

ICOM IC 7300 SDR

ADC ALIASING IMPROVEMENT BY F5LOL

The ICOM IC 7300 SDR radio has a very nice receiver for ham bands, but outside these bands the reception is not 100% reliable; e.g. when tuned between 30 to 36 MHz it is possible receive WFM broadcast signals or between 46 to 50 MHz it is possible to receive PMR Police or Fire brigades transmissions.

This is due to the ADC aliasing phenomena of SDR receivers. The IC 7300 sampling rate is 124.032MHz. When the IC 7300 is tuned at F1 it receives F1 but sometimes F1 and F2 with $F2=124.032-F1$.

The IC 7300 is equipped with good pre-selector filters in ham bands so F2 can't be received. Outside ham bands the pre-selector filters are too wide and strong signals like WFM or PMR relays can be eared.

RF ROUTING

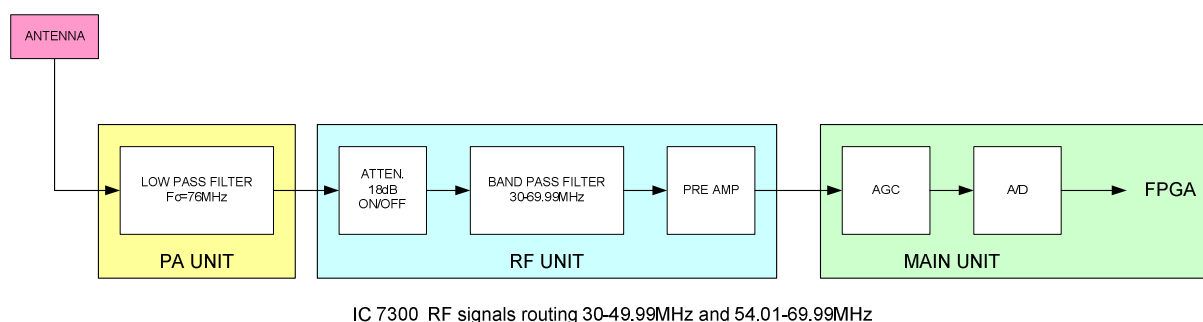


Fig. 1

According ICOM IC 7300 service manual Fig.1 shows the bloc diagram for 30 to 70MHz except for the 50MHz ham band. According this diagram, the signals above 70MHz are blocked by the RF Unit band-pass filter while the signals above 76MHz are also blocked by this filter and the PA unit low-pass filter.

But the reality is a little bit different: the 2 filters begin their attenuation above 95MHz as describe below.

According the aliasing rule explained hereabove: $124 - 30 = 94\text{MHz}$ and $124 - 36 = 88\text{MHz}$: the WFM band 88 to 94MHz can be received between 30 and 36MHz. It is easy to verify with the antenna connected.

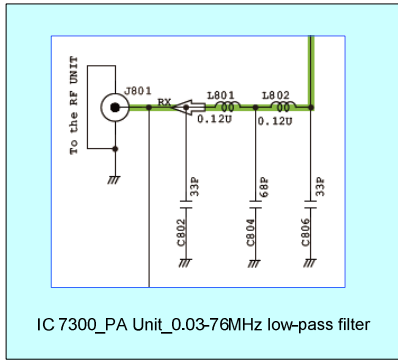
Idem: $124 - 78 = 36\text{MHz}$: PMR networks can be received but all are false receptions!

PA UNIT RX LOW PASS FILTER

The filter is calculated with RFSim99 software using the values of the Service Manual. We can see that the filter begins to cut above 94MHz while we read in the service manual: $F_c = 76\text{MHz}$.

Fig.2: the filter is measured with the spectrum analyzer in transmission mode between the antenna connector and J801 on the RF Unit.

According the measurement the attenuation at 94MHz is only 2dB!



