SO2R Box (Plus) Construction

Version 1.1-1

Tools Required

Soldering iron (preferably controlled heat)
Needle nose pliers
Diagonal cutting pliers
Phillips head screwdriver #0
Flat blade screwdriver 1/8"
Nut driver ¼"
Nut driver 3/8"

A small wrench can be substituted for the nut drivers.

Parts Installation

All parts are installed on the top of the board. Use regular 60/40 or 63/37 rosin core solder.

The holes are plated-through. Use enough solder to fill the hole and to produce a fillet. Don't use so much solder that it bridges. Note: The military used to recommend using the minimum amount of solder. Then they discovered that connections with minimum solder are more likely to crack. Don't skimp on the solder. It is recommended that you keep a wet sponge near your iron to keep the iron clean while soldering. Keep your iron clean.

There is nothing magical about the component installation below. You can install the parts in just about any order. It will be easiest if you install the smaller and lighter parts before the bigger and heavier ones.

When installing each component you can solder one lead of each part and check and adjust placement if necessary before soldering the other lead. If you have experience building equipment with printed circuit boards you know how to do this.

For multi-lead parts solder one or two pins and make sure the component is seated against the board before soldering the other pins. Once you solder the remaining pins it will be impossible to adjust it.

If you solder a part in the wrong location it is often easier to remove the part by breaking it and then taking each piece out separately.

Pre-form the leads prior to installing them so that there is no tension on the lead where it enters the component. After installing each of the below lines of components clip any excess leads before going to the next line.

Some parts are susceptible to ESD. Use of a wrist strap and normal ESD precautions are recommended.

If you are building a two-radio board save a few of the resistor leads you clipped. You will need them as jumpers.

- ☐ Get a copy of the parts list, inventory list, and the silkscreen from the http://so2r.k1xm.org/ website. Use the parts list to check component values. The silkscreen on the website may be easier to use to search for parts locations.

- ☐ Inventory all parts, bag by bag. Report any discrepancies to W1UE@arrl.net

The first parts to install are the resistors. These can be installed in either direction but it is good practice to install them all facing the same direction, usually with the gold or silver band on the right or bottom.

If you have trouble reading the color codes check them with an ohmmeter.

The color code for each resistor can be found on the inventory sheet and here in instructions. There are three color bands that represent the value and a fourth which represents the tolerance. The fourth band will be gold or silver.

All of the resistors are ¼ watt except the 270 ohm resistors which are ½ watt.

The value marked on the board for R118 is incorrect – the supplied part is 10K.

The first group of resistors is in front of J5, the DB-25 connector.

- ☐ Install R1, R2, R3 10KΩ (Brown-Black-Orange)

- ☐ R22 – R41 220Ω (Red-Red-Brown)

- ☐ Install R5,R6, R4 1KΩ (Brown-Black-Red)

- ☐ Install R21, R20, R19 1KΩ (Brown-Black-Red)

- ☐ Install R42, R43 33Ω (Orange-Orange-Black)

These resistors are in front of U1, the big chip at the center-left of the board.

- ☐ Install R8, R9 10KΩ (Brown-Black-Orange)

These resistors are along the front of the board behind the potentiometer and the LEDs.

- ☐ Install R7 220Ω (Red-Red-Brown)

- ☐ Install R17, R18, R15, R16 1KΩ (Brown-Black-Red)

These resistors are to the left of U3 and U201 near the center of the board.

- ☐ Install R10, R11, R12, R13 2.7KΩ (Red-Violet-Red)

- ☐ If you are building a four-radio unit install R201, R202, R203, R204 2.7KΩ (Red-Violet-Red)

These resistors are to the right of U102, the small surface-mount part near the center of the board.

- ☐ Install R111, R112 10KΩ (Brown-Black-Orange)

- ☐ Install R109, R110 1KΩ (Brown-Black-Red)

These resistors are between the transformers and the DIN connectors, J101 - J202.

- ☐ Install R101, R103 270Ω 1/2W (Red-Violet-Brown)

- ☐ Install R210 4.7KΩ (Yellow-Violet-Red)
- ☐ If you are building a four-radio unit install R205, R207 270Ω 1/2W (Red-Violet-Brown) and R209 4.7KΩ (Yellow-Violet-Red)

These resistors go in between the transformers.

