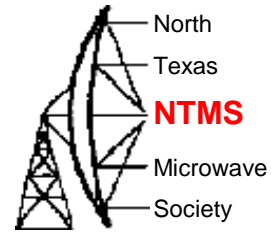W5HN

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North Texas Microwave Society

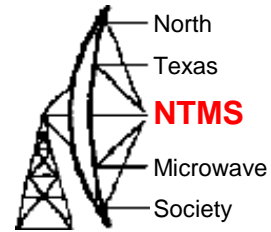# The Society : Hams working Microwave : Raspberry Pi

Cowtown Hamfest

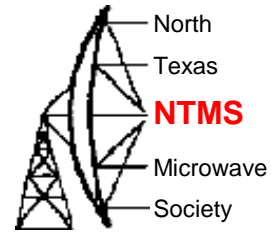January 21, 2017

What is NTMS

- An organization formed in 1986 but existing as a group of locals interested in microwave since about 1980.   > 35 Years!

- Focused on radio activity above 902 MHz.

- Lots of interest in building equipment, radios, testing, and operating equipment.

- A lot of sharing of equipment, ideas, and methods to operate with minimum investment.

Microwave Operation

- Operation is typically scheduled or the result of a contest.
- Every operation event is a experiment, learning, and growing experience to prove your equipment and skills.
- Beacons are an important asset. With beacons you can test your radio and antenna. The Beacon list is on the NTMS.ORG Website
- Frequency reference that is stable is best but not essential when SDR technology is used.
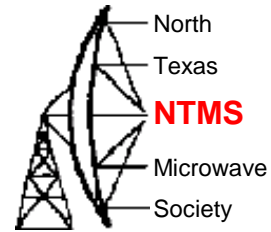
Microwave Technology

- Antennas
  - Yagis   Dish   Feed Horns   Waveguide
  - Typically smaller higher gain narrow beam angle
  - NTMS guidance with plans and methods
  - WA5VGB Kent is a legend and has given many years of help and support to making and measuring antennas.
  - Every Ham loves to work on antennas
  - Learning at one HAND wavelengths is easier

Review of Using a Raspberry Pi

- Which Raspberry Pi and Purchase Options

- The Ubuntu Mate Operating System and Linux

- RTL-SDR dongles

- Spectrum and Logging Spectrum Programs

- Microwave Examples

Focusing on the SDR using Raspberry Pi

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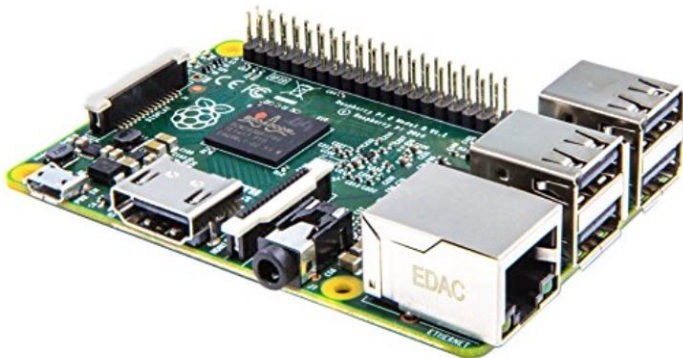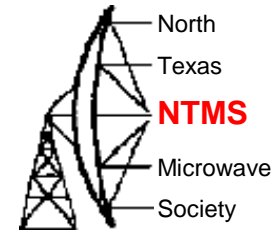
CanaKit Raspberry Pi 2 with WiFi and 2.5A Power Supply (UL Listed)

by CanaKit

★★★★½ ▼   14 customer reviews

Note: This item is only available from third-party sellers (see all offers).

Available from these sellers.

- New Raspberry Pi 2 (RPi2) Quad-Core 900 MHz 1GB RAM
- CanaKit WiFi Adapter / Dongle (Ralink RT5370 chipset)
- CanaKit 2.5A Micro USB Power Supply (UL Listed) specially designed for the Raspberry Pi 2 (5-foot cable)
- CanaKit Raspberry Pi Quick-Start Guide
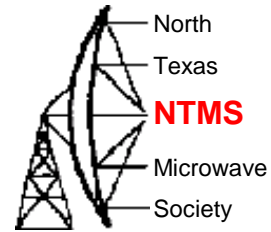
1 new from $69.99

Report incorrect product information.

Pi 2 Model B V 1.1
Or
Pi 3

Ubuntu **Mate**

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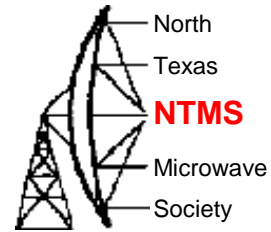
- Linux Operating System modified for the Raspberry Pi   -   ARM Processor.

- Works just like Linux on other computers.

- Supports Remote Desk Top connections.

- Be careful with available memory. Limited to the SD memory card used.

Getting Started

- When you receive your Pi use an HDMI to connect the Pi to a TV. If you have one connect a USB keyboard and mouse. Plug in the mini SD card. Connect the Wi-Fi interface or a network cable to your router.

- Make sure the TV is turned on and set to the proper Input. Then power up the Pi and watch the text and graphics as it boots.

Graphics Interface vs. Command Line

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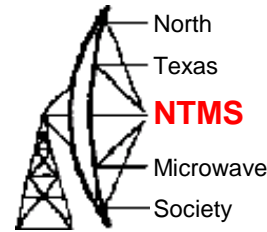
- You can accomplish a lot with the GUI. Mouse around and learn what is available.
- Learn to use the command line interface.
- Search for information on how to do things on the internet.
- Using the command line interface use "man command_name" to see instructions on how to use any command
- Buy a book on Ubuntu (Any book) at Half Price Books. Typically < $5. Use this for command reference.

Pi using Remote Desktop form another computer:

Important Linux Commands

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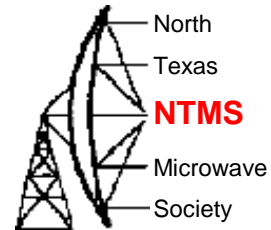
- ls –l (Directory, -l gives detail)
- Df (disk Free)
- Whoami & who (Who is logged in)
- Chmod (Set file permisions)
- Cp (Copy files)
- Passwd (Change a password)
- History (History of commands)
- Ifconfig (Shows your IP address)
- Shutdown –r now (Restarts)
- Man (Read info on a command)
- Rm (Remove a file)
- Find (Find a file)
- Pwd (Your current dirrectory)
- Tar (archive files – ZIP)
- Mount & umount (add a disk drive)
- Date (date and time)
- Su (Switch Users)
- Exit (close session)

- Text Editors – vi, gedit, nano, nedit
- If you have trouble with editors cp files to a thumb drive and edit in Windows and then copy back. Just work with pure text files.

- Try not to use spaces in file names. Use _ for a space.

- Most Linux commands are in lower case.
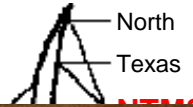
SMA Connector   USB Connector

Dongle Example

Note: SMA connector with a Bias Tee option for preamp power.

RTL-SDR Blog R820T2 RTL2832U 1PPM TCXO SMA Software Defined Radio with 2x Telescopic Antennas
by RTL-SDR Blog

$25.95 ✓Prime
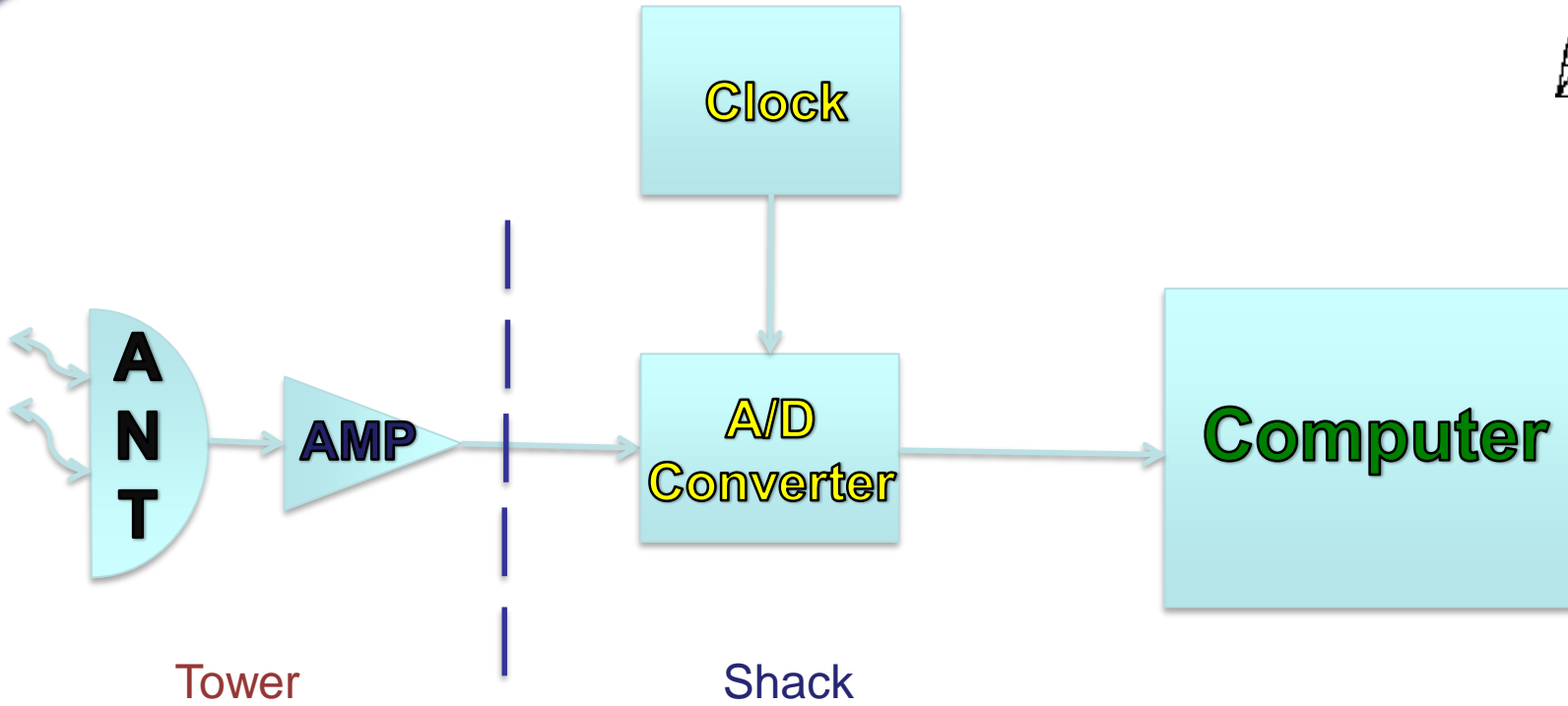Get it by Tomorrow, Oct 31

★★★★½ ▼ 181

Product Features
... Includes 1x *RTL-SDR* Blog brand R820T2 RTL2832U 1PPM TCXO HF Bias Tee ...
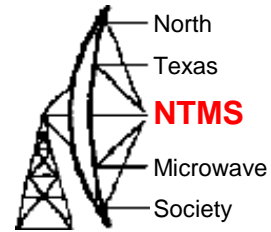
Electronics: See all 137 items

RTL-SDR Dongle
Example of a package deal on Amazon

Clock

A
N
T

AMP

A/D
Converter

Computer

Tower

Shack

Most Basic Software Defined Radio - SDR

Overview of the RTL-SDR

- A Two chip solution using a RF Analog chip
  - LNA front end with variable gain and external filter
  - Mixer
  - 2nd stage filter and variable gain amplifier driving output
  - A PLL based DDS Oscillator with I2C interface and a 28.8 MHz clock reference
- A digital processor or state machine to provide USB interface and control functions for RF chip.

