

Modifying an IC735 for the 630m band

© 2014 Jacek Lipkowski SQ5BPF <sq5bpf@lipkowski.org>

The IC735 is a very versatile transceiver, which can be obtained for a good price and is easy to modify and fix. It is easy to modify it to work on the new 472-479kHz band, without compromising HF performance.

Many other transceivers with an out-of-band transmit mod will stop transmitting below 1.8MHz, or 1.6MHz. To get below this limit would require modifying the processor firmware (which is not accessible). Fortunately the IC735 will try to transmit down to 100kHz, although the power drops with frequency very quickly.

There is another modification published by Erwin Rauh DL1FY available at: http://www.ov-erding.de/630m_Band.pdf . Unfortunately this modification has some drawbacks. It has less spectral purity, because bandpass filtering after the TX mixer is bypassed. Also it doesn't give full output power to real antennas, because of the SWR protection circuitry. No attempt is made to improve the receiver on MF. Despite the drawbacks, Erwin's article shows that it is easy to quickly get on the 630m band with available gear. The radio is a good choice, because it also enables one to use digital modes such as WSPR.

To modify the IC735, do the following steps:

- download the IC735 Service Manual
- check if the radio is working well before attempting any mods
- do the wide-band transmit mod (if it hasn't been done already)
- measure power at various frequencies
- modify the bandpass filter and the coupling capacitors
- enable the RX preamp below 1.5MHz
- measure power again
- make a simple external low-pass filter
- optionally disable the SWR protection circuit

Checking the radio

As with any other equipment, modifying a broken unit will not magically fix it, and result in frustration. Please check if the radio works first. The IC735 has some common problems:

- Settings are lost after power-up, the radio behaves strange: the backup battery needs replacement
- The radio doesn't transmit on all frequencies 1.8-30MHz (into a dummy load), the output is not spectrally pure, receiver has a lot of phase noise: the VCO trimmers need replacement
- The radio doesn't receive: maybe someone forgot to connect the small jumper cable on the back of the radio.
- The radio doesn't transmit, or transmits intermittently: cracked solder joint near the antenna connector.
- The radio doesn't power on: broken power switch (bridge it, and use the power supply switch).
- The radio transmits 50W: either the internal 50W/100W switch is set to 50W, or one of the PA transistors is broken (this doesn't prohibit one from making this modification, but you will just have less power)

- Lamps not working: replace with LED+resistor

There is a lot of information available how to deal with these problems. It is good to subscribe to the IC735 yahoo group: <https://groups.yahoo.com/group/IC-735> . Members have access to a lot of documentation in the files section. One should also look at <http://mods.dk> (available only to subscribers), and <http://www.hampedia.net/icom/ic-735.php> .

If you just bought the radio, try to use it for a while on the ham bands, to get a feel of it, and spot additional problems.

Modifying the radio

The radio consists of boards named: MAIN UNIT, PLL UNIT, PA UNIT, and various others. We will use the same naming convention here, to be consistent with the Icom 735 Service Manual.

Wide-band TX mod

Check if the radio transmits outside of the amateur radio bands. If not, do the wide-band transmit mod (most units I've seen have this done already). This requires removing D33 and D34 on the PLL UNIT. It is the easiest to just cut the diodes leads, without removing them from the board. This way the mod can be easily reversed by soldering the cut leads. This mod is well documented.

Measure power

Connect a dummy load, and measure the output power every 1MHz from 2MHz to 30MHz, and every 100kHz from 100kHz to 2MHz. Save this data for future reference. The power measurement doesn't have to be precise, as long as it is repeatable. If you don't have 100W output on HF see if the internal 50/100W switch is set correctly.

