HF converter for FunCube Dongle test report and improvement solutions

Many users of the kit of the HF converter for the *FunCubeDongle* complain on poor receiving quality.
The receiver shows a full spectrum of spikes and strong signals as broadcast stations saturate the FCD receiver.
Reducing the gain of the FCD enhances a little the performance, but the sensitivity is very poor compared to a classical HF receiver.
It was shown a high level of local oscillator at output and filters not well matched to the mixer.

This report concerns test of HF converter for FunCube Dongle sold in kit version by several suppliers :

- CT1FFU: http://www.ct1ffu.com/site/ then “KITS”
  http://www.ct1ffu.com/site/index.php?option=com_content&view=article&id=178&Itemid=104

- WIMO: http://www.antenne.wimo.de/cgi-bin/verteiler.pl?url=funcube-sdr-dongle-recepteur_f.html

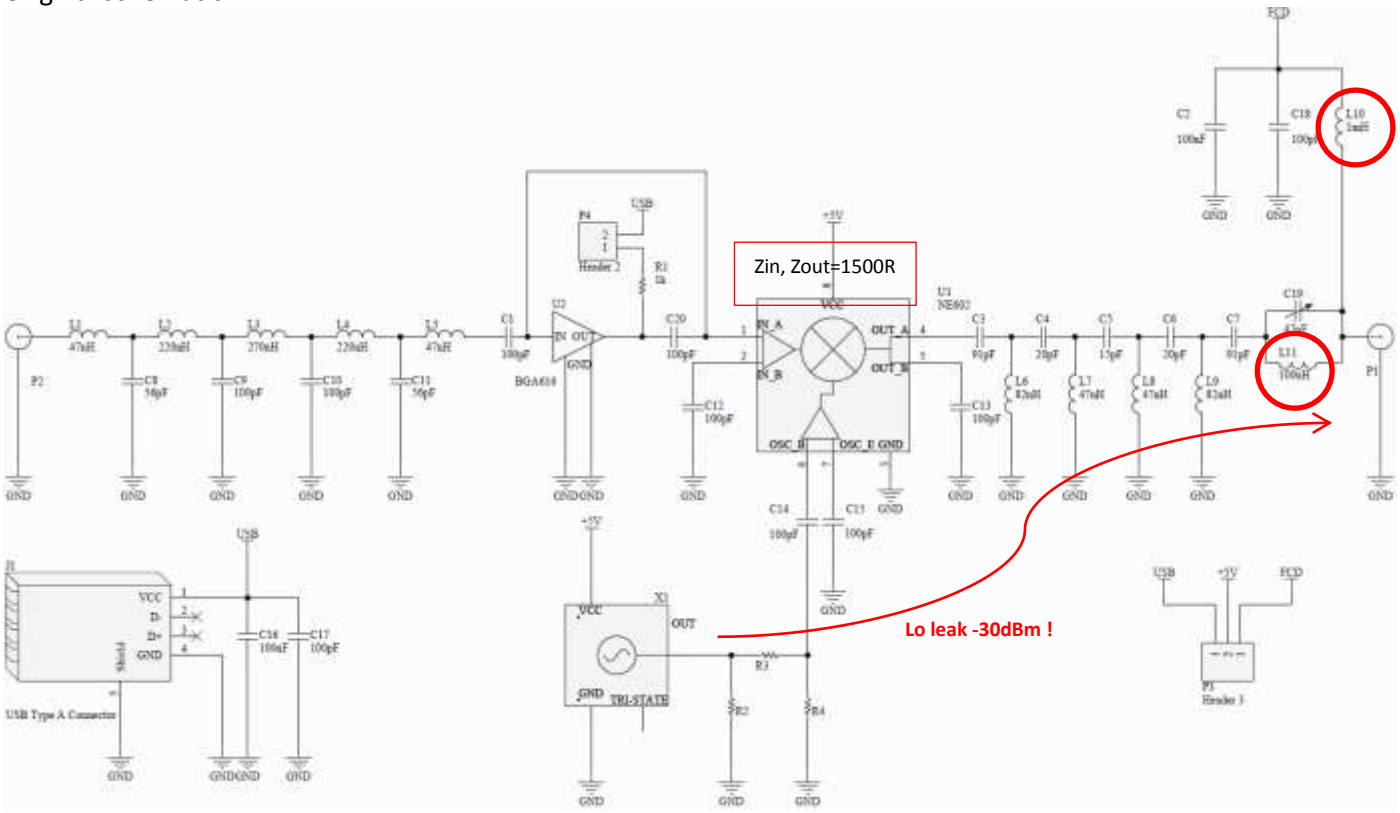
(pictures of the converter taken from CT1FFU website)

F6BZG gave me this converter for tests because **he got poor receiving conditions with FCD receivers.** He was very disappointed by results compare to FCD on VHF and UHF bands.