See:http://superkuh.com/gnuradio/R820T_datasheet-Non_R-20111130_unlocked.pdf for a block diagram.

RTL Dongle
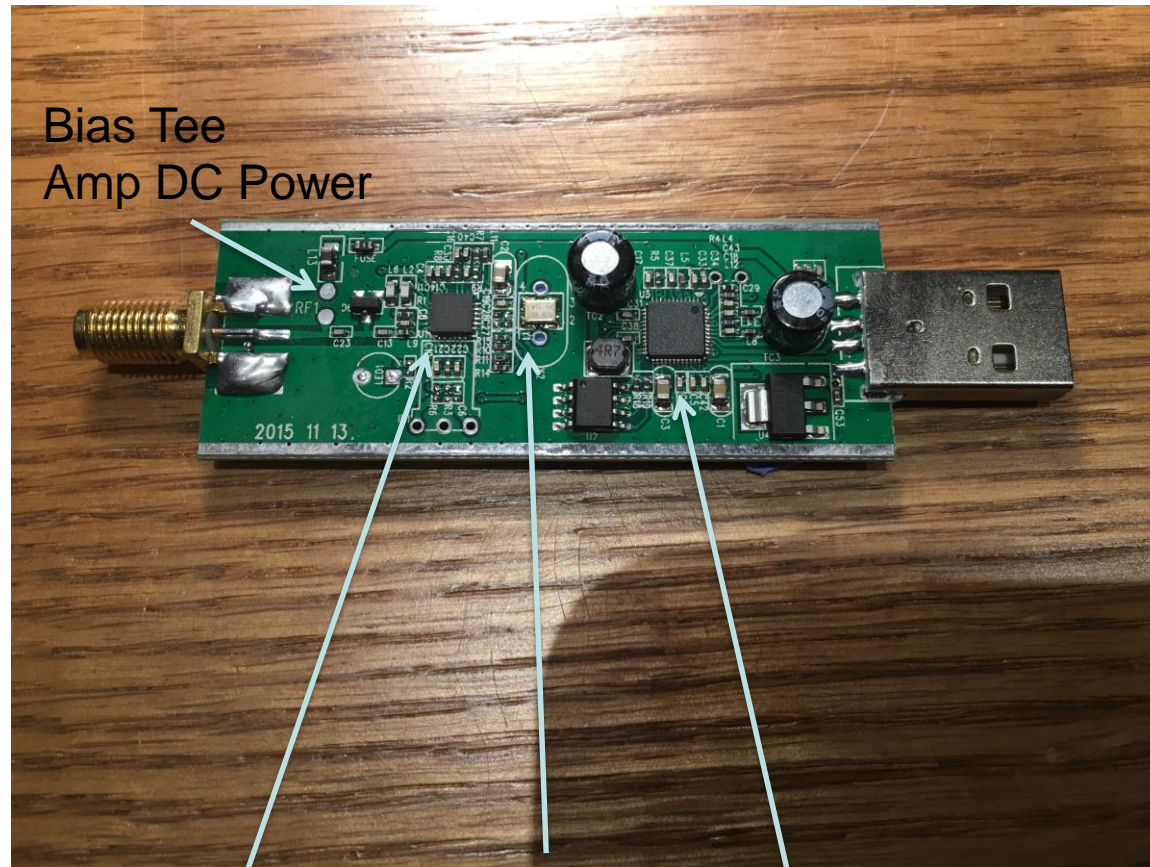
Bias Tee
Amp DC Power

Clock

A/D Converter
Analog – Gain Adjustment

Computer

Reads A/D Converts to USB format

R820T2   Note RF1 pads to bridge to have 5V Bias Tee operational.
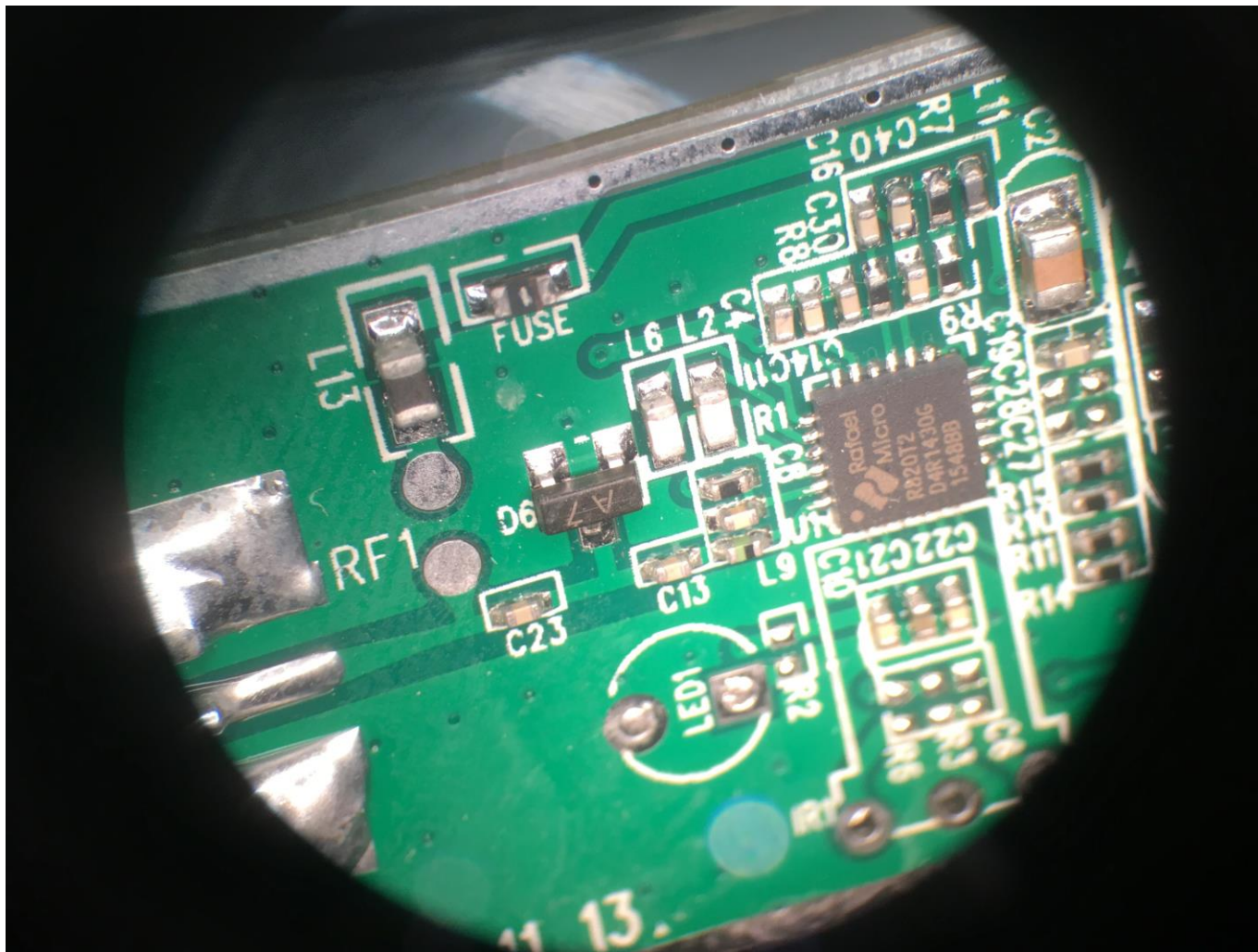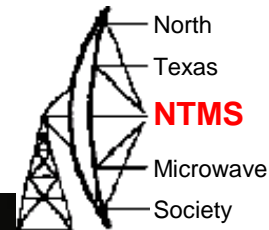
Using Raspberry Pi + RTL
To View RF Spectrum

- After installing necessary programs to run rtl_power_fftw the following command line will give you a spectrum view of the band selected:

```
rtl_power_fftw -f 900M:950M -n 10 -b 512 -c -q |    sed -u '/rtl-power-fftw/s/.*/
plot "-"/;/^$/{N;s/^\n$/e/}' |    gnuplot
```

- The frequency range here is 900 MHz to 950 MHz.

- The output of rtl_power_fftw is piped to sed and then piped to gnuplot for display.

Logging Spectrum Activity

- Rtl_power can be used to log RF power in a defined band of spectrum to a comma delimited file. The resulting file can be studied later of viewed as a JPG or PS file by processing the data with a program called heatmap.py. Use the Ubuntu Mate Graphics Application 'Eye of MATE Image Viewer'.

- Be careful about filling up your system memory with large data files. Save data to an externally mounted thumb drive to be safe.

Examples of commands needed:

```
rtl_power -f 900M:930M:100k /media/users_name_here/UBUNTU_1/900mhz_$mytime.csv -i 1
```

Stop data collection with CTRL C then process file with:

heatmap.py 900mhz_time.csv 900mhz_time.jpg

Then use the Application 'Eye of MATE…' to view the waterfall type image.

Using RTL to log RF

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Example of logging
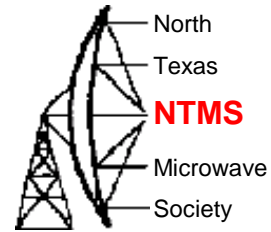
Threejs-Spectrum (Chrome) (Free) (Related Post)
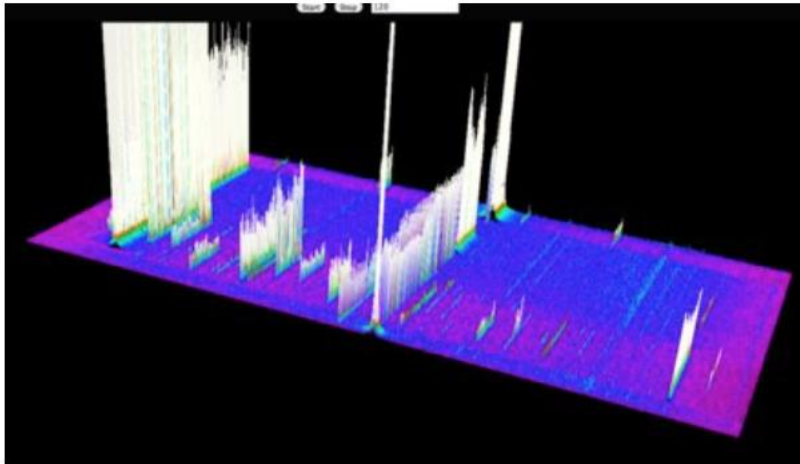
Chrome 3D Frequency Spectrum for RTL-SDR