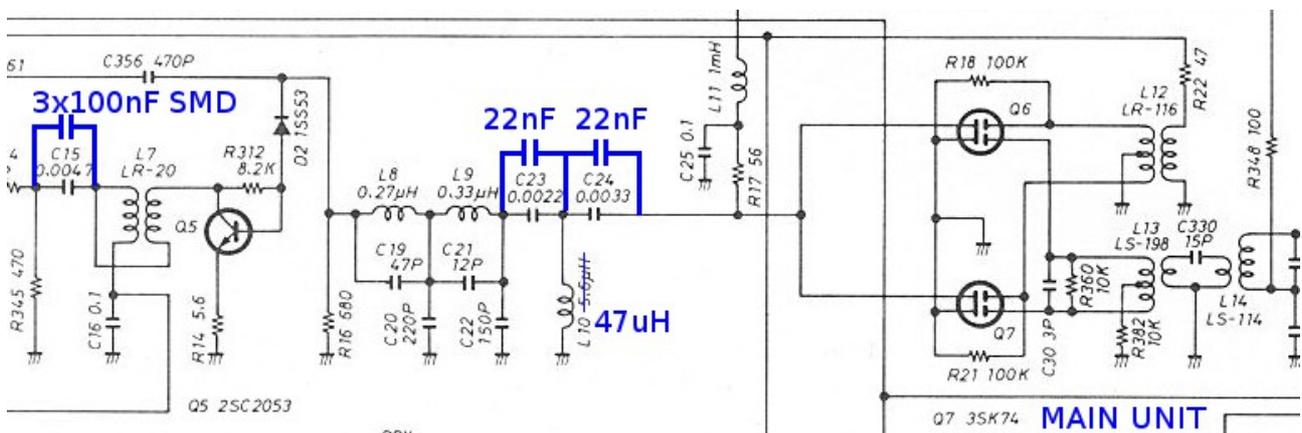
Modify the bandpass filter

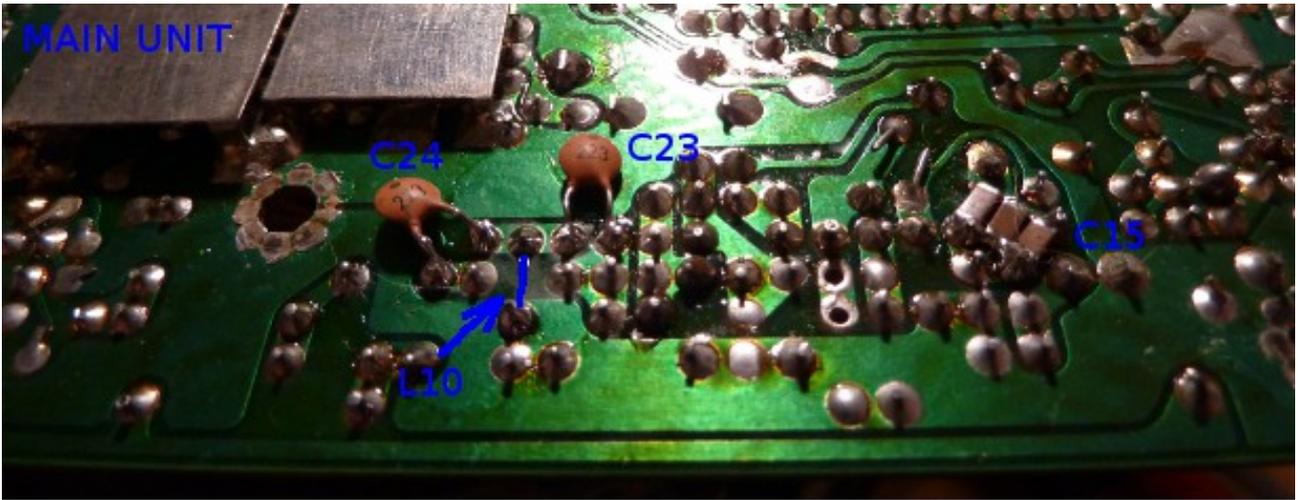
Why not just bypass it? In the DL1FY modification, the bandpass filter after the TX mixer is bypassed by a 220nF capacitor. The filter was designed to stop the unwanted signals (70MHz IF, the 70-100MHz VCO, IF+VCO and various combinations) from getting to the PA stages. These signals will of course be attenuated by low-pass filtering after the PA, and by the fact, that the PA doesn't have much gain at VHF frequencies anyway. However they will degrade the large-signal handling capabilities of the following stages, and some of them will pass to the output and especially to the transverter output. Icom's engineers chose to have the bandpass filter here for a good reason. We want to expand it's range a little on the low frequency side, not completely bypass it.

