ON4AKH Antenna Rotator controller
Version 1.0

1. <u>Some construction tips</u>

   The project consists out of 3 boards. The 1ˢᵗ board is the main board containing the PIC micro controller and the H-bridge components to turn the motor. A 2ⁿᵈ board contains the power supply. The 3ʳᵈ board is an extension board to make cabling towards the front panel a bit more tidy. The power supply will be depending on your motor. For my Yaesu G1000 26 volts and 0.7 amps is sufficient. The design with the LM317 will allow you to go up to about 35 volts and 1.5 amps. If you need more, you will need to look for another power supply.
   The Darlington transistors (TIP122 and TIP127) used in the H-bridge will allow you to use a voltage up to 100 volts and a current of 5 amps.
   Of course, if you want, you can cable the main board to the front panel without the small extension board.

2. <u>The main board</u>

   This board holds the PIC micro controller (18F2550), some external components to get it up and running and some stuff for the USB port. A H-bridge controlled by PWM from the processor is the interface to get the motor turning. The board is only suited for DC operated antenna rotator controllers. To measure the heading of the rotator, the potentiometer from inside the motor is used. At this moment if your rotator uses any other means (like pulses) to determine it's heading, this is not supported.
   The board is designed on a Euro size PCB. This allows for plenty of space for the small amount of components and should be easily reproducible. The board is designed using Eagle. The layout and component positions layout can be found at www.on4akh.be under the projects.
   Start building the board by placing the wire bridges and the components with low height such as the resistors. Note that there are 4 wire bridges, the picture below shows only 3.

Now place capacitors, potentiometer, and IC socket to hold the 18F2550.



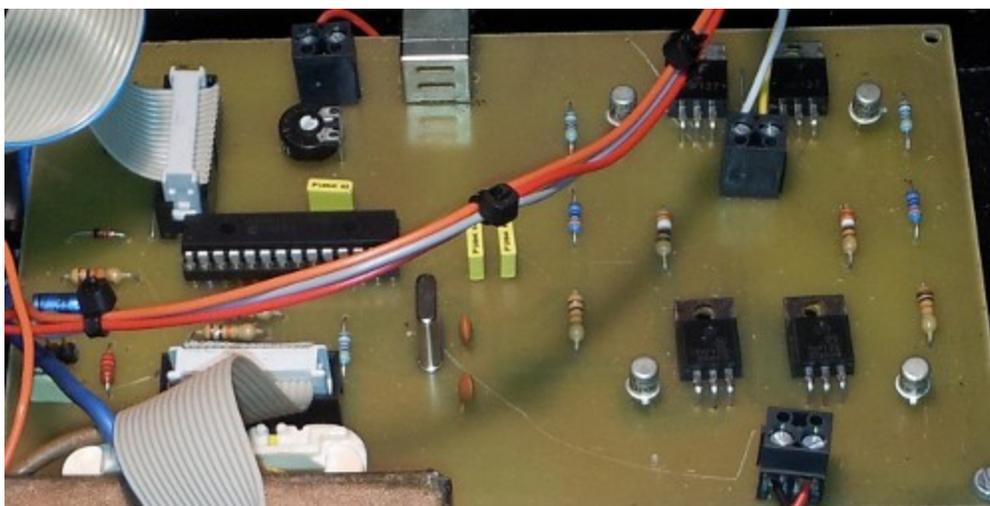Next come the Darlington transistors

As my motor only needs a current of 0.7 amps, cooling of the Darlington transistors was not needed.
Now put the 4 2n2222 transistors on the board.



Now it is time for the box headers, pin headers,screw connectors, 20Mhz crystal, elco and the USB connector.

