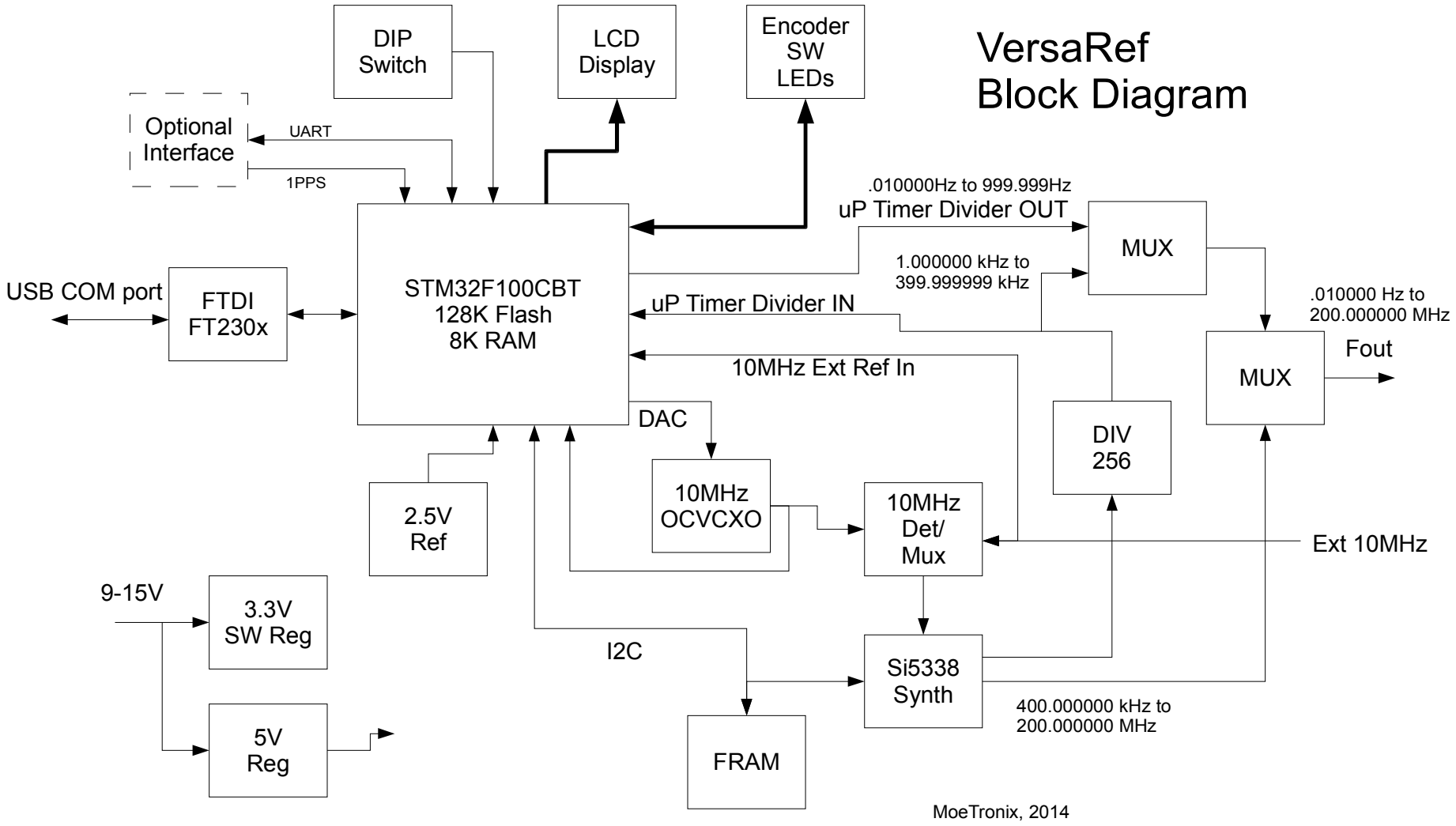
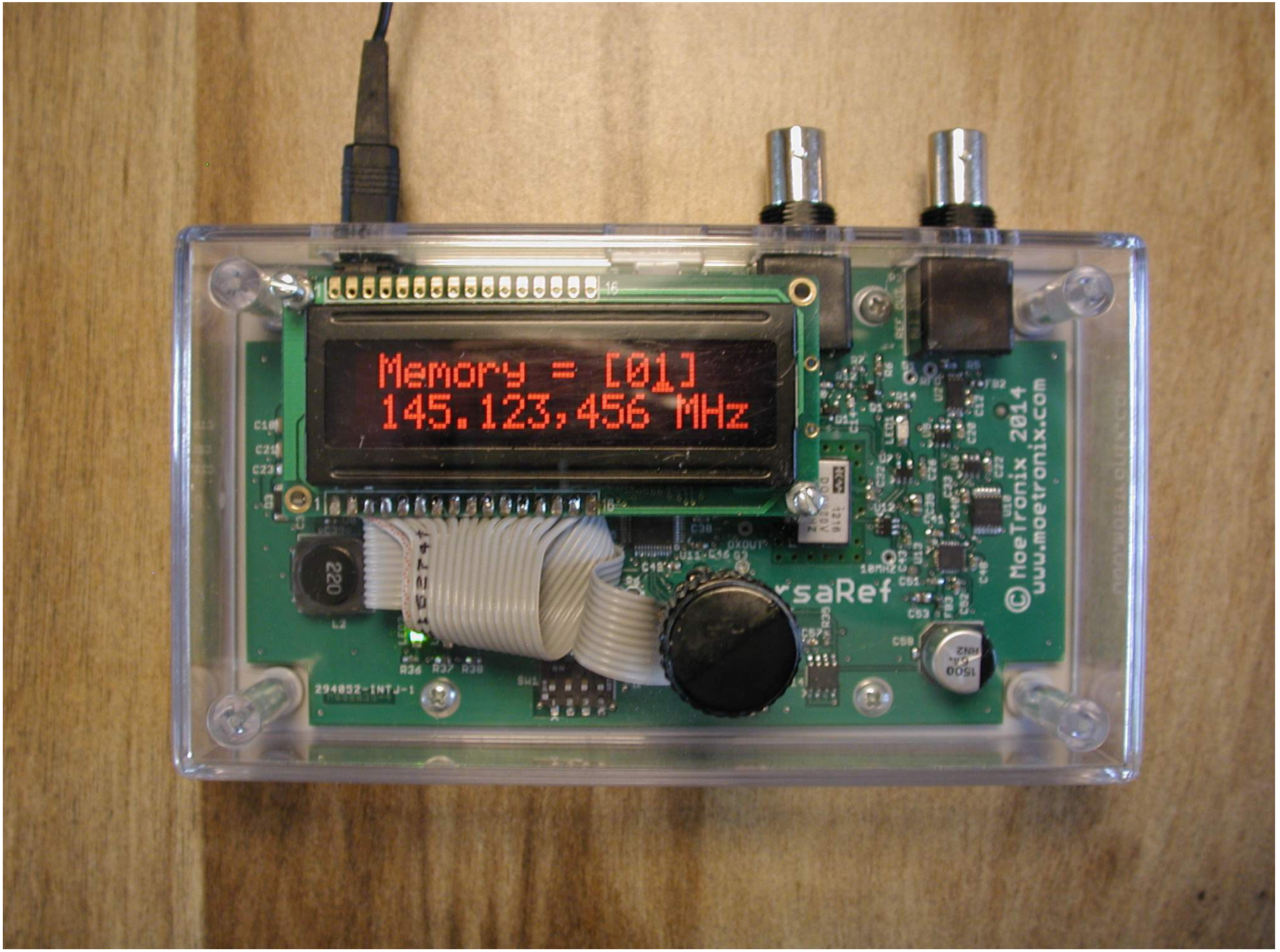
VersaRef
Reference Clock Generator

- 0.01Hz to 200MHz
- Internal 10MHz Oven Osc
- GPS Lockable
- 8-19 VDC Power
- 3.3V Square wave output

