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

Category	Examples		
Operational	Unmediated international communication	Emergency preparedness	Message handling
Technical	Electronics	Antennas	Telecom and networks
Technical	Propagation	HF/VHF/UHF/Micro wave	Space systems

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 curiousity* 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

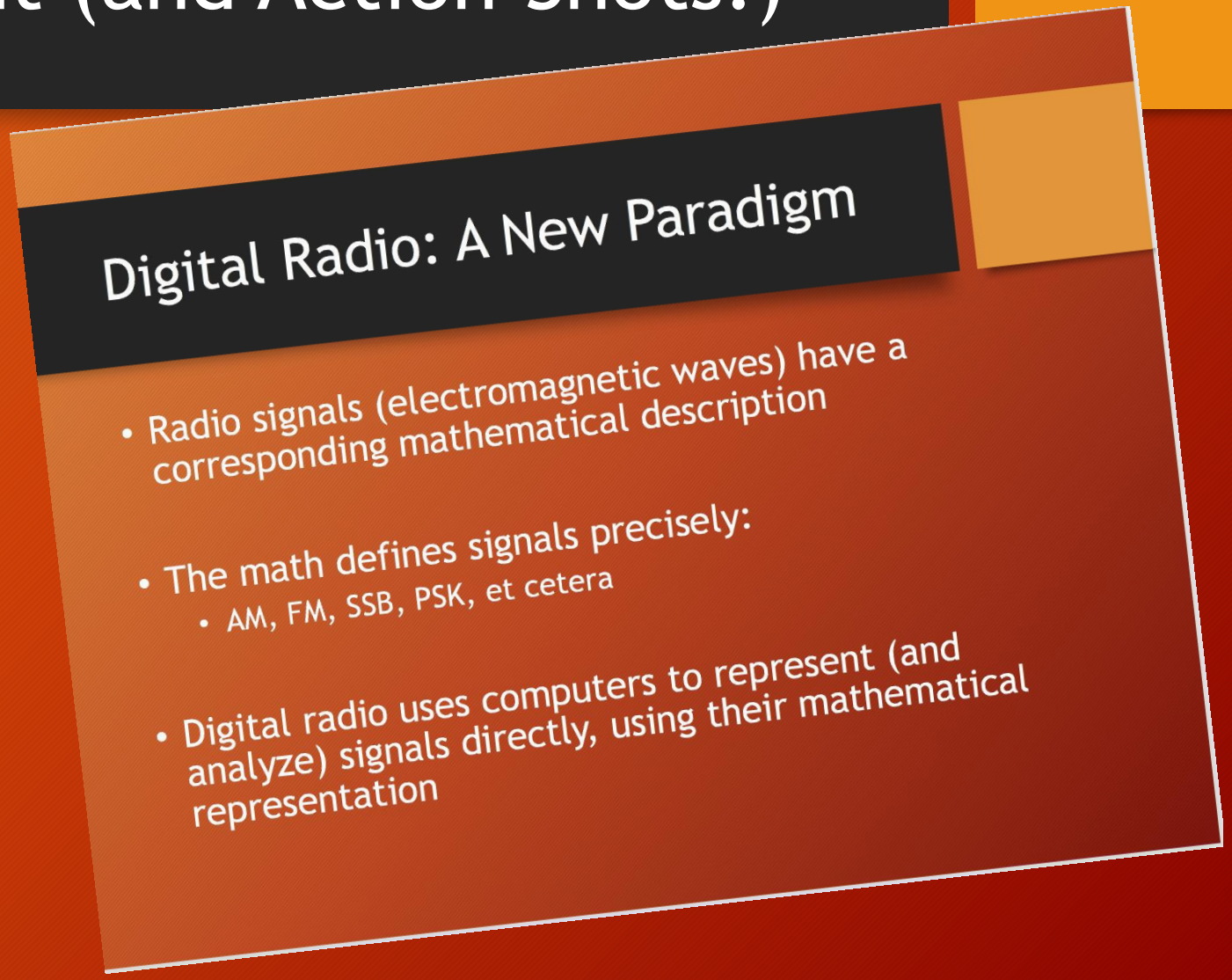
- Reduce students' apprehension about the perceived complexity of DSP/SDR and give them a starting point on which they can build
- Introduce DSP, digital techniques through comparison to better-understood analog processing
- Have students apply this new knowledge to build a digital receiver using gnuradio-companion

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

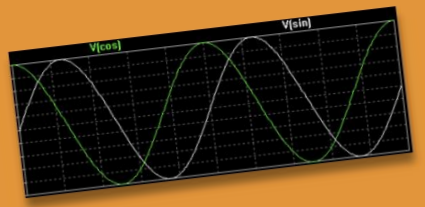


Soft Technical Content

- 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!

