GOES-16 Satellite Receiver Final Presentation

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Problem Statement

The goal of this project is to receive, decode, and display weather products from NOAA's GOES-16 weather satellite.

This project involves:

- Receiving and demodulating the analog signal (RF team)
- Digitizing the signal and transferring the data to Raspberry Pi 4 (ADC team)
- Decoding the data and image construction (software team)

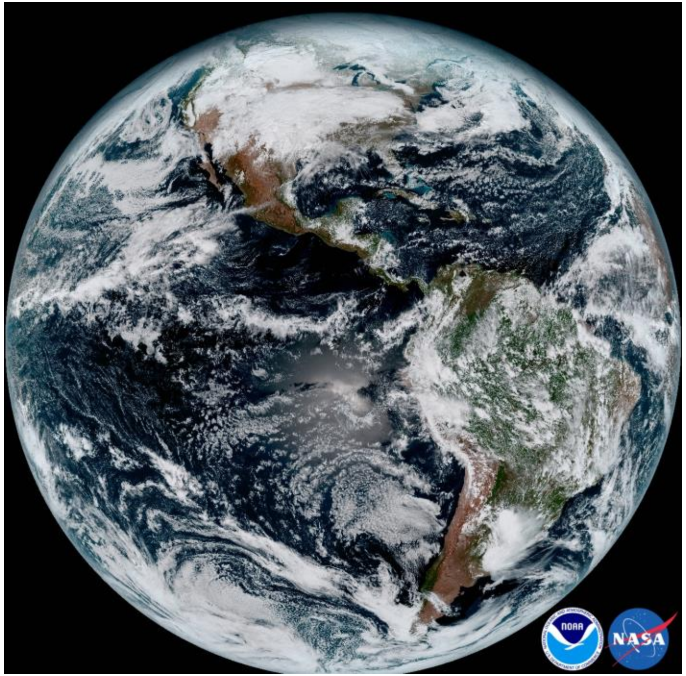
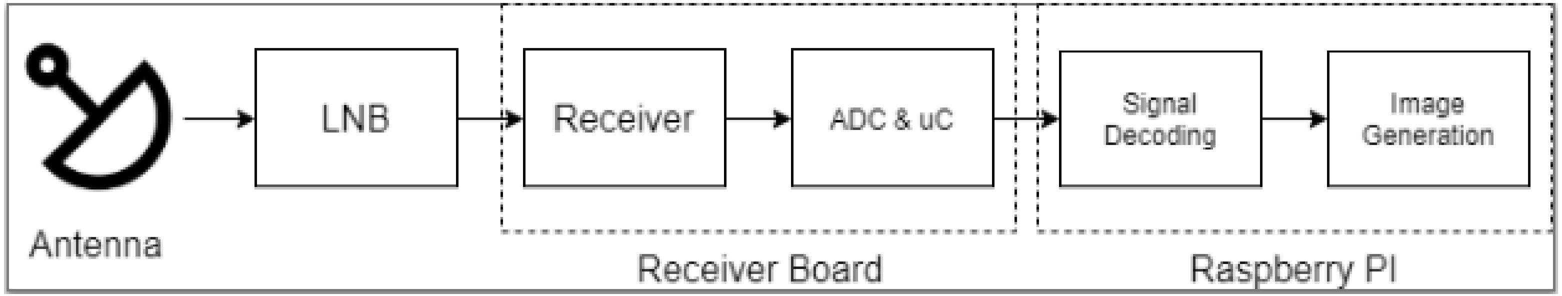
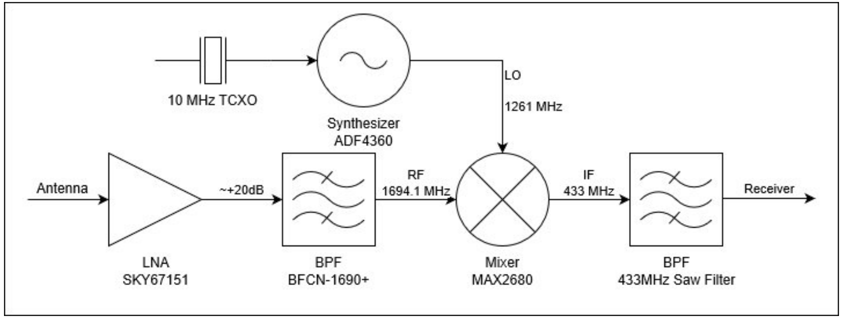