Moe Wheatley AE4JY

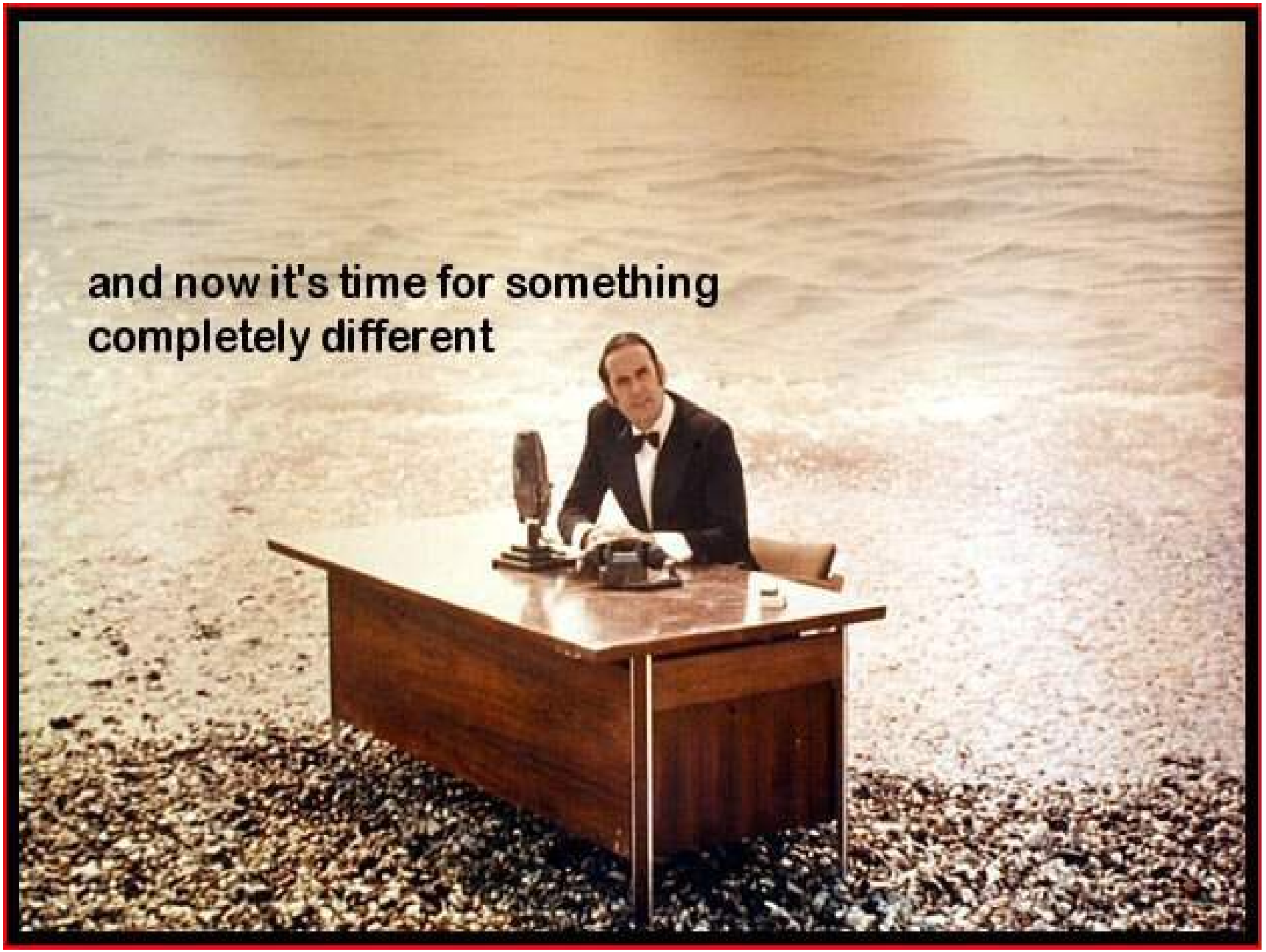

VersaRef
Block Diagram
DIP Switch
LCD Display
Encoder SW LEDs
Optional Interface
UART
1PPS
.010000Hz to 999.999Hz
uP Timer Divider OUT
MUX
1.000000 kHz to 399.999999 kHz
USB COM port
FTDI FT230x
STM32F100CBT
128K Flash
8K RAM
uP Timer Divider IN
.010000 Hz to 200.000000 MHz
Fout
MUX
10MHz Ext Ref In
DAC
DIV 256
2.5V Ref
10MHz OCVCXO
10MHz Det/ Mux
Ext 10MHz
9-15V
3.3V SW Reg
I2C
Si5338 Synth
400.000000 kHz to 200.000000 MHz
5V Reg
FRAM
MoeTronix, 2014

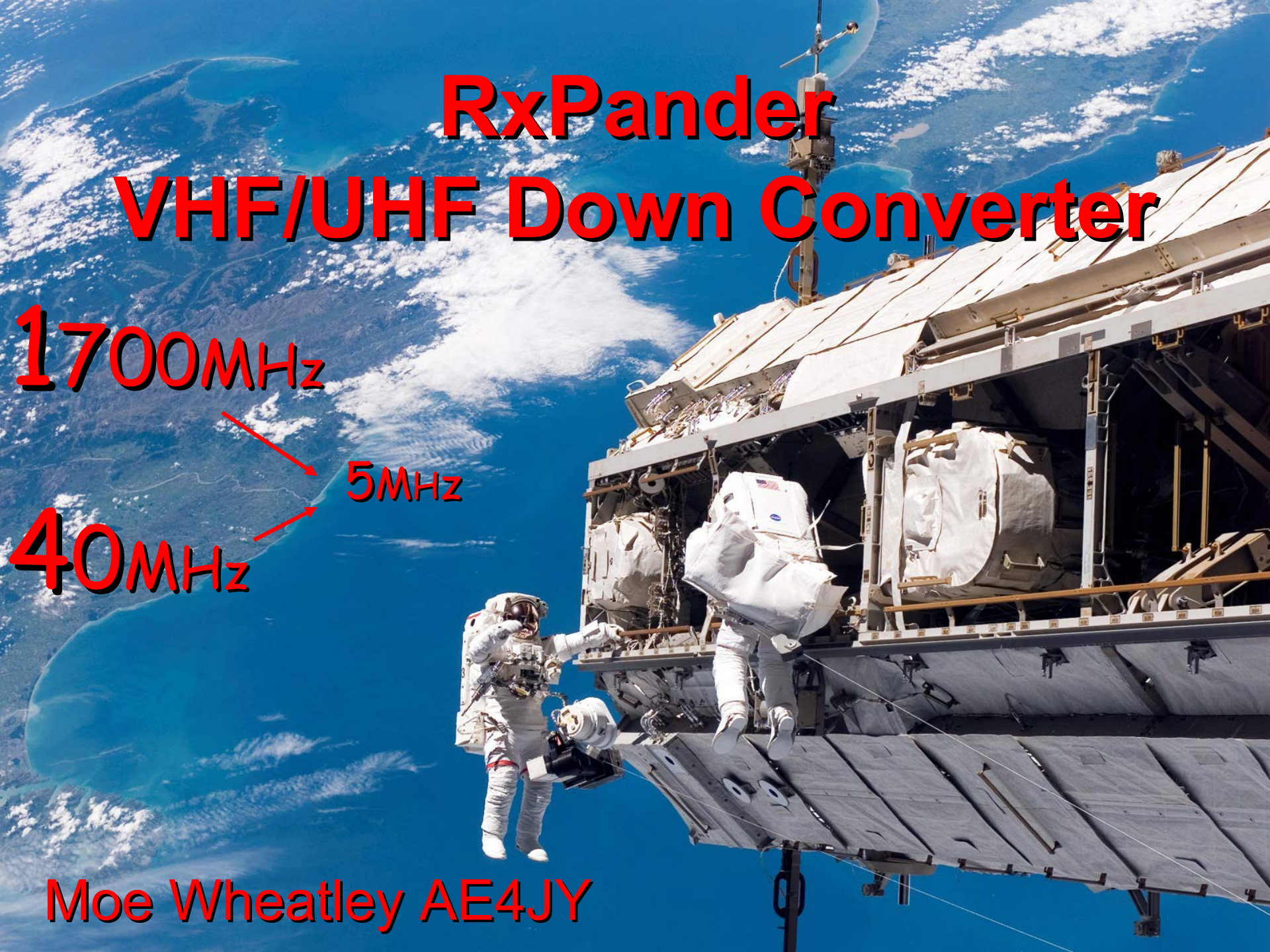

Memory = [01]
145.123.456 MHz
© MoeTronix 2014
www.moetronix.com

Pros & Cons

- Oven Osc stable within a minute
- Frequency Range and Resolution met.
- No Switching power supply noise

- Crystal Aging very apparent
- Si5338 Spurs could be an issue
- Probably too expensive to produce due to small market.


and now it's time for something
completely different


RxPander
VHF/UHF Down Converter
1700MHz
40MHz
5MHz
Moe Wheatley AE4JY

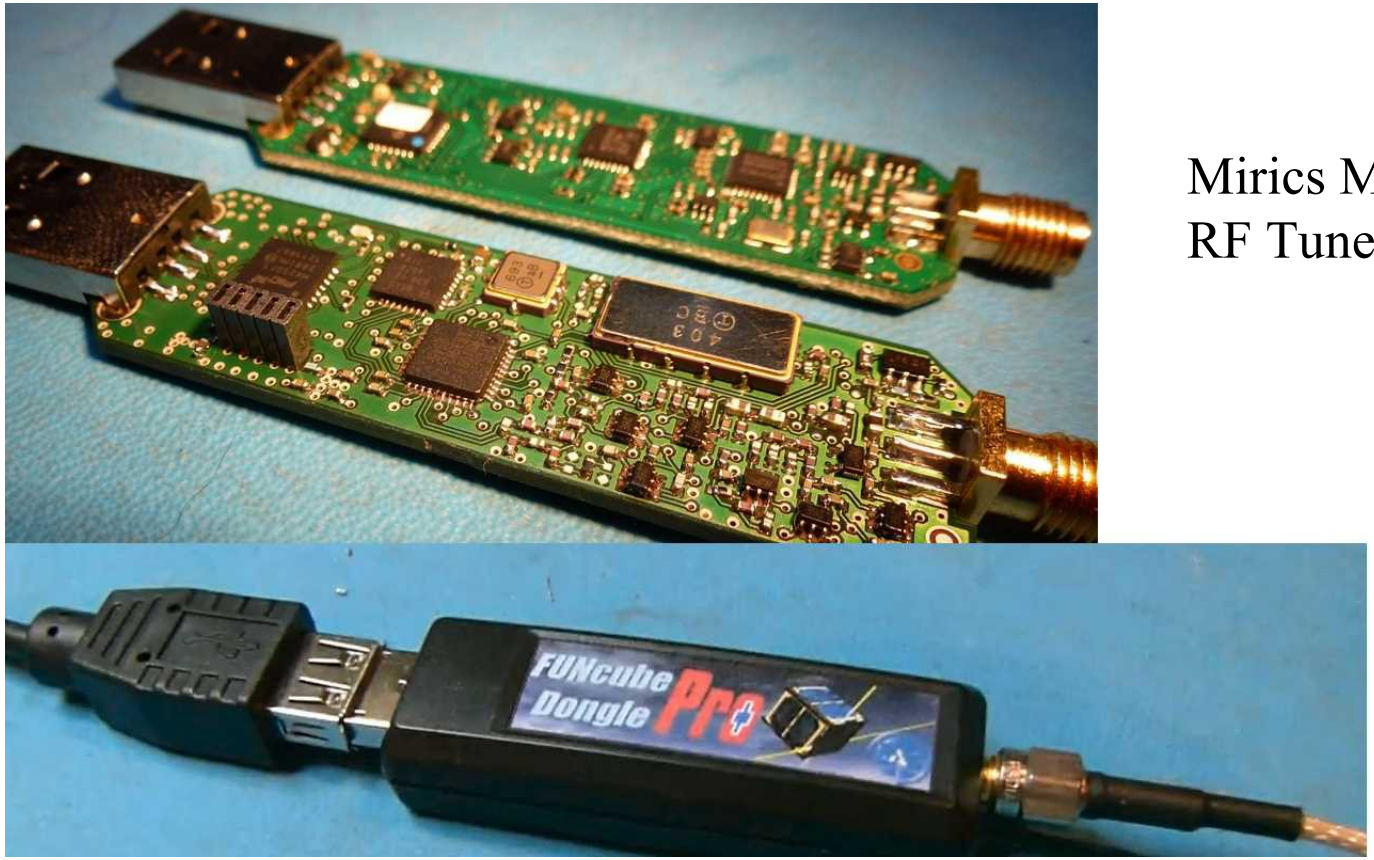
A Little History

- 2010 Howard Long, G6LVB designed a TV Tuner Chip based USB dongle for receiving amateur satellites called FUNcube Dongle.
- 2011 Antti Palosaari managed to get 8 bit I/Q data out of a TV tuner USB Dongle. From that the RTL Dongles were hatched.
- 2012 Osmocom's OsmoSDR and others??
- Youssef Touil author of SDR# and Airspy

The Questions

- The proliferation of cheap USB Dongle TV Tuners sparked an investigation into the “innards” to see if there was anything useful. Tens of thousands of these things have been bought as general purpose SDR's primarily for VHF/UHF reception.
- What kind of performance could be expected?
- Could the chips used in the dongles be purchased by “mortals” and put in a product?

