Automated Anechoic Chamber

## Requirements Specification

Revision 1.0

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# 1. Introduction

## 1.1 Purpose

## 1.2 Scope

## 1.3 Definitions, Acronyms, and Abbreviations

## 1.4 References

## 1.5 Overview

# 2. Overall Description

## 2.1 Product Perspective

## 2.2 Product Functions

## 2.3 User Characteristic

## 2.4 Design Constraints

## 2.5 Assumptions and Dependencies

# 3. Specific Requirements

|  |  |  |  |
| --- | --- | --- | --- |
| **Marketing Requirements** | **Priority Level** | **Engineering Requirement** | **Justification** |
| 1, 2, 4 | High | Use an antenna mount that will hold varying types of standard antennas | The product needs to be able to test a variety of antennas to accommodate the research of our sponsors. |
| 1, 8 | High | The actual orientation of the antenna is within one degree of the set orientation. | The antennas being tested by our sponsors do not have significant directivity variation in one-degree steps. |
| 1, 5 | High | Orientation of an antenna mount will vary over 2π on one axis and π over an axis normal to it. | The product needs to provide a wide range of motion to generate complete 3D radiation patterns and be able to support the antenna in each direction. |
| 1, 4, 7 | High | Motorized antenna mount will support antennas with a maximum mass of 2 kg and dimensions less than those of a 50 cm cube. | The product needs to support the variety of antenna types tested by researchers at CU. |
| 1, 8 | High | System must not introduce significant error to the measured signals in the 2-20 GHz range relative to what they would be in a vacuum. | Electromagnetic magnetic interference could alter the measured power. This range is specified by the design of the anechoic chamber. |
| 1, 5, 8 | High | The product will measure the power at the receiving antenna with a dynamic range of at least 60 dB. | Researchers need to measure received power to compute directivity and plot radiation patterns. |
| 3, 6 | High | Cost of newly purchased material should be under $3,000. | This is the budget of CU researchers. |

|  |  |  |  |
| --- | --- | --- | --- |
| 2, 5, 6, 7 | High | Output measurement data format is standard and easily-parsable. | The user needs to easily manipulate the data to interface with external software. |
| 2, 4, 7 | Low | Product will test a custom antenna built by DIRECRF capstone team. | Sponsors want DIRECRF team members to gain a well-rounded understanding of antennas. |
| 1, 2 | Medium | Product must take measurements while antenna is in motion. | This will allow for faster data collection. |
| 2, 7, 8 | Medium | Orientations of the second mount (e.g. receiver mount) must be able to vary over at least π on at least one axis. | This will allow for more accurate power measurement and eliminate the need to cancel polarization error post-process. |
| 1, 2, 4, 5, 7 | Low | Measurement system will be able to symmetrically test transmit and receive functionality on both antennas. | This will allow researchers to test both the transmit and receive characteristics of antennas without moving them. |
| 1, 2, 8 | High | The product will provide the user feedback when an error has occurred. | This will ensure that the system is running properly. |
| 3, 6 | High | The mounts will be made from easy to acquire and assemble parts. | This will ensure they are easily replaceable and inexpensive. |
| **Marketing Requirements** Product will position antennas in an anechoic chamber to automate RF research.Product will be user friendly.Product will be low cost.Product will be able to test a variety of different antennas.Product will enable flexible measurement protocols.Product will be easily maintainable.Product is modular and expandable to additional functionality.Product will produce reliable measurements. | | | |

# 4. Use Cases

### 4.0.1 UC1: System Initialization

* **Primary Actor**: User
* **Stakeholders/Interests**:
  + *User:* Wants to be able to begin using the system and receive clear indication when the system is ready to use.
* **Preconditions:** 
  + The user has basic knowledge of how to use lab equipment and has access to the anechoic chamber.
  + The antennas have not yet been mounted.
  + The measuring equipment is plugged in to the appropriate power sources.
* **Success Guarantee**:
  + All required equipment’s indicator lights are turned on and both antennas are securely mounted.
* **Main Success Scenario**:
  1. User places the selected antenna on the antenna mount.
  2. User turns on the motor control system.
  3. User turns on the function generator.
  4. User turns on the receiving power measurement device.
  5. User turns on the connected computer.
* **Extensions:**

2-5a. Measurement equipment does not have power.

