Table-Top Doppler Radar

Team Wave Riders

Introduction

Team Wave Riders:

- Michael Eck - Team Leader
- Mohammad Hussein - Team Secretary
- Ricardo Toledo - Client Liaison

Clients:

- Dr. Willie
- Dr. Chrysler

GTA Mentor:

- Arnau Rovira-Sugranes

Mike Eck

Problem Statement

- Problem:
  - Doppler radar systems are normally large and expensive, the use of a small and portable system is game changing
  - Clients both have an interest in antennas, radiation, and radar systems
  - Clients want a tabletop sized doppler radar that can measure and display the velocity of objects:
    - Transmit and Receive
    - 100 meter range
    - Measure Velocity of objects i.e. people, cars, etc.
- Motivation:
  - Students are able to physically see and better understand electromagnetic wave propagation and the doppler effect

Solution Overview

- Create Tabletop Radar Device that can be transported easily
  - SDR is lightweight and compact
- Single direction detection
  - Capable of 360 deg motion
- Part selection
  - SDR low price
- Transmit operation
- Receive operation
- Simultaneous transmit and receive
- Signal processing
- Display

Mohammad Hussein

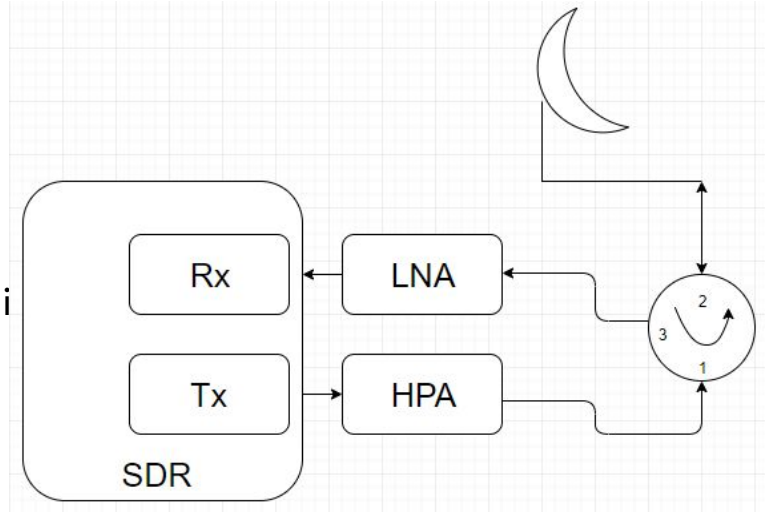
Requirements/Specs Review

- Tabletop
- Portable
- Usable by Professor with Tech. background
- Range of 100 meters
- Editable Code/Software for future use

Mike Eck

Architecture and Implementation

- Software Defined Radio
  - BladeRF 2.0 Micro xA9
  - MATLAB
- Other Hardware:
  - Circulator Counterclockwise
  - Low Noise Amplifier & High Power Ampli
  - SMA Coaxial Cable
  - Antenna
  - Antenna mount with motor



Radar system block diagram fig 1.

