Arduino Due (Programing Port) program to command azimuth and elevation antenna motors to track space objects. Works with any type of motors.

INTRODUCTIONS-
This is a CT4BB program that uses ARDUINO's open-source libraries to read SD cards, RTC Watch, I2C, SPI, etc. The system is designed to track DSN spacecraft probes and celestial objects using NASA's Ephemeris @ https://ssd.jpl.nasa.gov/horizons.cgi#top The data from this NASA site is in txt and are printed in files with the name of the space objects. Ex: Copy Sun data and paste it in the SD card as SUN.txt, and Mars Reconnaissance Orbiter (MRO) data and save it in the SD card as MRO.txt.
This is a program with mapped voltages(0->5V) to 0-> 4095 bytes using 12 bits resolution so, have on the SetUp the instruction analogReadResolution(12).
The model of the (ARDUINO DUE Programming Port) used does not start when the voltage is turned on. To fix this, you must solder a surface mount resistor (0603 size) onto the board: solder a 10k resistor between the ERASE line and + 3.3V, close to Fet T3.
In practice, solder it across the 2 upper pins of T3.
https://forum.arduino.cc/index.php?topic=256771.60
Arduino due is 3.3 V logic. To connect with I2C LCD or RTC1307 Logic 5V, a bidirectional voltage converter is required. The SDCard reader is 3,3V Logic but feed with 5V DC
External PullUp resistors of 5K must be placed to stabilize the digital inputs of pins 3,5,6,7 and 13, because the internal PullUp resistors of ARDUINO DUE are 50K and this high value causes instability and errors in the readings caused by induced noise, namely alternating current.

SYSTEM WORKING –
1 - The tracking system will only work on the day of the recorded Ephemeris, because it will compare the actual date with the date of the Object Ephemeris in the SD card.
If the dates are equal, it will read the actual Time- Hour Minute and Seconds - to compare with an equal Time in the file of the selected space object. If the actual time is equal to the recorded, it will catch and read the azimuth and the elevation of the object to activate the relays of the Azimuth and Elevation motors. Motors will run driving a multiturn potentiometer, with pre-calibrate voltages that are mapped to the angles. Motors will stop @ that precise Voltage/angle.
2 - The system reads the file and checks if the date is correct (if not, everything is null). If it is correct, the information loop for the actual UTC time and the Azimuth / Elevation in which the antenna is located begins. Every minute it compares the real time clock with times list in the file. If it is the same, reads the azimuth and the respective elevation. Then, compare these values with the previous Azimuth and Elevation to decide the CCW or CW movement of the respective engines. For good LCD messages, you must translate to your language in the firmware, all LCD comments, and menus.
3 – A calibration must be made if you change mechanical hardware.
Normally it is only necessary to do it once. Calibration will make the motors of the Az and El to run from the minimum angle/voltage (0 °) where a microswitch is activated to stop and after, motors travel to the maximum angle/voltage (360°) to switch on another microswitch to stop movement.

HARDWARE-
The pinout used on the Arduino Due is as follows:
Pin 11 digital OUTPUT: CCW control of Elevation motor
Pin 10 digital OUTPUT: Elevation motor CW command
Pin 8 digital OUTPUT: Azimuth engine CW command
Pin 9 digital OUTPUT: Azimuth motor CCW command
Digital pin 7 INPUT_PULLUP: Elevation limit switch sensor
Digital pin 6 INPUT_PULLUP: Elevation start sensor
Digital pin 5 INPUT_PULLUP: Azimuth limit switch of 360°
Digital pin 3 INPUT_PULLUP: Azimuth start sensor of 0°
Note : Pin 5 and Pin 3 can be connected to the same switch, because as the azimuth goes CCW or CW the software will wait for Pins ground @ respective direction to give a Byte value for 0° and 360°
Digital Pin 13 INPUT_PULLUP: Clicks of the Menu Button (single click, double click or long press).
Connections of 6 Pin IDC for SPI located in the middle of ARDUINO DUE to communicate with SD Card
IDC SPI-Pin 1 pin (dot or number 1) is digital MISO .
IDC SPI-Pin 2 Not used,
IDC SPI- Pin 3 SCK Clock communication with SD CARD.
IDC SPI- Pin 4 MOSI.
IDC SPI- Pin 5 RESET Not used
IDC SPI- Pin 6 GND Not used
Digital pin 4 CS (Chip select) for SPI communication with SD CARD
Analog A4 pin SDA for I2C communications RTC Watch DS1307 and I2C LCD
Analog A5 SCL pin for I2C communications RTC Watch DS1307 and I2C LCD
Analog A0 pin INPUT for analyzing the voltage of the azimuth potentiometer
Analog A1 pin INPUT for analyzing the voltage of the elevation potentiometer

