

Modification Procedure for Converting the MRS-1 Portable HF SSB Transceiver for 80m and 40m Amateur Radio Use with the SC+M Module

Introduction

The Mountain Radio Service MRS-1 portable HF SSB transceiver is a compact portable battery-powered HF SSB transceiver with a nominal output power of 5W PEP.

Usually fitted with two fixed 3MHz Upper Sideband (USB) mode channels, the MRS-1 transceivers were extensively used by MRS members and the public until the service finally closed down in 2024.

This document details the procedure to modify the radio for 80m and 40m amateur radio operation.



Figure 1 : The modified and upgraded MRS-1 radio

Overview of the MRS-1 Transceiver

The MRS-1 is a conventional single conversion filter-type SSB transceiver with a 10.7MHz IF. The block diagram of the original transceiver is shown in Figure 2.

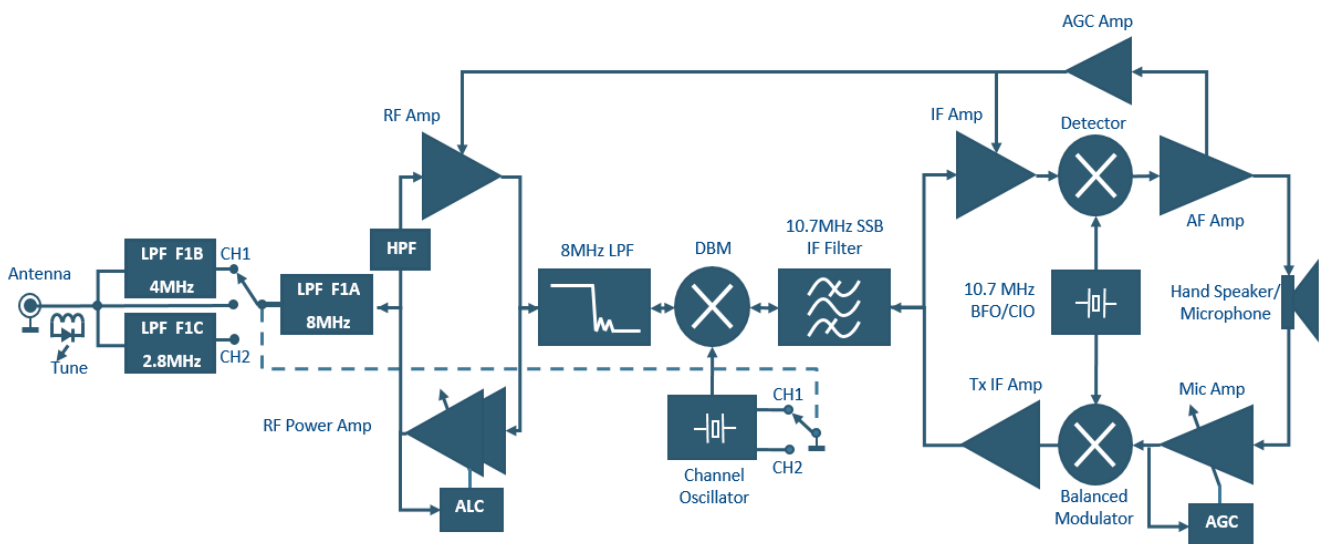


Figure 2 : This block diagram shows the main circuit elements of the original MRS-1 transceiver

Modification of the MRS-1 Transceiver

Figure 3 shows the block diagram of the modified transceiver.

