Using Gnuradio to Introduce Digital Radio Concepts to Amateur Radio Hobbyists

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Amateur Radio

• International activity, 100+ year history

• Government-sponsored cadre of radio hobbyists

• Licensed activity - standards set nationally and internationally
### Specialties Within the Activity

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<td><strong>Technical</strong></td>
<td>Propagation</td>
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Motivation

• For users:
  • The excitement of talking to other hobbyists all over the world, in an era before the Internet
  • Technical skills and learning, innovation

• For governments:
  • Historically, federal governments viewed amateur radio as a way of supporting a “technical reserve” of citizens who can be called on by the military in the event of war
Training and Licensing

- Amateur radio operators must be licensed by their respective federal governments:
  - Technical, operational, legal components
- Impetus:
  - Effectiveness of communication
  - Non-interference to other services
- Examinations in 2000s focus more on legal and operational aspects than on technical details of radio
Technical Training

• National technical training syllabi are based on international telecom/radio regulations (ITU)

• Foundation is analog theory, analog circuits

• Slow adoption of digital concepts such as SDR into national standards
Amateur Radio and Innovation

• Significant history of innovation by amateur radio operators:
  • Propagation theory
  • Early SSB
  • SSTV
  • Operating techniques

• Many amateurs retain the curiosity* and innovative spirit of their forebears, but lack current technical fundamentals to fully understand the new technologies and innovate in the amateur radio space

* Canadian/British spelling!
Public Safety

• Amateur radio continues to support public safety and emergency communications and is a valuable operational resource
Technical Skills

• The knowledge gap between hams’ federal licensing requirements in technology-related topics and the state of the digital radio art has become quite wide in the past 30 years

• Technologically, the hobby remains stuck, in many respects, in a communications paradigm of the 1970s
My Background

• Amateur radio operator since 1977

• “Amateur Radio and Innovation in Telecommunication Technology”:  
  • ISBN: 0612818934

• 40 years teaching experience

• Former lead instructor for amateur radio training classes in the  
  Vancouver area
Digital Radio

• Amateur hobbyists have strong interest in SDR and digital techniques, but no mandated training and little technical understanding of SDR/DSP

• Undermines some of the national objectives for the hobby

• Commercial amateur radio equipment manufacturers have adopted SDR, but with few exceptions equip their digital radios with traditional analog front panels
Digital Radio Training

• Gnuradio is a fantastic tool for introducing digital radio and SDR techniques to hobbyists with basic (and analog) technical understanding of radio

• Idea:
  • Offer an introductory SDR program to licensed amateurs in order to raise technical literacy

• Four classes offered in the Vancouver area in 2017-2018
Course Philosophy

• Reduce students’ apprehension about the perceived complexity of DSP/SDR and give them a starting point on which they can build.

• Introduce DSP, digital techniques through comparison to better-understood analog processing.

• Have students apply this new knowledge to build a digital receiver using gnuradio-companion.
Course Overview

• 4 hours in length
• Lecture - demonstration - hands-on
• Gnuradio “live CD”-based ISO
• Students must purchase and bring an RTL dongle to class
Sample Course Content (and Action Shots!)

- Short intro to digital radio

- Soft introduction to DSP, FFTs, and I/Q

- Interactive discussion using whiteboard

Digital Radio: A New Paradigm

- Radio signals (electromagnetic waves) have a corresponding mathematical description

- The math defines signals precisely:
  - AM, FM, SSB, PSK, et cetera

- Digital radio uses computers to represent (and analyze) signals directly, using their mathematical representation
Soft Technical Content

- Hams have proven technical ability
- Due to a number of factors they may feel threatened by the complexity of DSP/SDR
- Goal:
  - Reduce anxiety and inspire confidence
  - Despite age/background/etc., you can learn this!
Comparison-Based

- How analog circuitry was simply an approximation of the math behind radio

- CPUs and systems are now capable of simply doing the math

“Classic” Radio Compared With Digital Radio

- Analog radio (everything up until about the 1980s) used discrete components in circuits to represent the math behind radio transmission and reception

- These circuits approximated the math

- Why was this?
  - The math could not be computed directly as computers (at first) did not exist; later they were not fast enough
Allay Fears

• Build student confidence through soft explanation and provision of strong (but easily readable) reference material

• Realistic statements in regard to learning

I’m No Mathematician!

• Nor do you have to be, to be able to figure this out!

• I started in this area with simply an interest, and augmented that by extensive reading and thinking
Demo-Based Approach

- Hosted, iterative hands-on experimentation and testing
- Flexibility of software-based approach
• Students’ age ranged from early 20s through 70s

• Average age: probably 50
Action Shot

• Students come from all walks of life

• Physician, student, engineer, computer scientist, locksmith, concert pianist, psychologist!
Block Diagram Analogy

- Traditional high-level block diagrams support understanding of gnuradio blocks
- All students have been exposed to these traditional diagrams
- Good segue to GRC
Further Learning

• Realistic approach:
  • Complexity of the field is not under-represented to the class
  • Students are advised that they should expect to spend significant time studying, experimenting, learning

• Students are referred to quality introductory material for further study:
  • GnuRadio tutorials
  • “HackRF” video series by Michael Ossman
  • ”Scientists and Engineer’s Guide to DSP” by Steven Smith
Going Forward

• Students emerge with new knowledge and a stronger understanding of how and (importantly) why digital radio works

• ”Dabblers”:
  • Most students learned some fundamentals but will likely not become advanced gnuradio users

• “Adopters”:
  • About 2 or 3 students have been motivated to go further, have followed up and now have basic literacy in the field
Specific Results

• Several flowgraphs and a working FM band receiver

• Knowledge of how to use GRC

• Relief of any feelings of intimidation, and increased student confidence
Big Picture Results

• A small step in the overall picture

• Increased understanding of SDR/DSP in the local amateur radio community

• Realignment of amateurs’ skills in relation to the goals of amateur radio as a national and international resource
Implications

• Amateur radio regulations and training programs need to modernize

• Lack of technological currency limits amateur radio’s tradition of innovation

• Gnuradio can play an important part in training new “hams”
Challenges

• Need for international and national regulatory changes

• Disruption of long-established tradition and culture within a mature hobby

• Lack of sufficient SDR/DSP knowledge on the part of existing instructors
Questions?
Thank You!