

Adding Lower Sideband to the RT 320

Dr Andrew Smith. G4OEP

The RT230 (UK/PRC 320) is a super rig for amateur use, particularly on 7MHz, where its limitation to 30WPEP is not a problem. But it is precisely on this band that the absence of LSB is particularly felt. Adding LSB is quite an easy modification, but anyone who has one of these rigs is aware that they are very much sought after by collectors, and any modifications must be done with great care if the interest value of the rig is not to be destroyed. Fortunately it is possible to do the modification in such a way that no-one who is unaware of it could ever discover that it is there without opening the case.

General.

The final IF of the RT320 is at a nominal frequency of 1.750MHz. Due to a subtractive frequency conversion earlier in the system, an incoming USB signal appears as LSB in the 1.750MHz system. So to avoid confusion, USB and LSB will henceforth be used to refer to the incoming signal (or transmitter output) unless specifically stated otherwise.

The existing carrier insertion oscillator (CIO) for SSB generation is a 1.750MHz signal derived from the reference oscillator for the synthesiser. This signal is fed to the IF board (SD-D 218834) via pin F on the board. The modification takes the form of an additional crystal CIO running at 1.74680MHz (that is the crystal marking) whose output is switched to the IF board by a relay when LSB is selected. The relay also switches power to the LSB CIO so that it is only active when LSB is in use. The relay is activated by grounding pin G of either of the handset connector plugs. [See note at end of article].

Modification details.

Pins G of both handset connectors (on the back panel) were originally connected to pins D (audio out) behind the connector. These connections have been cut. Pins G have been joined together, and to pin 9 (previously unused) of the 9-way D plug marked 2PL3 on the back panel of the rig. Pin 9 of the mating socket on the main chassis is connected to the coil of a relay which is located (in this arrangement) under the IF board, and the relay coil circuit is completed to the incoming 24v via the front-panel switch. The correct connection to the switch can be found by testing with a continuity tester for a switchable through-connection to the external 24v battery-connection lug, with the battery removed.

The track connected to pin F on the IF board has been cut at the pin, and the pin, the track, and the new LSB CIO are joined to the relay change-over contacts as shown in Fig 1. Additional relay contacts are used to supply 24v power to the new oscillator, which is wrapped in insulating material, and tucked into a corner near the front-panel mode control switch. If the track on the pcb is cut carefully, it can subsequently be repaired (if required) with a small blob of solder. Fig 2 is the circuit diagram of the new oscillator.

Practical Notes.

a) Sources - I got my crystal from QSL Marketing (PO Box 19, Erith, Kent, DA8 1HL, 01322 330830. www.quartslab.com) who charged me £10 total for one-off. They could only supply an HC33 (wire-ended HC6U) package which is VERY BIG considering the amount of available room in the '320. If you can find a smaller one it is worth trying.

b) Setting it up. Check the amplitude of the existing USB CIO on pin F before you start, and then adjust the series resistor in the supply line of the new CIO to give a comparable output. About 200mV peak is what should be

expected. Start with 4.7kΩ and adjust to suit the activity of the crystal.

It is important to get the LSB CIO frequency exactly right (within 100Hz or less). If you have no instruments you can do this (approximately enough with care) by disconnecting the antenna and listening to the broadband receiver noise. There should be no noticeable change of pitch when you change from LSB to USB. If you have a reasonably accurate frequency counter you can get a very exact setting - see notes below on RT320 frequencies. Alternatively if you have an oscilloscope and an audio sig-gen proceed as follows. - With the '320 connected to a dummy load, select SSB, USB and low power. Using an appropriate audio attenuator feed a 1KHz audio signal into the mic socket, and connect the 'scope to the dummy load. Press the PTT and observe the rf output. Raise the audio frequency until the rf output voltage falls to half its original value (or any measured amount). Note the AF frequency. Then find the lower cut-off frequency by lowering the AF frequency. Switch to LSB and do the same. Adjust the CIO frequency until the upper and lower cut-off frequencies are the same for USB and LSB. On the fourth hand - I have found that the panoramic frequency display which is part of the Digipan PSK32 software (search for Digipan on the net) gives a very clear impression of the ssb filter pass band if you disconnect the antenna and adjust the volume so as to view the receiver noise. I expect you could use this to view the effect of shifting the CIO frequency- the passband would move up or down in the audio band, and should be the same (about 300Hz to 2800Hz) on both sideband settings.