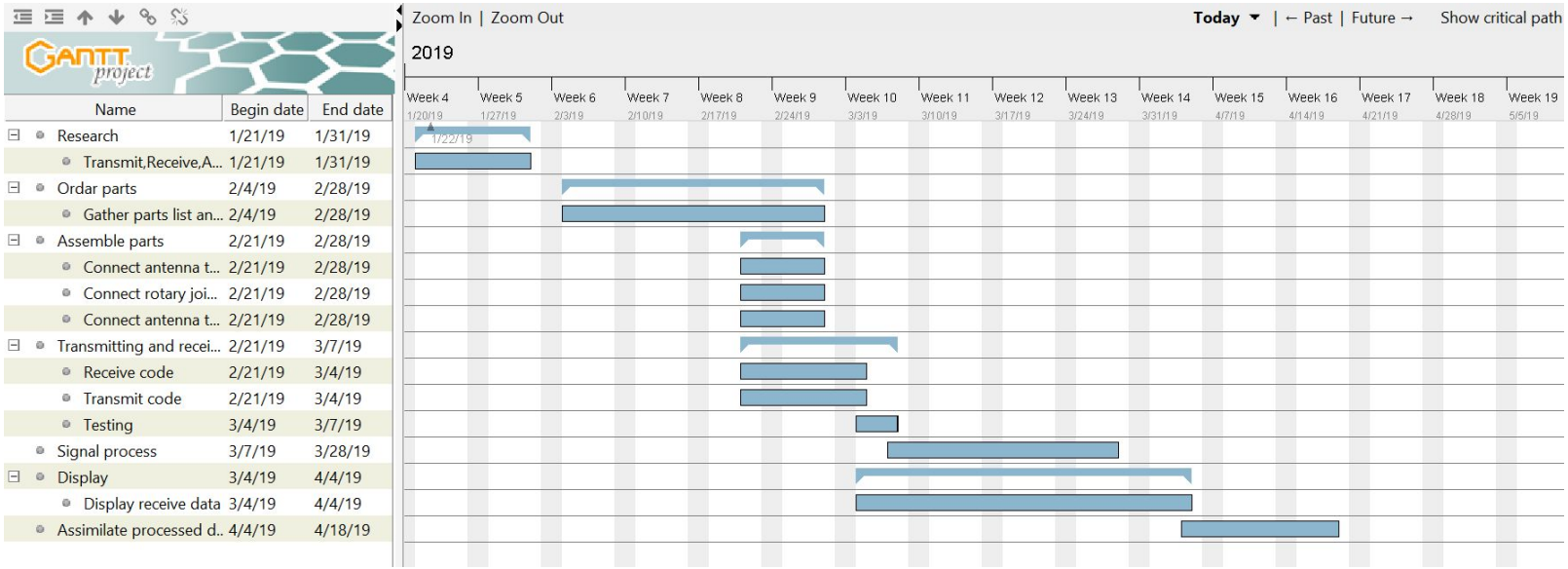
Ricardo Toledo

Challenges and Resolutions

- Clients requested a doppler radar to measure wind velocity
- Blind Speeds
- Unambiguous Range
- Range Resolution
- Power Restrictions FAA
- Solid State electronics instead of Vacuum tube electronics
- Physical Restrictions
    - Budget
    - Time
    - Purchasing improper equipment

Mike Eck

Schedule



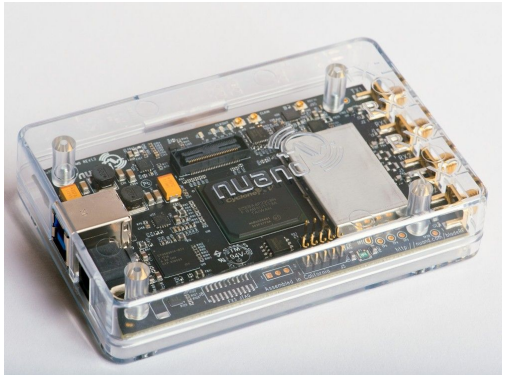
Name	Begin date	End date
Research	1/21/19	1/31/19
Transmit,Receive,A...	1/21/19	1/31/19
Ordar parts	2/4/19	2/28/19
Gather parts list an...	2/4/19	2/28/19
Assemble parts	2/21/19	2/28/19
Connect antenna t...	2/21/19	2/28/19
Connect rotary joi...	2/21/19	2/28/19
Connect antenna t...	2/21/19	2/28/19
Transmitting and recei...	2/21/19	3/7/19
Receive code	2/21/19	3/4/19
Transmit code	2/21/19	3/4/19
Testing	3/4/19	3/7/19
Signal process	3/7/19	3/28/19
Display	3/4/19	4/4/19
Display receive data	3/4/19	4/4/19
Assimilate processed d..	4/4/19	4/18/19

Mohammad Hussein

Testing

HackRF incompatible for design parameters fig 2.

- Transmit prototype hackrf GNUradio
  - Transmit song using modulation
- Receive prototype hackrf GNUradio
  - Listen to local radio station
- HackRf half Duplex incompatible for design
  - Unable to transmit and receive simultaneously
- BladeRf full Duplex
  - Hardware that is capable of transmit and receive simultaneously



BladeRf increase cost accommodates requirements fig 3.

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Testing

- Transmit MATlab
  - Cannot use CLI simultaneously
- Receive MATlab
- Circulator alternates between transmit and receive
- Software logic to transmit and receive simultaneously
- GUI to show doppler shift

```
%(1) Open a device handle:
 b = bladeRF('*:serial=43b'); % Open device via first 3 serial # digits
%(2) Setup device parameters. These may be changed while the device
%is actively streaming.
 b.rx.frequency  = 917.45e6;
 b.rx.samplerate = 5e6;
 b.rx.bandwidth  = 2.5e6;
 b.rx.lna        = 'MAX';
 b.rx.vga1       = 30;
 b.rx.vga2       = 5;
%(3) Setup stream parameters. These may NOT be changed while the device
%is streaming.
 b.rx.config.num_buffers   = 64;
 b.rx.config.buffer_size   = 16384;
 b.rx.config.num_transfers = 16;
 b.rx.timeout_ms           = 5000;
%(4) Start the module
 b.rx.start();
%(5) Receive 0.250 seconds of samples
samples = b.receive(0.250 * b.rx.samplerate);
%(6) Cleanup and shutdown by stopping the RX stream and having MATLAB
%delete the handle object.
b.rx.stop();
clear b;
```

Matlab code to run bladeRF fig 4.

Ricardo Toledo

Future Work

- Wind Velocity
  - Radar, rain drops
- Expand overall capability
  - Higher Frequency, Longer Range, Improved Resolution
- Improve Code
- Rotate Antenna
- Better range resolution
  - Compressed Wave Transmission
    - Blind Speed identification
- Filtering techniques
  - Clutter Rejection (mapping)
  - Target Improvement Factor

Mike Eck

Conclusion

- Reducing the size of doppler radar to a compact size
- Clients have a tool to show physical example of electromagnetic wave propagation
- Success in identifying components and simple processing capabilities
    - Identified limitations of design
        - Blind speeds
        - Range resolution
        - Monodirectional
- Single antenna without circulator was not possible
    - Circulator was required
- Created a device that will proved to be a great tool in assisting demonstration

Mike Eck