cb”, until you can receive 1377 kHz signal when the frequency dial reading is exactly 1377 kHz.

3) Because the adjustments of low end and high end will interact, so repeating the low end and high end adjustments is normally necessary.

When the low end and high end frequency readings are accurate, normally the frequency reading in the middle range does not have too much tolerance.

4. Overall adjustment

1) Listen to a low end frequency radio station (say 639 kHz), move the location of the coils (L1 and L2) on the

magnetic rod, until the volume is max.

2) Listen to a high end frequency radio station (say 1377 kHz), adjust “Ca”, until the volume is max.

3) Repeat steps 1) and 2) until the volume of both the high and low ends is max. You can also check the voltage between the two ends of the volume potentiometer with a multimeter in DC voltage measurement, until the voltage is the max.

4) Melt some wax by solder iron and drop some between the coils of L1 and L2 and the magnetic rod, to fix the coils on the rod. Note: Never drop the wax onto the “Ca” and “Cb”.

* If there is self-oscillation, exchange 5 and 6 pin of the secondary winding of the magnetic rod antenna (L2).

After adjustment, put on the rear cover and tighten the screw, and your homebrew “2P3” superheterodyne MW receiver is ready for service.