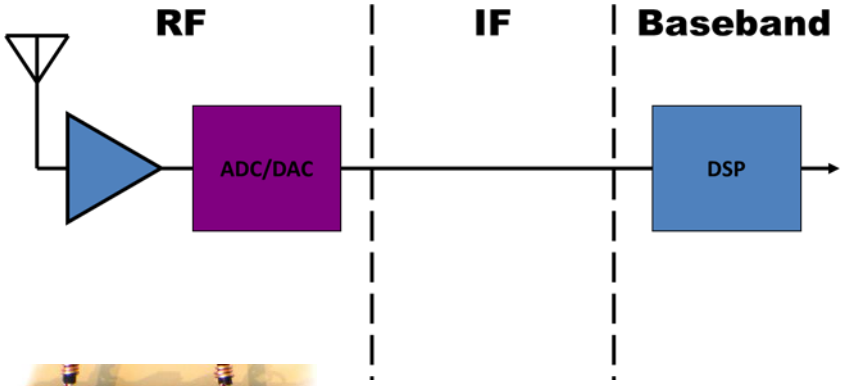
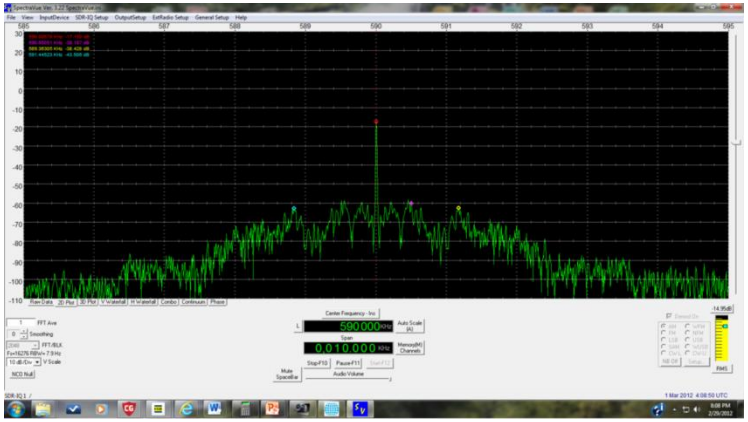
Software Defined Radios





What Is the SDR Radio ?

- An SDR in general is a radio that has:
  - Primary Functionality [modulation and demodulation, filtering, etc.] defined in software.
  - DSP algorithms implemented in configurable hardware and/or software
  - Performs the majority of signal processing in the digital domain using programmable DSPs and hardware support
  - some signal processing is still done in the analog domain, such as in the RF and IF circuits.

What Is the SDR Radio?

(continued)

- The ultimate device, where the antenna is connected directly to an A-D/D-A converter and all signal processing is done digitally using fully programmable high speed DSPs.
- All functions, modes, applications, etc. can be reconfigured by software.

What Is the SDR Radio?

(continued)

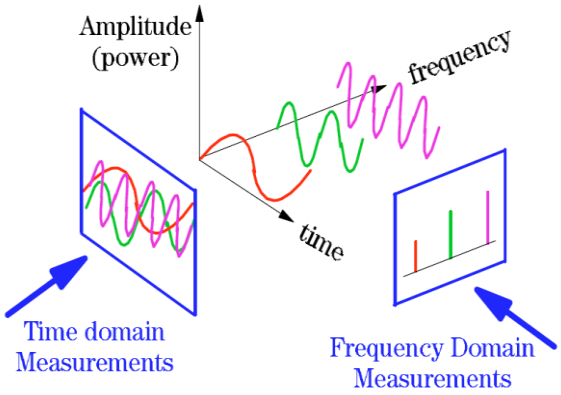
- Examples of SDRs:
  - Flex radio SDR 1500, SDR 1000, and flex 5000A
  - RF Space SDRIQ (with spectra view software)
  - Tony Parks, KB9YIG's soft rock series of kits
- An SDR is not:
  - A computer-controlled conventional radio
  - A conventional radio with a GUI integrated into uits front panel
  - A super hetrodyne rig with AF DSP

SDR Benefits

- Flexible
- Reduced Obsolescence
- Enhances Experimentation
- Brings Analog and Digital World Together
- Reprogrammable
- Multiband/Multimode
- Networkable
- Full convergence of digital networks and radio science.

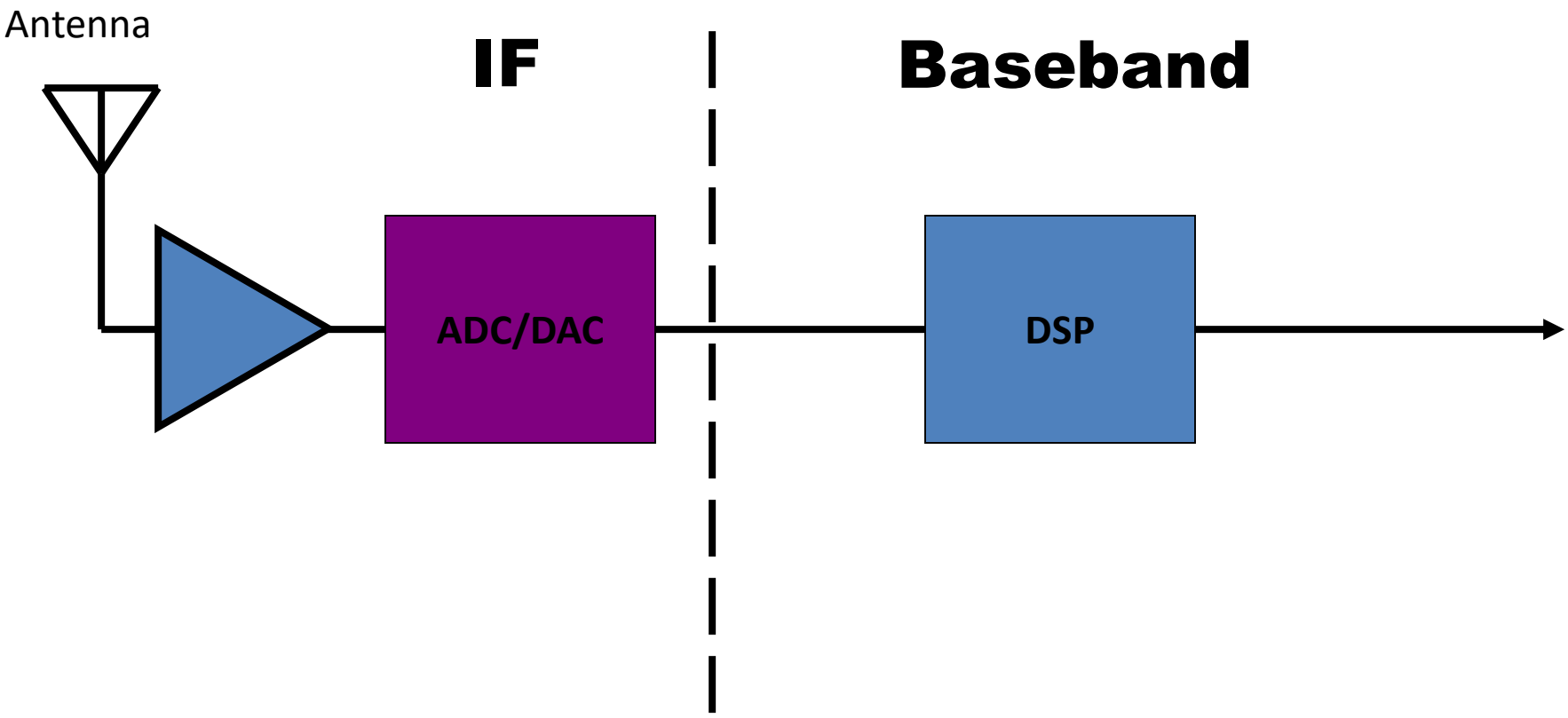
How does an SDR receiver work

- The incoming signal(s) fed into a low noise front end where the signal can be amplified, attenuated and filtered
- It uses a fast digital to analog converter to capture the analog signal
- Software then converts a the analog time domain signal to a frequency domain signal executing a Fast Fourier transform on the digitized analog signal. To convert it to the frequency domain.



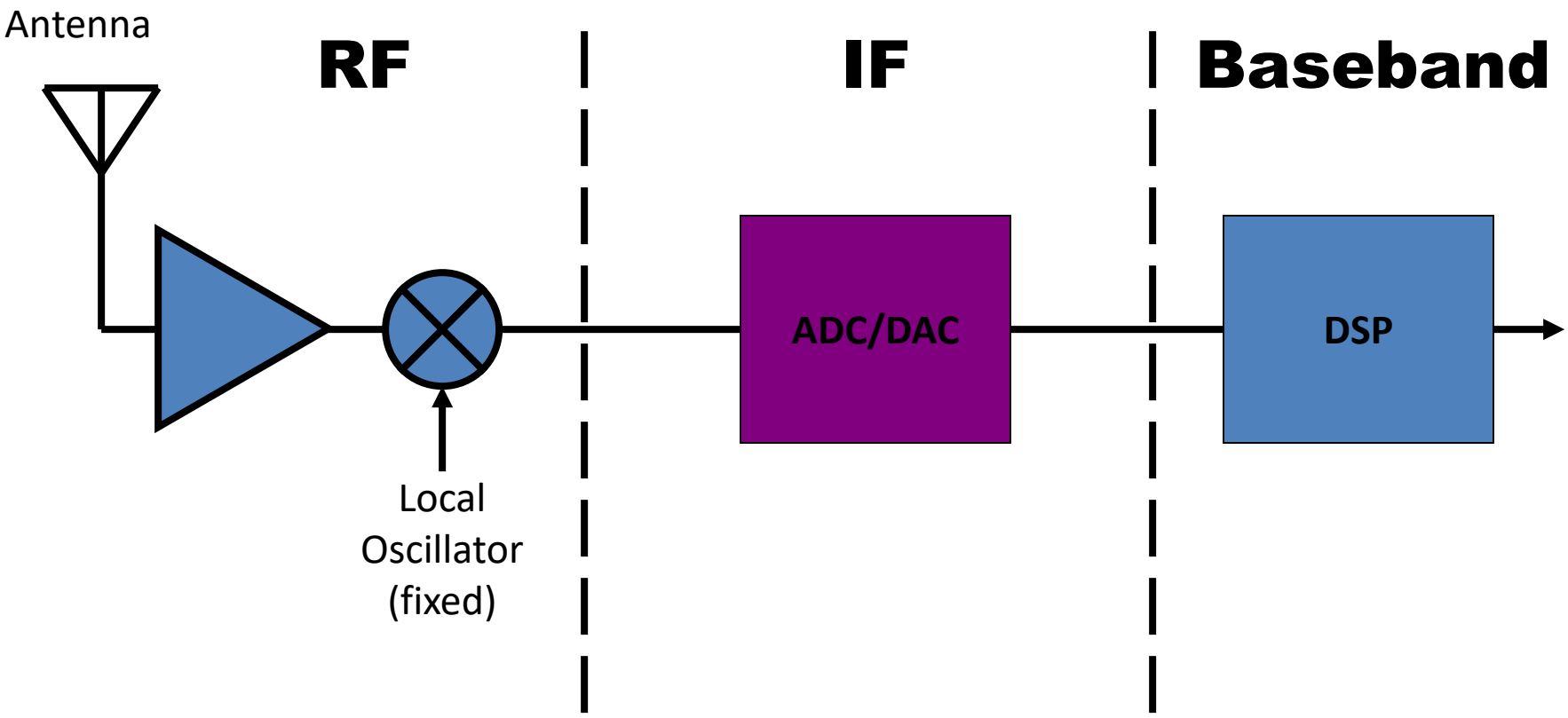
- The frequency domain signal is then processed using DSP software where filters and demodulation take place.

