Radio Telescope Control Room Application User Manual

Introduction

This User Manual serves as a reference to the Control Room Software and its User Interface, as well as how to operate the telescope from the Control Room Software, and how to troubleshoot certain issues should they arise.

The User Interface for the Control Room Application primarily operates with the following three Pages:

- Main Page - Initial settings for the radio telescope are set here. In addition to this, the user can start or stop the radio telescope from here.

- Radio Telescope Control Page - This page is the main method of control for the user to control the movement of the radio telescope in any capacity. This page allows the user to directly enter desired coordinates of their observation, direct manual control of the telescope, and control scripts the user may need to run.

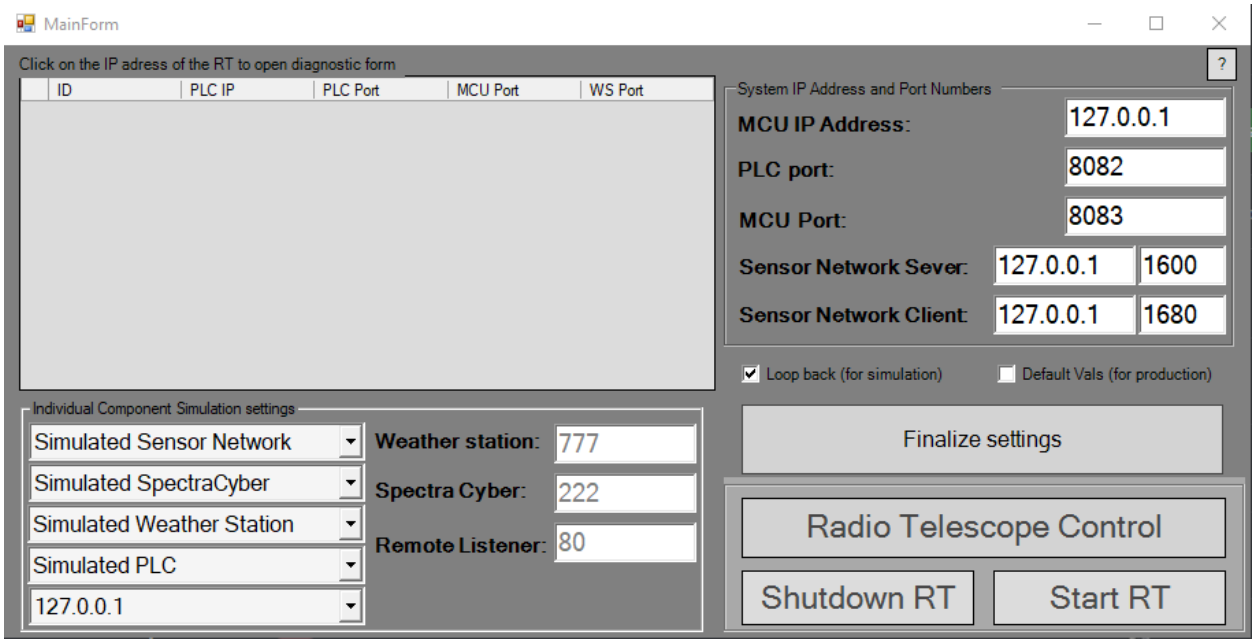
- Diagnostics Page - The Diagnostics Page consists of the following five tabs:
    - A - Appointment Control Tab
    - B - Sensor Data Tab
    - C - Sensor Override Tab
    - D - RFData Tab
    - E - Console Log Tab

When the Control Room Software is run, the Main Page is the first one to be displayed for the user. The Main Page allows the operator to set the conditions for the telescope they want to view (mostly just simulated vs. real sensor data). When the *Start RT* button is pressed, the IP address of the radio telescope you want to control should appear in the gray box at the top left corner of the page. From here, you can reach the Diagnostics Page by double-clicking the desired IP address. In order to reach the page to control the radio telescope manually, you click on the *Radio Telescope Control* button.

When testing the telescope it is often necessary to run the Control Room software as a simulation. In order to do this, the checkbox for *Loopback (for simulation)* should be checked before the *Start RT* button is pressed

Main Form

Main Form Overview



Features

Radio Telescope Data Grid Display Box

Located in the top left corner. Once the radio telescope has been started, the IP and PLC IP addresses will appear here as well as the port numbers set by the user that the PLC, MCU, SpectraCyber and Weather Station are operating on. Double-clicking on one of these will open up the diagnostics page for that telescope.

Simulation Settings Group Box

Located in the bottom left corner. This group box contains several spinboxes that allow the user to choose which hardware they would like to simulate and physically run. Multiple different computer ports for connections can be specified here as well. After the *Finalize Settings* button has been pressed, this group box will be deactivated temporarily (until the radio telescope has been started). If the radio telescope is already in use or has crashed, the user will receive the option to restart the telescope or leave it. The initialization options in this group box include:

- Sensor Network combo box:
    - Production Sensor Network - Physical Sensor Network hardware is used
    - Simulated Sensor Network - Simulates the Sensor Network using CSV files that can be used to test various situations the Telescope may encounter
- Weather Station combo box:
    - Production Weather Station - Use the physical weather station
    - Simulated Weather Station - Simulates the weather station
    - Test Weather Station - Partial simulation
- Spectra Cyber combo box:
    - Production SpectraCyber- Used to connect to physical SpectraCyber
    - Simulated SpectraCyber - Simulates SpectraCyber
- PLC group box:
    - Production PLC - Used to connect to physical telescope PLC
    - Simulated PLC Station - Simulates the PLC
    - Scale PLC - Used to connect to the scale model
    - Test PLC - Partial simulation
- IP group box:
    - This group box includes the recurring IP addresses used by the Control Room for different instances of radio telescopes. All local IP addresses used for the operating computer will appear as options. If a different IP is required the IP can be input directly from the IP Address and Port Numbers group box.
- Weather station COM Port:
    - The specific port number used for weather station communications. Default port number is 777.
- SpectraCyber COM Port:
    - The specific port number used for SpectraCyber communications. Default port number is 222.
- Remote Listener COM Port:
    - The specific port number used for Remote Listener communications. This includes communication with the Mobile Apps and Middleman. Default port number is 80.

System IP Address and Port Numbers Group Box

Located in the top right corner. This group box contains several text boxes that allow the user to manually input several important IP addresses and port numbers. The initialization options in this group box include :

- MCU IP address
    - The IP address used by the PLC and MCU
- PLC Port number
    - The port number used by the PLC
- MCU Port text box
    - The port number used by the MCU
- Sensor Network Server IP and Port
    - The IP address and port number used by the Sensor Network Server
- Sensor Network Client IP and Port
    - The IP address and port number used by the Sensor Network Client (the embedded sensor system)

Loopback (for simulation) Checkbox

Located below the left of the System IP Address and Port Numbers group box, this checkbox will autofill all of the System IP Address and Port Numbers using predetermined values to connect to all of the simulated components.