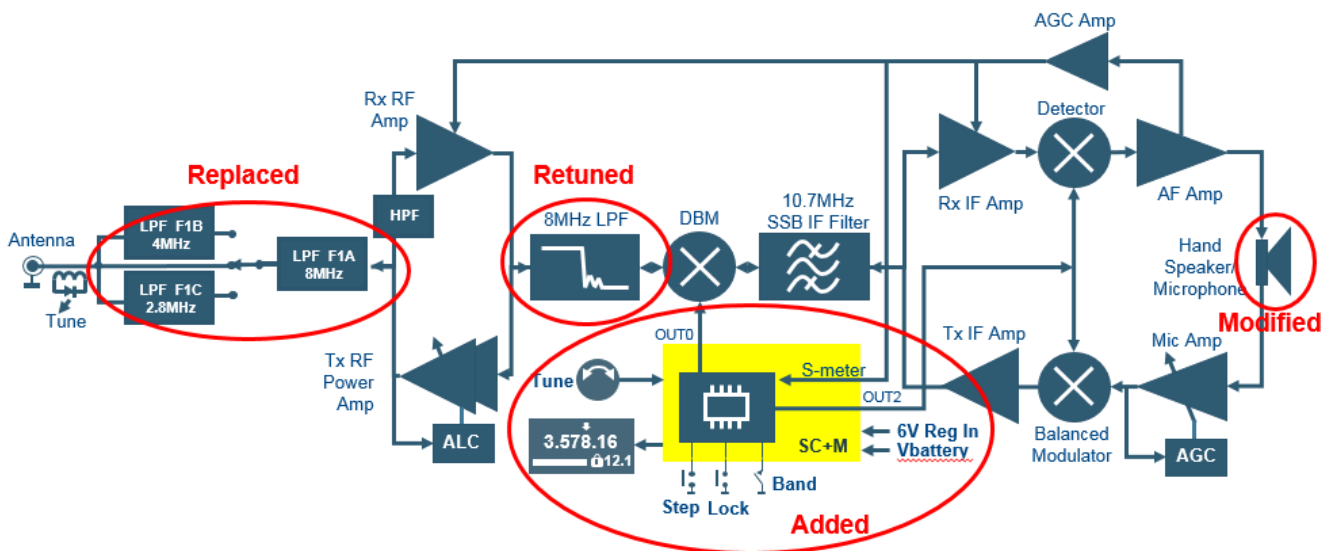


Figure 3 : The new “SC+M” module provides a synthesized VFO with 10Hz to 10kHz tuning steps, programmable band edge limits, and carrier/BFO oscillator. It also supports the OLED display with its near-linear S-meter and 3-digit battery voltage meter.

The modified transceiver will operate on the 80m and 40m ham bands. In New Zealand, these cover 3.50 – 3.90 MHz and 7.00 – 7.30 MHz respectively. These band edges are programmed into the VFO.

In addition, the original antenna low pass filters are replaced by band-specific LPFs. The 7-pole LPF may require retuning to permit 40m operation, and the selcall microphone, if fitted, may also require modification.

MRS-1 Modification Procedure

The following procedure assumes the availability of the MRS-1 ‘s purpose-designed SugarCube-Plus (“SC+M”) module. See the website for details.

The modification process:

- Replaces the front panel
- Removes components on the MRS-1 transceiver PCB
- Details installation of the SC+M module
- Adds some interfacing components for the SC+M on the MRS-1 transceiver PCB
- Modifies the MRS-1 antenna lowpass filters, and
- Describes alignment and testing

PLEASE (PLEASE!!) read all the relevant pages on the website and the various documents FIRST so you get an idea of the overall procedure and the steps involved in the conversion process.

Construction of the Front Panel

The new front panel is constructed from a front panel PCB and a panel spacer PCB. The latter eases mounting and alignment of the OLED display. Bolt the two PCBs together temporarily and use some hot glue to mount the OLED. The OLED connector should be adjacent to the encoder and Band switch.

Remove the front panel knobs from the original Formica panel and clean them before reuse. Record where the microphone cable connections are wired and then disconnect the cable. One of the prototypes had the wiring shown in Figure 4 but this may not hold for all microphones and transceivers. Remove the microphone cable and its grommet from the front panel. Remount the grommet into the new front panel assembly.

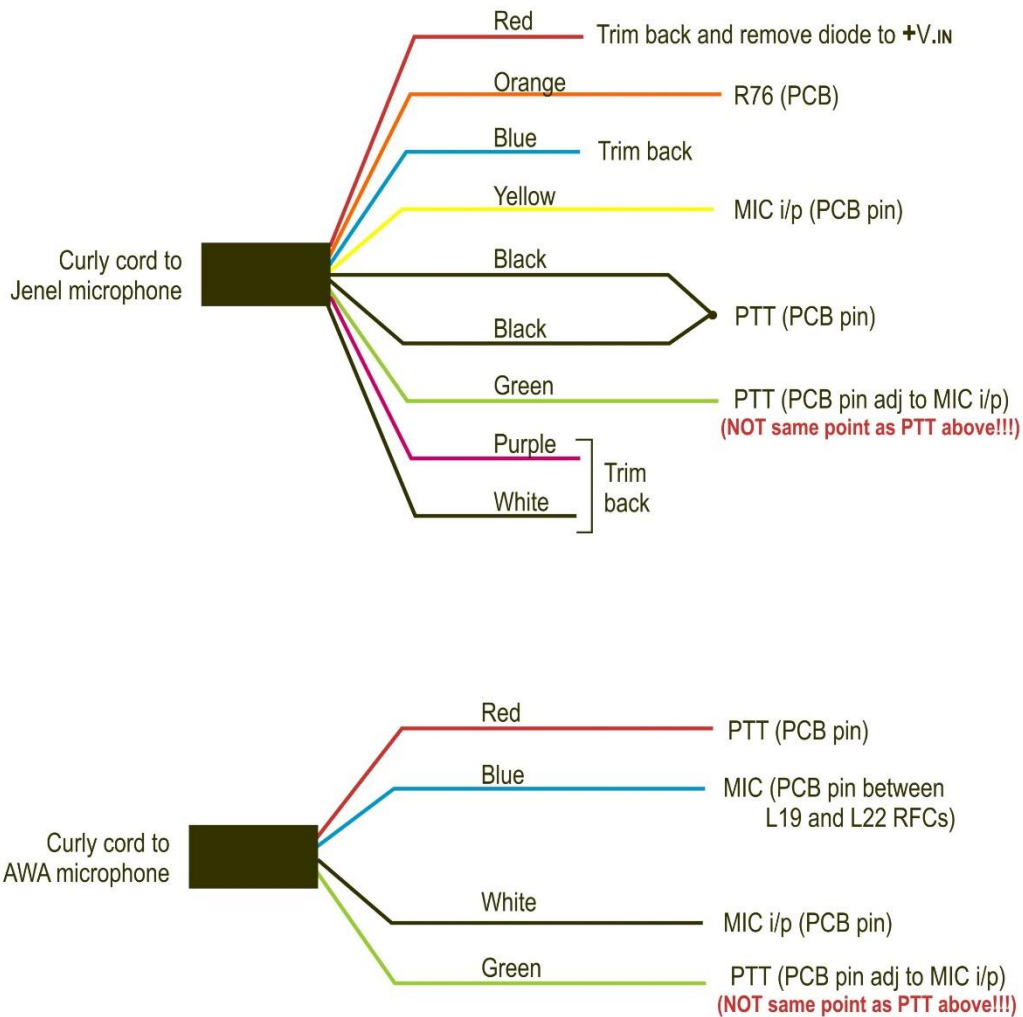


Figure 4 : Microphone cable wiring probably follows one of these two diagrams. Carefully check your transceiver before disconnecting the microphone cable.

