Programming AMRTs for reliable F5J performance

Feature article by Tuan Le (fnnwizard@gmail.com) October 2021

Forward: *We are very fortunate to have this article contributed by Tuan Le. Tuan is well known in the RC soaring community for his analytical and technical skills (in addition to being an excellent soaring competitor and all-around great guy!). This summer Tuan did a deep dive into how to program your TX so that it works predictably with your AMRT (altimeter/motor timer). One of the things he realized is that without a tool to display your motor control channel signal you were "flying blind" when it came to properly setting up your TX's motor control signal range.*

So Tuan rolled up his shirtsleeves and designed a clever control signal reader that displays the pulse width modulation (PWM) signal in microseconds. The construction of that reader is in this article. He also included a section on how to program a BL Heli ESC which is available in a separate PDF via the link at the end of this article. Thanks much for the article and sharing your design work, Tuan! --Editor

The AMRTs we use have specific settings per FAI code:

3.4 Motor Run Timer

3.4.1 The Motor Run Timer function must operate with the accuracy specified in item 2.3.5.

3.4.2 On initial power-up of the AMRT, the Motor Run Timer must be protected from false triggering during the period defined in Item 2.4 (c). After this period, the Motor Run Timer shall commence operation and 'Start Height' determination shall be initiated on the first occasion that the command signal exceeds 1.2 milliseconds.

3.4.3 After the Motor Run Timer has been triggered, the timing of the motor run ceases when either the command signal reduces below 1.2 milliseconds, or the elapsed time reaches 30 seconds and a definite stop command must be applied to the ESC by the AMRT.

3.4.4 The 'Start Height' determination process shall continue for a further 10 seconds after the instant of "motor stop".

3.4.5 Once the definite stop command has been applied to the ESC, the system must not respond to any further changes in the motor command signal.

3.4.6. A small amount of hysteresis is permitted in the sensing of the 1.2 milliseconds motor command signal to eliminate malfunction with jittering command signals.

From this code, we see that the "trigger" value for motor start and stop is at 1200us (1.2ms) with "a small amount of hysteresis" on either side of 1200us. I have found out the hysteresis is +- 20us. So to the up side, Altis sees motor on at 1220us, and sees

motor off at 1180us.

But the motor off has another step in there and can be verified with its logger. What happens is that the Altis measures and records the TX signal low throttle position when first booted up. It uses that as the default setting when we cross the 1180 threshold throttle off.

For example, if our throttle off position is 1000us, upon moving our throttle from above 1200us to below 1180us, the Altis immediately cuts it further to 1000us.

I've posted this info on RCG showing how an unscrupulous person can go about tricking the Altis to gain unfair advantage in a competition.
https://www.rcgroups.com/forums/showpost.php?p=47499577&postcount=21

Since most Tx/Rx combo have user settings capable of transmitting PWM signal between 900us - 2100us, the fixed 1200us setting specified can cause issues for the AMRT.

If we assume this hysteresis to be 20us in either direction for all AMRTs, (it may or may not be due to manufacturing tolerances of all the components for F5J) then the following programming can be used for effective control of Motor, ESC, AMRT.

This figure will help visualize what the PWM range should look like:

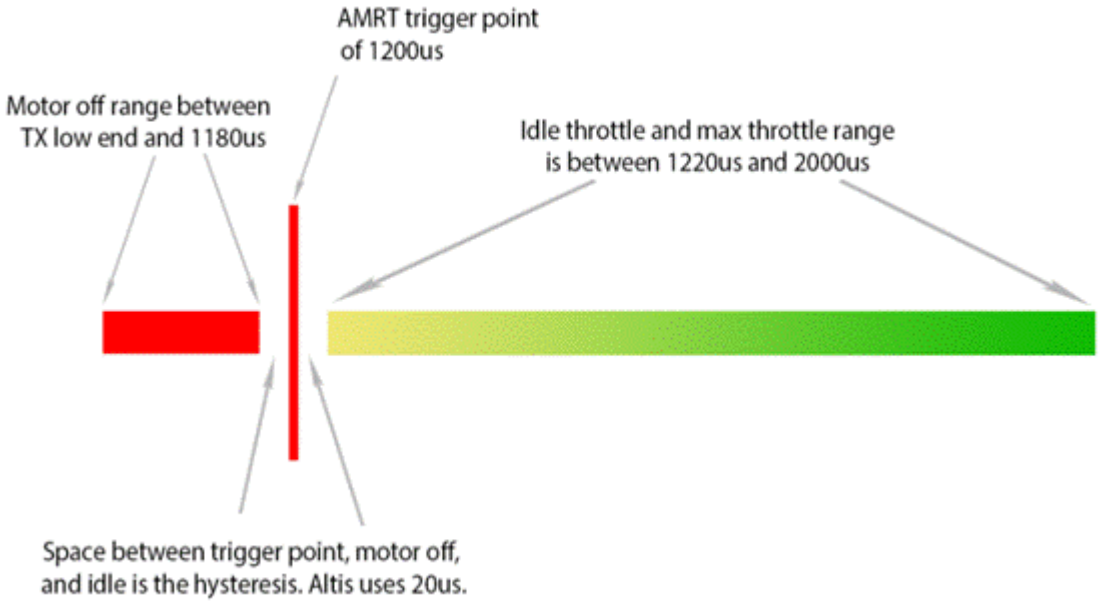


Figure 1 - PWM programming range

Tx/Rx **THROTTLE OFF**, using switch etc., should read lower than 1180us. I like to add some extra buffer of 30us so anything between 900us - 1150us.

Tx/Rx **THROTTLE IDLE** should be higher than 1200us. How high depends on your ESC/Motor/Prop/Battery setup. It basically is where neutral drag is for the spinning prop. I would guess it'll be 1300us - 1500us for most setups. This needs to be set in conjunction with ESC IDLE.

Tx/Rx **THROTTLE MAX** using slider, switch, stick etc should be 2000us or higher.

Just remember that it must not be lower than 1180us (again depending on jitter of Tx/Rx, I add about 25us as a buffer here), since that is where Altis sees and sets ESC off to, see below.

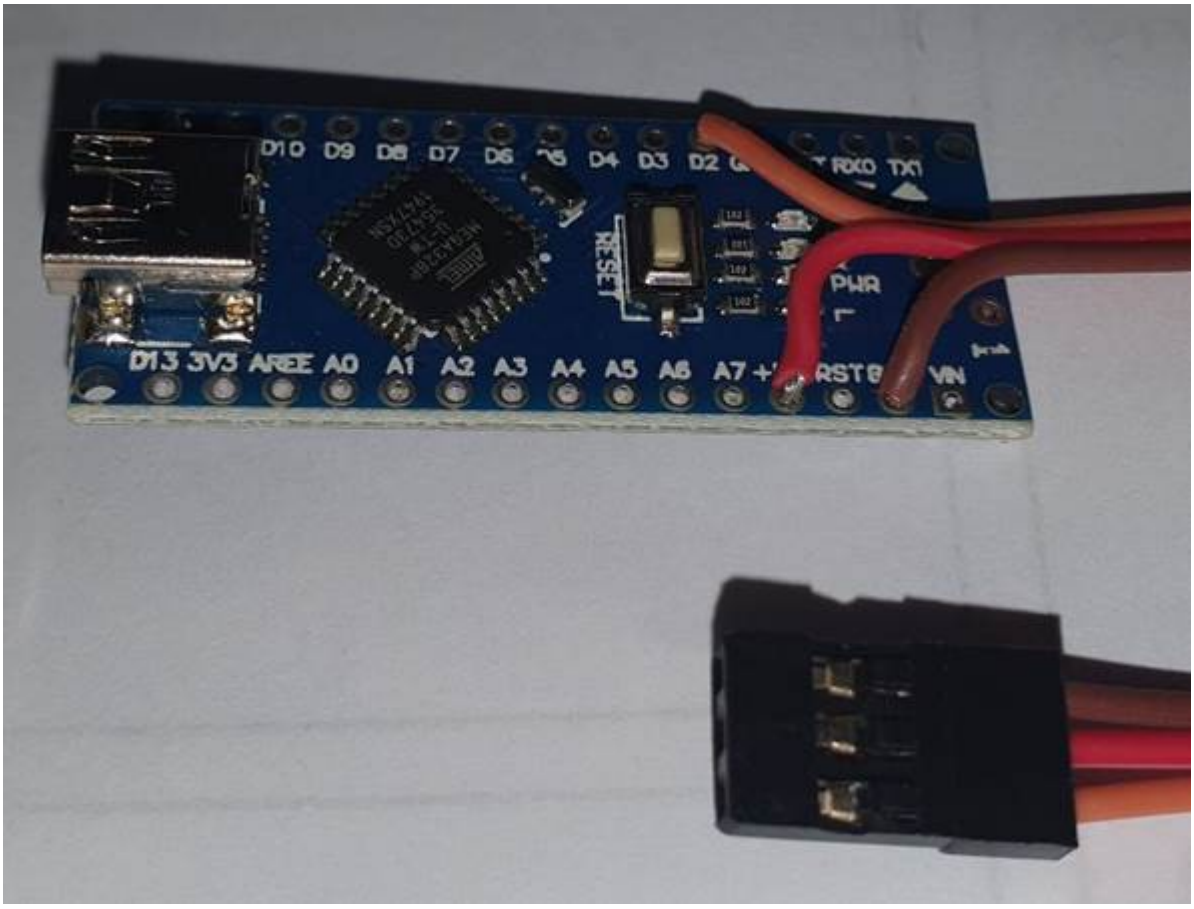
ESC **THROTTLE OFF** should be just slightly higher than 1200us (Mine is set at 1205us)

ESC **THROTTLE IDLE** again depends on power setup. I would guess it'll be between 1300us - 1500us for most setups but it can be in just about any range and still work since you can always program accordingly in the TX.