To log to a CSV file:
Rtl_power –f 904M:908M:100K /log/filename.csv   -I 1

GQRP on Pi

RTL-SDR Applications

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http://www.rtl-sdr.com/big-list-rtl-sdr-supported-software/
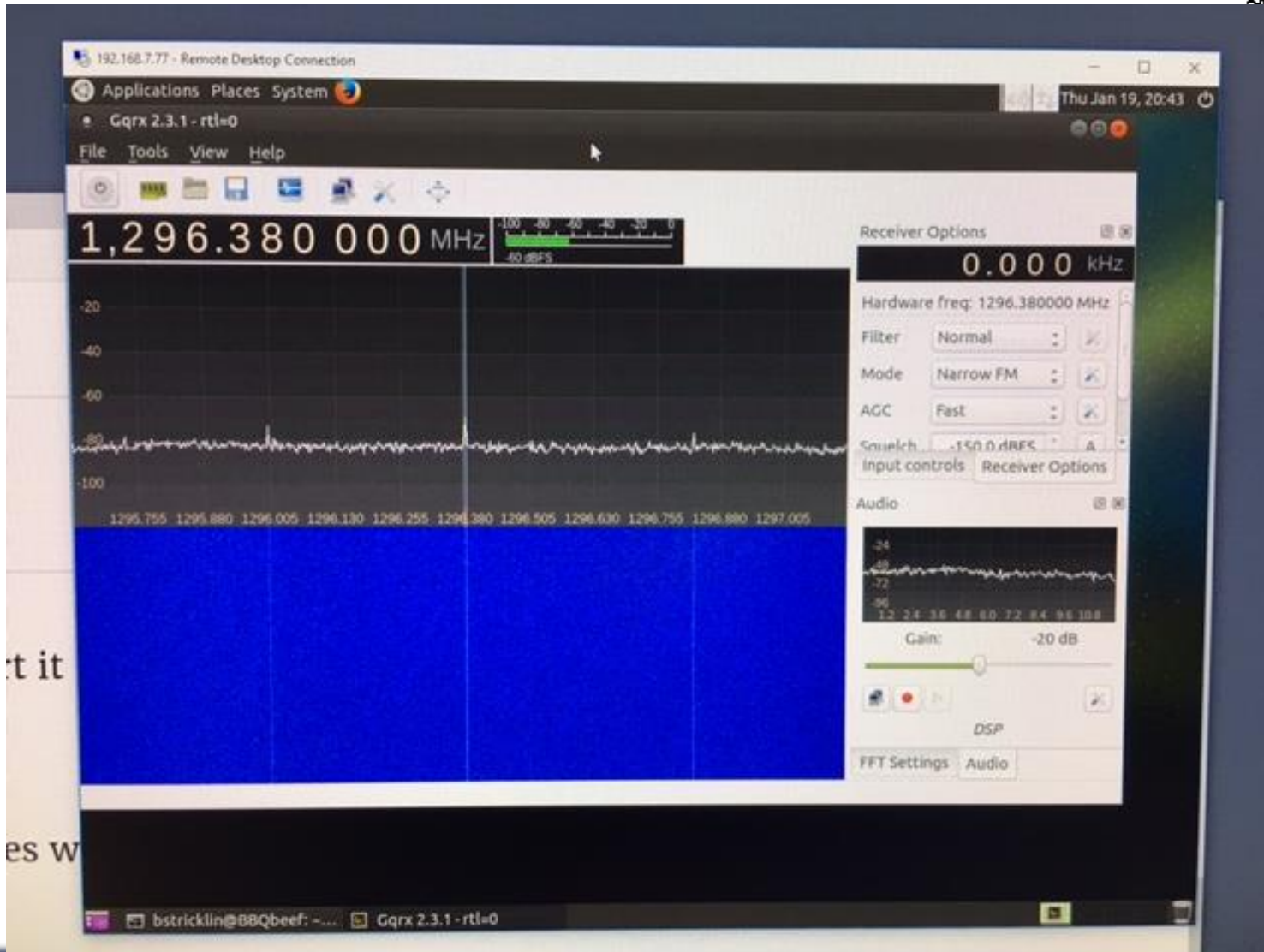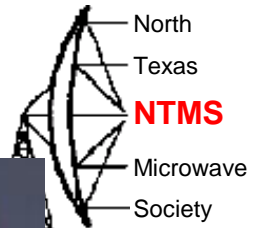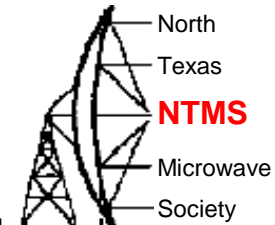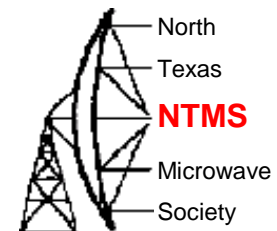
13/02/2014 – Added Sodira, gr-wmbus, rtlsdr-waterfall, QTRadio, multimon, sdrangelove, lte-scanner, rtl_tcp, rtl_sdr_FS20_decoder.

17/02/2014 – Updated the Linrad description.

28/04/2014 – Added Modesdeco and Trunk88.

30/05/2014 – Added RTL Panorama, RTL SDR Panoramic Spectrum Analyzer, Chrome Radio Receiver, SeeDeR, DAB Player, RTL SDR Installer, PD/Max Wrapper, SDRWeather, LTR Analyzer, softEOT/softDPU and ScanEyes.

26/07/2014 – Added PiAware, OOK-Decoder, rtl_fm_python, rtl_power heatmap viewer, RTL Bridge, threejs-spectrum, CANFI Software, PNAIS, FLARM Decoder, Xastir, RTLSDR-Airband, SDRTrunk.

13/11/2014 – Added Touchstone, RFAnalyzer, RTL1090 XHSI Interface, Parus Decoder, PlotRTL1090, LRPT Decoder.

05/02/2015 – Added rtl_tool_kit, CubicSDR, OregonWeather, FreqWatch.

15/04/2015 – Added ADSBox, YouSDR, FlightAware Flight Feeder, Frequensea, Track your flight EUROPE, QSpectrumAnalyzer, Doppler & Demod, Redsea, rtl_heatmap, gr-gsm, driveby, SDRecord.

23/12/2015 – Added Remote rtl_udp, AISRec, dump978, AISDeco2, SDRrecorder, OpenWebRX, dsame, RTL-Widespectrum, rtl_ais, rtl_gopow, ham2mon, rtl_ais_android, inmarsatdecoder, spektrum, qtcsdr, rtl_power_fftw, JAERO, GNSS-SDRLIB, SVxLink.

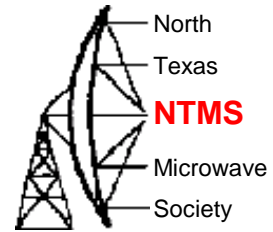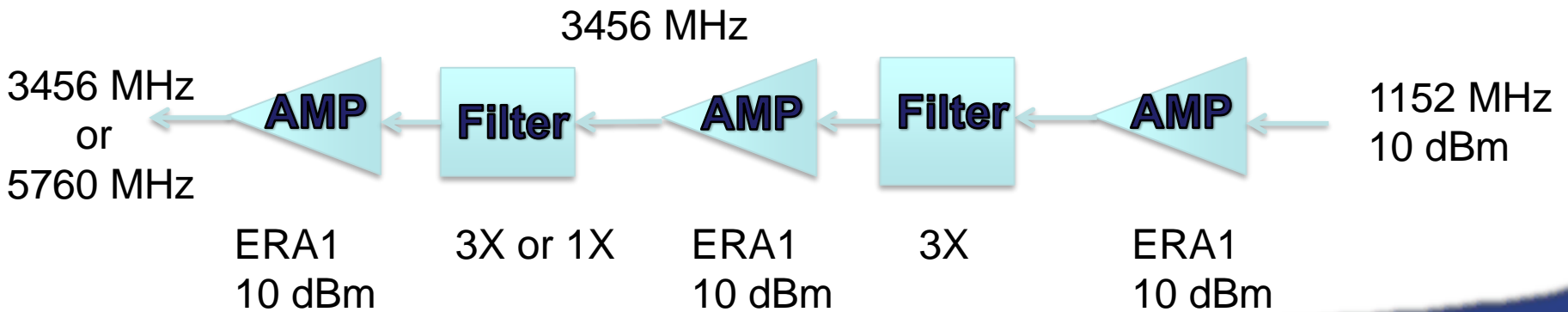# Microwave Radio Receiver

RTL-SDR + Pi

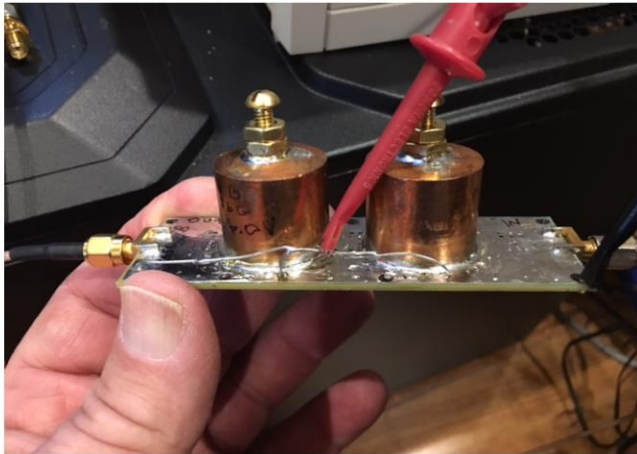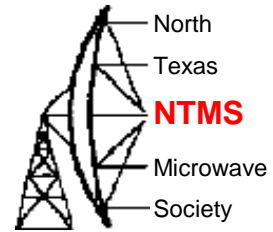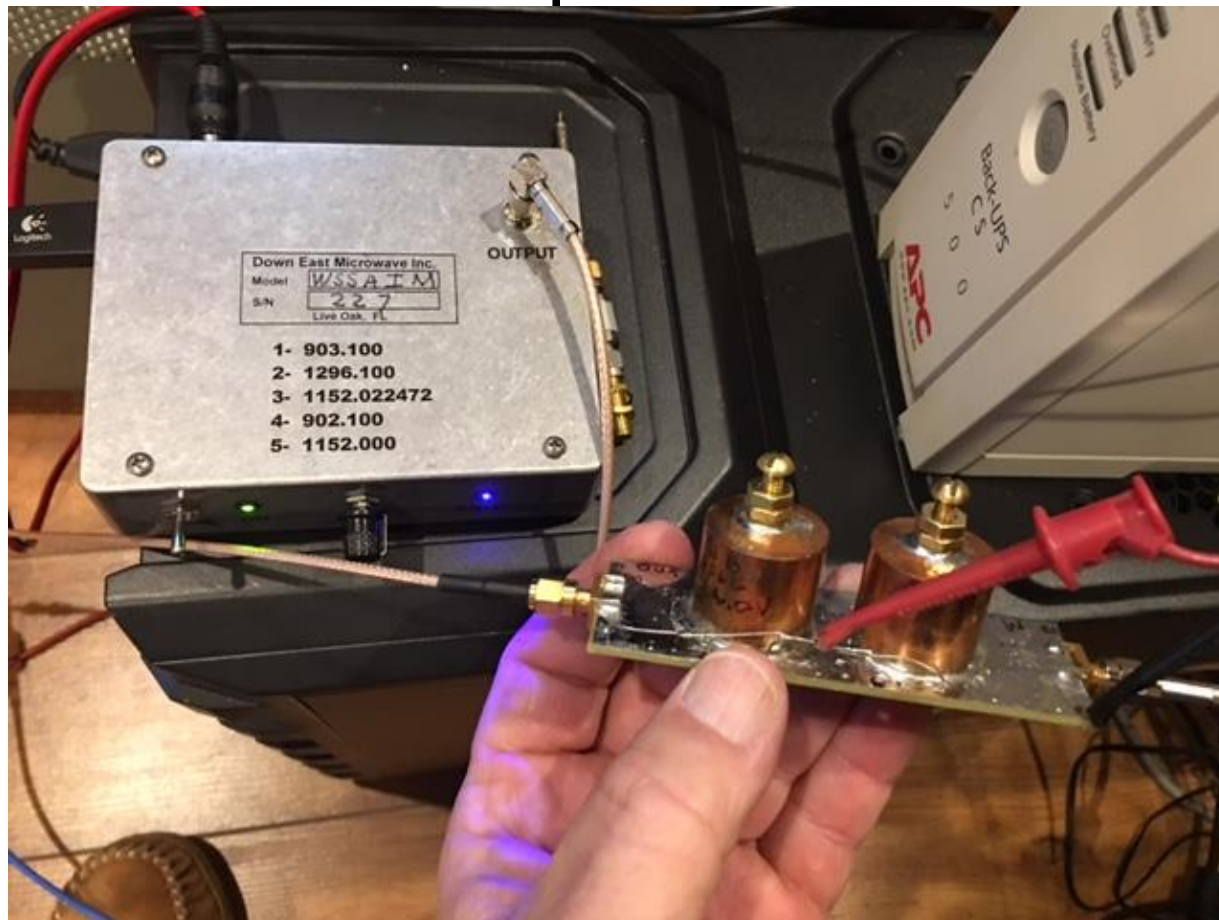# Spectrum 1.401 GHz to 1.403 GHz