Carefully feed the microphone cable back through the grommet again allowing enough cable length to reconnect it to the transceiver. DON'T reconnect those microphone wires just yet.

Loosen the rest of the front panel hardware including the volume potentiometer, channel switch, antenna connectors and the Antenna and Battery LEDs.

Remove the original Formica front panel and complete the removal of the panel components but do not disconnect them from the radio yet. Disconnect the antenna connector wiring at the panel connectors to allow the transfer of the connectors to the new panel. **Be VERY careful not to damage the antenna LED or its associated resistor (R6 – 220 ohms) or the toroid (L5)!!!!**

Remove the channel switch and associated wiring and set aside.

Mount the new panel using the three original screws. Replace any corroded screws.

Refit the volume potentiometer, the two LEDs, and the antenna connectors into the new panel.

Resolder the antenna connector wires back in place. Each of the two LEDs can be held in place with a drop of hot glue.

Mount the new Lock pushbutton using hot glue. Check that the pushbutton is not rubbing against the sides of the hole.

Loosely mount the new Band switch in the panel. This makes it easier to wire later.

Fit the ground wire and the two resistors to the rear of the encoder and mount it loosely on the new panel assembly. This makes it easier to attach the two encoder wires later. **Note that the encoder used is one of the (cheaper) pulse type encoders, the ones that give a momentary closed contact as they rotate. If your encoder outputs remain closed to the ground at the detent, it will not function correctly with this software.**

Using four thin insulated stranded copper wires, make a cable for the 4-wire cable going to the front panel OLED display. Terminate the OLED end with a four pin 0.1" DuPont **socket** to match the pins normally supplied with the OLED display. The wires in this cable in the prototypes measured **75mm** before soldering.

The front panel wiring will be completed once the SC+M module is installed in the transceiver. For clarity, the wiring details are shown in Figure 5, 6 and 7.

(See diagrams on next pages)

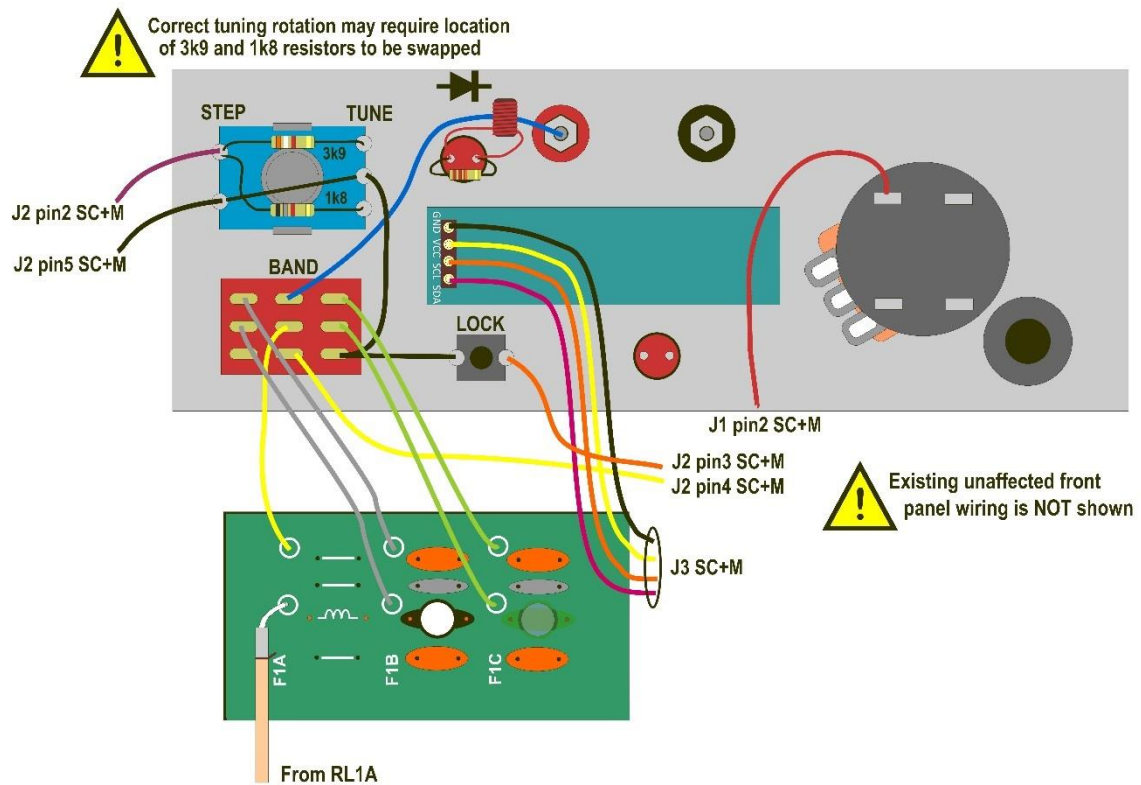


Figure 5 : The additional front panel wiring is shown in this drawing. The antenna current toroid wiring is shown for clarity due to the change to the blue antenna wire which now goes to the Band switch. The SC+M module requires additional wiring to the MRS-1 PCB which is detailed later.