ESC **THROTTLE MAX** should be lower than TX Max, 2000us or less (Mine is set at 1980us).

Ok, now that we have an idea what needs to done, we can setup the TX/RX accordingly. There are tools out there that will read the signals, as well as some TX's have the feature built in. But we can also use an Arduino Nano to help us find that PWM signal.

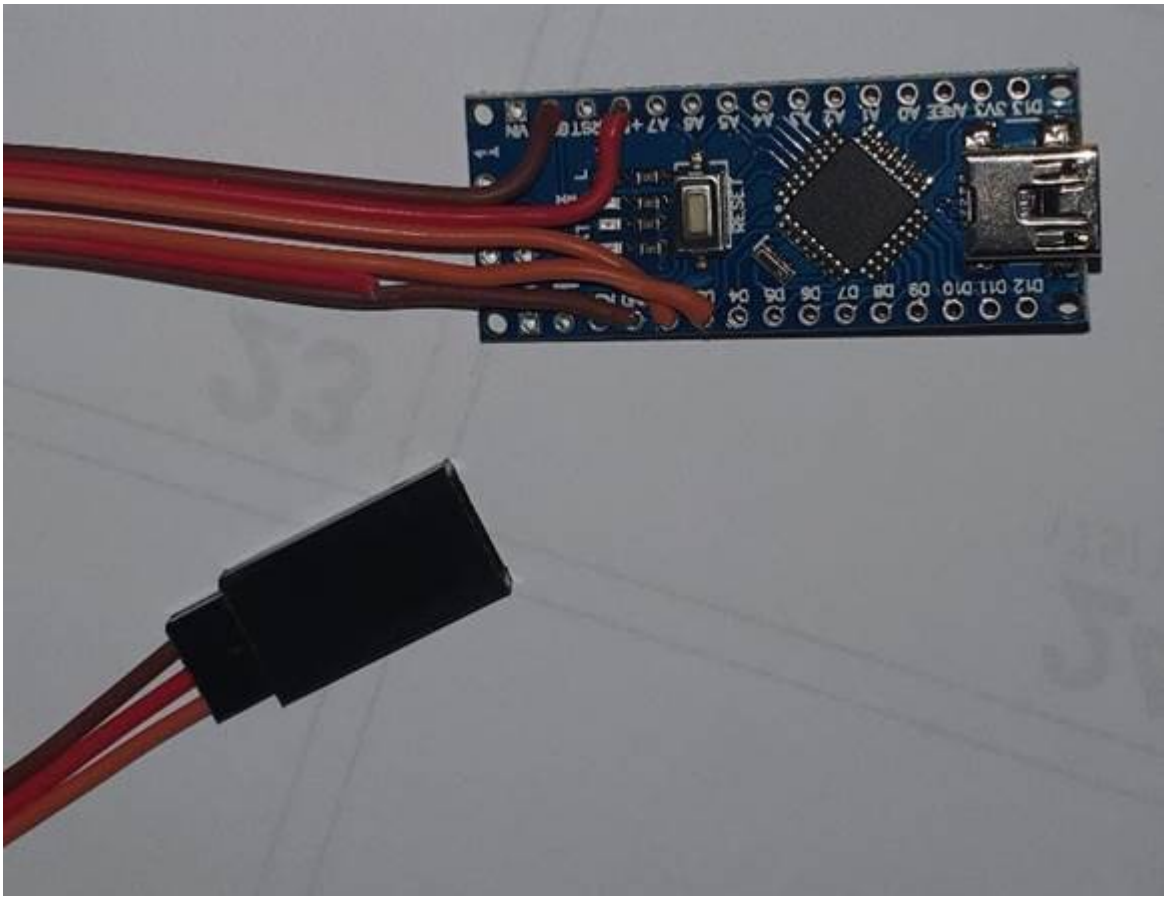
Programming an Arduino NANO to read PWM from a plane's RX



I bought the Nanos without headers and soldered the female end of a servo extension to the board. This connection goes into the throttle channel of the receiver to read its PWM signal. Connections are:

- Servo Ground to 1 of the ground pads on the Nano
- Signal (orange wire) to D2 pad
- Positive to +5v on Nano Pad

Preparing the NANO for programming BLH ESCs



The male end will be used to program the BLH ESC's later on. Make these connections:

- Ground (brown wire) soldered to another GND pad of the Nano.
- Signal to D3 pad on the NANO
- DO NOT CONNECT the positive wire (you can see I cut that)

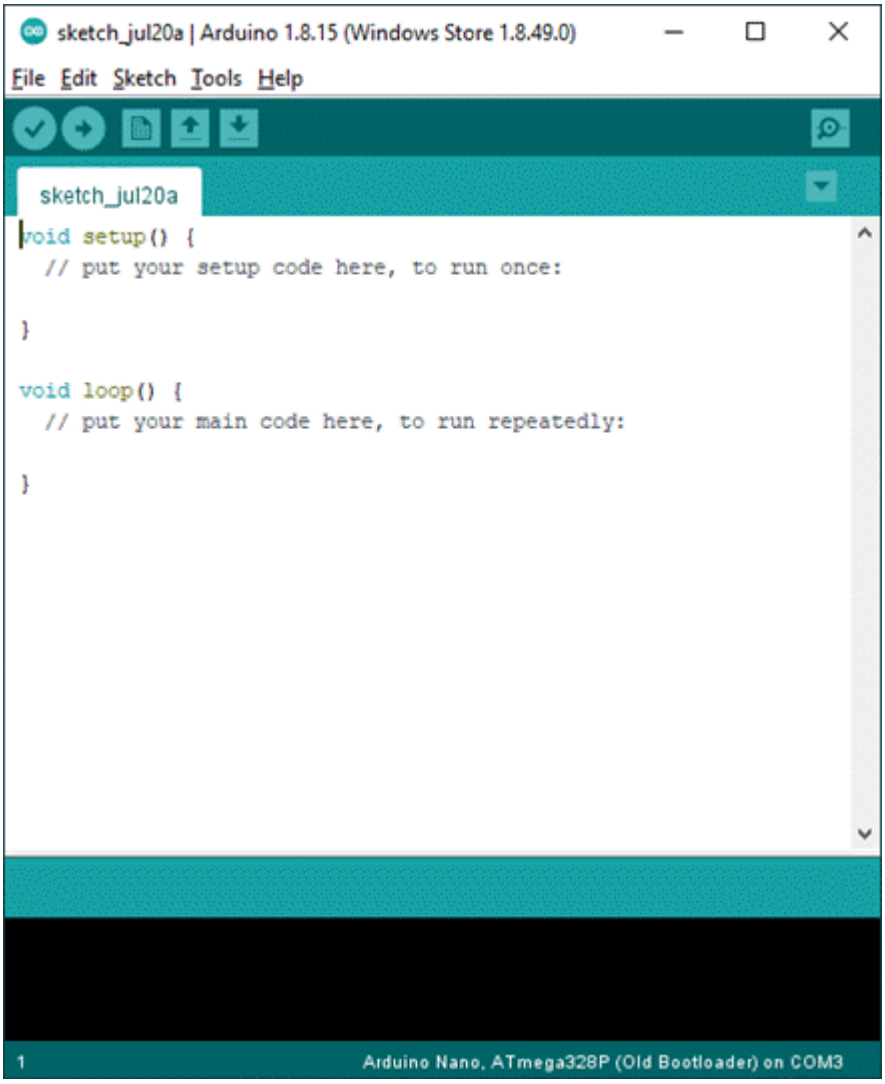
Finish with some heat shrink to prevent shorts.

Now we need to prep the software:

Nano Driver link:
https://drive.google.com/file/d/1oDpJ2ZBGofbW4FNgFWabktUkfJhaJLi_/view?usp=sharing

Arduino App link:
https://downloads.arduino.cc/arduino-1.8.15-windows.exe
Download and Install. Then Open the App.

We get this default screen:



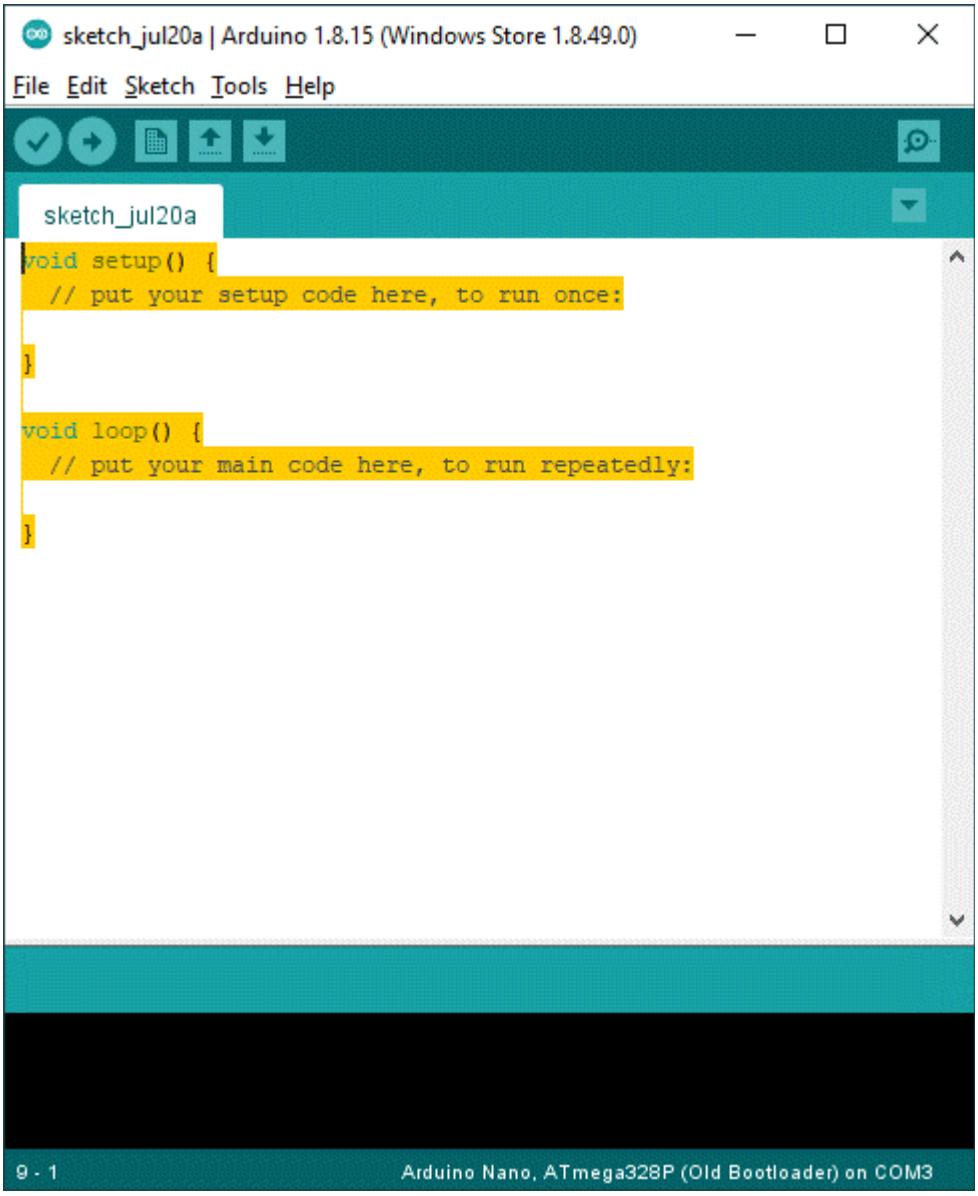
Go to Tools and set three things there:

1. Select Board = Arduino Nano
2. Processor = ATMega328P (Old Bootloader)
3. Port: Choose Com port corresponding to what is shown in your device manager. In Ports (COM & LPT), look for USB-SERIAL CH340, it'll show the COM #

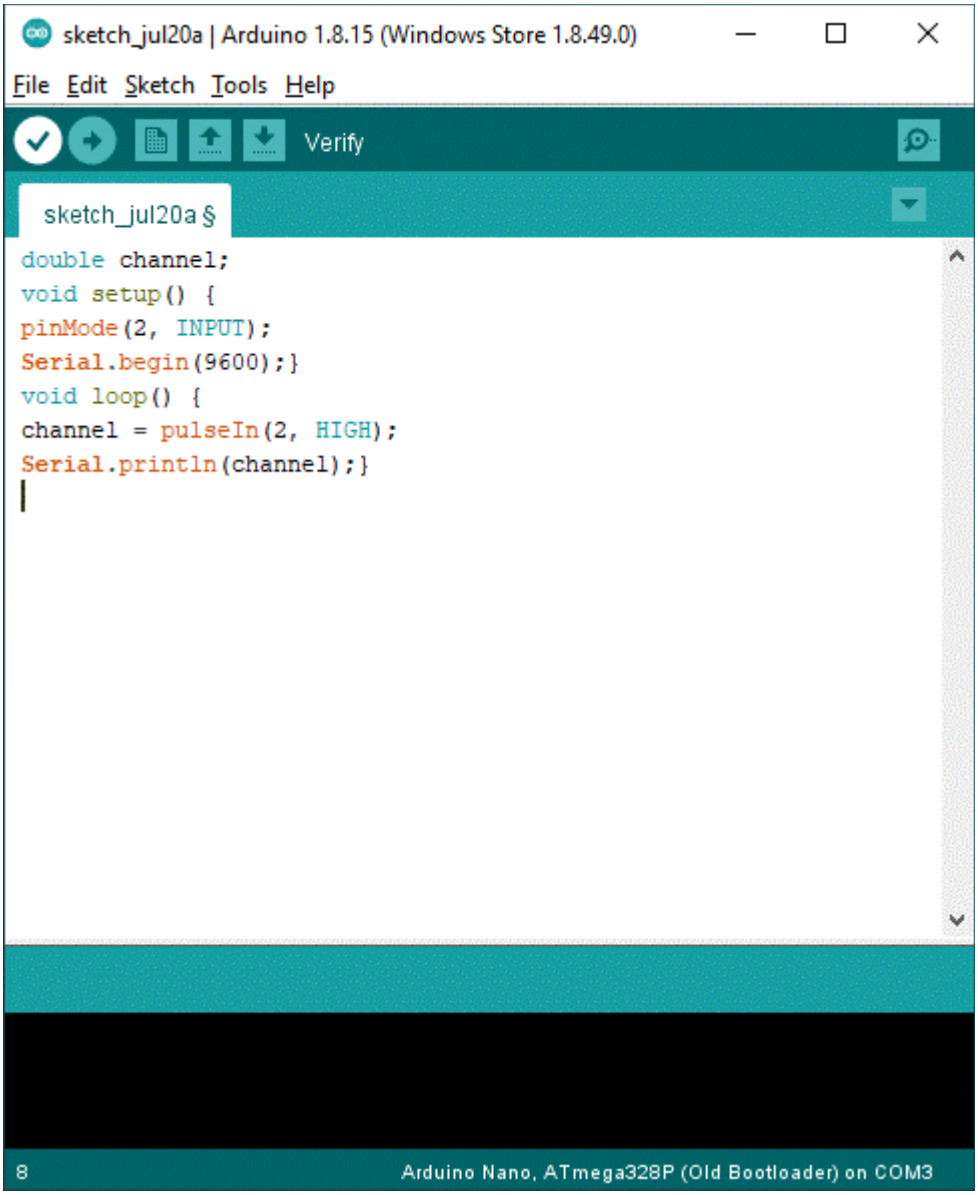
Then copy this code:

```
double channel;
void setup() {
pinMode(2, INPUT);
Serial.begin(9600);}
void loop() {
```

```
    channel = pulseIn(2, HIGH);
    Serial.println(channel);}
```

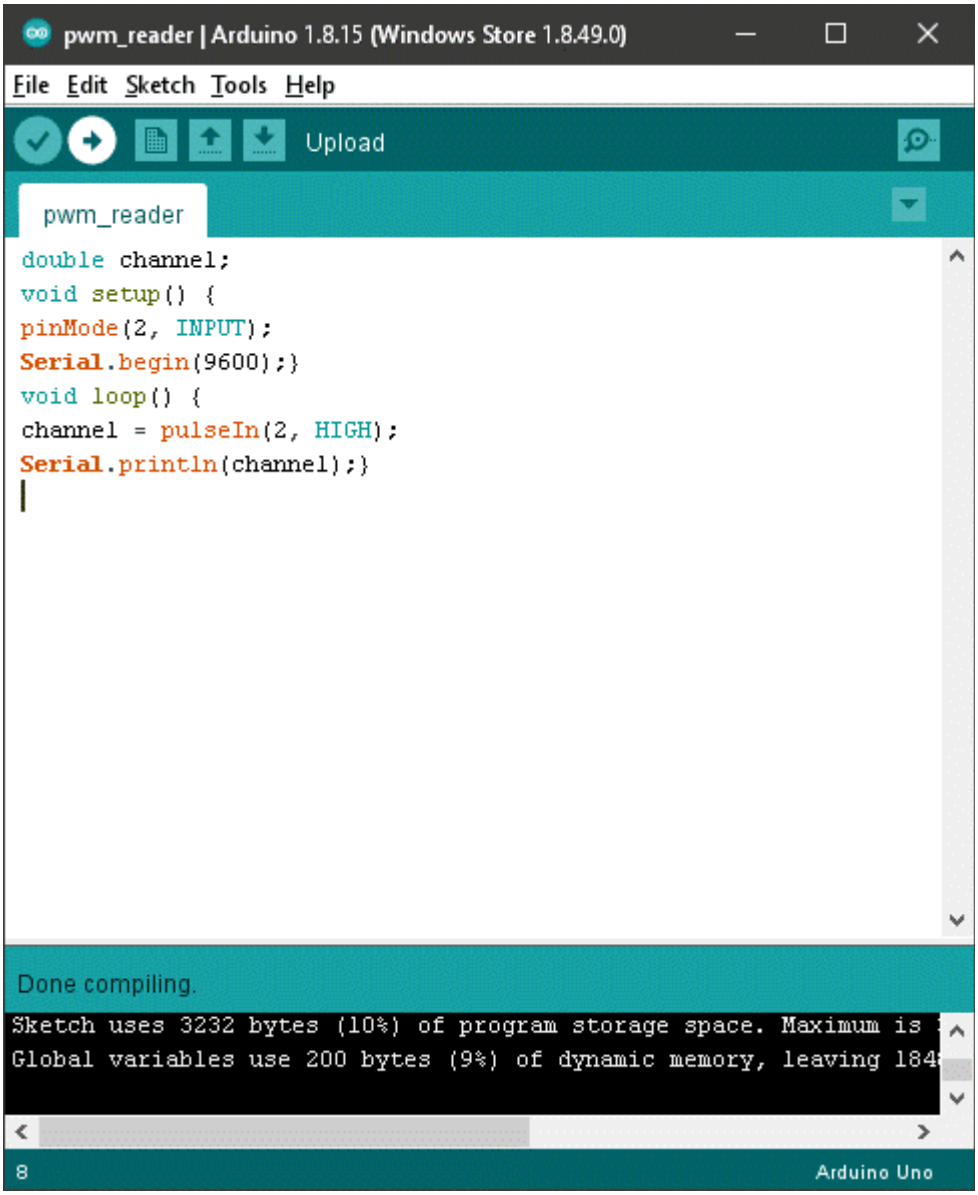


Then highlight the above default code in yellow and paste the copied code into box overwriting the default lines.



