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
  - DSP performance
  - Compatible front end hardware

BANNER YEAR FOR DSP/SDR

- 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

HAM FRIENDLY DSP

- 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

HAM FRIENDLY DSP

- 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 DSP LIBRARY

- 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**

GNU RADIO COMPANION (GRC)

- 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

GRC DEMONSTRATION

- 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

SDR Q & A

Q: Why do Hams care about DSP?

A: To build SDRs, of course!

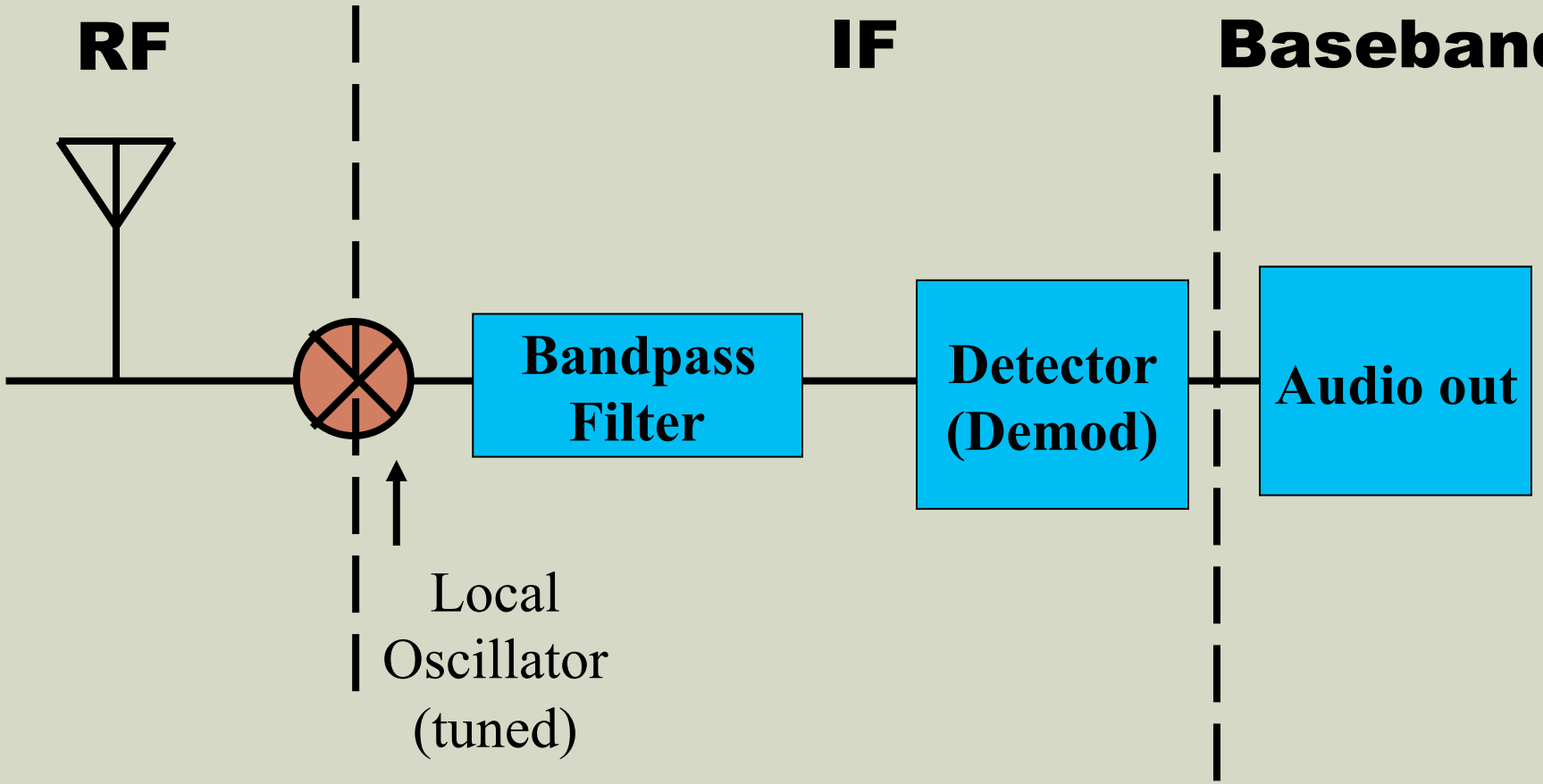
3 EASY STEPS TO BUILDING A DSP FOR YOUR SDR