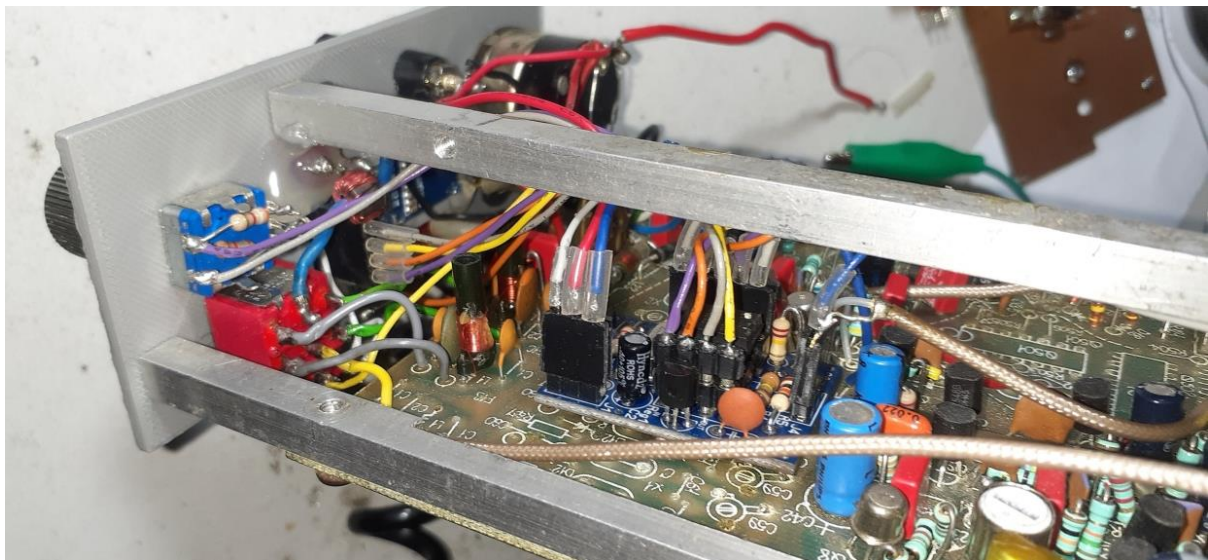


Figure 6 : The two antenna lowpass filters can be seen to the left of the SC+M module along with the rotary encoder, the upper part of the Band switch, and the OLED wiring.



Figure 7 : The lower section of the Band switch wiring as well as the Lock switch and OLED mounting can be seen here.

Mounting the SC+M

This is done in two stages, the first being to remove the unwanted crystal oscillator components.

Remove the existing Channel Crystal Oscillator components. See Figure 8 for details. The red dashed line highlights the ground track surrounding the oscillator which quite precisely identifies the location of the parts to be removed.

Remove the following parts adjacent to the double balanced mixer (SBL-1):

- R52, R53, R54, R55
- C67, C68
- Q16
- L34
- "Local Osc" coax cable tail running next to R118 (Next to the balanced modulator trimmer resistor R119) to the channel oscillator. Set this aside.

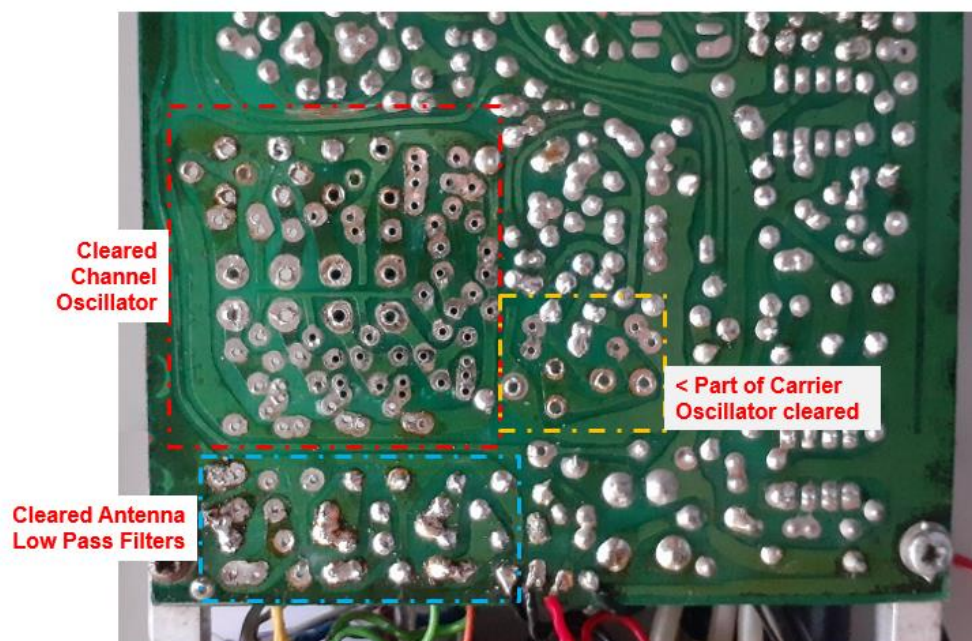


Figure 8 : View of the underside of the MRS-1 PCB showing areas to be cleared of components

Install a 100n disc ceramic capacitor, 100 ohm resistor, and 47 ohm resistor as shown in Figure 9.