- ☐ Install R102, R104 270Ω 1/2W (Red-Violet-Brown)
- ☐ Install R119, R120 1MΩ (Brown-Black-Green)
- ☐ If you are building a four-radio unit install R206, R208 270Ω 1/2W (Red-Violet-Brown) and R211, R212 1MΩ (Brown-Black-Green)

These resistors are near U101, the surface-mount part near the front-right of the board.

- ☐ Install R105, R106 100KΩ (Brown-Black-Yellow)
- ☐ Install R107, R108, 3.9KΩ (Orange-White-Red)
- ☐ Install R113, R114 1KΩ (Brown-Black-Red)

This resistor is located between U103 and U101. The value marked on the board is incorrect – the supplied part is 10K.

- ☐ Install R118 10KΩ (Brown-Black-Orange)

All of the resistors are now installed. Check the board for solder bridges and cold solder joints.

The direction matters with the diodes. Match the bar on the diode with the bar on the PC board. The diode part number is on each diode.

This diode is at the far left end of the board in front of the fuse holder, F1.

- ☐ Install D5 (1N4004)

These diodes are to the right of U3 and U201.

- ☐ Install D6, D7, D8, D9 (1N4004)
- ☐ If you are building a four-radio unit install D203, D204, D205, D206 (1N4004)

These diodes are in front of the DIN connectors.

- ☐ Install D202 (1N4148)
- ☐ If you are building a four-radio unit install D201 (1N4148)

Match the notch on the IC socket with the notch drawn on the PC board. Note that for U1 the notch is on the right but for U4 and U5 it is on the left. U103 does not have a socket.

- ☐ Install IC sockets at U1, U4, U5, U3
- ☐ If you are building a four-radio unit install an IC socket at U201

Ferrite beads and RF chokes can be installed in either direction. L2 is not used. L4 is an example of a component where one end is grounded. You may need to solder it on the top of the board as well as the bottom.

The Ferrite beads are near the DB-25 connector and the RF choke is in front of U1.

- ☐ Install Ferrite Beads L3, L4, L5

☐ Install RFC at L1

Check your work for solder bridges, especially between the IC socket pins, and for cold solder joints.

The capacitors are next. The electrolytic capacitors must be installed in the correct direction. The part number stamped on each capacitor for identification purposes can be found on the inventory list and here in the instructions.

These capacitors are near the front of the board close to U2, U104, U102, and U101

☐ Install C9, C115, C102, C103, C111 .33μf marked 33J63

These capacitors are between U4 and X1.

☐ Install C6, C7 15pf marked 15

These capacitors are at the far left end near U2 and the far right end near T204. They are electrolytic so make sure they are installed in the correct direction.

☐ Install C15, C110 100μf electrolytic marked 100μf

These capacitors are near U2 and U104 near the front of the board. They are electrolytic so make sure they are installed in the correct direction.

☐ Install C11, C117 10μf electrolytic marked 10μf

These capacitors are near U1, U2, U4, and U5 and in the top right corner of the board.

☐ Install C4, C5, C10, C12, C13, C14 .1μf marked 104

☐ Install C8 .47μf marked 474

☐ Install C17 .001μf marked 102

These capacitors are near J4, above the fuse, and near U1.

☐ Install C1, C2, C3, C16, C18 .01μf marked 103,

These capacitors are near U104, U103, and U101.

☐ Install C101, C109, C116 .1μf marked 104

These capacitors surround U102.

☐ Install C104, C105, C106, C107, C108 1μf marked 105k

The crystal is between U1 and U4. Be careful not to overheat it.

☐ Install X1

Transistors are not installed flush with the board and they must be installed in the correct direction. Relays only fit in one direction. If you are building a two-radio unit you will install two jumpers made from cut-off resistor leads. The transistor leads may be bent incorrectly. You man need to bend the base lead to the opposite side. Make sure it matches the silkscreen on the board.

☐ Install Q202 2N3904

☐ If you are building a four-radio unit install Q201 2N3904

☐ Install K203

- ☐ If you are building a four-radio unit install K201, K202
- ☐ If you are building a two-radio unit install jumpers between pins 2 & 3 and between pins 6 & 7 of K201.

Bend the leads of the TO-220 voltage regulators, U2 and U104 so that the leads go through the holes and the screw hole lines up with the hole on the board. Try not to make the bend too sharp.

U2 has a heatsink, U104 does not. If you have heatsink grease you can use some but it is not necessary.

You may have trouble soldering the center pin of the regulator because the regulator itself is drawing the heat from the lead to the heatsink or ground plane. If this happens remove the screw and bend the regulator slightly so it is not contacting the board, solder the connection, and re-install the screw.

