Buddihex™ Rotator Software System

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Buddihex™ is a product of Buddipole, Inc. https://www.buddipole.com/info.html

Overview

The system has two software components; Arduino compatible software that is loaded onto the ESP8266 WiFi MCU and a Windows application with a graphical user interface (GUI).

The ESP8266 Controller firmware listens to commands and responds as needed. It monitors the rotator position with a QMC5883L 3-axis magnetic sensor and controls the rotator motor with a L293D stepper motor controller.

Data is exchanged between the ESP8266 Controller and other applications over WiFi using UDP.

The Windows application is a custom app that displays the rotator's current bearing and allows the user to manually select new bearings. It also monitors for bearing commands from other applications running on the computer that can issue PST rotator commands such as N1MM, spotting software and loggers such as Log4OM.

Use of the Windows application is optional. Any PST-compatible software that can issue PST commands over WiFi UDP can be used to directly control the rotator. N1MM and Log4OM are examples of two such programs.

ESP8266 Micro-controller

The ESP8266 is software compatible with the Arduino micro-controller, and as such, the Arduino IDE (https://www.arduino.cc/en/software), Arduino studio or another compatible IDE can be used to make changes to the code and to load the binary onto the device.

By default program running on the ESP8266 connects to a WiFi hotspot, opens a known UDP port and then listens for incoming commands. Responses are returned to the IP address and UDP port number from which the command came. The default UDP port number is 4210. With a small change to the rotator sketch, the ESP8266 can provide a DNS access point to which a computer can connect to. See the section on WiFi Setup and Configuration.

Commands to return the current bearing, go to a bearing or to stop rotating are supported.

When commanded go to a bearing, the software determines the rotation direction and starts the motor. Once the rotator reaches the desired bearing or the rotation stops unexpectedly (stuck), the motor is powered off.

ESP8266 setup

Several default constants are set in the software:

- SSID = "HexRotator"
- Password = "12345678"
- UDP Port Number = 4210
- Declination = -11

If different parameters are needed, then the values must be changed in the rotator sketch and recompiled before loading onto the ESP8266.

Compiling and Installing the Rotator Control Sketch into the ESP8266 Micro-controller

Although several other IDEs may be used to compile and upload the rotator sketch into the ESP8266 the following instructions are for the Arduino IDE v2.2.1.

1. Download and install the Arduino IDE from the Arduino website (https://www.arduino.cc/en/software).
2. Download the following three rotator control files from GitHub. Links are provided in Section GITHUB Repositories
   - rotatorControllerESP8666.ino
   - rotatorControllerESP8266.h
   - HexRotatorControl.exe
3. Copy these files into a folder called “rotatorControllerESP8266”
4. Connect the rotator to your computer via a USB cable. Windows should recognize the ESP8266 and assign it a COM port. You can verify the ESP8266 is successfully connected to the computer and find the assigned COM port number by opening Windows Device Manager and looking under Ports.
5. Run the Arduino IDE and open the rotatorControllerESP8266.ino file.
6. Install the ESP8266 libraries and tools into the Arduino IDE as follows: (The libraries and tools are available on GitHub here: https://github.com/esp8266/Arduino)
   - Under File → Preferences
   - Open the Settings tab and add the following line into the “Additional boards manager URLs” field: **http://arduino.esp8266.com/stable/package_esp8266com_index.json** and click OK.
   - Open: Tools → Board Manager and enter ESP8266 in the Search field.
   - Click Install on the ESP8266 package.
7. Set the Board to ESP8266 in the Arduino IDE:
   - Open: Tools → Board → esp8266 and click on Generic ESP8266 Module.
8. Install the QMC5883L compass library.
   - The library can be found here: https://github.com/dthain/QMC5883L
   - Follow the direction on the github link to download and install the library.
9. Click the Upload to compile and install the software into the ESP8266.

Note: The Serial Monitor in the IDE can be used to see connection information and commands as they are processed. The connection baud rate should be set to 115200 baud.