Default Vals (for production) Checkbox

Located below the right corner of the System IP Address and Port Numbers group box. Functions the same as the *Loopback* checkbox, but uses values to connect to the physical telescope.

Finalize Settings Button

Located below the *Loopback* and *Default Vals* checkboxes. This button finalizes the settings input by the user in the Simulation settings group box as well as the system IP addresses and port numbers group box. Once this button has been pressed, those group boxes will be deactivated and the remaining functionality on the Main Page will be activated to allow the user to finish creating the current radio telescope instance. If the user clicks this button again, they will be able to edit their settings, and fields will be re-enabled. Please note that this button will *only* be enabled if the user has provided valid input values to all of the respective fields (MCU IP Address and Port, Spectra Cyber COM Port, Weather Station COM Port, PLC Port, Sensor Network Server and Client IP Addresses and Ports, Remote Listener COM Port). Tooltips will pop up if any invalid values are entered to inform the user where the errors are located.

Radio Telescope Control Button

Located below the *Finalize Settings* button. This button brings the user to the Radio Telescope Control Page. This page provides the user with access to the control scripts in addition to allowing the user control over the RT both manually and by inputting coordinates. This button remains inactive until the user clicks on the *Start RT* button.

Start RT Button

Located below the *Radio Telescope Control* button in the bottom right corner. This button starts the telescope. If the user desires to run the control room software as a simulation the loopback (for simulation) checkbox needs to be checked before the *Start RT* button is pressed. No other functionality on this page will be active until this button has been pressed. This button will not be enabled until the *Finalize Settings* button has been pressed. When this button is pressed, the program will read the input from the RadioTelescopeConfig JSON file that is located in the same directory as the executable. Inside this file, the user can select a specific preexisting telescope to run by entering its ID in the telescopeID field. The user also has the option to specify that they would like to create a new telescope, which is set by default for the first use of the software. In this case, simply set the newTelescope flag to true inside the configuration file. A value of true for this flag will override the ID entered into the ID field. Below is an example of a valid JSON configuration file:

```
1    {"telescopeID":134,"newTelescope":false}
```

The user need only worry about editing the values after the colons. The file is already formatted to be JSON correct. In the event that an error occurs with the file, the user will be notified after clicking *Start RT* and will have the option to either recreate the file or go back and edit it. If everything checks out, the user will see the telescope they selected (or newly created) pop up inside the top-left window.

Shutdown RT Button

Located below the *Radio Telescope Control* button and to the left of the *Start RT* button. This button shuts down the telescope as well as the Control Room Software. This button will remain disabled until the *Start RT* button has been pressed.

User Interface Operation

After clicking on the executable, the first page the user will encounter is the Main Page. The purpose of this page is to set all of the initial conditions necessary to activate an instance of the radio telescope.

Starting The Radio Telescope

The *Start RT* button for the radio telescope will only activate after these steps have been completed.

Step 1 - Locate the Simulation Settings group box in the bottom left corner of the Main Page. This group box contains 5 dropdown boxes that each pertain to a different component of the radio telescope. The user must select between simulation and production for each of the components in this group box (with the exception of the IP spinbox). This group box also contains 3 COM port numbers that each pertain to a different communication line. These will fill automatically if the user checks the *Loopback* box or the *Default Vals* box but can be specified otherwise if needed.

Step 2 - Locate the System IP Address and Port Numbers group box in the top right corner of the Main Page. This group box contains 7 text boxes that pertain to different components of the radio telescope. The user can enter specific IP addresses and port numbers for each component. These will fill automatically for the simulation if the user checks the *Loopback* box, and for a physical telescope if the user checks the *Default Vals* box.

Step 3 - After the user has finished inputting the settings, they must click on the *Finalize Settings* button. This button disables all of the functionality in the settings groupboxes and enables the *Start RT* button.

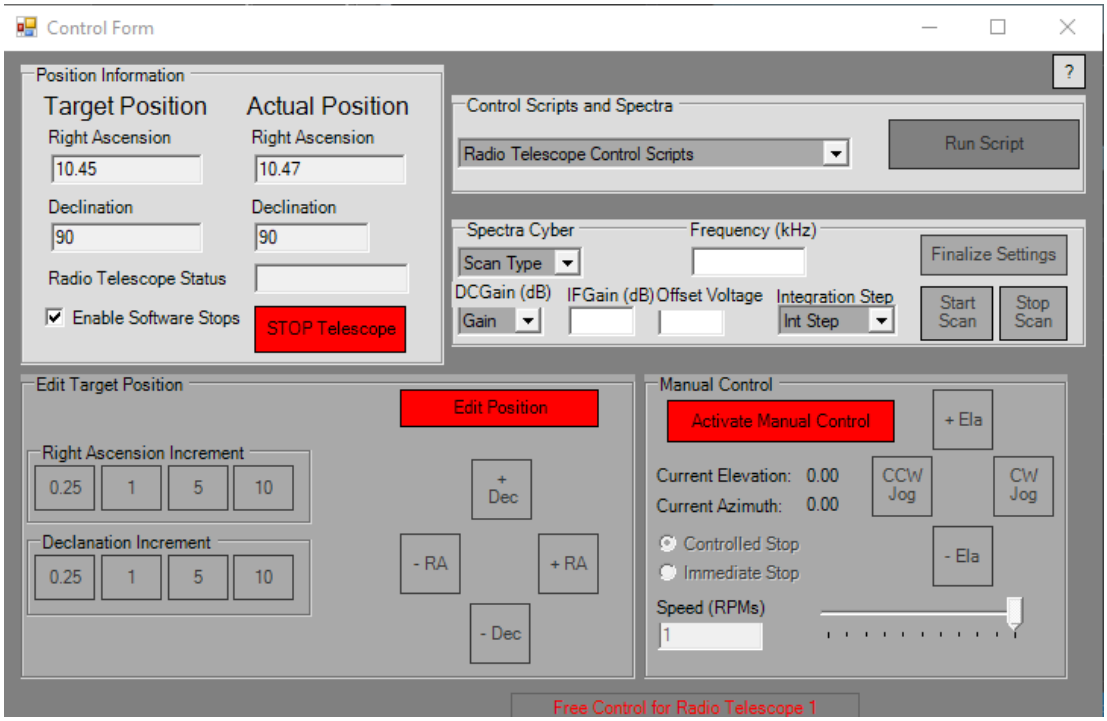
Step 4 - If steps 1-3 have been completed correctly, the *Start RT* button should be enabled. The last step to creating and starting an instance of the radio telescope is to hit the *Start RT* button. Once the *Start RT* button is pressed, the user should see several changes happen to the page. The first change is that the settings group boxes re-enable. The Data Grid display box on the top left corner of the page should populate with the values from the IP Address and Port Number group box, and the *Radio Telescope Control* button and *Shutdown RT* button will be enabled as well.