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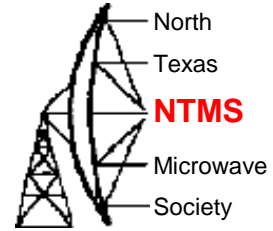
N=100
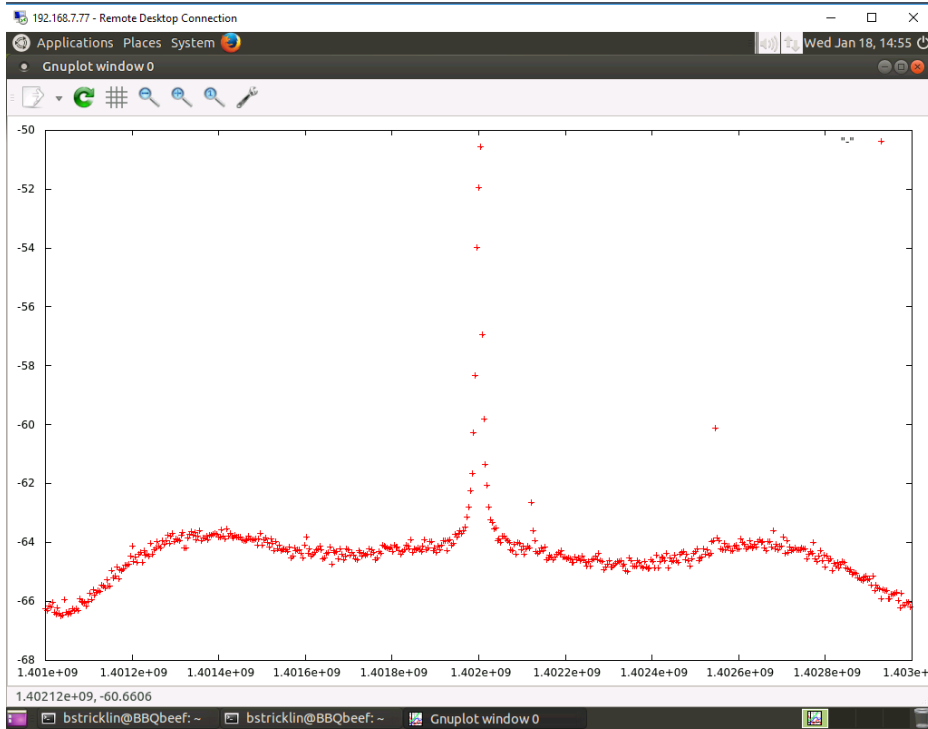
N=10
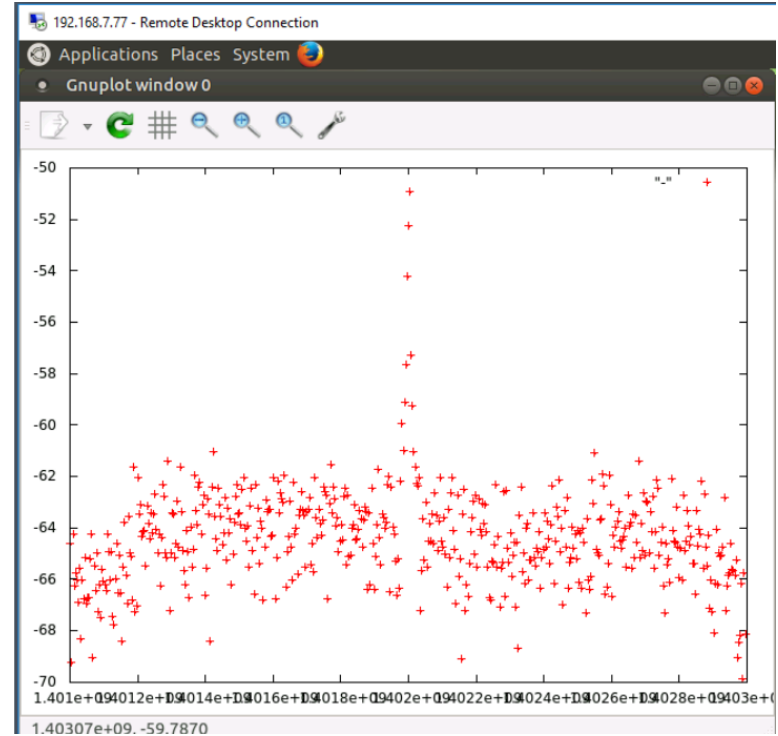
Spectrum 495 MHz to 505 MHz

W1GHZ Personal Beacon

3456 MHz

3456 MHz or 5760 MHz ← **AMP** ← **Filter** ← **AMP** ← **Filter** ← **AMP** ← 1152 MHz 10 dBm
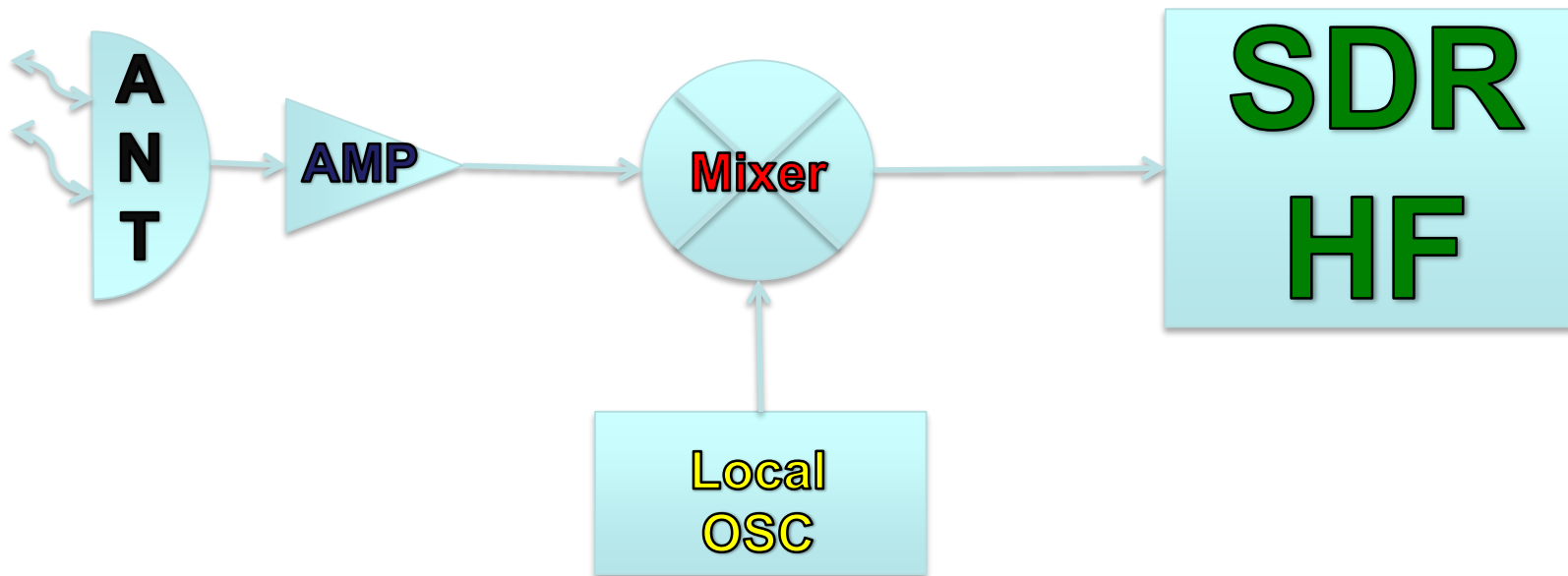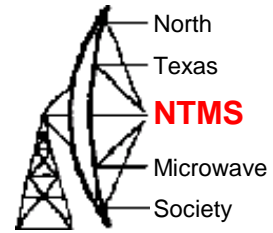
ERA1 10 dBm   3X or 1X   ERA1 10 dBm   3X   ERA1 10 dBm
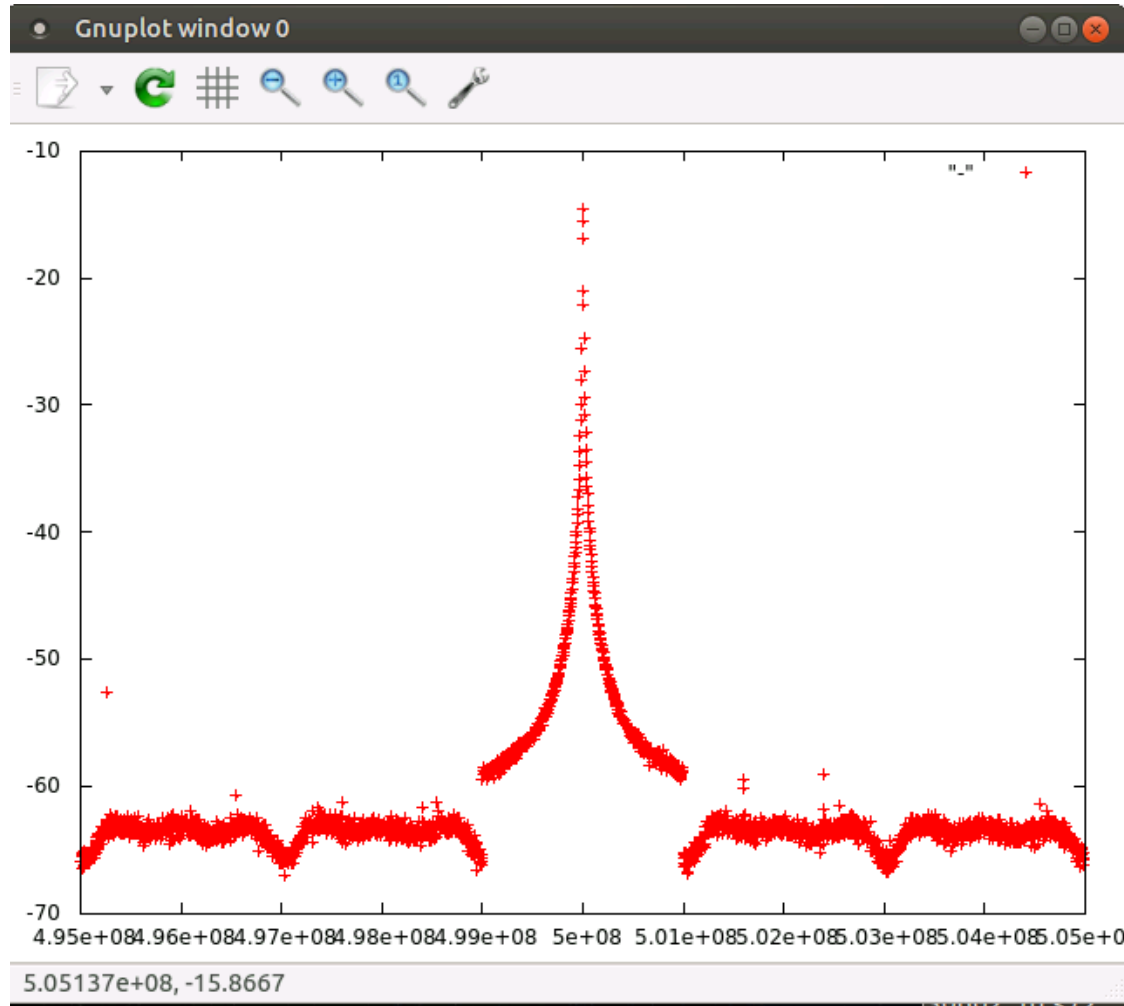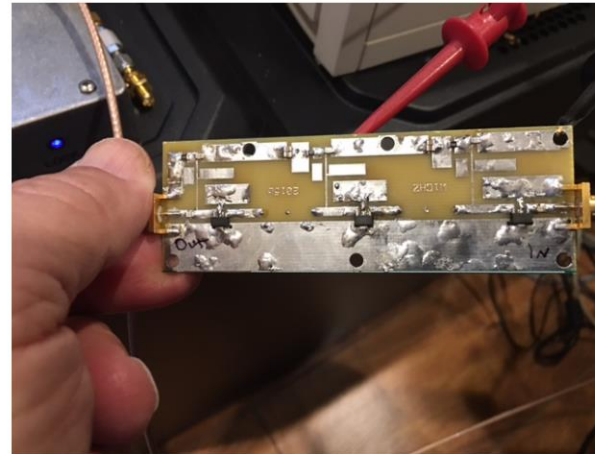
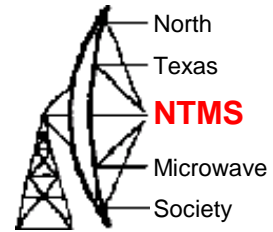# Down East Microwave Frequency Reference - Steve Hicks N5AC ApolLo
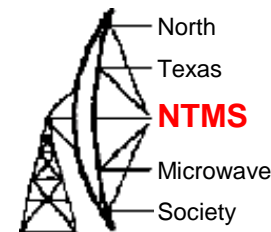
http://01895fa.netsolhost.com/PDF/Manuals/VHFApolLO_Operation.PDF