- ☐ Mount U2 on board, using 4x40-3/8" screw, lockwasher, and nut to secure the heatsink. Solder the three leads.
- ☐ Mount U104 on board, using 4x40-1/4" screw, lockwasher, and nut. Solder the three leads.

The leads on U103 must be bent to fit into the board. The easy way to do this is to put the chip upside down on a flat surface and then rotate it 90 degrees so that it bends all of the pins on one side. Then rotate it the other way to bend the pins on the other side.

Make sure the notch on the IC matches the notch drawn on the board.

- ☐ Install U103

The headers are supplied in one long strip. The strip can be cut with a sharp knife or with diagonal cutters. If some of the plastic is cracked it will not matter as long as both pins can be soldered to the board.

The short ends are soldered to the board. Don't try to trim them after soldering.

- ☐ Cut 5 sections of header, each with two pins. Install JP1, JP2, JP3, JP101, JP102
- ☐ If you are building a four-radio unit cut four sections of header, each with two pins. Install JP201, JP202, JP203, JP204

The fuse holder is made up of two identical pieces. Make sure you orient them properly – the notches go away from each other to hold the fuse.

Also note that the fuse holder pieces get quite hot when soldered. Let them cool for a moment before continuing to work on the board.

- ☐ Install Fuse Holder halves F1

Make sure that the connectors, switches, LEDs, and potentiometer are positioned properly so that they will fit through the corresponding holes in the case. They should be mounted flush on the board and be square-on to the front or back of the board. Solder one or two leads and check for position before soldering the rest.

- ☐ Install DC Power connector J1
- ☐ Install USB connector J2

- ☐ Install DB25 connector J5
- ☐ Install RCA phono connector J4
- ☐ Install ¼″ phone connectors J3, J103
- ☐ Install ⅛″ phone connector J203
- ☐ Install DIN connectors J101, J102, J201, J202

Check connector alignment with the back panel here and solder the rest of the pins.

- ☐ Install switch SW1
- ☐ Install switch SW2
- ☐ Install switch SW3
- ☐ Install red LEDs D3, D4 on either side of SW2
- ☐ Install green LEDs D1, D2 on either side of SW1
- ☐ Install the potentiometer R14

The transformers have a dot which should match the dot on the PC board. The dot on the transformer is a black dot on the top of the windings.

- ☐ Install transformers at T101, T102, T103, T104
- ☐ If you are building a four-radio unit install transformers at T201, T202, T203, T204

Check the board for solder bridges, especially around the connectors, for cold or unsoldered connections, and for pieces of solder or component lead clippings which may have become wedged under or between parts.

All components are now soldered to the board.

All units should not have parts installed at L2, R44, R115, R116, R117, C112, C113, C114. Two-radio units should also not have parts installed at R201, R202, R203, R204, R205, R206, R207, R208, R209, R211, R212, Q201, K201, K202, T201, T202, T203, T204, U201.

Preliminary Checks

These are a few tests before completing assembly. A good place to connect to for ground is the tab and bolt of U2 or U104.

- ☐ Install the fuse F1 in the socket
- ☐ Set S3 On (up)
- ☐ Measure the resistance between either side of the fuse and ground. The resistance should be at least 1K ohms. It may start lower and go up as the capacitors charge. There is a diode in this path so meter polarity matters. Connect the ground lead of the meter to ground on the board.
- ☐ Measure the resistance between either side of L1 and ground. It should be at least 1K ohms when the capacitors have charged.
- ☐ Measure the resistance between U104 pin 3 and ground. It should be at least 1K ohms when the capacitors have charged.
- ☐ Set S3 Off (down)
- ☐ Connect a 12 volt power supply to J1 (A plug is supplied for this purpose)

☐ Measure the voltage between either side of the fuse and ground and verify that it is between 10 and 15 volts.

☐ Set S3 On (up)

☐ Watch the fuse and the board for signs of failure – the fuse should not glow and there should be no noise or smoke.

☐ Check that U2, U104, U102, U101, U103 are not warm or hot. Be careful because if one of these parts does get hot it can burn your finger.

☐ Measure the voltage between either end of L1 and ground. It should be between 4.8 and 5.2 volts.

☐ Measure the voltage between U104 pin 3 and ground. It should be between 4.8 and 5.2 volts.

☐ Set S3 Off (down) and disconnect the power supply.

