MicroHAMS Digital Conference 2010

SDR for Beginners

(Operators. Not Designers.)

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Overview

- Non-Technical

- Definitions

- The Primary Innovation for Operators

- Strengths and Weaknesses

- Inexpensive Hardware

- Hidden Costs

- Wrap Up

SDR for Beginners

- We Can Approach SDR in a Technical or a Non-Technical Way

- For Comparison, We can Talk About Antennas In a Non-Technical Way:
  - Toss a Wire In A Tree And Operate
  - Use Your Tennis-Ball Launcher
    - Don't Aim It At Anyone

- Or We Can Get Technical…

Antennas: Maxwell's Equations

- **The field form**

  - $\mathbf{F} = F_{\alpha\beta}\, \mathrm{d}\,x^\alpha \wedge \mathrm{d}\,x^\beta$

- **The current form**

  - $\mathbf{J} = \dfrac{4\pi}{c} J^\alpha \sqrt{-g}\, \epsilon_{\alpha\beta\gamma\delta} \mathrm{d}\,x^\beta \wedge \mathrm{d}\,x^\gamma \wedge \mathrm{d}\,x^\delta$

- **The Bianchi identity**

  - $\mathrm{d}\mathbf{F} = 2(\partial_\gamma F_{\alpha\beta} + \partial_\beta F_{\gamma\alpha} + \partial_\alpha F_{\beta\gamma})\mathrm{d}\,x^\alpha \wedge \mathrm{d}\,x^\beta \wedge \mathrm{d}\,x^\gamma = 0$

- **The source equation**

  - $\mathrm{d} * \mathbf{F} = F^{\alpha\beta}{}_{;\alpha}\sqrt{-g}\, \epsilon_{\beta\gamma\delta\eta}\mathrm{d}\,x^\gamma \wedge \mathrm{d}\,x^\delta \wedge \mathrm{d}\,x^\eta = \mathbf{J}$

- **The continuity equation**

  - $\mathrm{d}\mathbf{J} = \dfrac{4\pi}{c} J^\alpha{}_{;\alpha}\sqrt{-g}\, \epsilon_{\alpha\beta\gamma\delta}\mathrm{d}\,x^\alpha \wedge \mathrm{d}\,x^\beta \wedge \mathrm{d}\,x^\gamma \wedge \mathrm{d}\,x^\delta = 0$

    - Here g is as usual the determinant of the metric tensor $g\alpha\,\beta$.

SDR for Beginners

- **I Prefer Non-Technical!**

- **To Get Started, Let's Define a Few Acronyms So I Can Sound Like I Know What I'm Talking About**
    - And You'll Have the Magic Decoder Ring
    - "...Drink Ovaltine..."

SDR: Acronyms and Definitions

- Software Defined Radio (SDR)
  - Much of the Radio Functionality is Handled by Digital Signal Processing (DSP)
  - You Can Load New Software to:
    - Get New Functions
    - Improve Old Ones
    - Fix Bugs
  - DSP Can be Done By an Embedded DSP Chip
  - DSP Can be Done by a PC

SDR: Acronyms and Definitions

- Quadrature Sampling Detector (QSD)
  - A Type of Mixer or Detector Often Used in SDR
    - Direct-Conversion
    - Image Rejecting
- Analog-to-Digital Converter (ADC or A/D)
  - Converts Analog Signals to Digital Bitstream
  - Characterized by:
    - Number of Bits (We Want At Least 16)
   - Sampling Rate (We Want At Least 48 kHz)

SDR: What It Is Not!

- The Software Need Not be Open Source
  - Or Even Partially Open
- An SDR Need Not Be PC-Based
  - Or Require a PC At All!
  - Think 'Elecraft K3'
    - Full Disclosure: I Work for Elecraft…
- Let's Focus on PC-Based SDR…

SDR: Operating Features

- **What Makes SDR Enticing To Operators?**
  - **Others Can Dig into the Theory**
    - Remember Maxwell!
  - **Let's Forget About Updating and Bugs**
    - These are Owner Issues
  - **Let's Not Get Into a Debate About Knobs…**
    - These are` Preferences
- **The Primary Operating Feature Is…**

