A Cheapskate's SDR

"On a stick"

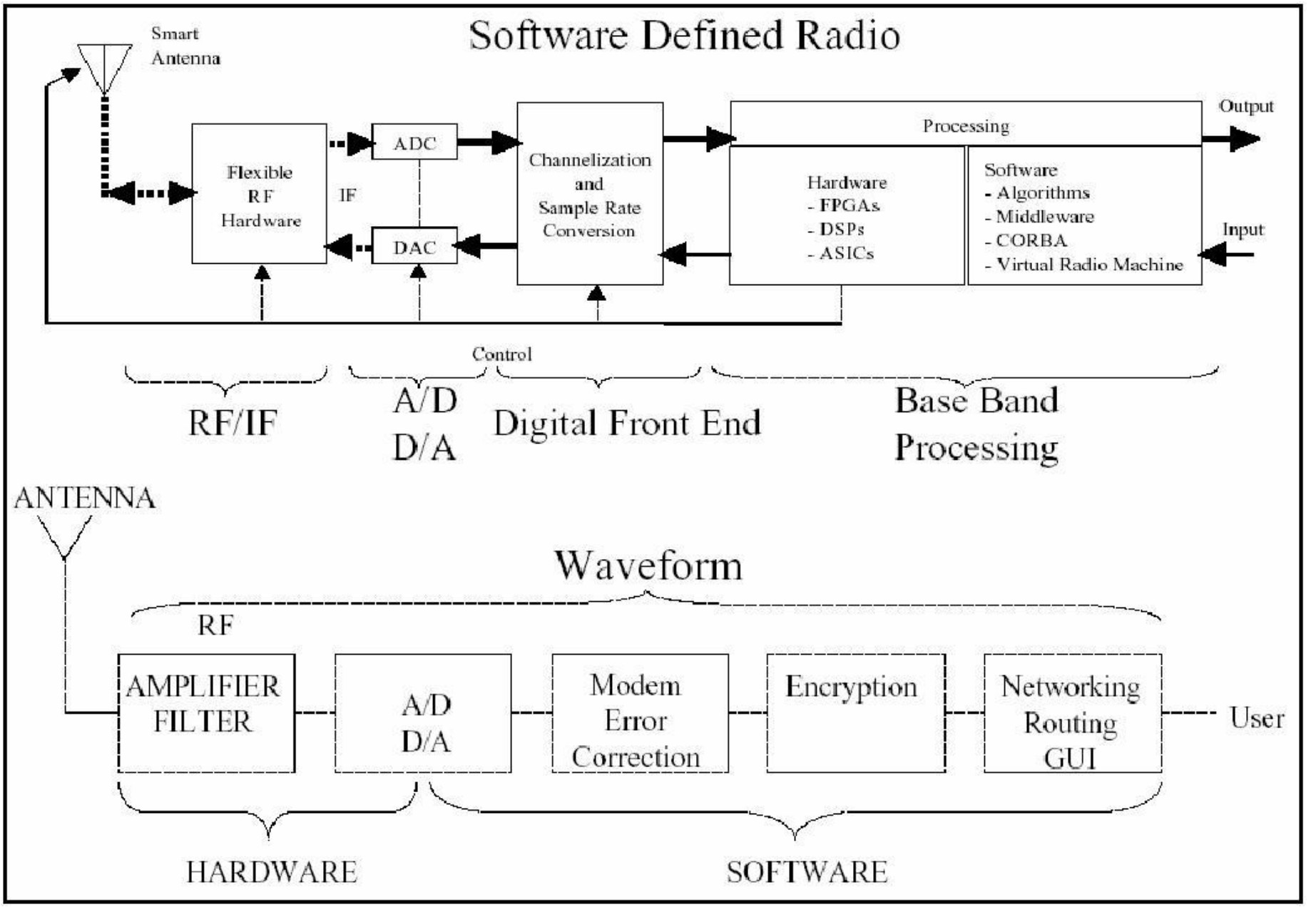
Bruce Ratoff, KO4XL

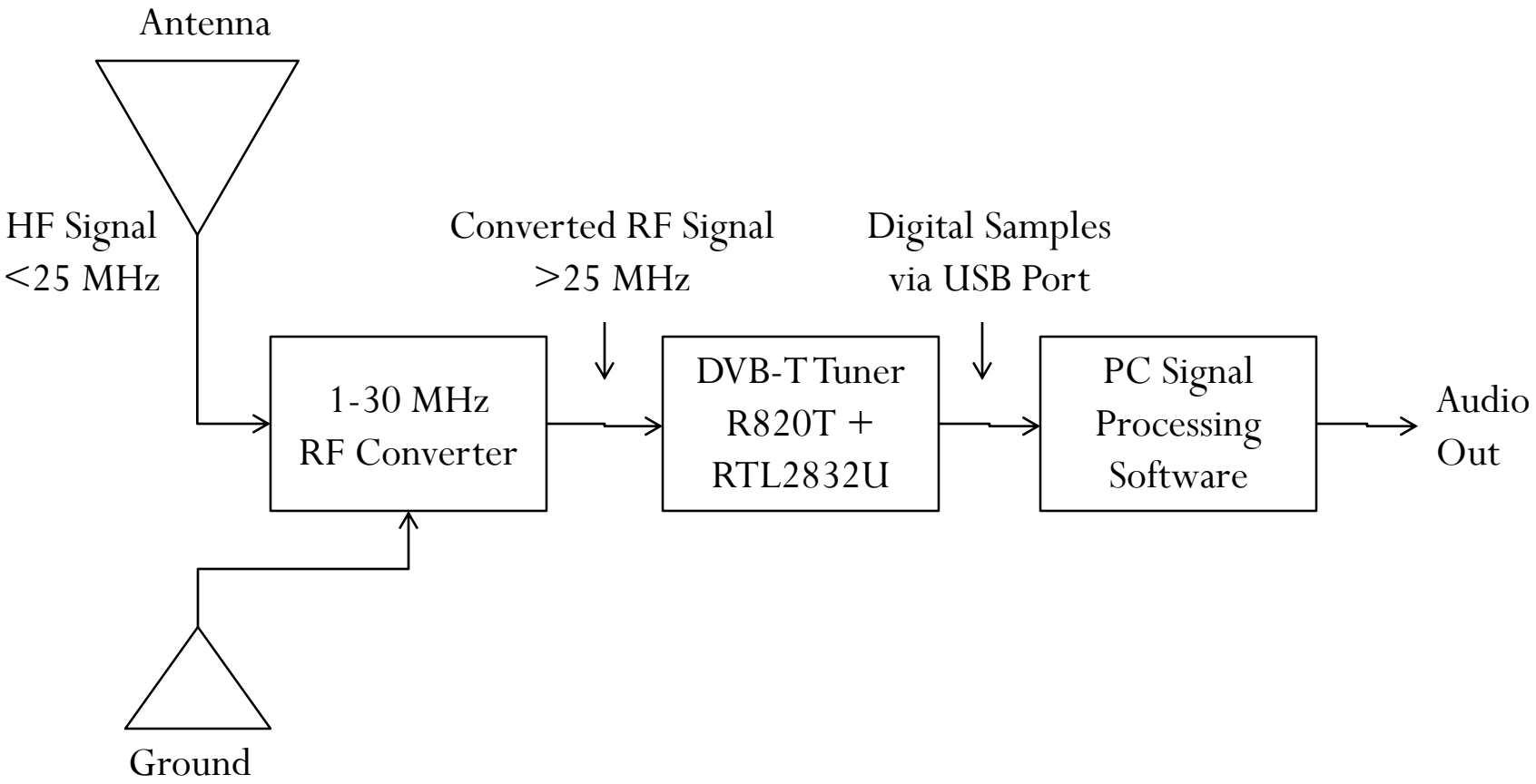
Why?

- Low cost entry to SDR world
  - Experiment with SDR without a major investment
  - Free software
  - Receive only
- Compact and Portable
  - Small laptop computer
  - DVB-T USB stick
  - Simple HF adapter (in an Altoids can, of course!)
- Simple
  - Works reasonably well with random wire antenna
  - VHF/UHF does not need adapter
- Inspired by article in July 2015 Nuts and Volts

What is a Software Defined Radio?

- A radio system where traditional analog circuits (mixers, filters, detectors, modulators, etc.) have been replaced by software algorithms running on a PC or embedded processor
- Not a new concept, but has become much more feasible as LSI and PC technology has advanced
- Typical configuration:
  - PC with sound card - mainly for audio out
  - RF front end – converts RF to a stream of digital samples
  - Software
    - Control front end
    - Mathematical algorithms for signal processing