WiFi connection

There are three ways to connect the rotator to a WiFi network as follows:

1. The rotator can be connected to a hotspot set up on the windows computer.
2. The rotator can be connected to a router and hence a local area network.
3. A DNS server can be established on the ESP8266 that will accept connections from wireless devices via an IP address provided by the server.

Directions on how to use each of these methods are provided in the section ESP8266 WiFi Setup and Configuration.

Calibrating the Magnetometer

The QMC5883L 3-axis magnetic sensor should be calibrated when first powered up. To do this, rotate the rotator completely counterclockwise and then clockwise at least once. If the rotator can not be

manually rotated, use a controlling software such as the N1MM or the custom HexRotatorControl application. See the HexRotatorControl section Calibration for a procedure to follow.

Command Interface

ESP8266 Controller will listen for and process the following incoming commands:

- PST commands:
  - <PST><STOP>1</STOP></PST>
  - <PST><AZIMUTH>85</AZIMUTH></PST>
  - <PST>AZ?</PST> Return the current bearing as: AZ:xxx.x<CR>
- N1MM commands:
  - <N1MMRotor><goazi>xx.x
  - <N1MMRotor><stop>
- Custom Commands:
  - GET_BEARING: Return the current bearing as: GET_BEARING:xxx If the rotator is currently rotating, the direction is appended, for example: GET_BEARING:xxx CW

HexRotatorControl Windows Application

The custom Windows application is called **HexRotatorControl.exe**. This application is specifically designed to operate with the ESP8266 rotator control.

This application communicates with the ESP8266 rotator controller through a client UDP port. A second UDP port is monitored for incoming commands from external programs that support the PST protocol and for commands from N1MM.

Use of the HexRotatorControl application is optional. The ESP8266 controller can receive commands directly from N1MM and other PST compatible programs without the need to run this application.

Installation

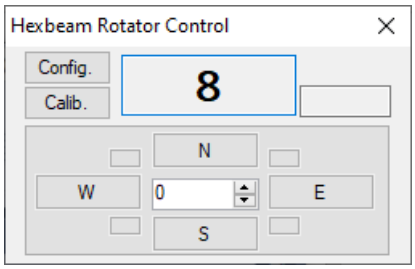
HexRotatorControl.exe is provided as a single Windows executable binary file. Simply place the file in a directory of your choosing. Run it by double clicking on the file name or right clicking on the file name and then click on Open in the window that pops up. The application is not signed so when it is started Windows may issue a warning indicating that it’s an unrecognized app. Allow it to run if is to be used.

HexRotatorControl needs to open UPD ports. The first time the application is run, Microsoft may issue a Firewall security warning. Allow access so the program can communicate with the rotator and other applications on the computer.

Uninstalling

To uninstall, simply delete HexRotatorControl.exe from the folder where it resides.

User Interface



The interface has a set of buttons and a numeric up/down number entry box.

The number enter box in the center of the buttons is the Bearing Command box and allows entry of an arbitrary bearing value. Any time this value changes, a new bearing it sent to the rotator controller.

The buttons are:

- Conf. - Opens the Configuration dialog.
- Calib. - Performs a calibration. Discussed below.
- N, S, E and W – Pressing these sets the corresponding bearing into the Bearing Command box. If the value is different from the prior value, the new bearing is sent to the controller.
- Four buttons between the N, S, E and W – Allow quickly setting NE, SE, etc. bearings into the Bearing Command box.
- Large surrounding button – All around the other buttons is one large button. Clicking anywhere on that issues a Stop command to the controller.

The large number top center is the current bearing as reported by the controller. If it displays a value of 0, it means that the QMC5883L is returning a status of not ready.

To the right of the current bearing is a box that will display either CW or CCW when the rotator is in motion clockwise or counterclockwise respectively. If the controller detects that rotation is stalled, it will say “Stuck”.