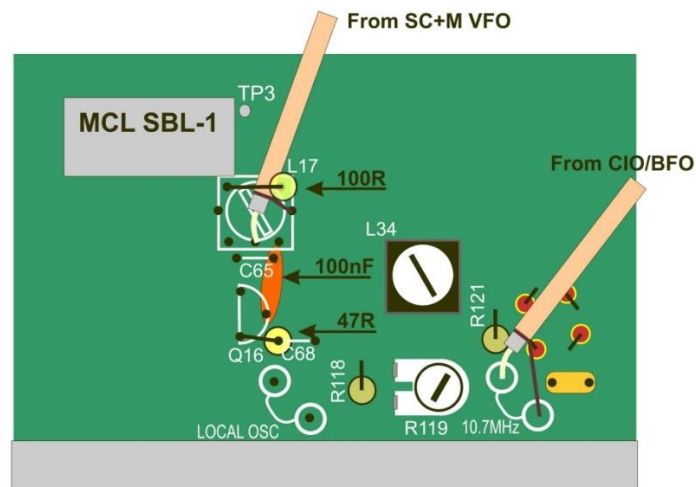


Figure 9 : Location of new components near the SBL-1 mixer. This drawing also shows the new location of the VFO coax cable tail from the SC+M which is fitted later.

Remove the following parts from the Carrier Oscillator (Figure 8):

- C71, C72, C73, C74
- R58, R59
- X2
- Q17

Install a 100nF disc ceramic capacitor and a 100 ohm and 4k7 resistor as shown in Figure 10.

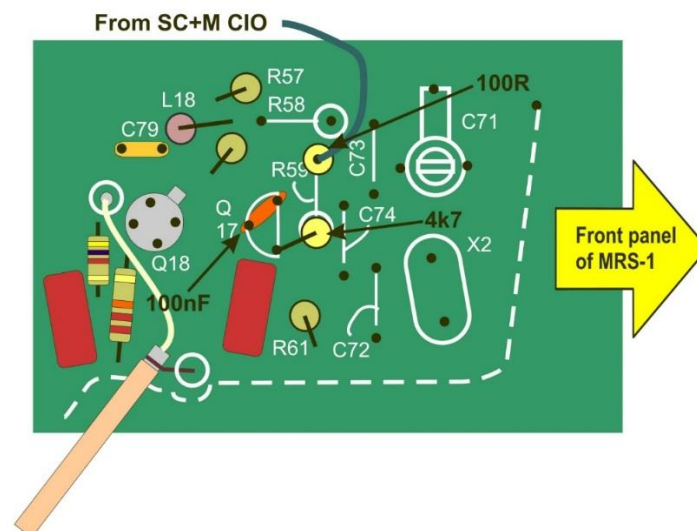


Figure 10 : Mounting location of Carrier Oscillator interface components.

Fitting the SC+M Module

Install three thin wires in the corners of the SC+C. Cutoff capacitor leads are one source of suitable wires.

Mount the SC+M in the area previously used by the channel oscillator. The three wires should be fitted into the holes indicated in Figure 11. These connect the SC+M PCB ground securely to the MRS-1 PCB ground. J1 on the SC+M board should be adjacent to the antenna low pass filters. You can see the placement of the SC+M clearly in Figure 6 above.

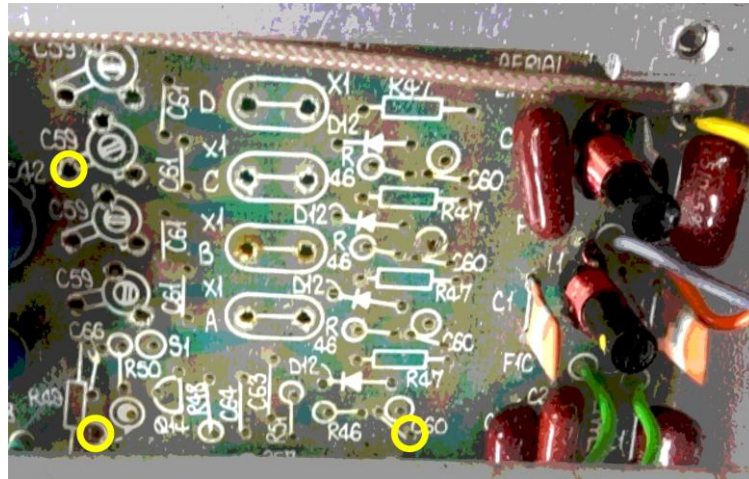


Figure 11 : Three points are used to secure the SC+M module via short cutoff component leads.

Figure 12 shows the additional wiring required for the SC+M. This is in addition to the wiring which goes to the front panel described earlier and shown in Figure 5.

