



Software Defined Radio

DIY Techniques in  
Modern Amateur Radio



# Agenda

- SDR Background
- Current SDR Hardware
- Advantages and Disadvantages
- Direct Digital Conversion Architecture
- Practical Considerations
- Some Examples
- Conclusion
- Resources

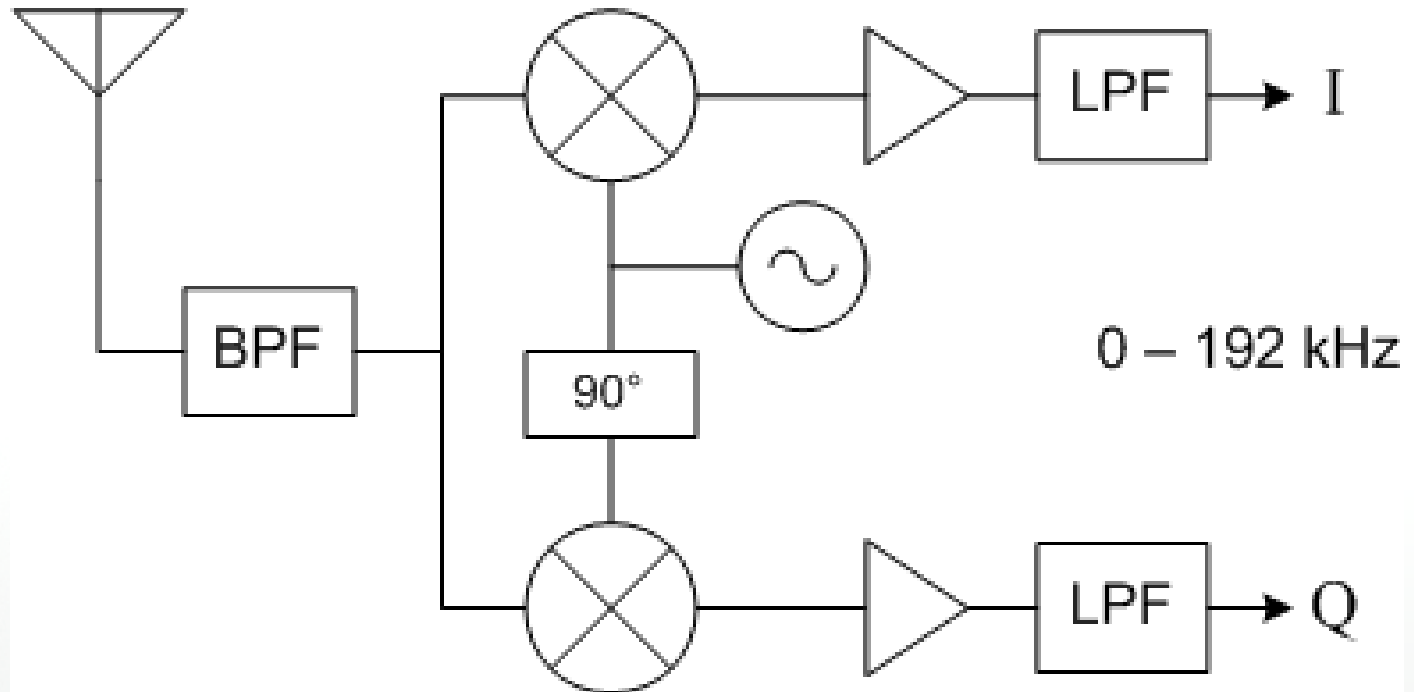