The box header closest to the micro controller connects to the LCD display. The used display is a  DEM 20231 SYH-PY. This is a 20 character x 2 line display. It has the standard 16 PIN port. So any other display with these characteristics could be used.

| Pin No. | Symbol | Function |
|---|---|---|
| 1 | Vss | Ground terminal of module |
| 2 | VDD | Supply terminal of module +5 V |
| 3 | V0 | Power Supply for Liquid crystal Drive |
| 4 | RS | Register Select<br>RS = 0… Instruction Register<br>RS = 1… Data  Register |
| 5 | R/W | Read / Write<br>R/W = 1 (Read)<br>R/W = 0 (Write) |
| 6 | E | Enable |
| 7 | DB0 | Bi-directional Data Bus, Data Transfer is performed is once , thru DB0~DB7 , in the case of interface data . Length is 8-bits; and twice , thru DB4~DB7 in the case of interface data length is 4-bits . Upper four bits first then lower four bits . |
| 8 | DB1 | |
| 9 | DB2 | |
| 10 | DB3 | |
| 11 | DB4 | |
| 12 | DB5 | |
| 13 | DB6 | |
| 14 | DB7 | |
| 15 | LED- (K) | LED power supply terminals. |
| 16 | LED+ (A) | |

The LCD module is connected by means of a 16 wire flat cable. When attaching the connectors to the flat cable, make sure PIN 1 at both sides of the cable is connected to the same wire. Flat cables typically have a colored wire indicating the wire that should be connected to PIN 1.

3. Power supply

The power supply used in my project consists out of a 5V supply based on a 7805 and a variable supply 3-33V 1.5 amps build around a simple LM317 design. Schematics, board layout and component layout can be found at www.on4akh.be under projects. Note that depending on the transformer in use and thus the voltage after rectification you might need to cool the LM317 and 7805. For example a 12V rms AC transformer will after rectification yield a voltage of (square root of 2 x 12 = 12 x 1.414) 16.9 Volts. So voltage has to be reduced by 11.9 volts. The dissipated power will be 11.9 x 0.15 which is around 2 Watts if the no load power is added. If your motor needs more juice you will need to build a different power supply.

4.  Extension board

The extension board is just a way to use a 16 wire flat cable to wire the main board to the different buttons, potentiometer and LED. This way I could run a nice flat cable through the box instead of separate wires. By no means this is needed. If you want, you can use single wires. If single wires are used, I would replace the box header by pin headers which will fit at the same place on the main board.

5. Brown-out

Some special not on Brown-out. Brown-out for a PIC is a condition where at power off the voltage drops to a level where the PIC comes in some undefined state. Typically it will lose track of it program execution counter and will start executing code at random. Depending on how fast your power supply goes to 0 volts after switch off, the brown-out condition may exist for a longer time. The software in this antenna rotator controllers makes use of the internal EEPROM of the 18F2550. The EEPROM is used to store calibration and as memory for the 8 memories available to store some frequent used headings. During a Brown-out condition it is possible that the program code to write to the EEPROM is randomly executed, leading to corruption in the EEPROM data. Some PICS contain a Brown-out detection circuit, using a voltage comparator that resets the PIC when voltage drops below a set level, thus making sure no code is executed at random.
The power supply I used caused the PIC to go into Brown-out condition and sometimes corrupt the EEPROM data. I choose not to use the Brown-out circuitry of the 18F2550. Instead I use a bi-polar switch to cut power to the controller. One part of the switch is used to cut the 220 volts to the transformer, the other part cuts the 5 volts coming from the power supply to the main board. As no significant capacitors are used on the main board in the 5 volts supply circuit, voltage drops instantly to 0 volts. So no Brown-out condition occurs.

6. First power up of the main board

When you have finished building the main board, do not insert the PIC 18F2550 in the socket. Apply 5 volts to the board first. With a multimeter measure the current. It should be close to 0mA. If not, check the board for any short circuits.
Now connect the LCD module to the main board. Power up. The back light LEDS on the LCD should be lit. The current of the board should be well below 100mA. With the potentiometer on the board you can set the brightness of the LCD display. Typically without the processor inserted you should be able to adjust the brightness of the displayed blocks of the first row of the LCD module.
Now insert the PIC gently in the socket. Power up. If all is OK a current of around 150mA is drawn
After this step connect the motor power supply to the board. Power up again and see that the current on 5V is again around 150mA. There should be no significant current be drawn from the motor power supply.

