System Requirements Specification

RF Direction of Arrival System

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Version/Author	Date
V1.0	2/11
V2.0	3/4
V3.0	4/13

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1. INTRODUCTION

1.1. System to be Produced

The design of an affordable system that detects the direction of arrival of a radio frequency (RF) propagating wave, in the ISM band, with the intention of eventually being used in a classroom setting.

1.2. Applicable Standards

This section provides a description of the project from a management perspective and an overview of the framework within which the conceptual system design was prepared. If appropriate, include the information discussed in the subsequent sections in the summary.

1.3. Glossary

AP-S – Antennas and Propagation Society
CT – Continuous Time
DoA – Direction of Arrival
ERAU – Embry Riddle Aeronautical University
IEEE – Institute of Electrical and Electronics Engineers
ISM – Industrial, Scientific, and Medical
LNA – Low Noise Amplifier
RF – Radio Frequency
SDR – Software Defined Radio

2. PRODUCT OVERVIEW

2.1. Assumptions

The project is assumed to be affordable, with a budget of $2500 through sponsorship from Qorvo. It is assumed that the system will detect the incoming signal and process it to determine the DoA.

2.2. Stakeholders

Justin Parkhurst: An electrical engineering graduate student at ERAU, is the product owner.
Dr. Eduardo Rojas: An assistant professor of Electrical and Computer Engineering at ERAU, is the customer of the project. Dr. Rojas provided project specifications and requirements that originated from the IEEE AP-S Student Design Contest Array for DoA Detection and Visualization.
Dr. Jianhua Liu: An associate professor of Electrical and Computer Engineering at ERAU, is the professor evaluating the SCRUM process and overall progress of the project.
High School students: Students who come onto ERAU campus to explore the options the university provides.

2.3. Event Table

There are no event tables for this system.

2.4. Use Case Diagram

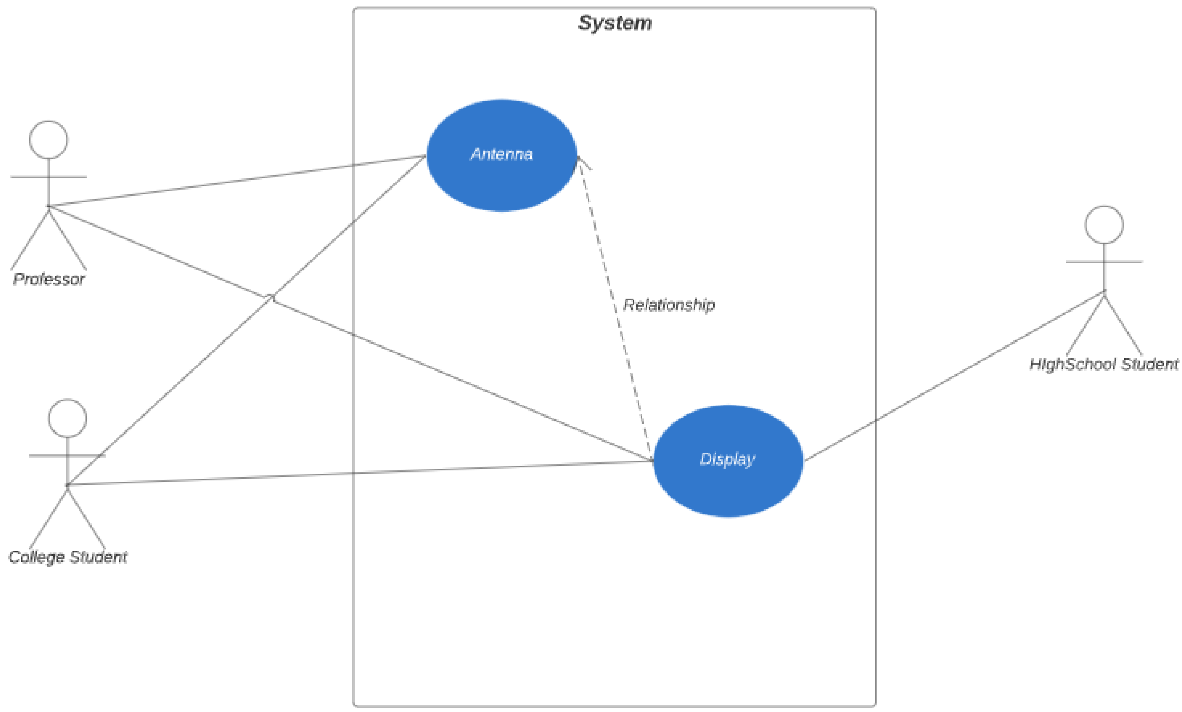

Figure 1- Use Case Diagram of System

2.5. Use Case Descriptions

2.5.1. Professors: Will be using the product to use and teach in class. May need high accuracy for detecting signals because it is in a classroom setting as an example.
2.5.2. College Students:Will be using the product as a hobby or in class or clubs. May need high accuracy depending on use.
2.5.3. High School Students: Will be using the product to learn the basics of RF detection. Will not need the high level of accuracy just enough to understand what is going on.
2.5.4. RF Signal Display: User will be able to view the RF signals through the GNU radio that will be running on the Raspberry Pi.
2.5.5. Antenna: User will be able to see the antenna and how it was built.