c) Reservations. The system as described here works well and produces very acceptable LSB SSB which attracts good reports on-air. However, there are one or two theoretical points of the nature of a disclaimer. - i) the sideband filter is an LSB filter specifically intended for the 1.750MHz LSB system. This means it is asymmetrical and is non-optimal for the new USB role. In practice this seems to make no difference at all - carrier suppression is excellent on transmitted LSB. ii) It is not possible to kill the existing USB CIO when using LSB. The resulting 2.4 kHz beat frequency due to leakage of the USB CIO into the mixer is just perceptible during receive when no other signal is present. Use screened connections to keep this under control. iii) In use, if you select CW make certain that you have also selected USB. Your CW note will be wrong (lower than normal) if you select LSB with CW Wide, and will not get through the narrow IF filter at all if you select LSB and CW Narrow. Also - always return to USB when selecting AM if you want to avoid some very strange effects. Ideally the USB/LSB selection system should be interlocked with the mode selection - but that is a refinement for another day. None of these errors of settings will harm the rig.

d) Opening the case. To open the case first undo the screws fastening the back panel and then remove it

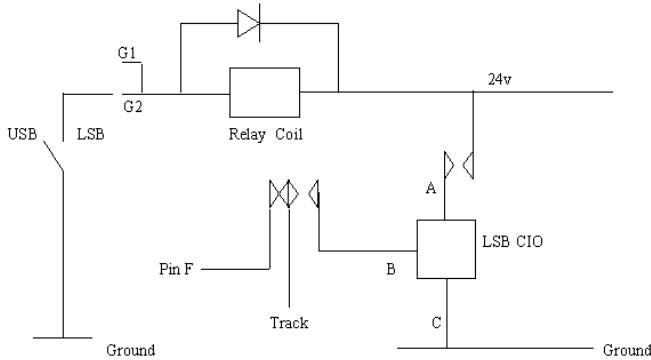


Fig 1. Interconnections

before undoing the front-panel screws. If your rig is a virgin you will have to use gentle force the first time, since the gasket will have stuck the two parts together - be careful how you separate them. The back panel connects to the inner chassis by means of several multi-way connectors which should be separated (and re-assembled when the time comes) very carefully. Just do it slowly and gently, and make certain that the connectors are aligned properly when putting it back together. When re-assembling, DO NOT tighten the screws unless you are certain that the connectors are mating properly. When the back is off you can undo the front screws and remove the front panel from the case - the main chassis will come with it. You can now put the case aside and re-plug the back panel to the chassis for functional tests, being careful that it does not all fall apart unexpectedly.

2) Break-Out Box. If you use pin G as mentioned above you will need a spare plug to give access to the LSB/USB control. These are available at rallies, or the Military Radio Company (on the net). I do not use the Clansman handset, preferring a pair of headphones and a fist microphone. So I have made up a little box with a Clansman-type plug attached. The box contains a socket for the fist microphone, a jack socket for the 'phones and a switch for sideband selection. The box is fixed to the rig using the existing tapped holes on the left hand side of the case. I can plug the standard handset into the other socket if I want to use it.