FUNcube Dongle



Mirics MSi001
RF Tuner Chip

~$200 150kHz to 2GHz 190kHz BW

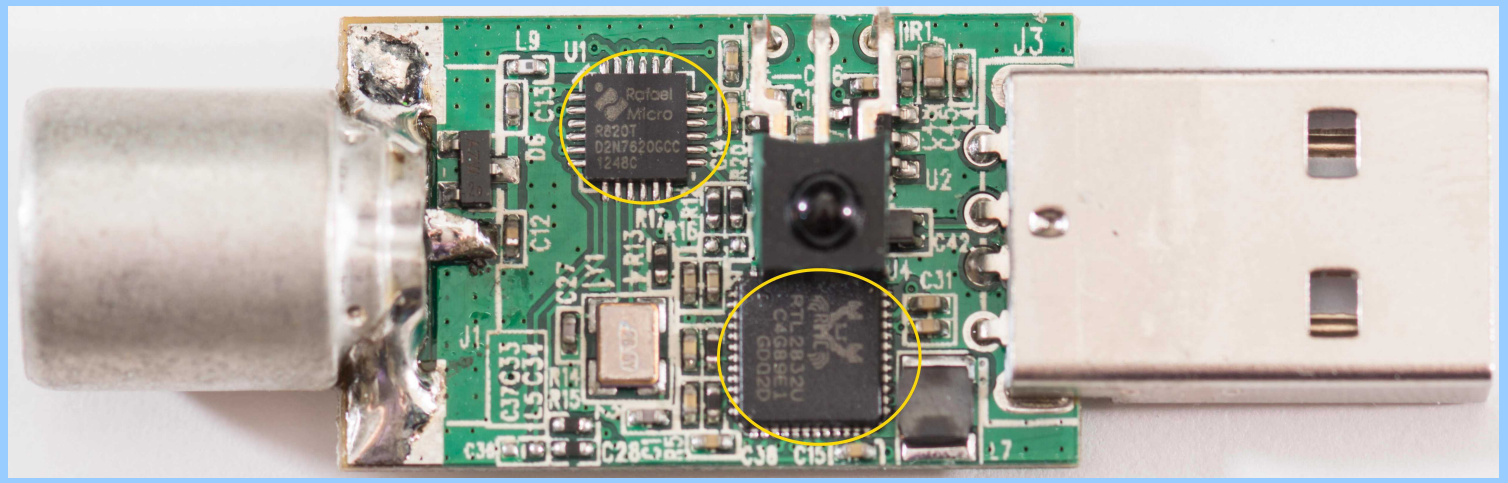
RTL Dongles

~$20 25MHz to 1.7GHz
~2.8MHz BW

What's in an RTL Dongle?

The Dongles contain two main chips.

- An Analog Down Converter chip, usually an R820 or E4000.
- A Realtek RTL2832U DVB-T COFDM Demodulator + USB 2.0 interface.



Limitations of the RTL Dongle

- Frequency controlled by simple crystal with no temperature compensation.
- Frequency PLL step size ~1kHz or so.
- No RF filtering so easily overloaded by just about any strong signal.
- The USB interface limited to 8 bits I/Q so Gain Control is required.

The Interesting Part

- The RTL2832 chip is primarily a DTV demodulator chip so is not much use for general reception except for the raw I/Q mode which has major limitations.
- The Rafael Micro R820 chip is generic and is just a programmable analog RF down converter. It looked like it could be a very useful building block.
- Very limited technical information on this chip so could it be integrated in a custom design?

Down Converter Design Goals

- Improve dynamic performance with some RF Filtering.
- Be able to lock the frequency to a 10MHz GPS reference.
- Have 1 Hz frequency resolution.
- Get maximum IF BW around 8MHz
- Find a source and info for the R820 chip.

Terrestrial DTV TV Silicon tuner

Rafael Revolution
R series

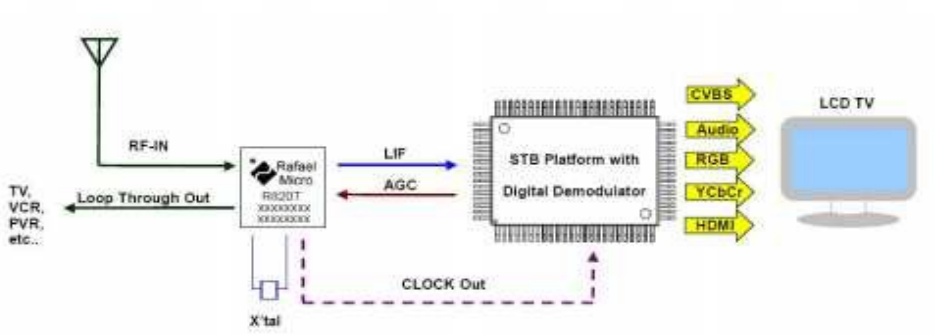
R820T

Features

- Support all digital TV standards: DVB-T, ATSC, DTMB, IRIB and ISDB-T.
- Lowest BOM cost WITHOUT external SAW filters, LNA, balun, LDO, and adjustable parts.
- Low cost Single-In Digital TV Application
- Compliant with EN 300 744, Nordig 2.2, D-BOOK 7.0, ARIB B21, ABNT 15604, ATSC A74 and GB20600-2006
- Compliant with EN-55020, EN55013 and FCC
- Ultra low power consumption < 190mA
- Single power supply with 3.3V
- 2-wired I2C interface
- 24-pin 4x4 QFN lead-free package

Applications

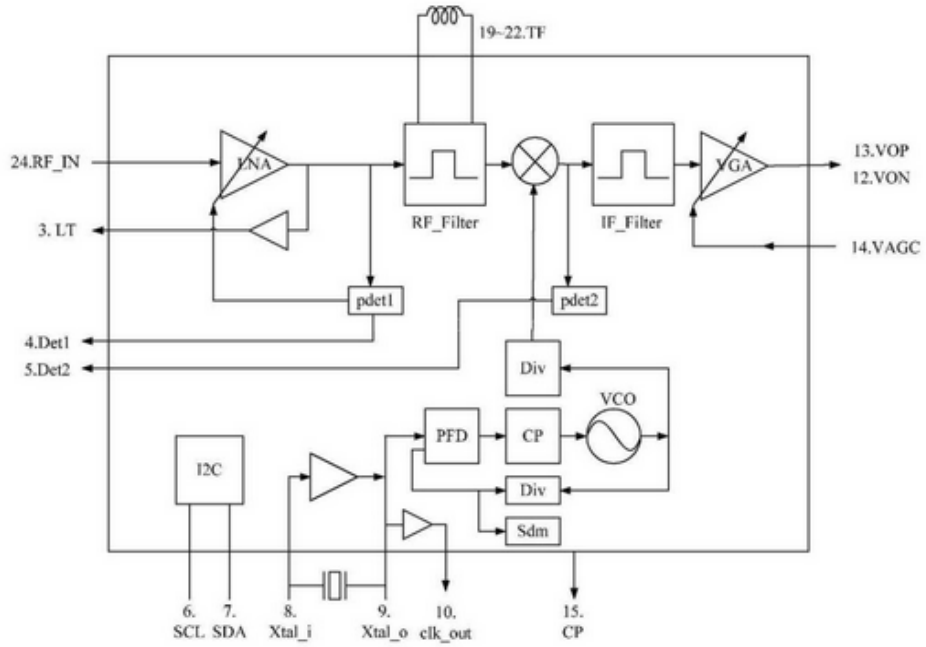
- Terrestrial Digital TV
- Desktop/Laptop PCTV, Mini-card, and USB peripherals
- Set Top Box
- Portable Media Player



Universal DTV

From http://radioaficion.com/cms/r820t-rafael-micro/

Simplified R820T Block Diagram



Quick Reference Data

Typical figures

- Frequency range: 42 to 1002 MHz
- Noise figure : 3.5 dB @ RF_IN
- Phase noise: -98 dBc/Hz @ 10 kHz
- Current consumption: <178 mA @ 3.3V power supply
- Max input power: +10 dBm
- Image rejection: 65 dBc

First Prototype

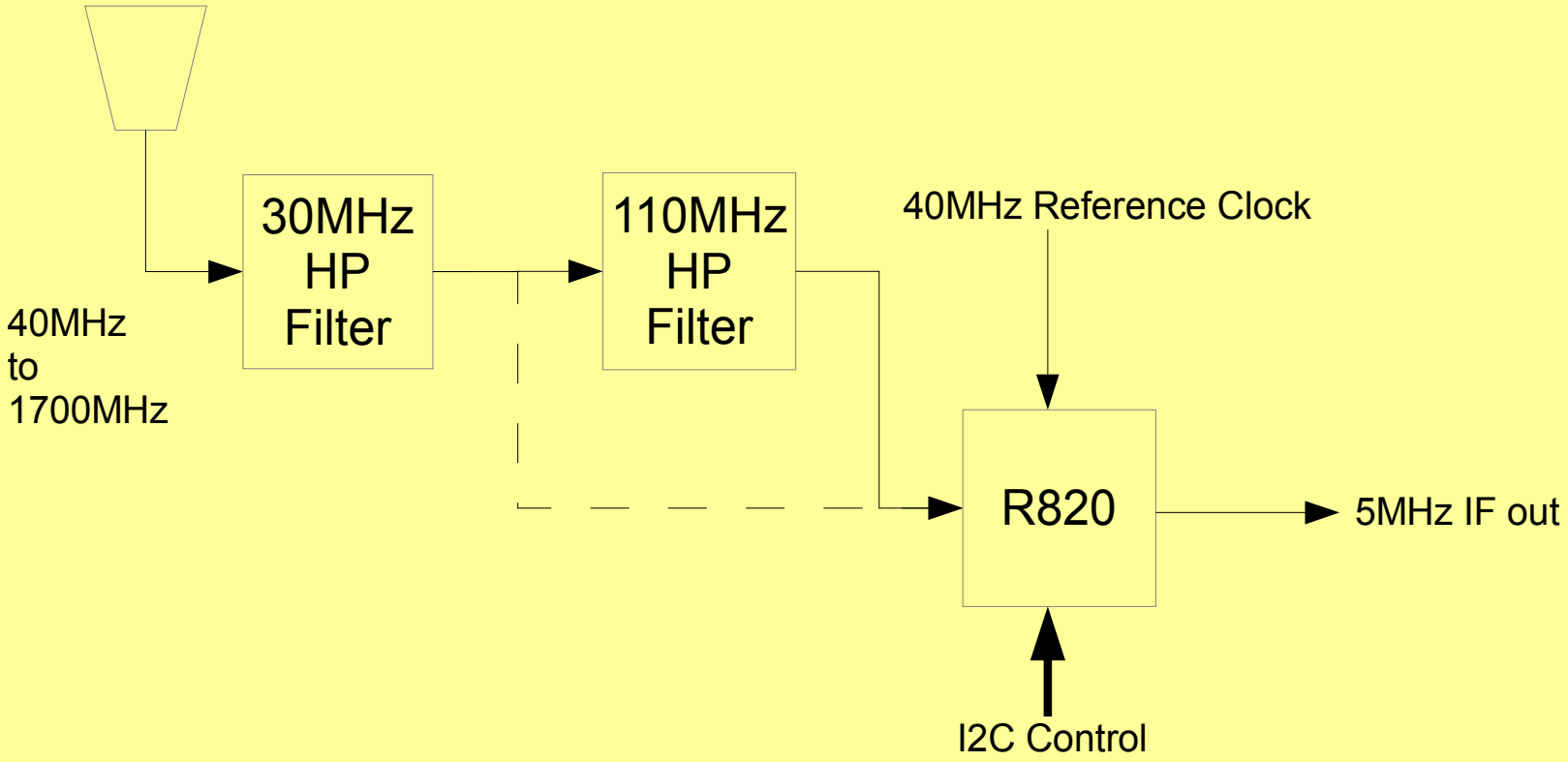
- The easiest platform for us to work on was the RFSpace NetSDR radio since it already had headers in place for a down converter module.
- A PCB was made and some R820 chips were de-soldered from some RTL Dongles and reused.
- In parallel, a request to Rafael Micro was made to see if the chip could be purchased as well as get more detailed technical information.