Real-Time Spectrum Display
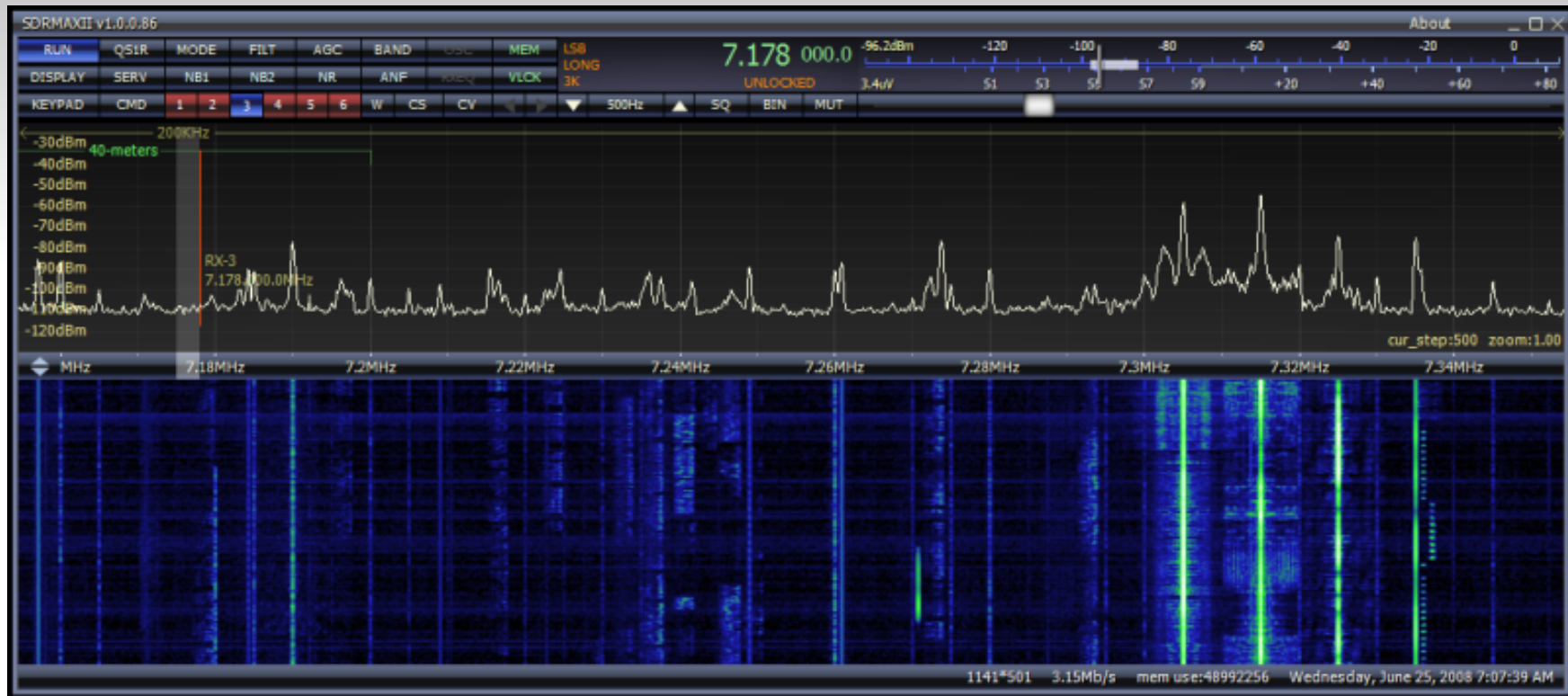
- This is the Paradigm Shift for Operators

(Image shown is SDRMAX from N8VB)

SDR: Spectrum Display

- Find Open Spots in Crowded Bands

- Find Activity in Quiet Bands

- Identify Signal Modes Instantly

- Check for Splatter
  - The Other Station's, Not Yours, Of Course ☺

- Quickly Tune to the Frequency You Want
  - Not Just MHz, But Busy/Quiet/CW/SSB/AM …

- "Understanding the Waterfall" Would Easily Fill a Complete Presentation Timeslot!

SDR: Other Advantages

- Open Source Software Assists Self-Education
- Simple Hardware Designs Like Softrock Allow Inexpensive Experimentation
  - More Self-Education
  - This is How I Got My Ph.D in SE-AR
- Customization of Radio Features or Interface
- Appeals to Younger (Potential) Hams
  - They Grok GUIs

SDR: Potential Drawbacks

(Lest You Get Seduced By the Sirens' Song)