# Overview

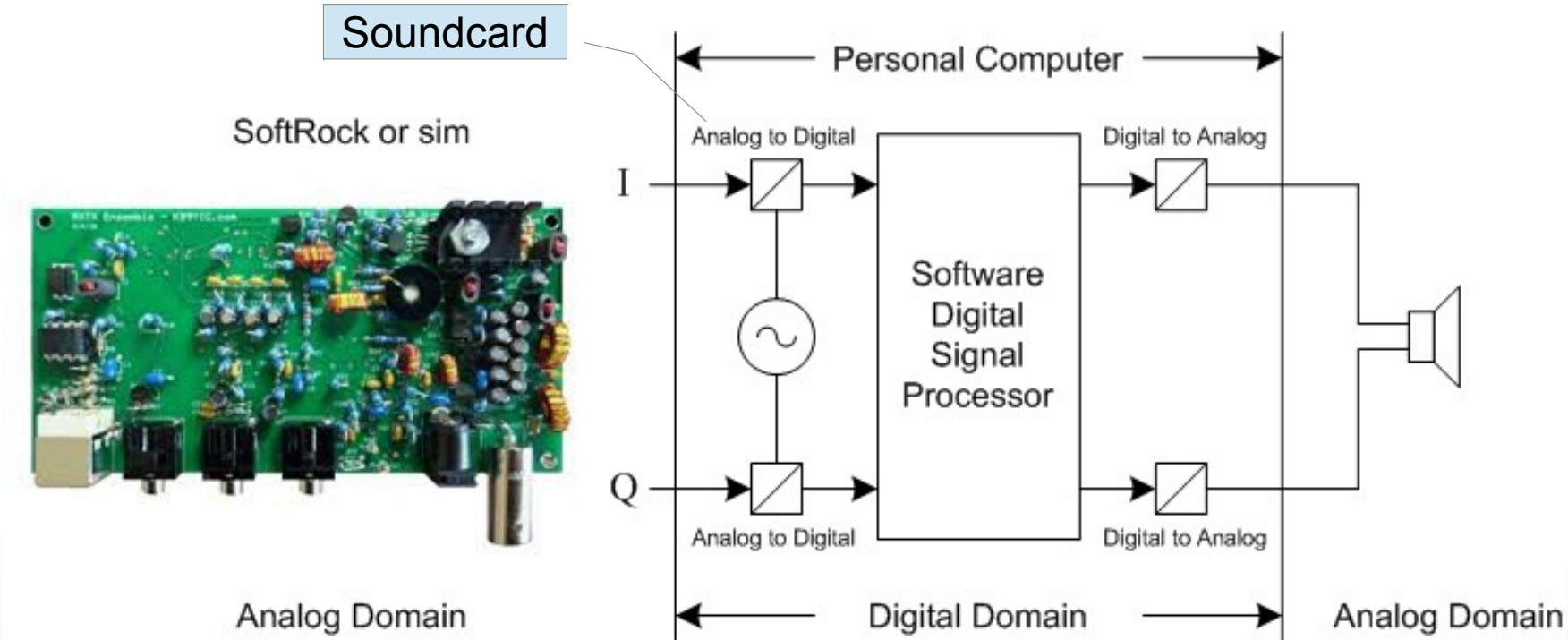
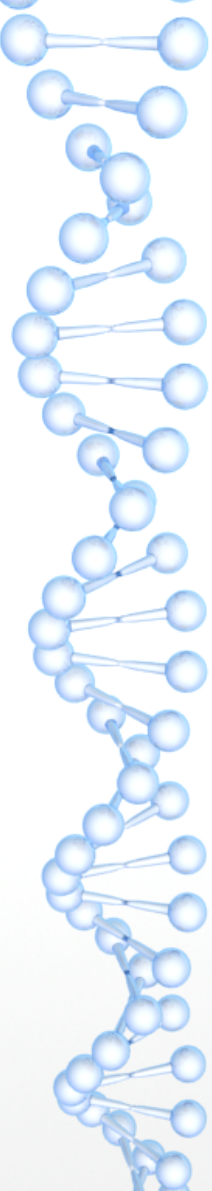
- What is a “Software Defined Radio”?
- Modern SDR systems are on par with the best analog designs
- Trend to move digitization towards the antenna – connect the antenna directly to the ADC
- How does it work?
- How well does it work??