Good News Bad News

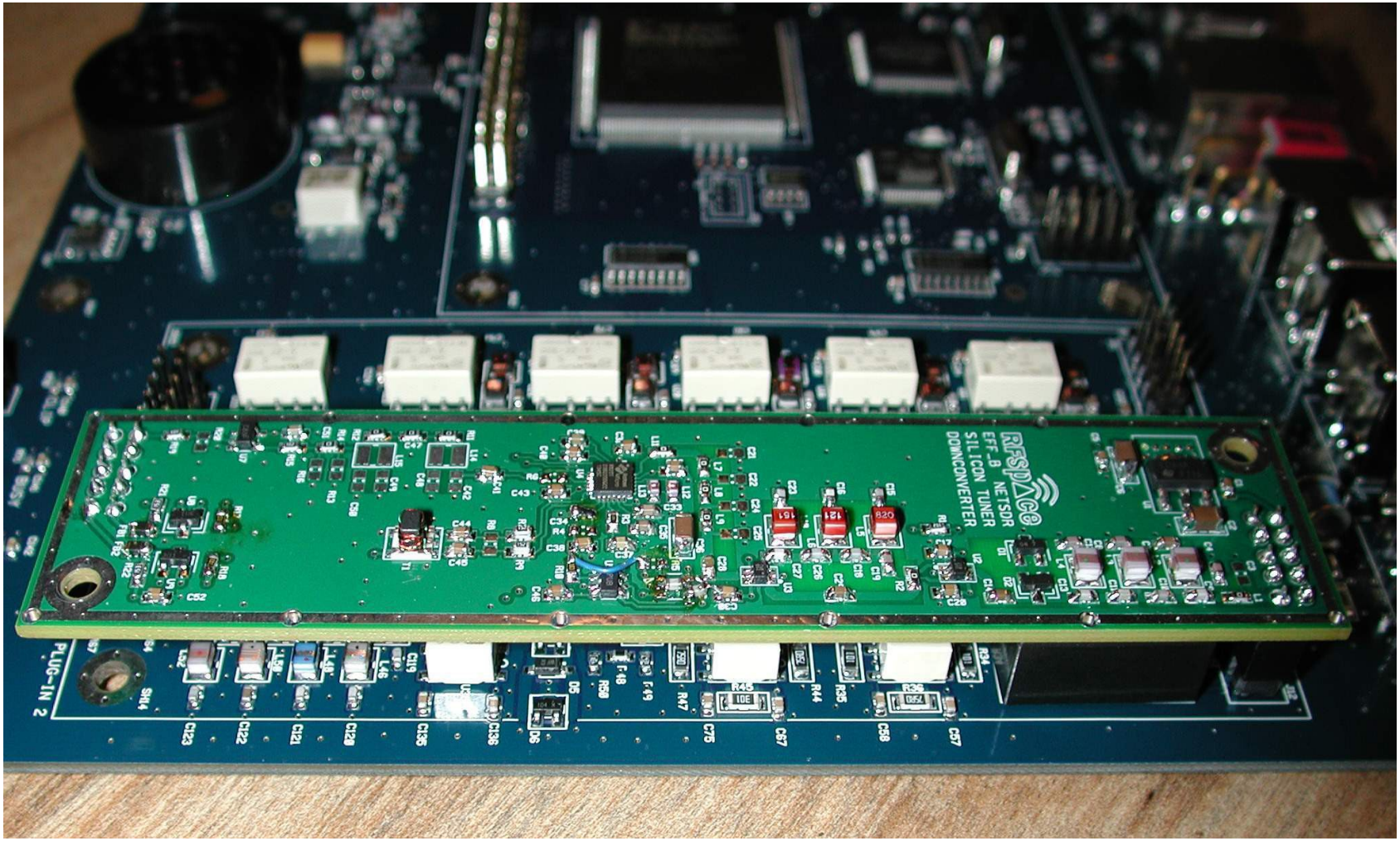
- R820 chips could be purchased for production quantities.
- Data Sheet and Example Driver code required NDA.
- Data Sheet same non-detailed one as bootleg one found on Internet.
- Example driver code had no explanation as to how it worked.
- With modifications to get better frequency resolution, the Driver was ported to NetSDR Micro Controller.

EFF Module Block

(Extended Frequency Function)