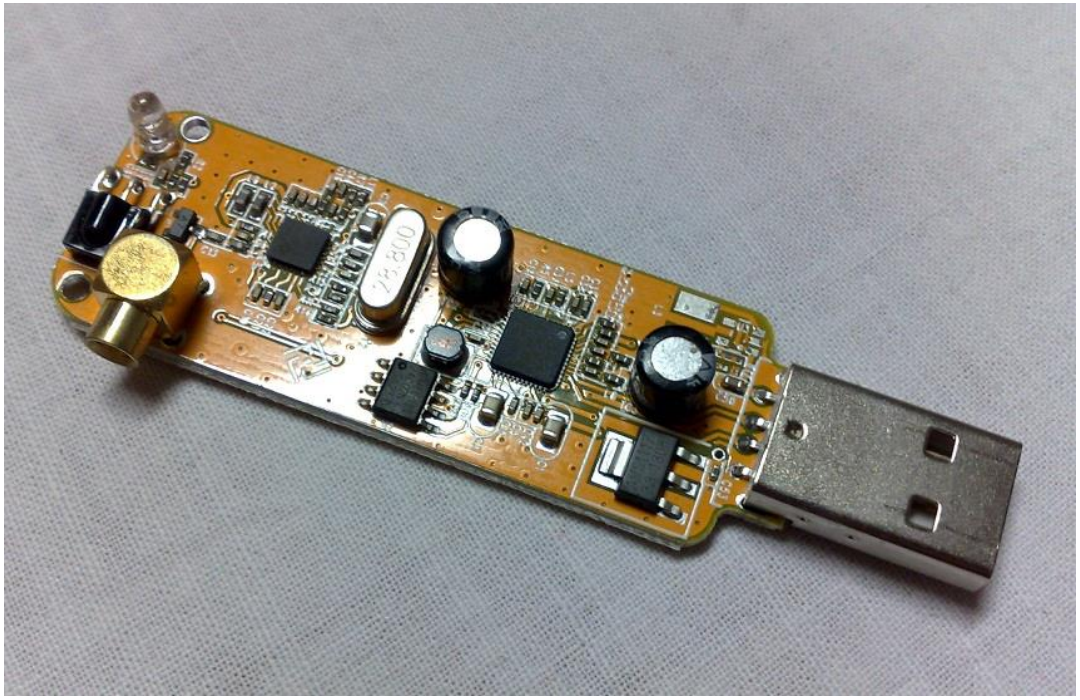

Software Defined Radio
Smart Antenna
Flexible RF Hardware
IF
ADC
DAC
Channelization and Sample Rate Conversion
Processing
Hardware
- FPGAs
- DSPs
- ASICs
Software
- Algorithms
- Middleware
- CORBA
- Virtual Radio Machine
Output
Input
Control
RF/IF
A/D
D/A
Digital Front End
Base Band Processing
ANTENNA
Waveform
RF
AMPLIFIER FILTER
A/D D/A
Modem Error Correction
Encryption
Networking Routing GUI
User
HARDWARE
SOFTWARE

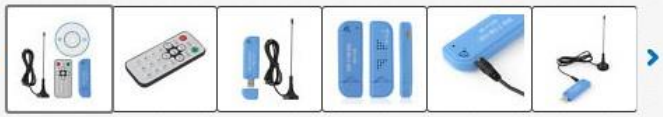

Antenna
HF Signal
<25 MHz
Converted RF Signal
>25 MHz
Digital Samples
via USB Port
1-30 MHz
RF Converter
DVB-T Tuner
R820T +
RTL2832U
PC Signal
Processing
Software
Audio
Out
Ground

DVB-T Tuner

- Originally intended for European TV / FM reception
- Can tune ~24 MHz - ~1.7 GHz
- USB 2.0 output
- Weird antenna connector (MCX) – requires pigtail
- IMPORTANT: Must be the right chip set!
  - Rafael Micro R820T tuner
  - Realtek RTL2832U controller / USB interface
- USB stick and pigtail ~ $10 on ebay


DVB-T+DAB+FM
DVB
USB2.0





$ Have one to sell? Sell now

USB2.0 Digital DVB-T SDR+DAB+FM HDTV Tuner Receiver Stick HE RTL2832U+R820T2 *#

Condition: New

Pattern: DVB-T

Quantity: 1 — 10 available / 2 sold

Price: US $8.95

Buy It Now

Add to cart

Add to watch list

Free shipping | 30-day returns

Shipping: FREE Economy Shipping from outside US | See details
See details about international shipping here.
Item location: Selangor, Malaysia
Ships to: Worldwide See exclusions

Delivery: Estimated between Thu. Aug. 2 and Wed. Sep. 5
Please note the delivery estimate is greater than 7 business days.

Payments: PayPal VISA MasterCard AMERICAN EXPRESS DISCOVER

PayPal CREDIT
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Returns: 30 day returns. Buyer pays for return shipping | See details

Guarantee: ebay MONEY BACK GUARANTEE | See details
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Covers your purchase price and original shipping.