When antenna is connected all FCD **spectrum is covered by spikes** even with LNA gain at 0 dB on FCD input.
The converter works better with tuned loop antenna and with 10 to 20 dB attenuation at FCD receiver input (remote supply not possible in that case). We tried with separated supply in case of noise in coming from USB port, but no better results !

This converter is very poor in performances and not suitable for 30 and 50 MHz band due to poor sensitivity.

Original schematic :

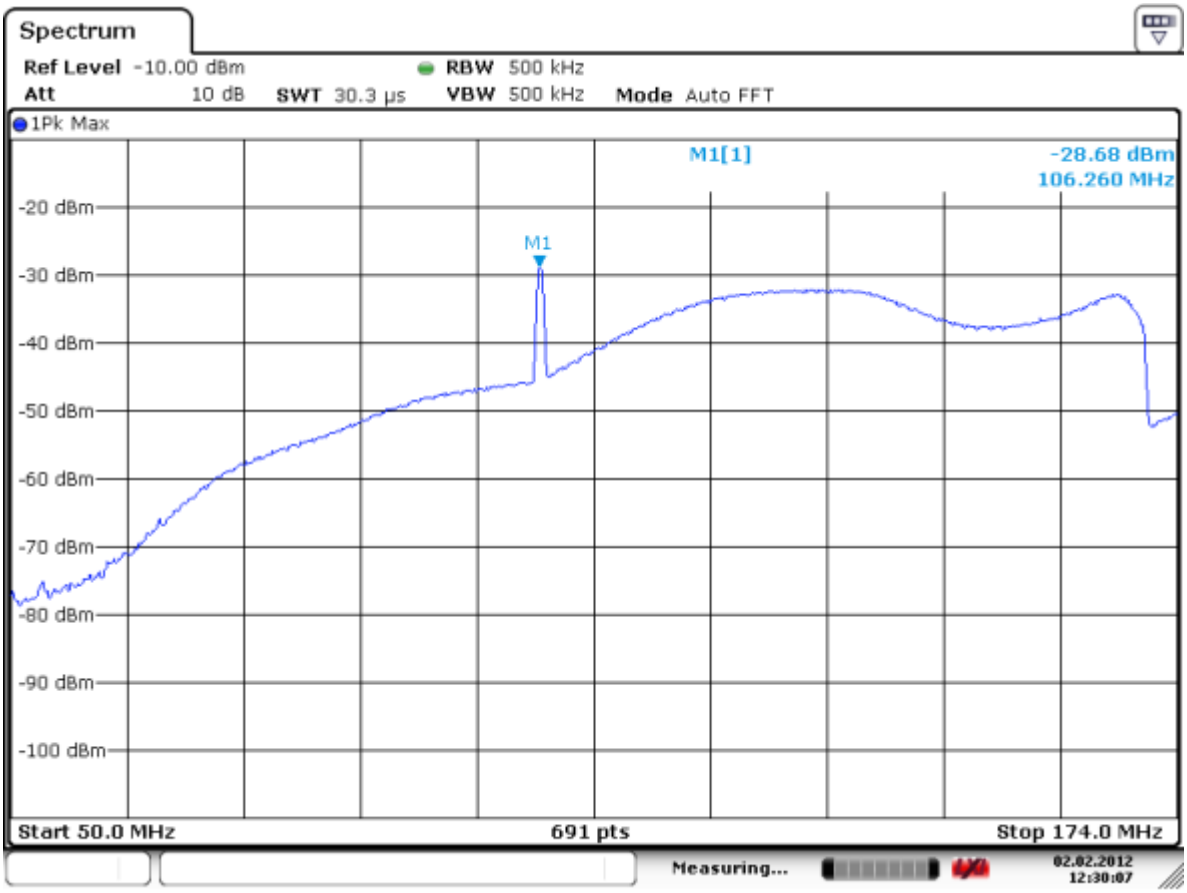


The LNA is not mounted and not necessary on HF band.

Schematic expertise gave impression of a circuit constructed with simulated block but never completely measured, neither totally checked !