Click the check circle in white above. This Opens a box to Save. Name it Pwm Reader or whatever.

It'll then verify and compile.



Then plug the Nano into your computer using a USB cable.

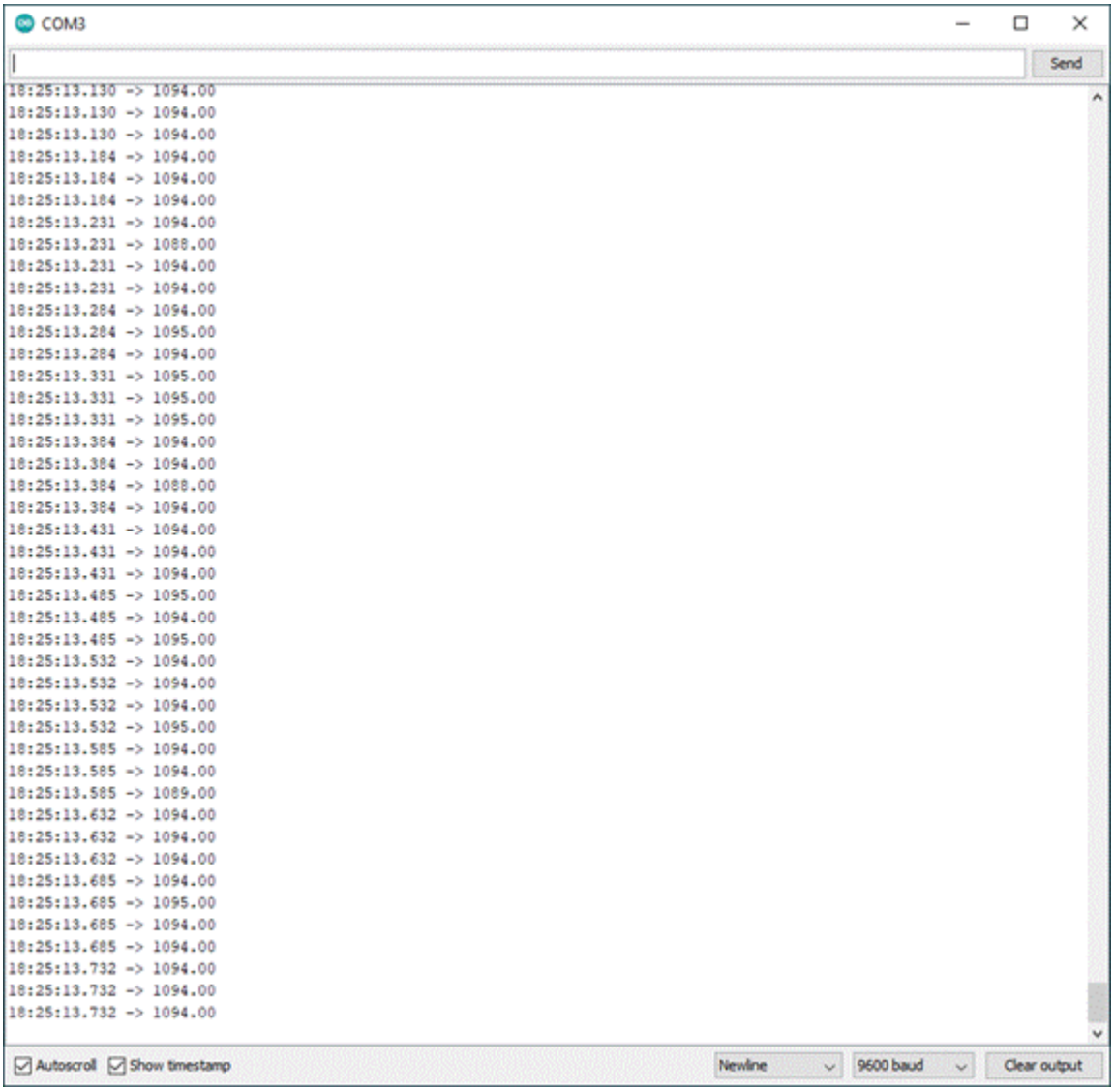
Click the right arrow highlighted in white above to load the code into the Nano.

Give it a few seconds. When it's done uploading the code (sketch).

Plug NANO into RX channel you want to monitor.

Select Tools, Serial Monitor

You should now see the PWM signal value in microseconds being displayed (as in the example screen below):



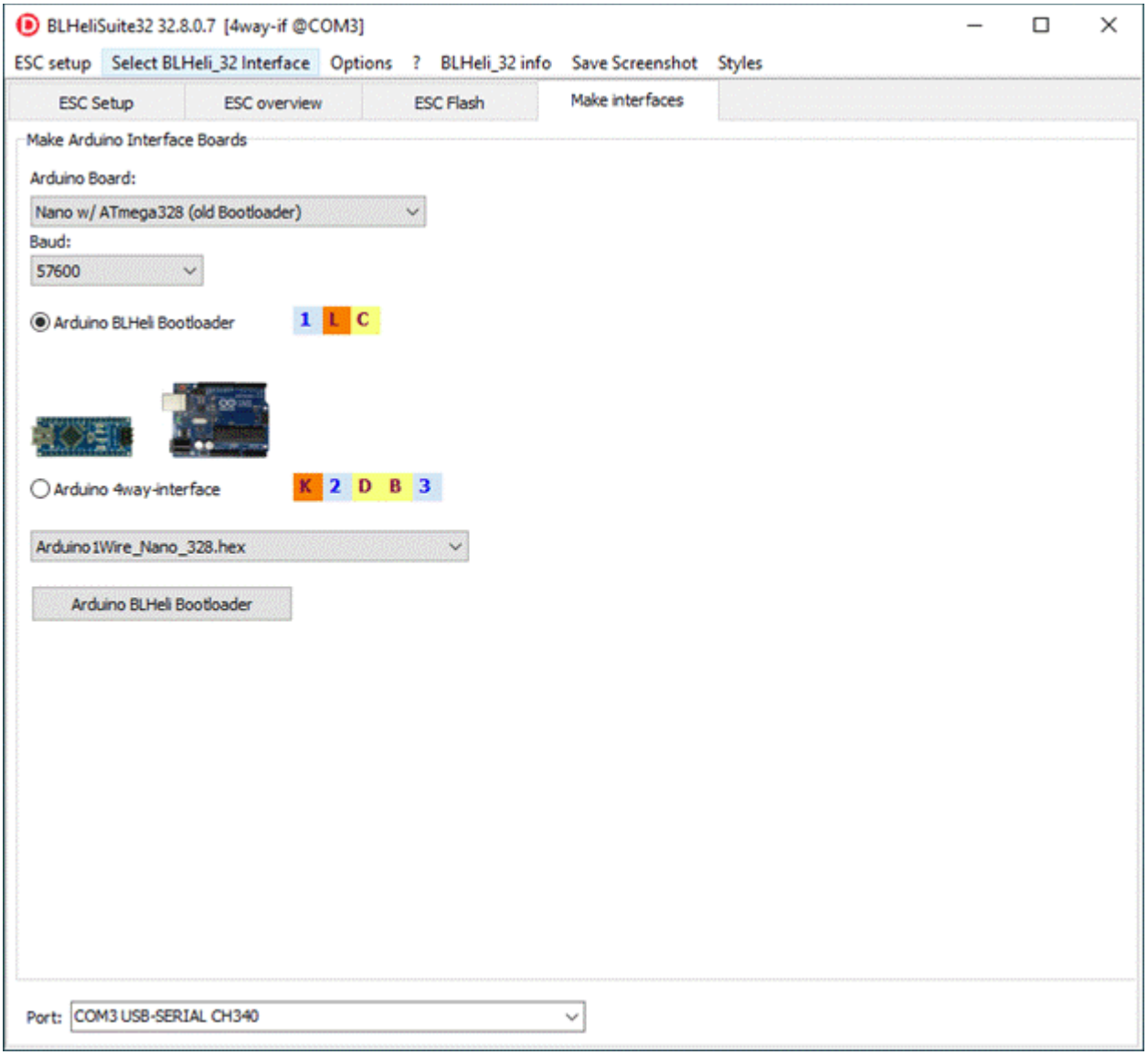
Please Note: the displayed PWM value could have errors between 1-10us.
For our purposes this doesn't matter much.

Now you can set the throttle channel endpoints for your arming switch and whatever control for variable throttle you are using per Figure 1 above. Keep in mind the variable throttle control should not turn off the motor at its lowest setting.

If you want to monitor other channels on the RX, just plug servo connector into the corresponding channel. You will need to close and restart the serial monitor screen to see the new results.