SDR Basic Block Diagram



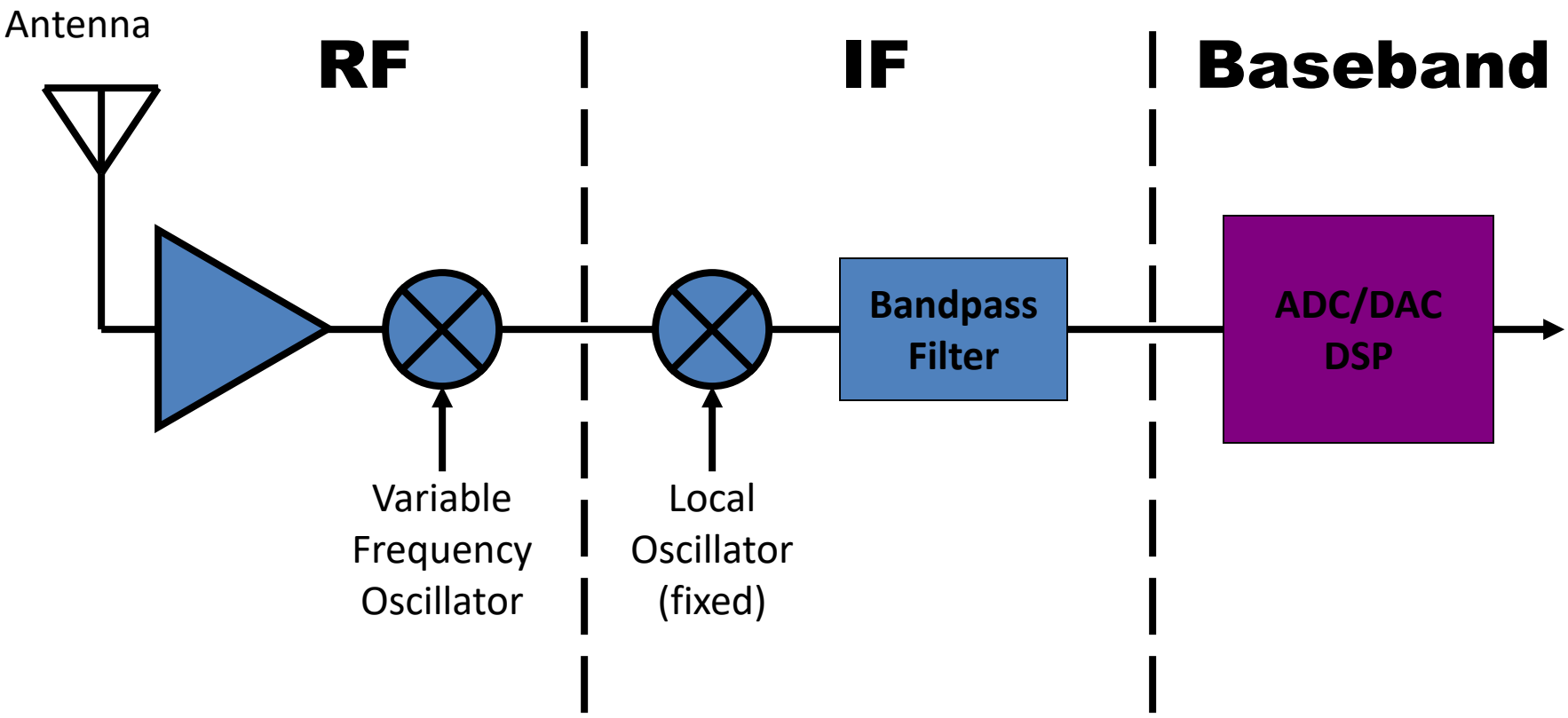
SDR Block Diagram

(Single Conversion)



SDR Block Diagram

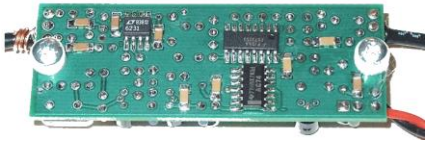
(double conversion)



SDR Example Hardware

Softrock Lite II 40 M SDR Receiver

Bottom of the Board



- Kit only, with surface mount components
- Interfaces with computer sound card I/O
- Requires 12VDc for operation
- Requires external software for the computer
- Very basic SDR but low cost, $19
- Other kits available for other bands and for TX/RX
- Made by Tony Parks, KB9YIG

SDR Example Hardware

- The **FLEX-1500**. A new low-cost, low-wattage SDR transceiver
- Allow ham radio operators the ability to experience the capabilities and fun of operating a software defined radio without breaking the budget.
- Full HF/6m transmit capability
- 5 watt output (adjustable down to milliwatts)
- Free software on Flex web site
- With a price around $700.

RF Space SDR -IQ Receiver Description

- The SDR-IQ™ is a 14-bit software defined radio receiver.
- It offers a broad range of spectrum analyzer and demodulation capabilities.
- The hardware samples the whole 0.0001-30 MHz band using a high performance, 14 bit analog to digital converter (ADC) running at 66.6 MHz. The digital data from the ADC is processed into I and Q format using a direct digital converter (DDC). The I and Q data is then sent to the PC for processing using a USB 2.0 interface.
- All of the demodulation and spectral functions are done on the PC side.

RF Space SDR -IQ Overall Description (continued)

- The SDR-IQ™ comes with a High Frequency (HF) amplified front-end with switched attenuators, switched filters and 1Hz tuning.
- The SDR-IQ™ comes with the latest version of Moetronix SpectraVue™ and SDR-Radio software. It supports AM, WFM, N-FM, USB, LSB, DSB and CW with fully adjustable DSP Filter bandwidths and FFT sizes of 2048 to 262144 points.
- The resolution bandwidth can be as Narrow as 0.031 Hz.

RF Space SDR-IQ Hardware

- 14 bit 66.6 Mega Samples Per Second
- Switched input attenuators and filters
- 500 Hz to 30 MHz receiver/spectrum analyzer
- Uses Computer sound system
- USB 2.0 powered – no power supply needed
- Linux/Windows Network Server allows remote use
- SpectraVue software for Windows 2000, XP, Vista, 7 included
- Cost: $499.

RF Space SDR-IQ Uses

- High performance HF Receiver with 190 KHz real-time Panoramic Adapter
- Ultrasound experimentation (Sonar, Underwater ultrasound, Bat and Insect detectors)
- IR(Infrared)subcarrier detection and communications
- Record up to 190 KHz of spectrum to hardrive for later playback and demodulation
- Panoramic adapter for Communication Receivers Very Low Frequency (VLF) Studies
- Processor for Radio Astronomy receivers

RF Space SDR-IQ Features

- Built in serial RS-232 port. This port can be used to communicate with external radios.
- Supports AM, FM, NFM, WFM, LSB, USB, CW, CWR, DSB, DRM and customs demod filters / offsets.
- Outputs data in I/Q Wave Format, Excel and graphic formats with resolutions as wide as 262144 pixels.
- Totally self contained. No power supply needed. You will be up and running in 5 minutes
- SDR with RF DSP™ that samples the whole HF band at once and performs the initial filtering at 67 MHz sample rate with 23 bit accuracy.

RF Space SDR-IQ Features

(continued)

- Sends 16 bits of I/Q Data to the PC via USB.
- RF pre-selection filters for great IMD performance.
- Serial port to directly interface with radios like the Icom IC-R8500, IC-R9000, IC-R9500, IC R7000, IC-R7100 and AOR AR- 5000.
- 50 ohm RF input that can be easily interfaced to antennas, and other RF equipment.
- Adds panoramic display features to transceivers like the Yaesu FT1000MP MV, FT2000, FT9000 , FTDX5000 and IC-7800 using the RX output connector, RX loopback or IF Output.