- Input filter designed under 50 Ohms not matched to NE602 input (Zin 1500 Ohms).
- Output filter designed under 50 Ohms not matched to NE602 output (Zin 1500 Ohms).
- FM band notch C19 // L11 not efficient ! calculated resonant frequency 100µH (low Q ferrite inductor) with 25 pF is about 3.2 MHz ! May be a calculation mistake, inductor should be 100 nH !
- Local oscillator (HCMOS) and NE602 LO input are not 50 Ohms !
- Poor supply decoupling from USB !
- L10 at 1 mH is more capacitive than inductive from 106 to 136 MHz ! It should be 1 µH !
- C1 and C12 are too low value and limits frequencies under 20 MHz as high pass filter ! better with 1 nF.

We measured a strong LO leak of -30 dBm at output.
This will block FCD receiver and saturate its LNA, even with 0dB gain configuration !



The spectrum here at converter output in max hold mode, with a swept signal of -30 dBm at converter input.

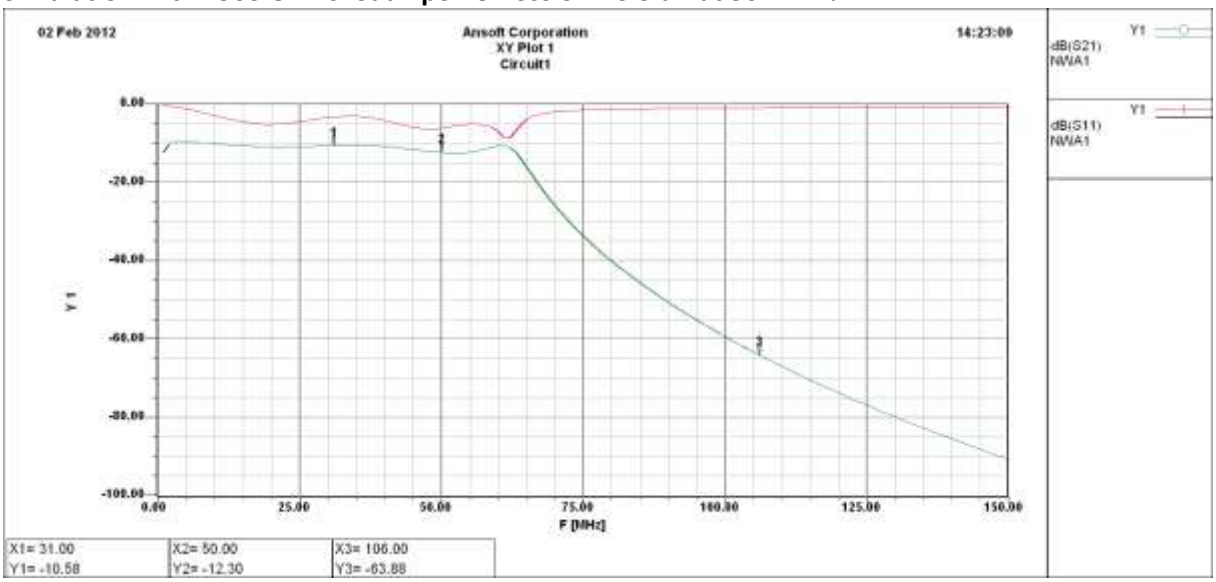
- LO leak : -30dBm

- Conversion gain is not flat and results of a loss from -2 to -10 dB
  Conversion loss related to -30 dBm at input

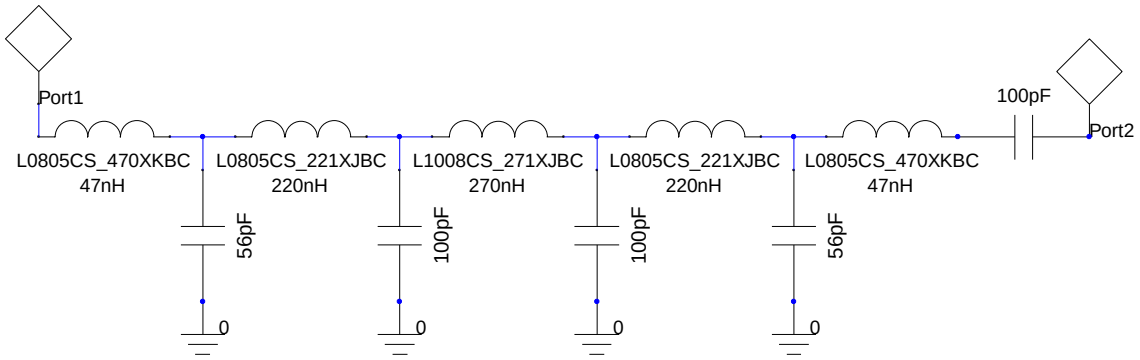
Poor gain for freq < 10 MHz

Let’s go deeper in analysis !