Programming a BLH ESC

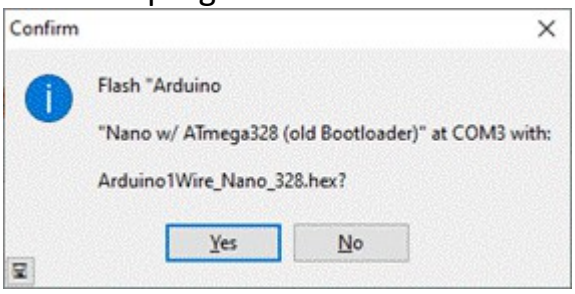
Download this App:
https://drive.google.com/file/d/1sj4R5AhuPm7YktLXzl2rvbQn4gocl5bm/view?usp=sharing



Now execute these steps:

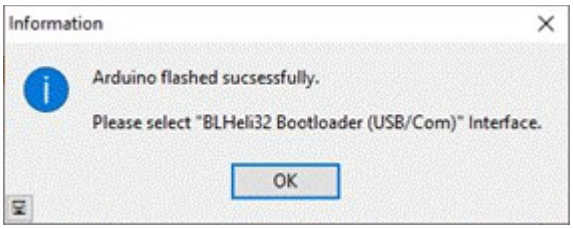
- Select 4way-if under Interface Tab Hi-Lite Blue in Picture
- Select Make interfaces Tab
- Select Nano Board with Old Bootloader
- Baud Rate 57600
- Click Arduino BLHeli Bootloader

Then the program will ask:



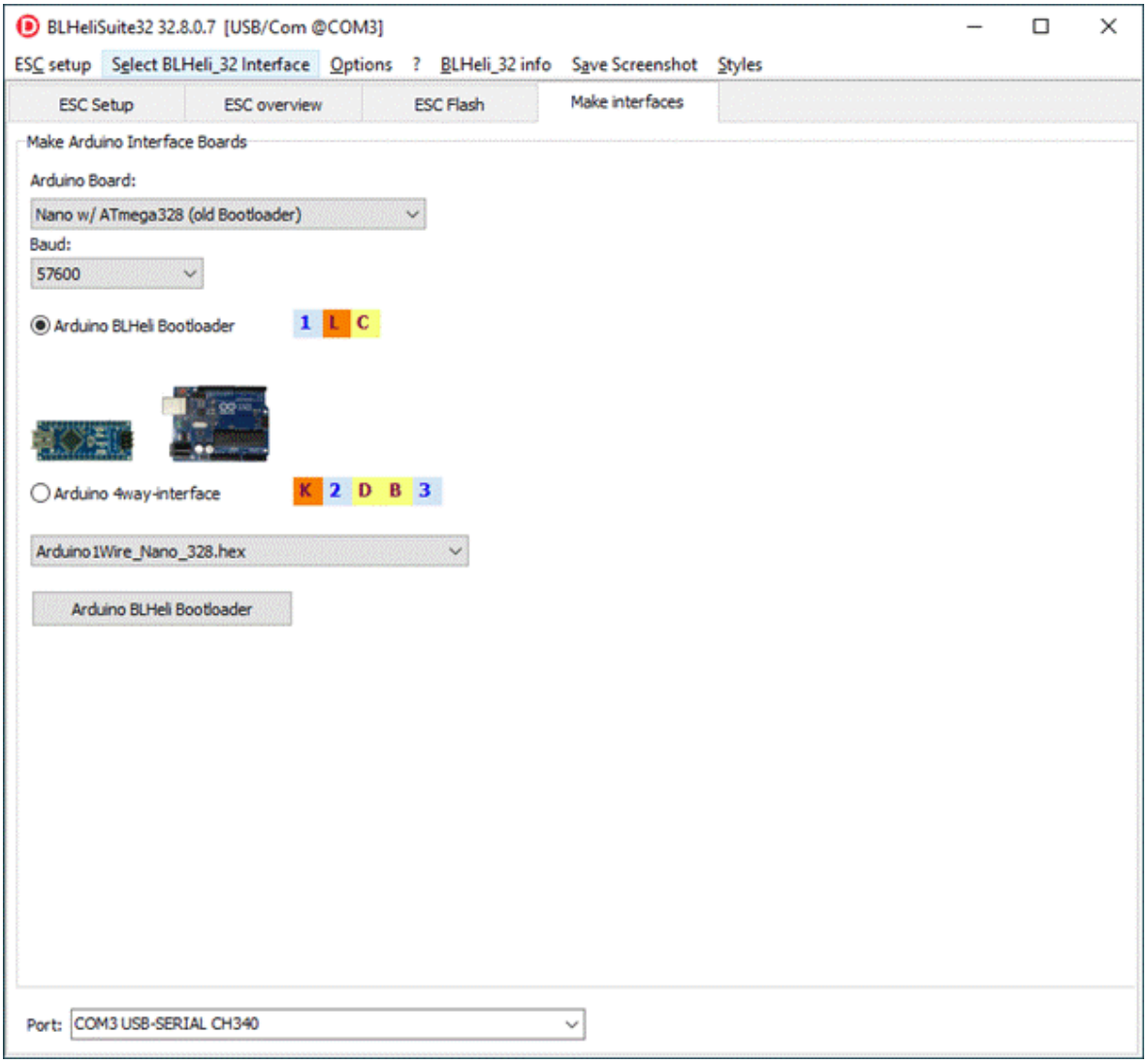
Hit Yes to Confirm.

Result:

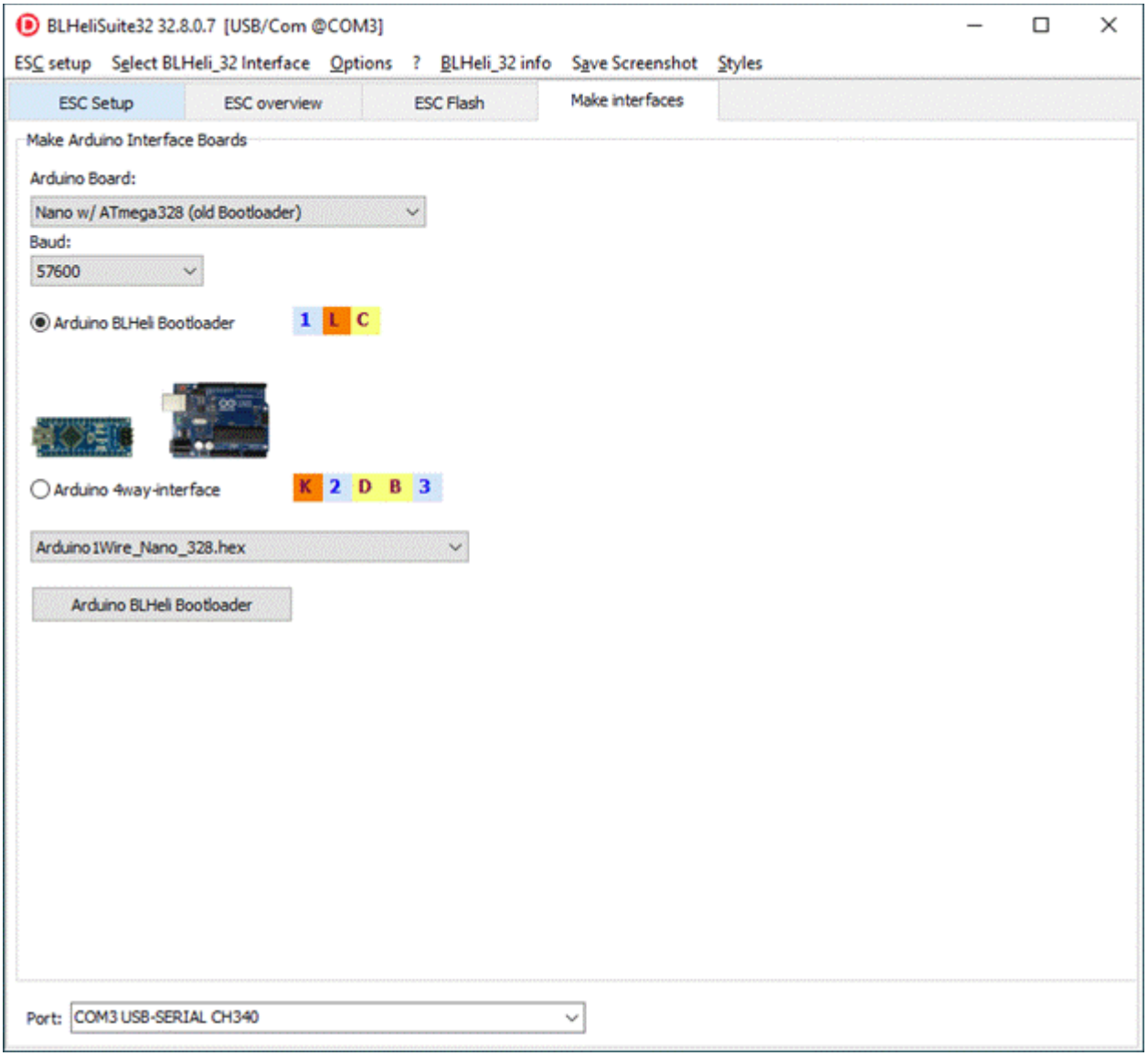


Hit Ok.