1. User plugs in equipment to an appropriate power source or outlet.

1a. Measurement equipment remains unresponsive.

1.Examine the equipment for damage.

* **Special Requirements**: N/A
* **Open Issues**:
  + Safety due to equipment configuration and placement inside the chamber

### 4.0.2 UC2: Creation of Custom Scripts

* **Primary Actor**: User
* **Stakeholders/Interests**:
  + *User:* Wants to easily create a highly customizable script.
* **Preconditions:** 
  + The user knows how to use the same programming language as the pre-written functions.
* **Success Guarantee**:
  + The custom script, made by custom and existing function blocks, is successfully uploaded to the routine repository.
* **Main Success Scenario**:

1. User adds a positioning calibration command to the script by implementing existing calibration function blocks.
2. User adds a power check command to the script by implementing existing calibration function blocks.
3. User adds a positioning command to the script by implementing existing positioning function blocks.
4. User adds a measuring command to the script by implementing existing measuring function blocks.
5. Repeat steps 3-4 as many times as the user’s test routine requires.

* **Extensions:**

\*a. User may choose to create their own functions by writing a variant of an existing function or writing a new function and adding it to their custom script.

\*b. User may choose to write their own script in which they communicate directly with the connected devices, rather than using pre-written functions.

4a. User wants to make several measurements at one orientation.

* + - 1. After the positioning command is written in the script, the user can write as many measuring commands as they desire before writing another positioning command to send the antenna to the next orientation.
* **Special Requirements**:
  + The custom script is written using the same programming language as the pre-existing functions.
  + The custom script must be compatible with the main software script.
* **Open Issues**: N/A

### 4.0.3 UC3: Run Automated Scripts

* **Primary Actor**: User
* **Stakeholders/Interests**:
  + *User:* Wants the ability to easily automate antenna test procedures and interface with system error checking.
* **Preconditions:** 
  + The user has completed the System Initialization use case.
  + The desired measurement routine has been pre-programmed as either a provided or custom script.
* **Success Guarantee**:
  + Automated script generates files with the measurements at each orientation specified by the selected routine.
* **Main Success Scenario**:
  1. User selects a predefined routine of antenna orientations and measurements.
  2. System runs a calibration routine to calibrate the antenna starting orientation.
  3. System orients antenna to next orientation in routine and waits for antenna to stabilize.
  4. System carries out all measurements prescribed by routine at given orientation.
  5. System saves data from measurements at the specified orientation.
  6. System repeats steps 3 through 5 until test routine is complete.
* **Extensions:**

2a. System is unable to calibrate.

1. System cancels simulation routine.
2. System notifies user that there is an error in the system calibration.

3a. Antenna has not stabilized after 20 seconds of waiting.

1. Automated script pauses measurement routine.
2. Script notifies user of inability of the antenna to stabilize at given position and asks user if they wish to either (1) proceed with measurements at current orientation despite lack of stabilization, (2) skip measurements at current orientation and move to next orientation, or (3) cancel entire measurement routine.

5a. Invalid data received from system.

1. User is notified to check signal integrity to system.
2. User is prompted to continue test routine.
3. System continues test routine as usual.
   1. System continues to receive invalid data.
4. System cancels simulation routine.
5. System notifies user that data signal is still not connected.

* **Special Requirements**: N/A
* **Open Issues**: N/A

### 4.0.4 UC4: Power Off

* **Primary Actor**: User
* **Stakeholders/Interests**:
  + *User:* Wants the system powered off and in a safe state for future use.
* **Preconditions:** 
  + The testing process has completed.
  + The user has basic knowledge of the use of lab equipment and anechoic chamber access.
* **Success Guarantee**:
  + All required equipment’s indicator lights are turned off and both antennas are removed from the mounts.
* **Main Success Scenario**:

1. User turns off the motor controller system.
2. User removes both antennas and returns them to a safe storage system.
3. User turns off the function generator.
4. User turns off the receiving power measurement device.
5. User turns off the connected computer.

* **Extensions:**

1a. An antenna cannot be removed from its mount.

1. Contact technician.
2. Extract the antenna from the mount by any means necessary, including breaking the mount, but without damaging the antenna. Reprint the antenna mount and install it in the system prior to its next use.

* **Special Requirements**: N/A
* **Open Issues**:
  + Safety due to equipment configuration and placement inside the chamber