STRUCTURE AND OPERATION –

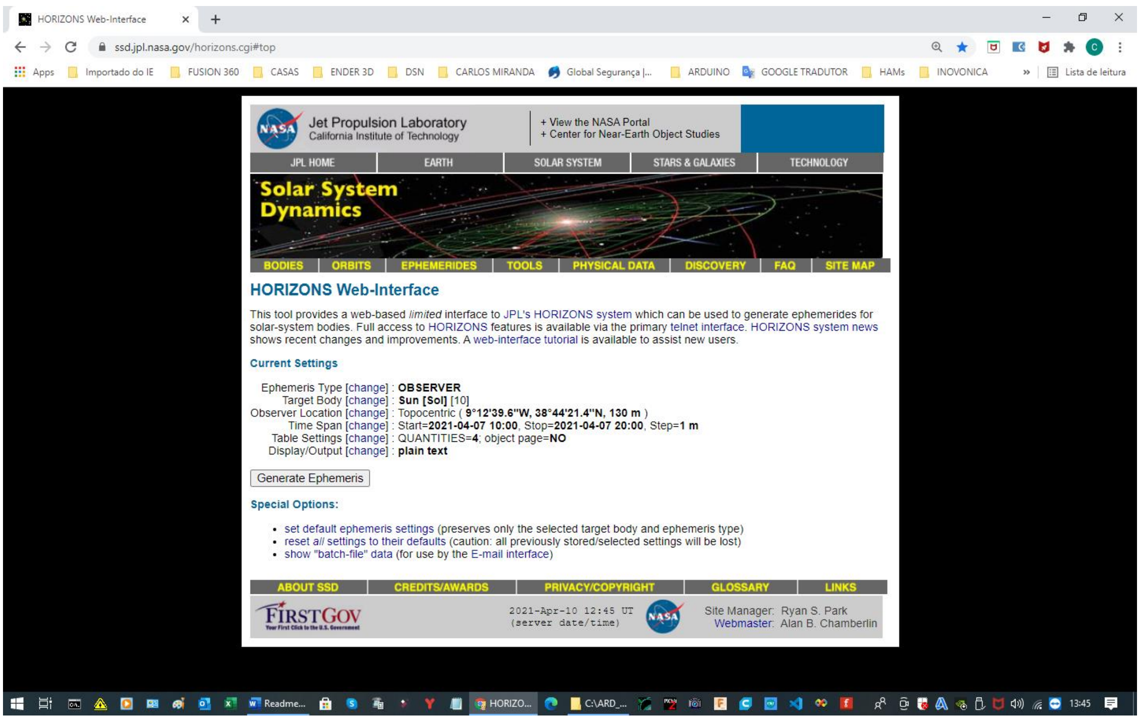
(In the text, SOL means Sun).

When connecting, the system runs the Settings and Setup (). In the setup (), will read the Date and Time and the day in the DataHoraRTC () function, then in the setup (), it will compare the Year, Month, day of the card with the actual RTC. System uses as start the reading of the date of the file SOL.txt defined inside the setup () as a start reference to put the Tracking structure pointed to the Sun. The function that does this operation is ler_SOL_Data (). In this function, at the end of reading and registering, it will return to the setup () to make Date comparation with the function compara_Datas run () . Comparing the dates and, if they are the same, it will read the directories of all SDCard files. With the function * ler_DIRECTORIA_SD (File dir, int numTabs) reads the directory and stores in the Strings A, B, C, D, E, F, G, H the menu is prepared for choosing the file to open. Space Objects (Probes) selection, is done in PROBES with sondastr = "Click to open" that will appear on the LCD. When clicking to open with the probes () function, the object file to be followed is chosen. When defining this choice, all data from the object in question is loaded into the Data (u) buffer in a matrix that will be carefully accessed. The Loop then starts with the selected object where, every 5 minutes, it will be checked whether the actual Hour and Minutes are in the respective file. If there are HOURS = HORASSD and MINUTES = MINUTOSSD, the respective AzNovo and ELNovo will be read soon using the lerHM_AZ_EL () function. These data are available for processing the movement of the antenna. During the 5-minutes interval to read new data, the LCD will inform the UTC Date / Time and the azimuth and also where the Az/El is pointed or, in the case of movement, where the antenna is going to new Az/El. The program uses ARDUINO IDE by opening the file TRACKANTENUINO.ino which is inside the folder TRACKANTENUINO. The libraries used in the program are all within this folder. The use of more recent versions of the libraries may require the correction of the instructions in the software. For the operation of the system, it is not necessary to use more recent versions of the libraries. This program, essentially, operates relays that can excite other power relays or power contactors that, in turn, excite bidirectional power motors by switching contacts and connections. The stopping point of the motors is defined by a voltage 0-> 5V mapped in movements 0-> 90 degrees for Elevations and 0-> 360 degrees for Azimuths. These voltages can be obtained by rotating a multi-turn potentiometer engaged in the motors. It is a mechanical question that each one can study and develop, making the turns of the potentiometers to be mapped in the voltage of 0-> 5V and in the respective angular excursions of 0-> 90 degrees Elevations and 0-> 360 degrees Azimuths.