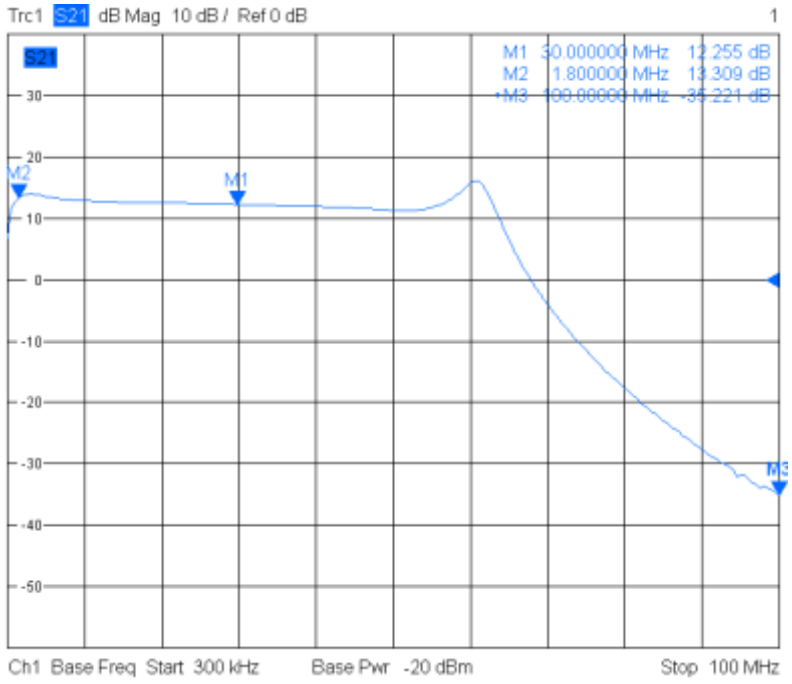
Input filter simulation : Input filter designed under 50 Ohms, not matched to NE602 input (Zin 1500 Ohms).
Simulation with 1500 Ohms load : power loss of -10.5 dB at 30 MHz !



Schematic of simulated filter :



Measurement :



Network analyzer measurement .

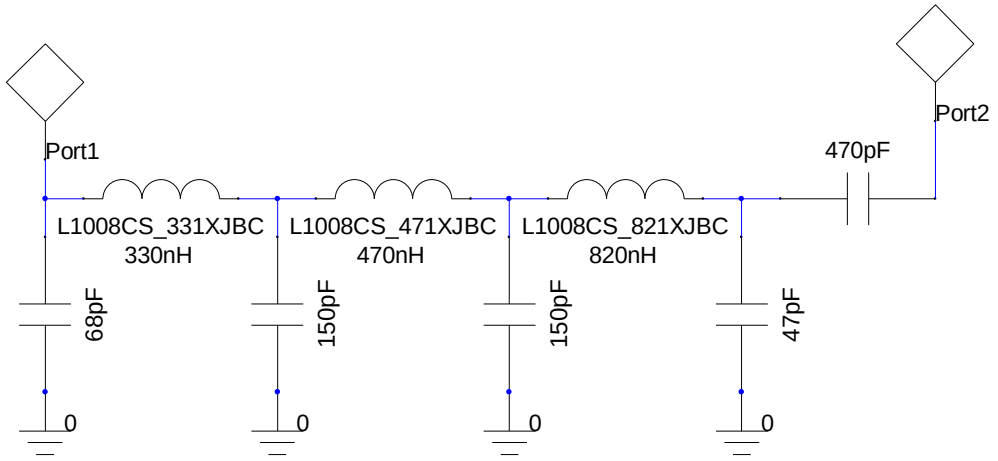
- Input at 50 Ohms
- Ouput measured with HiZ probe at NE602 input