Step 5 - The *Radio Telescope Control* button should be enabled once the radio telescope has been created and started. The user can navigate to the radio telescope control page by clicking on the *Radio Telescope Control* button located above the *Start RT* button.

Step 6 - Once the radio telescope has been started, the user can navigate to the Diagnostics Page by double-clicking on the desired radio telescope IP address displayed in the Data Grid display box in the top right corner of the Main Page.

Radio Telescope Control Page

Radio Telescope Control Page Overview



Features

Position Information Group Box

Target Position Information - These boxes display the current value for the target position of the radio telescope.

Actual Position Information - These boxes display the current value for the actual position that the radio telescope is pointed at.

Radio Telescope Status -

Enable Software Stops Checkbox - This checkbox is used to enable/disable the radio telescope's software stops. The software stops is software that will stop telescope movement if it moves out of range or tries to move further out of range. By default the software stops will be enabled. Clicking the checkbox to disable the software stops will cause a confirmation box to pop up in case the disabling was accidental.

STOP Telescope Button - This button is used to interrupt and stop the current movement being run.

Edit Target Position Group Box

Edit Position Button - This button allows the user to edit the target position information for the RT. None of the functionality within the Edit Target Position group box will be accessible to the user until this button has been pressed.

Increment Right Ascension Buttons - These buttons allow the user to control the amount each button click of the plus or minus Right ascension buttons increments onto the target value for the telescope

Increment Declination Buttons - These buttons allow the user to control the amount each button click of the plus or minus Descension buttons increments onto the target value for the telescope

Save Position - This button finalizes and applies the changes to target position data made by the user. After this button is clicked the telescope will start moving towards the new target position

Manual Control Group Box

Activate Manual Control - This button allows the user to begin controlling the telescope manually. Until this button is pressed the rest of the functionality within this group box for manual manipulation of the radio telescope will be disabled.

Current Azimuth Label - Displays the value of the radio telescope's current azimuth. This azimuth reading comes from the azimuth motor encoder.

Current Elevation Label - Displays the value for the radio telescope's current elevation. This elevation reading comes from the elevation motor encoder.

Speed (RPM) Slider - This slider allows the user to change the speed at which the radio telescope jogs with. Speeds can be selected from 0 RPM to 1 RPM with 0.1 RPM increments in between.

-*Jog Button* - This allows the user to move the telescope counterclockwise.

+Jog Button - This allows the user to move the telescope clockwise.

+Ela Button - This allows the user to move the telescope upward.

-Ela Button - This allows the user to move the telescope downward.

Controlled Stop - When this option is clicked the telescope will come to a controlled stop when it is no longer being told to move.

Immediate Stop - When this option is clicked the telescope will come to an immediate when it is no longer being told to move.

Deactivate Manual Control - This button is clicked when you are finished manually controlling the telescope. You need to press this button in order to use the Edit Target Position group box.

Control Script Group Box

Radio Telescope Control Scripts Combo Box - This allows the user to select which Control script they would like the telescope to perform (Descriptions of these scripts can be found in the General Maintenance section of Script Descriptions).

Run Script Button - This button will run the script that the user has selected in the Radio Telescope Control Scripts Combo Box.

Spectra Cyber Group Box

Scan Type Combo Box - This allows the user to select which type of scan they would like to perform (continuous or spectral). Continuous scans scan at the single frequency of 1.42 GHz, while spectral scans scan ±(input frequency text) in constant steps.

Frequency Text Box - Allows the user to input the frequency that they would like to scan through in Spectral mode (0 <= Frequency).

DC Gain Combo Box- Allows the user to change the gain applied to the SpectraCyber's scan (1, 5, 10, 20, 50, or 60 dB).

IF Gain Text Box - Allows the user to input the specific IF gain that they want to use (10dB to 25.75dB).

Offset Voltage Text Box - Allows the user to change the voltage that will be offset in the SpectraCyber scan (0 <= Offset <= 4.095 Volts).

Integration Step Combo Box - Allows the user to change the time interval that the SpectraCyber reads rf data during a scan (Spectral: 0.3, 0.5, 1.0 | Continuum: 0.3, 1.0, 10.0)

Finalize Settings Button - Locks in the selections that the user has made for the parameters described above of the SpectraCyber. If the user would like to edit their settings after clicking this button, clicking it again will re-enable the fields.

Start Scan Button - Starts a scan using the specified parameters described above.

Stop Scan Button - Stops a currently ongoing scan.

Operation of the Radio Telescope Control Page

After clicking the *Radio Telescope Control* button, the Control Page will be displayed for the user. This control page provides several different options for the user. These options include control scripts, “free control”, and manual control. The free control and manual control however cannot be activated at the same time as that would send conflicting commands to the radio telescope and the scripts override both free and manual control.

When free control is activated the user may input their desired coordinates directly into the text boxes or they may use the buttons provided in the edit target position group box located in the bottom left corner of the Control Page.

When manual control has been activated the user can control the telescope directly using the jog and elevation buttons located in the manual control group box located in the bottom right corner of the control page. In addition to this functionality, the user can also control the speed of movement and the type of stop executed by the radio telescope.

The control scripts the user has access to here consist of actions that the telescope will have to execute regularly. For example, snow dump, calibrate, and stow are script functionalities. The user simply has to select their desired script and then hit

the run script button to execute that script. This overrides appointments and manual control, however.

At any point, the SpectraCyber can be configured and set to start or stop scanning.

Free Control Operation

Step 1 - In order to activate the free control functionality (appointment control using coordinates), the user must first press the edit position button located in the edit target position group box. Once this button has been pressed, the entire target position group box will be enabled for the user to operate.

> ***Step 1.a*** - If the manual control group box is currently active then the edit position button will be disabled because the radio telescope cannot operate with instructions from free and manual control simultaneously. You must deactivate manual control.

Step 2 - The user can use the ± Right Ascension and Declination buttons to edit their desired target position. The current position, as well as the active target position, are displayed for the user in the top left corner of the page in the position information group box.

> ***Step 2.a*** - If the user desires a different increment for the right ascension and declination buttons then they may choose a new increment in the section provided to the left of the right ascension and declination buttons.

Step 3 - If the user has a specific coordinate already picked out then they may skip the tedious process of clicking on it using the right ascension and declination buttons and instead simply enter the desired coordinates in the target position fields located in the Position Information group box.