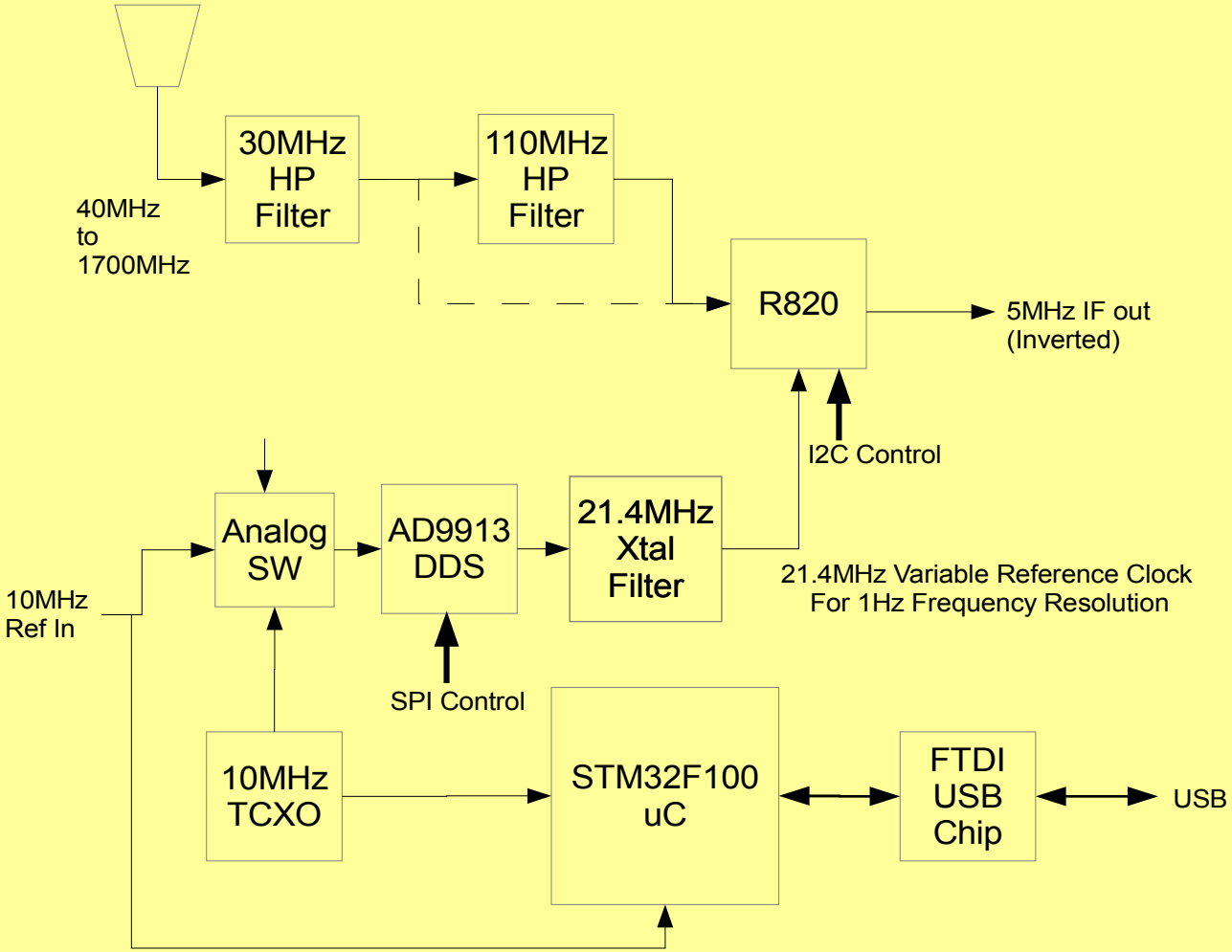
EFF Module for NetSDR



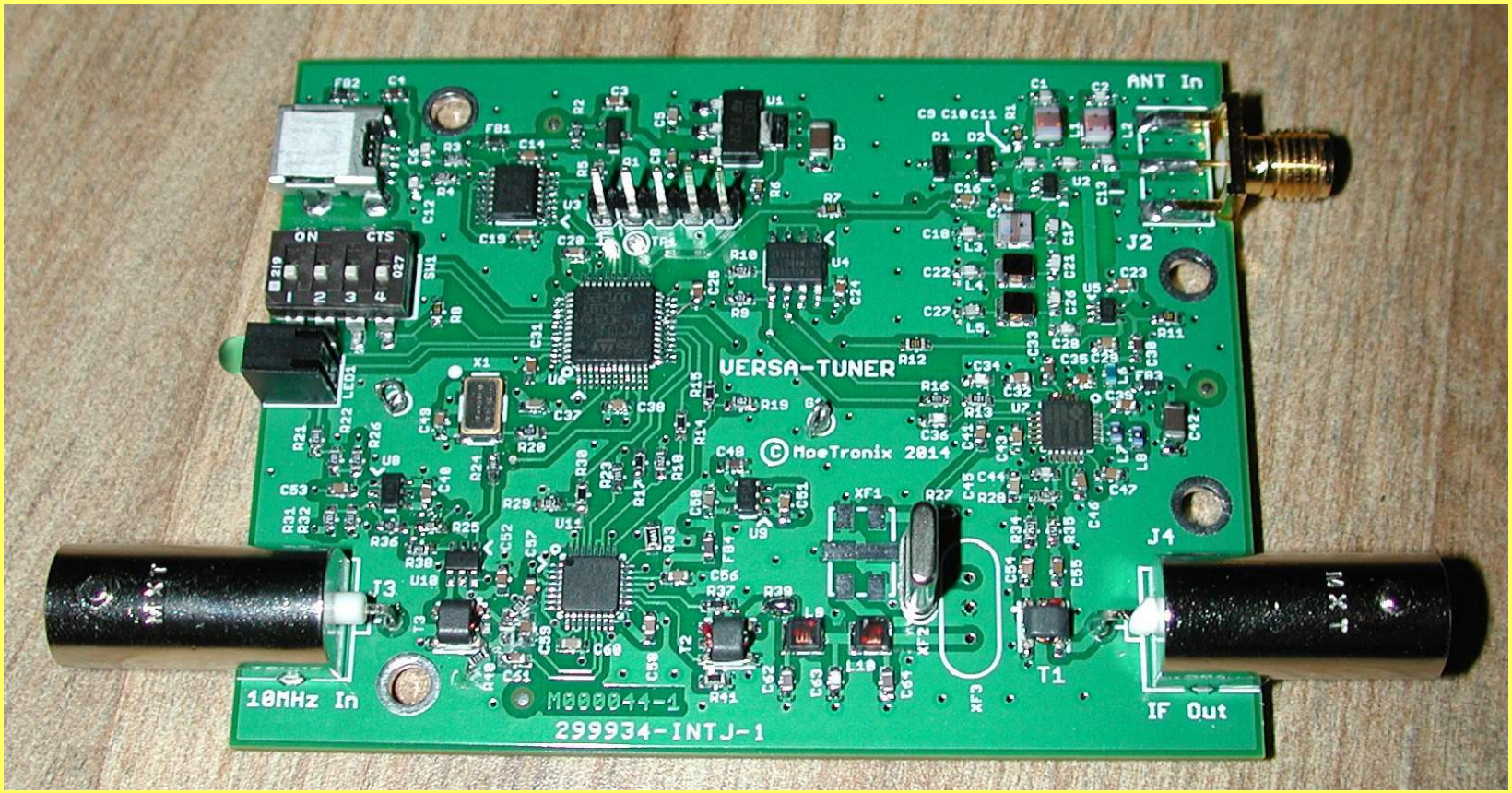
But I don't have a NetSDR..

- Now that we knew how to “Drive” the R820 chip, how about a general purpose down converter?
- So the “RxPander” project was launched.
- Basically a stand alone analog down converter taking 40 to 1700MHz down to 5MHz.
- Adds a USB virtual serial port for frequency control and power along with a 10MHz reference input.