Schematic

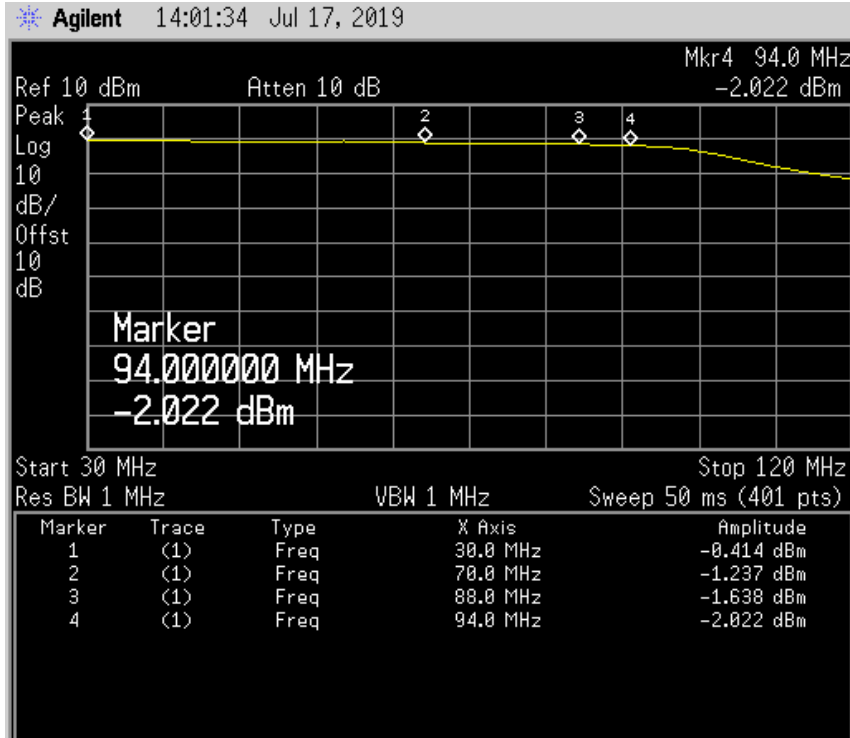
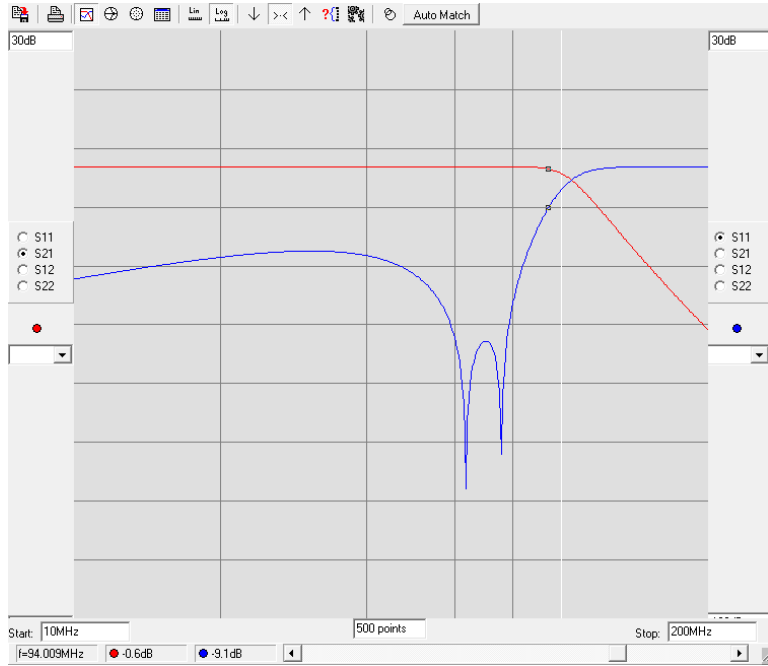
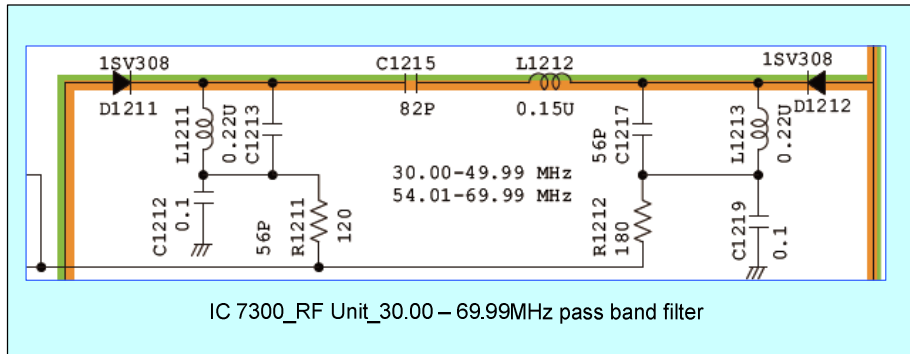


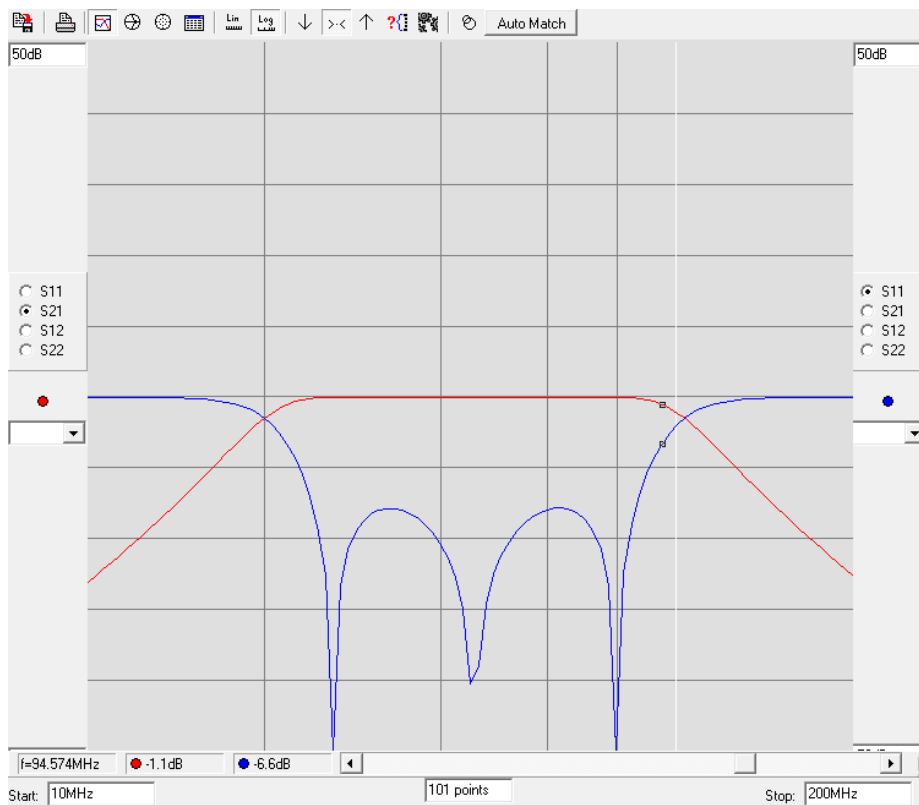
Fig. 2 Antenna to J801

RF UNIT BAND PASS FILTER

The filter is calculated with RFSim99 software using the values of the Service Manual. We can see that the filter begins to cut above 94MHz while we read in the service manual 30 to 69.99MHz.