Seller information

lusomuch (95991 ★)
97% Positive feedback

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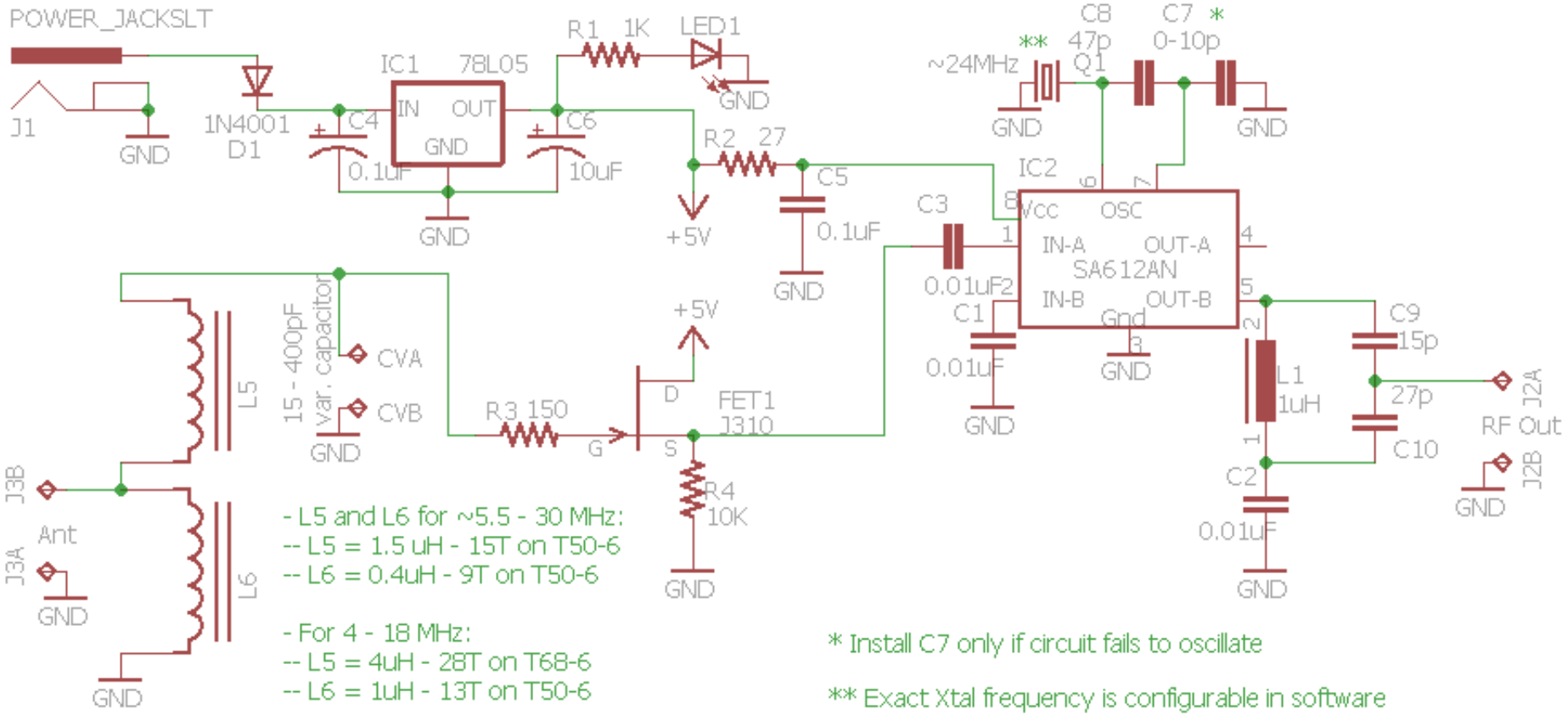
RF Converter

- Shifts HF signals up into the VHF range so that the DVB-T can receive them
- 3 basic sections:
  - Power supply
    - Provides regulated 5v from battery or wall wart
  - Input filter and FET preamp
    - Reduces interference from strong out-of-band stations
    - Improves sensitivity
  - Oscillator / Mixer in a chip (SA612)
    - Frequency conversion by traditional heterodyning technique
    - Crystal based local oscillator for stability



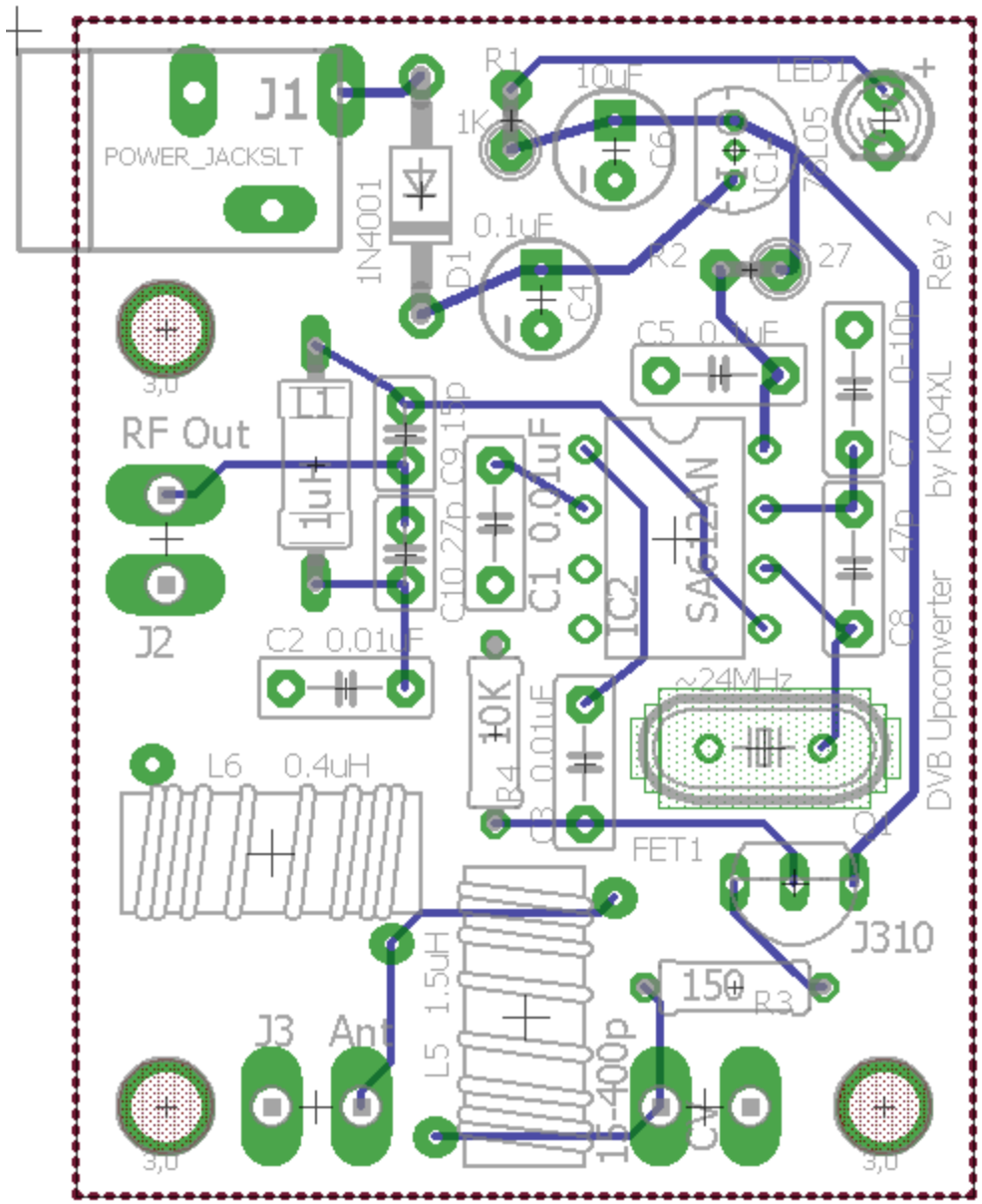
- L5 and L6 for ~5.5 - 30 MHz:
-- L5 = 1.5 uH - 15T on T50-6
-- L6 = 0.4uH - 9T on T50-6