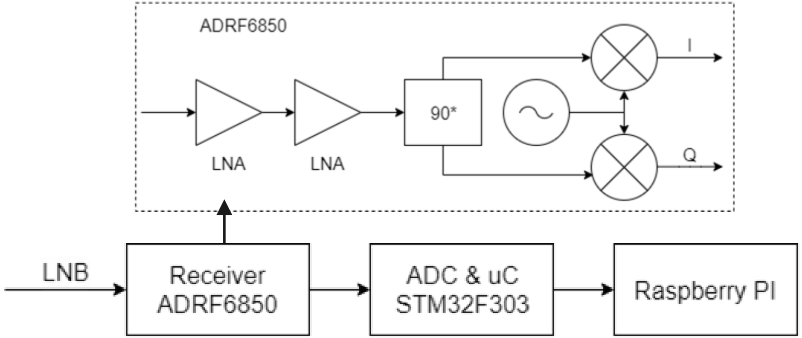
Image credit: NOAA

Conceptual Sketch



Detailed Design





LNB

- Input : 1694.1 MHz from antenna
- Output: 433 MHz downmixed and filtered signal

Receiver and Microcontroller

- Input: 433 MHz from LNB
- ADC: 4x 12-bit 5 MSPS inside µC
- µC: Integrated usb and small DSP
- RPI: Runs Open Satellite Project tools

Requirements

Functional

- The system must download a current Earth image from the GOES-16 satellite
- RPi4 will host a website to display information about the downloading process and full images

Non-functional

- RF section:
  - System must receive 1694.1MHz signal with at least 1.205MHz of bandwidth from NOAA's satellite and output a baseband signal

- ADC section:
  - System must digitize the baseband signal and output received binary to Raspberry Pi
- Software section:
  - Software must receive the binary information from the ADC, decode the information, and generate an image file

Technical Considerations

Receiver architecture takes advantage a mix of SDR and superheterodyne strengths

uC capabilities

- Data rate
- Resolution
- ADC sampling rate
- Communication

Software must compile and run on Raspbian

Computation limitations of RPi4

Market Survey

This project is geared more for hobbyists

- Information transmitted from GOES-16 is available for public consumption

Our project is not a competing product

- Components to build similar projects are available for purchase off-the-shelf
- Attempting to build a version different from similar existing projects

The RF implementation is the primary component of the project that is unique

- ADCs are standard for this type of project
- Software is open-source

Potential Risks and Mitigation

Completion Risks

- Risk to hardware exists by improper connection and powering of system components.
- Signal strength matching - ensuring that the boosted signal is within tolerance for other system components.

Physical and Environmental Risks

- Low - Physical risk present when improperly transporting equipment such as the antenna.

Risk Mitigation

- Meticulously integrate systems to prevent damage to components
- Through calculations, testing, and datasheet analysis, ensure signal strength levels are appropriate
- Properly store and transport the system within Coover.

Resource/Cost Estimate

- Most of the costs are for hardware
    - Antenna
    - RF Boards, Components, RF Cables, and Connectors
    - Raspberry Pi 4
- Software is open-source
    - OpenSat project (Teske)
- Total cost estimate is approximately
    - 700$

Milestones

RF team

- Layout, fabricate, assemble, and test first board prototypes
- Begin work on second revision and design LNB enclosure

ADC team

- Communicate to all of the necessary components - microcontroller, Raspberry Pi 4, IQ demodulator, PLL
- Digitize output of RF section

Software team

- Compile code from Open Satellite Project repository on Raspberry Pi 4
- Get RPi-hosted website operational

Test Plan

Functional

- Test each subsystem for proper operation
  - RF system output is an analog demodulated signal
  - ADC team output is raw binary data
  - Software team output is processed image

Non-functional

- Image quality is the best measure of how well the system functions

Hardware Platforms Used

Prototyping

- STM32F303 Nucleo (microcontroller development board)
- Raspberry Pi3/Pi4
- ADRF6850 I/Q Demodulator development board

Final Implementation

- ADRF6850 I/Q Demodulator
- LCOM 2.4GHz 24 dBi Dish Antenna
- SKY67151 LNA
- BFCN-1690 BPF
- MAX2680 Mixer
- ADF4360 Synthesizer
- STM32F303 Microcontroller (pending circuit design)
- Raspberry Pi4