# Older SDR Architecture

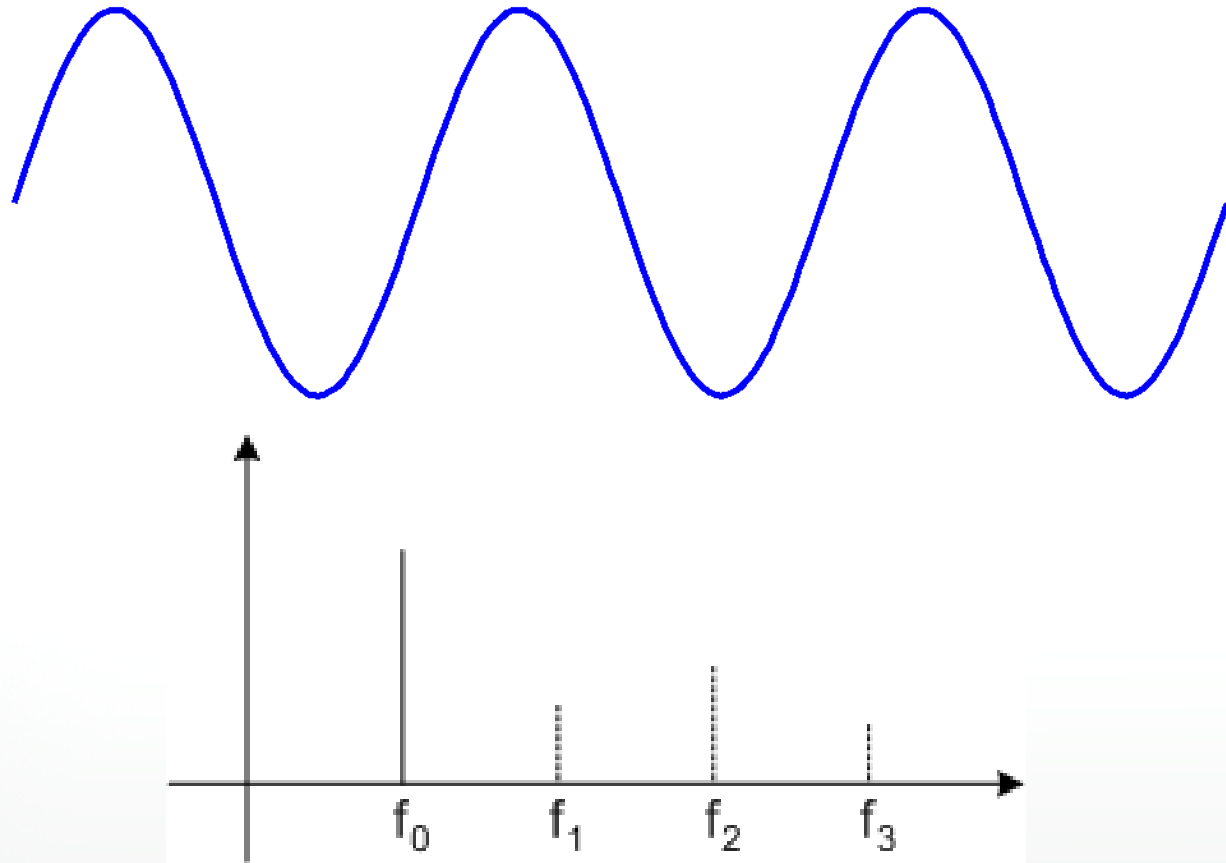
- Earlier SDR architectures used PC computer sound cards:



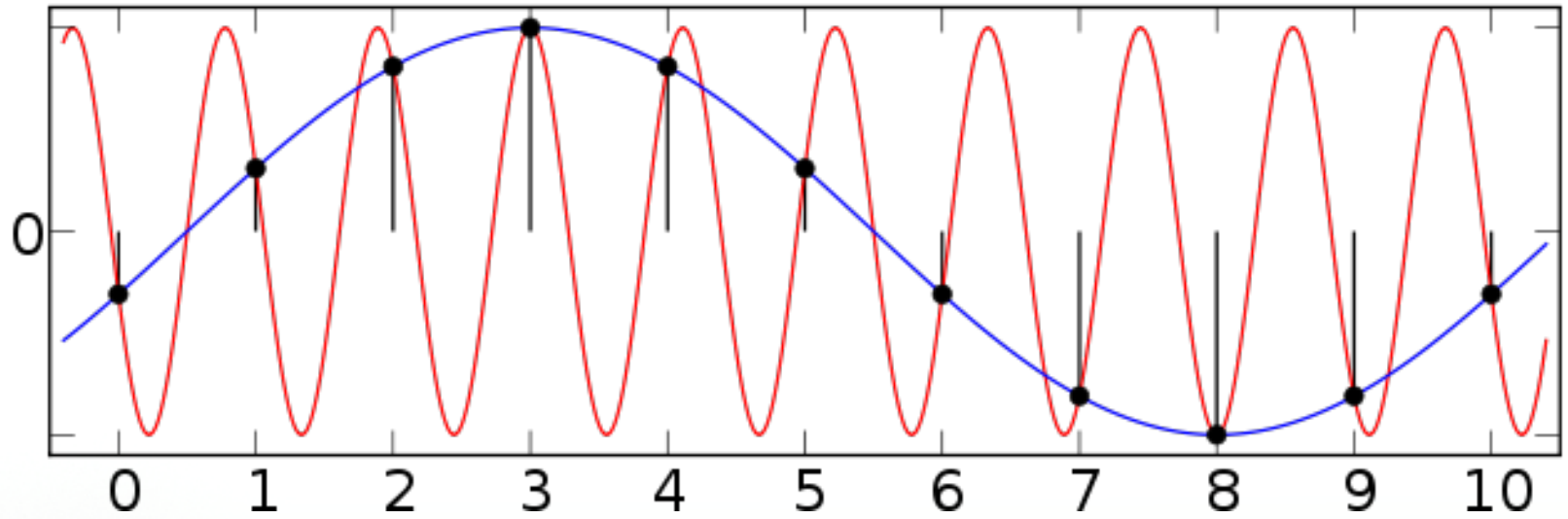
# Using a PC in an SDR



# Sampling



# Aliasing



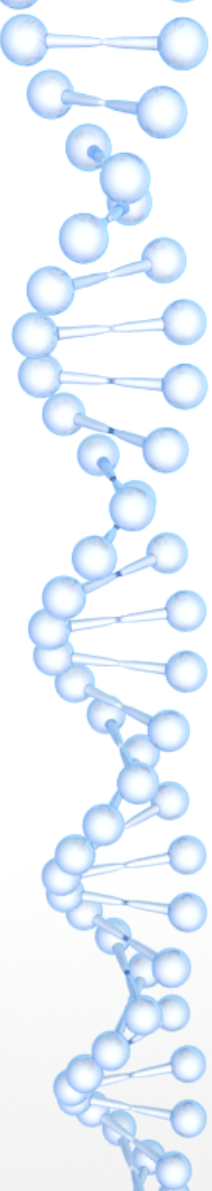


# Performance of Aliasing Method

- Bandwidth width restricted to sampling rate of SoundCard
- Image response – basically just a direct conversion receiver... but as a superhet??
  - eg. 14.100 MHz with a 10 kHz IF --> image at 14.080 MHz
  - Phasing methods to get rid of the image
  - Image rejection depends on amplitude and phase coherence

Rejection	Phase (°)	Amplitude (dB)
40 dB	1.0	0.1
60 dB	0.1	0.01
80 dB	0.01	0.001
100 dB	0.001	0.0001