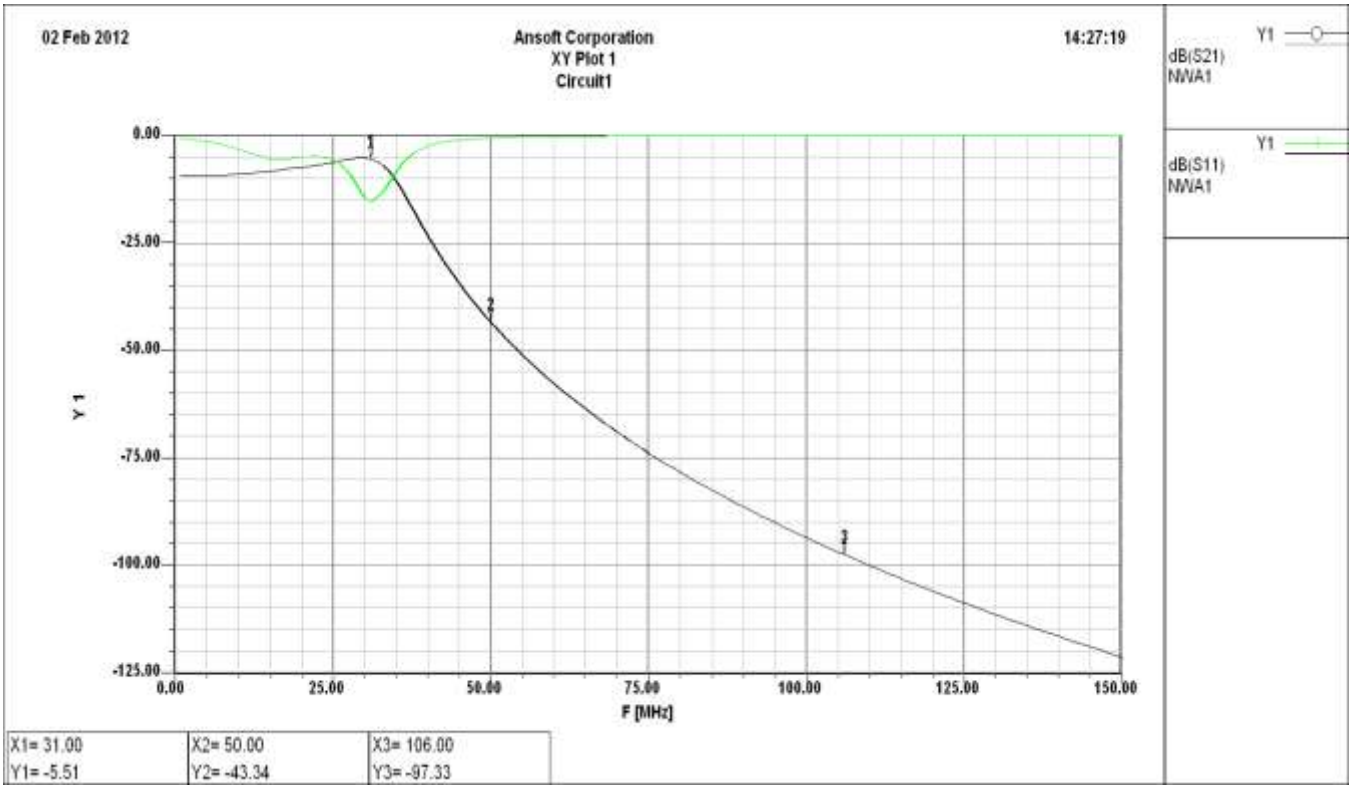
12 dB loss at 30 MHz (M1)

INPUT FILTER :

Input filter introduce more than 10 dB loss. It is not possible to match 50 Ohms antenna input to 1500 Ohms of the mixer over a wideband from 2 to 50 MHz.

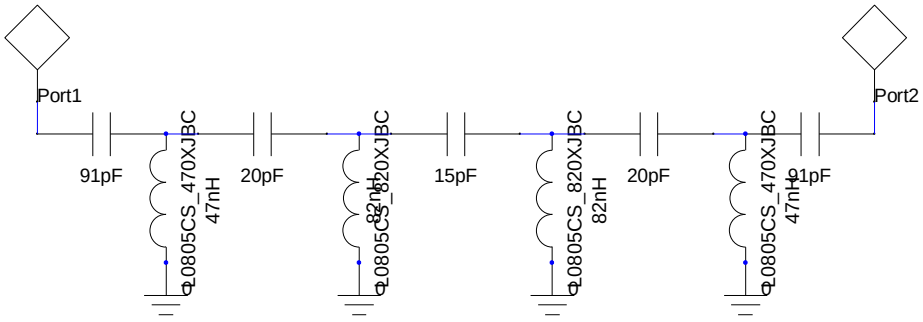
A compromise of low pass transformation filter can be found to get about -5 dB loss at 30 MHz and -10 dB at 2 MHz.
Better give up 50 MHz band due to poor gain and noise figure of this mixer !
Here below, a proposal of a better filter with only 3 inductors !