Step 4 - Clicking on the *Save Position* button will close free control and will instruct the telescope to move to the requested location.

Manual Control Operation

Step 1 - In order to activate the manual control functionality (direct control of radio telescope movement), the user must first press the *Activate Manual Control* button located in the manual control group box on the right

side of the page. Once this button has been pressed the entire manual control group box will be enabled for the user to operate.

> **Step 1.a** - If the edit position group box is currently active then the activate manual control button will be disabled because the radio telescope cannot operate with instructions from free and manual control simultaneously.

Step 2 - The user must first choose the speed at which they want the radio telescope to operate. To do this, the user must find and use the *Speed(RPMs)* slider in the bottom left corner of the manual control group box. The default speed set is 1RPM.

Step 3 - Next the user must specify whether they desire a controlled stop or an immediate stop by using the radio buttons located directly above the *Speed(RPMs)* slider.

Step 4 - Now that the other settings have been modified, the user is ready to control the telescope. To do this the user may use the elevation and azimuth buttons located in the bottom right corner of the manual control group box. The following buttons are included:

> *Ela(+)* - This button increases the elevation of the Radio telescope. An elevation of 0 is horizontal while an elevation of 90 is pointing straight up.
> *Ela(-)* - This button decreases the elevation of the Radio telescope. An elevation of 0 is horizontal while an elevation of 90 is pointing straight up.
> *Jog(+)* - This button rotates the telescope clockwise. This corresponds to a +RA.
> *Jog(-)* - This button rotates the telescope counterclockwise. This corresponds to a -RA.

When using the RT manual controls, the user can view the current elevation and azimuth displayed in the top left corner of the manual control group box.

Step 5 - When the user is finished using manual control they must press the *Deactivate Manual Control* button (same button as activate manual control).

Control Script Operation

Step 1 - The first step for running a control script is to locate the control scripts group box in the top right-hand corner of the control form. Within this group box is a combo box with all of the available control scripts as well as a run script button.

Step 2 - First the user must click the drop-down arrow and select the desired script. After a script is selected the run script button will be enabled.

Step 3 - After a script is selected the user may run the chosen script by clicking the run script button. This will interrupt any current appointment or script being run.

Spectra Cyber Operation

Step 1 - Input the type of scan that you want to perform, the bandwidth, the gain, the offset voltage, and the integration step (See above for descriptions).

Step 2 - Click the *Finalize Settings* button to lock in your parameters and unlock the *Start Scan* button.

Step 3 - Click the *Start Scan* button to begin the scan. The *Finalize Settings* and *Start Scan* button will lock and the stop scan button will unlock.

Step 4 - Once you have completed the scan to your liking, click the *Stop Scan* button to end the scan, and unlock the *Start Scan* and *Finalize Settings* button. The stop scan button will also lock.

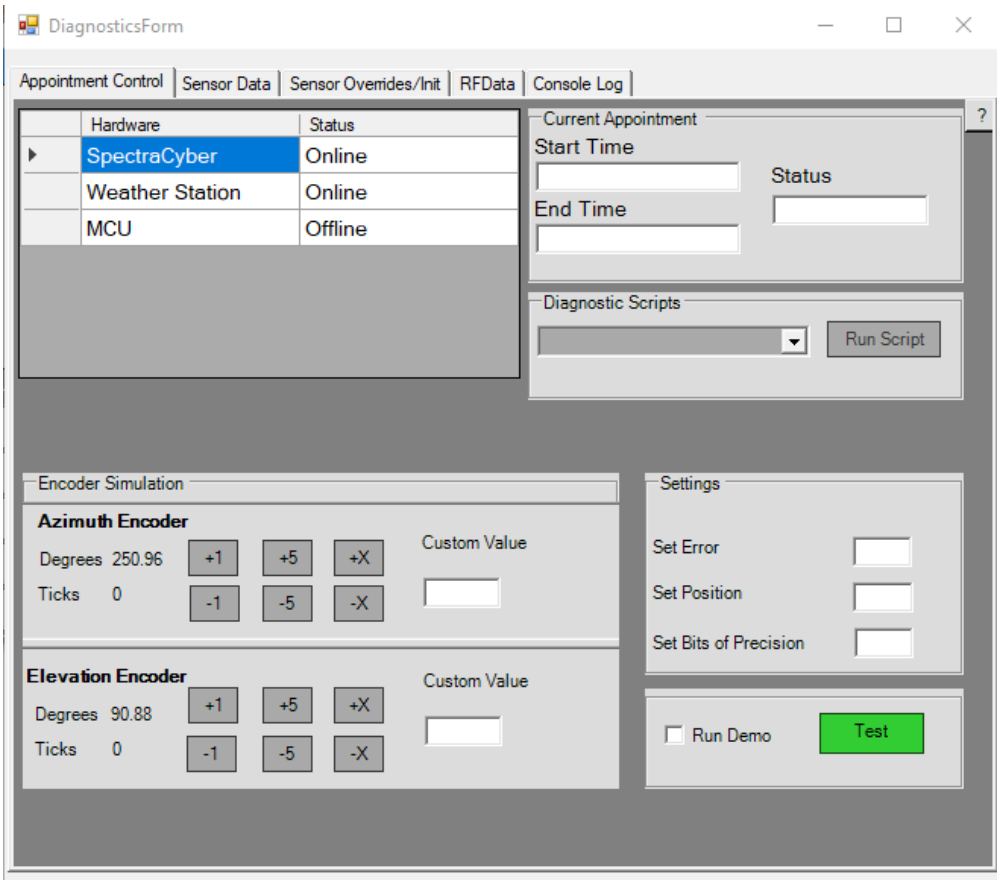
Diagnostics Pages

Diagnostics Page Overview

After clicking the radio telescope IP address, the diagnostics page will be displayed for the user. This page is organized into five different tabs:

1) Appointment Control Tab
2) Sensor Display Tab
3) Sensor Override/Init Tab
4) RF Data Tab
5) Console Log Tab

Appointment Control Tab Overview



Features

Hardware Status Box - This box displays different hardware components for the radio telescope and the current status of these pieces of hardware.

Encoder Simulation Group Box - This box displays the azimuth and elevation encoder tick and degree values and allows for changes to them via +1, +5, and +X buttons, the x determined by the Custom Value text box to the right of the buttons.

Current Appointment Group Box - This displays the current appointment start and end times, as well as the status of the appointment.

Diagnostic Scripts Dropdown - This dropdown box contains a list of the diagnostic scripts that a user may want to run. In order to run these, select a script from the dropdown box, and then click the Run Script button. The only scripts implemented here are the upper and lower limit switch movements.