7. Further cabling the main board

Now it is time to connect the different buttons, potentiometer, and LED tot the main board. On the extension board the component layout shows which element should be connected to which pin header. In total 4 push buttons need to be connected (Counter clock wise, Clock wise ,Mode and Set). The LED is used to indicate when the rotator goes into overlap if you motor supports this. The potentiometer is used for the "point and shoot" feature.

The rotator is typically is wired with 5 wires. Two wires to the motor and 3 wires to the embedded potentiometer in the rotator. The two wires of the motor need to be connected to the screw header for the motor on the main board. The three wires for the potentiometer to the pin headers for this on the main board. As I do not know which rotator you are attaching I can not tell you how the polarity of the wires should be.

For the motor, the wires should be attached in such a way that if the CCW button is pressed, the rotator turns counter clock wise. This can be easily found out once you are performing the calibration. For the 3 wires going to the potentiometer, hook them up so that in the calibration the shown value of the ADC goes to a minimum when fully turning the motor CCW.

8. Programming the 18F2550

The main board contains circuitry to allow on board programming. The 5 pins PIN header is used to connect an in circuit programmer like the PICkit3 from MicroChip. At the time of writing this document, this is a link to it:

http://www.microchip.com/stellent/idcplgIdcService=SS_GET_PAGE&nodeId=1406&dDocName=en538340



The PICkit3 has a 6 pins connector that will fit the 5 pins program header on the main board. The white down arrow should be connected to the 1$^{st}$ pin of the program header, leaving the last pin free on the PICkit3.
On the computer side, the PICkit3 connects through a USB cable.
The software to use with this programmer is also available from MicroChip. It is called MPLAB X and can be downloaded from the MicroChip web site.
The hex file to program the antenna rotator controller can be found on www.on4akh.be under the projects section. To import the hex file into MPLAB, follow these steps.