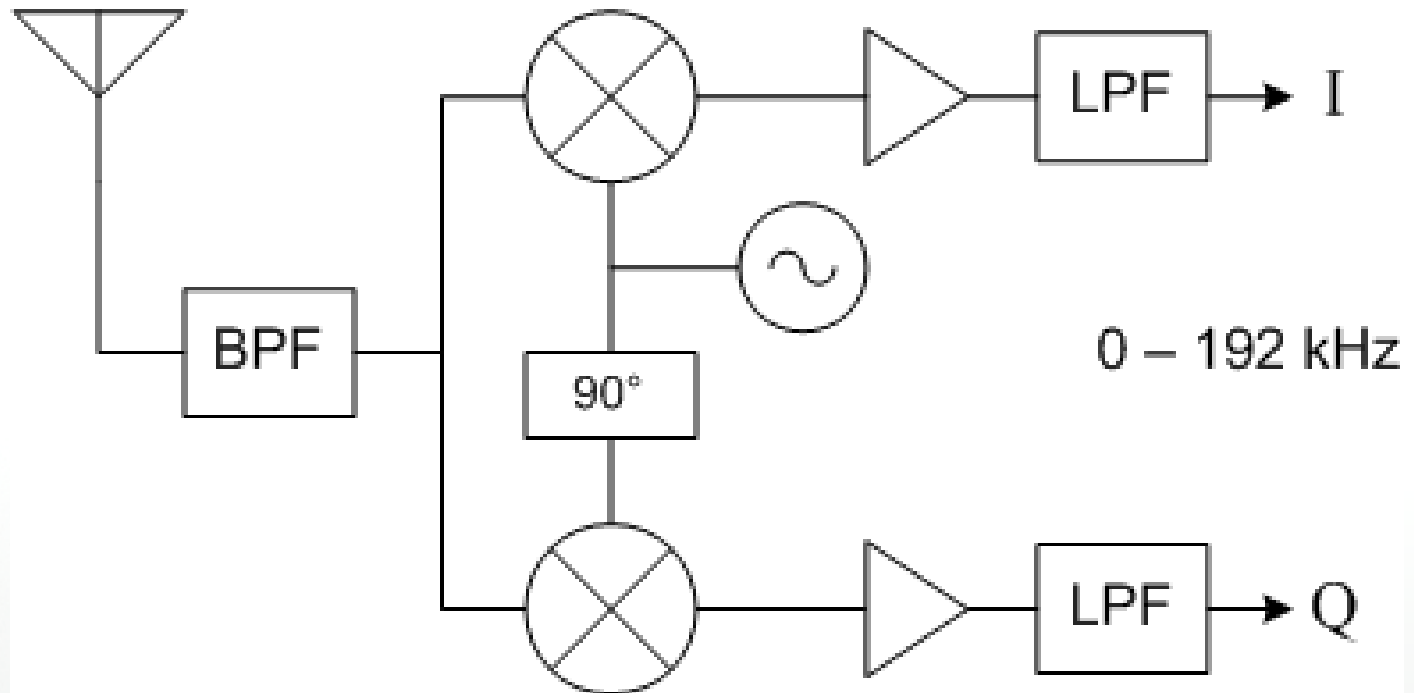




# I & Q Error Adjustment

- Adjust analog levels and phase manually
- Spectacular on one frequency! Band edges not so much
- Affected by SWR of antenna, by band, component drift
- Its time consuming to adjust
- Automatic methods (eg. “Rocky” S/W VE3NEA)
- Built-in signal generator sweeps band and auto adjusts
- But... is there a better way?