Schematic



Band pass according the component values

IC 7300 PRESELECTION FILTERS DIAGRAM

Fig.3 below shows the pre-selector filters chain of the IC 7300:

On the top it is the filters according the specifications. Below it is the filters according the actual design theoretical and measured.

This explains why the band 74 to 94MHz can be received between 30 and 50MHz with few attenuation.

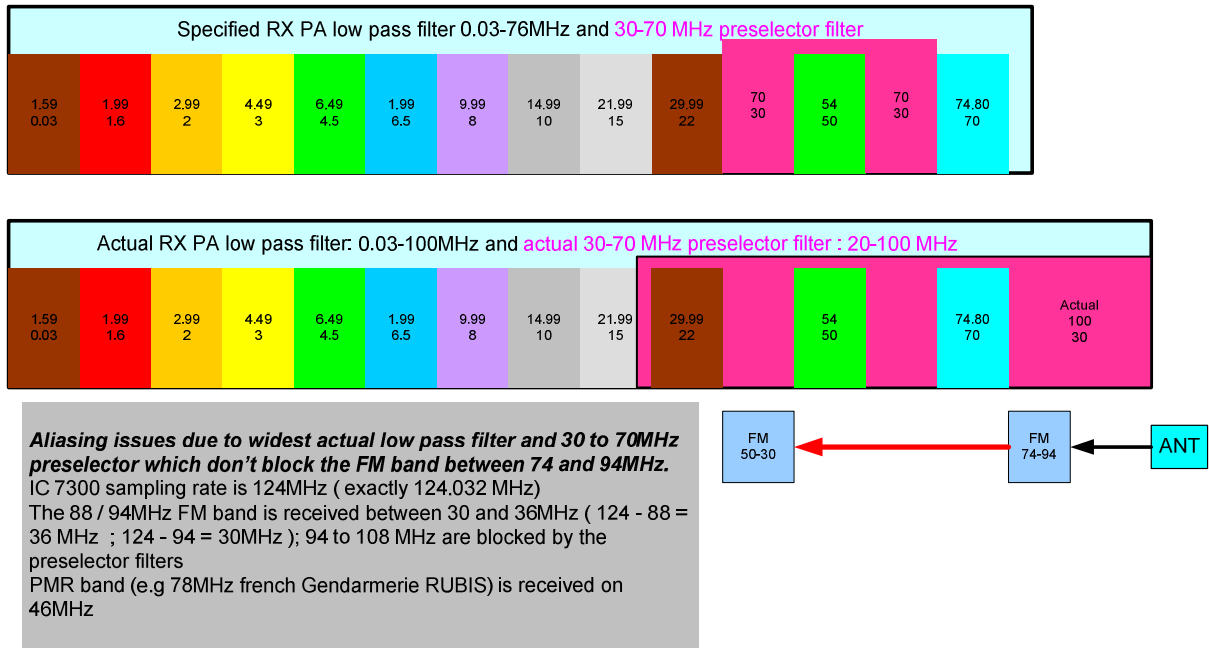


Fig. 3

F5LOL FILTER IMPROVEMENT

It is impossible to reduce easily the band of the RF Unit band pass filter. But it is easy, (on the paper!) to modify the low pass filter of the PA because the printed circuit is already equipped with free pads allowing the modification.