Under the File menu, choose Import → Hex/ELF (Prebuilt File)
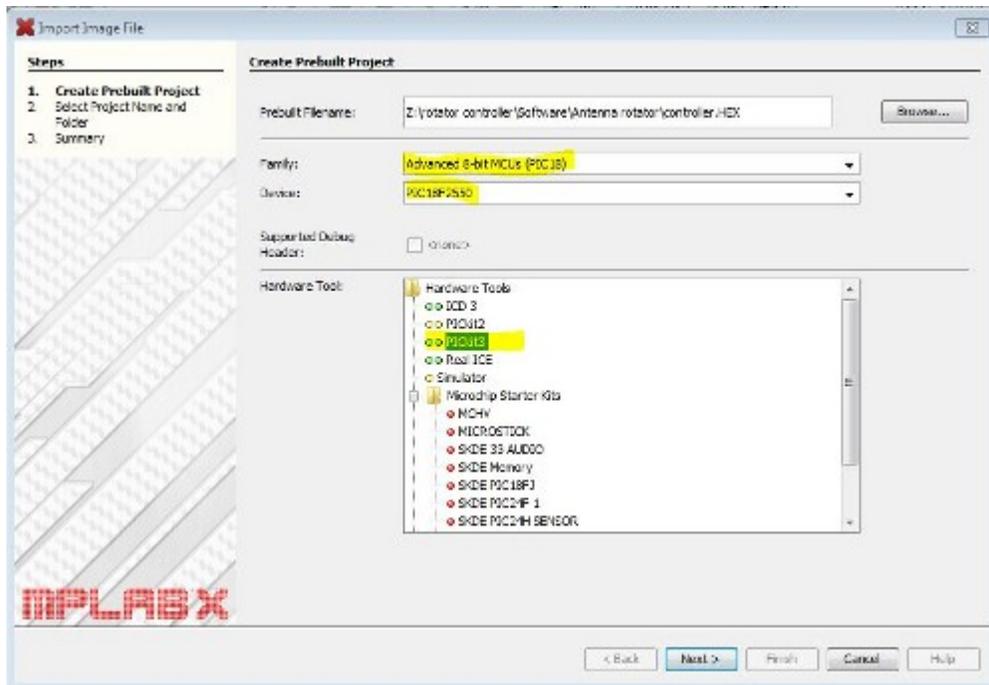
Browse to the directory where you saved the hex file, select the PIC family = PIC18.
Select the correct PIC which is 18F2550. Select the correct programmer which is PICkit3.
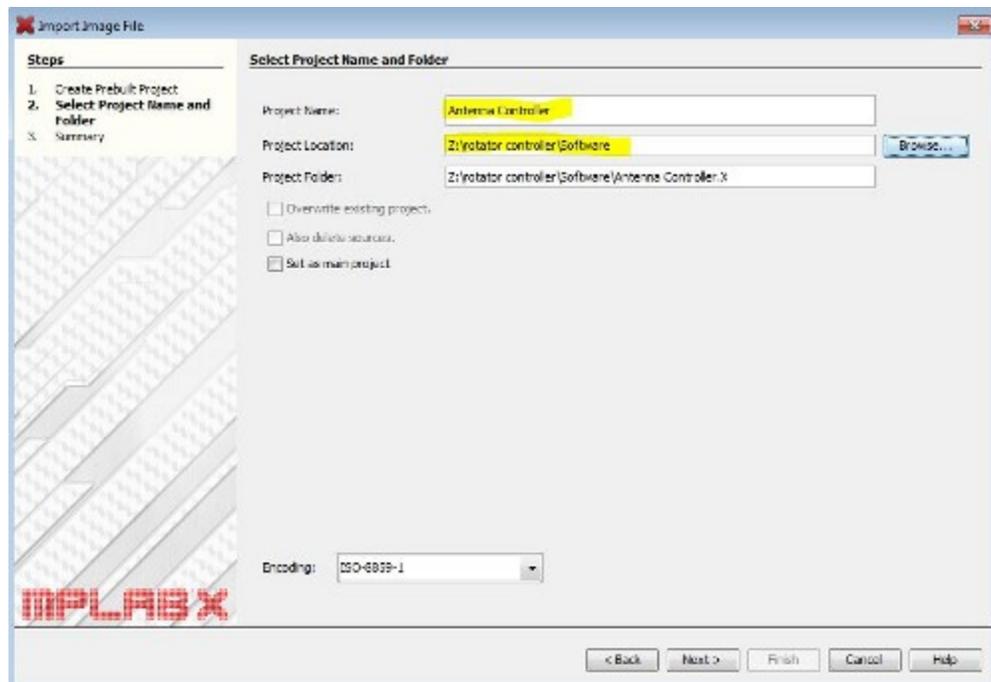
Next step is to give the project a name, a project location which should be the same root directory as your hex file. Press next, a summary screen of your selections will be shown. Select Finish.
You should now have the project in the Projects portion of the MPLAB window. If not restart MPLAB as it sometimes tends to be a bit buggy.



Highlight the project by selecting it. In the Run menu, select Run project. The 18F2550 will now be programmed. If programming is successful you will see this in the output screen. Power of the controller, remove the programmer and power it up. You should see the welcome message at the LCD, followed after a few seconds with the start of the calibration sequence.

9. Calibration

Once the main board if fully cabled  and the PIC programmed, it is time for the calibration. After the welcome screen the first thing to set is the end point of the rotation of the motor. This can either be in the North or South.



Use the CCW and CW buttons to move the X. Use the SET button to save this setting.

Now we need to set the amount of degrees the motor will go into overlap if it supports it. If the motor doesn't support overlap, set the value to 0.



Use the CCW and CW buttons to set the amount of degrees. Press the SET button to store this value.

