

TS-850 modifications to allow for transmitting on LF

Modifications have been developed by Bob Vernal ZL2CA

Version 2 notes 10 November 2000

General comment

Amateur transceivers with general coverage receivers are potentially all band transmitters if the appropriate control circuitry can be modified. On LF transmit, the transmit mixer stage usually develops about 100 millivolts but the coupling and response of following transmitter stages is generally poor to negligible over the LF range (the transmitter was designed to handle a lowest transmit range of 1.8 MHz). It is necessary to "pick off" the LF transmit signal in a suitable manner from the transmit mixer.

In the TS-850, there is a more complicated operating system than for Icom and Yaesu transceivers that have been modified by ZL amateurs for transmitting on LF. The TS-850 has significant differences (arising from software) for transmitting on frequencies below 1.62 MHz.

Transmit inhibit (TXI)

To have all band transmit for bands ABOVE 1.62 MHz, this can be achieved by appropriate selections of "destination diodes" D8 through D12 on the Digital Unit (located behind the front panel). The diodes go to pins on IC3. D11 and D12 are shown in parallel on the circuit diagram, but if D12 is fitted, it is a surface mount device (SMD) diode mounted UNDER the PCB. It is a difficult task to remove the digital PCB to get at D12 as the PCB is retained by special head security head screws. In order to transmit over all of the HF band 1.62 - 30 MHz, fit only D9 (noting the possible presence of a D12 under the PCB). While this is the recognized mod for "opening up" all HF bands, the programming of "destination diodes" does not appear to allow for transmission on frequencies BELOW 1.62 MHz.

To transmit on LF, the "transmit inhibit" (TXI) needs to be defeated in some way. This was achieved by modifying the BKSW module X59-3880-00 which is a sub-PCB located on the rear right hand side of the IF Unit. Pin 9 feeds the TXI logic to the base of transistor Q2. To defeat this control, cut the PCB track from pin 9, and install a thin jumper wire from Q2 base to pin 6 of the BKSW module (this forces a steady "1" on Q2 so it never inhibits the transmitter, whatever the dial frequency). The IF unit PCB does not need to be removed from the rig to do the modification, but access needs the PCB to be raised in situ (removing retaining screws and lift the PCB within the constraints of connecting cables).

The TS-850 is then capable of transmitting on LF when the PTT is activated, or a Morse key closed. Note that the existing transmit driver and PA does not respond to LF, so there is no useful output to be obtained from the SO239 antenna socket. There is low level transmit drive from the Tx mixer passing via the 500 kHz low pass filter, and this can be extracted with existing circuitry using the rear panel "transverter" port. It is convenient to use this port, but the drive is actually at LF and not transverted.

Using the transverter port for LF

The TS-850 has an internal changeover relay that can direct the transmit drive to a rear panel phono connector rather than going to the HF PA. Refer to page 49 of the Kenwood operating manual for information on using the IF OUT 1 phono connector, in this case the drive is on frequency and does not need a transverter. An external LF PA raises the power level for separate application to an LF transmit antenna. If DC is applied to the IF OUT 1 phono inner lead, it invokes the changeover (such as when an external transverter is turned on). This can be automated for LF output (but inoperative on HF) by using the band selection data from IC1 of the RF Unit. IC1 pin 3 outputs a "0" when the 0-500 kHz band is selected. This can be inverted with a PNP transistor to feed a "1" to the phono inner. Note that IC1 pin 16 is a +5 volt point.

The automatic selection PNP buffer logic circuit used by ZL2CA is with the emitter of a PNP transistor to IC1 pin 16, 10k ohms from emitter to base, and 10k ohms from base to IC1 pin 3. 10k ohms from collector to PCB ground and 1k ohms to the DRV2 phono lead (moderate resistance needed to not shunt the RF output).