- Latency

- Blocking Dynamic Range

- Close-In Dynamic Range

- This Looks Like Techie Stuff, But It Is Important To Understand Operationally

- Let's Take a Quick Look At These…

SDR: Potential Drawbacks

- Latency
  - Time That Elapses Between a Signal Arriving at the Antenna and Audio at the Speaker/Phones
  - Listen to an Analog Radio and an SDR in Parallel
  - Causes:
    - Filters ("25 Hz Brick Wall")
      - DSP FIR Filter Delay = 0.5 * (taps/sample_rate)
    - Buffers
      - PC OS Not "Real-Time" So Buffering Needed
      - May Not Be An Issue With Embedded DSP (K3…)

SDR: Potential Drawbacks

- Latency, Continued
  - Impacts Ability to do QSK
  - May Impact Ability to Read CW Paddle
  - May Impact Tx Audio Monitoring
    - Irritating in SSB
  - Minimize by
    - Fewer "Taps" in Filters (less Sharp)
    - "Tuning" PC to Minimize Required Buffers

SDR: Potential Drawbacks

- Blocking Dynamic Range: How Strong an Off-Frequency Signal Must Be Before It Affects the Signal You Want to Hear

- Improved by:
  - Pre ADC Filtering (aka Roofing Filter)
    - QSD Typically 200 to 300 kHz
    - "Roofing Filter" Can Add 20 to 80 dB Improvement
  - Raw ADC Performance
    - More Bits!

SDR: Potential Drawbacks

- Narrow Spacing Dynamic Range
  - 2 kHz in ARRL Lab and Sherwood Engineering
  - Typically Inside "Roofing Filter"
  - Most Applicable to CW and Narrow Digital Modes
- Performance Issues from "HFO"
  - DDS: May Be Clean But Always Has Spurs
  - PLL: Fewer Spurs But May Have "Phase Noise"
  - These Affect Close-In and Well-Separated Signals
  - Check Tx Noise Plot in QST Reviews

SDR: PC Software

- PowerSDR (tm Flex Radio Systems)
  - Many Variants
- WinRAD and WinRADHD
- LinRad
- Rocky
- MacHPSDR
- KISS Konsole

Softrock: SDR On The Cheap

- Let's Look at an Introductory-Level Receiver

- KB9YIG Offers the Softrock Series Kits

- Monoband Rx: $20

- All-Band Rx: $56

- 1 To 3 Band TxRx: $74

- Quadrature Sampling Detector Architecture

- Think SSB, Phasing Method, Direct Conversion…

SDR: Softrock Ensemble

- Softrock Ensemble Receiver Kit
  - $56 plus shipping
  - 160m-10m
    - Several Small Toroids
    - USB Port for Control
   - Some Surface Mount Parts
  - Requires 12V at
    about 120 mA
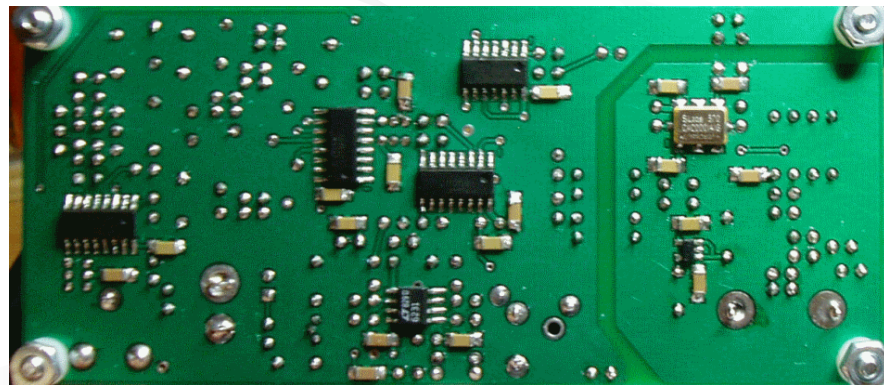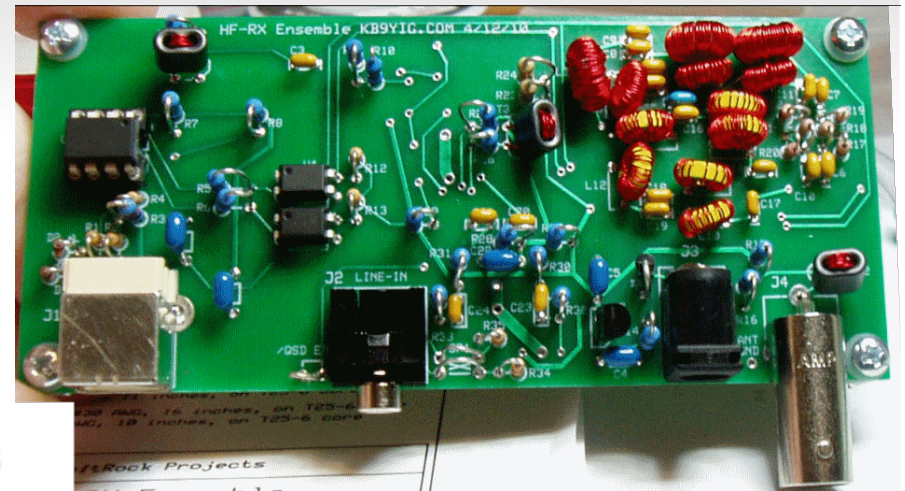
SDR: Ensemble Soundcard