Settings Group Box - Allows the user to set error, position, and bits of position. This functionality has yet to be implemented in the code

Test Group Box - This lets the user select the Run Demo check box which will iterate through the encoder positions, hitting all of the sensors in its range to ensure they work correctly. The Test button has no functionality.

Appointment Control Operation

Step 1 - To provide simulated information while testing press the run demo check box located in the bottom right corner of the page. This activates a demo for how a functioning RT will be working.

Step 2 - To customize values used by azimuth and elevation encoders locate the encoder simulation group box in the bottom left corner of the page. This group box includes buttons to incrementally increase or decrease values for azimuth and elevation encoders. The custom value being set is then displayed in the custom value text box located on the right side of this group box.

Step 3 - The user may view current appointment information and status in the top right corner of the page.

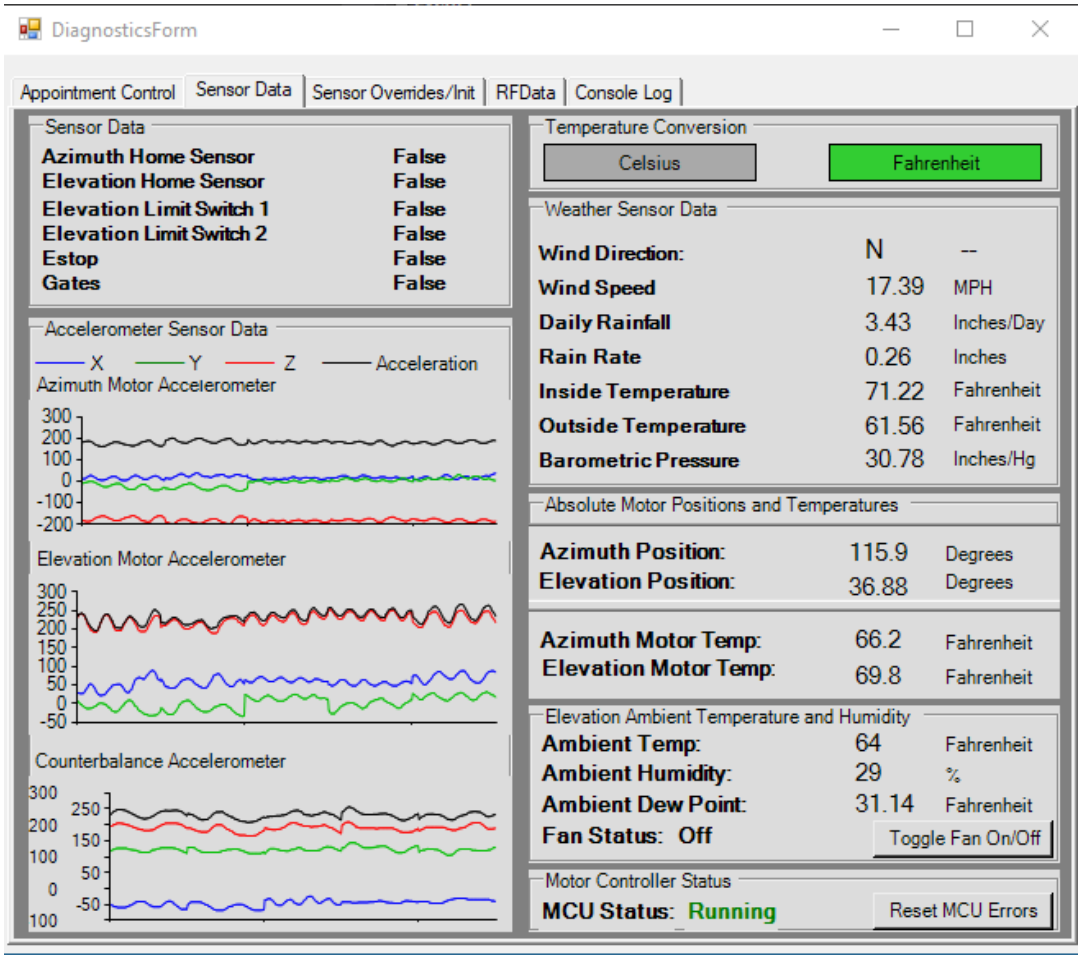
Diagnostic Script Operation

Step 1 - The first step for running a control script is to locate the control scripts group box in the top right-hand corner of the control form. Within this group box is a combo box with all of the available control scripts as well as a run script button.

Step 2 - First the user must click the drop-down arrow and select the desired script. After a script is selected the run script button will be enabled.

Step 3 - After a script is selected the user may run the chosen script by clicking the run script button. This will interrupt any current appointment or script being run.

Sensor Data Page Overview



Features

Sensor Data Group Box - This group box allows the user to view the status of the azimuth and elevation's home and limit switch sensors, the E-Stop, and the Gate.

Temperature Conversion Buttons - In the temperature conversion group box on the top right side of this page there are 2 buttons with the words Fahrenheit and Celsius. Pressing either of these will convert all of the temperatures displayed to that unit of measurement. If a temperature sensor is disabled, it will show as “--”.

Weather Sensor Data - This group box allows the user to view the current values of being read in by the weather station:

Wind Direction - no units are associated with this measurement
Wind Speed - measured in MPH
Daily Rainfall - measured in inches
Rain Rate - measured in inches
Inside Temperature - measured in Fahrenheit or Celsius
Outside Temperature - measured in Fahrenheit or Celsius
Barometric Pressure - measured in Inches/Hg

Absolute Motor Positions and Temperatures - This group box allows the user to view the current azimuth and elevation absolute positions of the RT as well as the current temperature for both the azimuth and elevation motors. The absolute positions are those from the absolute encoders.

Elevation Ambient Temperature and Humidity - This group box allows the user to view the current ambient temperature and humidity inside the elevation. A calculated dew point is also displayed. The status of the fan is also here, indicating if the fan is currently turned on or off. The *Toggle Fan On/Off* button can be used to manually toggle the fan, but will only stay toggled if the *Ambient Temperature and Humidity Override* is set on the Sensor Override/Init Page.

Accelerometer Sensor Data - This group box shows a visualization of each of the three accelerometers present on the Telescope. If they are disabled, no graph will appear, and there will be text telling the user the sensor has been disabled. The Y-axis is raw accelerometer data.

Motor Controller Status - This group box allows the user to view any current motor controller errors.