Microwave Radio Receiver

ANT → AMP → Mixer → SDR HF

Local OSC → Mixer

Mixer   LO + RF = IF - 20 dBm
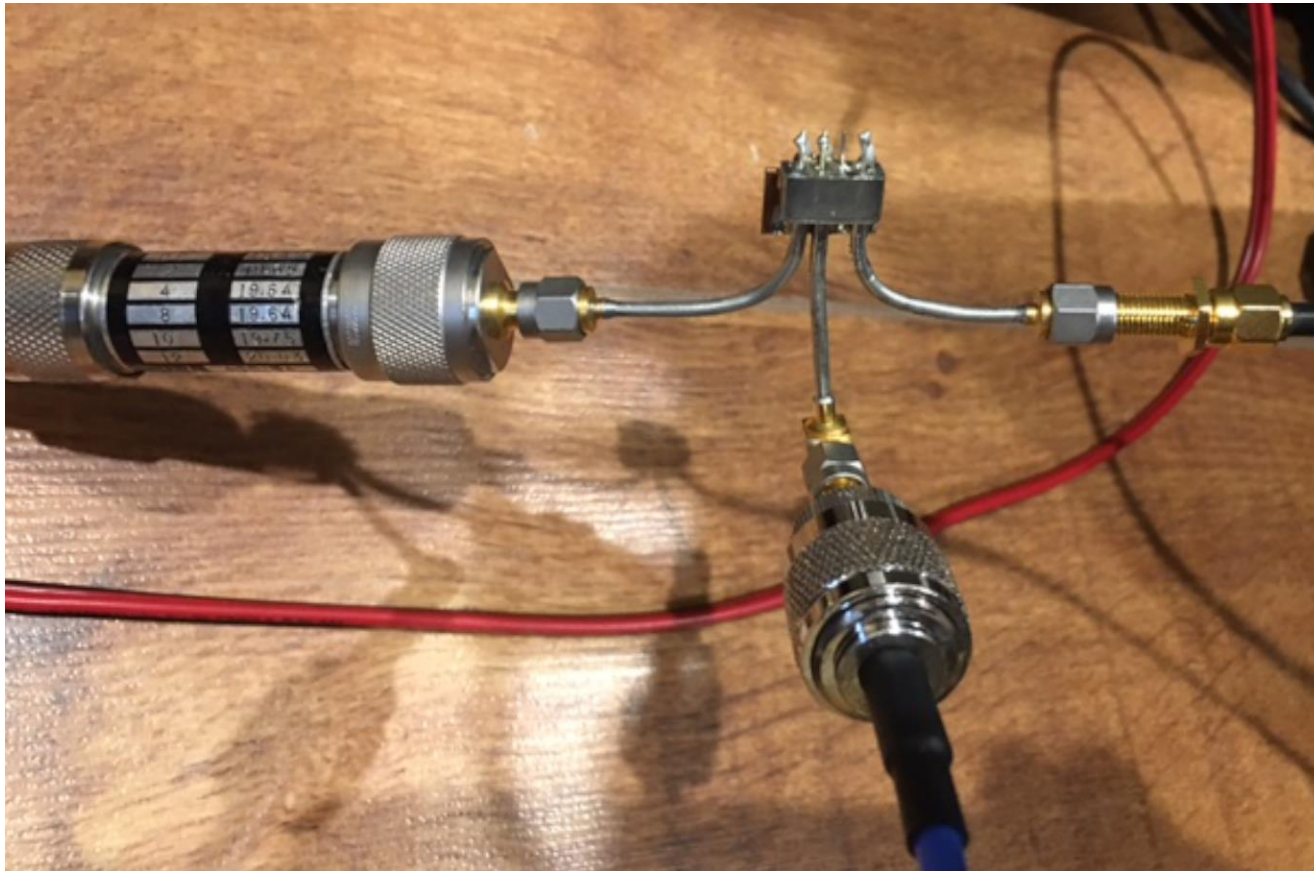
Using Mixer and 3456 Beacon
LO = 2456 → IF = 1000 MHz
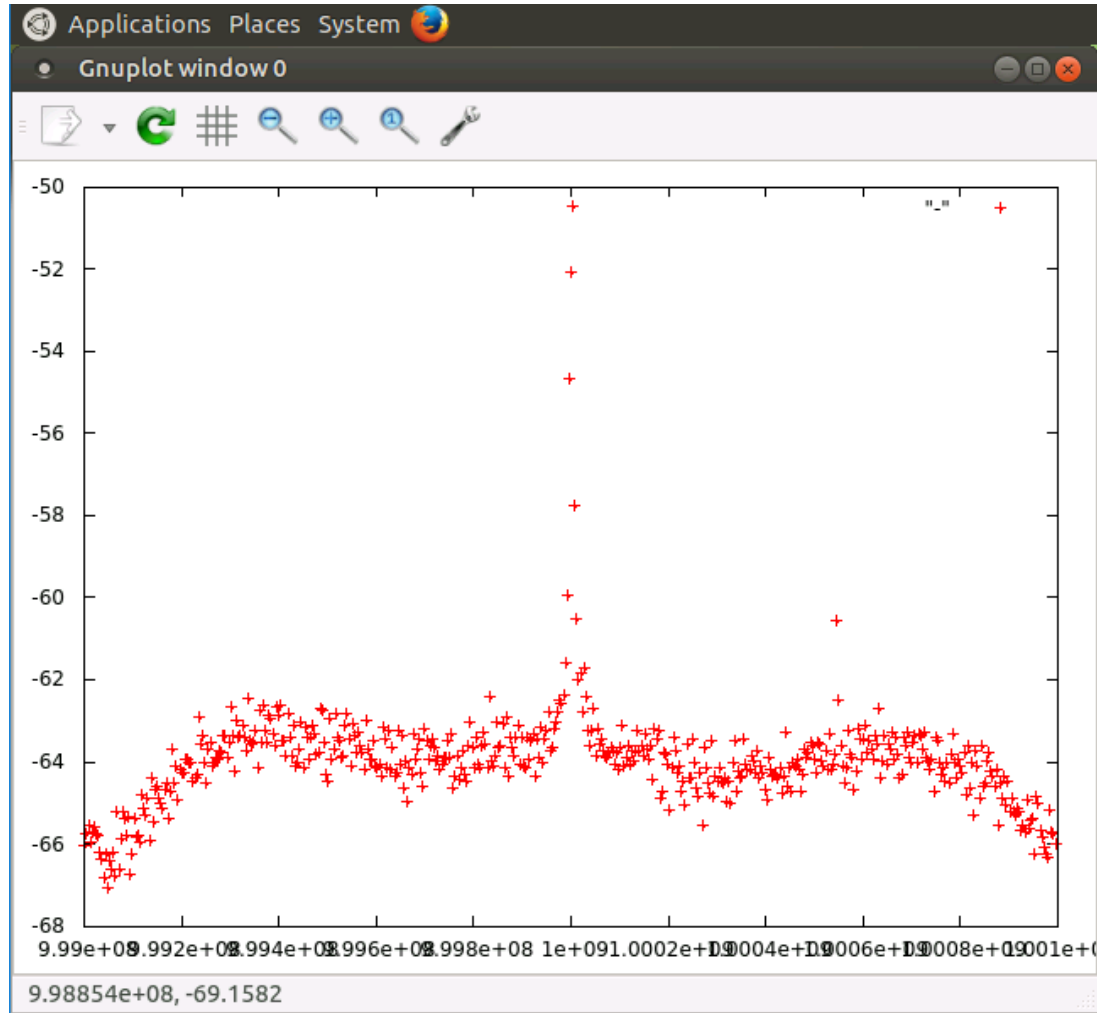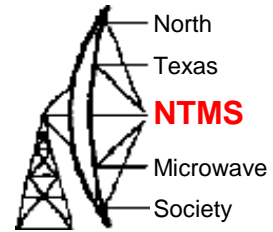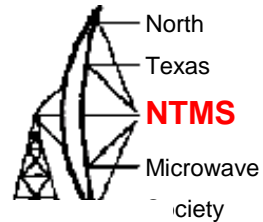
10.368 GHz Personal Beacon