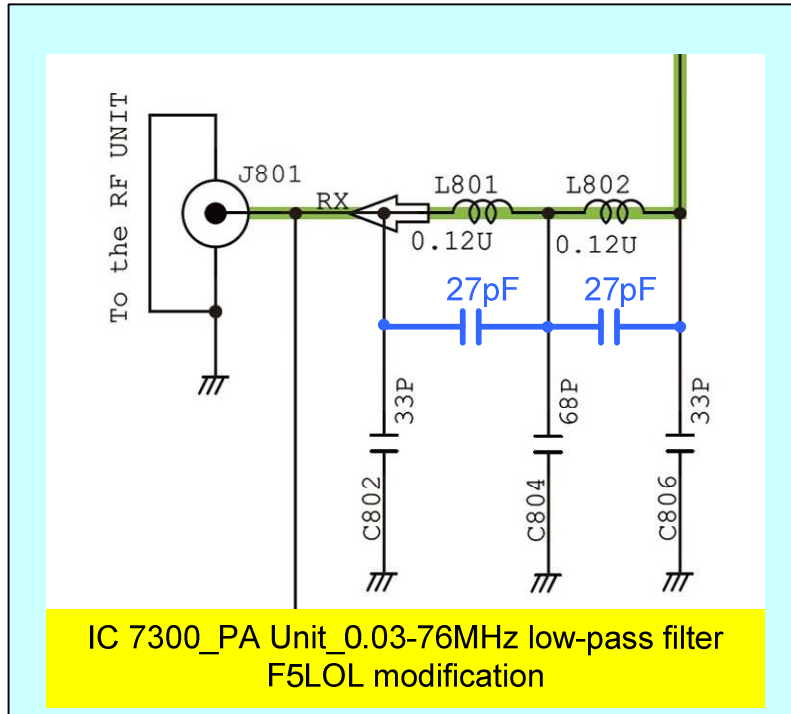


Fig. 4

THEORETICAL ANALYSIS OF THE MODIFICATION

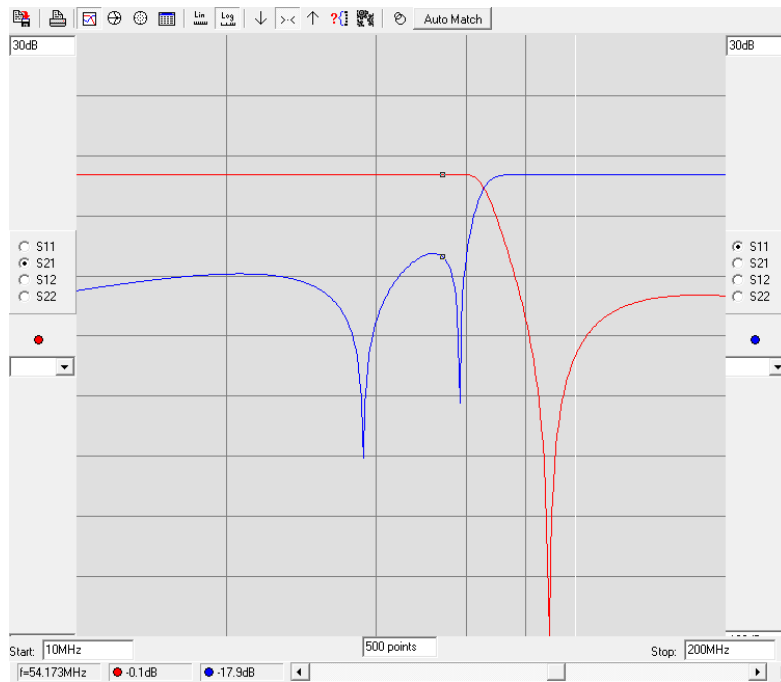


Fig.5 Modified LP filter: -0.1dB at 54MHz

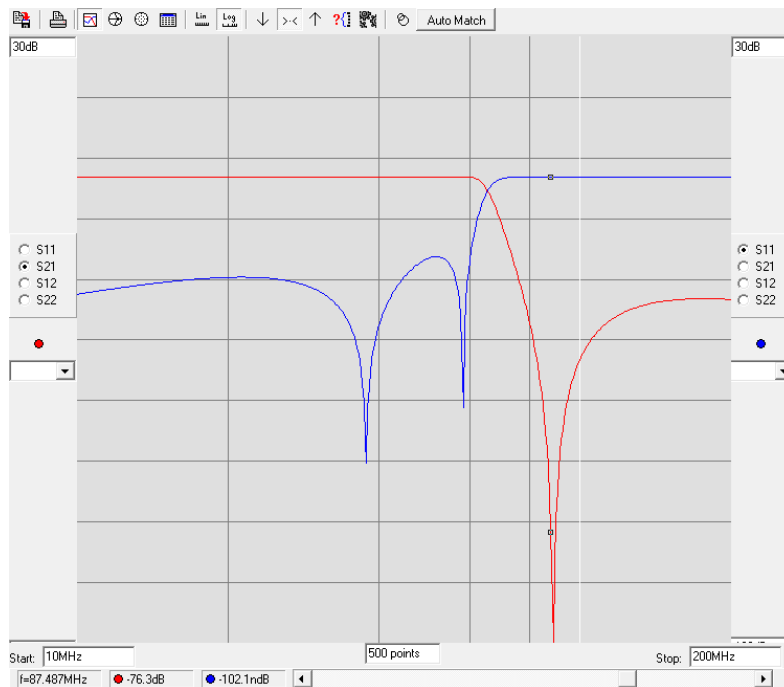


Fig. 6 Modified LP filter: -76dB at 88 MHz

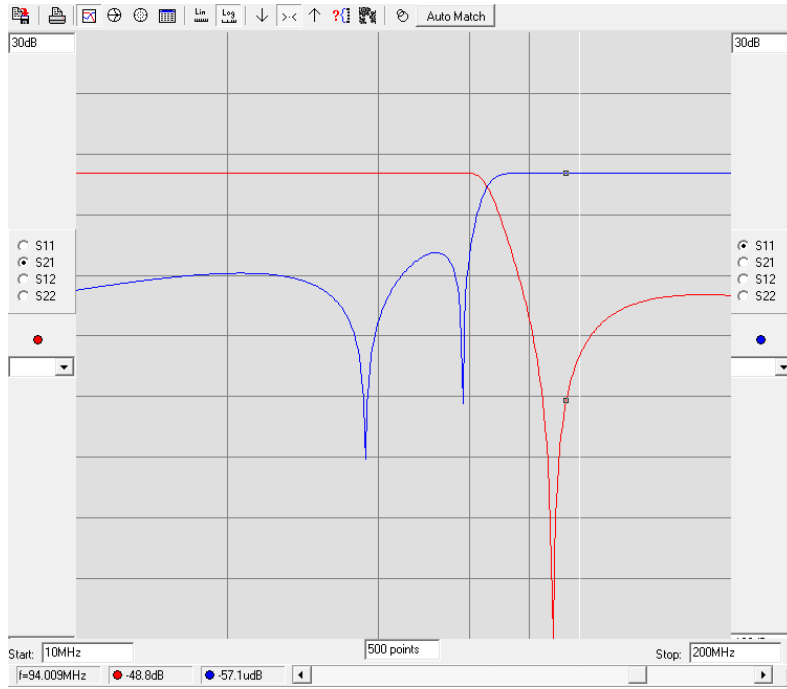


Fig. 7 Modified LP filter: -48dB at 94 MHz

REALISATION

Fig. 8 shows the two 27pF capacitors on the free pads in parallel with L801 and L802.