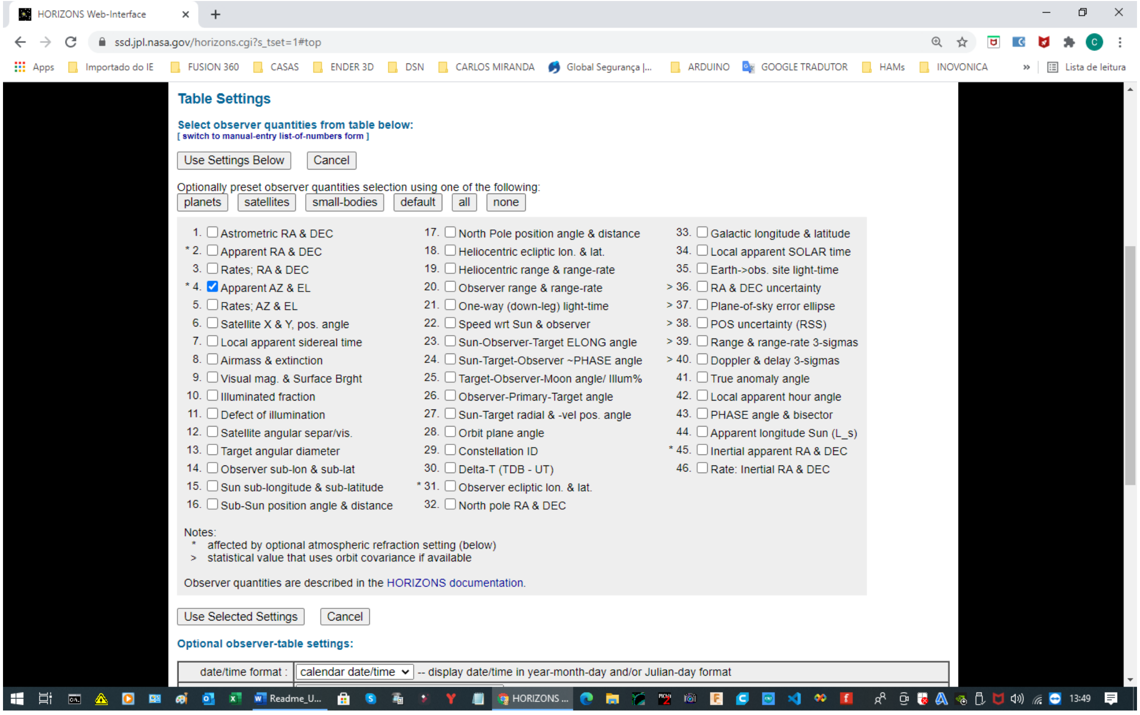
How get and format data from NASA Horizons Ephemeris to put in the SD Card:

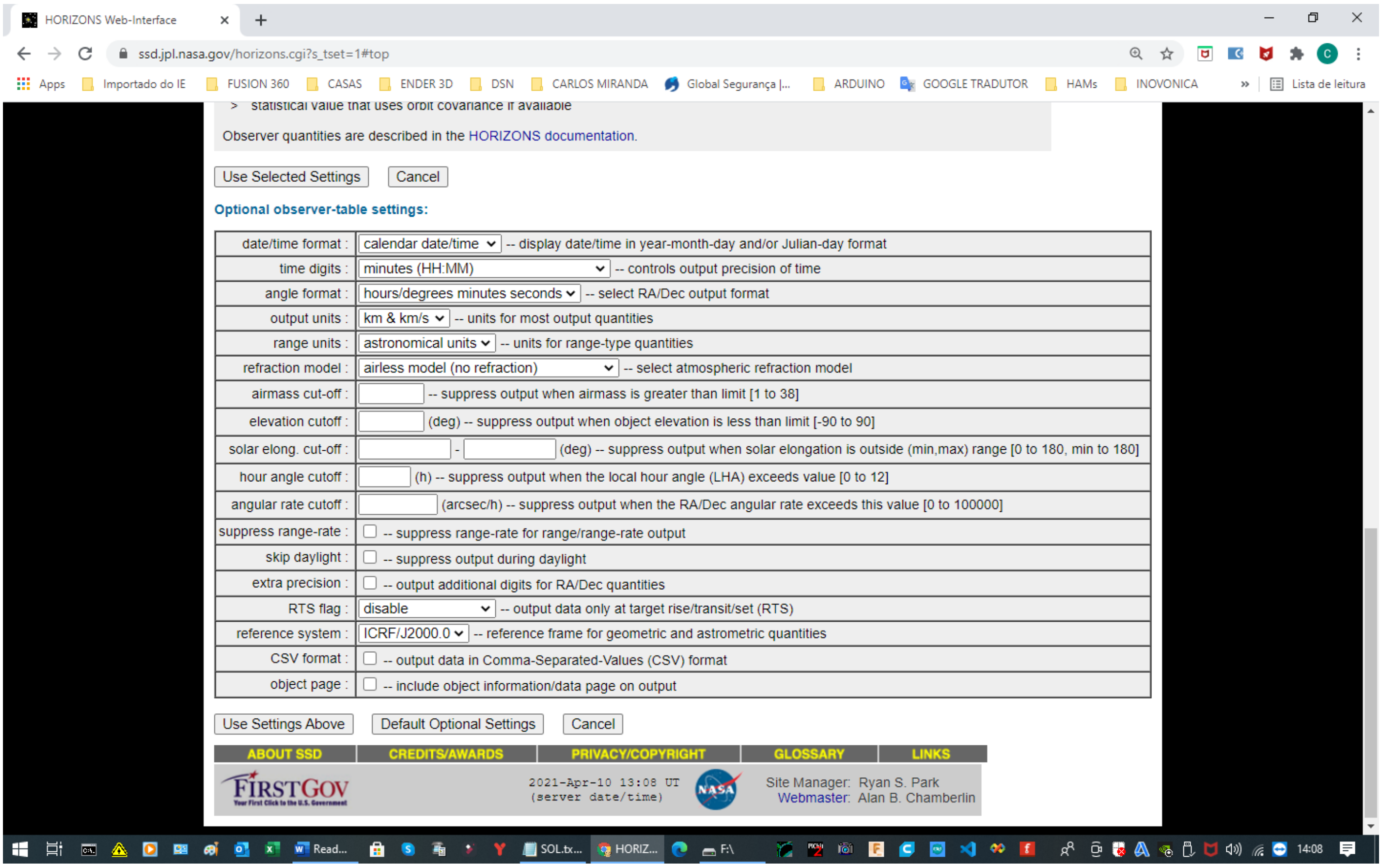
1 – Go to the site https://ssd.jpl.nasa.gov/horizons.cgi#top