The next step is to calibrate the point where the motor is turned to the North (or South) turning it in the CCW direction.
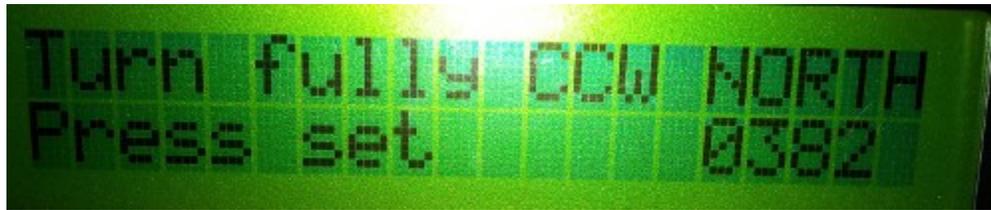


This is the point where you can find out if the wires of the rotator are connected correctly to the main board. By pressing the CCW button, the motor should move into the counter clock wise direction. If not change the polarity of the wires on the motor screw header on the main board. Also here the connection of the embedded potentiometer can be verified.
When moving in the CCW direction, the number in the right bottom corner of the LCD should go down. If not, change the polarity of the 2 wires going to the fixed resistor of the potentiometer.
When the rotator is fully in the North direction using CCW movement, press the SET button to store the measured value.

Finally we need to move the rotator 360 degrees using CW direction. So the rotator should end up again pointing to the North.



When the desired heading is reached, press the SET button to store this value.
This concludes the calibration method.
To erase the calibration info from the EEPROM, power up the rotator controller pressing the CW button.

10. Using the rotator controller

After the calibration you should see following on the LCD. If the endpoint of your rotator is North, the heading should show 360 degrees. If the endpoint is South, the heading will display 180 degrees.

Next to the current heading you see an indication of the name of the direction.
Moving the rotator now with the CW and CCW buttons should change in the heading
being adapted and the direction name changing (N, NE ,E, SE, S, SW, W, NW).
When pressing the CW or CCW button for longer than 2 seconds will lead keep the rotator
turning into that direction. To stop turning press one of these buttons momentarily.
The Preset value is the heading the rotator will go to when the SET button is pressed at this
point. The preset heading can be changed by changing the position of the "Point and shoot"
potentiometer.

Pressing the mode button will change the mode of the controller.

Memory mode

There can be up to 8 headings programmed in the EEPROM of the controller. This is done with
software through the USB port. In memory mode, using the CW and CCW button you can
select the memory position. Pressing the SET button will turn the rotator into the heading that
is stored in the selected memory.
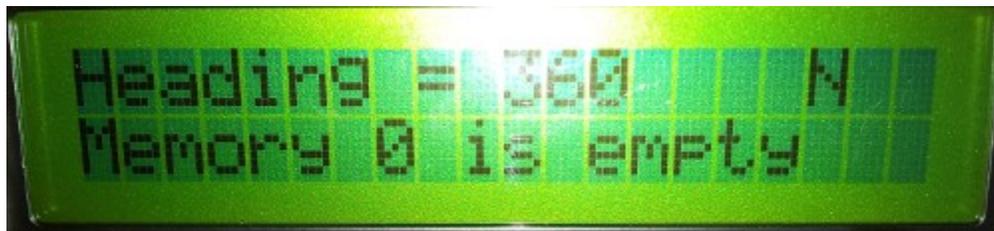


The memory heading is given as a direction (ex USA, Far East …) which can be programmed
by you.

Speed selection

The speed with which the rotator turns can be selected as a percentage in 10% increments.
This setting is used then both in manual, memory, USB and "point and shoot" mode.
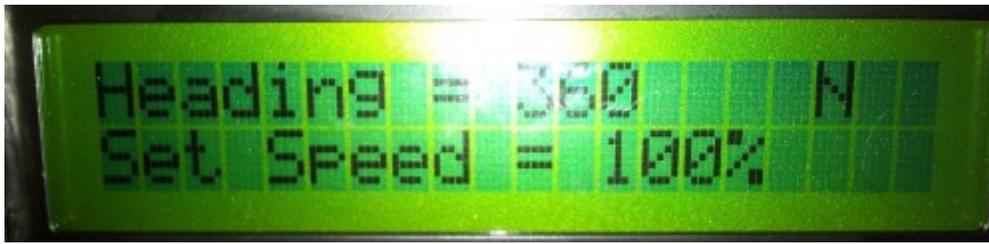
Use the CCW and CW buttons to change the speed. Use the MODE button to leave this mode.