On the MAIN UNIT:

Solder 22nF capacitors parallel to C23 and C24. Change L10 to 47uH.

Solder 220nF or more parallel to C15 (I used 3x100nF SMD capacitors).

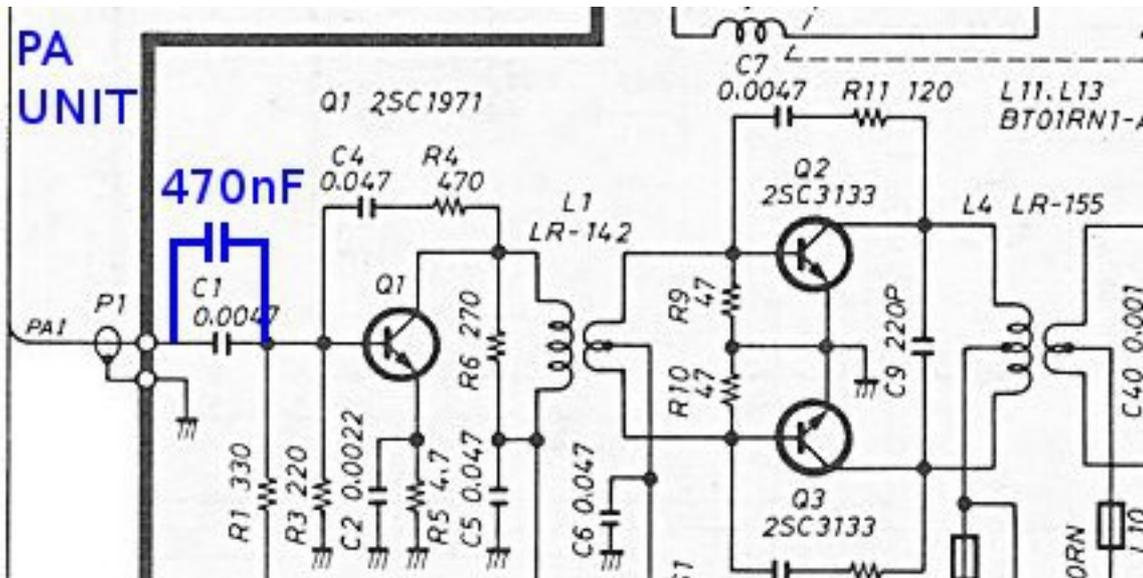




Bandpass filter modification

On the PA UNIT:

Solder 470nF parallel to C1: Bend C1 on the side and carefully scrape the C1 leads, tin them, and solder 470nF to them. This way removing the PA board can be avoided (which is troublesome).