Modifying the Antenna Low Pass Filters

80m and 40m operation requires modification of the antenna low pass filter(s) in the MRS-1 as shown in the schematic in Figure 13.

(See diagrams on next pages)

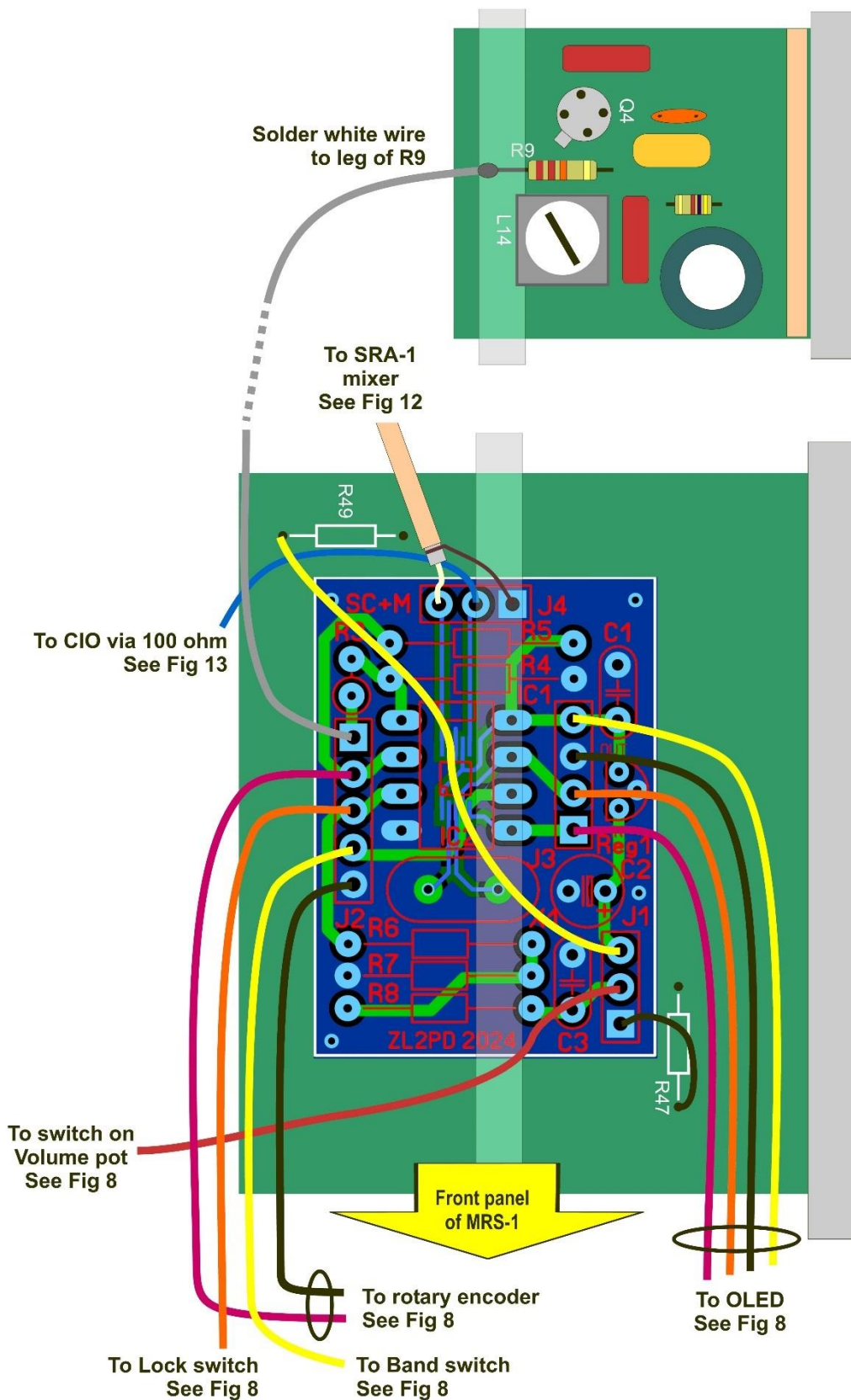
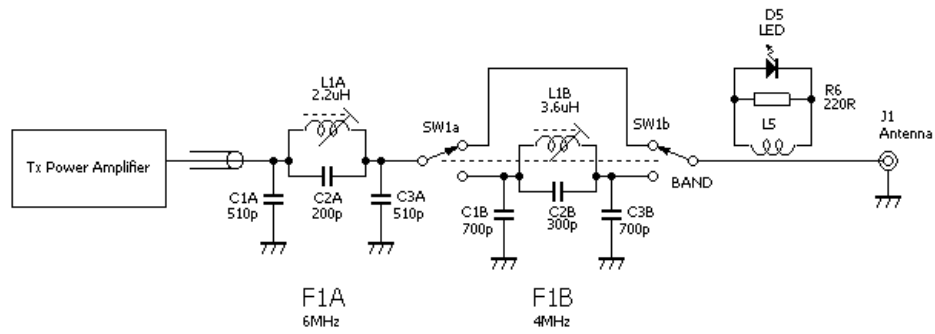


Figure 12 : Additional wiring to the SC+M is for the regulated 6VDC supply, the AGC voltage for the S-meter, and the VFO and CIO/BFO oscillator outputs.