- For 4 - 18 MHz:
-- L5 = 4uH - 28T on T68-6
-- L6 = 1uH - 13T on T50-6

- For 2 - 9 MHz:
-- L5 = 16uH - 56T on T68-6
-- L6 = 2uH - 20T on T50-6

* Install C7 only if circuit fails to oscillate

** Exact Xtal frequency is configurable in software



- Created board using Eagle CAD free edition
- Layout is important
  - Top and bottom layer ground planes
  - Keep all connections short
  - Isolate functional areas
  - No sharp bends
- Send CAD output to proto board house
  - Inexpensive and way less hassle than etching your own board
  - 2-sided
  - 1.6mm fiberglass
  - Solder mask both sides
  - Silk screen both sides
- Board cost: $2 to $5 depending on quantity


The Original
ALTOIDS
CURIOUSLY
Artificially
Flavored
NET WT
1.76 OZ (50g)


9V
03-2017
PILE ALCALINE
Energizer

1P x SA612AN IC SA612A Double-Balanced Mixer Oscillator VHF

Condition: New

Quantity: 1 294 available / 6 sold

Price: US $2.79

Buy It Now

Add to cart

Add to watch list

Free shipping | 30-day returns | Longtime member

Shipping: FREE Standard Shipping from outside US | See details
See details about international shipping here.
Item location: HK, Hong Kong
Ships to: Worldwide See exclusions

Delivery: Estimated between Tue. Jul. 31 and Thu. Aug. 9

Payments: PayPal VISA MasterCard AMERICAN EXPRESS DISCOVER

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Returns: 30 day returns. Buyer pays for return shipping | See details

Guarantee: ebay MONEY BACK GUARANTEE | See details
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Seller information
janeh2100 (105666 ★)
99.3% Positive feedback

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$ Have one to sell? Sell now

5pcs New 24.000MHZ 24MHZ 24M HZ HC-49S Crystal Oscillator

Be the first to write a review.

Condition: New

Quantity: 1 More than 10 available

Price: US $0.99

Buy It Now

Add to cart

Best Offer: Make Offer

Add to watch list

Free shipping | 60-day returns | Longtime member

Shipping: FREE Economy Shipping from outside US | See details
See details about international shipping here.
Item location: wenzhou, China
Ships to: Worldwide See exclusions

Delivery: Estimated between Thu. Aug. 9 and Thu. Sep. 13
Please note the delivery estimate is greater than 12 business days.