2 - Fill the Page with your requirements



3 - Open the Table Settings and check as shown



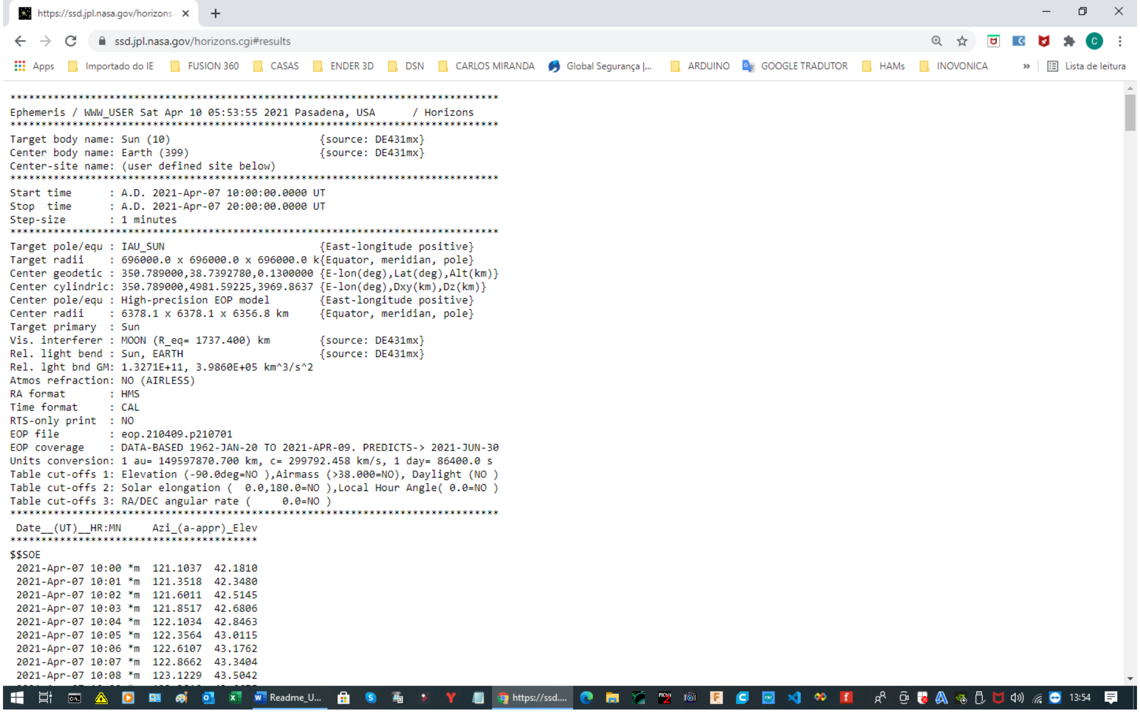


4 – Click Use Selected Settings

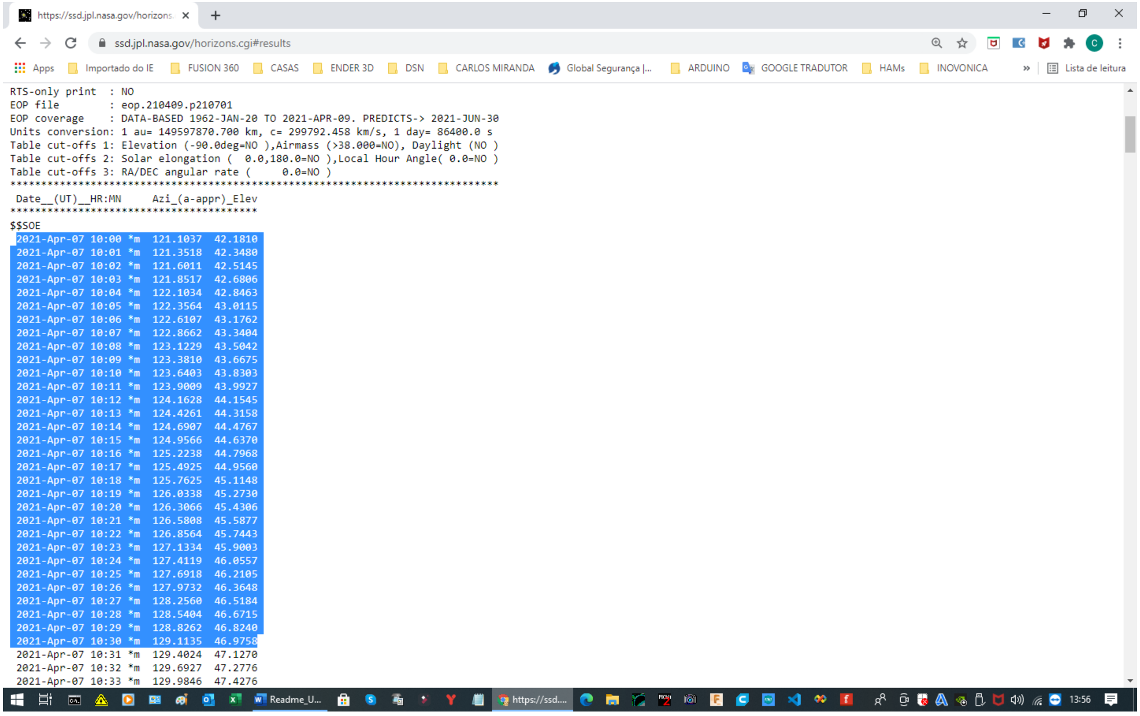