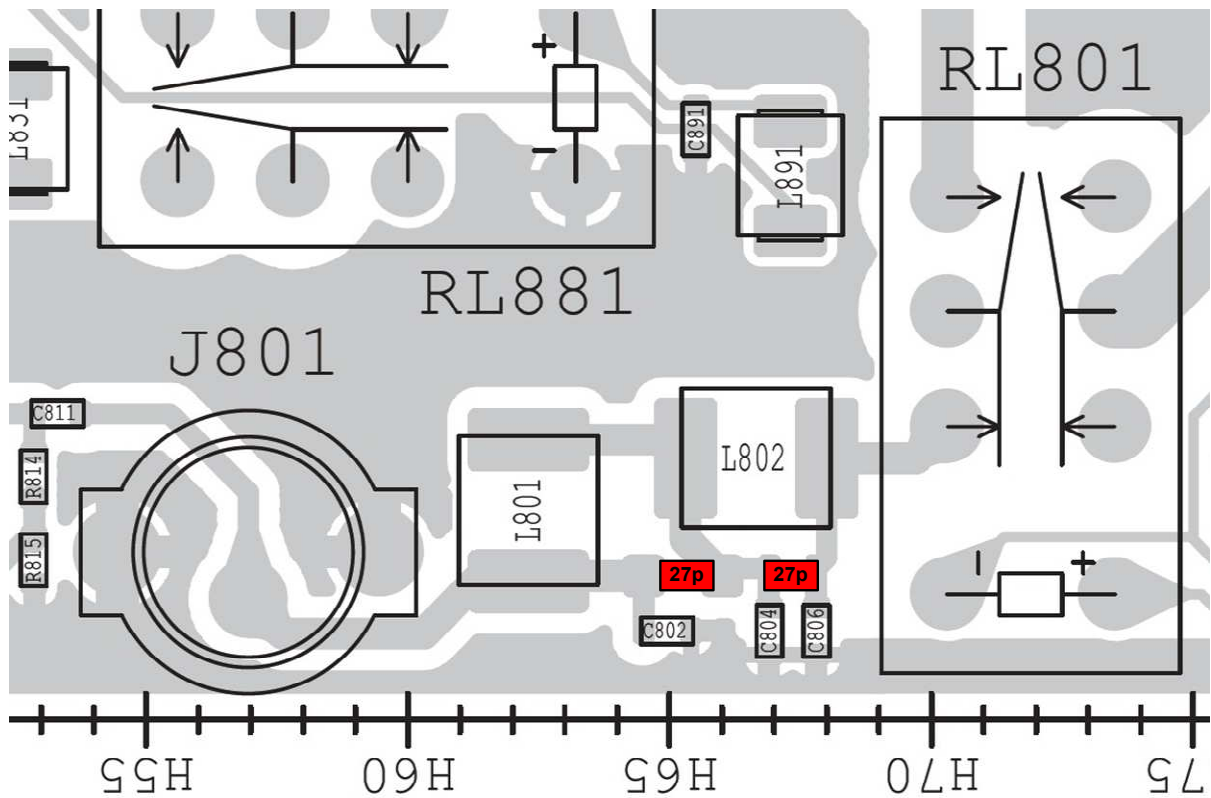
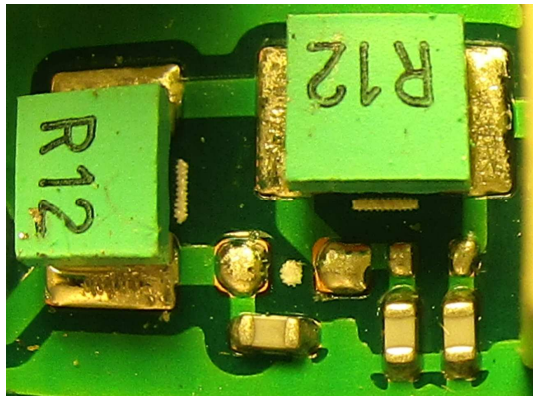
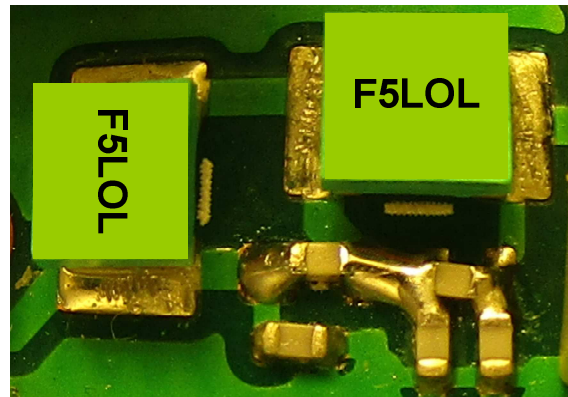


Fig. 8



Before modification



After modification

The capacitors are KEMET 24pF,25V,5%, COG/NP0, 0402 (size = 1mm). During soldering, RL801 must be protected against burning with a small metallic shield. The capacitors are very small and need very accurate soldering.