Payments: PayPal VISA MasterCard AMERICAN EXPRESS DISCOVER

PayPal CREDIT
Special financing available. Apply Now | See terms

Returns: 60 day returns. Buyer pays for return shipping | See details

Guarantee: ebay MONEY BACK GUARANTEE | See details
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Seller information
socoolmart (58353 ★)
99.7% Positive feedback

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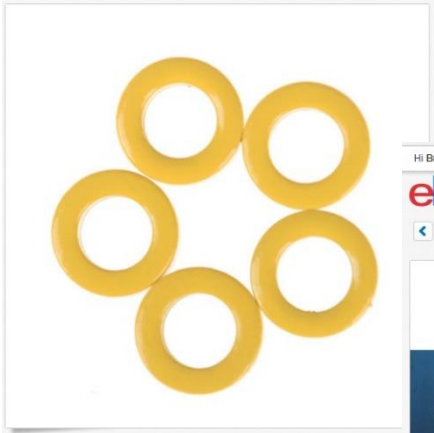

$ Have one to sell? Sell now

5Pcs Yellow Micrometals T50-6 Iron Powder Toroidal Core RF Toroid TB

Condition: New

Quantity: 1 More than 10 available / 4 sold

Price: C $1.90 Approximately US $1.45 Buy It Now

Seller information
trail-blazer21 (239207 ★)
98.5% Positive feedback
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$ Have one to sell? Sell now

(4 PCS) T-68-6 JW MILLER RF TOROID CORE OD=.690" x ID=.370" x HT=.190"

Condition: New

Quantity: 1 2 available / 1 sold

Price: US $5.95 Buy It Now

Seller information
specspecialty (5005 ★)
99.5% Positive feedback
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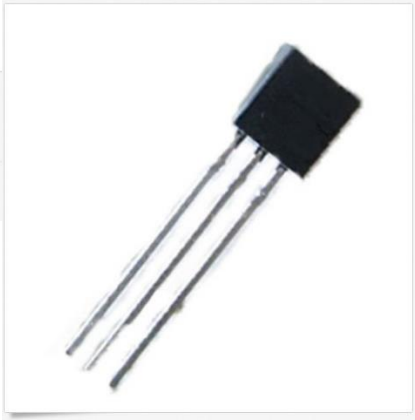

$ Have one to sell? Sell now

1/5/10/15Pcs JFET Transistor Tube Triode 2SJ310 J310 RF VHF/UHF Amplifier TO-92

Condition: New

QTY: - Select -

Quantity: 1 More than 10 available / 1 sold

Price: US $1.35 Buy It Now Add to cart
Add to watch list

Free shipping | 30-day returns | Longtime member

Shipping: FREE Economy Shipping from outside US | See details
See details about international shipping here.
Item location: HK, Hong Kong
Ships to: Worldwide See exclusions

Delivery: Estimated between Thu. Aug. 9 and Thu. Sep. 13
Please note the delivery estimate is greater than 12 business days.

Payments: PayPal VISA MasterCard AMERICAN EXPRESS DISCOVER

PayPal CREDIT
Special financing available. Apply Now | See terms

Returns: 30 day returns. Buyer pays for return shipping | See details

Guarantee: ebay MONEY BACK GUARANTEE | See details
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Covers your purchase price and original shipping.

Seller information
monsbasket (101710 ★)
99% Positive feedback
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EXTRA 5% OFF 2+ ITEMS See all eligible items ▸

$ Have one to sell? Sell now

15cm Cable BNC Female Jack To MCX Male Plug Right Angle RG316 6in Pigtail B1

Top selling product ★★★★★ 4 product ratings

Condition: New

Quantity: 1 More than 10 available / 74 sold

Was: US $1.73

You save: $0.09 (5% off)

Price: US $1.64 Buy It Now

100% buye

Shi

De

Payr

Re

Guar

Seller information
bruceshark-001 (29524 ★)
99.1% Positive feedback
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$ Have one to sell? Sell now

20cm RG58 Cable BNC Male Plug To SO239 UHF Female Jack Straight Pigtail 8in BS5.

★★★★★ Be the first to write a review.

Condition: New

Quantity: 1 4 available / 8 sold

Price: C $3.77 Approximately US $2.87 Buy It Now Add to cart Add to watch list

Limited quantity remaining | More than 66% sold | Free shipping

Shipping: FREE Economy Int'l Shipping | See details
See details about international shipping here.
Item location: Guang Zhou, China
Ships to: Worldwide See exclusions

Delivery: Estimated between Thu. Aug. 2 and Thu. Aug. 16
Seller ships within 1 day after receiving cleared payment.
Please note the delivery estimate is greater than 7 business days.

Payments: PayPal VISA MasterCard AMERICAN EXPRESS DISCOVER

Returns: 60 days, buyer pays return shipping | See details

Guarantee: ebay MONEY BACK GUARANTEE | See details
Get the item you ordered or get your money back.
Covers your purchase price and original shipping.