5 - Select Target Body (Sun, Moon, MRO, Perseverance, Parker Solar Probe, etc)

6 – Click Generate Ephemeris

7 – You get:



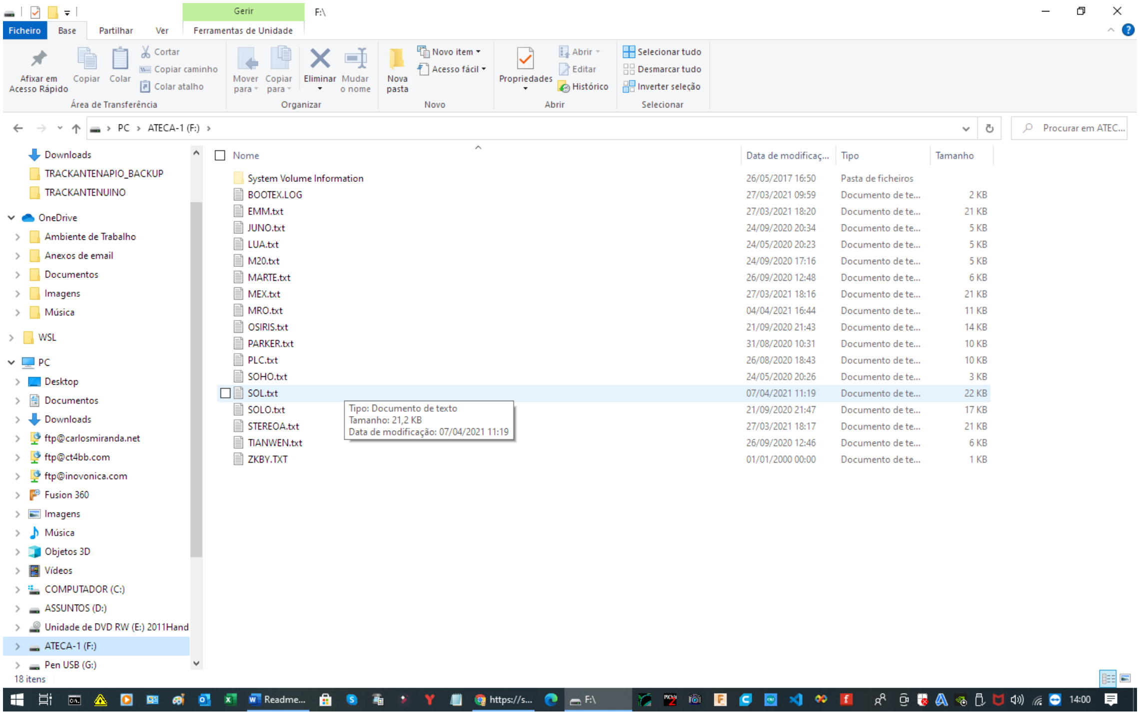
8- Select data columns with Date Azimuth and Elevation o object like this