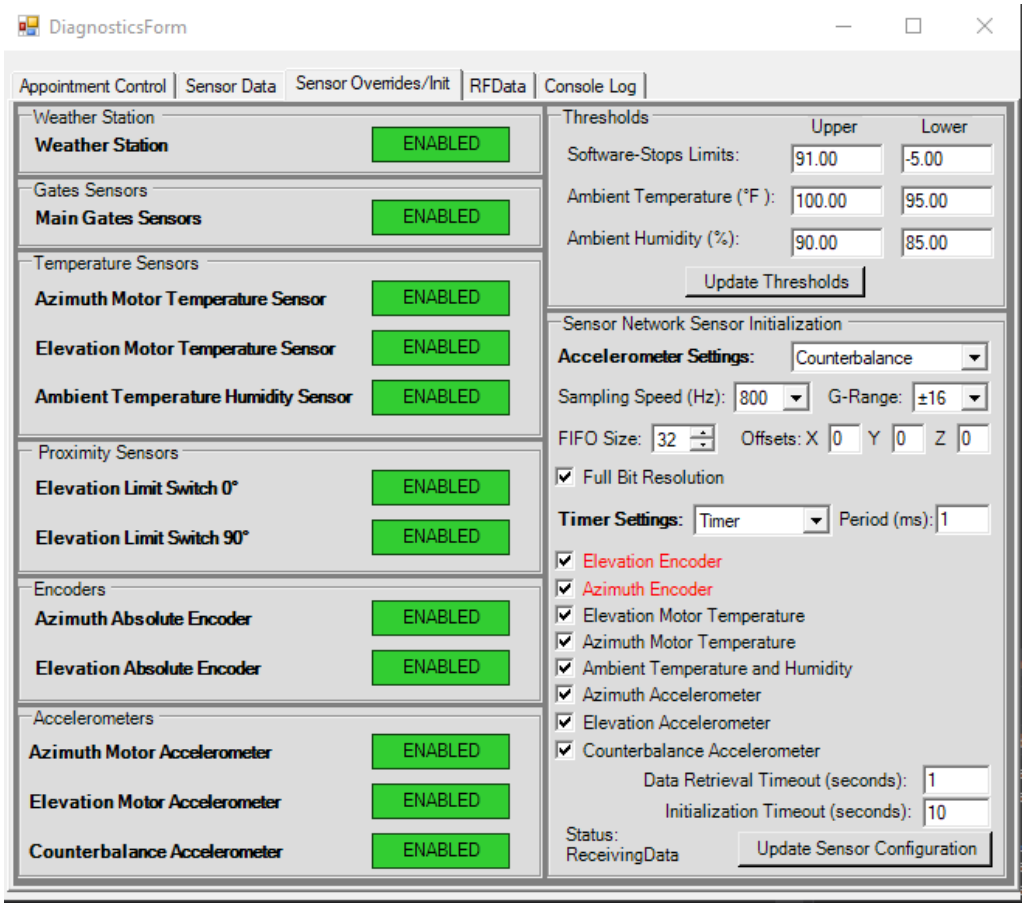
Sensor Data Operation

Step 1 - This tab is fairly simple because it is primarily designed to display information and not have many interactions from the user. The default unit of measurement for temperature is Fahrenheit. Pressing the *Celsius* button converts all temperature values on this page into celsius while the *Fahrenheit* button switches all temperature values to Fahrenheit.

Step 2 - In the bottom right corner, there is a small box displaying any possible MCU errors. These errors will typically not interfere with the operation of the telescope, but sometimes they can prevent it from moving. One situation where this can happen is if homing fails. In order to clear these errors and allow the telescope to move again, the user must click “Clear MCU Errors.”

Step 3 - In the Ambient Temperature and Humidity tab, there is a button that can toggle the fan on or off. If the fan is to be manually toggled, the Ambient Temperature and Humidity Override must be set to Override on the Sensor Overrides/Init Page first. Otherwise, the fan logic will keep bringing the fan back to the state it is supposed to be in.

Sensor Overrides/Init Page Overview



Overrides

Weather Station - Overrides the wind speed data received from the weather station in case of an error.

Main Gate - Overrides the main gate sensor in case of error.

Motor Temperature Sensors - These buttons override the Motor Temperature sensor in case of error or if the user is not concerned about the temperatures being too hot.

Ambient Temperature Humidity Sensor - This overrides the ambient temperature and humidity data used for the fan logic. Overriding this allows the Fan Toggle On/Off button to be used on the Sensor Data tab.

Proximity Sensors - These buttons override the limit switches in case of an error.

Encoders - These override the absolute encoders in case the user is not concerned about their difference from the motor encoders.

Accelerometers - These buttons override the accelerometers in case the user is not concerned with the current vibration.

Thresholds Group Box

Software Stops Limits Text Boxes - These are the limits that the software stops will trigger once reached. The default values are 91 for the upper limit and -5 for the lower limit. They can be changed to restrict or loosen the allowed range of motion for the elevation. Tooltips will appear if there is any invalid input, explaining what needs to be changed.

Ambient Temperature Text Boxes - These are the thresholds used for the ambient temperature fan control logic. The upper threshold determines what temperature the fan will turn on, and the lower threshold determines what temperature the fan will turn off. Tooltips will appear if there is any invalid input, explaining what needs to be changed.

Ambient Humidity Text Boxes - These are the thresholds used for the ambient humidity fan control logic. The upper threshold determines what humidity the fan will turn on, and the lower threshold determines what humidity the fan will turn off. Tooltips will appear if there is any invalid input, explaining what needs to be changed.

Update Thresholds Button - Clicking this button will update the thresholds described above to the user's select values. This button will be disabled if there is invalid input in the thresholds text boxes.

Sensor Network Sensor Customization Group Box

This group box is where the sensor network can be customized. From here, the accelerometers can be configured to the user's liking, the different timing periods can be changed, the initialization status for each sensor can be configured, and the timeout settings can be set as well.

Accelerometer Settings

Accelerometer Location Dropdown - This dropdown holds all the locations of the accelerometers on the telescope. Changing this dropdown will change the values

in all the other accelerometer UI elements to be the selected accelerometer. This dropdown will be disabled if there are any invalid accelerometer UI elements.

Sampling Speed Dropdown - This dropdown holds all the different sampling speeds that the accelerometers can be configured to. The sampling speed affects how quickly each accelerometer sample will be taken until the FIFO queue on the accelerometer is full.

G-Range Dropdown - This dropdown holds the different g-ranges that the accelerometers can be configured to sense. The g-range is the range of g's that the raw acceleration data corresponds to. If the Full Bit Resolution checkbox is checked, g-range settings will not affect the data. If it is not checked, the g-range will affect the resolution of the raw acceleration data, with higher g-range's leading to a lower resolution.

FIFO Size Numeric Up Down - This numeric up down is where the accelerometer FIFO size is selected. With a maximum value of 32 and a minimum value of 1, the FIFO size determines how many samples the accelerometer will store until it signals that it is full and ready to transmit the data. Lower FIFO sizes correspond with lower read times and can help speed up data rates.