Transverter Example
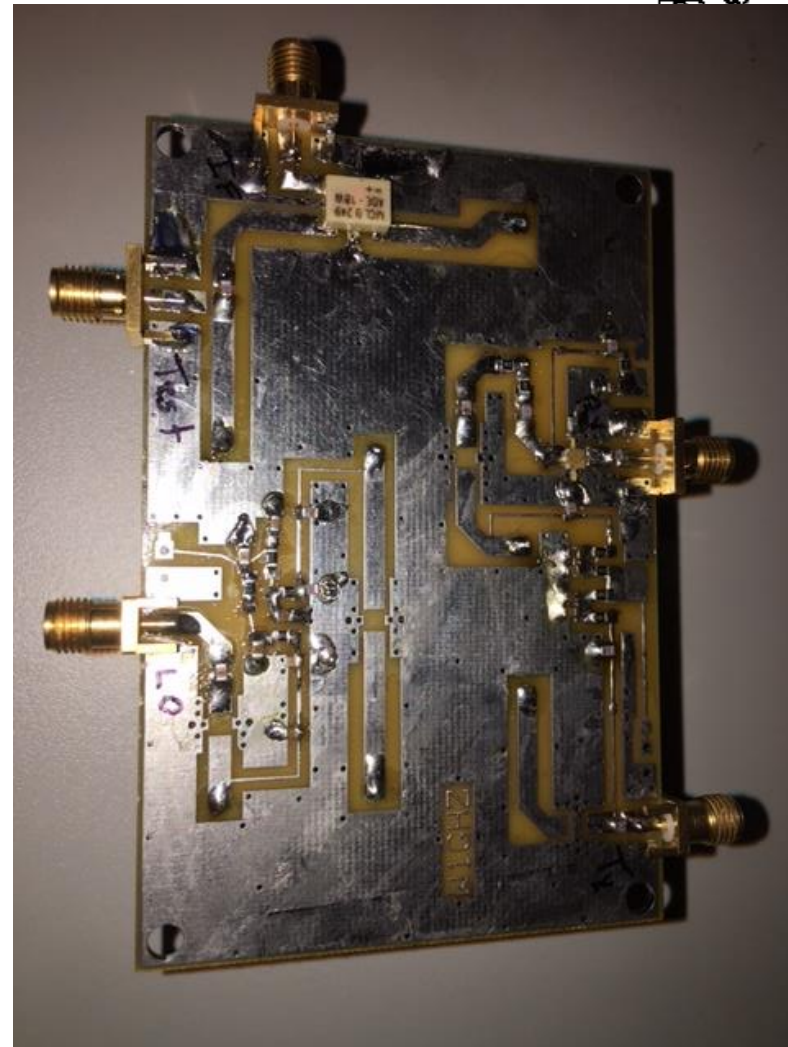
5760 Transverter

Paul Wade W1GHZ PCBs

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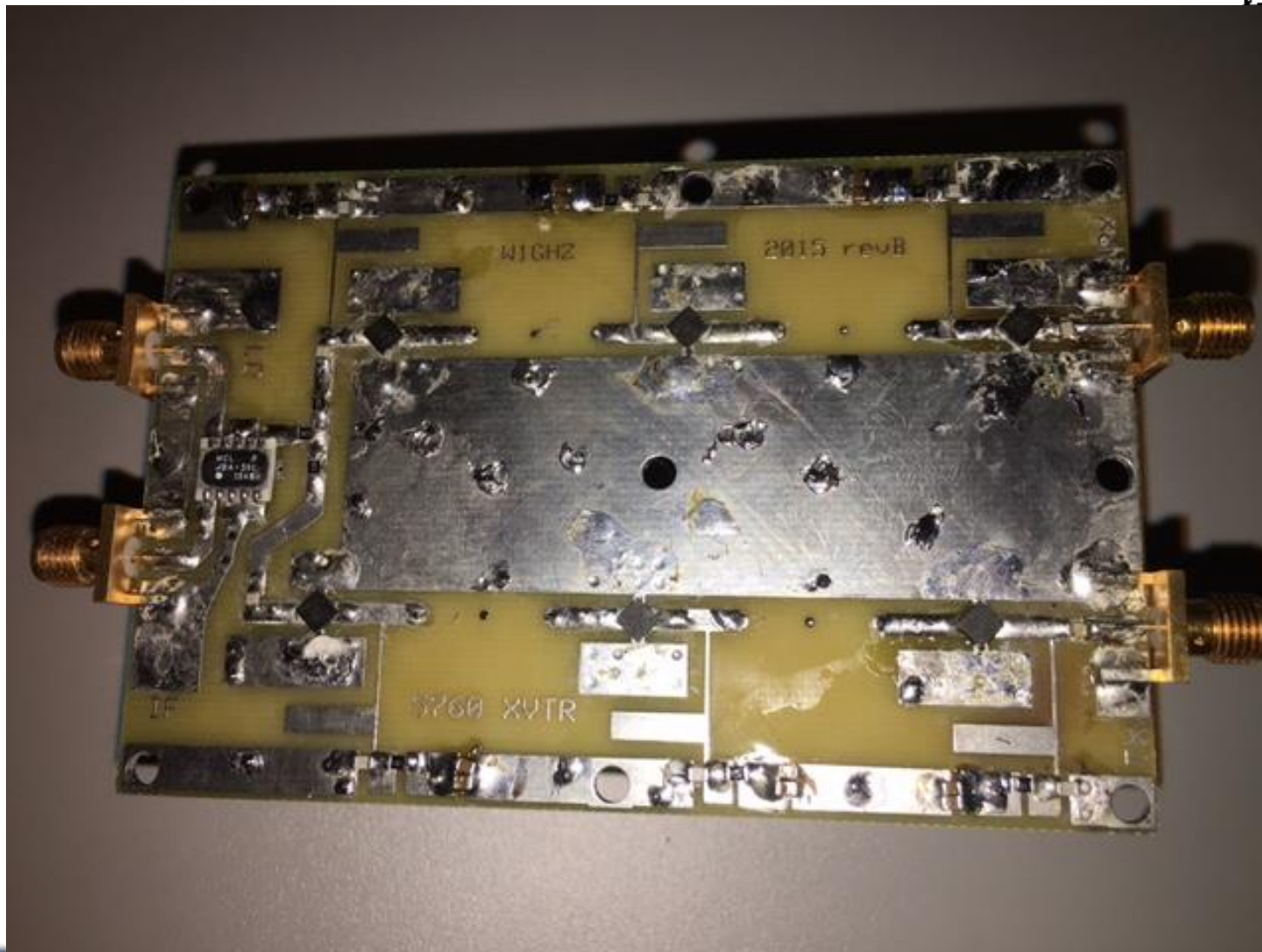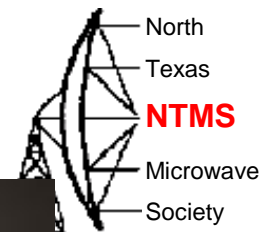
_____ Simple, yet "Fool-Resistant" Sequencer, RevisionB $5

_____ Simple Low-cost 5760 MHz Transverter for Rover $11

_____ MBA-591 Mixer for 5760 Transvert $10

_____ LO or Personal Beacon for 5760 or 3456 MHz $6

_____ VCXO lock for Microwave LO - flexible version $6
with prescaler good to 1.1 GHz
_____ 80 MHz version for Multiband Transverter $3

_____ Flexible VCXO Lock (GPS or other reference) $6
Low frequency version (<30 MHz)

_____ Modest Power Amplifier (GVA-84) $3.00
                two for $5
_____ ADL5324 Power Amplifier and PGA-103 preamp $3.50
                three for $10

_____ Panadapter for FT-817 and Funcube Dongle $3.50

_____ Miniverter-F tiny 144M transverter for Flex-1500 $6
see kits below
_____ ADE-2 for VHF and UHF $5

_____ Personal Beacon for 10 GHz $6

Multiband Microwave Transverter for the Rover:
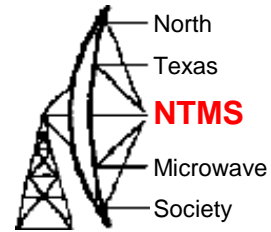see http://www.w1ghz.org/new/Multiband_Rover_Transverter.pdf

_____ Local Oscillator Board 720 or 756 MHz $12

_____ Transverter Board for 2304 or 3456 MHz $10
_____ ADE-18W mixer for 2304 and 3456 $5

_____ Transverter Board for 1296 (right side up only) $10
_____ uses Power Splitter (Minicircuits TCP-2-25x) $3
_____ ADE-5 mixer for 1296 or 902 $5

_____ Local Oscillator Board 1152 MHz $12

_____ Transverter Board for 902 $10

_____ LO Board + one transverter board (choice) $20

_____ LO Board + two transverter boards $29

_____ LO Board + three transverter boards $37

_____ Relay board (pin and surface mount)   out of stock

Mixers from Minicircuits (only available with boards):

_____ ADE-18W for 2304 and 3456 $5

_____ ADE-5 for 1296 or 902 $5

_____ ADE-2 for VHF and UHF $5
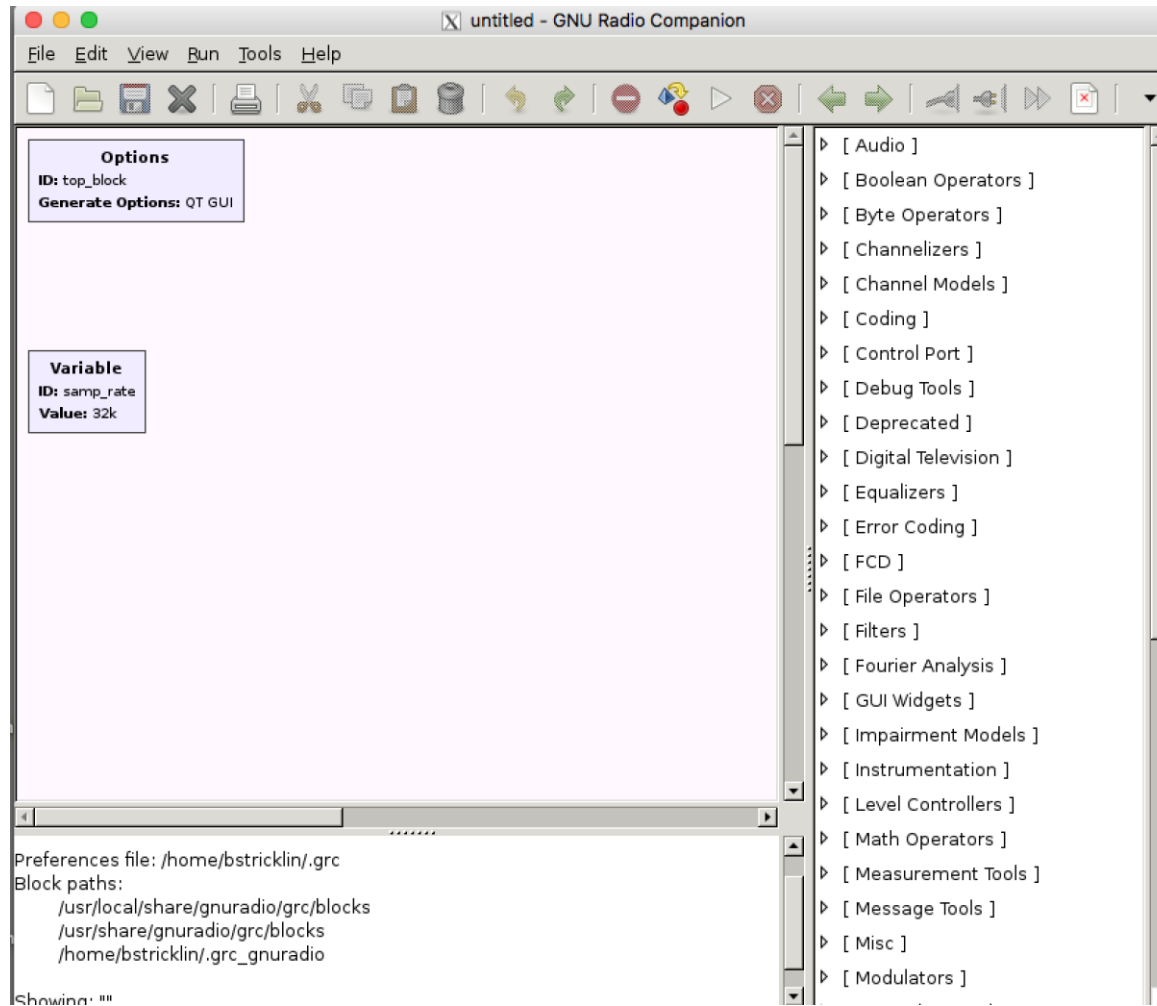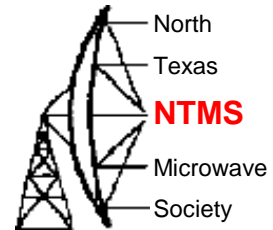
_____ MBA-591 for 5760 $10