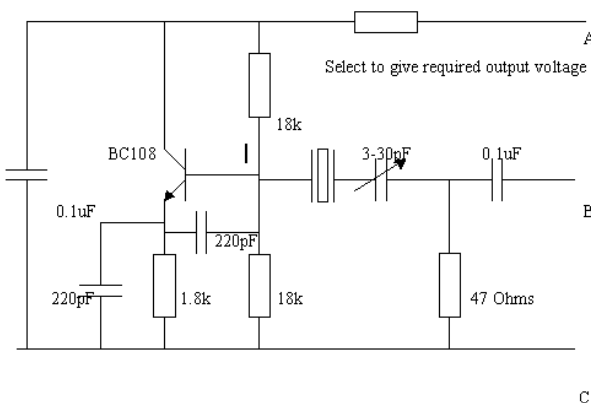


Fig 2. LSB Carrier Insertion Oscillator

RT 320 Frequency Readings

The User Handbook for the RT320 states that the frequency indication on the decade switches is 2kHz above the suppressed carrier frequency on USB, is the same as the carrier frequency on AM, and is equal to the emitted frequency on CW. The reason for the 2kHz offset on USB is not known. When the RT320 is modified by adding a LSB CIO, a different offset (~1.2kHz) becomes apparent on the LSB setting, and moreover, in CW (W) mode, the emitted output changes frequency (lower)

when switching from USB to LSB. No output at all is produced if LSB and CW (N) are selected. The following notes attempt to explain these effects.

It is known (from the User Handbook) that the CW(N) filter has a bandwidth of 250Hz, and is used with a CW audio tone of 2kHz. It is also known that the SSB filter has a bandwidth of 2.7kHz.

Using all of the above information, the following frequency scale can be constructed (note, however, that the sense of the frequency differences is in reality reversed, due to the USB/LSB reversal) -

- f1) reference, 0Hz USB CIO
- f2) +250Hz Lower cut-off of SSB filter
- f3) +1200Hz LSB CW output (see below)
- f4) +1875Hz Lower cut-off of CW(N) filter (f5 -125Hz)
- f5) +2000Hz Indicated frequency - mid-point of CW(N) filter.
- f6) +2125Hz Upper cut-off of CW(N) filter (f5 +125Hz)
- f7) +2950Hz Upper cut-off of SSB filter (f2 + 2700Hz)
- f8) +3200Hz LSB CIO. (f7 +250Hz = f5 +1200Hz)

Now, if it is assumed that the CW signal is produced by inserting a 2kHz audio tone into the SSB mixer the following behaviour will be expected -

Setting	Behaviour
a) USB, CW(W) and CW(N)	Output at indicated frequency as specification.
b) LSB, CW(W)	Output at f8-2000Hz: i.e. f3 or +1200Hz, This is 800Hz below the indicated frequency.
c) LSB CW(N)	Same as (b), i.e. +1200Hz, but this is below the CW(N) lower cut-off frequency (f4, or +1850Hz) and is therefore suppressed. No output expected.

These predictions agree with observed behaviour except in the details of the precise frequencies (see below - Calibration), and so the interpretation given here is confirmed.

Calibration.

The frequency table allows the correct setting of the LSB CIO to be determined. It is precisely 3,200Hz below the existing USB CIO. Further, a very convenient way of setting the new CIO can be found. Set the RT320 to CW(W), USB. Key the ptt, and measure the output frequency (on any frequency setting) with a digital counter. Then switch to CW(W), LSB, and adjust the new CIO until the output frequency is exactly 800Hz different from before. Extreme precision in the calibration of the counter is not required, since it is only the difference in frequency which is important. As a matter of interest, the original 'by-ear' technique produced a setting which was about 20Hz off. The specification of the RT320 states that the frequency accuracy is 1ppm, so this is a good way of checking your counter !

Editor's Note: I have carried out this conversion, and it works very well! However, pin D and G of the audio plug are strapped for a good reason - some audio gear has the earpieces wired separately, one to D and one to G, apparently so separate comms could be fed to each ear. To avoid separating the connection, I looked for a simpler way of providing the LSB switching: Pin 16 of the mainboard, which is easily accessible, goes to +24 volts when the meter switch is in the 'batt check' position and I used this to feed the relay (other side earthed) to provide LSB switching: switch to 'batt chk' and you have LSB.