3. SPECIFIC REQUIREMENTS

3.1. Functional Requirements

3.1.1. The system shall be able to detect a 5.0GHz signal in the ISM band.
3.1.2. The system shall be able to distinguish separate signal gain on each antenna by utilizing a copper housing.
3.1.3. The system shall be able to receive a signal in the 4.9-5.1 GHz range for interpretation using the antenna array.
3.1.4. The system shall be able to accurately gather data off of each antenna utilizing the antenna switching array.
3.1.5. The system shall filter out noise using the bandpass filter.
3.1.6. The system shall amplify the signal through the LNA.
3.1.7. The system shall process the signal from analog to digital through the SDR.
3.1.8. The system shall analyze the signal through the algorithm run on the computer.
3.1.9. The system shall determine the DoA of the 5.0 GHz signal.
3.1.10. The system shall display the DoA of the 5.0 GHz signal.
3.1.11. The system shall repeat the process starting from functional requirement 3.1.1 once functional requirements 3.1.9 and 3.1.10 are met.

3.2. Hardware Requirements

The RF Direction of Arrival System hardware consists of several components working in tandem to control the system. The RF Direction of Arrival System consists of a copper antenna to receive signal and a Raspberry Pi to process and read the data.

3.2.1. The system shall turn on when a switch is flipped to the ON position.
3.2.2. The system shall turn off when a switch is flipped to the OFF position.
3.2.3. The testing hardware shall be coordinated by a single-board computer.
3.2.4. The testing hardware shall consist of the following:
  3.2.4.1. Software Defined Radio (HackRF One)
  3.2.4.2. Whip Antenna
3.2.5. The Raspberry Pi shall be running Python.
3.2.6. The Raspberry Pi shall consist of:
  3.2.6.1. Broadcom BCM2711, Cortex-A72(ARMv8) 64-bit SoC @ 1.5GHz
  3.2.6.2. 4GB LPDDR4 SDRAM
  3.2.6.3. Gigabit Ethernet
  3.2.6.4. Standard 40-pin GPIO header
  3.2.6.5. Dual micro-HDMI ports
  3.2.6.6. 2 USB 3.0 ports
  3.2.6.7. 2 USB 2.0 ports
  3.2.6.8. 2-lane MIPI DSI display port
  3.2.6.9. 2-lane MIPI CSI camera port
  3.2.6.10. 4-pole stereo output and composite video port
  3.2.6.11. Micro SD port
  3.2.6.12. 5V/2.5A DC power input
  3.2.6.13. Power-over-Ethernet (PoE)

3.2.7. The antenna shall consist of the following:
3.2.7.1. The antenna base shall be made out of a conductive material, in this case, copper.
3.2.8. The system shall have a SPDT switch PCB consisting of the following:
3.2.8.1. SKY13351-278LF RF Switch
3.2.8.2. 50 ohm SMA connectors
3.2.8.3. 5GHz matched transmission lines
3.2.9. The system shall have two SP4T switch PCBs consisting of the following:
3.2.9.1. E4244A-Z RF Switch
3.2.9.2. 50 ohm SMA connectors
3.2.9.3. 5GHz matched transmission lines

3.3. Software Requirements

The RF Direction of Arrival System is composed of several software systems working in unisom to receive data. To configure the software defined radio receiver, the computer shall run GNU Radio. The Raspberry Pi computer will consist of a computer running Python.