The TS-850 transmit drive to the transverter port is reasonably broadband as manufactured, and passes some LF energy for amplification using an external LF amplifier. It is difficult to modify the TS-850 circuitry to decrease the LF droop without impacting on response at other HF bands. One modification to improve low frequency response is to supplement the value of C219 (a 0.01 uF capacitor, located near L88). It is possible to solder a parallel capacitor to the top side of the RF Unit PCB. Otherwise the "broadband" circuits in the TS-850 transmit drive are accepted for what they are. With C219 supplemented in value, 180 kHz output from IF OUT 1 is between about 100 and 250 millivolts, whereas on HF it is more like 1 volt.

Response droops across the LF range (to the lower limit of 30 kHz set by the TS-850 synthesizer logic) but is still probably useful for use with an external LF PA. No RF feedback has been encountered with on-site LF transmitting with a 1000 watt PA (on 180 kHz) so it is concluded that the TS-850 is reasonably well shielded and unlikely to "take off" with LF on-site transmission.

Operating system issues encountered

There is a fundamental "problem" with the software operating system for frequencies below 1.62 MHz. Operation is possible using SSB and CW, but with certain operating limitations. SSB mode includes the likes of PSK-31 or other data modes using an audio drive.

Operating limitations found to date include:

1. On transmit, RIT is not canceled (probably the digital logic thinks it is still in receive mode?).
2. For CW transmit, the emission is higher than the dial frequency by the selected CW tone (probably because the digital logic thinks it is still in receive mode?) (the side tone can be selected in 50 Hz steps over the range 400 Hz to 1000 Hz, so whatever it is needs to be taken into account on LF CW tx, use a frequency counter to confirm what is happening).
3. For CW transmit, there is no emission for certain narrow band filter selections. This appears to be software rather than passband issues? Medium bandwidth filter settings do work for LF CW tx.
4. Sometimes on receive, when narrow filters are selected, there is no IF output, but it "wakes up" after a wider filter is selected, then works for narrow filters (a software matter?).

5. There is no split frequency function (probably because the digital logic thinks it is still in receive mode?).

6. There is no emission for AM or FM (or FSK?) transmit (these carriers need to be off to not interfere in receive mode, so once again a digital logic issue).

With the above-described modifications, for trying to transmit on frequencies below 1.62 MHz, the TS-850 partly "thinks it is still receiving" even though the TXI function has been fooled in the BKS module. The difference in functionality can be probed by trying transmission on either 1.620 or 1.621 MHz and observing differences (with a dummy load on the TS-850 SO239 connector).

For SSB, the 455 kHz BFO runs continuously on receive, and this happens to also be the correct frequency for transmit (either the LSB or USB suppressed carrier frequency), so the modifications to date are satisfactory for SSB transmit and receive operation using the digital dial frequency (but accepting the RIT is not canceled, and no split mode).

For CW transmit, keying control is a separate function and works regardless of dial frequency, but below 1.62 MHz the keyed 455 kHz "carrier" presumably continues to be the frequency used for CW receive (+ offset by the audio tone frequency). For spot frequency working, it is possible to use separate memory channels offset by the tone frequency, with memory having wider filters for transmit, but it does require manual selection of memory channel between transmit and receive.

For AM and FM transmission, it requires the TS-850 to generate a 455 kHz carrier at centre frequency, and no such carrier is generated as it "thinks it is still in receive mode" (if a mid band frequency was generated by the BFO oscillator during receive, it would cause bad interference). For frequencies above 1.62 MHz the AM, FM and FSK carrier works fine on transmit.

ZL2CA has yet to ponder how to negate the operating system logic that makes some of the transceiver think it is still receiving. It must be related to the frequency data of the digital dial? If this could be solved then the TS-850 would be able to flexibly be used as an all mode LF transceiver with all of the functions that are available on HF. For the time being there are a number of compromises to watch out for. It would be nice to have a ROM that knew about hams who wanted to transmit on LF.

These notes are passed on in good faith. Obviously punters take responsibility for diving in and modifying their rigs.

Good luck,

Bob Vernall ZL2CA