Check w1ghz.org for availability pricing and shipping cost.
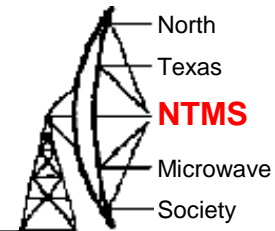
Other Learning Tools and Possibilities

- Installed GNU Radio on Ubuntu MATE using the command line:

- Apt-get install gnuradio

- After install completes you can launch with:

  Pi~$: gnuradio-companion

GNU Radio Companion

GNU Radio Model Construction

Output of GNU Radio Simulation

https://www.youtube.com/watch?v=bp9b0ozsboI

Microwave Radio using Software Defined Radio - SDR

W5HN

North
Texas
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Microwave
Society

LO

GPS Slave Clock

A **N** **T**

AMP

AMP

Mixer

A/D D/A Converter

SDR + Pi

100(0) MB

xx GHz

Microwave Transverter

HF – 10 Meters SDR

Tower

Antenna

100(0) MB

Shack
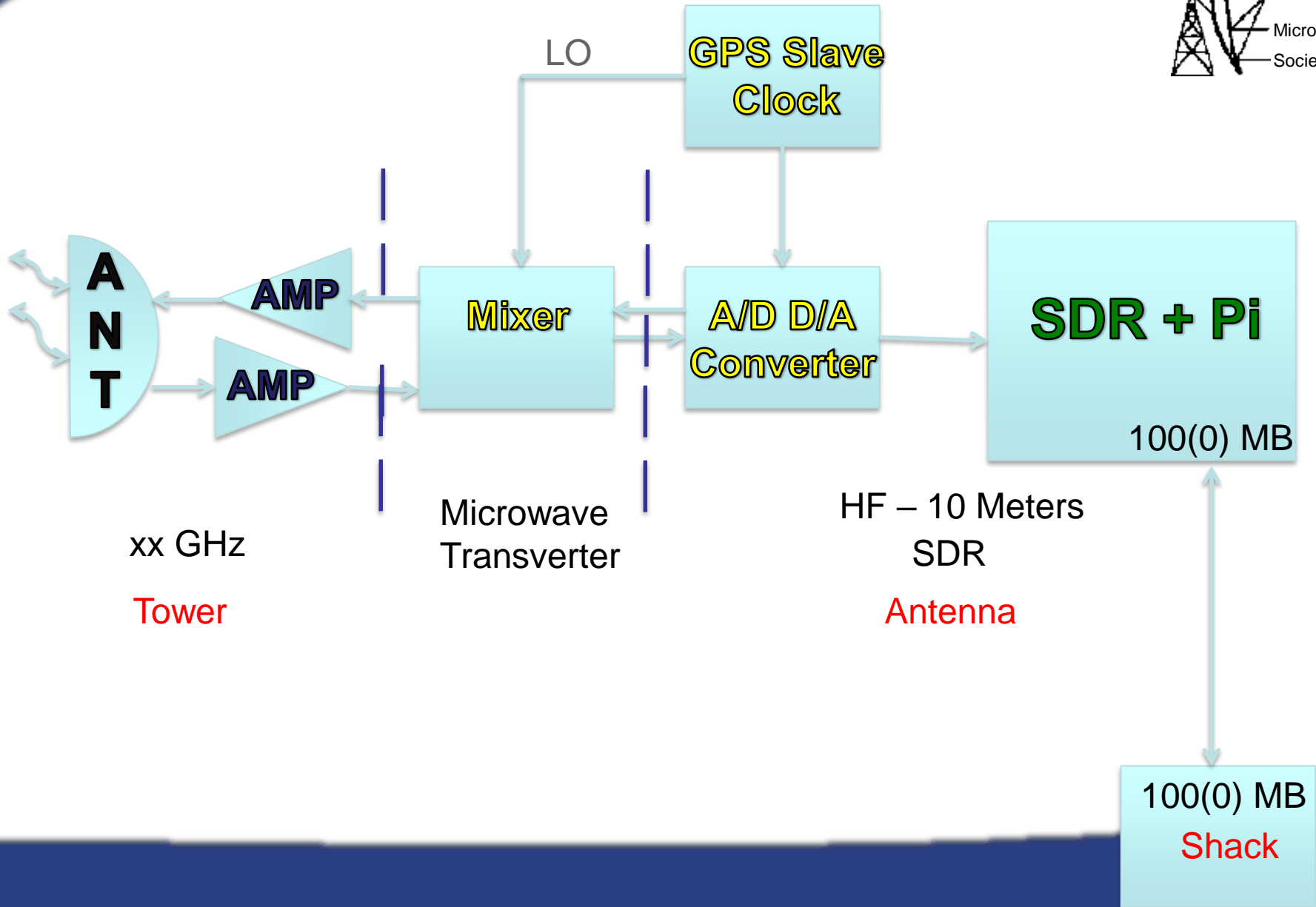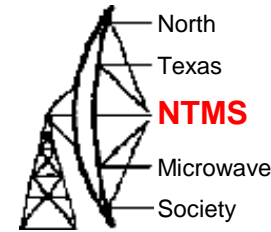
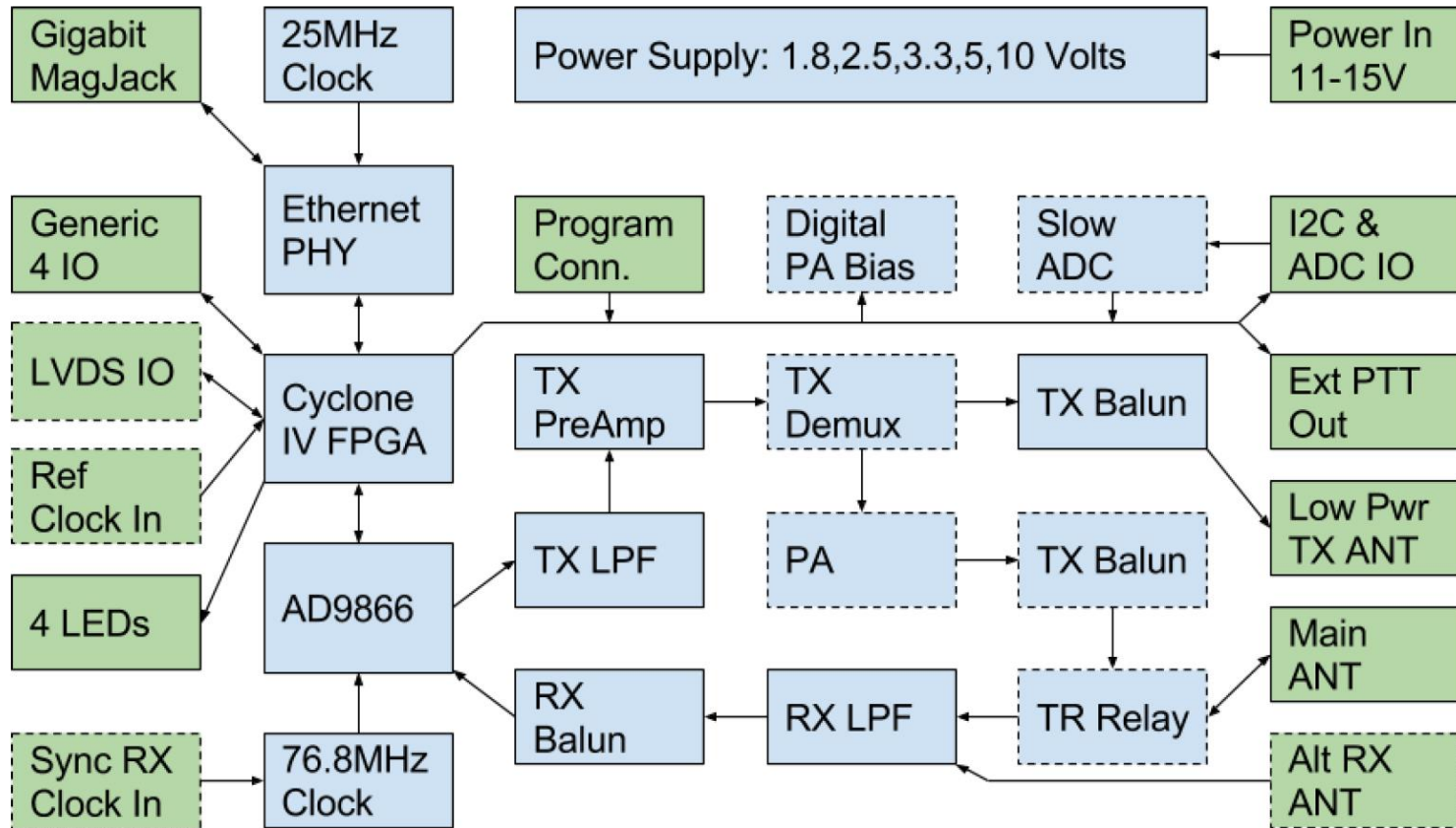# Analog Devices AD9866
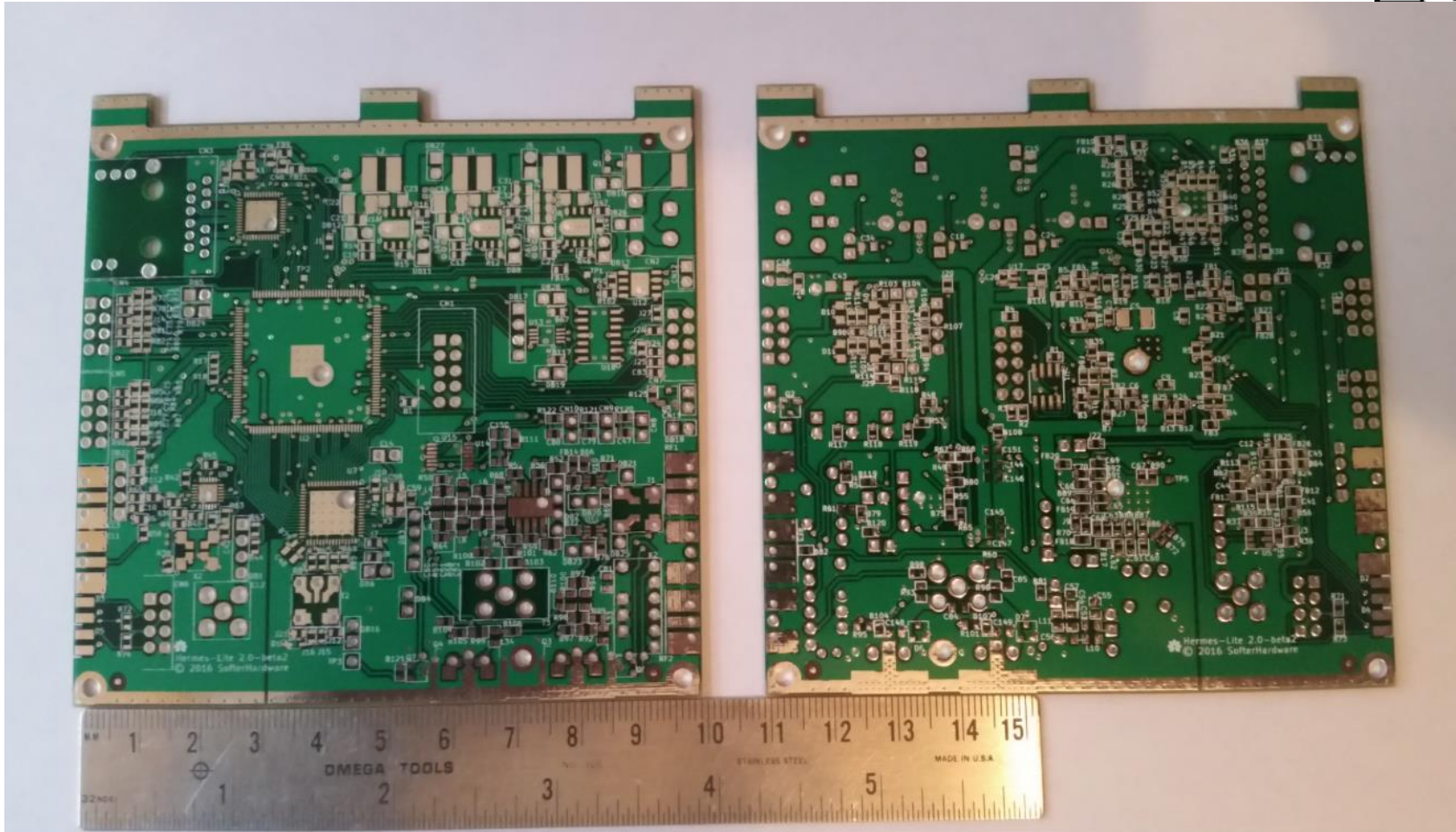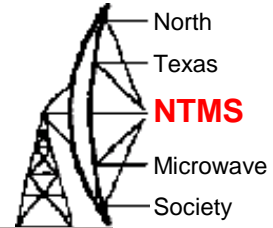# Mixed-Signal Front End (MxFE®)
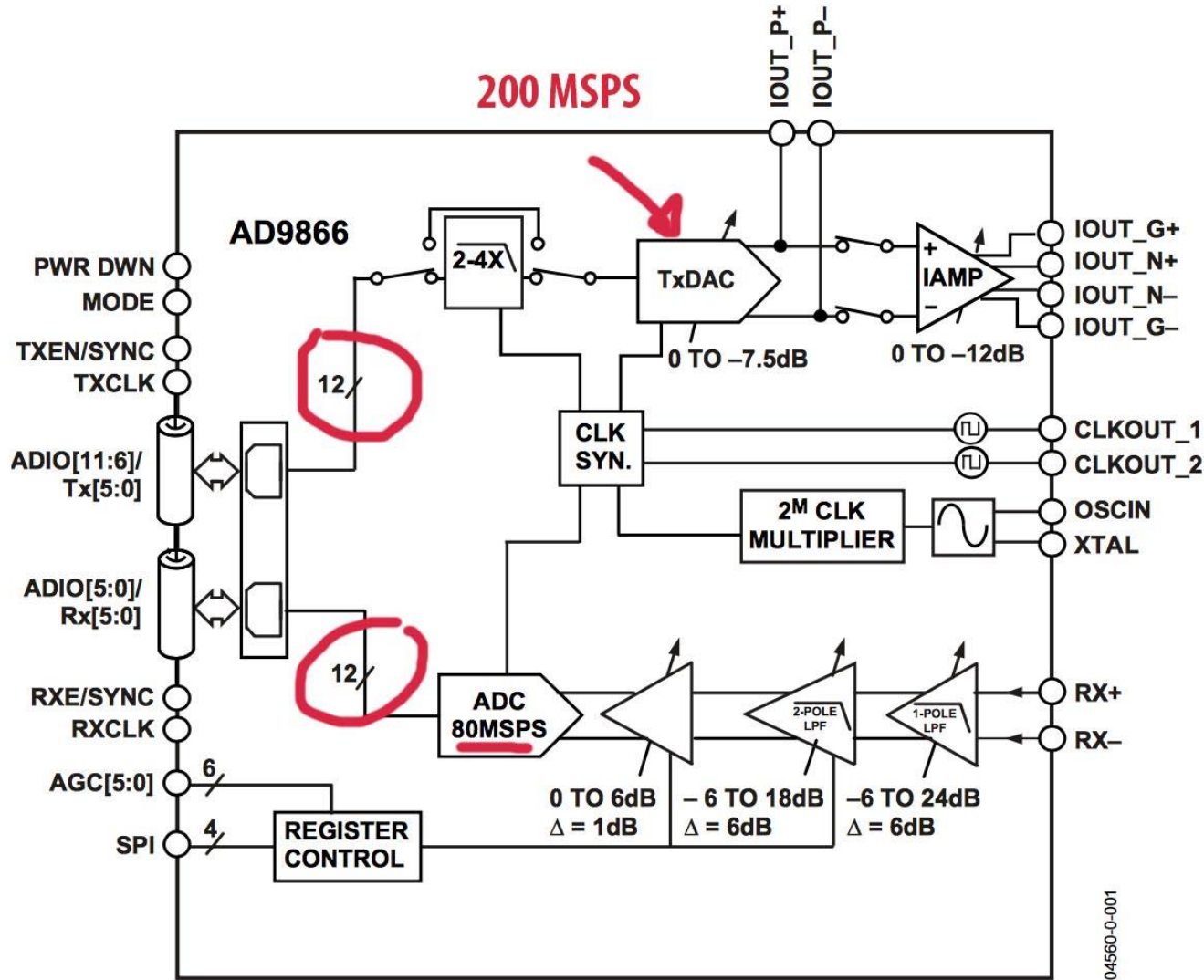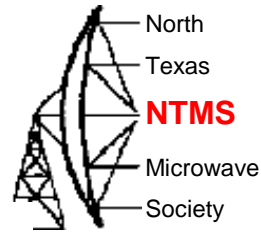
Figure 1.