- Requires Stereo Line In "Soundcard"
  - Mono Won't Do
  - Older "AC97" Built-In Are Usually Not Very Good
  - Many Modern "HD" Motherboards are OK
  - Otherwise Can Use PCI, Cardbus, USB or Firewire Soundcards
- Stereo Is Necessary for "I" and "Q" Signals from the QSD

SDR: Ensemble PC

- Requires Moderately Powerful Computer
  - Dual Core or Better Preferred
  - 2 GHz or Better Preferred
  - Windows XP or Windows 7 Preferred
    - VISTA is More… Challenging
  - Linux and Mac Can Be Used
    - But This is Redmond…
  - 1024x768 Display is Minimum for PowerSDR
    - 1024x600 Netbooks Can Be Problematical

SDR: Softrock Ensemble
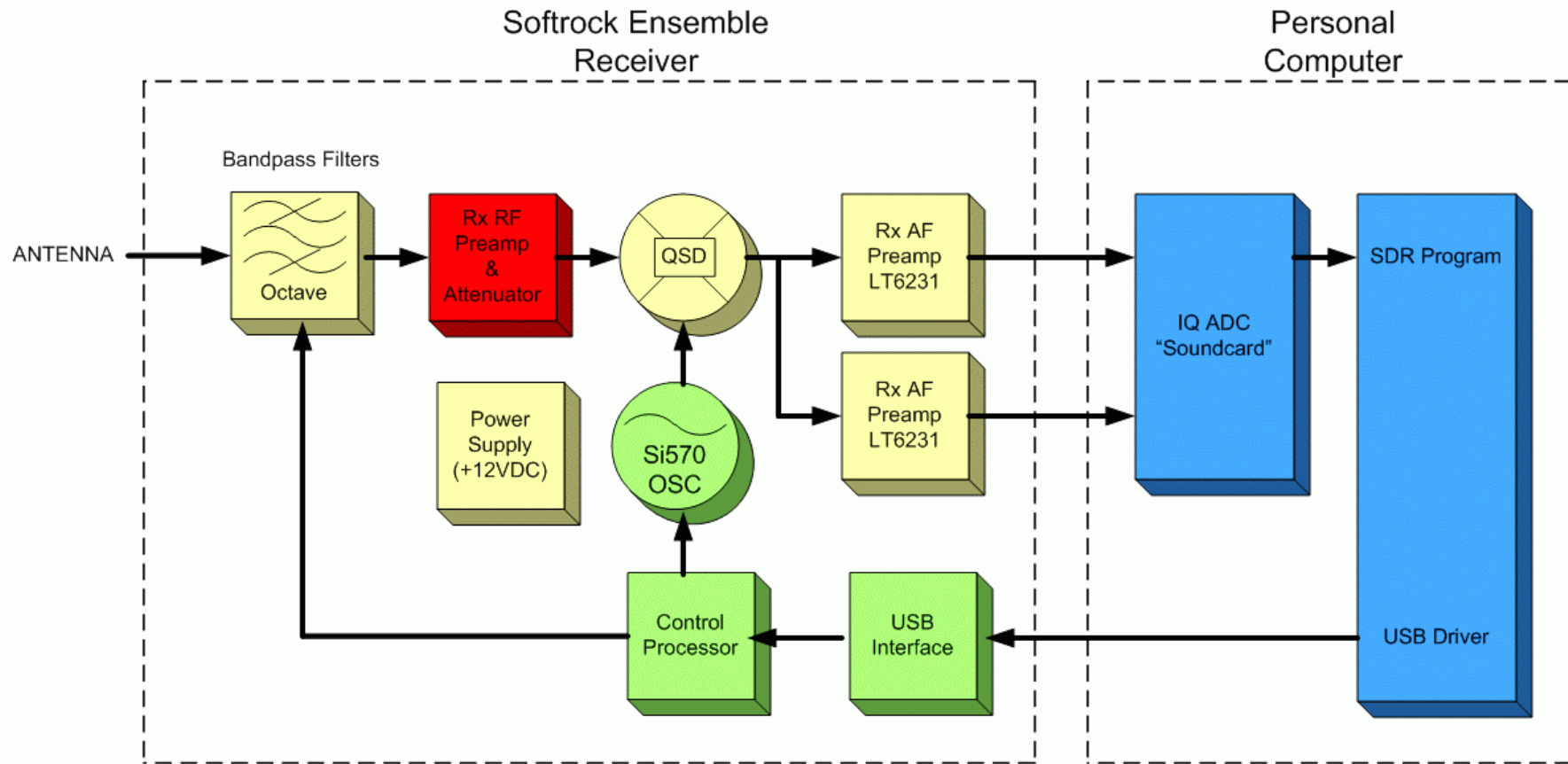
SDR: Softrock Ensemble