RF Space SDR-IQ Specifications

- Frequency Range: 500Hz to 30 MHz in 1 Hz steps. (Usable down to 100 Hz)
- Input Impedance: 50 Ohms
- Maximum Frequency display BW: 190 KHz
- Sampling Rate: 66.666 MHz
- I/Q Image Rejection: 80 dB+ (Typ)
- MDS (500 Hz): -127 dBm @ 14 MHz
- Input IP3: 15dBm+ (Typ)
- Voltage: 5 Volts (USB port powered)
- Current Draw: 425 mA

RF Space SDR-IQ Specifications

(continued)

- Analog Demodulation : AM, WFM, USB, LSB, N-FM, DSB and CW
- Measurements Functions: IQ vs. Time, Power vs. Frequency, Power vs. Frequency vs. Time 3D Surface, Power vs. Frequency vs. Time Spectrogram, Power in BW vs. Time, IQ Phase
- Screen Update Rate: 50 FFTs/sec , 190 KHz SPAN @ 100 Hz RBW
- Connectors: BNC (RF In), USB 2.0, RS-232 (Serial Bi-directional)
- Dimensions: 3.75x3.75x1.25 Inches

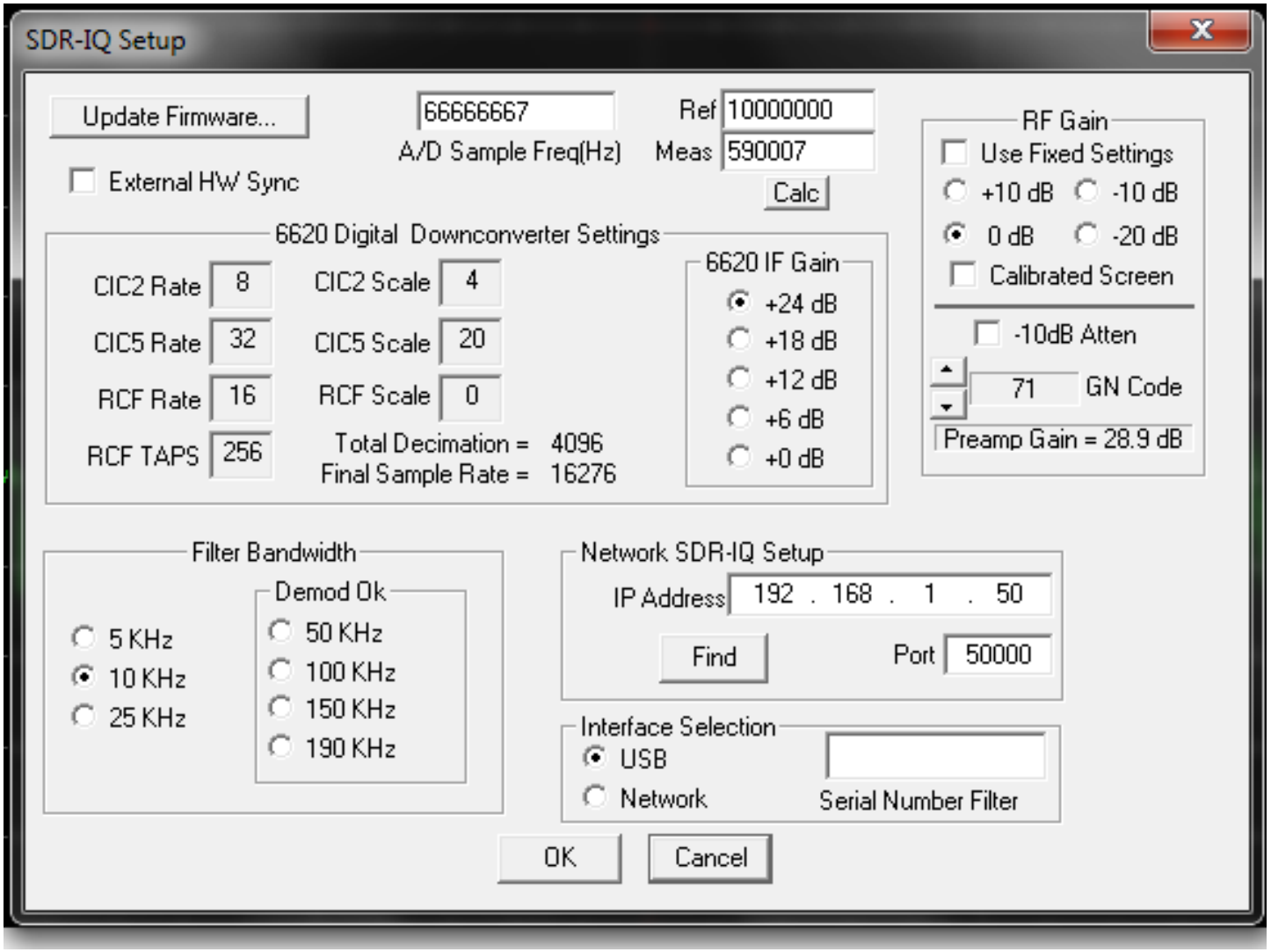
RF Spase SDR-IQ Specifications

(continued)

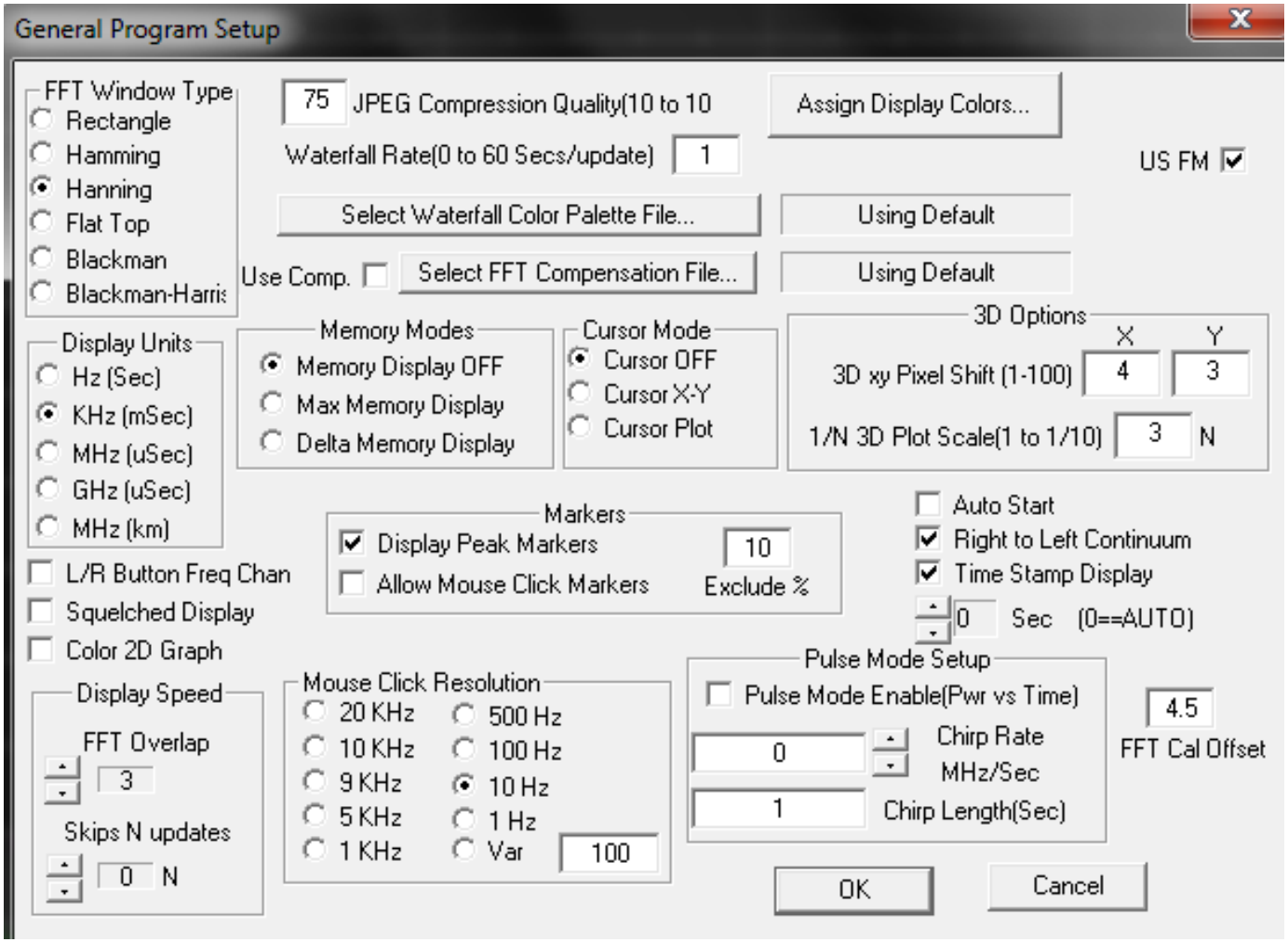
Span vs Resolution Bandwidth

SPAN	IQ DATA RATE	Min Resolution Bandwidth
5 KHz	8.138 KHz	0.031 Hz
10 KHz	16.276 KHz	0.062 Hz
25 KHz	37.792 KHz	0.14 Hz
50 KHz	55.555 KHz	0.21 Hz
100 KHz	111.111 KHz	0.42 Hz
150 KHz	158.730 KHz	0.61 Hz
190 KHz	196.078 KHz	0.75 Hz