Configuration

After launching the program, click the Config. button to open the Configuration dialog. The following settings can be configured:

- UDP Inbound Port – This is the port the application monitors for incoming commands from other rotator control programs. Refer to the rotator control program’s documentation to determine what port it sends on. For example, N1MM sends on 12040 which is the default here. Processed commands are listed below in Section External PST Interface.

- ESP8266 UDP Port – This is the port number the ESP8266 is listening on. By default this is 4210 and should only be changed if the ESP8266 value is changed. The next higher port number is used by the application for receiving response UDP packets.

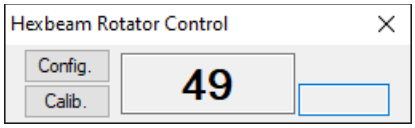
- ESP8266 IP or Netmask – This is the IP address that was assigned to the ESP8266 when it connected or connect to. A UDP broadcast IP address can be used if there is a single ESP8266 rotator in the system eliminating the need to know the actual IP end point address. If there are multiple rotators in the system the complete IP address of the rotator to be controlled must be entered here. See section ESP8266 WiFi Setup and ConfigurationESP8266 WiFi Setup and Configuration for information on methods of connecting a ESP8266 rotator controller to the network.
    - If connecting to a ESP8266 rotator using the computer's hotspot: Windows setups the network DHCP service using 192.168.137.1 as the gateway and leases out addresses on the 192.168.137.xxx network so the default for this setting is 192.168.137.255.
    - If connecting to a ESP8266 rotator via a network router: Routers typically setup the network DHCP service using 192.168.1.1 as the gateway and lease out addresses on the 192.168.1.xxx network. Verify this is the case by checking the router setup and then change the default for this setting to 192.168.1.255 or what the router is providing.
    - If connecting to a ESP8266 rotator configured as a hotspot: The ESP8266 setups the network DHCP service using 192.168.4.1 as the gateway and leases out addresses on the 192.168.4.xxx network. Change this setting to 192.168.4.255 or 192.168.4.1.

Press the "Save Program Settings" button and then close the dialog using the X in the upper right corner.

Note: Program settings are saved in the Windows Registry under:
Computer:HKEY_USERS:SOFTWARE:<user name>:HexbeamRotatorControl:<version>

Minimal View

The GUI can be shrunk to a minimal showing just the top portion of the dialog. This can be useful if bearing control is being done from another program such as N1MM. In that case HexbeamRotatorControl can be used to just view the current bearing and rotation status. To toggle between the minimal view and full view, double click anywhere on the background. The minimal view looks like this:



External PST Interface

As previously described, the Windows program listens on the user selected port for incoming PST compatible commands to forward them to the ESP8266 Controller.

i. The following commands are decoded and processed:
    - <PST><STOP>1</STOP></PST>
    - <PST><AZIMUTH>85</AZIMUTH></PST>

ii. N1MM commands supported are:

- <goazi>
- <stop>

Calibration

If the rotator unit can not be rotated manually then the recommended procedure is to click on W until the rotator stops and then press S to rotate completely South. Next press E and wait until that motion completes and follow with S again. Finally rotate back to N.

The user can change the ESP8266's Declination value after performing the full rotation described above by using the Calib. button. Move and verify the antenna is pointing directly North using an independent compass. The numeric up/down can be used to incrementally move the rotator. Once the antenna is pointing North, press the Calib. button to calculate a new offset. This should also help compensate for nearby metallic components.

Note: Magnetic declination, sometimes called magnetic variation, is the angle between magnetic north and true north. For more information see: https://ngdc.noaa.gov/geomag/declination.shtml

ESP8266 WiFi Setup and Configuration

The ESP8266 rotator can be easily be modified to work in several different WiFi network configurations with slight modifications to the sketch. Parameters that might need modifying are grouped at the top of the rotatorControllerESP8266.ino file in a section called “WiFi Configuration”.

Connecting the ESP8266 to a WiFi router

The following procedure allows users to connect the rotator to an existing local area network that the rotator can reach via WiFi.