- This is a Basic, Entry –Level Receiver
- What's Missing?
    - Preamp for (15m/12m/10m)
    - Attenuator for (160m/80m/60m/40m)
- What's Important for Rx Performance
    - A Really Good A/D Converter on Line In
        - Dominates Dynamic Range
        - Determines Spectrum Display Width
        - Large Impact on Sensitivity

SDR: SoftRock Ensemble

- QSD Strengths
  - Simple (1 IC, 2 Capacitors)
  - Low Cost (About $1)
  - Low Loss (1-2 dB, vs 6-8 dB for Diode Ring)
- QSD Weaknesses
  - Performance Depends on Source Resistance
  - Strong Harmonic and Other Responses
  - Requires Quadrature LO
    - I+Q Image Rejection

SDR: SoftRock Ensemble

- The Ensemble Is Capable of Excellent Performance Within Its Limitations
- Learn Strengths and Weaknesses of QSD
- Wonderful Tool to Explore PC-based SDR
- The Spectrum Display is Done by Software
  - Thus the Softrock Ensemble Has It
- PNWQRP Group Purchased as Learning Tool

Rocky (for Softrock) Software

- Free, Closed, Elegant, Requires Win 2K or XP

- Little Screen Real Estate

- Grab and Drag Most Controls

  (Images Are Not the Same Signals)

- Skimmer was derived from Rocky!

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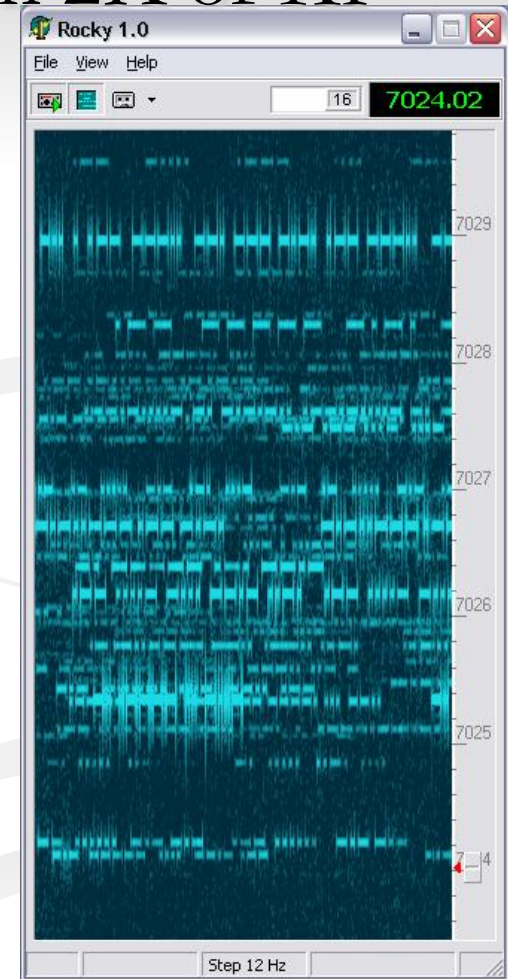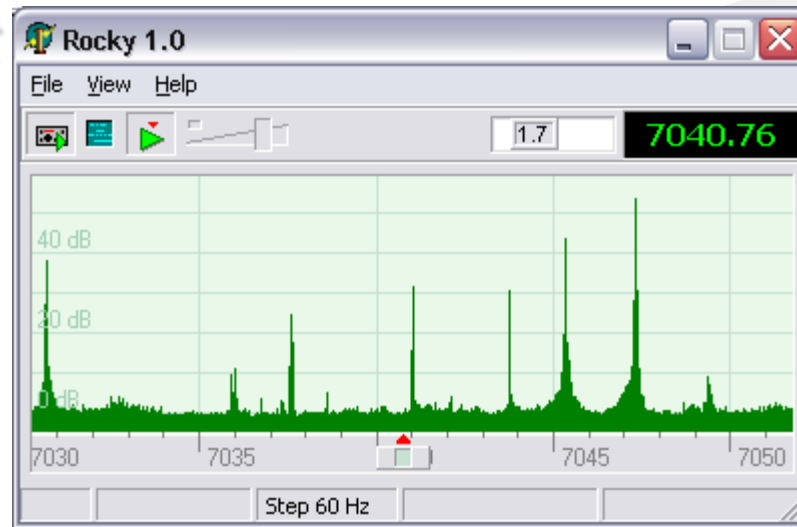
SDR: Hidden Costs