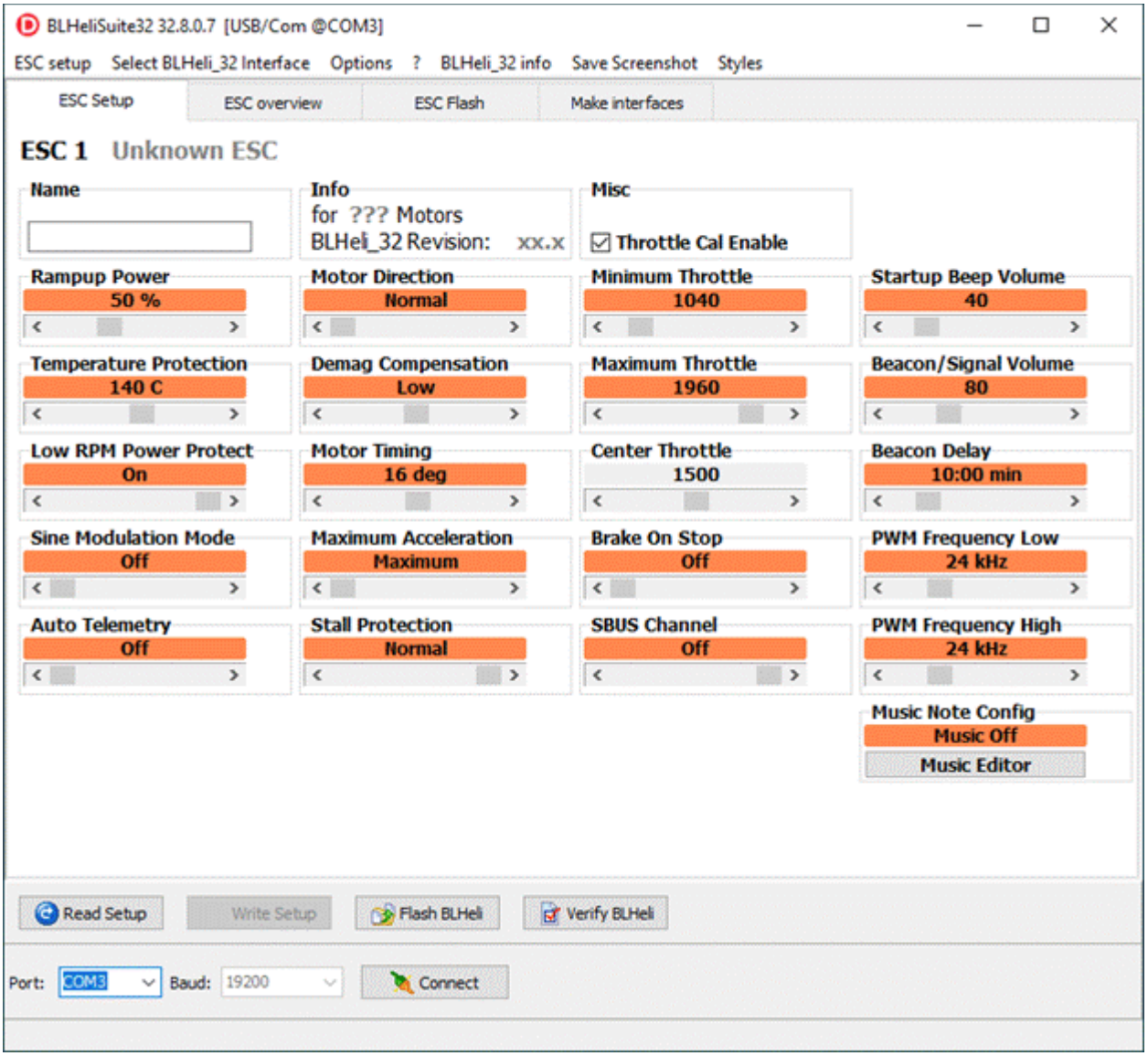
Configuring the BLHeli ESC



Back to Select Interface in blue above, choose USB.

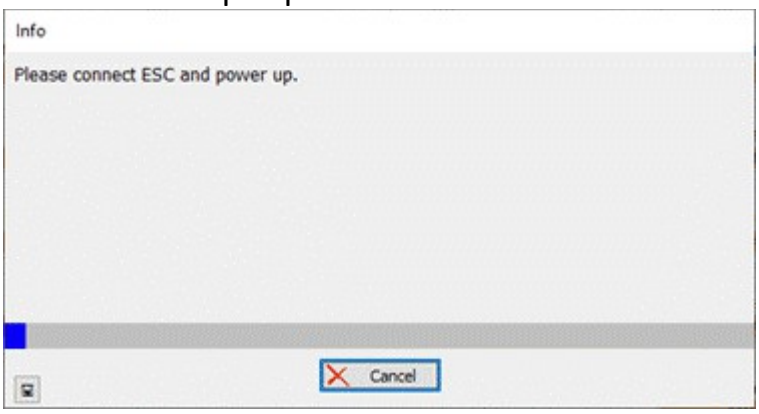


Click ESC Setup in blue above

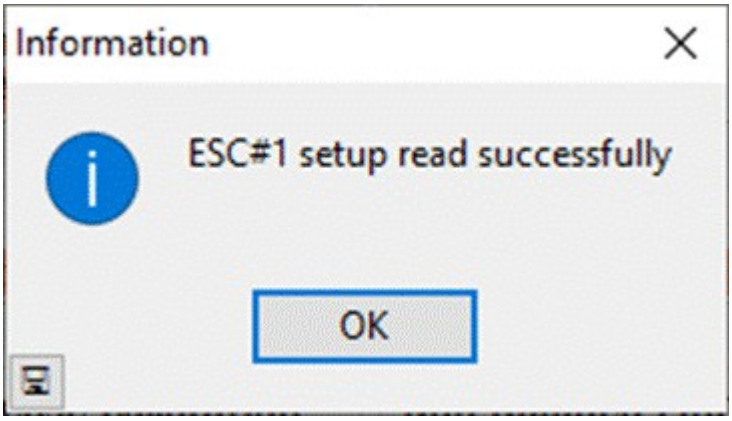


Make Sure Port Matches, (Blue Hi-Lite)
Connect Speed Control to Nano via servo wire, then
Click Read Setup.

This Screen Pops up

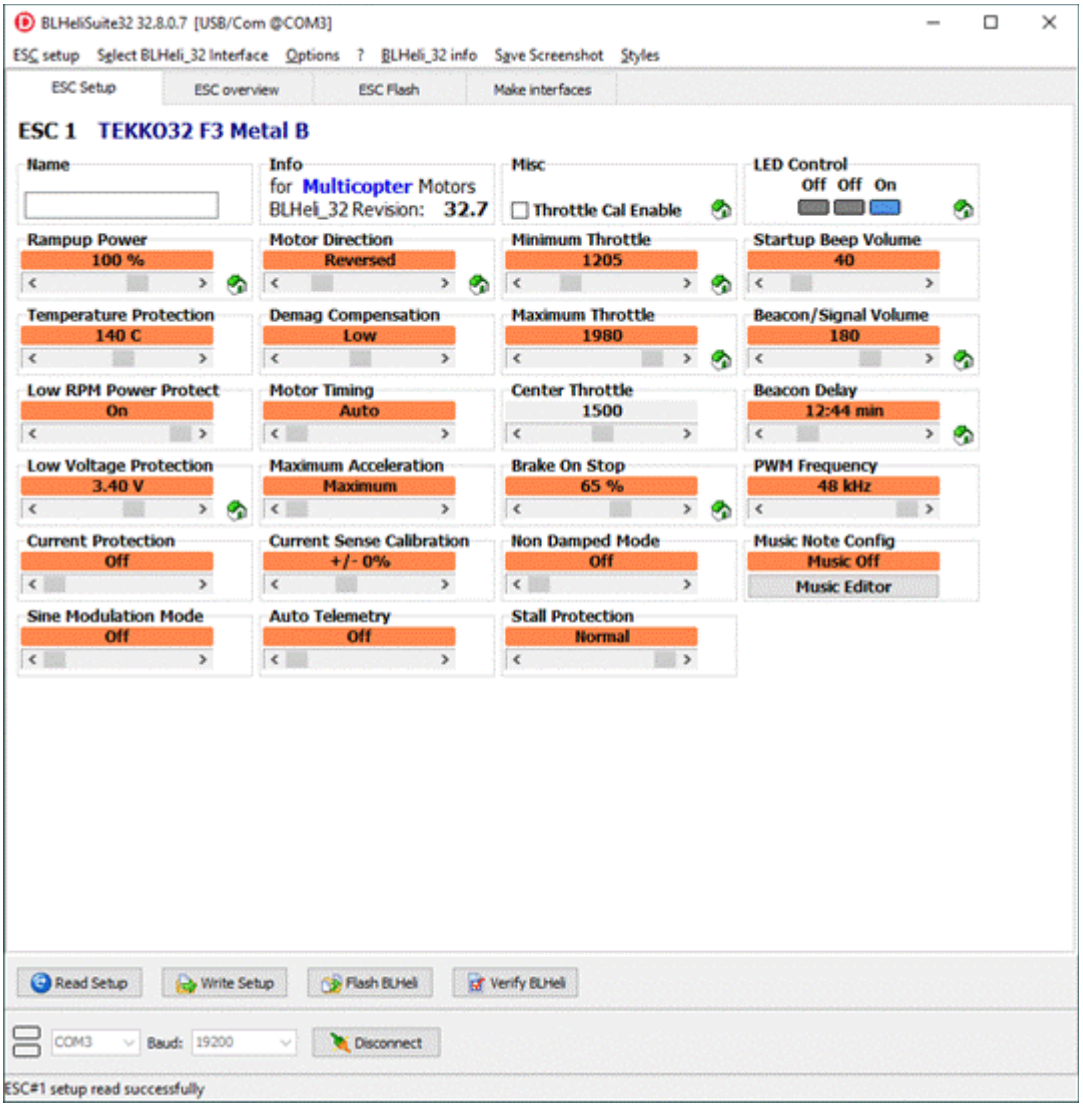


Connect Battery to ESC and wait a few seconds



Click Ok

You can now adjust each of the parameters.