11. Connecting to a computer

The controller can be connected to a computer using the USB port. It used the IDIOM PRESS protocol with a slight extension to store info in the memories of the controller.
This protocol is supported by many rotator controller software among which the popular Ham Radio Deluxe.
The controller uses the standard Windows USB to serial port driver (CDC). The needed .inf file can be found at www.on4akh.be under projects.
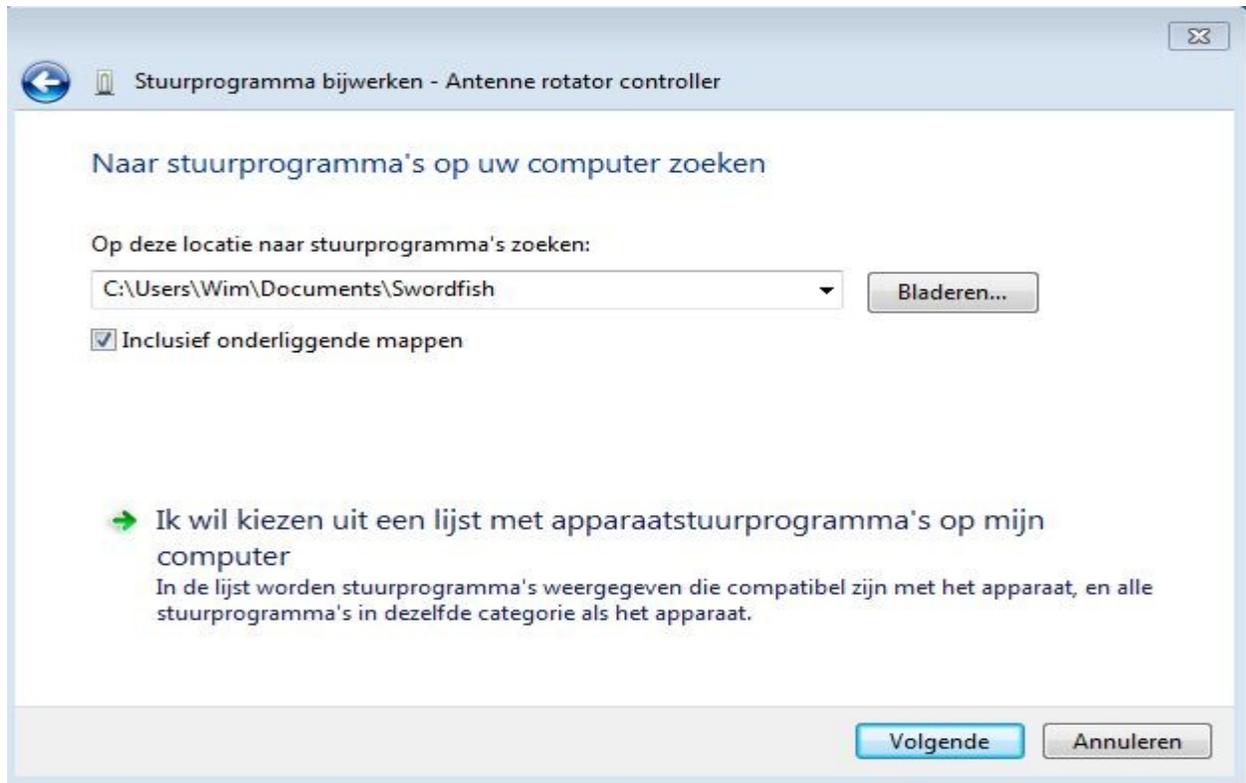
Installing the driver

Plug the controller into one of the USB ports of your computer. If not already done, power up the controller. Your computer will detect a new device, but will not be able to load the needed driver. Under the Control Panel, select Device management. You will see the antenna rotator controller under the unknown devices with a yellow exclamation mark.