Original:



New LPFs:

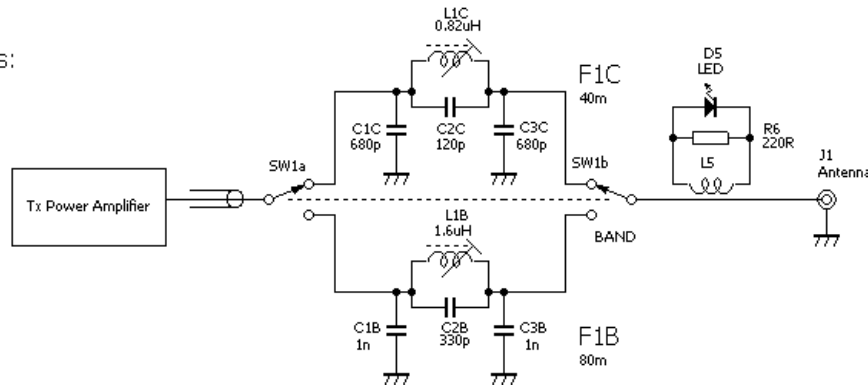


Figure 13 : The low pass filters were redesigned for 80m and 40m operation. Some original LPF components are reused in the new filters (See text).

Using Figure 14 as a guide, begin by carefully desoldering and setting aside all the antenna low pass filter parts fitted in the original MRS-1 including any short input and output wires. Take care removing the delicate inductors!

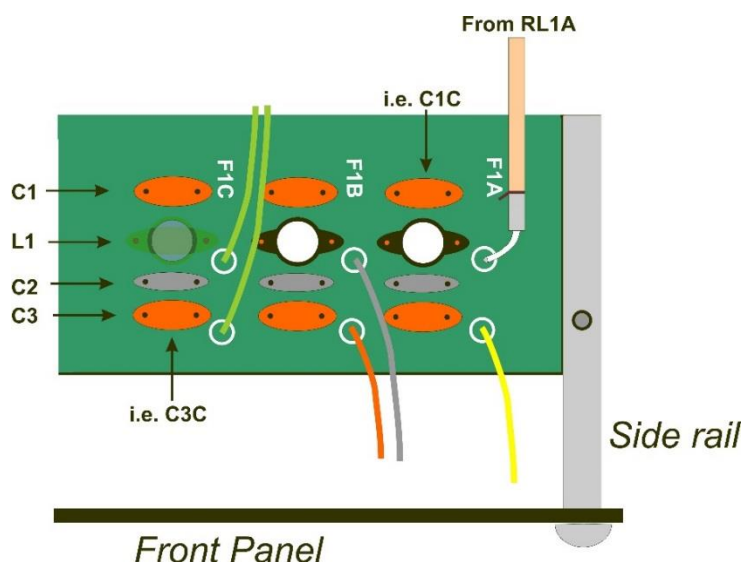


Figure 14 : Layout of the MRS-1 antenna low pass filter components

Reinstall the larger of the two variable inductors as L1B.

Remove the wire used on the smaller of the two variable inductors. Rewind this coil with 12 turns of 0.25mm enameled copper wire. Fit this inductor as L1C.

Install the LPF capacitors shown in Figure 16 into locations identified in Figure 17. Some of the components set aside earlier may be used in this step.

Alignment and Testing

1. Calibrate the SC+M output frequency. Refer to the calibration details in the SC+M build details.
2. Confirm the programmed band edges and starting frequencies for both bands are correct.
3. Confirm the CIO frequency is 10.69850 MHz (LSB)
4. Align the 80m and 40m antenna lowpass filters using a 1kHz test tone into the transmitter. Some adjustment of L7, L8 and L9 may be required. The latter requires specialized test equipment and only undertaken if absolutely necessary.
5. Verify the MRS-1 output power is 3W PEP across both bands.
6. Verify the receiver sensitivity (Better than 10dB SINAD for 0.2uV) on both bands

Final Comments

With the alignment and testing completed, the modified MRS-1 transceiver should now be working correctly.

Despite what may appear to be extensive modification instructions and procedures, this modification is actually a quite straight-forward conversion. The most time-consuming task is probably removing the unwanted crystal oscillator parts. The other steps, including building the SC+M module and fitting the new front panel, are quite easy although they will take a little time.