RF Space SDR-IQ Setup

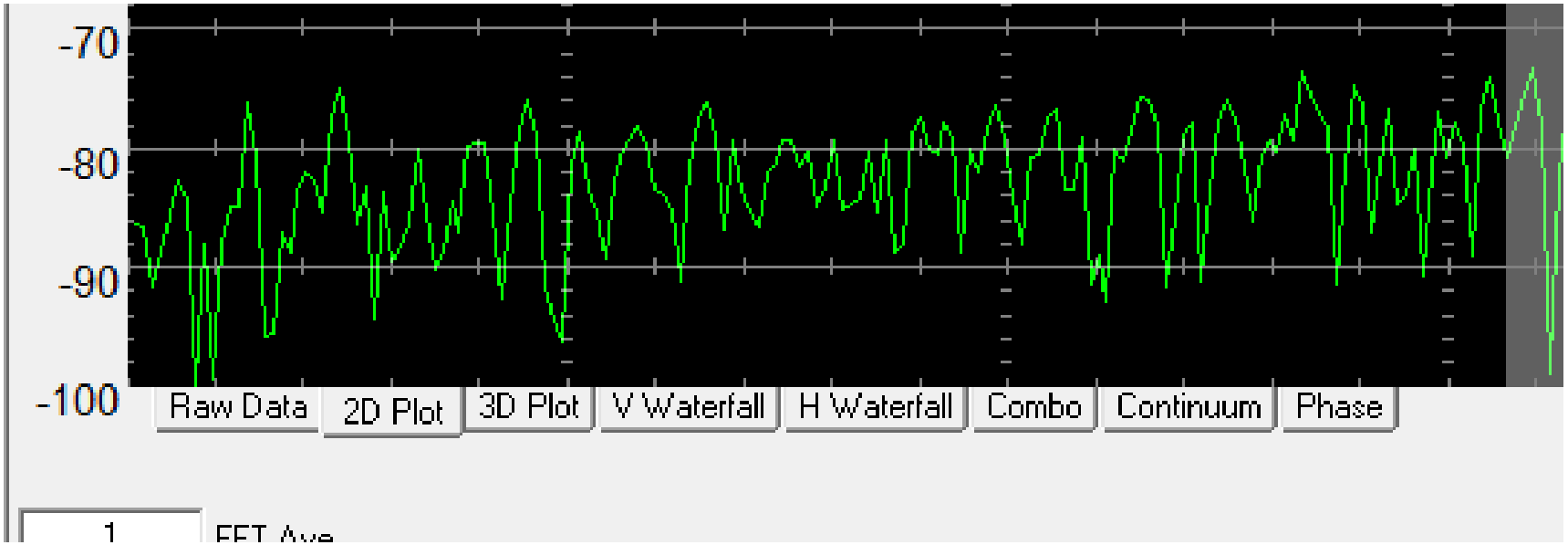


General Setup Screen

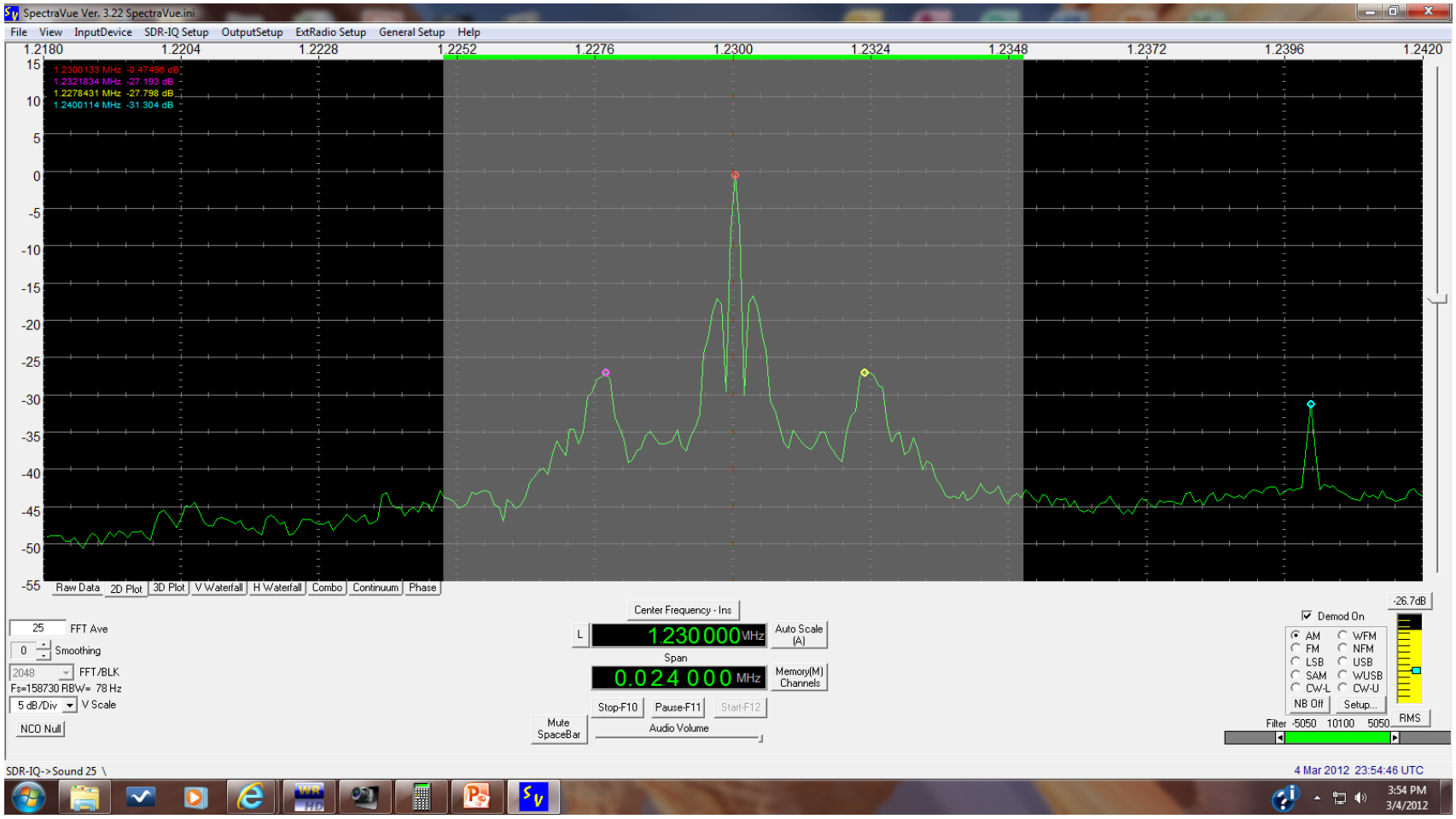


What Can You Display?

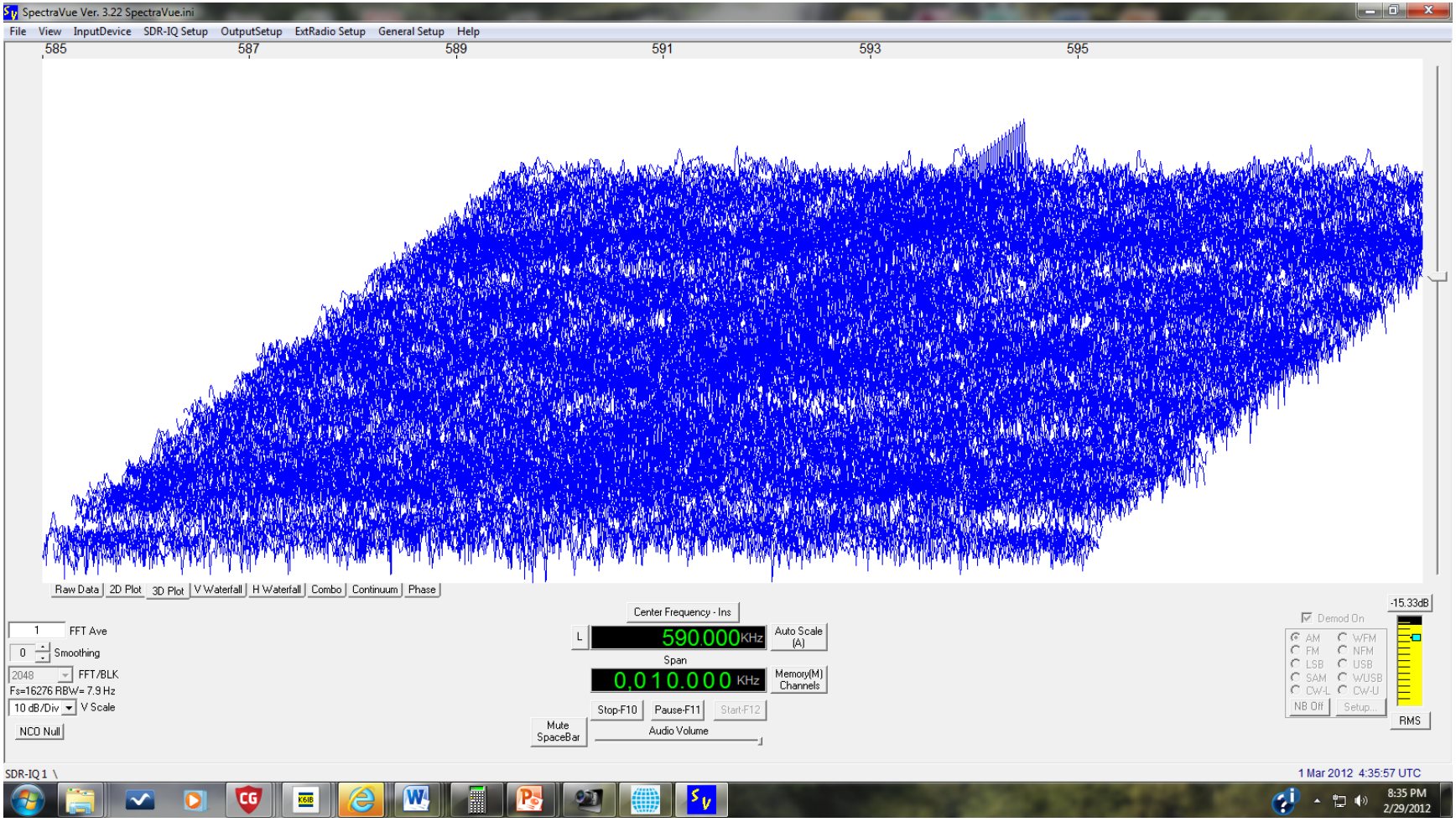
The SDR IQ™ receiver can display a signal im many different ways. Simply select how you want to display the signal by pressing the tab below the signal display area.