RxPander Block Diagram

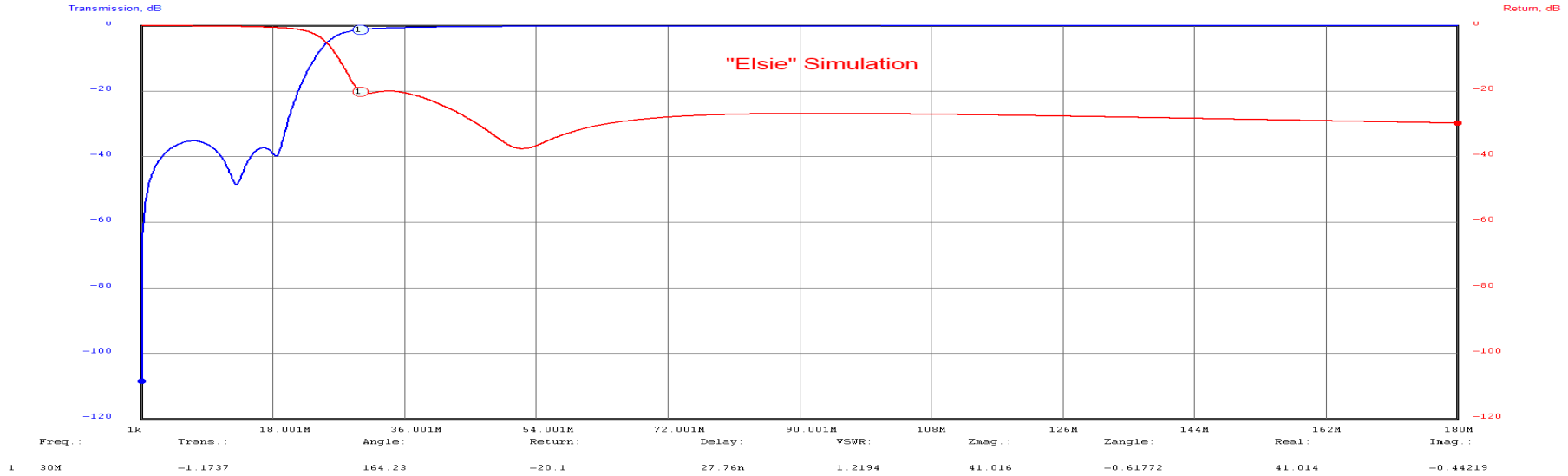


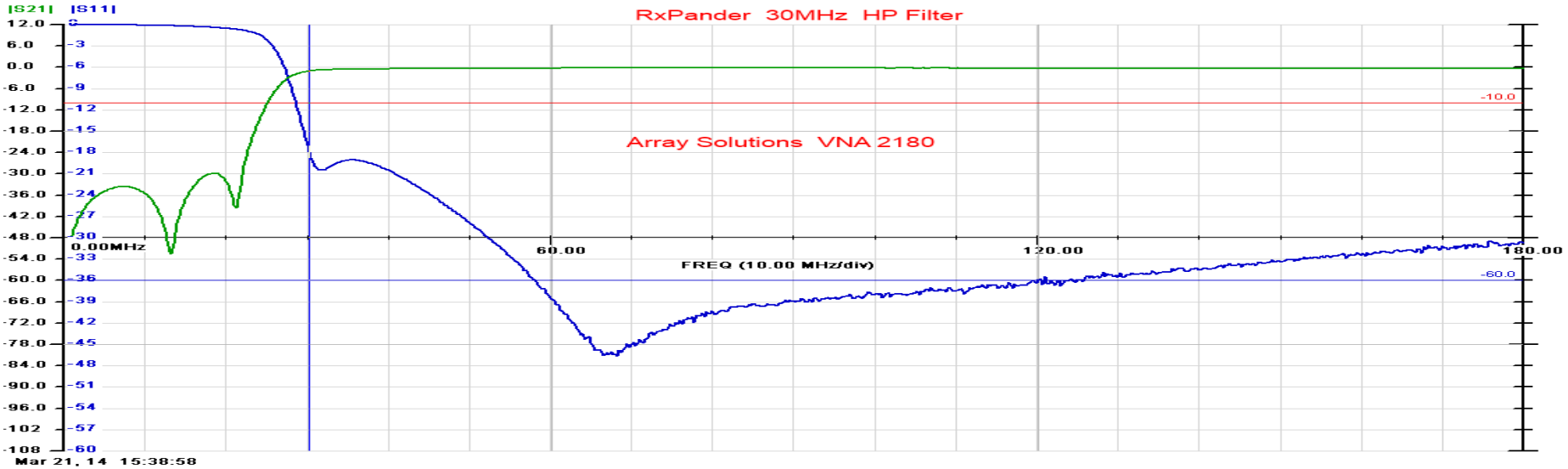
First Prototype



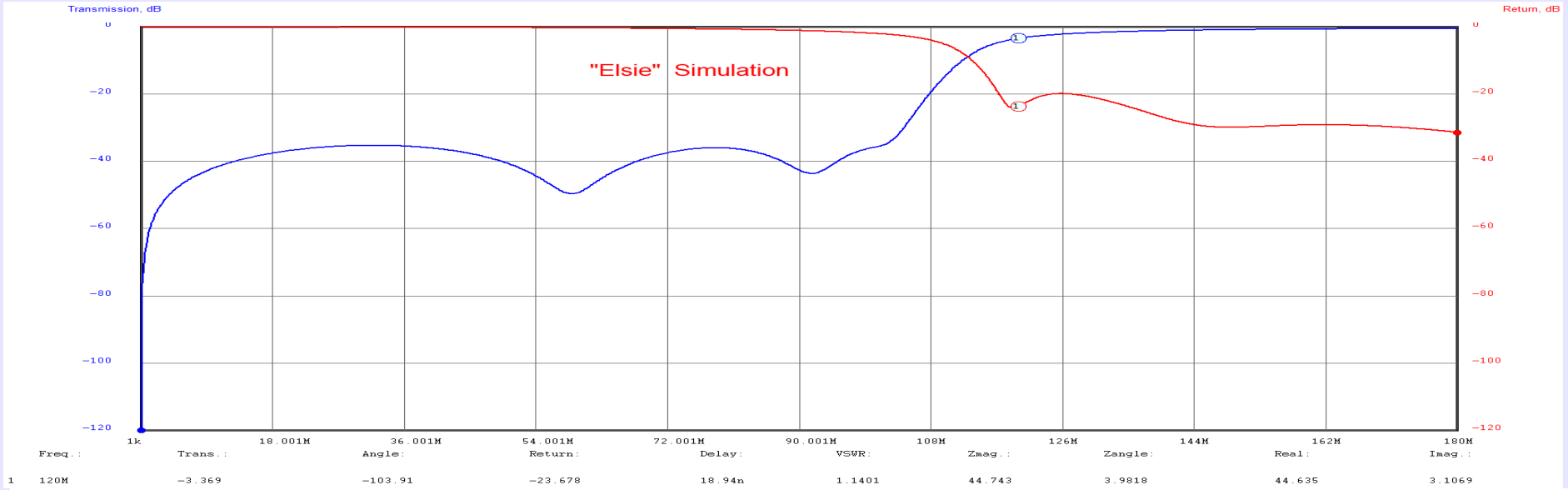
In a Hammond Enclosure

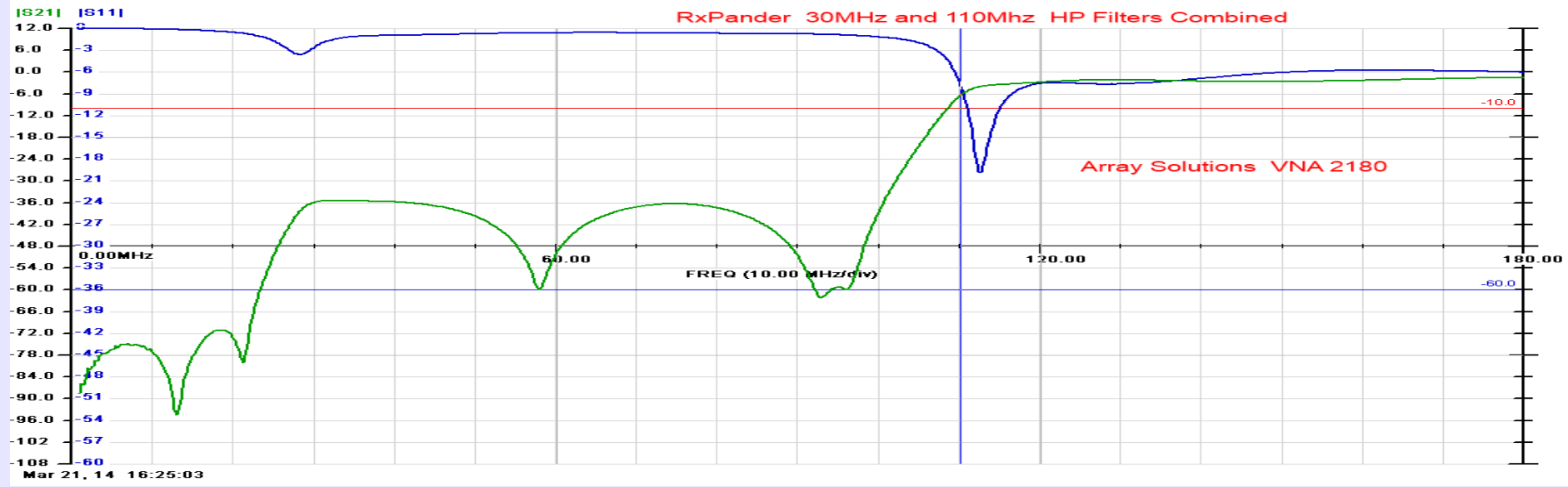
HF Filter Verification



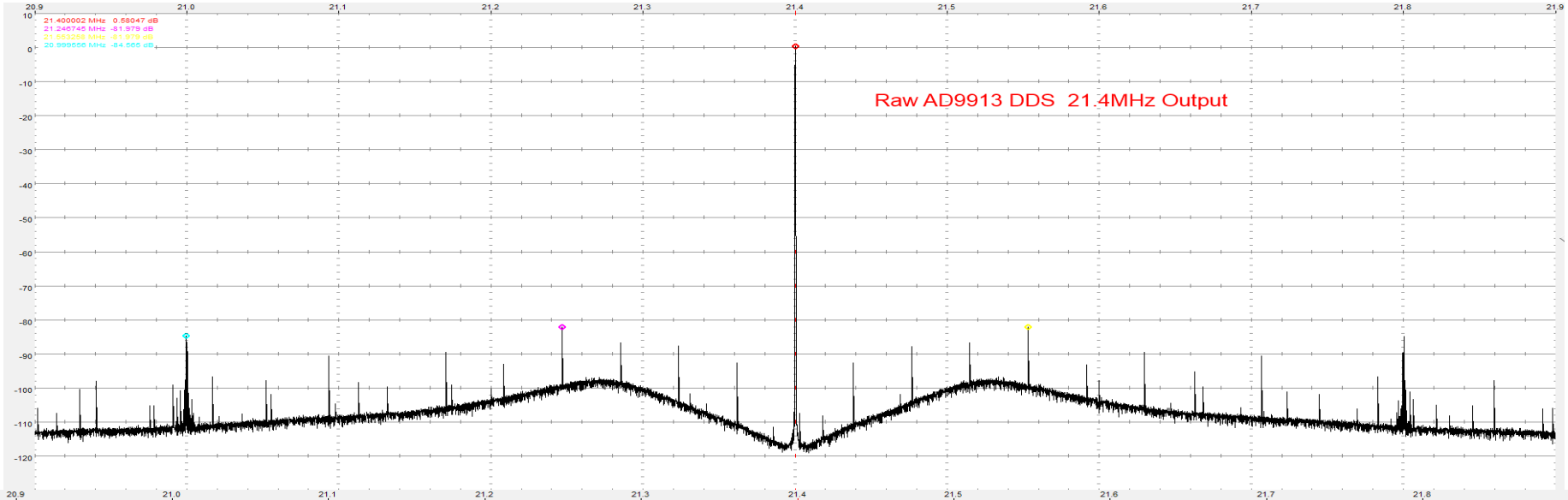


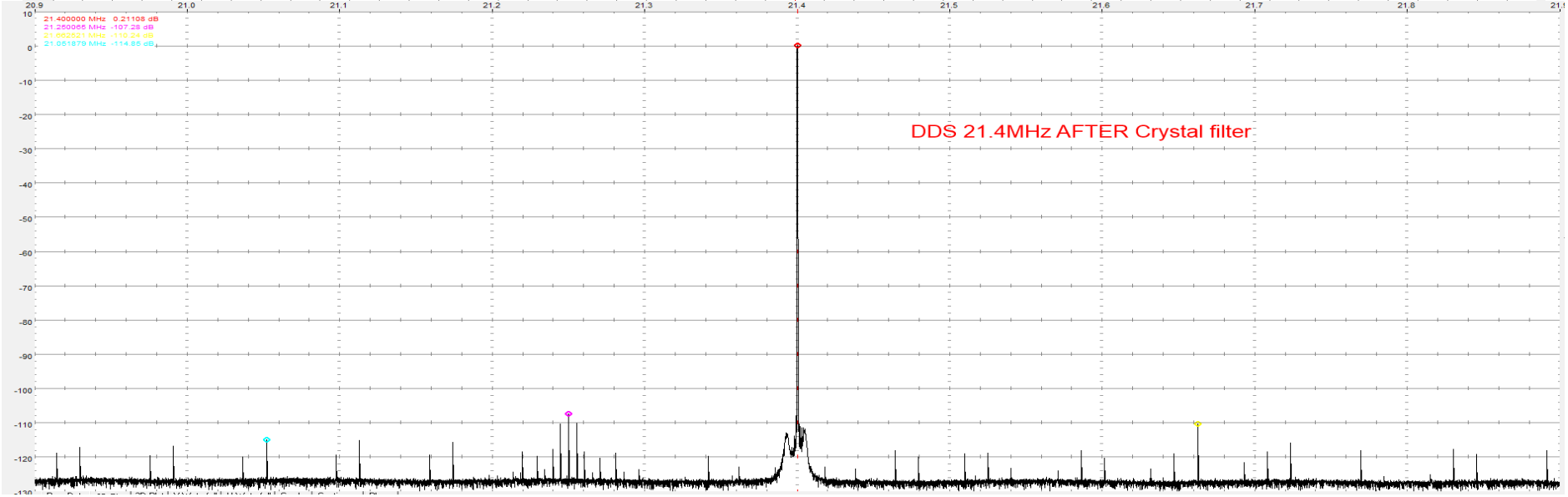
FM Filter Verification





PLL Reference Phase Noise Test

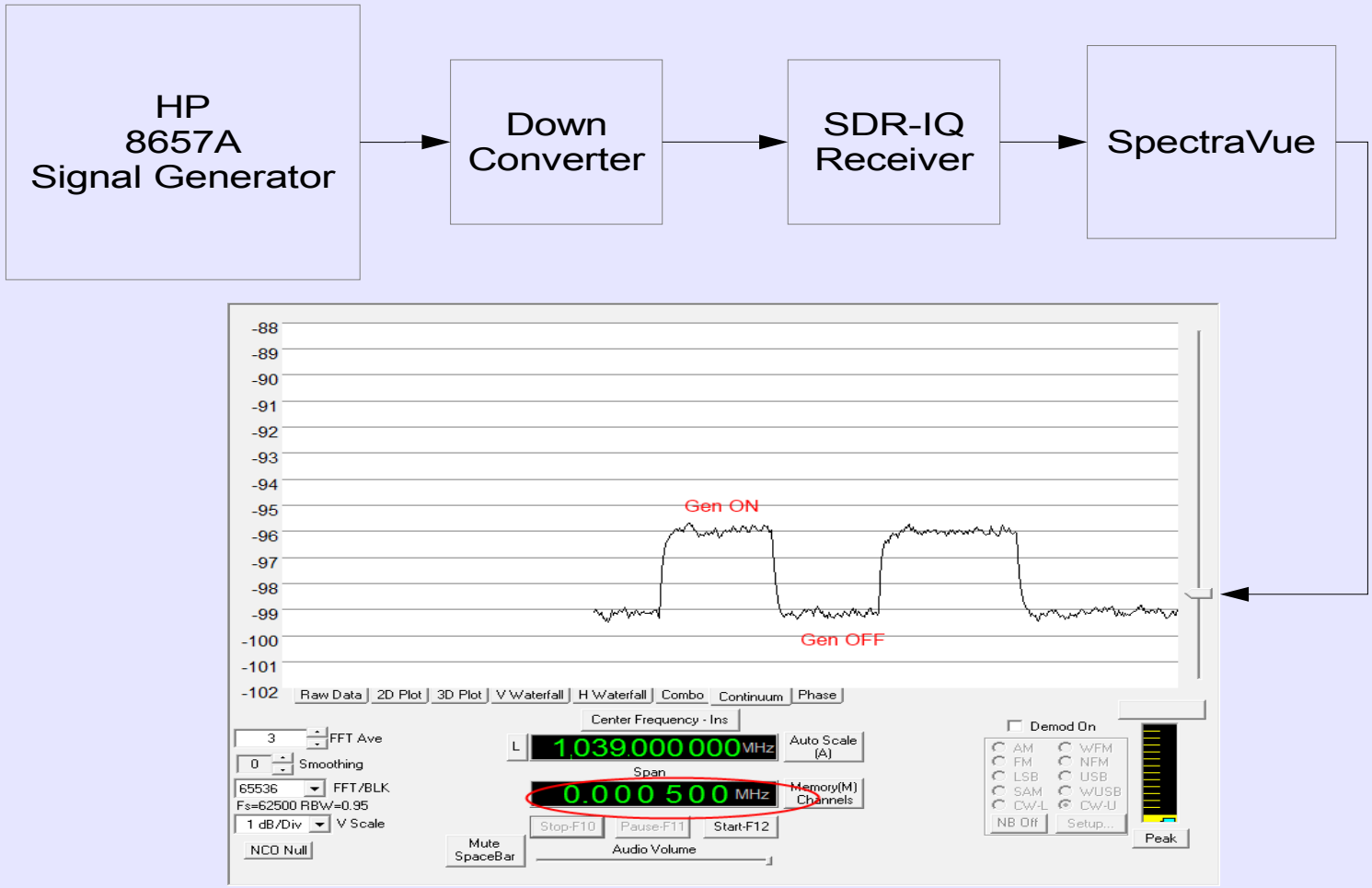




Sensitivity Measurements

MDS = -174dBm/Hz + NF(dB) + 10log BW (Hz)