IC Installation

The pins of the ICs will need to be bent to fit in the sockets. Use the same technique as described for U103. The pins must line up with the IC socket before you press the chip down into the socket.

Make sure the notch in the chip matches the notch in the socket and the board. Some parts face left and other face right.

☐ Install U4 U5 Labelled SN74HC594

☐ Install U3 Labelled PS2502

☐ If you are building a four-radio unit install U201 Labelled PS2502-4

☐ Install U1

Check carefully for pins which are not in the sockets. Particularly look for pins which have been bent under the IC.

Microprocessor Test

If something gets hot turn it off immediately.

☐ Set S1, S2 to their center positions

☐ Connect a 12 volt power supply to J1

☐ Set S3 On (up)

☐ Observe that LEDS D3 and D1, to the left of SW2 and SW1 are illuminated.

If the LEDS are illuminated in another pattern or are blinking turn S3 Off and quickly back On. If this causes the correct LEDs to illuminate contact Paul at k1xm@k1xm.org. You can use turning it off and on as a work-around until a software update is available to permanently fix the problem.

☐ Set SW2 to the right. Observe that D3 darkens and D4 illuminates.

☐ Set SW1 to the right. Observe that D1 darkens and D2 illuminates.

☐ Set S3 Off (down). Set SW1 and SW2 to their center positions.

☐ Connect a USB cable between J2 and a computer.

- ☐ Install the SO2R Box software as described in the SO2R Box (Plus) Owner's Manual.
- ☐ Start the SO2R Box Utility program.
- ☐ Set S3 On (up). The PC may say that it has detected new hardware, that it is installing drivers, and that the new hardware is ready to use.
- ☐ Click Connect in the SO2R Box Utility. The program should say that it has connected. Try various commands as documented in the SO2R Box (Plus) Owner's Manual.
- ☐ (Optional) Construct DIN Plugs using pin-out in the manual. Make sure you have the proper orientation of the plug when you wire it up. Connect them to a radio and test the functions of the SO2R Box.

Case Installation

The case must be electrically connected to the board and to the ground bolt. The paint is an insulator and must be removed. This can be done with sandpaper or a Dremel tool.

Remove paint from the inside of the box only.
- ☐ Remove the paint from around the right rear hole at the bottom of the case.
- ☐ Remove the paint from around the ground bolt hole on the rear panel between the PTT and AUX connector holes.

The ¼″ phone connectors have a nut and plastic collar. The potentiometer has a nut and a washer. This hardware must be removed before the board is installed in the case.
- ☐ Remove the nuts and collars from J3 J103.
- ☐ Remove the nut and washer from R14.

There are six holes in the bottom of the box. The feet are installed in the four corners.

Don't over tighten the screws which hold the feet or you will tear them.
- ☐ Attach the feet as follows: Place a pan head screw through one of the feet. Then put the screw through one of the corner holes in the bottom of the case. Put a threaded spacer onto the screw. Do this for all four feet.
- ☐ Install the remaining two spacers as follows: Put a lockwasher on a pan head screw. Put the screw through one of the remaining two holes in the bottom of the case. Put a threaded spacer onto the screw. Do this for both remaining spacers.
- ☐ Put the #10 lockwasher on the #10 bolt and put this through the ground hole on the rear panel (the screw head is inside the box). Put a nut on the outside and tighten it. Put a second nut on and leave it loose.

Looking at the inside bottom of the case you should see six spacers.

The PC board is a tight fit into the case. Make sure to tighten the middle spacers securely.

Everything should line up when the board is inserted.
- ☐ Slide the board into the box so that the switches, LEDs, and potentiometer go through the front panel and the holes in the board are over the spacers.
- ☐ Bolt the board to the case using six screws and lockwashers.
- ☐ Replace the washer and nut which were removed from the potentiometer.

The side pieces on the top/rear cover go inside the side panels of the case.

If the top does not fit properly you may need to remove the fiber washers on J3 and J103.

Do not over-tighten the jack screws on the DB-25, as it is possible to break them at the base of the spacer.

- ☐ Install the top cover on the case.
- ☐ Bolt the cover on using eight black screws and black lockwashers.
- ☐ Replace the collars and nuts on J3, J103
- ☐ Screw two jack screws into the DB-25 connector
- ☐ Install the knob on the SPEED potentiometer

There will be some hardware left over. Add it to your junkbox.

Congratulations! You have assembled the coolest SO2R box on the planet.