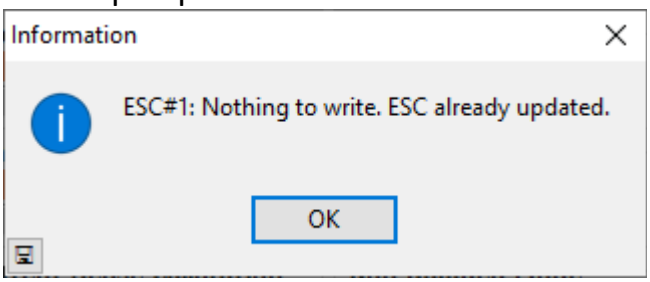


These are some of my settings

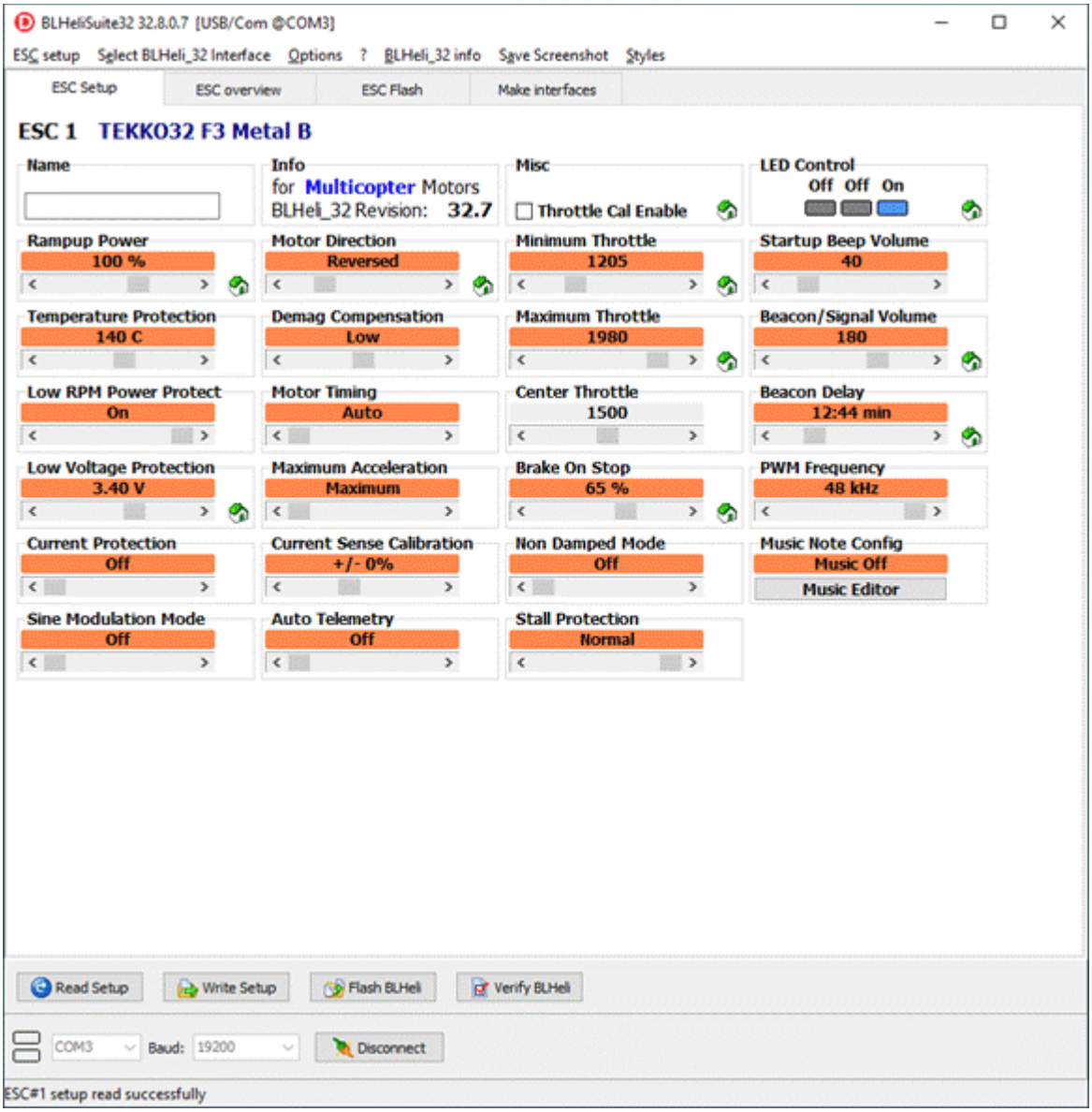
NOTE! Make sure **Throttle Cal Enable** above Minimum throttle setting is UNCHECKED!

Click Write Setup when you want to transfer settings to ESC

This Pops Up



Click OK, mine says nothing to write because it already is setup this way.



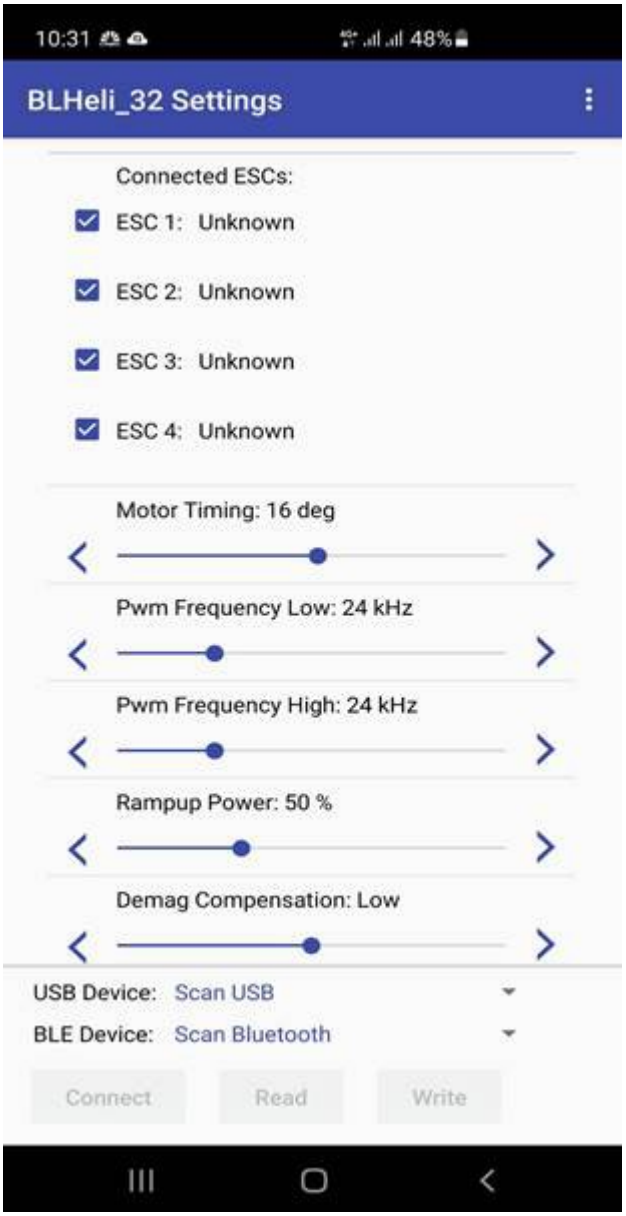
Click Read Setup again to verify settings have been transferred