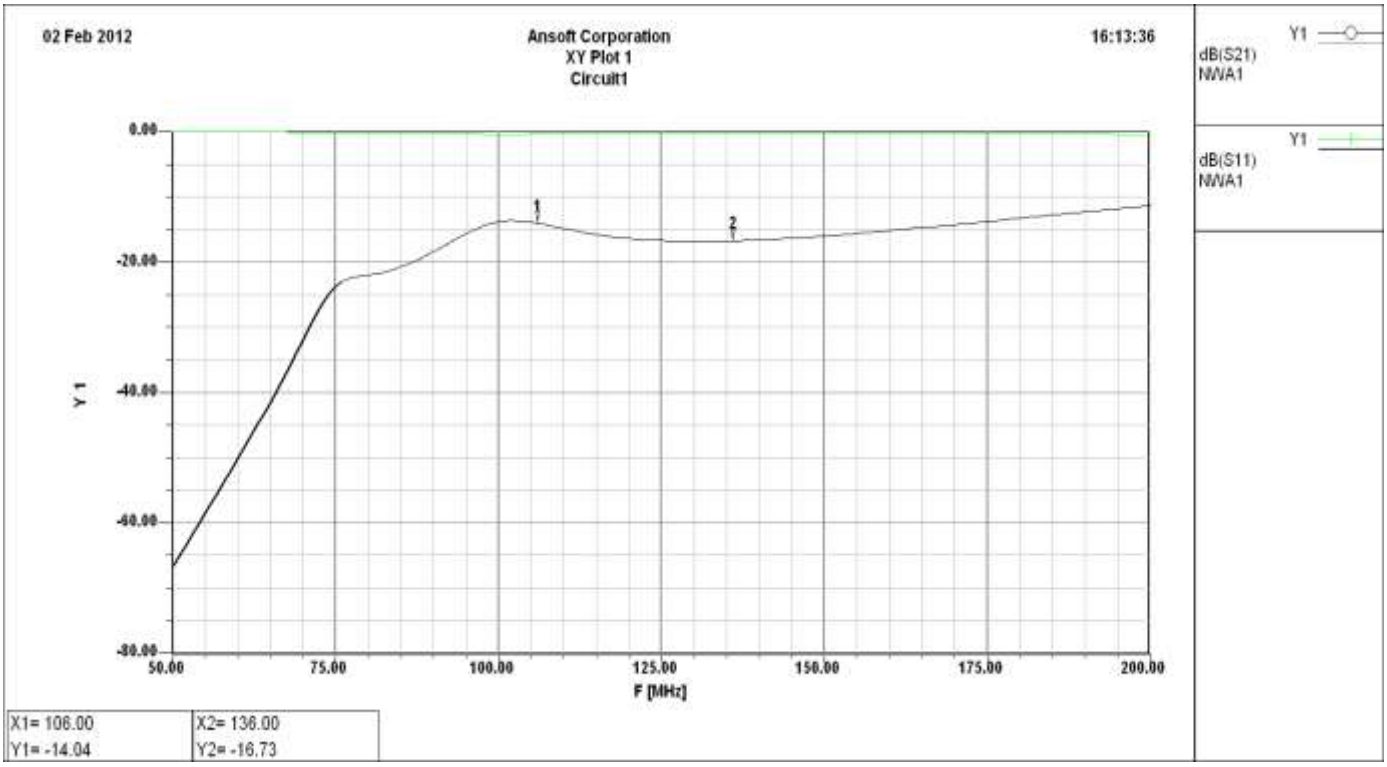




OUTPUT FILTER :

Same situation with output filter !
It introduces more than 16 dB loss at 136 MHz!
It is not possible to match 1500 Ohms mixer to 50 Ohms output over a wideband!





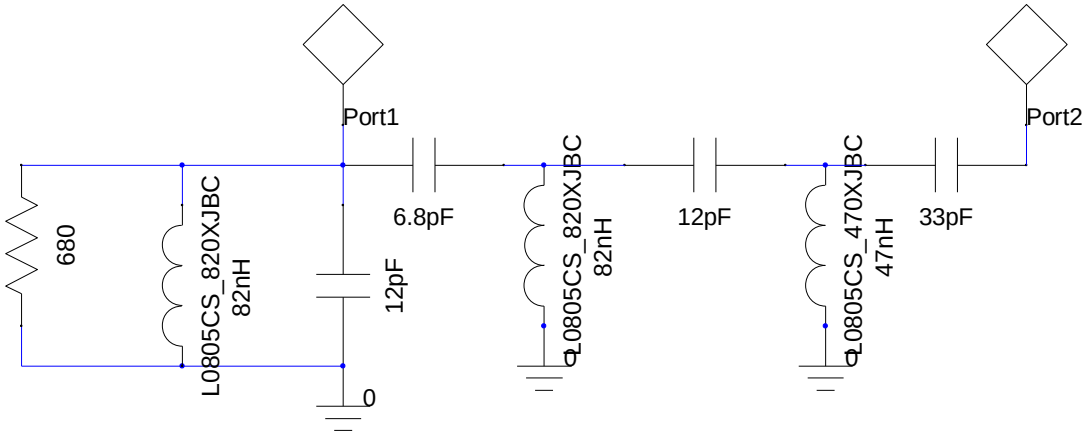
Simulation results for 1500 Ohms source impedance at input and 50 Ohms at output