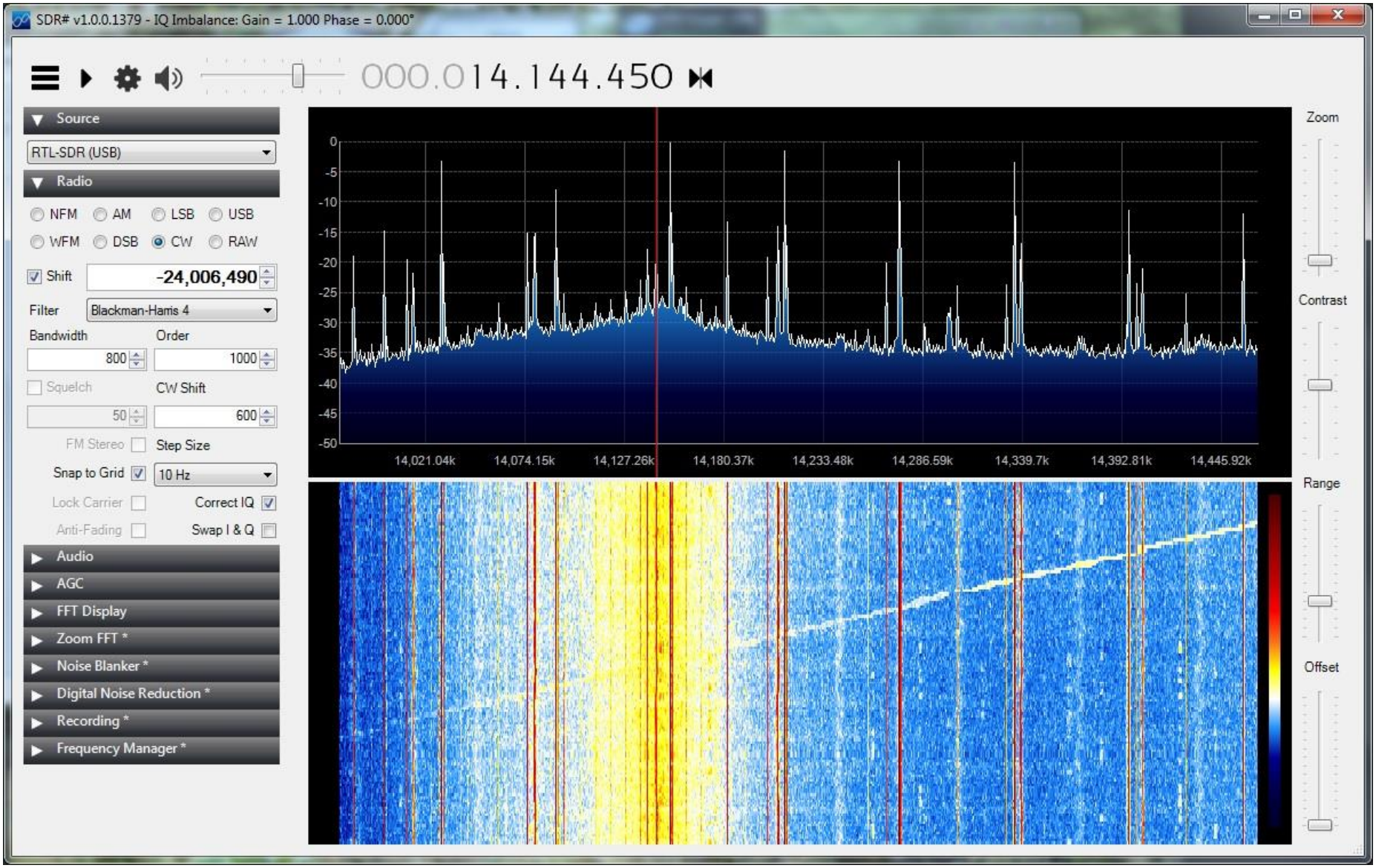
Seller information
bruceshark-005 (12874 ★)
99% Positive feedback
Save this Seller
Contact seller
Visit store

Other essential items

- Power Source
  - 9v battery for converter
  - Laptop's power
- Headphones or ear buds (optional)
- Cables
  - Pigtail adapter for USB stick
  - Antenna wire (and lead-in)
  - Connectors, connectors, connectors!