To configure the ESP8266 to connect to a WiFi router, the router must have a 2.4GHz access point.

Make the following changes in the rotatorControllerESP8266.ino file and then reload the ESP8266:

- Comment out: **//#define PROVIDE_AP**
- Set **const char *ssid = “ssid of desired network”** to match the WiFi 2.4 GHz access point or set the router’s SSID to match the ESP8266 (default “HexRotator”).
- Set **const char *password = “password of desired network”** to match the WiFi 2.4 GHz access point or set the router’s PASSWORD to match the ESP8266 (default “12345678”).

For applications on the network to access the ESP8266 they will need to know the netmask for the WiFi network. Typically this is 192.168.1.XXX. Check the router’s administration page to make sure that the address is correct. If there is only one router in the system, use the broadcast IP address of 192.168.1.255. If there are more then one rotator in the system, use the IP address assigned to the ESP8266 rotator. The addresses should be displayed on the router’s administration page.

Connecting the ESP8266 to a computer hotspot

The following procedure allows users to connect to the rotator via a hotspot set up on the Windows computer being used to control the rotator.

A disadvantage of this approach is that each computer needs to have an internet connection. Windows won’t allow a hotspot to operate on a computer that has no connection to the internet. Simply having a connection to a router, such as might be the case at a Field Day, is not enough.

Depending on the computer it may need to have two network cards, with one connecting to the rotator and the other connecting to the local area network of computers operating in the contest site. Some computer WiFi adapters allow starting a hotspot on at 2.4GHz while simultaneously connected to a router at 5GHz. Alternatively, connect to the router at the slower speed.

Using the Arduino IDE make the following changes in the rotatorControllerESP8266.ino file and then reload the ESP8266:

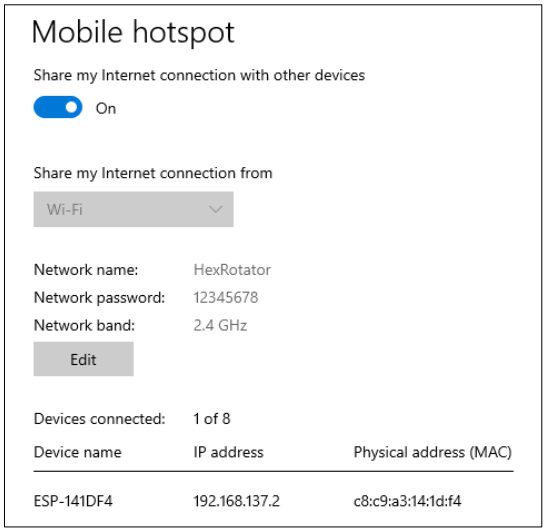
- Comment out **//#define PROVIDE_AP**

Turn on the mobile hotspot on Windows10 or Windows 11 computer:

1. Select Start → Settings → Network & Internet → Mobile hotspot.
2. Select the adapter under “Share my Internet connection from”
3. Click on the Edit icon.
    a. SSID = HexRotator (or to match the **ssid** in the ESP8266 if changed)
    b. Password = 12345678 (or to match the **password** in the ESP8266 if changed)
    c. Speed as 2.4 GHz
4. Click Save
5. Turn mobile hot spot **On** using the switch icon at the top of the Mobile Hotspot window.

Windows assigns an IP netmask of 192.168.137.XXX to computer hotspot networks. If there are multiple stations and rotators in the field, each hotspot computer and the rotator it wishes to control must use a unique SSID.

If the ESP8266 has been loaded and is powered on, it should show up under the connected hotspots. Open Windows Settings→Network & Internet and click on Mobile Hotspot. Under Devices connected the ESP8266 should be displayed.



Partial screen shot of the Network & Internet Settings after proper hotspot setup.

ESP8266 as a DNS access point server

The ESP8266 can be configured to act as a DNS access point. When setup as a DNS access point a computer can directly connect to it. The ESP8266 will provide an IP address for the computer on a network with a netmask of 192.168.4.XXX.