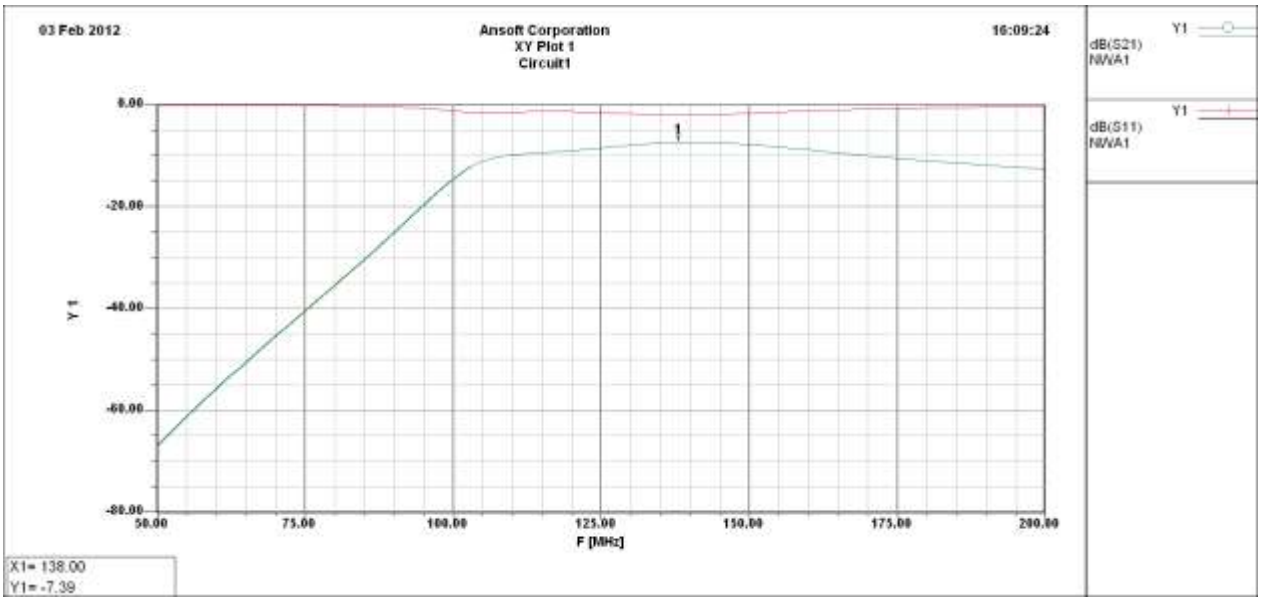
Here a simulation with a filter based only on 3 inductors :

- Better performances at 136 MHz (Rx = 30 MHz band)
- Better attenuation under 106 MHz.

Note :

- C3 = 100 pF is connected from mixer to port 1 of filter
- Port 2 goes to FCD input





OSCILLATOR matching :

It is not necessary to overdrive the mixer and have a heavy load by attenuator.
Attenuator values are changed as follow:
R2 not mounted !
R3 = 150R
R4 = 33R