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

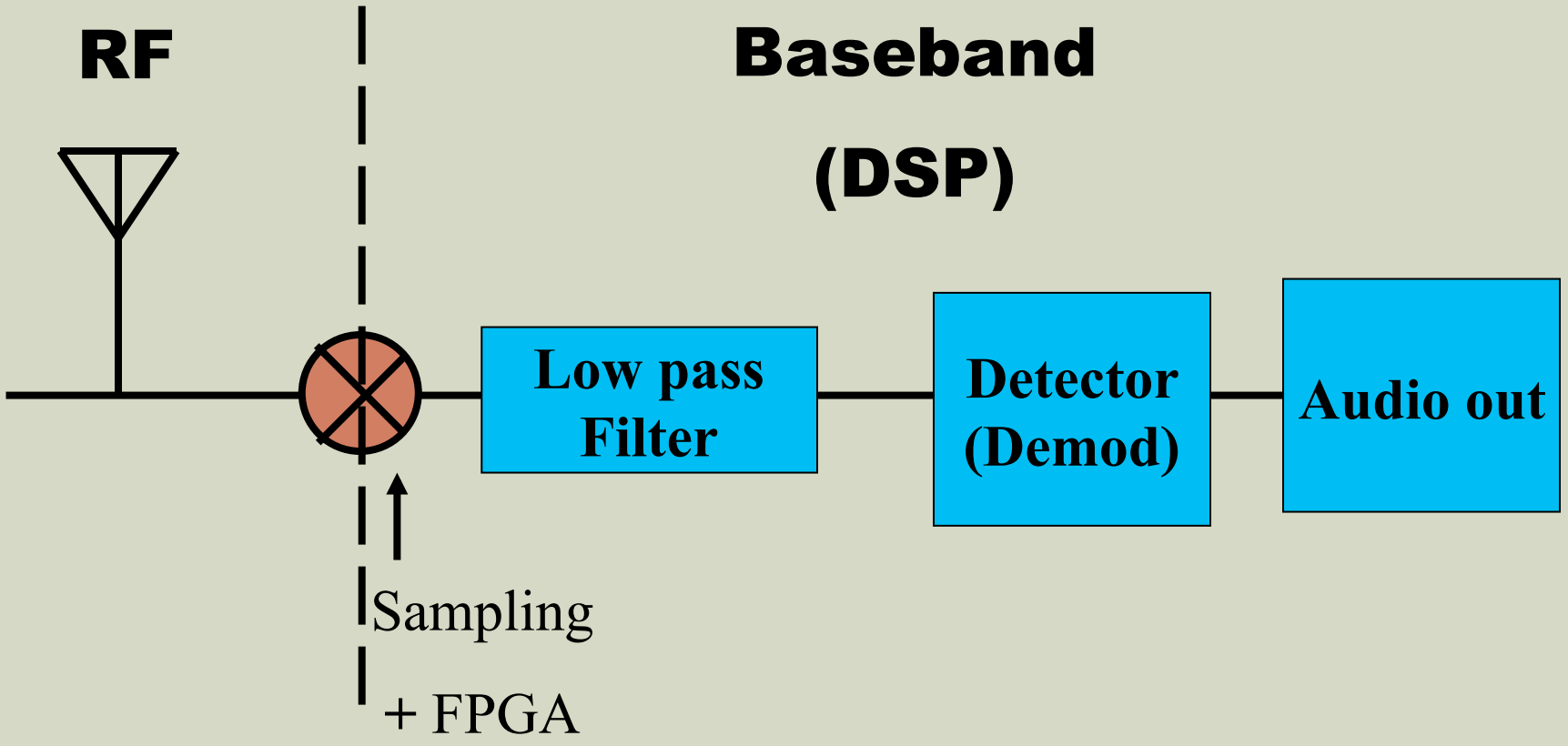
SDR 101

- 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



ANALOG VS. DIGITAL SIGNAL PROCESSING MODERN COMPLETELY DIGITAL SDR



ANALOG VS. DIGITAL SIGNAL PROCESSING

- 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 CHARACTERISTICS

- 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

DSP CHARACTERISTICS

- 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"

HPSDR Hermes	Tx & Rx	~$895
Ettus USRP	Tx & Rx	~$1700
SDRstick^{tm}	Tx & Rx	$579
FUNcube Dongle	Rx only	~$120
TV Dongle	Rx only	~$20

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://gnuradio.org/redmine/projects/gnuradio

- http://www.ece.uvic.ca/~elec350/lab_manual/ar01s02.html

DSP REFERENCES

- Understanding Digital Signal Processing, Richard Lyons, ISBN 0-201-63467-8

- http://complextoreal.com/ Charan Langton

QUESTIONS

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