# Remove the Analog Components



# Remove the Analog Components

→ I

→ Q



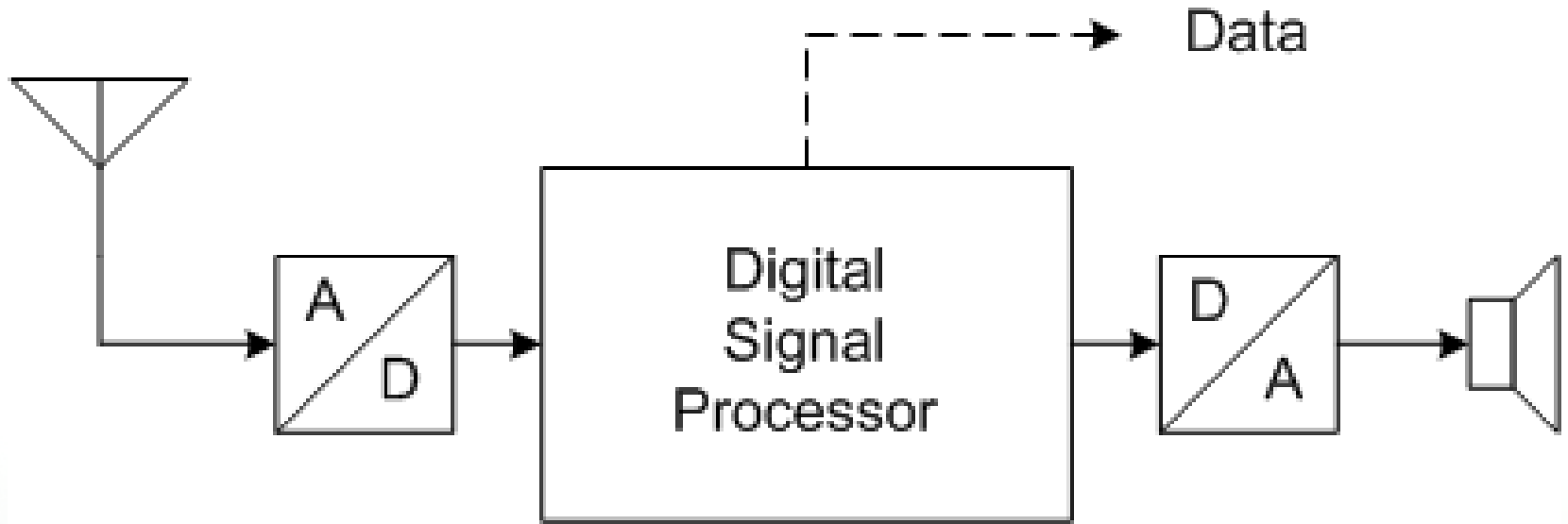
# Remove the Analog Components

→ I

**No More I&Q Balance Problems!!**

→ Q

# Fully Digital Approach





# Practical Considerations

- “How do you solder it when you can’t even see it??”
- Programming – *its not so Basic!*
- Add --> Subtract --> Multiply --> Divide --> *Convolve!*
- Your Advantage: You are a **HAM!!**
- Bare Metal vs LINUX vs Pre-Built
- HPSSDR/Flexradio
- GNU Radio
- GNU Radio Companion



# Some Examples

- Bare Metal
  - 40 meter CW, high efficiency Class E final, SDR RX
- Cheap GNU Radio
  - RTL-style USB dongle
- Expensive GNU Radio
  - ETTUS Research
- Really GNU Radio (or HPSDR)
  - Red Pitaya

# Resources

- Digital Signal Processing
  - <http://www.dspguide.com>
- LINUX
  - <https://www.ubuntu.com/download/desktop>
- Bare Metal
  - <https://www.cprogramming.com/gcc.html>
- GNU Radio
  - <https://gnuradio.org>
  - [https://wiki.gnuradio.org/index.php/Main\\_Page](https://wiki.gnuradio.org/index.php/Main_Page)
- HPSDR/Pre-Built OpenSDR
  - <https://openhpsdr.org>
  - <https://github.com/TAPR/OpenHPSDR-PowerSDR/releases>
- Red Pitaya
  - <https://www.redpitaya.com/index2>
  - <https://ludens.cl/Electron/SDR/redpitayasdr.html>