3.3.1. The system shall use GNU Radio to display 5GHz signals.

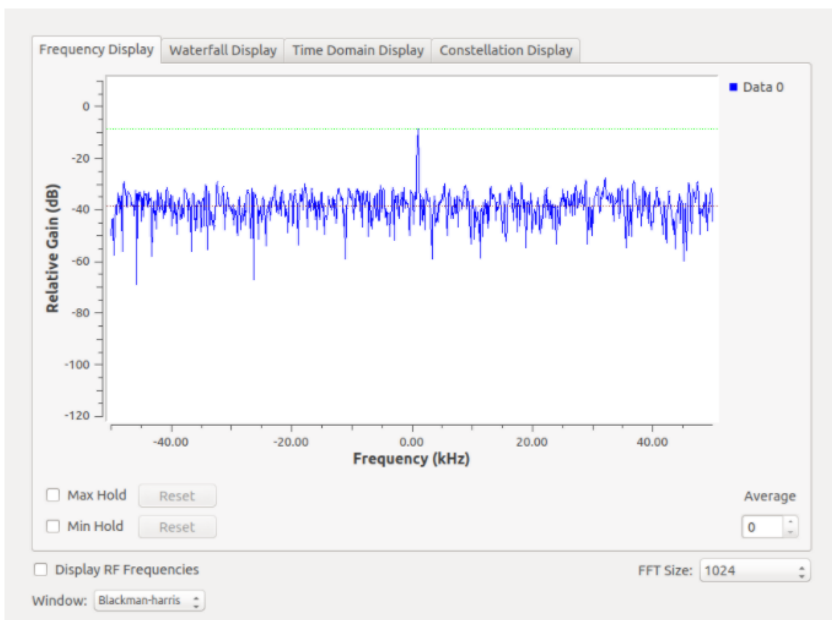

Figure 2- Example GUI of system displaying signal received.

3.3.2. The system shall use GNU Radio to print signal readings to a file.
3.3.3. The system shall use GNU Radio to process the signal received by the SDR.
3.3.4. The computer shall be running Windows or Linux operating systems.
3.3.5. The system shall create a digital sample of the signal received.
3.3.6. The system shall display the direction of the signal.

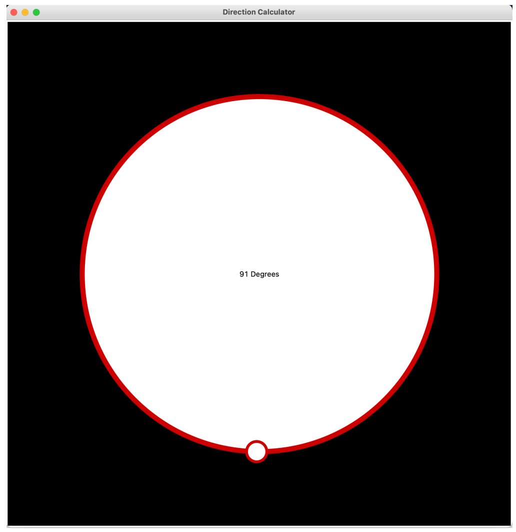

Figure 3- Example GUI of the system.

3.3.7. The Raspberry Pi shall run Python to run all systems in tandem.
3.3.8. The system shall use Python to calculate the location of the signal.
3.3.9. The Raspberry Pi shall run Python to control the GPIO pins and subsequently the antenna switching.

3.4. Physical Environment Requirements

3.4.1. The system shall operate outdoors during clear weather conditions.
3.4.2. The system shall operate indoors without interruption from other signals outside its frequency range.

3.5. Users and Human Factors Requirements

3.5.1. The system shall be understood by non-specialists.
3.5.2. The system procedure shall be understood by non-specialists.
3.5.3. The system shall provide detailed, step-by-step instructions for teaching purposes.
3.5.4. The user shall be able to turn the system on with a switch.
3.5.5. The user shall be able to turn the system off with a switch.
3.5.6. The user shall be able to see the direction of the signal displayed on the screen.
3.5.7. The user shall be able to easily transport the system from one place to another.
3.5.8. The user shall be of at least highschool age to understand and operate the system.

3.6. Documentation Requirements

3.6.1. The documentation shall be understood by individuals with a high school level of education.
3.6.2. The documentation shall give a brief overview of the system.
3.6.3. The documentation shall describe all system features.
3.6.4. The documentation shall list all contingencies regarding the system.
3.6.5. The documentation shall state all test cases that have been tested and not tested.
3.6.6. The documentation shall state if test cases have passed or failed.
3.6.7. The documentation shall list all parties involved in the system.
3.6.8. The documentation shall describe the software interfaces.
3.6.9. The documentation shall describe the hardware interfaces.
3.6.10. The documentation shall state all functional and nonfunctional requirements.
3.6.11. The documentation shall instruct the user on how to use the system.

3.7. Data Requirements

3.7.1. The system shall collect the signal characteristics and save them for reference.

3.8. Resource Requirements

3.8.1. The system shall require components that can be purchased from vendors only.
3.8.2. The price of components to build the system shall be less than or equal to $2500.

3.9. Quality Assurance Requirements

3.9.1. The system shall not exceed 20 lbs.

4. OTHER NONFUNCTIONAL REQUIREMENTS

4.1. Performance Requirements

There are no performance requirements for this system.

4.2. Safety Requirements

4.2.1. All electrical connections shall be concealed or wrapped.

4.3. Security Requirements

There are no applicable security requirements for this system.

4.4. System Quality Attributes

4.4.1. The screen shall display the direction of signal.