MEASUREMENTS AFTER MODIFICATION

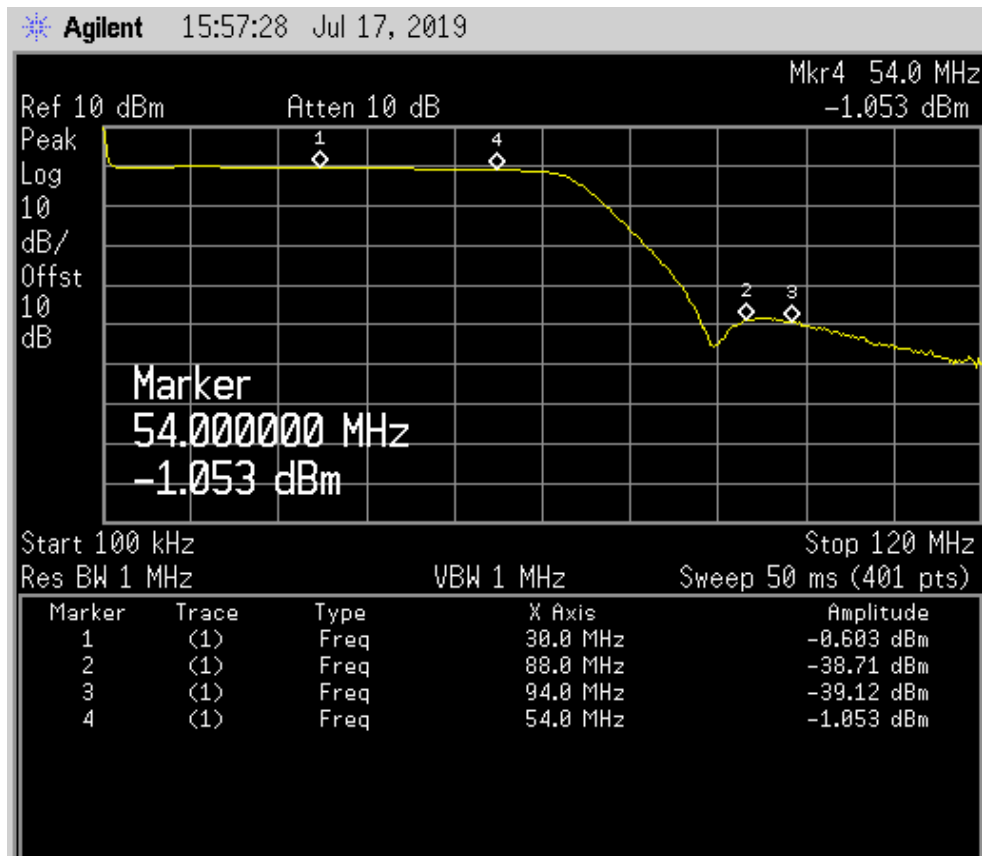


Fig. 9

The attenuation is not so deep than the theoretical study but we obtain about -39dB of attenuation for the WFM band 88 to 94MHz. With this modification the 70MHz band can't be used.

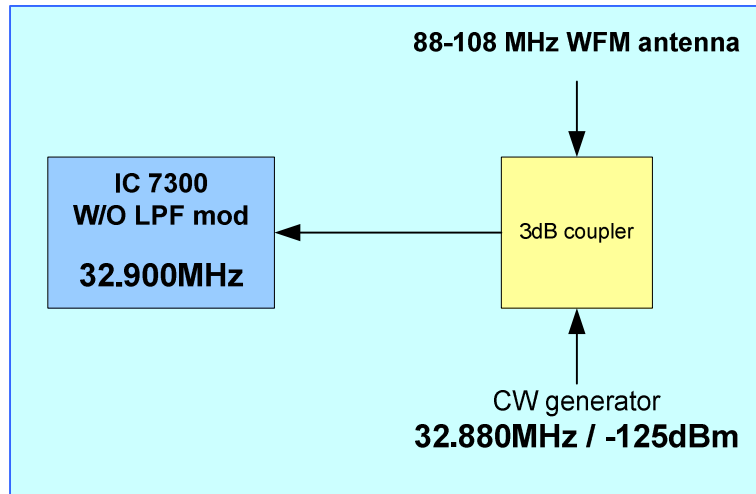


Fig. 10

Fig. 10 shows the bench used to test the modification against the WFM band. The purpose is to measure a 32.880MHz signal at -125dBm mixed with the signals of the broadcast WFM antenna. The output of the splitter is connected first to J1071 on the RF Unit (without LP filter) and after it is connected to the antenna input with the modified LP filter connected to J1071. The preamplifier is set to "P.AMP2"