XYZ Offset Text Boxes - These text boxes are where the accelerometer offsets are applied. The offsets are values that are subtracted from the raw accelerometer data and are useful for accelerometer calibration. Look in the accelerometer calibration section for more information on how to come up with these offsets.Their values range from -128 to 127. A tooltip will appear if the input is valid and it will disable the *Accelerometer Location* dropdown and the *Update Sensor Configuration* button.

Full Bit Resolution Checkbox - This checkbox determine whether or not the accelerometer will use full bit resolution or 10-bit resolution. The resolution ultimately determines how the raw data is mapped to the g-range. Full bit resolution will use the maximum number of bits for the specified g-range and every 256 units of raw data will be equivalent to 1 g. 10-bit resolution will always map the raw data to the g-range using only 10 bits.

Timer Settings

Timing Dropdown - This dropdown list contains all the different sensor network timing related features that can be modified. Changing the dropdown list value will update the *Period* text box with the corresponding period value. This

dropdown will be disabled if the *Period* text box is invalid. The possible timing options are:

- Timer:
    - The timer option is how often the timer interrupt on the embedded sensor system code will execute. Lowering this will increase the accuracy of the counters on the embedded sensor system and raising it will generate less interrupts and allow the code to loop faster.
- Ethernet:
    - The ethernet option is how often a standard sensor network packet should be sent to the control room PC. Lowering this will decrease the time it takes to receive data updates from the embedded sensor system but will also slow down other parts of the control room software.
- Temperature:
    - The temperature option is how often the temperature sensors should be sampled on the embedded sensor system.
- Encoder:
    - The encoder options is how often the encoder packet should be sent to the control room PC. The encoder packet only contains position data and is used for real time updates on the telescope's physical packet.

Period Text Box - This textbox is used to hold and customize whichever *Timing* dropdown option is selected. It holds time in ms and will accept integer values greater than 1. Any invalid input will bring up a tooltip explaining what is wrong, and the *Timing* dropdown box and *Update Sensor Configuration* button will be disabled

Sensor Initialization

Sensor Network Sensor Initialization Checkboxes - This corresponds to what sensors are enabled vs disabled from the sensor network. Encoders are marked in red because these are *critical* sensors that determine the position of the telescope. Disabling them will cause the software to rely on the motor encoders instead.

Data Retrieval and Initialization Timeout Text Boxes - These are used to set how long the control room software should wait before timing out. Data retrieval timeout is how long to wait for new sensor network data to be retrieved. Initialization timeout is how long to wait for a response from the

embedded sensor system after the initialization packet has been sent. Invalid values put into these textboxes will prompt a tooltip to appear and disable the *Update Sensor Configuration* button.

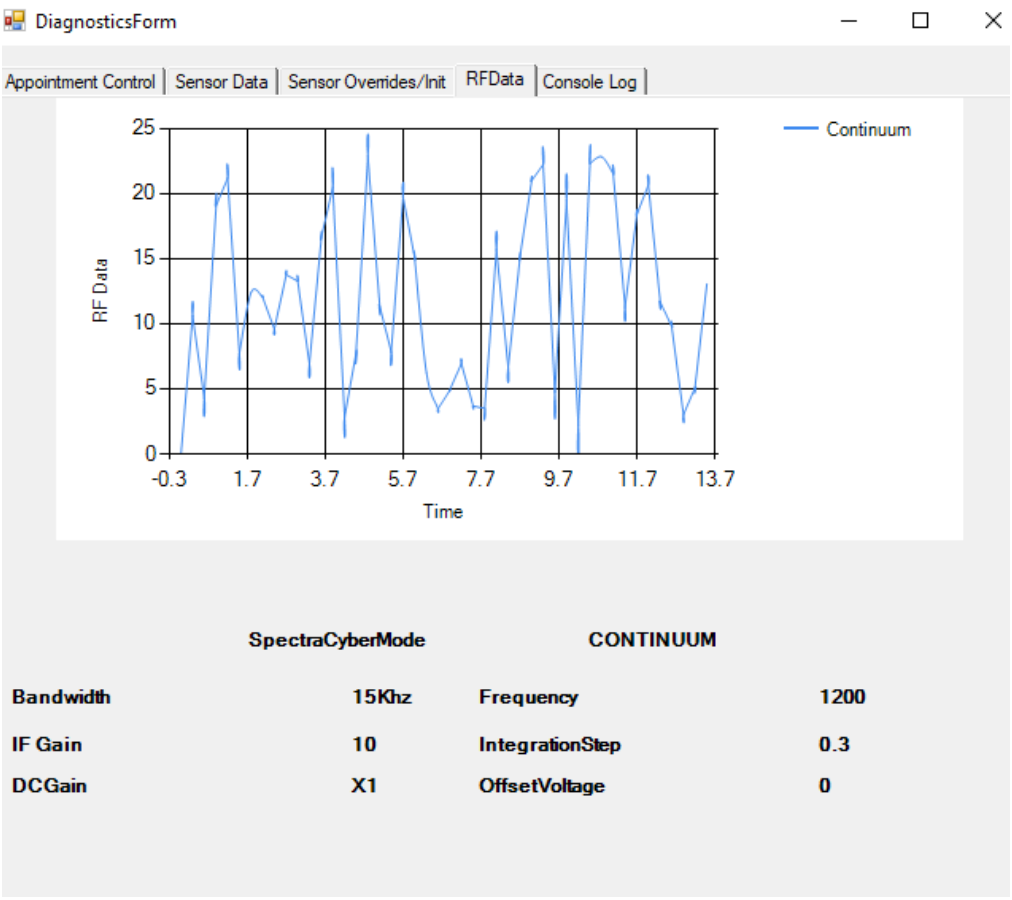
Update Sensor Configuration Button - This button will update the embedded sensor system with the settings specified and will save the settings to the database for future use. This button will be disabled if any of the sensor setting inputs are invalid.

Sensor Override Operation

Step 1 - Each of these buttons overrides the sensor it is labeled with. Clicking any of these buttons will send a push notification to all administrators with the admin app.

Step 2 - The accelerometers and/or timing settings can be changed to fit the user's liking. Each checkbox in the Sensor Network Sensor Initialization group box can be checked to allow the user to enable or disable sensors as they please, as well as update timeout values. When the user is ready, this information is updated and the Sensor Network is restarted, taking the new changes.

