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.

The sketch 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. It also creates a DNS access point on 192.168.4.1.

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.

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 rotator control files from GitHub. Links are provided in Section GITHUB Repositories
   - rotatorControllerESP8666.ino
   - rotatorControllerESP8266.h
   - webConfigure.ino
   - webConfigure.h
   - HexRotatorControl.exe
3. Copy these files into a folder called “rotatorControllerESP8266”
4. 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 →Board Manager and enter ESP8266 in the Search field.
   - Click Install on the ESP8266 package.
5. Set the Board to ESP8266 in the Arduino IDE:
   - Open: Tools→Board→esp8266 and click on Generic ESP8266 Module.
6. Install the QMC5883L compass library.
   - To install the library into the Arduino environment, download the latest release file to your desktop: https://github.com/dthain/QMC5883L/releases
   - In the Arduino app, select the menu Sketch->Include Library->Add Zip Library and then select the downloaded file.
   - See the complete library documentation and additional information at https://github.com/dthain/QMC5883L.
7. 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.
8. Run the Arduino IDE and open the rotatorControllerESP8266.ino file. Open the Serial Monitor (Tools → Serial Monitor or Ctrl+Shift+M) and set the connection baud rate to 115200. You will need information that will be displayed on the monitor when the ESP8266 boots (see step 11).
9. Click the Upload to compile and install the software into the ESP8266.
10. Watch the information printed in the Serial Monitor and find the line showing the Rotator Name. Record the name as it will be needed when connecting to WiFi.

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 WiFi router and hence a local area network.
3. An access point and DNS server are 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.

Command Interface

The ESP8266 Controller will listen for and process commands received over the WiFi. The information presented in this section is for those wishing to interface the controller with other software packages.

The following incoming commands are accepted:

- 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

ESP8266 WiFi Setup and Configuration

When the compiled sketch is initially loaded onto the ESP8266, the WiFi router information blank. The WiFi SSID and password need to be set before the Controller can connect to the router. The ESP8266 Controller will create an access point and start a web server to allow setting these.

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. Note that only WiFi routers with a 2.4GHz access point will work with the ESP8266 chip set.

The Controller's SSID and Password must be set using the Controller's access point and web server.

- Connect to the Controller's access point using a computer or smart phone with a browser. The access point will be in the list of available connection points with the Rotator's Name that was recorded during the sketch installation step on page 3.
- Open a web browser and go to 192.168.4.1. This is the address the ESP8266 Controller has the web server running at. A web page will be displayed to allow setting the SSID and Password for the desired WiFi router.

Current SSID: no_cfg
Current Password: no_cfg

Input:

Use the Input box above to:

- To update the router SSID and Password enter the following:
  1. Set a new SSID with: **ssid=*new ssid***
  2. Set a new password with: **password=*new password***
  3. Save the changes with: **save** (Note: Saves the new setting and reboots the controller so they take effect.)
- To clear the router SSID and Password enter the following:
  1. Reset with: **reset** (Note: Resetting clears the SSID and password. Save is required to save the changes and reboot.)
  2. Save the changes with: **save** (Note: Saves the new setting and reboots the controller so they take effect.)

- In the Input box, set the WiFi router's SSID by entering "ssid=*new ssid*" and pressing enter.

- In the Input box, set the WiFi router's password by entering "password=*new pw*" and pressing enter.
- Finally, enter "save" into the Input box and press enter. This causes the ESP8266 controller to save the SSID and password into non-volatile memory and restart. The Controller will now attempt to connect to the configured router WiFi.
- Close the browser and disconnect from the Controller's access point.

Note: Allow the web page to reload after entering new commands in the Update box and pressing enter before entering the next command.

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.

Changing to a different WiFi router

Use the same procedure as described in Connecting the ESP8266 to a computer hotspot to update the SSID and password for the new WiFi router.

Connecting the ESP8266 to a computer hotspot

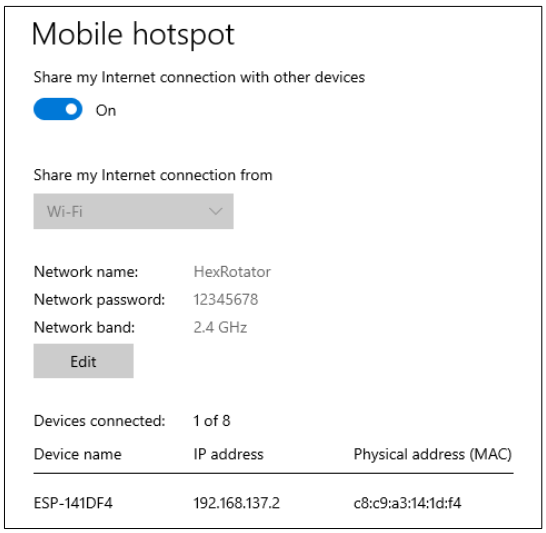
Use the same procedure as described in Connecting the ESP8266 to a computer hotspot only use the SSID and password of the hotspot instead of the WiFi router's.