Note that a WiFi adapter can only connect to a single network (access point) at a time. An adapter can not be connected to a WiFi router and the ESP8266 controller acting as a DNS access point at the same time unless a second WiFi adapter such as a USB-WiFi dongle is used.

Make the following changes in the rotatorControllerESP8266.ino file and then reload the ESP8266:

- Ensure **#define PROVIDE_AP** is not commented out.
- If there are more then one ESP8266 rotator in the system, set the **ssid** differently for each.

Connect the computer's WiFi to the rotator by selecting the ESP8266's **ssid** from the available networks. Application's on the computer can either use IP address 192.168.4.255 or 192.168.4.1.

N1MM Notes

N1MM always broadcasts rotator commands on port 12040.

If you want to use HexRotatorControl with N1MM, you must use that port number. This is set under HexRotatorControl's Config. → UDP Inbound Port entry. Set the IP address in N1MM to 127.0.0.1. Using the HexRotatorControl with N1MM allows the user to see the rotator's current bearing and rotation. N1MM alone does not show this data.

If you want to send commands directly to the ESP8266 and not use HexRotatorControl, enter the ESP8266's IP address or its subnet broadcast address.

Note: If the broadcast address is used, both the HexRotatorControl and the ESP8266 will receive the command if both are running.

The N1MM setup is done via its Config→ "Config Ports, Mode Control, etc" under the Broadcast Data tab.

There are several ways to set a new bearing from N1MM:

- Enter the new bearing value in the CALLSIGN box and press Alt-J.
- Entry the callsign in the CALLSIGN box and press Alt-J. N1MM looks up the proper bearing info.
- Pressing Alt-L sets the long path when a callsign is entered.
- Pressing Ctrl-Alt-J issues a Stop command.

GITHUB Repositories

- HexRotatorControl: https://github.com/mdannhardt/HexbeamRotatorControl
  In the list, click on HexRotatorControl.exe. A new page is displayed with a download icon that allows the program to be downloaded.
- ESP8266 Controller: https://github.com/mdannhardt/rotatorControllerESP8266

Tips, Problems and Solutions

Tip: Twist the DC power lines together. Twist the I2C bus lines to the QMC5883L together.

Tip: Debugging data can be sent to the Arduino IDE Serial Monitor or other terminal emulator. In the Arduino file **rotatorControllerESP8266.ino**, find the line ***//#define DEBUG*** and remove the comment characters **//** so the line reads ***#define DEBUG*** Various messages will be sent to the Serial Monitor indicating rotation status that may help in debugging any problems.

Problem: Bearing reading QMC5883L is consistently off by some factor of near 90, 180 or 270
Solutions: Check that the QMC5883L is mounted correctly and not upside down.

Problem: Bearing reading QMC5883L is consistently off by a small but inconsequential amount
Solutions: Check that there are not metal or magnetic objects near the control box. Perform a calibration to account of declination.

Problem: Large and rapidly changing swings in the bearing readings while the rotator is stationary.
Solutions: Verify that the battery is connected and the control electronics are not being powered by the USB port. The ESP8266 can not supply enough power to the QMC5883L for it to operate properly and in fact may damage the ESP8266.

Problem: Large and rapidly changing swings in the bearing readings while the rototating or rotation stops almost immediately.
Solutions: Check that the motor DC power lines are routed away from the QMC5883L. The DC power lines will generate a magnetic field when current flows and the QMC5883L will detect it. If the problem persists, try mounting the QMC5883L further away from the other control electronics, even outside the control box. Twist the DC power lines together. Twist the I2C bus lines to the QMC5883L together.

References

PST Rotator documentation is here: https://www.pstrotator.com/ANT/PstRotator%20User%20Manual.pdf

N1MM References:
https://n1mmwp.hamdocs.com/setup/interfacing/#rotator-udp-packet-information
https://n1mmwp.hamdocs.com/setup/interfacing/#n1mm-rotator-control