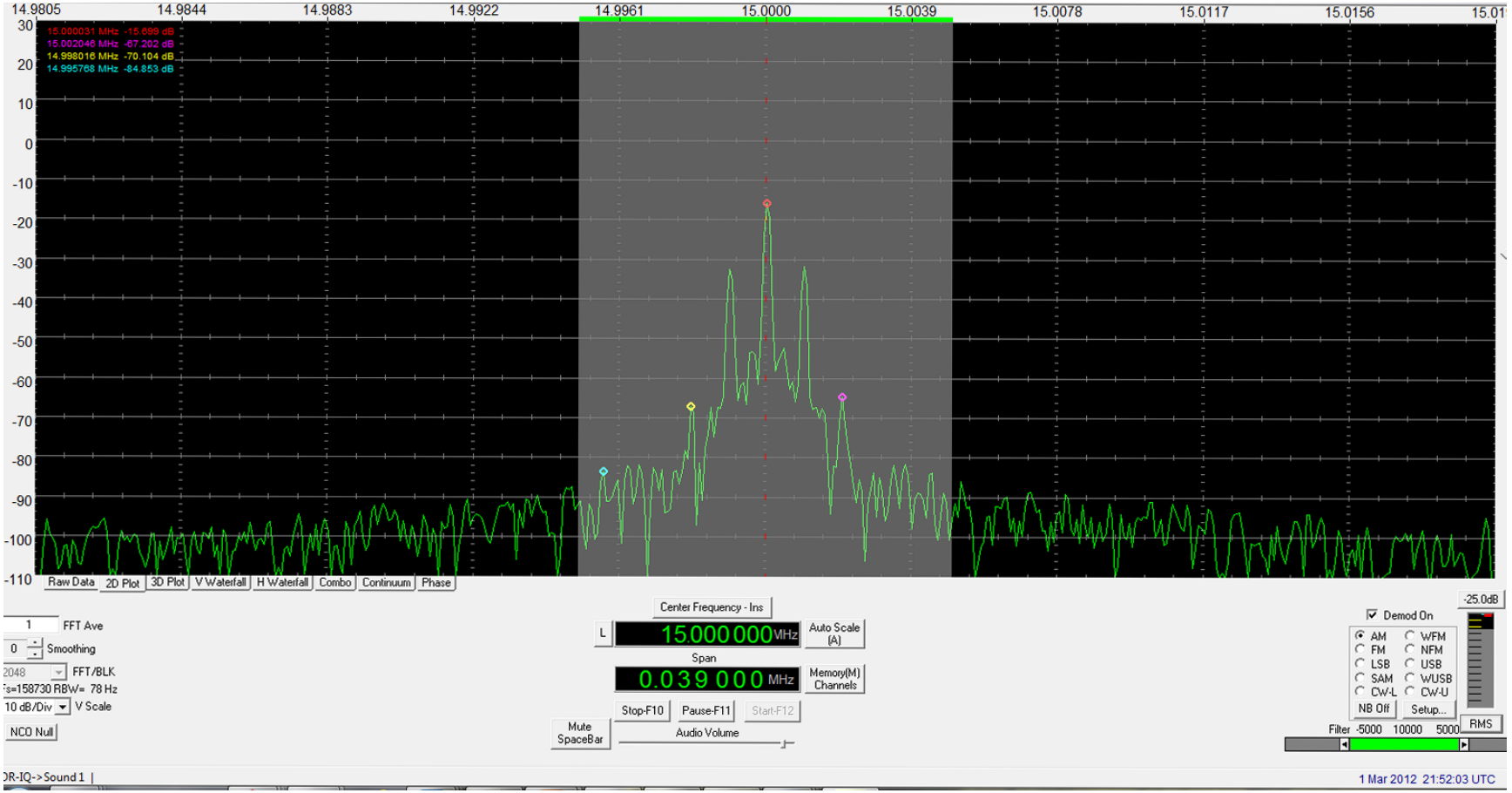
SpectraVue SA Display



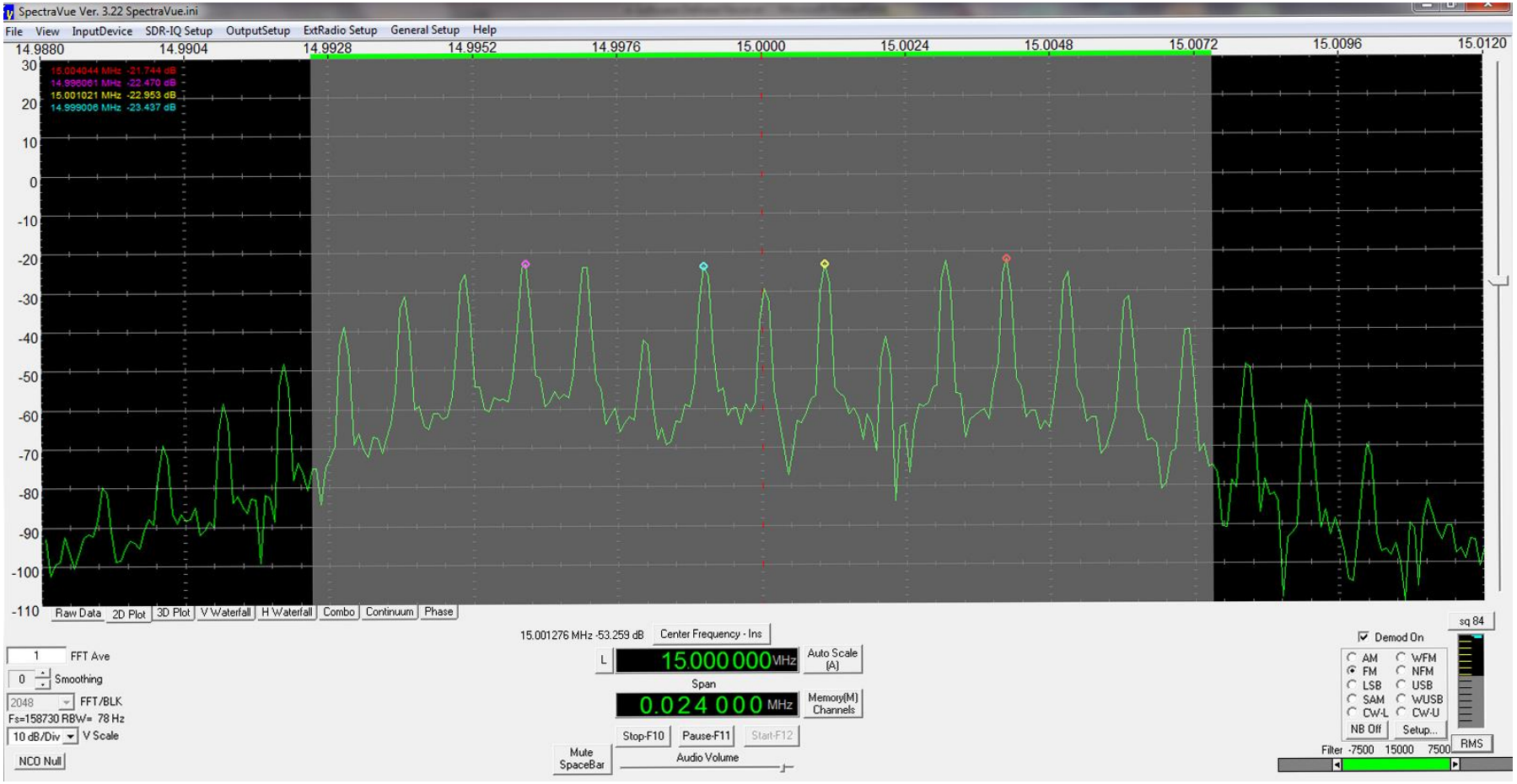
SpectraVue 3D Display



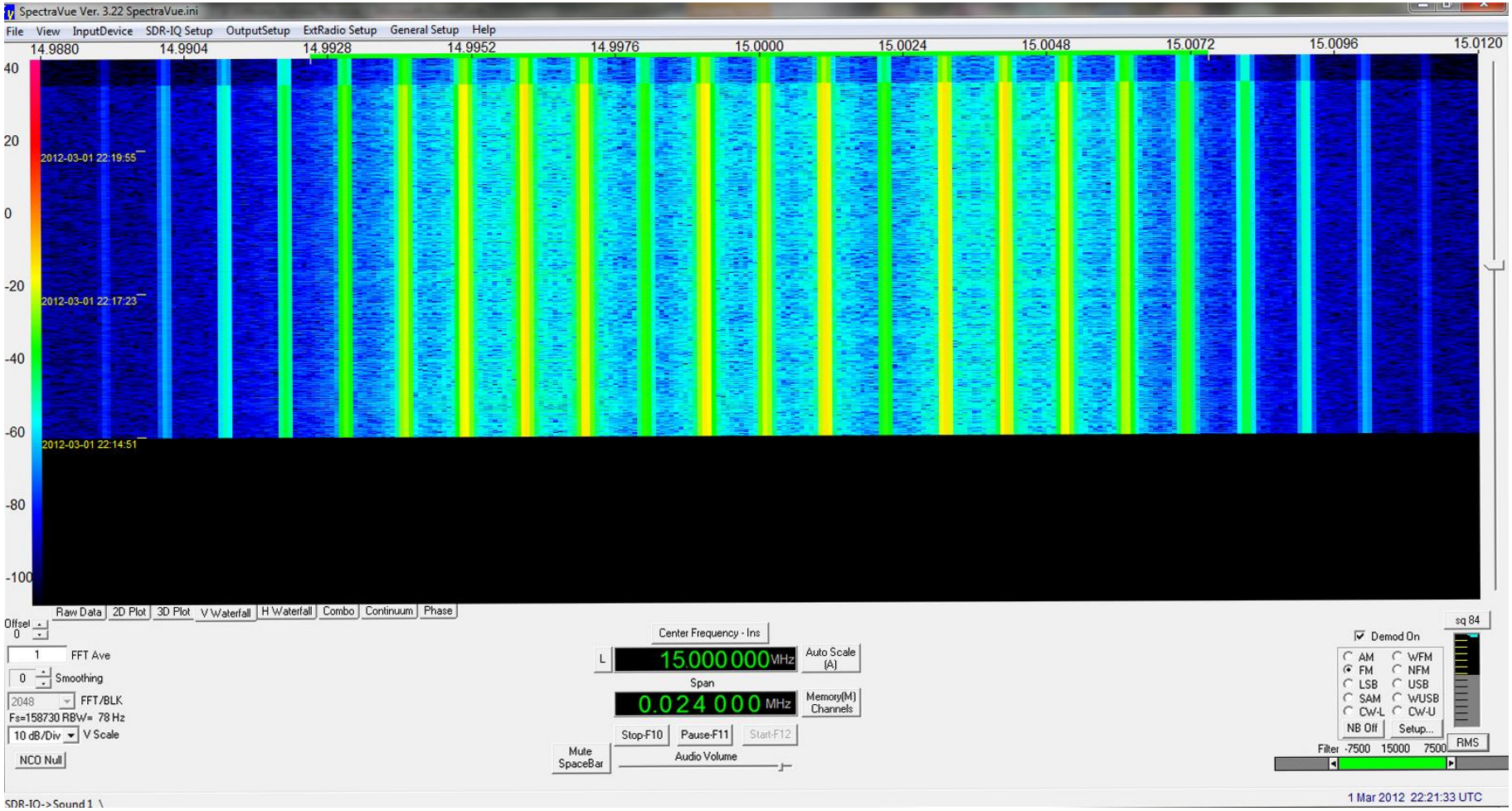
15 MHz signal with 30% 1KHz AM



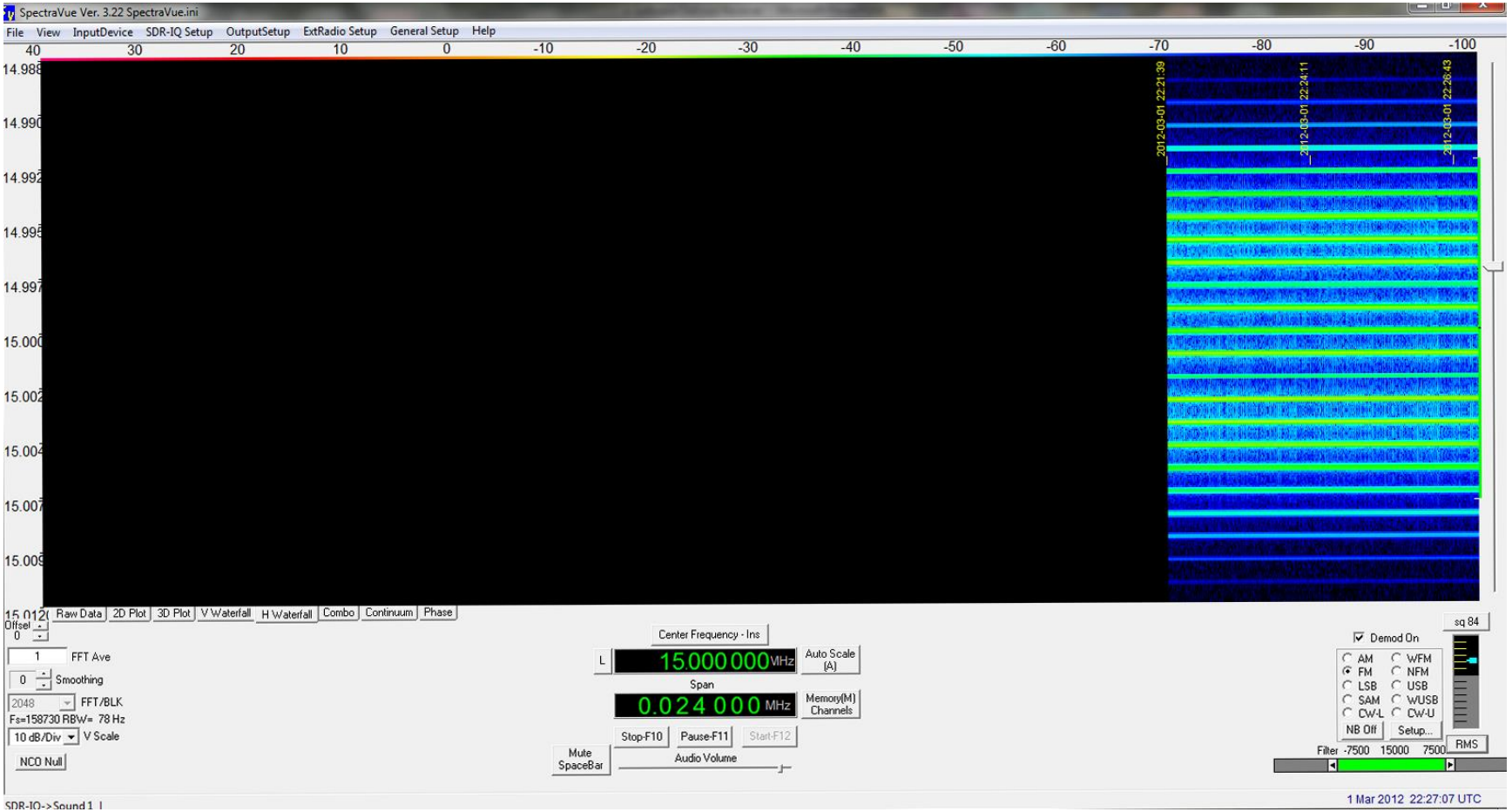
15 MHz signal with 1 KHz tone and 5KHz Deviation SA View



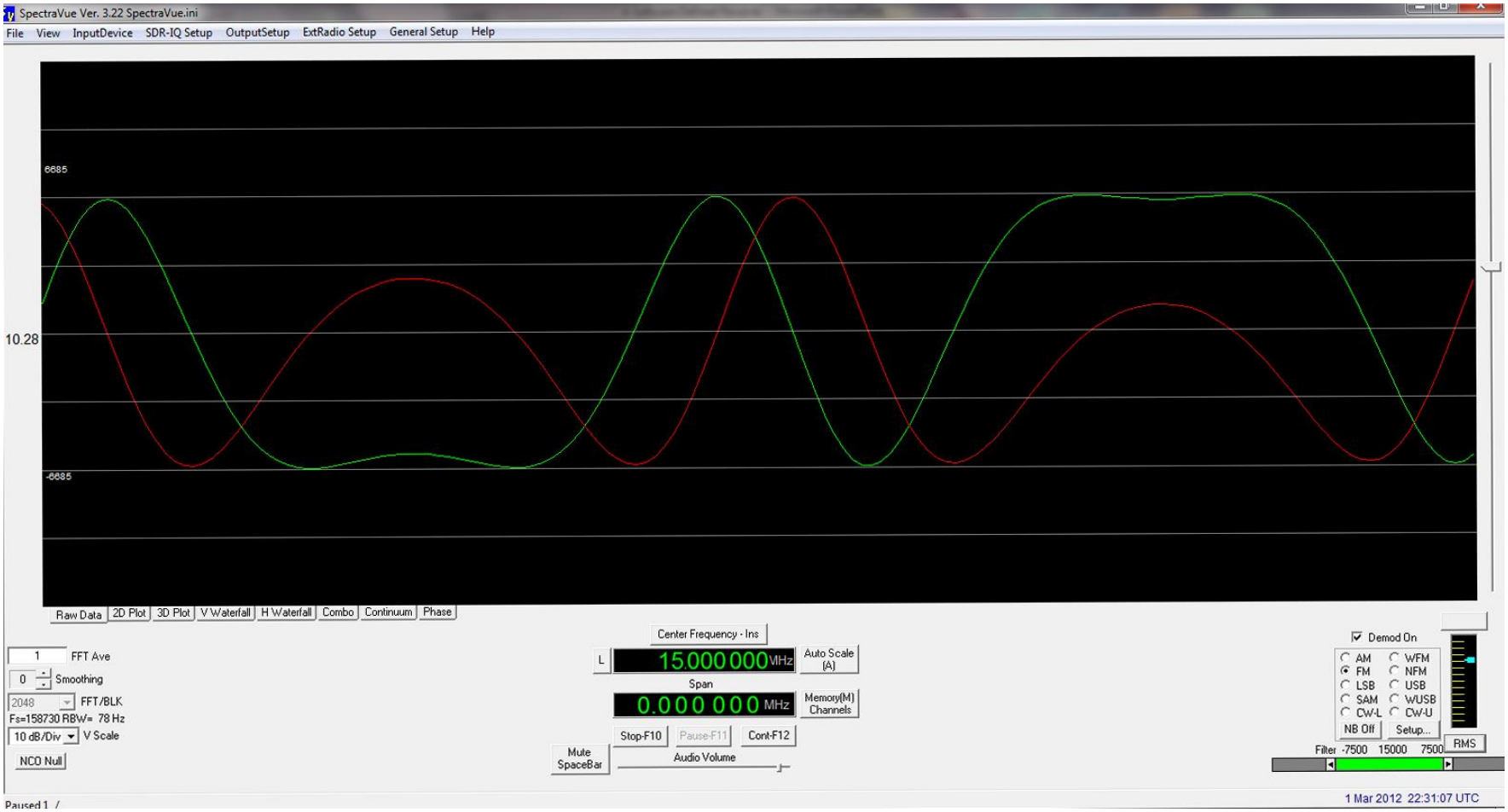
15 MHz signal with 1 KHz tone, 5KHz Deviation - Waterfall



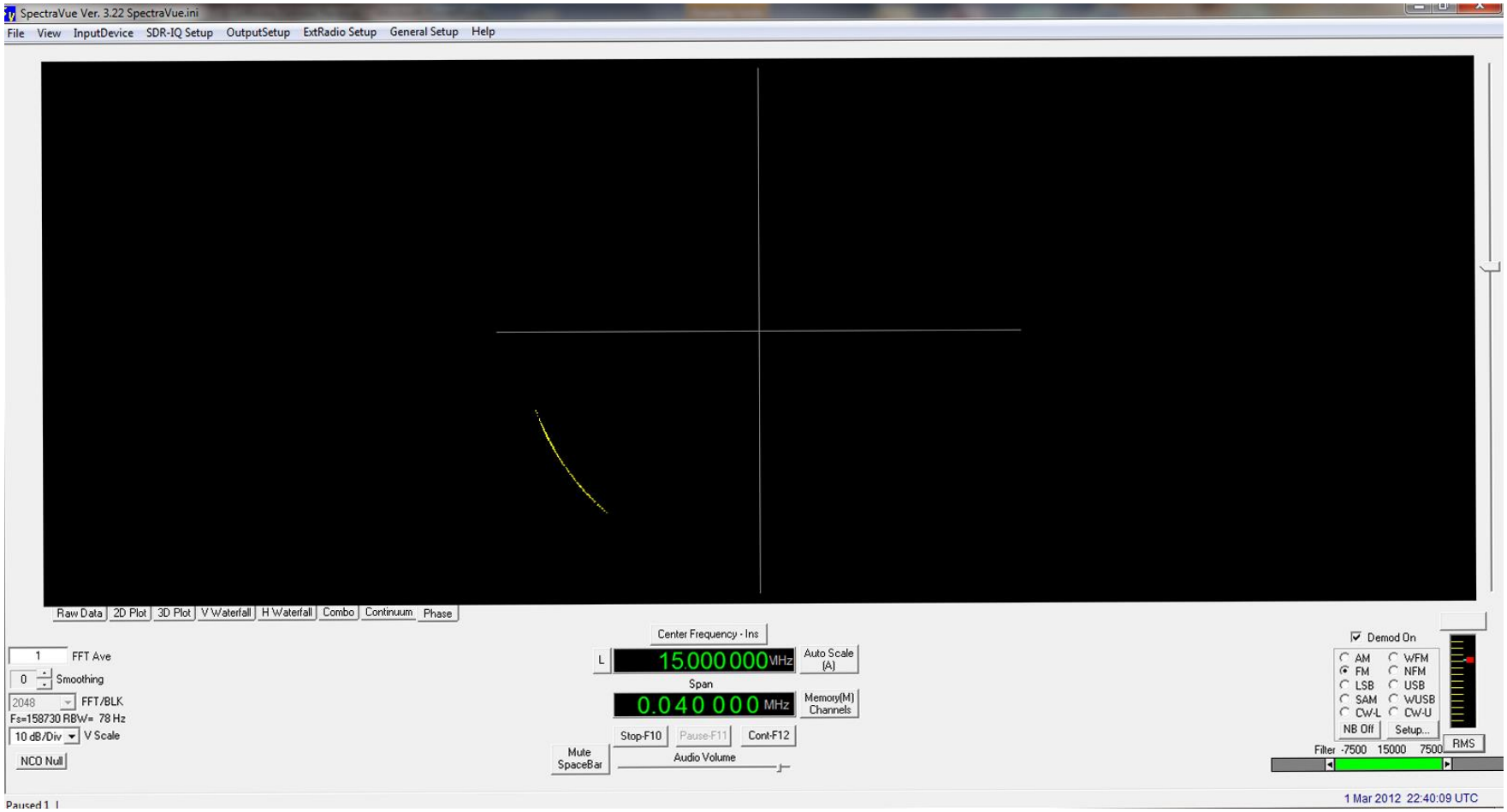
Horizontal Waterfall Display



Raw IQ Signal Data



IQ Phase Display



Looking Ahead

- **Smart Radios** that configure themselves to perform the communications task requested (using different frequency bands, modes, etc.)
- **Cognitive Radios** that learn about their environment (e.g., other users nearby, interference, location, elevation) to optimally configure themselves to maximize efficiency and reduce interference.