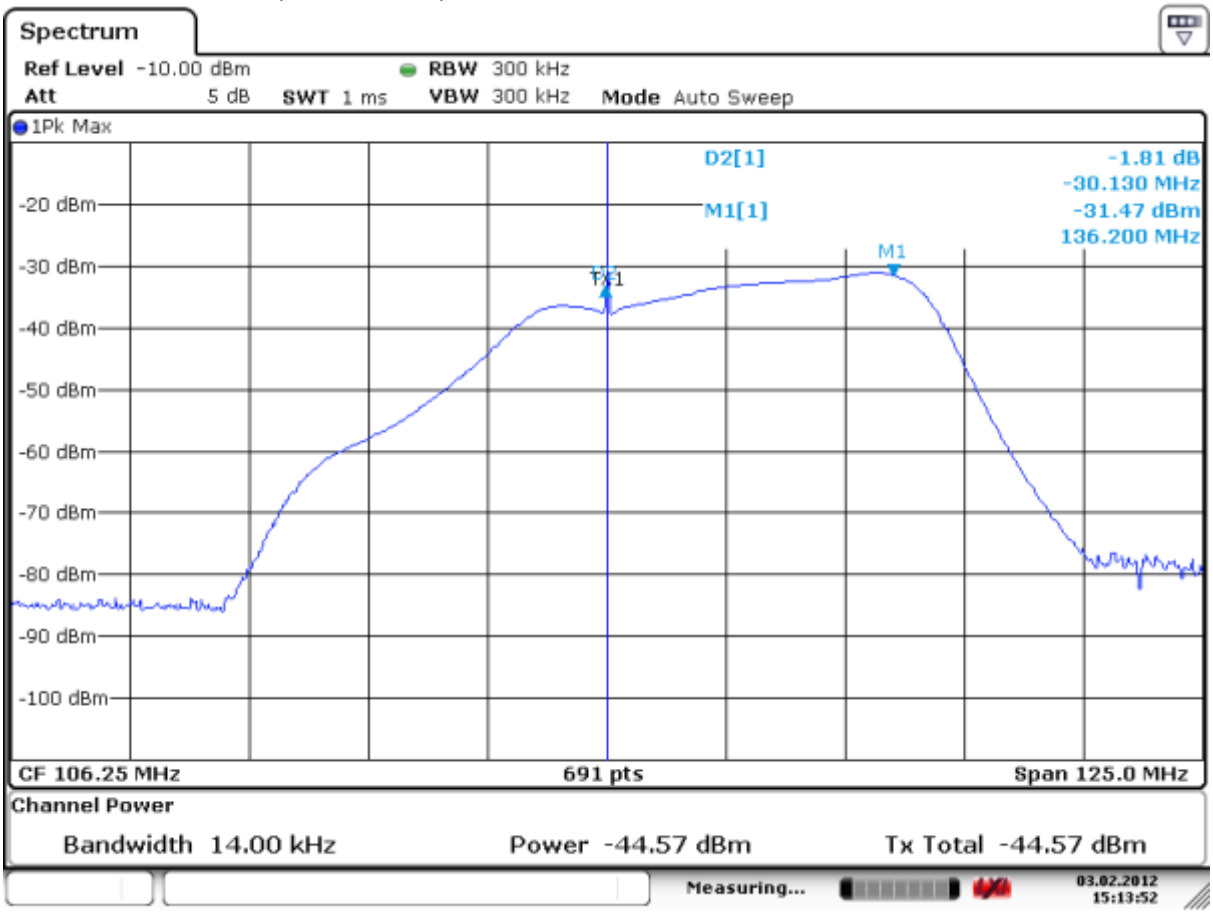
LO leak at output is now -35 dBm
Conversion gain -10 to -2 dB

L10 (1mH) replaced by 100µH (L11) for DC from FCD.
C3 = 100pF

Oscillator notch : to improve LO leak, but layout is so bad that oscillator is radiating all over the board !
The layout and the schematic need to be completely revised.
L11 : 2 turns of 0.5 mm silver wire on 4 mm diameter strap, adjust spacing to tune to 106 MHz
C19 : 100pF SMD 1206

Final results :

- Gain -8 to -1.5 dB.
- Flat response; higher gain at 28 MHz rather than 7 MHz.
- Lower LO level at output.
- Measured compression at input -23 dBm.



Now we get better performances with modified version and 0 dB LNA gain on FCD, but it is still a “compromise” !
We did performance measurement of the FCD receiver, it was shown poor dynamic performance and IP3 of this receiver : any signal greater than -45 dBm reduce the sensitivity by blocking receiver chain. LO leak of this converter is too high for FCD receiver. This converter can be improved but, the combination of this converter with FCD receiver is very bad.
For HF band, it is better to use ring diode mixer for easier matching and higher intermodulation level. Don’t expect performance on this kit, a good “softrock” receiver is better for HF band.

73s de F5RCT
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FCD list : http://uk.groups.yahoo.com/group/funcube/

more serious converter but gain seems to be too high for HF band :
http://www.hsmicrowave.com/FCD-5-55-UC_102711.PDF
Better, but needs a notch on LO at output : http://www.george-smart.co.uk/wiki/FunCube_Upconverter

Oscillator can be found here as spare part :
SARONIX Oscillator 106.25MHz STAA9FC-106.2500T
http://www.ebay.com/itm/SARONIX-Oscillator-106-25MHz-STAA9FC-106-2500T-SMD-Qty-10-/400272682219