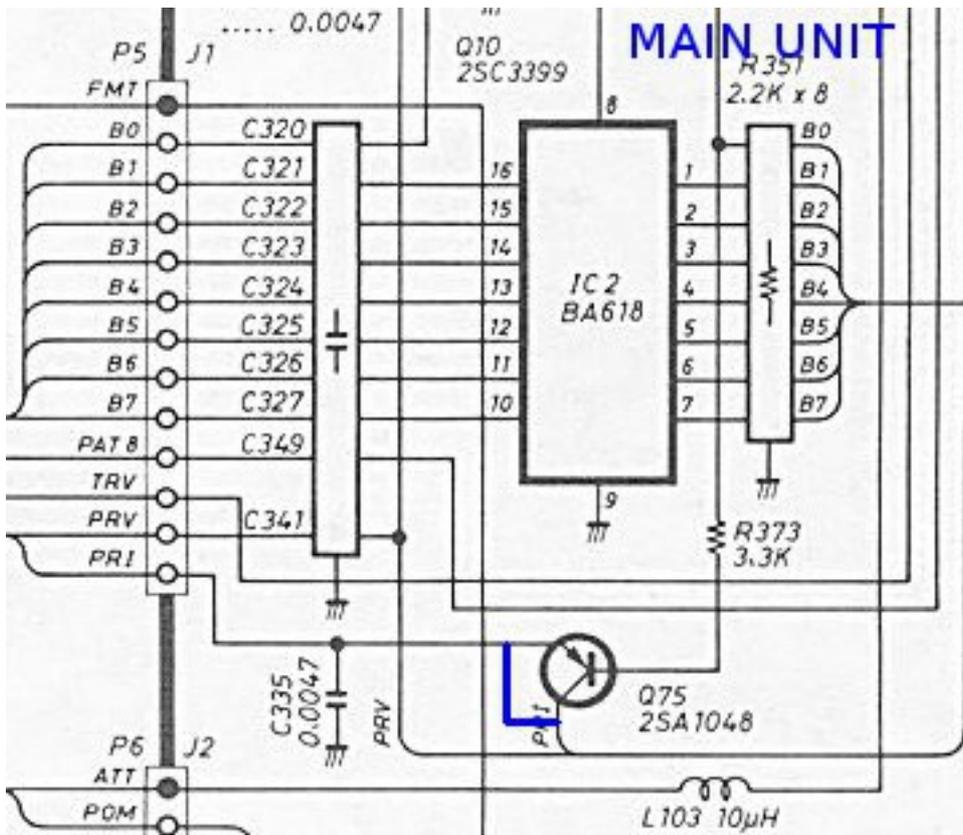


PA board coupling capacitor modification

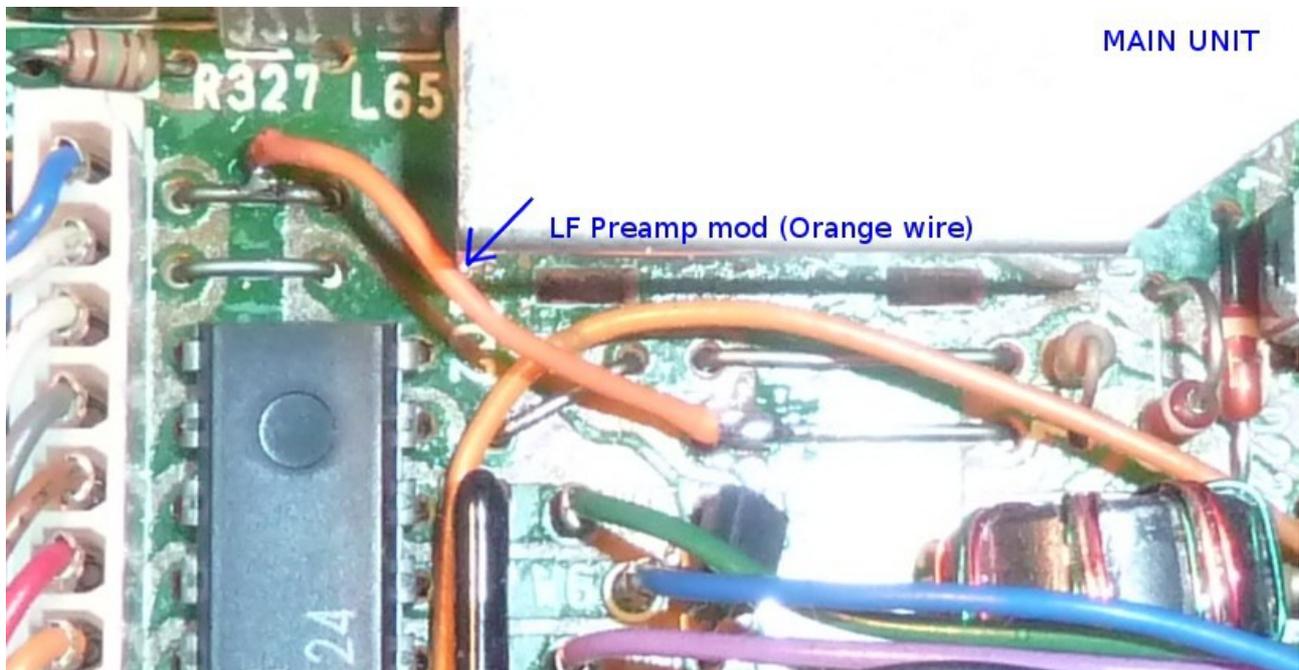
Enable the RX preamp below 1.5MHz

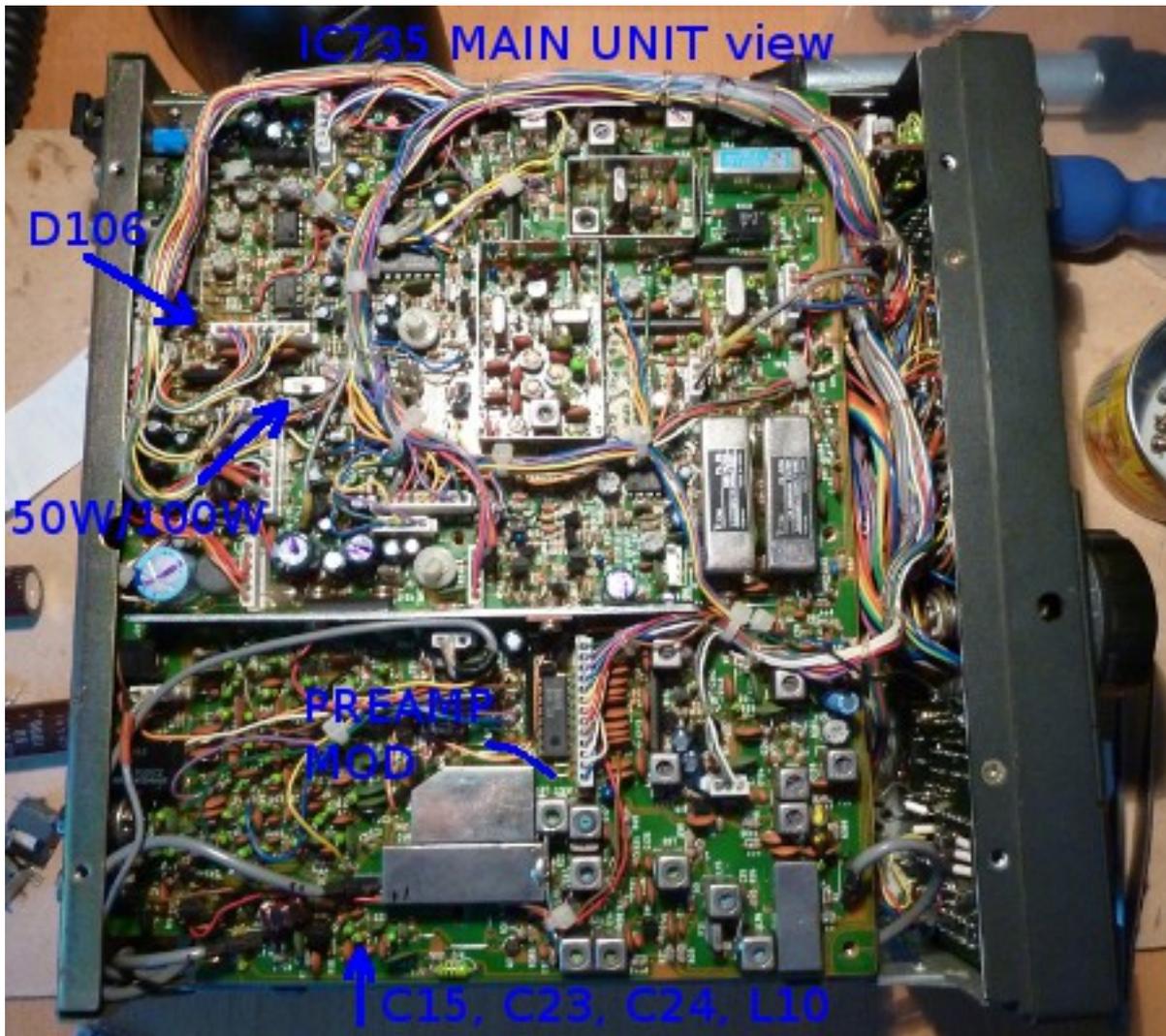
The receive preamplifier is disabled for frequencies below 1.5MHz. This is done, because usually there is no need for a preamplifier, as the signal levels can be very high, and enabling it would only increase the distortion. However for our purposes it is nice to have the option to switch the preamp on again for some more sensitivity, especially if additional RX bandpass filters are used or RX antennas having a low output level.