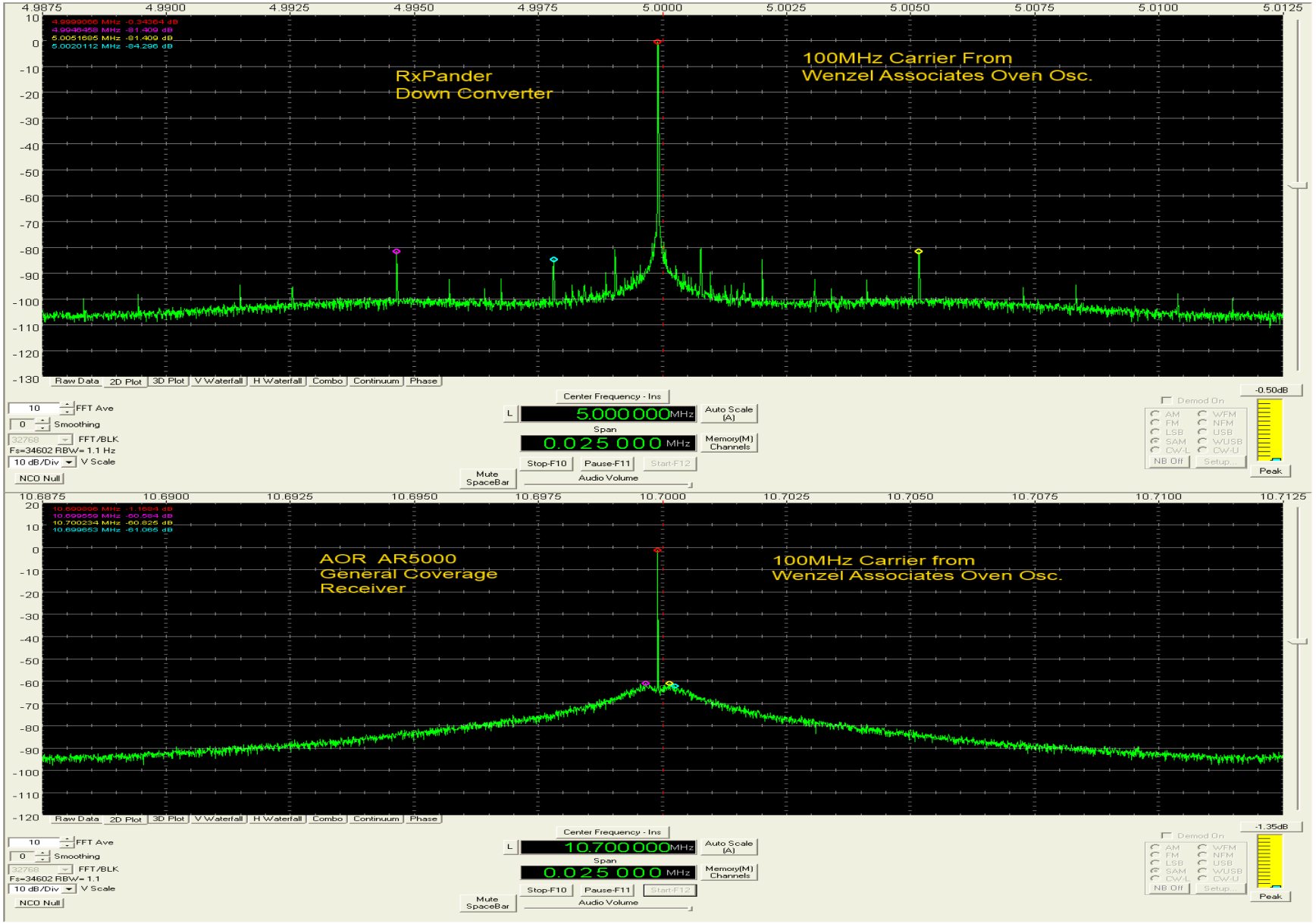
Insert a carrier until the power in a specified bandwidth is doubled. S=N



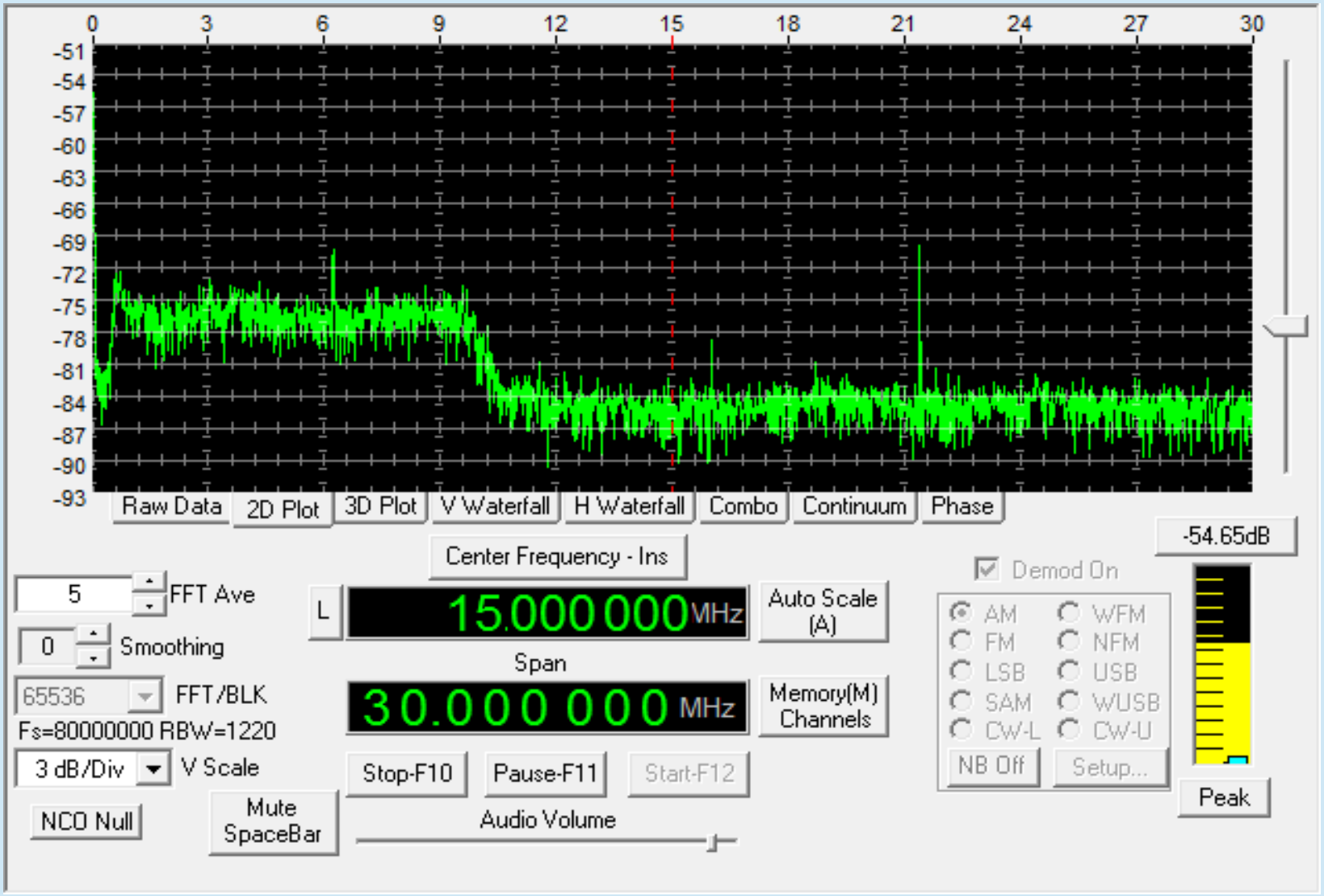
Sensitivity Results

Frequency (MHz)	MDS (dBm)	NF (dB)
50.2	-137	10
123	-138	9
145.1	-141	6
223	-142	5
433	-138	9
710	-140	7
1039	-142	5