This will track the object between 10:00 and 10:30 AM UTC @ 21 Apr 07

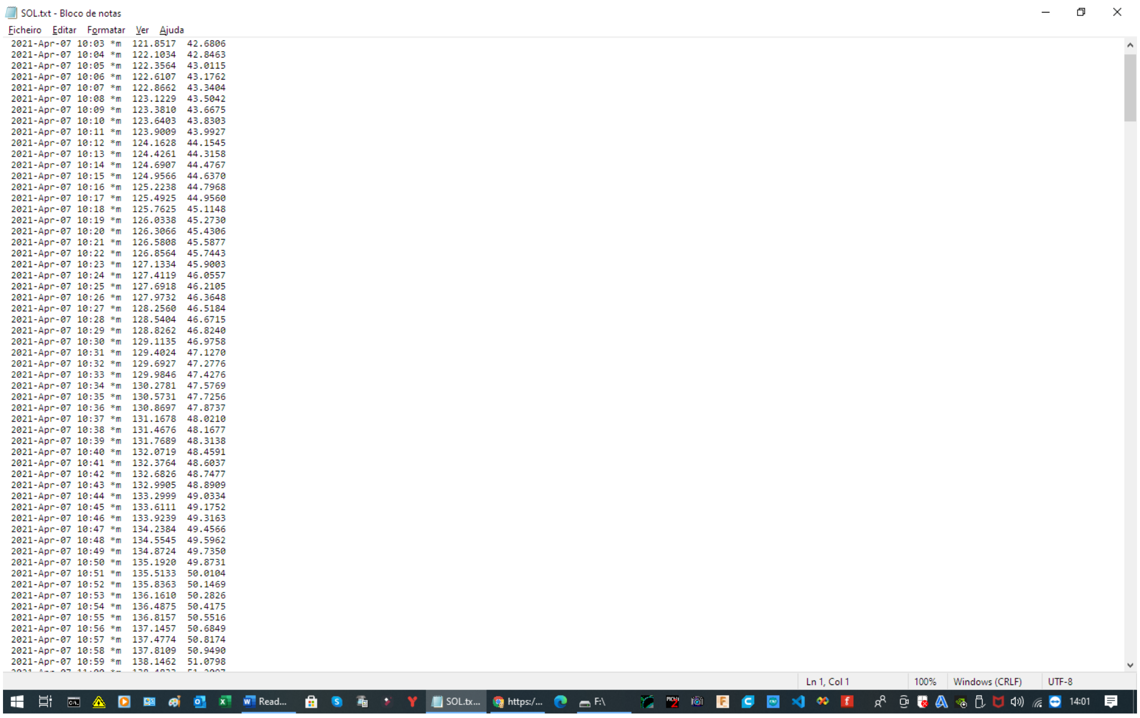
Copy this and put on the SD Card inside a folder with the object name.

Like this SD Card shows some txt files where to paste the data:



Data is from SOL (Sun), so, open the folder SOL.txt (Sun.txt) and paste inside.

Remember the first column must be a space!