Foundation

- Any radio signal can be represented by the sum of one or more "sine" waves
- In fact, two sine waves can be used to represent *any* form of modulation
- I and Q represent the instantaneous magnitude of two sine waves 90 degrees out of phase
- Modulation and demodulation is just math!



Comparison-Based

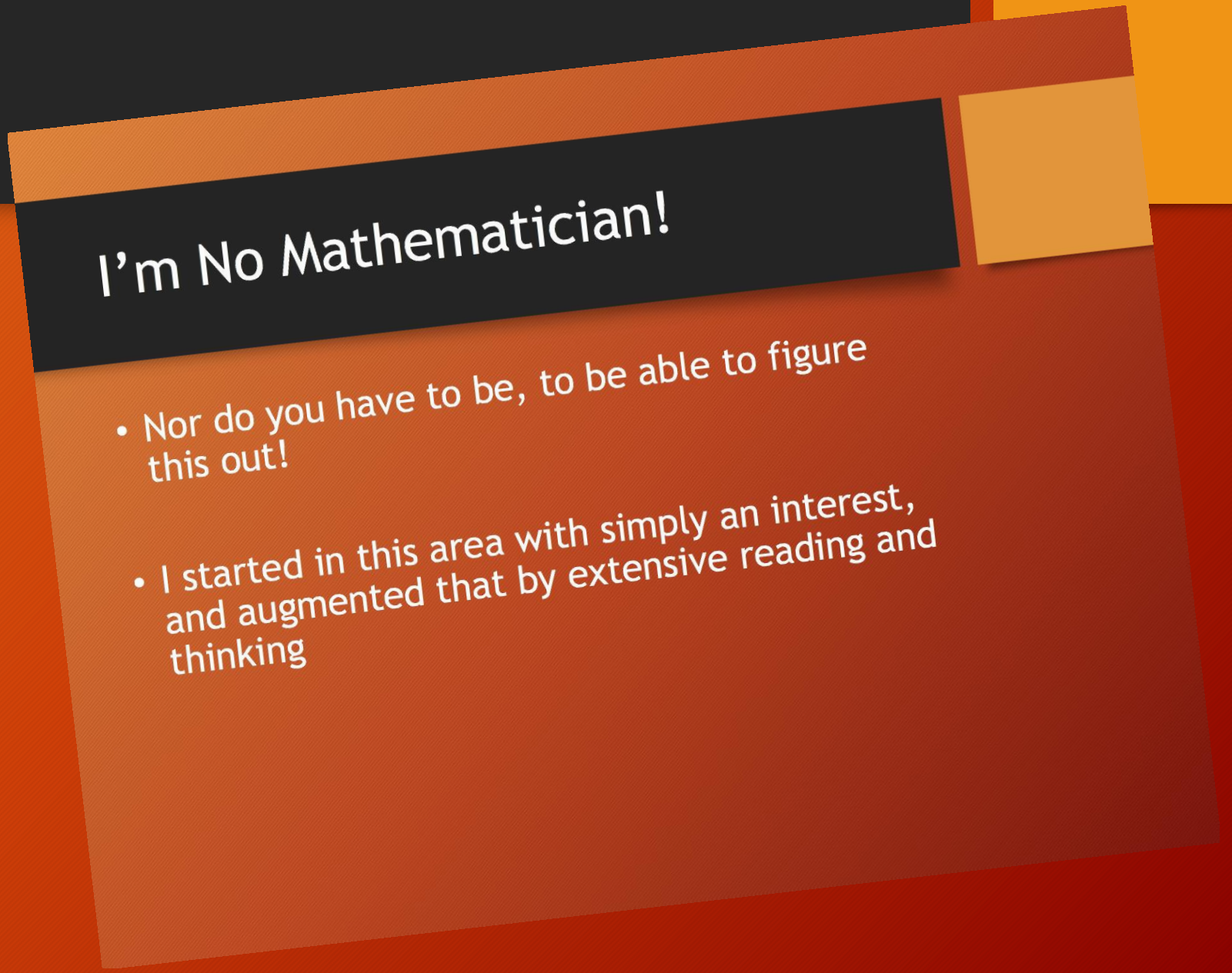
- How analog circuitry was simply an approximation of the math behind radio
- CPUs and systems are now capable of simply doing the math