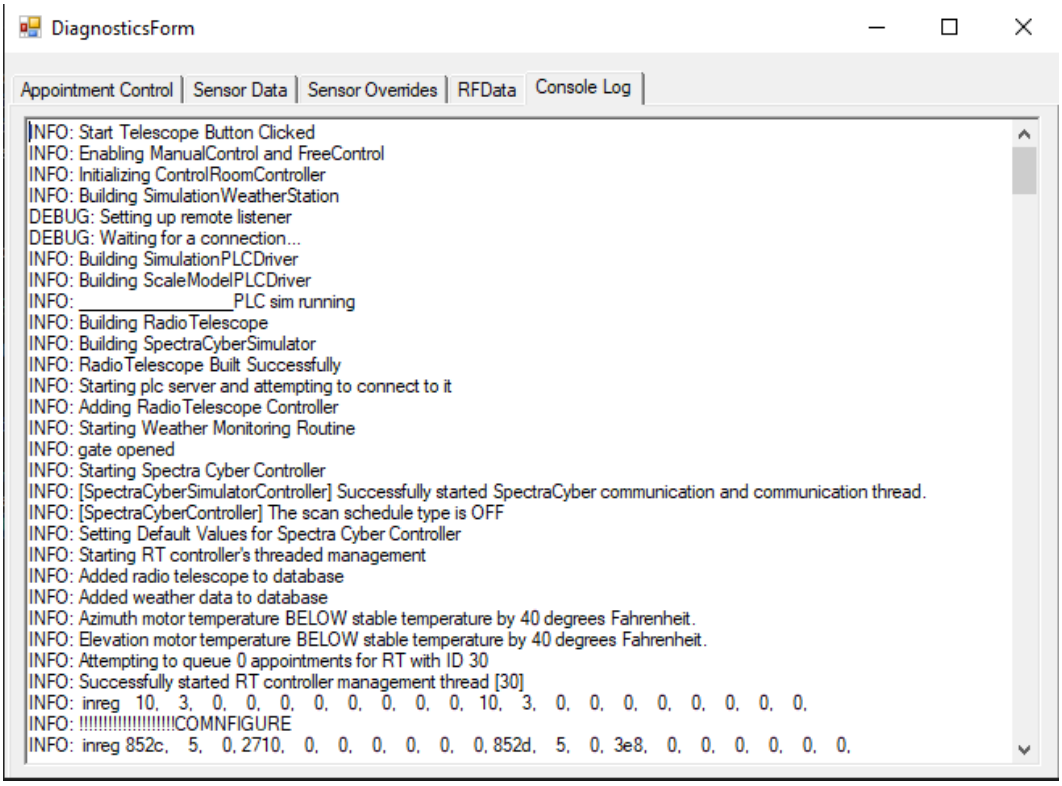
RF Data Tab



SpectraCyber Scan Chart and Configuration Values

This line chart displays the radio frequency data intensity received from a SpectraCyber scan. The data received is measured on the Y-axis. For Continuum scans, the time received from the start of the scan in seconds is displayed on the x-axis. For Spectral scans, the frequency received, measured in a kHz offset from 1.42GHz, is displayed on the x-axis. For Spectral scans, different frequencies are displayed across a period of time. Below the chart, displays the current configuration values of the spectra cyber. These are the values available for the user to change on the Radio Telescope Control Page: Mode, Frequency, IF Gain, Integration Step, DC Gain, and Offset Voltage.

Console Log Tab



This tab displays the output of the logger function used throughout the code to log when various functions are performed, current values within the system, and errors and exceptions that may occur during the operation of the telescope. By default the output automatically scrolls down to the most recently added log statement, however, the user can select the output window to scroll freely within the log statements.

Script Descriptions

General Maintenance(RT Control Scripts)

- Stow Telescope: Moves the telescope to 0° on the azimuth and 90° on the elevation.
- Full Elevation: Moves the telescope elevation from -10° to 90°.
- Full 360 Clockwise: Moves the telescope azimuth from 0° to 360°.
- Full 360 Counter-Clockwise: Moves the telescope azimuth from 360° to 0°.
- Calibration: Moves the telescope to 200° azimuth and 20° elevation.
- Snow Dump: Moves the telescope to a different azimuth position every time and lowers the elevation to -5 to dump any possible accumulated snow, then returns to the original position.
- Home Telescope: Home the telescope motors so that the control room software knows where it is at.
- Custom Orientation Movement: Move to a custom orientation specified in an input box.
- Endless Azimuth Rotation: Endlessly rotate the telescope azimuth.
- Hardware Movement Script: Run through a series of movements to test full mobility of the telescope.

Emergency Recovery Scripts

- Recover From Limit Switch: This script is a loop that checks both the encoder values and the limit switch sensors on both the azimuth and elevation and moves the telescope away limit switches.

Diagnostic Scripts

- Hit Elevation Lower Limit Switch: Moves the telescope along the elevation to hit the lower limit switch at approx. -8°
- Hit Elevation Upper Limit Switch: Moves the telescope along the elevation to hit the upper limit switch at approx. 94°

General Help and Troubleshooting

Connection Issues to Telescope After Moving to New Computer

After setting up the software on a new computer, the telescope hardware may not be able to connect to the PC due to networking issues. To check if this is a networking problem and fix it if it is:

Step 1 - Open up the Control Panel and go to Network and Internet, Network Connections, and then right click on the Ethernet option that is used to connect with the telescope and select Properties.

Step 2 - Click on the Internet Protocol Version 4 (TCP/IPv4), and click on the properties option.

Step 3 - Make sure that the “Use the following IP address” radio button is selected. If it is not, select it. Then make sure that the IP address, Subnet mask, and Default gateway are 192.169.0.10, 255.255.255.0, and 192.168.0.1 respectively. If they are not change them.

Step 4 - Click OK and exit the form. If the IP addresses were the problem, it should be fixed now.

Software Stops Executing Too Soon or Too Late

As time goes on, the counterbalance position data may become inaccurate and cause the software stops to execute too soon or too late. This means that it is time for a recalibration of the counterbalance accelerometer. To do this:

Step 1 - Print out the XYZ raw acceleration values coming from the accelerometer so that live acceleration data is displayed (print from Sensor Network or CR)

Step 2 - Move the telescope to 90° elevation.

- ***Step 2a*** - Two of the axis should be reading close to 0 and the other reading only the force of gravity in the positive or negative direction

Step 3 - Find the average value for each of the axes

- ***Step 3a*** - The average value can be eyeballed or computed. Either method will not affect the offset calculation much

Step 4 - Calculate the offset errors for each axis:

- ***Step 4a*** - For the vertical axis:
    i. If the average acceleration value is positive:

$$256 - (\text{average accel})$$

ii. If the average acceleration value is negative:

$$-256 - (\text{average accel})$$

Step 4b - For the other axes:

$$0 - (\text{average accel})$$

Step 5 - Finally, calculate the offset for each of the axes and place them in the accelerometer's offset fields on the Diagnostics Page:

$$Round(\frac{(\text{offset error})}{4})$$