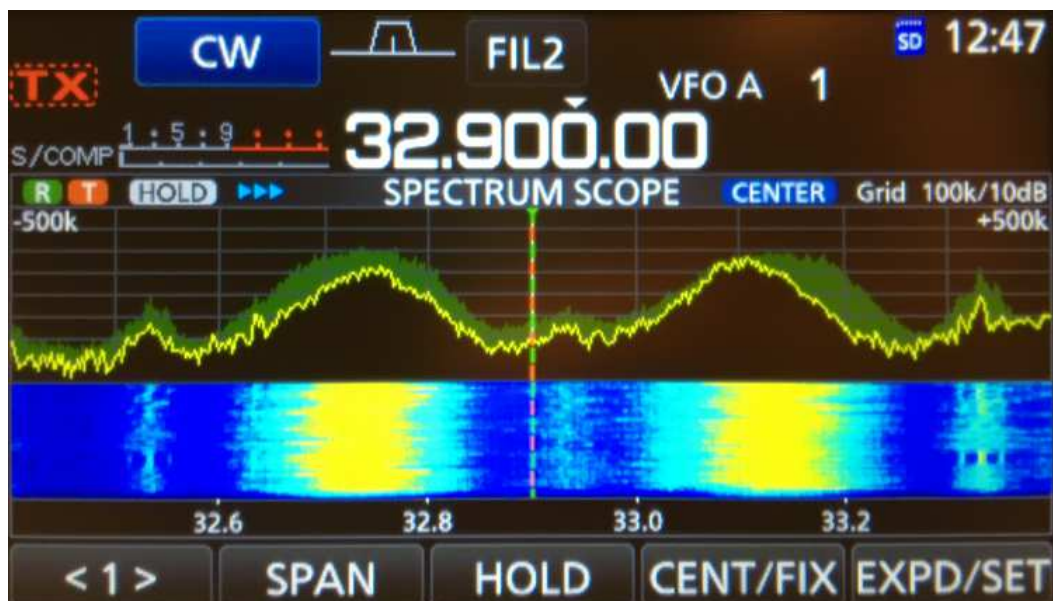


Fig. 11: before modification

Fig. 11 shows the aliasing effect around $124 - 32.9 = 91.1\text{MHz} \pm 0.5\text{MHz}$. The signal at 32.880MHz is in the noise.

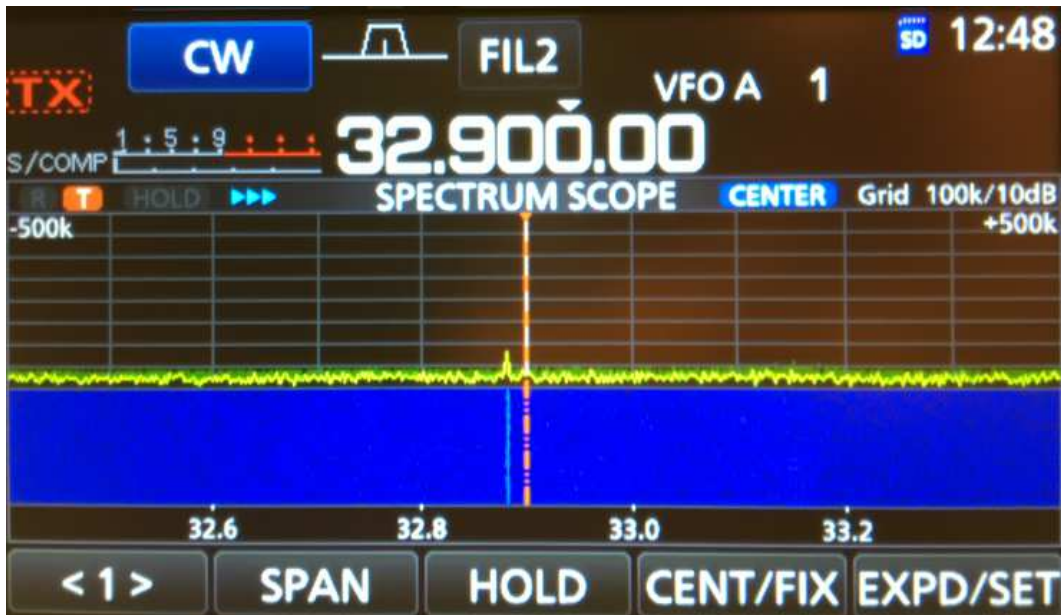


Fig. 12: after modification

Fig. 12 shows the same input with the LP filter modified inserted. The WFM signals and the noise of the FM band are removed and we see the signal at 32.880MHz / -125dBm.

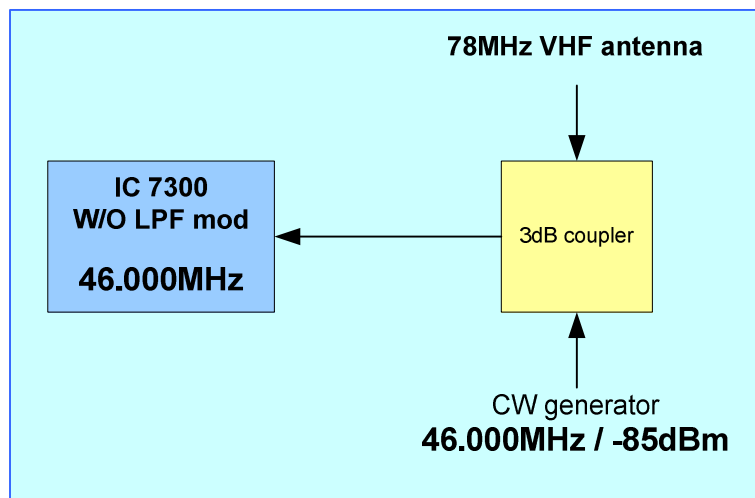


Fig. 13

Fig. 13 shows the bench used to test the modification against the PMR band. The purpose is to measure a 46.000MHz signal at -85dBm mixed with the signals of the VHF 78MHz PMR antenna