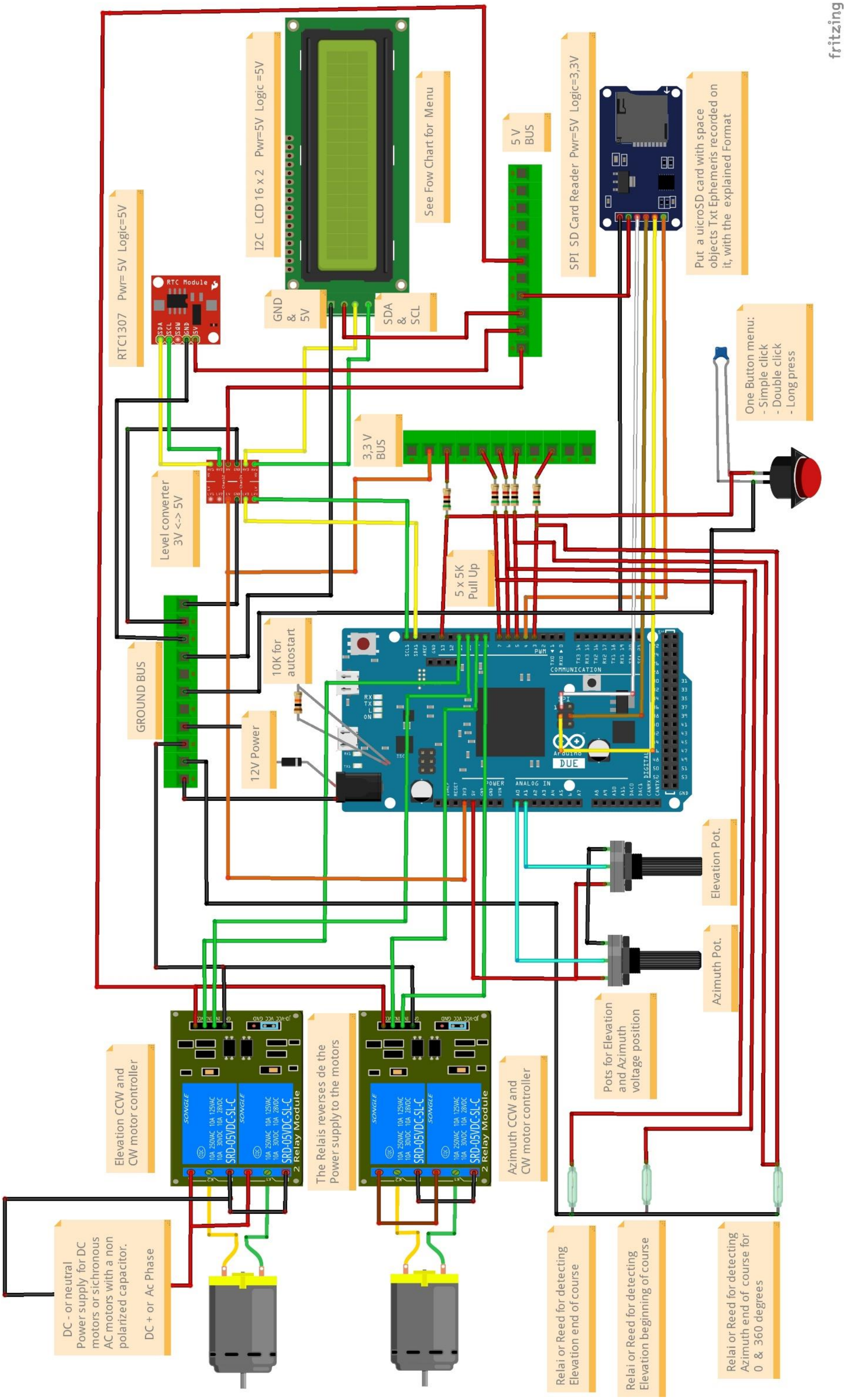
```
SOL.txt - Bloco de notas
Ficheiro  Editar  Formatar  Ver  Ajuda
 2021-Apr-07 10:03 *m  121.8517  42.6806
 2021-Apr-07 10:04 *m  122.1034  42.8463
 2021-Apr-07 10:05 *m  122.3564  43.0115
 2021-Apr-07 10:06 *m  122.6107  43.1762
 2021-Apr-07 10:07 *m  122.8662  43.3404
 2021-Apr-07 10:08 *m  123.1229  43.5042
 2021-Apr-07 10:09 *m  123.3810  43.6675
 2021-Apr-07 10:10 *m  123.6403  43.8303
 2021-Apr-07 10:11 *m  123.9009  43.9927
 2021-Apr-07 10:12 *m  124.1628  44.1545
 2021-Apr-07 10:13 *m  124.4261  44.3158
 2021-Apr-07 10:14 *m  124.6907  44.4767
 2021-Apr-07 10:15 *m  124.9566  44.6370
 2021-Apr-07 10:16 *m  125.2238  44.7968
 2021-Apr-07 10:17 *m  125.4925  44.9560
 2021-Apr-07 10:18 *m  125.7625  45.1148
 2021-Apr-07 10:19 *m  126.0338  45.2730
 2021-Apr-07 10:20 *m  126.3066  45.4306
 2021-Apr-07 10:21 *m  126.5808  45.5877
 2021-Apr-07 10:22 *m  126.8564  45.7443
 2021-Apr-07 10:23 *m  127.1334  45.9003
 2021-Apr-07 10:24 *m  127.4119  46.0557
 2021-Apr-07 10:25 *m  127.6918  46.2105
 2021-Apr-07 10:26 *m  127.9732  46.3648
 2021-Apr-07 10:27 *m  128.2560  46.5184
 2021-Apr-07 10:28 *m  128.5404  46.6715
 2021-Apr-07 10:29 *m  128.8262  46.8240
 2021-Apr-07 10:30 *m  129.1135  46.9758
 2021-Apr-07 10:31 *m  129.4024  47.1270
 2021-Apr-07 10:32 *m  129.6927  47.2776
 2021-Apr-07 10:33 *m  129.9846  47.4276
 2021-Apr-07 10:34 *m  130.2781  47.5769
 2021-Apr-07 10:35 *m  130.5731  47.7256
 2021-Apr-07 10:36 *m  130.8697  47.8737
 2021-Apr-07 10:37 *m  131.1678  48.0210
 2021-Apr-07 10:38 *m  131.4676  48.1677
 2021-Apr-07 10:39 *m  131.7689  48.3138
 2021-Apr-07 10:40 *m  132.0719  48.4591
 2021-Apr-07 10:41 *m  132.3764  48.6037
 2021-Apr-07 10:42 *m  132.6826  48.7477
 2021-Apr-07 10:43 *m  132.9905  48.8909
 2021-Apr-07 10:44 *m  133.2999  49.0334
 2021-Apr-07 10:45 *m  133.6111  49.1752
 2021-Apr-07 10:46 *m  133.9239  49.3163
 2021-Apr-07 10:47 *m  134.2384  49.4566
 2021-Apr-07 10:48 *m  134.5545  49.5962
 2021-Apr-07 10:49 *m  134.8724  49.7350
 2021-Apr-07 10:50 *m  135.1920  49.8731
 2021-Apr-07 10:51 *m  135.5133  50.0104
 2021-Apr-07 10:52 *m  135.8363  50.1469
 2021-Apr-07 10:53 *m  136.1610  50.2826
 2021-Apr-07 10:54 *m  136.4875  50.4175
 2021-Apr-07 10:55 *m  136.8157  50.5516
 2021-Apr-07 10:56 *m  137.1457  50.6849
 2021-Apr-07 10:57 *m  137.4774  50.8174
 2021-Apr-07 10:58 *m  137.8109  50.9490
 2021-Apr-07 10:59 *m  138.1462  51.0798
Ln 1, Col 1   100%   Windows (CRLF)   UTF-8
```