"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



Demo-Based Approach

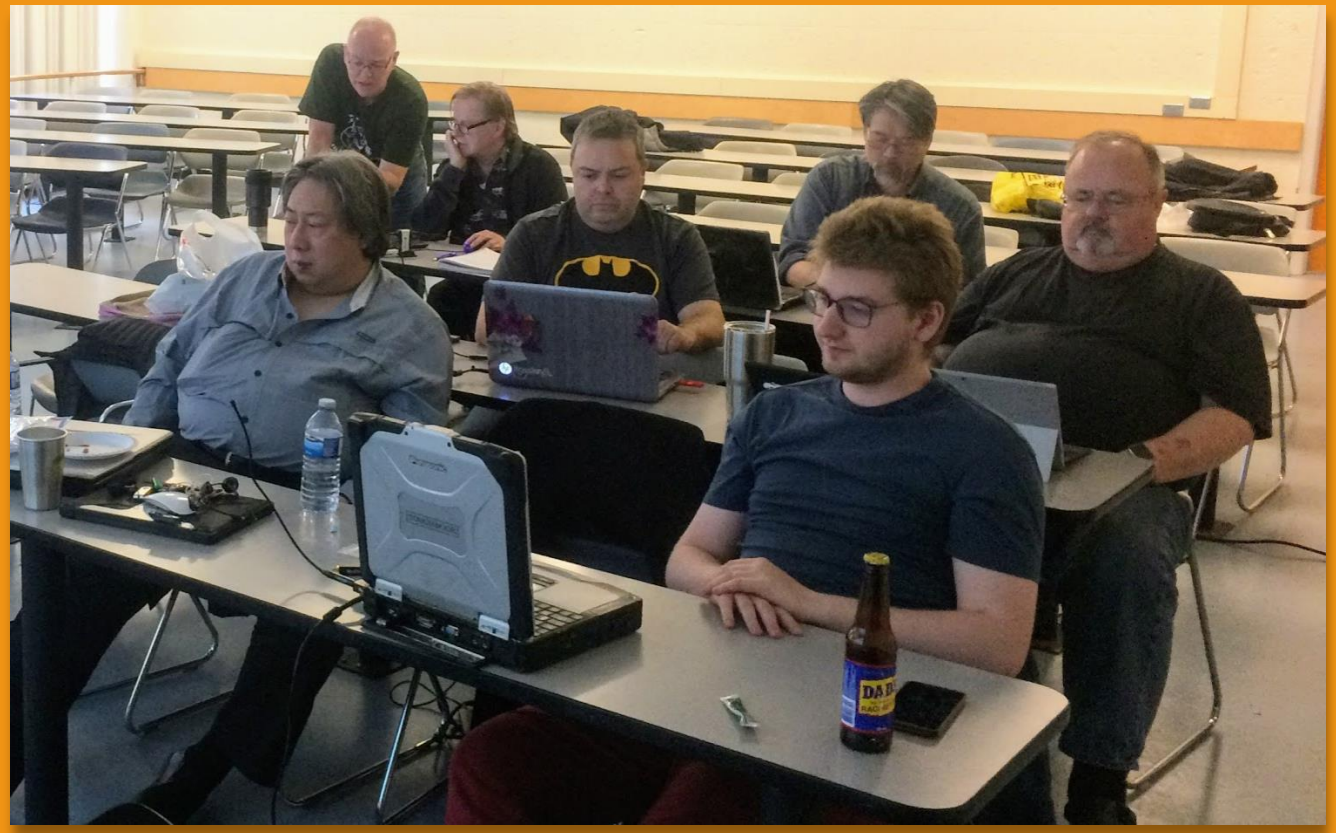
- Hosted, iterative hands-on experimentation and testing
- Flexibility of software-based approach