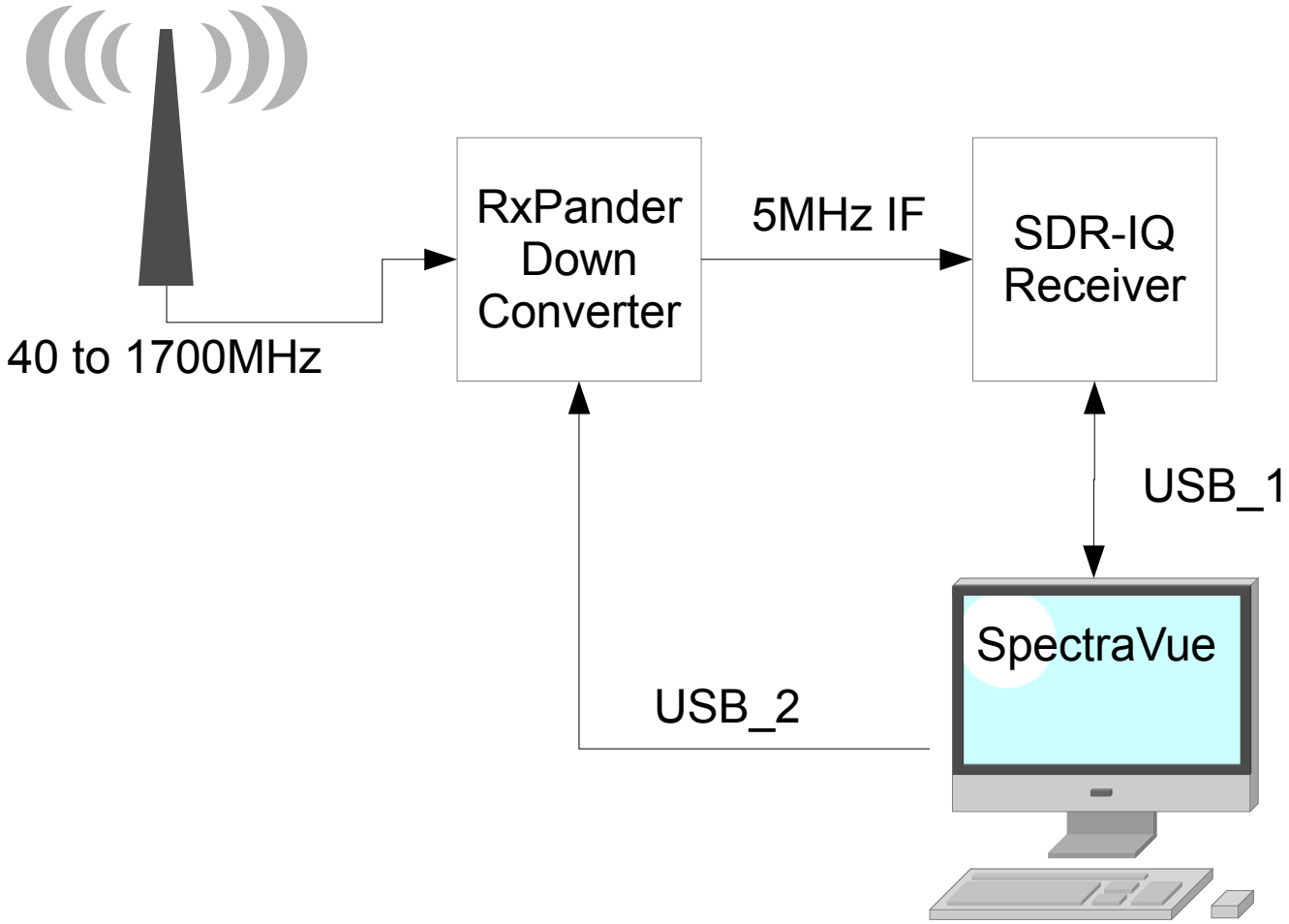
Receive Phase Noise



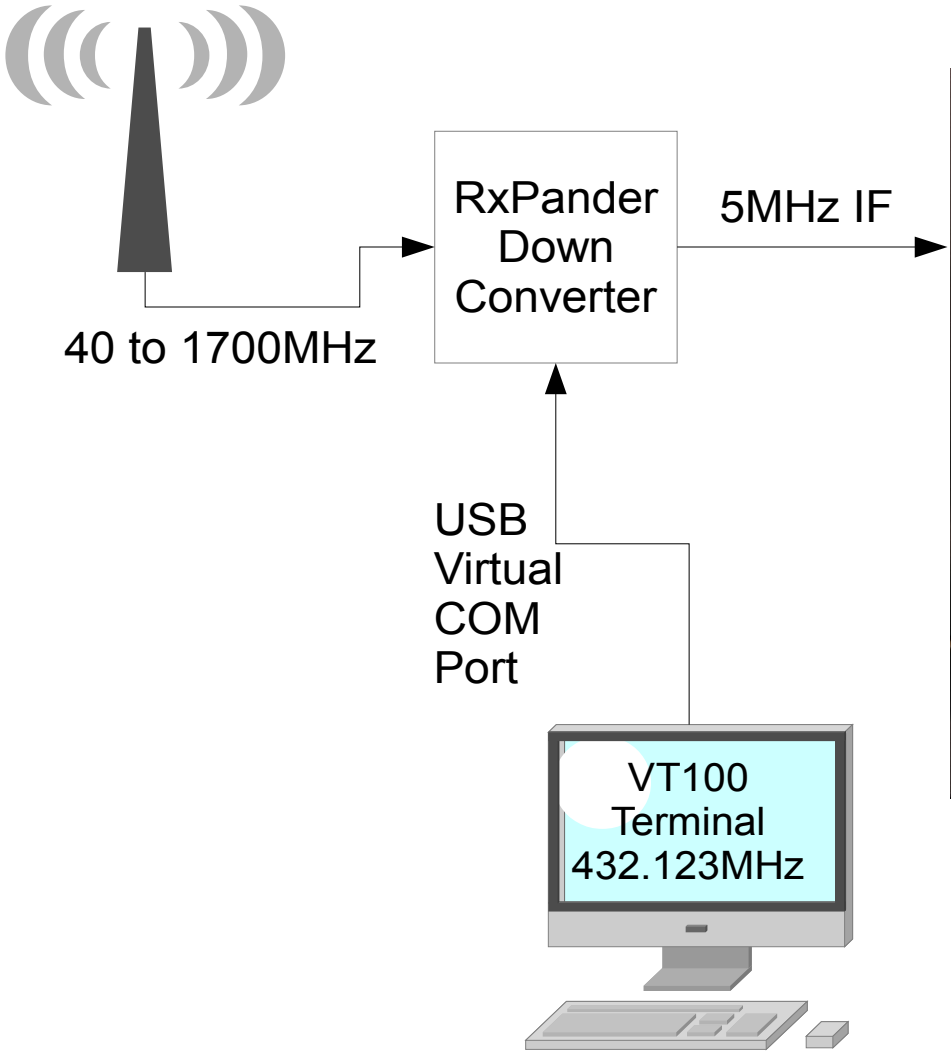
5MHz IF Output Bandwidth

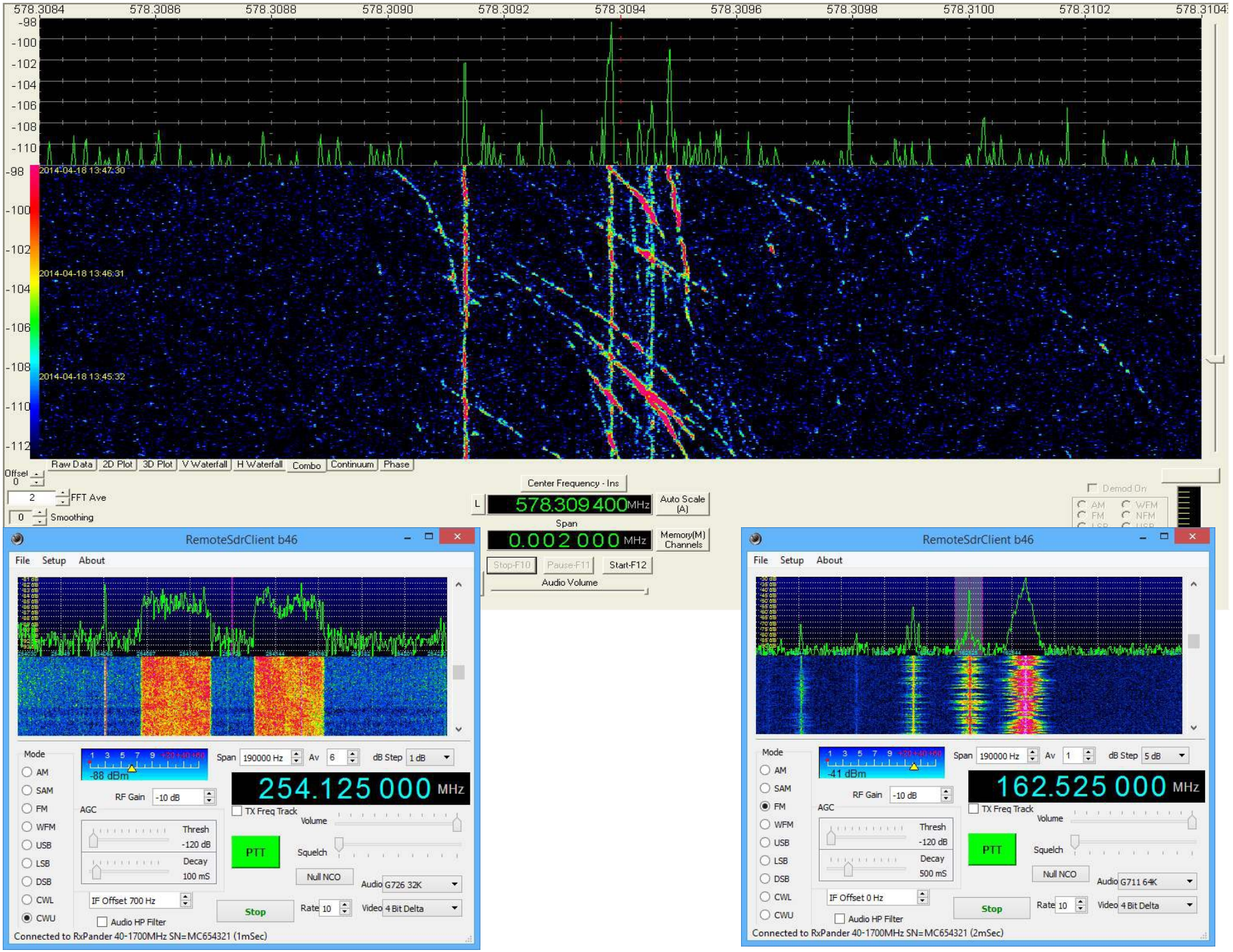


Configuration #1



Configuration #2




578.3084
578.3086
578.3088
578.3090
578.3092
578.3094
578.3096
578.3098
578.3100
578.3102
578.3104
-98
-100
-102
-104
-106
-108
-110
-112
2014-04-18 13:47:30
2014-04-18 13:46:31
2014-04-18 13:45:32
Raw Data
2D Plot
3D Plot
V Waterfall
H Waterfall
Combo
Continuum
Phase
Offset
0
2
FFT Ave
0
Smoothing
Center Frequency - Ins
L
578.309 400 MHz
Auto Scale (A)
Span
0.002 000 MHz
Memory(M) Channels
Stop-F10
Pause-F11
Start-F12
Audio Volume
Demod On
AM
FM
LSB
WFM
NFM
USB
RemoteSdrClient b46
File
Setup
About
Mode
AM
SAM
FM
WFM
USB
LSB
DSB
CWL
CWU
-88 dBm
Span 190000 Hz
Av 6
dB Step 1 dB
RF Gain -10 dB
AGC
Thresh -120 dB
Decay 100 mS
254.125 000 MHz
TX Freq Track
Volume
PTT
Squelch
Null NCO
Audio G726 32K
IF Offset 700 Hz
Audio HP Filter
Stop
Rate 10
Video 4 Bit Delta
Connected to RxPander 40-1700MHz SN=MC654321 (1mSec)
RemoteSdrClient b46
File
Setup
About
Mode
AM
SAM
FM
WFM
USB
LSB
DSB
CWL
CWU
-41 dBm
Span 190000 Hz
Av 1
dB Step 5 dB
RF Gain -10 dB
AGC
Thresh -120 dB
Decay 500 mS
162.525 000 MHz
TX Freq Track
Volume
PTT
Squelch
Null NCO
Audio G711 64K
IF Offset 0 Hz
Audio HP Filter
Stop
Rate 10
Video 4 Bit Delta
Connected to RxPander 40-1700MHz SN=MC654321 (2mSec)

To Do's

- Fix some PCB issues.
- Fix FM filter return loss
- See if able to make board ~$100 MSRP
- Layout for different TCXO
- Make small run to see if viable product.

More Info:

- (www.moetronix.com/RxPander) Will eventually have more information as this develops.