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.

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 offers DNS access point such that 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.

Connect the computer's WiFi to the rotator by selecting the ESP8266's **SSID** from the available networks. The SSID will be the Rotator Name and look like ESP-XXYYZZ. The name should be noted and recorded when the sketch is loaded the first time. Application's on the computer can either use IP address 192.168.4.255 or 192.168.4.1.

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

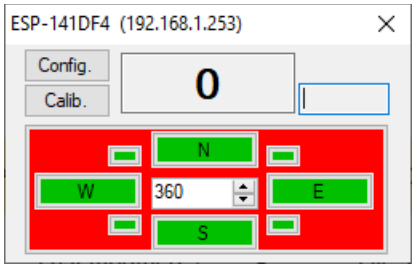
HexRotatorControl.exe is provided as a single Windows executable binary file. Simply place the file in a directory of your choosing. Run it by double clicking on the file name or right clicking on the file name and then click on Open in the window that pops up. The application is not signed so when it 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 current bearing is display top center. If the controller hasn't been found yet it displays dots and dashes or if communications is lost. A set of question marks.

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 title bar displays the name of the ESP8266 controller board which the app will control. The IP address of the controller is displayed after the name or “searching …” if the controller has not yet been discovered.

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.

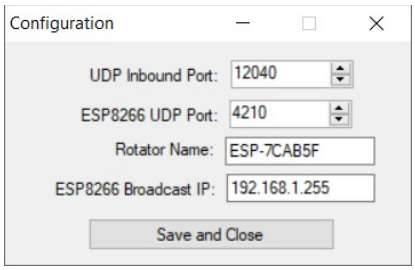
The large number top center is the current bearing as reported by the controller. If it displays a value of 0, it means that the QMC5883L is returning a status of not ready.

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”.

If the bearing displayed is a negative value and Error! Is displayed to the right, a fatal error has been encountered. The follow are the possible errors:

- -1 The QMC5883L was not found.
- -2 The QMC5883L not ready.
- -3 The QMC5883L calibration failed.

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.

- Rotator Name – Enter the name of the rotator. Use the IDE Serial monitor view when the sketch is loaded and run the first time and note the line displaying the Rotator Name. Label the rotator with the name for future reference and use that name in this enter field.

- ESP8266 IP or Netmask – Enter the broadcast address for the network the ESP8266 is on. The program will broadcast a request for the rotator with the Rotator Name entered above to provide its IP address.

  See section ESP8266 WiFi Setup and ConfigurationESP8266 WiFi Setup and Configuration for information on methods of connecting a ESP8266 rotator controller to the network.

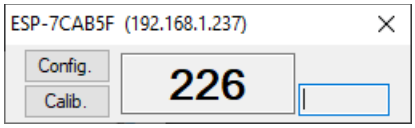
  - If connecting to a ESP8266 rotator using the computer's hotspot: Windows setups the network DHCP service using 192.168.137.1 as the gateway and leases out addresses on the 192.168.137.xxx network so the default setting in this case is 192.168.137.255.
  - If connecting to a ESP8266 rotator via a network 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_CURRENT_USER\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

N1MM Notes

N1MM can be used to send rotate and stop commands to the ESP8266 Controller via the HexRotatorControl windows application or to the ESP8266 Controller directly so that the HexRotatorControl application is not required.

Using the HexRotatorControl app with N1MM allows the user to see the rotator's current bearing and rotation in the app. N1MM alone does not show this data.

Setup

In either case; commands sent via HexRotatorControl app or direct to the Controller, N1MM must be configured with the IP address and the port number to send to. These are set by clicking on Config→ Configure Ports, Mode Control, WinKey, etc… to bring up N1MM's Configurer window. Select the tab called Broadcast Data. Under "Type of data" find the row labeled Rotor. To the right is where the IP Address and Port numbers are entered.

If you want to use HexRotatorControl with N1MM, set the IP Address to the local host: 127.0.0.1 and the port number to the value set under HexRotatorControl's Config. → UDP Inbound Port entry. The default is 12040. As an example, in the N1MM Configurer Rotor field, enter 127.0.0.1:12040.

If you want to send commands directly to the ESP8266 and not use HexRotatorControl, use the ESP8266's IP address or its subnet broadcast address and the ESP8266 UDP port number of 4210. As examples of what to enter into the N1MM Configurer Rotor field:

- To send commands directly to a specific ESP8266 Controller at IP address of 192.168.1.253, enter 192.168.1.253:4210
- To send broadcast commands ESP8266 Controllers without knowing the specific IP addresses for them enter: 192.168.1.255:4210

Note: If the broadcast address is used, the HexRotatorControl if running and all ESP8266 on the network will receive the command.

Sending Rotate and Stop Commands

There are several ways to set a new bearing and stop commands from N1MM to the ESP8266 Controller:

- 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 rotating 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