Hermes-Lite 2.0beta2 Block Diagram

- Green boxes are external connectors
- Dashed boxes are common optional blocks
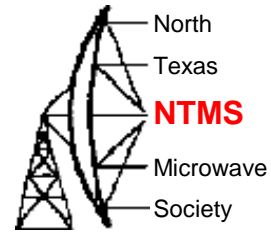- Additional external filtering required for TX to meet harmonic emissions regulations

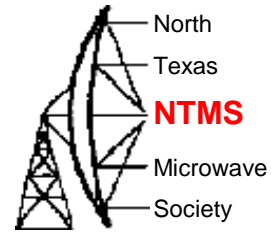KF7O Steve Haynal Schematics and Block Diagram

Hermes Lite 2 PCBs

Good links for more info:

- http://kmkeen.com/rtl-power/
- http://www.rtl-sdr.com/tag/rtl_power/
- http://www.rtl-sdr.com/tag/r820t2/
- http://sdr.osmocom.org/trac/wiki/rtl-sdr
- http://www.hermeslite.com
- http://www.rtl-sdr.com/big-list-rtl-sdr-supported-software/
- https://sites.google.com/site/g4zfqradio/installing-and-using-hdsdr

Next NTMS Meetings

North
Texas
NTMS
Microwave
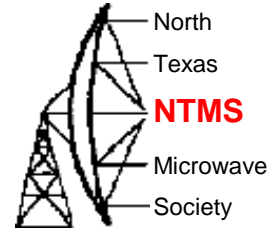Society
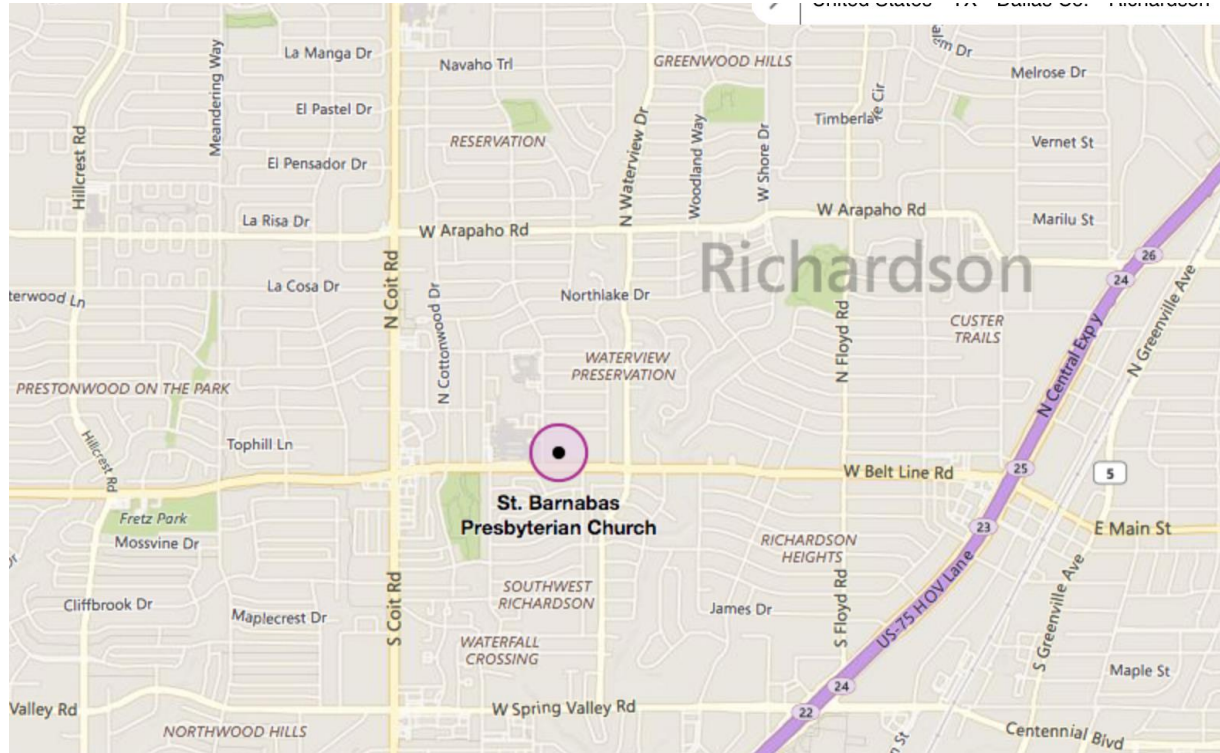
- First Saturday of the month.
- Announced on NTMS.ORG
- Next Meeting will be February 4, 2017 starts at 12:00 with discussions and presentations start at 1:00 PM.

NTMS Meetings

North
Texas
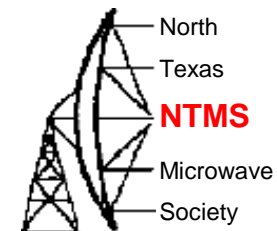**NTMS**
Microwave
Society

1220 W Belt Line Rd, Richardson, TX 75080

1st Saturday each month

Feb 4th , Mar 4th, Apr 1st

NTMS Topics and Plans

North
Texas
NTMS
Microwave
Society

- Discussion on Members Projects

- More on GnuRadio

- Testing results of W1GHZ Personal Beacon and other projects

- Discussion of January VHF contest results

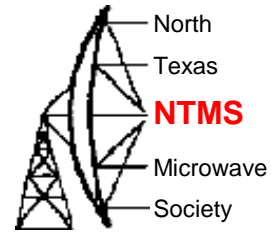- Planning for 10 GHz contest operations

Big Ham Radio Events

- Local Hamfest
- Dayton Hamvention - May 19-21
  - 4 Days in May - QRP
  - TAPR AMSAT Events
- Microwave Update – MUD - San Jose Ca. Fall
- VHF Society Meetings – CSvhfs.org – July 27 2017 – Albuquerque NM
- EME conference – 2018 – Netherlands

(Many Videos on Web of past events.)

W5HN

North
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Microwave Information Resources

- NTMS.org   ARRL.org   W1GHZ.org

- Dubus Magazine

- UK Microwave Group

- Ham-Radio.com/SBMG   SLAM