- PC-Based SDR Has Many Hidden Costs
    - Some Try To Argue These Costs are "Free"
    - You Decide!
- Let's Work an Example…

SDR: Hidden Costs

- Base Station
  - 100W Tx
  - HF+6m
  - Digital Modes, CW, SSB
  - Logging Program
- Question 1: Is Your PC Up to the Task?
- Question 2: Are You Up to the Task?

SDR: Hidden Costs

- PC (Desktop)
  - Flex-Radio links to Abroham Neal as a Supplier for "Flex-Ready" PCs
  - Three Offerings:
    - Low Cost: Starts at $729
    - Medium: Starts at $1149
    - Premium: Starts at $1849
    - Add Screen(s), Keyboard, Mouse, Etc.
  - Your Existing PC May be OK…

SDR: Hidden Costs

- **PC Tuning**
  - **There are Issues of Latency**
    - Windows is Not a Real Time OS
    - Some Drivers or Housekeeping May Seize the Computer for a Few Milliseconds
      - Or a few tens of milliseconds
    - This Causes Audio Dropouts (like Web Streaming)
    - You Need to Increase Buffering to Protect
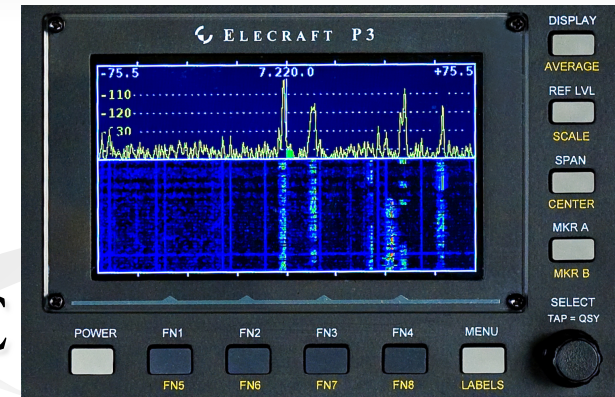   - or "Tune" the Computer to Minimize Buffers

SDR: Hidden Costs

- PC Screen Size
  - PowerSDR Needs 1024 x 768 Pixels
  - Other Programs Vary
  - You May Need A Larger Screen, or a Second Monitor, to Use Digital Modes, Logging, Etc.
- You May Already Have a Suitable PC and Screen(s)
  - If So, These Costs are Zero
  - If Not, …

SDR: Hidden Costs

- Another Example: Portable Station
- Guidance for Laptops
  - "Passmark" of 500 Minimum, 1000 Recommended
  - Screen Pixels, Memory are Important
  - Power Management Can Get In The Way
    - Expect to Spend Some Time "Tuning"
- Some Netbooks Can Work
  - But is the Screen Adequate?

SDR: Summary

- Real-Time Spectrum Display is Paradigm Shift
- Simple Systems Can Provide Good Performance
- Good for Self-Education
- Not a Magic Pill
- Work Required to "Tune" PC
- There May Be Significant Hidden Costs
- SDR Does Not Mean a PC is Required!

References

- SoftRock
  - http://www.kb9yig.com
  - http://www.wb5rvz.com/sdr/ensemblerx
  - http://groups.yahoo.com/softrock40/group/softrock40

References

- Softrock SDR Software (Windows based)
  - http://www.flex-radio.com
  - http://www.dxatlas.com/Rocky
  - http://www.hdsdr.de
  - http://www.sm5bsz.com/linuxdsp/linrad.htm
- Passmark Ratings
  - http://www.cpubenchmark.net/

SDR for Beginners

THANK YOU!

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