Done Programming BLH ESC

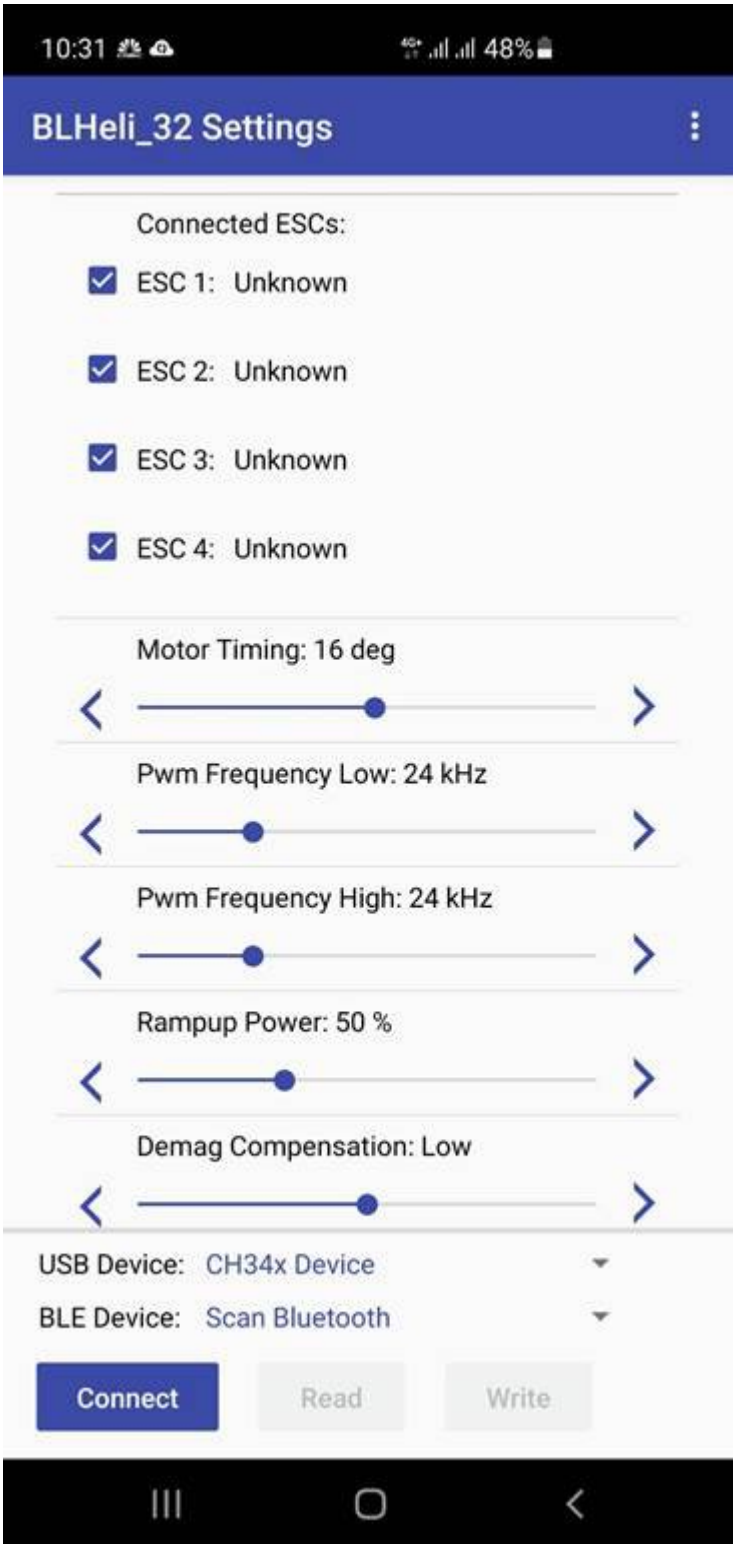
Using BLH with Android

Search for BLHELI_32 in the play store, and load it on an Android device.

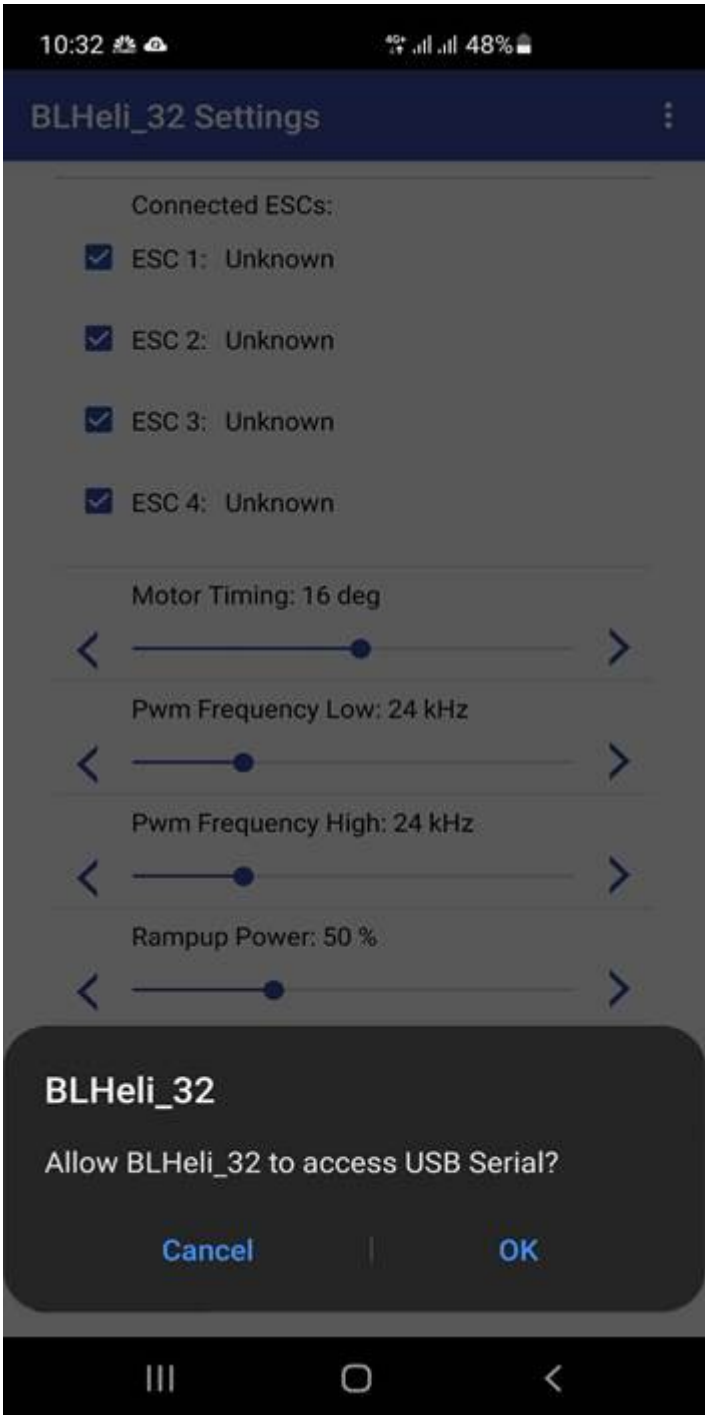
You will need a USB cable that goes from the phone to the Nano.
Launch the app and plug in the Nano



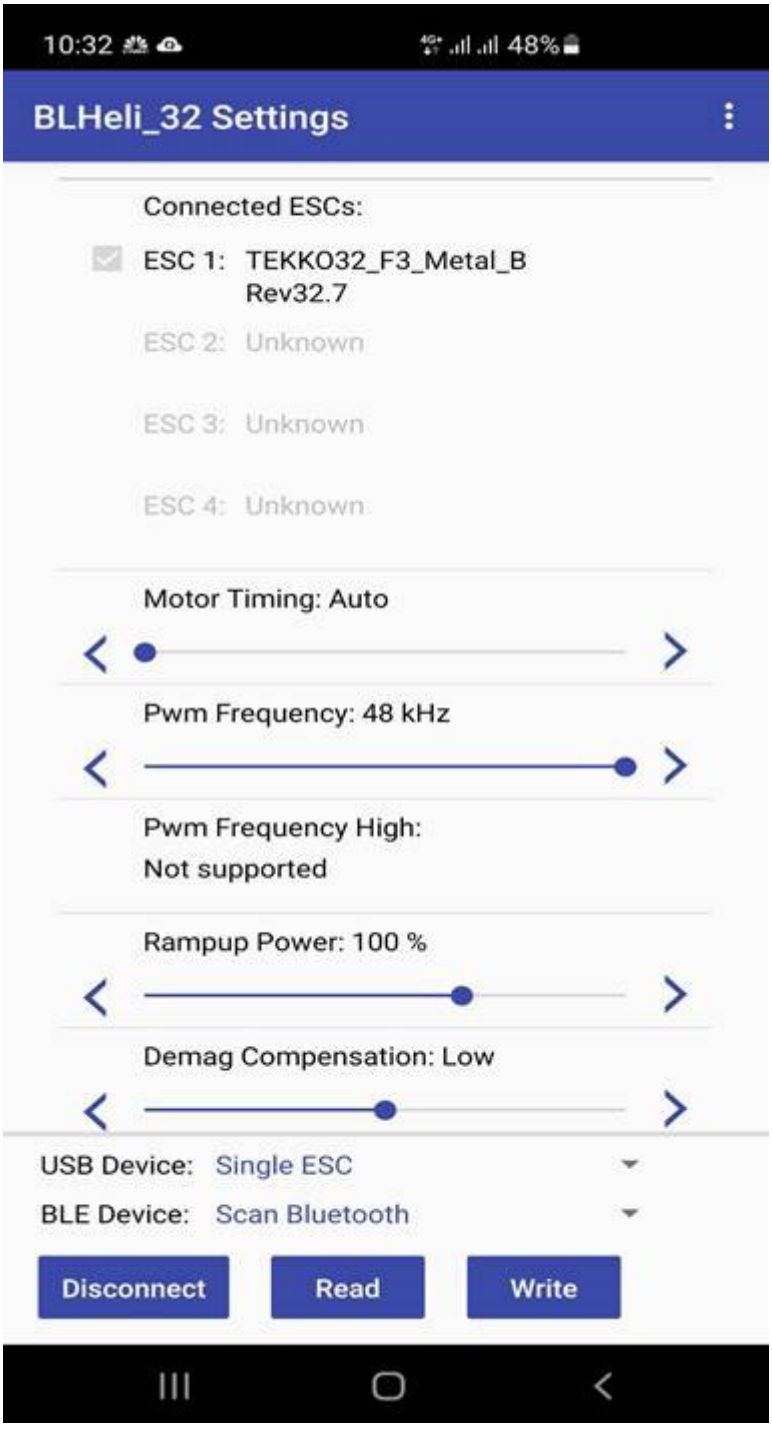
Tap on Scan USB


10:31
48%
BLHeli_32 Settings
Connected ESCs:
ESC 1: Unknown
ESC 2: Unknown
ESC 3: Unknown
ESC 4: Unknown
Motor Timing: 16 deg
Pwm Frequency Low: 24 kHz
Pwm Frequency High: 24 kHz
Rampup Power: 50 %
Demag Compensation: Low
USB Device: CH34x Device
BLE Device: Scan Bluetooth
Connect
Read
Write

Tap Connect


10:32
48%
BLHeli_32 Settings
Connected ESCs:
ESC 1: Unknown
ESC 2: Unknown
ESC 3: Unknown
ESC 4: Unknown
Motor Timing: 16 deg
Pwm Frequency Low: 24 kHz
Pwm Frequency High: 24 kHz
Rampup Power: 50 %
BLHeli_32
Allow BLHeli_32 to access USB Serial?
Cancel
OK

Allow



Now you can do the same Read/Write functions.