How to Build a SDR

- DSP-10 by Bob Larkin, W7PUA

  QST - Sep, Oct, Nov 1999

  http://www.proaxis.com/~boblark/dsp10.htm

  http://www.arrl.org/tis/info/vhfproj.html

- R2-DSP by Rob Frohne, KL7NA

  QST - Apr 1998

  http://www.wwc.edu/~frohro/R2_DSP/R2-DSP.html

- A Panoramic Transceiving System for PSK31 by Skip Teller, KH6TY and Dave Benson, NN1G

  QST - Jun 2000

  http://www.arrl.org/tis/info/psk31.html

  (see also the new 80M "Whistler" radio by the same folks)

Why SDR?

Why would you do that? (Use a PC for a radio, that is?)

- Radios look more and more like computers – user acceptance
- Highest performance: FlexRadio FLEX-5000A
- Lowest Cost: Soft Rock RXTX, US $31
- Most Flexible: HPSDR, USRP
- Demodulation/Filtering/Interfacing flexibility – user demands
- Pervasive, inexpensive *and* high performance PC platforms
- Open Source (GPL, OHL, NCL) builds synergy

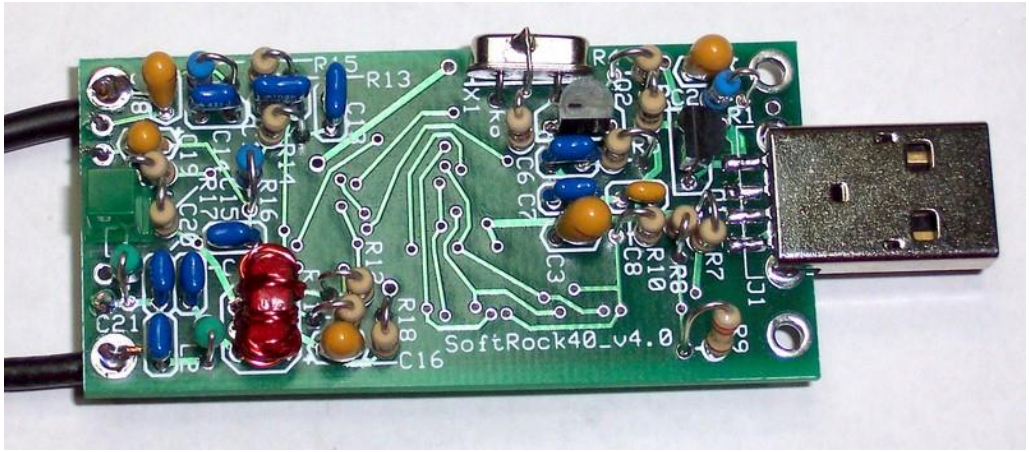
SDR Examples: Software

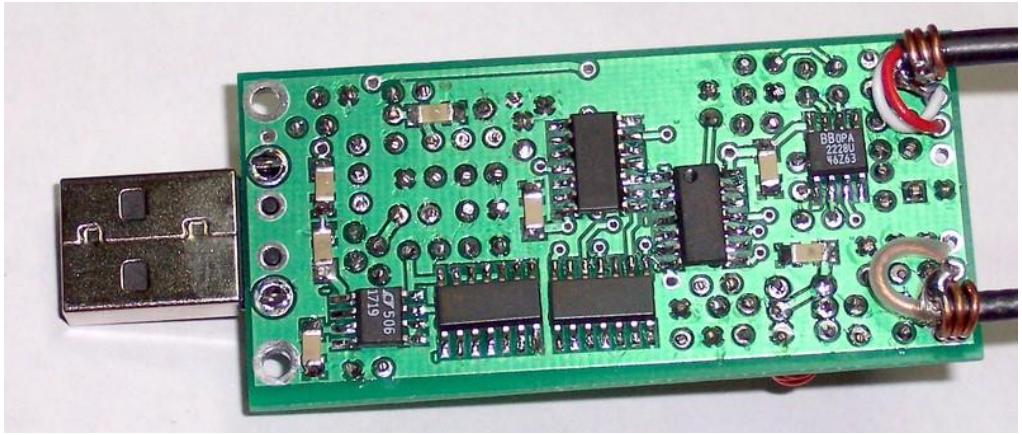
Some Examples of SDR Software

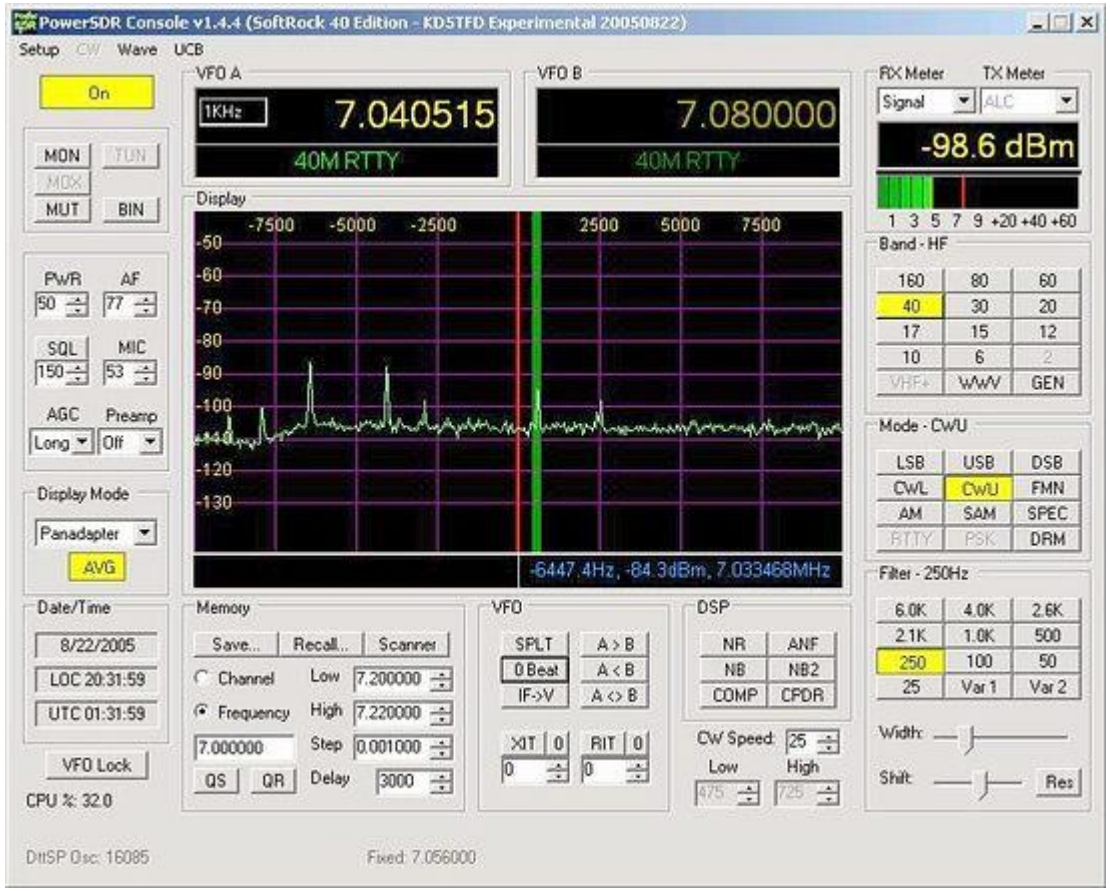
- PowerSDR (http://www.flex-radio.com)
- Rocky (http://www.dxatlas.com/rocky)
- uWSDR (http://uwsdr.berlios.de)
- SDRMAXII (http://groups.yahoo.com/group/qs1r)
- SDR-Shell (http://ewpereira.info/sdr-shell)
- Linrad (http://www.nitehawk.com/sm5bsz/linuxdsp/linrad.htm)
- Winrad (http://www.winrad.org/winrad/)
- SpectraVue (http://www.moetronix.com)
- DttSP (http://dttsp.sourceforge.net)