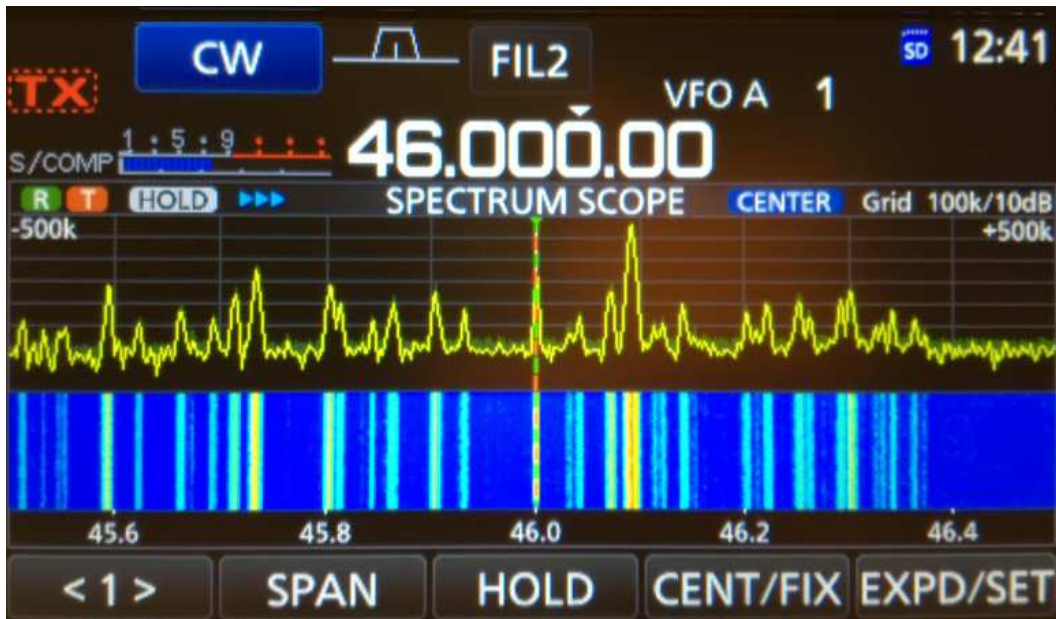


Fig. 14

Fig. 14 shows the aliasing effect around $124-46 = 78\text{MHz} \pm 0.5\text{MHz}$ and the signal at 46.000MHz.

The VHF PMR signals (here it is mainly French Gendarmerie digital communications) are received on 46MHz!

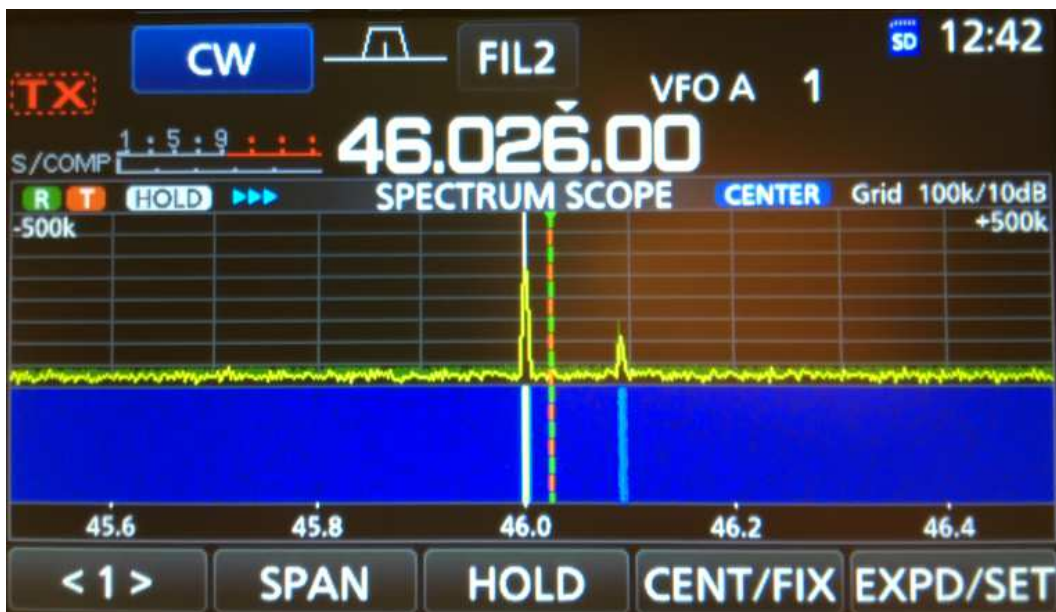


Fig. 15

Fig. 15 shows the same input with the LP filter modified inserted. The PMR signals and the noise of the VHF band are removed but the signal at 46.000MHz / -85dBm remains.

CONCLUSIONS

The modification of the LP filter located on the PA Unit is effective and reduced drastically the strong FM signals in the 88/94MHz band and also the strong PMR stations in the 74/80MHz band.

According the service manual, the ICOM design of the LP filter should cut at 76MHz, but the components values and the tests show that the filters begin their attenuation at 95/100MHz allowing aliasing exactly in the receiving band.

To avoid the aliasing, one solution is to use an external 100W tunable pre-selector connected before the antenna output or a low power tunable pre-selector connected between the PA and RF Units.

The modification proposed by F5LOL is technically better, the only issue is the removing of the 70MHz RX band.

The price for the capacitors is only few cents but the soldering is not easy to do.

I hope that the next evolution of the IC 7300 will include a better design of the LP and BP filters removing the aliasing effects leading to a true continuous coverage HF/VHF SDR receiver.