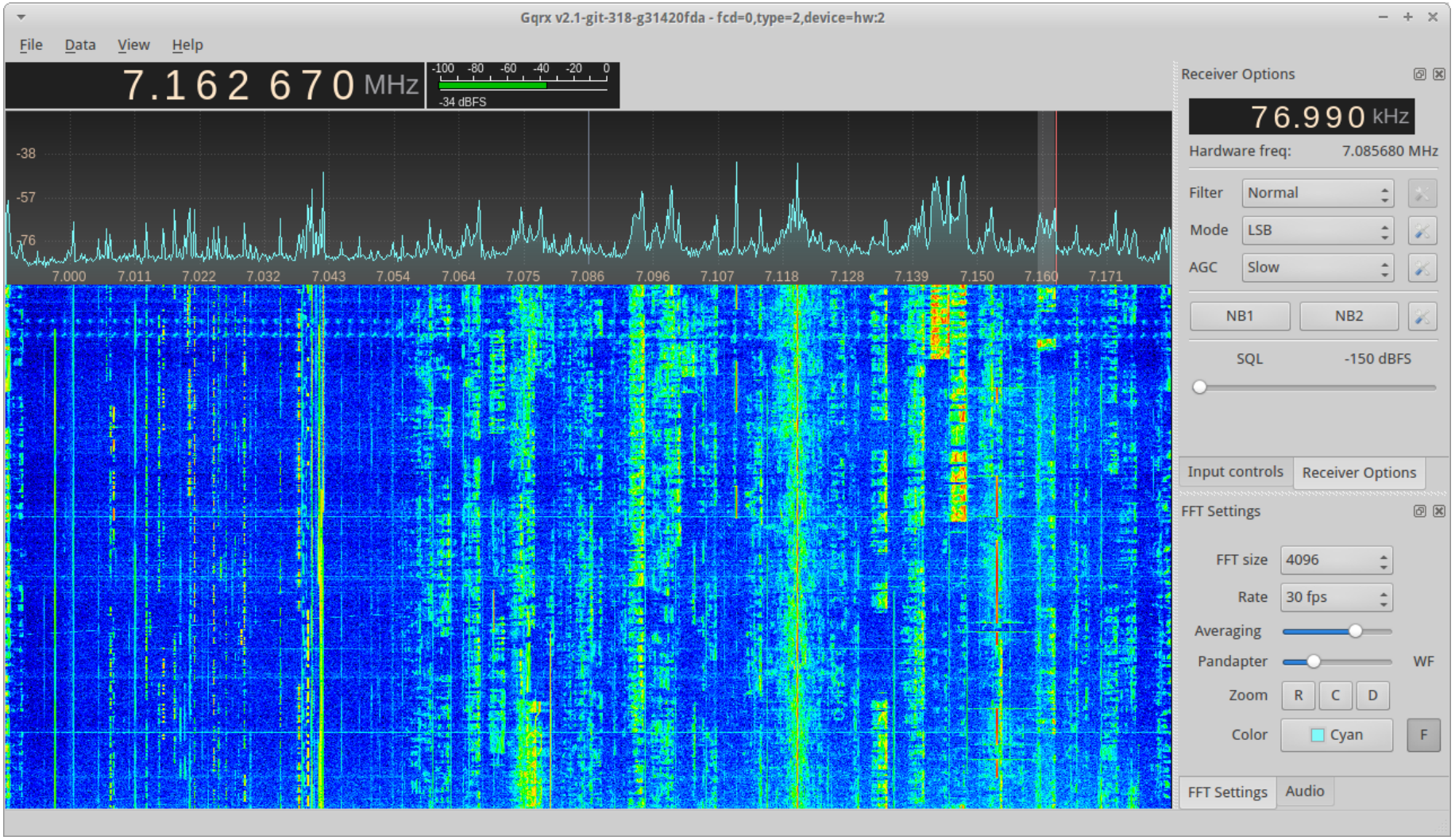
PC Software

- DO NOT install the software that came with the stick!
- SDR# ("SDR Sharp")
  - Includes correct USB drivers
  - Provides "virtual radio" user interface
  - Designed for Windows, but will run under Linux using Mono
- Websites:
  - www.rtl-sdr.com/rtl-sdr-quick-start-guide
  - www.rtlsdr.org/softwarewindows
  - inst.eecs.berkeley.edu/~ee123/fa12/rtl_sdr.html
  - airspy.com/download/


SDR# v1.0.0.1379 - IQ Imbalance: Gain = 1.000 Phase = 0.000°
000.014.144.450
Source
RTL-SDR (USB)
Radio
NFM AM LSB USB
WFM DSB CW RAW
Shift
-24,006,490
Filter
Blackman-Harris 4
Bandwidth
Order
800
1000
Squelch
CW Shift
50
600
FM Stereo
Step Size
Snap to Grid
10 Hz
Lock Carrier
Correct IQ
Anti-Fading
Swap I & Q
Audio
AGC
FFT Display
Zoom FFT *
Noise Blanker *
Digital Noise Reduction *
Recording *
Frequency Manager *
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
14,021.04k
14,074.15k
14,127.26k
14,180.37k
14,233.48k
14,286.59k
14,339.7k
14,392.81k
14,445.92k
Zoom
Contrast
Range
Offset

What about linux?

- GNU Radio
  - Ongoing “virtual radio” project
  - Powerful but very complex
  - More of a build-it-yourself kit than a ready to go app
- GQRX
  - Ready to go app powered by GNU Radio
  - http://gqrx.dk
- Run SDR# on linux using Mono
  - Not guaranteed, but works in current version


Gqrx v2.1-git-318-g31420fda - fcd=0,type=2,device=hw:2
File
Data
View
Help
7.162 670 MHz
-100 -80 -60 -40 -20 0
-34 dBFS
-38
-57
-76
7.000 7.011 7.022 7.032 7.043 7.054 7.064 7.075 7.086 7.096 7.107 7.118 7.128 7.139 7.150 7.160 7.171
Receiver Options
76.990 kHz
Hardware freq: 7.085680 MHz
Filter Normal
Mode LSB
AGC Slow
NB1
NB2
SQL -150 dBFS
Input controls
Receiver Options
FFT Settings
FFT size 4096
Rate 30 fps
Averaging
Pandapter
WF
Zoom R C D
Color Cyan
F
FFT Settings
Audio

Questions?

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