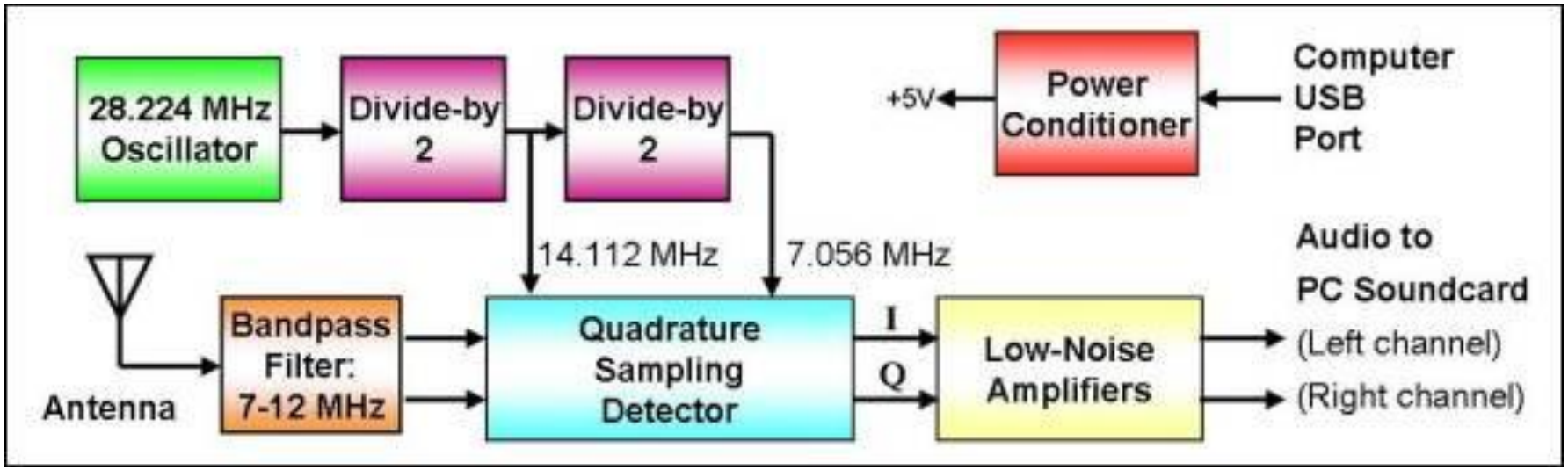
SoftRock-40

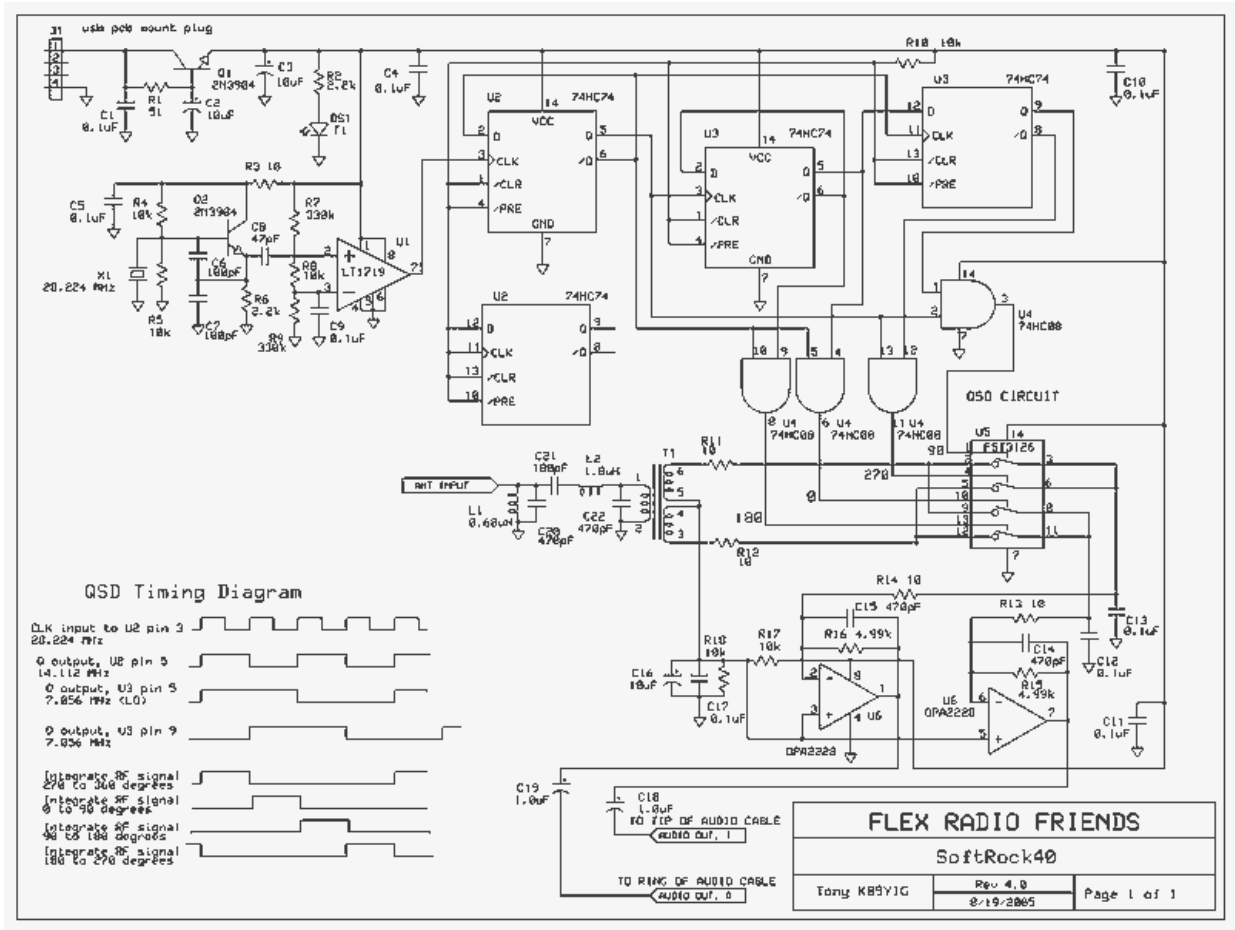
A small, low-cost "Software Defined Radio" receiver kit for 40-meters





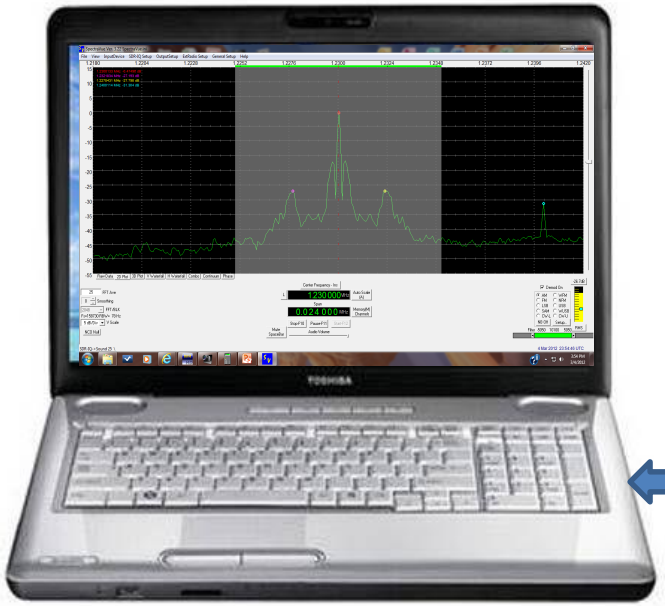

PowerSDR Console v1.4.4 (SoftRock 40 Edition - KD5TFD Experimental 20050822)
Setup
CW
Wave
UCB
On
MON
TUN
MOX
MUT
BIN
PWR
AF
50
77
SQL
MIC
150
53
AGC
Preamp
Long
Off
Display Mode
Panadapter
AVG
Date/Time
8/22/2005
LOC 20:31:59
UTC 01:31:59
VFO Lock
CPU %: 32.0
VFO A
1KHz
7.040515
40M RTTY
VFO B
7.080000
40M RTTY
Display
-7500
-5000
-2500
2500
5000
7500
-50
-60
-70
-80
-90
-100
-110
-120
-130
-6447.4Hz, -84.3dBm, 7.033468MHz
Memory
Save...
Recall...
Scanner
Channel
Frequency
Low
7.200000
High
7.220000
7.000000
Step
0.001000
QS
QR
Delay
3000
VFO
SPLT
0 Beat
IF->V
A > B
A < B
A <> B
XIT
0
RIT
0
DSP
NR
ANF
NB
NB2
COMP
CPDR
CW Speed:
25
Low
High
475
725
RX Meter
TX Meter
Signal
ALC
-98.6 dBm
1 3 5 7 9 +20 +40 +60
Band - HF
160
80
60
40
30
20
17
15
12
10
6
2
VHF+
WWV
GEN
Mode - CWU
LSB
USB
DSB
CWL
CWU
FMN
AM
SAM
SPEC
RTTY
PSK
DRM
Filter - 250Hz
6.0K
4.0K
2.6K
2.1K
1.0K
500
250
100
50
25
Var 1
Var 2
Width:
Shift:
Res
DttSP Osc: 16085
Fixed: 7.056000


28.224 MHz Oscillator
Divide-by 2
Divide-by 2
+5V
Power Conditioner
Computer USB Port
14.112 MHz
7.056 MHz
Audio to PC Soundcard
Antenna
Bandpass Filter: 7-12 MHz
Quadrature Sampling Detector
I
Q
Low-Noise Amplifiers
(Left channel)
(Right channel)


J1 usb pcb mount plug
Q1 2N3904
C1 10uF
R2 2.2k
C4 0.1uF
C3 0.1uF
R1 91
C2 10uF
DS1 TL
R3 10
C5 0.1uF
R4 10k
Q2 2N3904
R7 330k
C8 47pF
U1 LT1219
XL 20.224 MHz
C6 100pF
R6 2.2k
R8 10k
R5 10k
C7 100pF
R9 330k
C9 0.1uF
U2 74HC74
VCC
GND
U3 74HC74
R10 10k
C10 0.1uF
U4 74HC08
Q5 U4 74HC08
6 U4 74HC08
11 U4 74HC08
QSD CIRCUIT
U5 FSI3126
ANT INPUT
C21 100pF
L2 1.8uH
L1 0.68uH
C20 470pF
C22 470pF
T1
R11 10
270
0
180
90
R12 10
R14 10
C15 470pF
R16 4.99k
R13 10
C13 0.1uF
C14 470pF
R15 4.99k
C12 0.1uF
R18 10k
R17 10k
C16 10uF
C17 0.1uF
U6 OPA2228
C11 0.1uF
C19 1.0uF
C18 1.0uF
TO TIP OF AUDIO CABLE
AUDIO OUT, 1
TO RING OF AUDIO CABLE
AUDIO OUT, 0
QSD Timing Diagram
CLK input to U2 pin 3
20.224 MHz
Q output, U2 pin 5
14.112 MHz
Q output, U3 pin 5
7.056 MHz (LO)
Q output, U3 pin 9
7.056 MHz
Integrate RF signal
270 to 360 degrees
Integrate RF signal
0 to 90 degrees
Integrate RF signal
90 to 180 degrees
Integrate RF signal
180 to 270 degrees
FLEX RADIO FRIENDS
SoftRock40
Tony KB9YIG
Rev 4.0
8/19/2005
Page 1 of 1

Any questions before the Demo?

Demo Time



USB Cable