On the MAIN UNIT: Connect C and E of Q75 together. This can be done from the element side by soldering two jumpers together.



RX Preamp modification





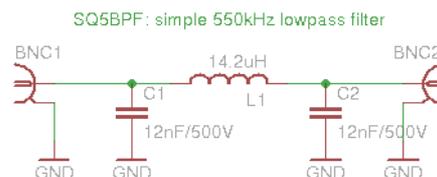
Locations for all modifications on the MAIN UNIT

Measure power again

Connect a dummy load, and measure the output power every 1MHz from 2MHz to 30MHz, and every 100kHz from 100kHz to 2MHz. Save this data for future reference. Compare this with the previous power measurement. You should see that the power starts to drop off at much lower frequencies. At 472kHz you should have about the same power as on 1.8MHz.

Make a simple external low-pass filter

Unfortunately there is no free space inside the radio to incorporate a low-pass filter for the 630m band. Usually the antenna is narrow-band enough not to radiate harmonics (unless you have a full $\frac{1}{4}$ wave for 630m), but at least some low-pass filtering should be attempted. Here is a simple low-pass filter to connect between the antenna and the radio:



L1 - 19 turns with 0.8mm wire on 38mm former

2nd harmonic attenuation: -19dB , 3rd harmonic attenuation: -30dB. Use only good quality capacitors. If possible measure L1 after winding.

Optionally disable the SWR protection circuit

When doing tests you will notice that the power output is lower on 630m with the low-pass filter and dummy load (or antenna) connected, and that the meter shows high SWR. The IC735 measures SWR after the low-pass filters, and since there is no low-pass filter for 475kHz (the 1.8MHz filter is used), it measures match at the desired frequency and its harmonics. The antenna (or dummy load and low-pass filter) is well matched to 475kHz, but it is not well matched to harmonics, so the meter will show high SWR. Also the high SWR protection circuit will kick in and lower the output power.

BEWARE: it is possible to break the PA when transmitting into a mismatched load and this circuit is disabled. Always tune the antenna at low/medium power. On HF if you see high SWR, stop transmitting (on 630m the meter will show high SWR all the time, so there is no such luxury).

There is a simple way of dealing with this by disabling the high SWR protection.

Easy method: Cut D106 lead on the PA board

A bit safer method: Connect 4 silicon diodes in series to D106, to make the circuit very insensitive, but not disable it completely (but the PA is still at risk). It is the easiest to mount the diodes on a small piece of perfboard and mount it on the cut D106 pins.

