HAM FRIENDLY DIGITAL SIGNAL PROCESSING (DSP)

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SESSION OUTLINE

- Overview of Ham Friendly Digital Signal Processing (DSP)
- Demonstration of an easy to use, DSP program development environment
- DSP for Software Defined Radio (SDR): SDR architecture and DSP performance
  Compatible front end hardware
New releases of affordable graphical DSP software
New “ham friendly” DSP text books
New advanced technology SDR ‘front ends’ based on a high speed sampling and FPGA architecture
Why should Hams consider DSP projects?

- DSP is a major area for modern radio innovation, necessary component of SDR building projects
- DSP software program development environments now available at no cost, suitable for building working radios
- DSP software is the modern equivalent of the soldering iron of yesteryear
DSP software provides learning and building opportunities for Hams

- Advances computer skills
- Hands on education in signal processing technology
- Hands on experience at building radios that work
- Opportunities to experiment with advanced DSP techniques, e.g., digital modulation, spectrum monitoring, radar
GNU Radio is an open source library of DSP functions written in C++ to maximize computation speed and efficiency, with a Python shell.

GNU Radio Companion (GRC) is the graphical user overlay on top of GNU Radio. GRC permits visualization and manipulation of DSP functions (a.k.a. algorithms) without learning a programming language.
GRC and GNU Radio permit real-time signal processing suitable for use in functioning receivers/transceivers.

GRC is designed for hands on, trial and error experiments with DSP. Make a mistake? Change an algorithm or a parameter. Adjust parameters while operating the DSP-enabled SDR.
Main screen, work space, DSP library
Move and link DSP blocks, execute a DSP program
Filter implementation
Mixer(multiplier) implementation
Mixer plus filter implementation
Amplifier (multiply) implementation
FM demodulation using TV Dongle to receive FM broadcasts
Q: Why do Hams care about DSP?

A: To build SDRs, of course!
3 EASY STEPS TO BUILDING A DSP FOR YOUR SDR

1. Learn the basics of DSP theory and practice

2. Learn to use GRC and the GNU Radio software library to author your own DSP

3. Link the DSP you authored to an available “front end” of your choice
SDRs require both a hardware “front end” and the software DSP “back end” to function. A key component is the software link with the DSP.

SDR “front ends” provide the I & Q signals ready for DSP.

SDR “front ends” are increasingly complex and difficult for Ham level building projects. High performance “front ends” readily available.
ANALOG VS. DIGITAL SIGNAL PROCESSING

TRADITIONAL ANALOG RADIO

RF

Local Oscillator (tuned)

Bandpass Filter

Detector (Demod)

Baseband

Audio out
RF

Baseband (DSP)

Low pass Filter → Detector (Demod) → Audio out

Sampling + FPGA
Signal flow is the same

Analog SP occurs at RF and IF frequencies

Digital SP (DSP) comprises the signal processing that occurs at baseband, near 0 Hz

Both SPs use the same components with sometimes different names:
- analog mixer a.k.a. digital multiplier
- analog amplifier a.k.a. digital multiply
- analog detector a.k.a. digital demodulator
DSP begins after the RF signal sampling and A/D converter (The SDR “front end” creates the digitized I&Q signal for the DSP that follows)

DSP processing components are implemented as mathematical algorithms and resolved as math problems
Authoring a DSP involves selecting the proper algorithm, assigning the proper math parameters and linking the algorithms.

DSP always accompanied by some processing latency. Expect your DSP signal to be delayed as it processes.
DSP BENEFITS

- DSP provides significantly increased precision compared to Analog SP, e.g., “perfect” filter

- DSP signal processing easily accomplishes what in the Analog SP world may be difficult or impossible

- DSP is easily modified using a computer and does not require the use of physical and often expensive radio components
**EXAMPLES OF GRC COMPATIBLE SDR “FRONT ENDS”**

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<th>SDR</th>
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<tr>
<td>HPSDR Hermes</td>
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SUMMARY

- **GRC Leverages What Hams Already Know!** DSP processes are essentially the same as traditional Analog signal processes.

- **GRC is Easy for Hams to Learn!** DSP authoring is easy to learn and in reach, the result of modern graphically rendered DSP programs.

- **Hams are Empowered to Build/Design the “Back End”!** Don’t forget, DSP is the “other half” of an SDR.
GNU RADIO


- [http://www.ece.uvic.ca/~elec350/lab_manual/ar01s02.html](http://www.ece.uvic.ca/~elec350/lab_manual/ar01s02.html)
DSP REFERENCES

- http://complextoreal.com/
  Charan Langton
QUESTIONS

Special thanks to Howard Burns, W1HMB, for his generous assistance with preparing this material.