LCOM 2.4GHz 24 dBi Dish

ADRF685
0

STM32F303 Nucleo

Raspberry Pi4

Software Platforms Used

STM32CubeMX IDE

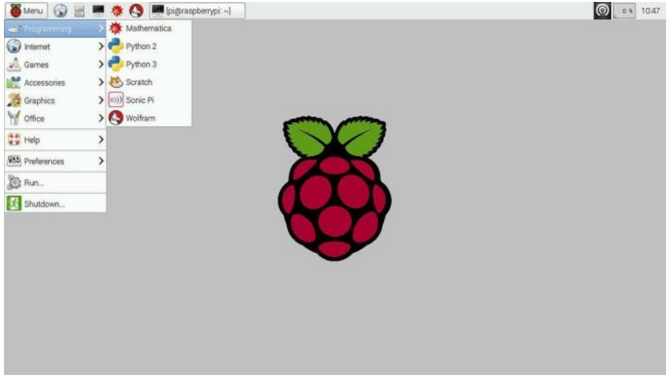
- Used to initialize the STM32F303 uC

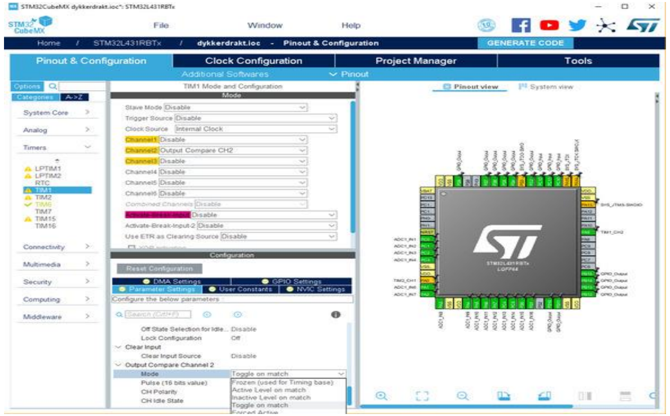
Mbed IDE

- Platform for creating and compiling firmware to be used on uC

Raspbian OS

- Operating system for Raspberry Pi4





Project Status

RF Team

- Antenna assembled and ready for modification
- Schematics made for RF boards (LNB, ADRF6850, and microcontroller interface)
- RF board layout in-progress

ADC Team

- STM32F303 uC configured for ADCs, and SPI communication,
- Interfacing uC to Raspberry Pi4

Software Team

- Working on compiling code from the OpenSatProject
- Trouble with executing linux commands as stated in compiling guide.

Team Member Contributions

Ted Mathews - RF Design and Testing

- SME, All system component recommendations, Antenna tripod build, Antenna assembly and modification, RF circuit design and layout

Jonathan Massner - RF Design and Testing, System Design

- Antenna assembly, RF circuit design and layout, system integration, managerial tasks

Riley Stuart - ADC Design and Testing

- STM32F303 Nucleo communication with I/Q demodulator, microcontroller initialization, ADC circuit design and layout (Spring 2020), system integration

Jordan Tillotson - ADC Design and Testing

- STM32F303 Nucleo communication with Raspberry Pi4, ADC circuit design and layout (Spring 2020)

Nick Butts - Software/DSP Development

- Setup of Raspberry Pi4 OS, implementation of OpenSat project material to our project

Yong Yi Lim - Software/DSP Development

- Setup of Raspberry Pi4 OS, implementation of OpenSat project material to our project

Plan for next semester

(subject to minor changes)

RF Team

- February 14 - Working RF hardware prototype including filtering, amplifying, and demodulation
- March 1 - RF circuit design completed

ADC Team

- January 19 - functioning ADC code (arbitrary signals similar to actual signals)
- February 25 - Tested and working ADC code
- March 1 - ADC circuit design completed

Software Team

- January 13 - OpenSat code compiled and working properly
- February 3 - Test demodulator and decoder for correct operation
- March 2 - Raspberry Pi4 hosted website operational

System

- March 10 - PCB designs complete and ordered for RF and ADC circuits
- April 1 - Operational system constructed with final prototype
- April 22 - Reviewed hardware and software documentation released

Works Cited

Teske, Lucas. “Open Satellite Project.” *GitHub*, github.com/opensatelliteproject.