Appendix A : Part List

| Value | Description | Qty | Designation | Notes |
|----------------------|---|-----|-------------|--|
| Resistors | | | | |
| Through-hole | | | | |
| 1k8 | 1/4w 5% resistor | 1 | R1 | Mounted on encoder |
| 3k9 | | 1 | R2 | Mounted on encoder |
| 47R | | 1 | - | MRS-1 interface |
| 100R | | 2 | - | MRS-1 interface |
| 4k7 | | 1 | - | MRS-1 interface |
| 10k | | 1 | R5 | |
| 12k | | 1 | R7 | |
| 47k | | 1 | R8 | |
| 100k | | 1 | R6 | |
| 220k | | 1 | R3 | |
| 330k | | 1 | R4 | |
| Capacitors | | | | |
| 100n | Disc ceramic | 2 | C1, C3 | |
| | | 2 | - | MRS-1 interface |
| 1uF/16V | Miniature electrolytic | 1 | C2 | |
| ICs | | | | |
| ATtiny85 | ATtiny85-20PU 8-pin DIL microcontroller | 1 | IC1 | |
| Si5351A | Si5351A-B-GTR MSOP-10 PLL IC | 1 | IC2 | |
| 78L33 | 3V3 100mA TO-92 regulator | 1 | REG1 | |
| Switches | | | | |
| Band | Sub-miniature DPDT toggle switch | 1 | SW2 | e.g. Jaycar ST0355 |
| Lock | Momentary TACT pushbutton 6x6x7mm | 1 | SW3 | |
| Rotary Encoder | PULSE-type rotary encoder with integrated push switch | 1 | SW4 | e.g. AliExpress etc (NOT Jaycar) |
| Miscellaneous | | | | |
| OLED | 128x32 pixel OLED display (SSD1306) | 1 | - | c/w 4-pin DuPont male pin connector |
| Crystal | 25MHz HC-49U crystal | 1 | X1 | |
| - | 8 pin DIL IC socket | 1 | - | For ATtiny85 |
| - | SC+M VFO module PCB | 1 | - | |
| - | MRS-1 front panel and spacer PCB(s) | 1 | - | |
| - | 20 pin 0.1" DuPont/JTS header pin strip | 1 | - | |
| - | 20 pin 0.1" DuPont/JTS header socket strip | 2 | - | |
| - | 250mm 26-conductor ribbon cable | 1 | - | |
| - | 150mm 1.5x2.5mm (ID/OD) clear silicon sleeving | 1 | - | |

(Continues...)

| Antenna Low Pass Filters | | | | |
|--------------------------|---------------------------------|---|---|--------------------------|
| Inductors | 0.6uh-1.7uh adjustable inductor | 2 | - | 12T with HF core |
| 120pF | 100VDC disc ceramic | 1 | - | |
| 330pF | 100VDC disc ceramic | 1 | - | |
| 680pF | 100VDC disc ceramic | 2 | - | |
| 1000pF | 100VDC disc ceramic | 2 | - | Likely reuse MRS-1 parts |
| | | | | |

Multistrand Hookup Wire Length Estimation Calculation:

| Wire Colour | Length (mm) |
|-------------|--|
| Red | 100 |
| Yellow | 50+100+100 |
| Violet | 100+100 |
| Grey | 100+100 |
| White | 100 |
| Black | 50 |
| Orange | 100+100 |
| Blue | 100 |
| Thin coax | 150 (Reuse existing channel oscillator coax) |

Appendix B : Modification Details for Jenel Microphone

Some modifications may be required if your MRS-1 has a Jenel microphone. These remove the undesirable tone call functionality which is not required in amateur radio.

These modifications should be carried out BEFORE testing the modified transceiver. If these are not completed, the MRS-1 will probably not get microphone audio and the PTT signal will not work!

1. Open the back of the Jenel microphone and set aside the three screws.
2. Remove the Jenel tone control board from the microphone leaving the keypad and its LED PCB in place. To do this, desolder the ribbon cable from the Jenel PCB and fold the ribbon cable down against the keypad. Also, desolder the red and black wires going to the keypad LED PCB.
3. Rewire the microphone audio, PTT and ground wires as shown in Figure 1. Use heatshrink to cover the cable joints.
4. Use a cable tie to retain the spare microphone cable wires.
5. Carefully place the wires inside the microphone so that the back of the microphone can be fitted and the three screws tightened.

Appendix C : MRS-1 AA-cell Battery Modification

The MRS-1 contains a dual battery holder inside the transceiver case. This was originally fitted with eight 1.5V alkaline AA batteries which were inserted into the holder from a screw-on cover on the cover's base. These batteries provide a nominal power supply to the radio of 12V.

These batteries could continue to be used in the modified MRS-1 transceiver but at a relatively high operational cost.

Alternative rechargeable options include using three (3S1P) or six (3S2P) AA-size **LiPo** cells. These deliver a cell voltage ranging from 4.2V/cell (charged), 4.0V/cell during operation, and a minimum voltage and load disconnect terminal cell voltage of 3.5V/cell. In this option, the battery system terminal voltage ranges from 12.6V (charged) to 10.5V (recommended minimum/disconnect voltage). Using an arrangement such as a 4S1PS or 4S2P LiPo configuration places excessive voltage on the radio and is **NOT** recommended.

A battery system using a 3S1P set of the popular 18650 LiPo cells offers a better capacity within the available battery holder space and a reduced weight over the original eight AA alkaline batteries. This is the recommended solution.

Another option is to use four or eight **LiFePo4** AA cells. a cell voltage ranging from 3.65V/cell (charged), 3.2V/cell during operation, and a minimum voltage and load disconnect terminal cell voltage of 2.5V/cell. A 4S1P or 4S2P arrangement delivers between 10 and 14.4V for the 100mA (Rx) and 300-700mA (Tx) current load of the transceiver.

All of these options (aside from the AA alkaline batteries) require a charging system as well as a cell-based battery management system and a low voltage disconnect to ensure balanced charging and protection from accidental discharge below minimum recommended cell voltages.

If this is installed, it is also likely the original battery holder hardware inside the transceiver case will have to be removed or extensively modified in some way and the new battery, mounting, and battery management system fitted. This work has not yet been undertaken.

END