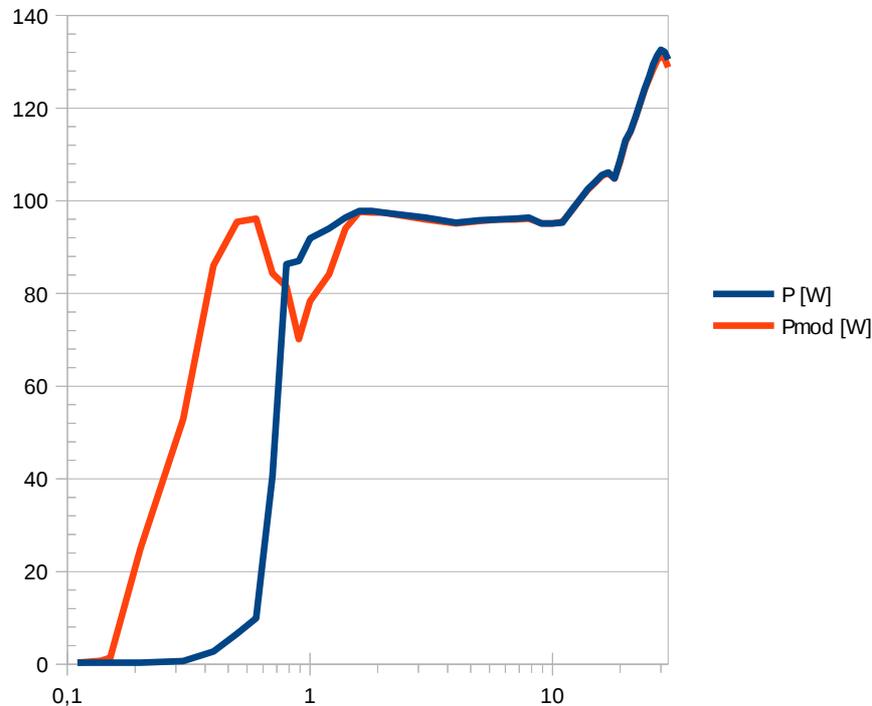


This modification makes the power increase about 2 times, but the drawback is that the PA might be more easily destroyed.

Results:

These are measurements into a 50ohm load, without an additional lowpass filter:

SQ5BPF IC735 mod. Power before/after



Power at 500kHz is about 95W, almost the same as on 1.8MHz (97W).

Additional notes:

Before proceeding, read all the information on the IC735 there is on the Internet. Also practice using it for a week on HF.

When opening the radio for the first time clean it, and look for any modifications which might harm the radio performance.

Install (and get used to) a narrow CW filter. MF is almost useless without narrow filtering.

Use an external keyer. While it is possible to install a keyer inside, there isn't enough switches that one could use for message memory etc.

Watch out when using high duty cycle modes. I've used QRSS3, and the PA can get really hot. Use an external blower to cool the back side of the rig. If necessary lower the power output.

Try some simple bandpass filtering and an external preamp, and see if it makes a difference. The IC735 receiver is not bad on MF, but with the quiet signals on the band it needs all the help it can get. Also try a different receive-only antenna.

The modification is repeatable. Two radios have been modified so far.

These modifications should apply to some other rigs. Do a wide-band TX mod, and check if the power gently lowers, as the frequency is lowered. This would indicate that the firmware doesn't block transmit below some frequency, and that a similar adjustment of filtering is needed.

If you think you need even more power, then don't remove the SWR protection circuit, just build an external PA.

This modification also gives about 5W on 137kHz. Probably more could be obtained by further widening the bandpass filter, but it is still not enough power to use this band. Use an external PA to get the kilowatts you need. Also use a good bandpass filter and preamp on receive.

And of course remember: I give no warranty. If you break something for any reason it's your fault.

And most of all, enjoy the new 630m allocation!
VY 73 DE Jacek / SQ5BPF