Right click on the line that shows "Antenne rotator controller" and select update driver.
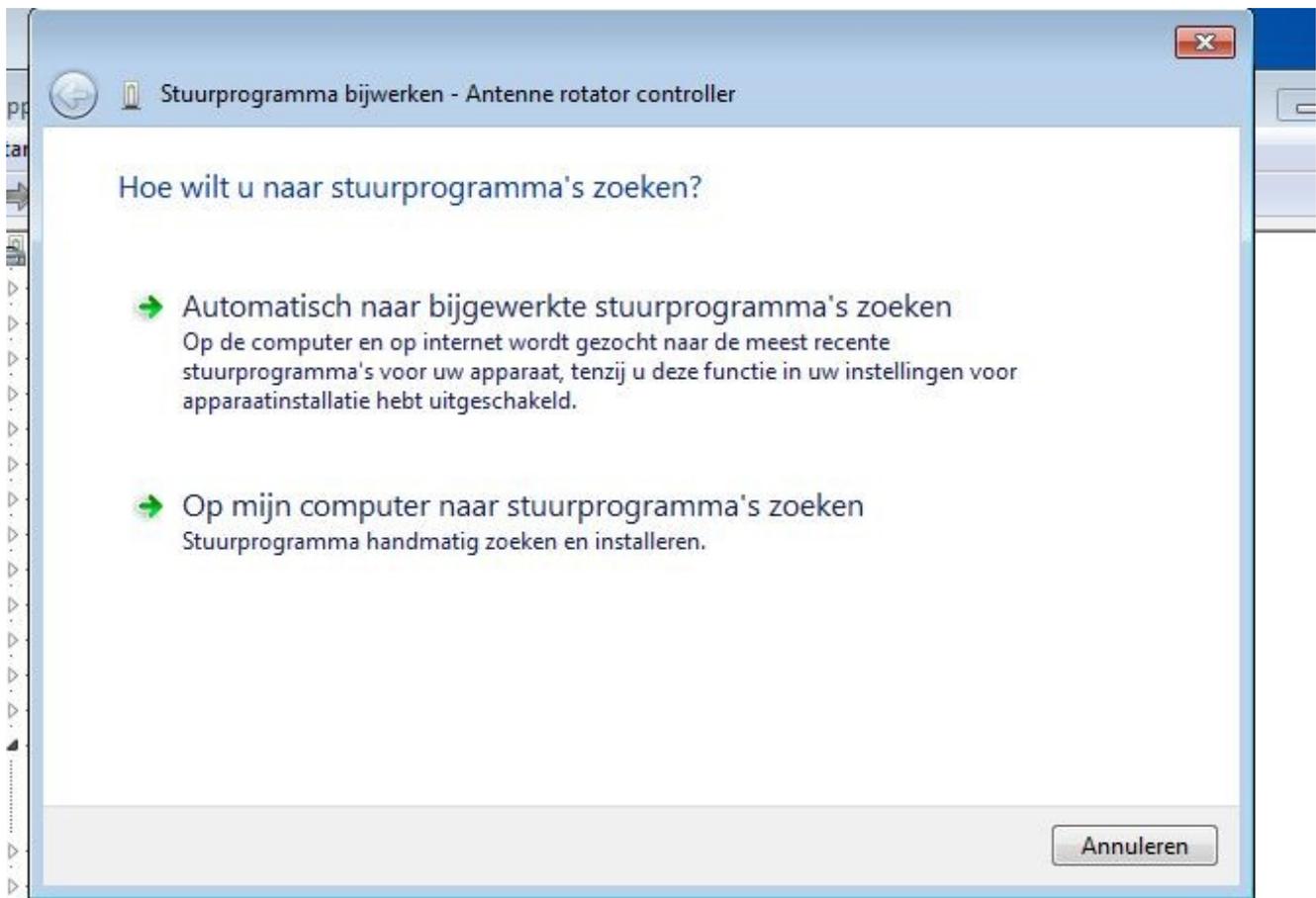
In the window that opens, select "Search for drivers on my computer".
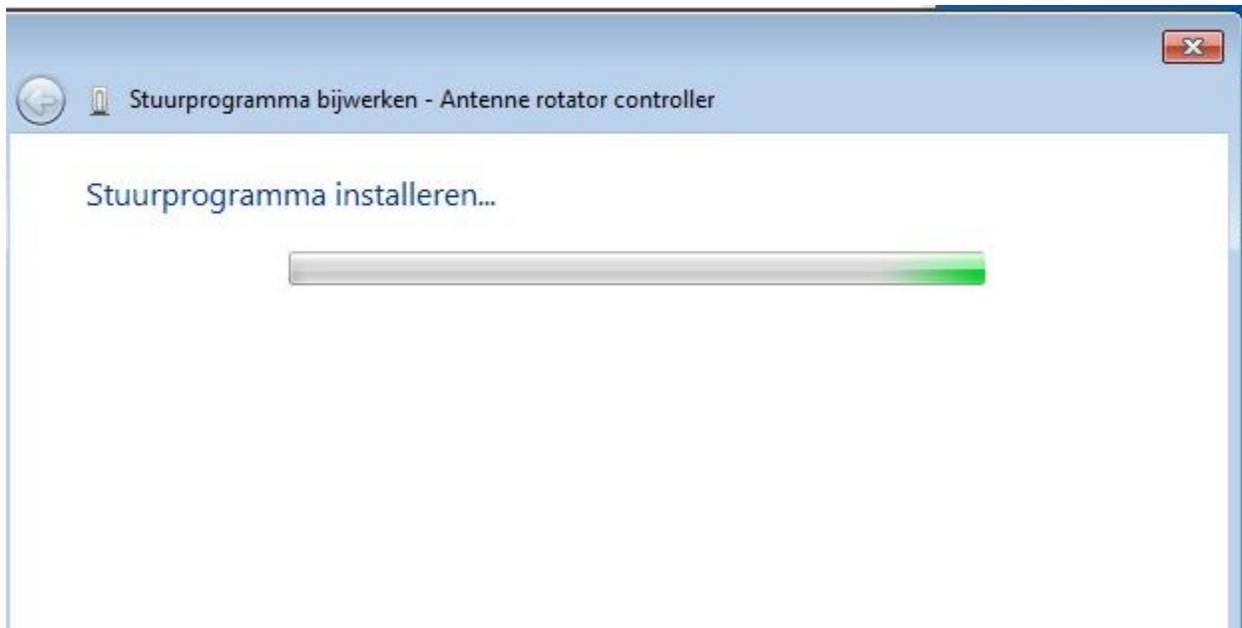Now browse to the directory where you have saved the file ON4AKH_CDC.inf.
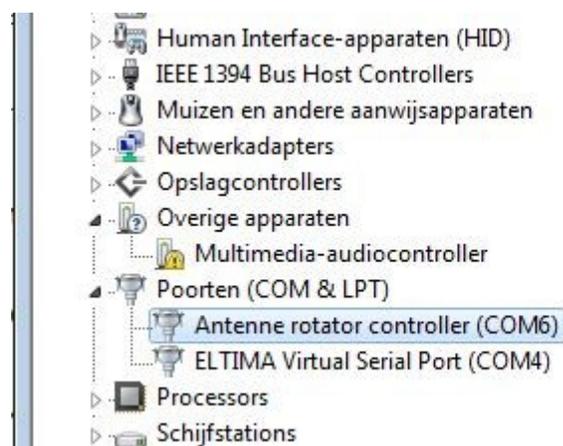
Press the next button.
You will get a warning about the origin of the driver. Choose to install the driver anyway.



Windows will start to install the driver

Once the driver is installed, under the device manager it should show up in the Ports (COM & LTP) section, with no yellow exclamation mark besides it.



As you can see, my computer has assigned COM port 6 to the controller. This is the port that you know should select in your rotator control software. Note that in your case the COM port can be different.

## 12. <u>IDIOM PRESS protocol</u>

Only a subset of this protocol is implemented right now (V1.0 of the controller software)
And there is an addition to program the memory channels into EEPROM

APxxx : turns the rotator to heading xxx
Gxxx.x : turns the rotator to heading xxx.x
AI1 : returns the current heading to the computer
D : turn CCW
U : turn CW

Additional
M(channel 0-8)(20 characters for memory name)(heading 3 digits)   Note that the brackets
are not used in the command.