Action Shot

- Students’ age ranged from early 20s through 70s
- Average age: probably 50

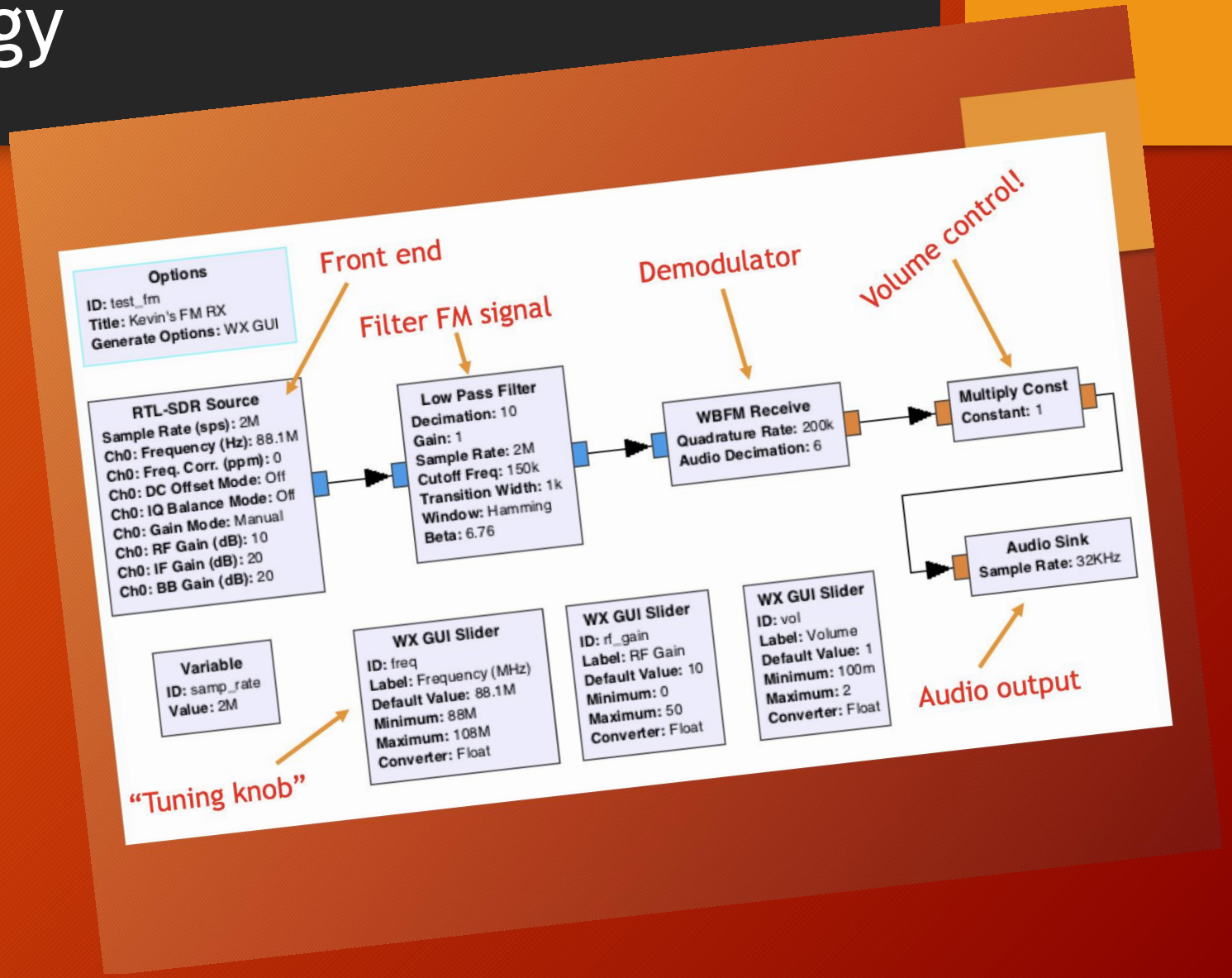
Action Shot

- 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!