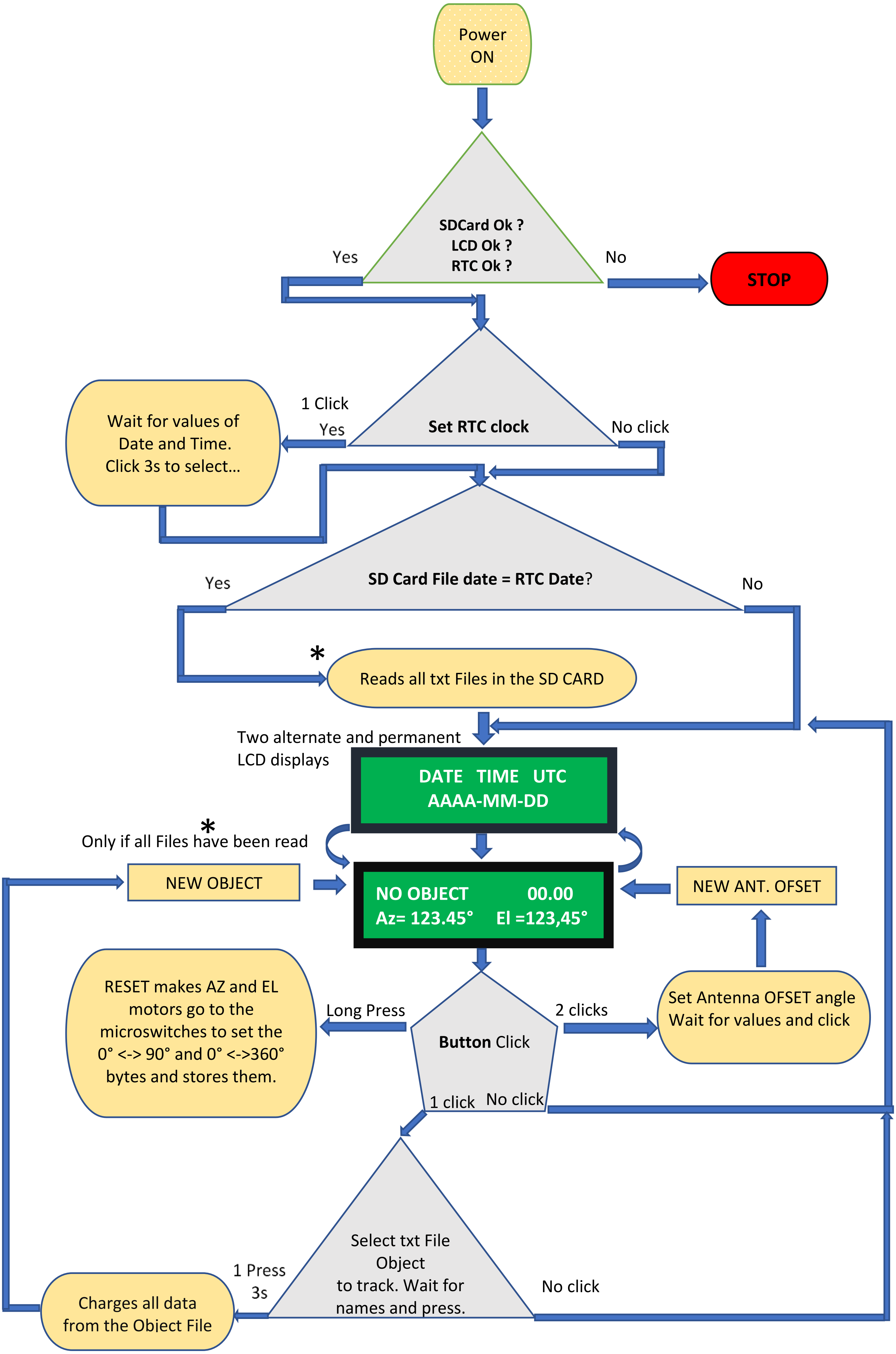
Save.

Do the same for all the objects you want to track on a specific day

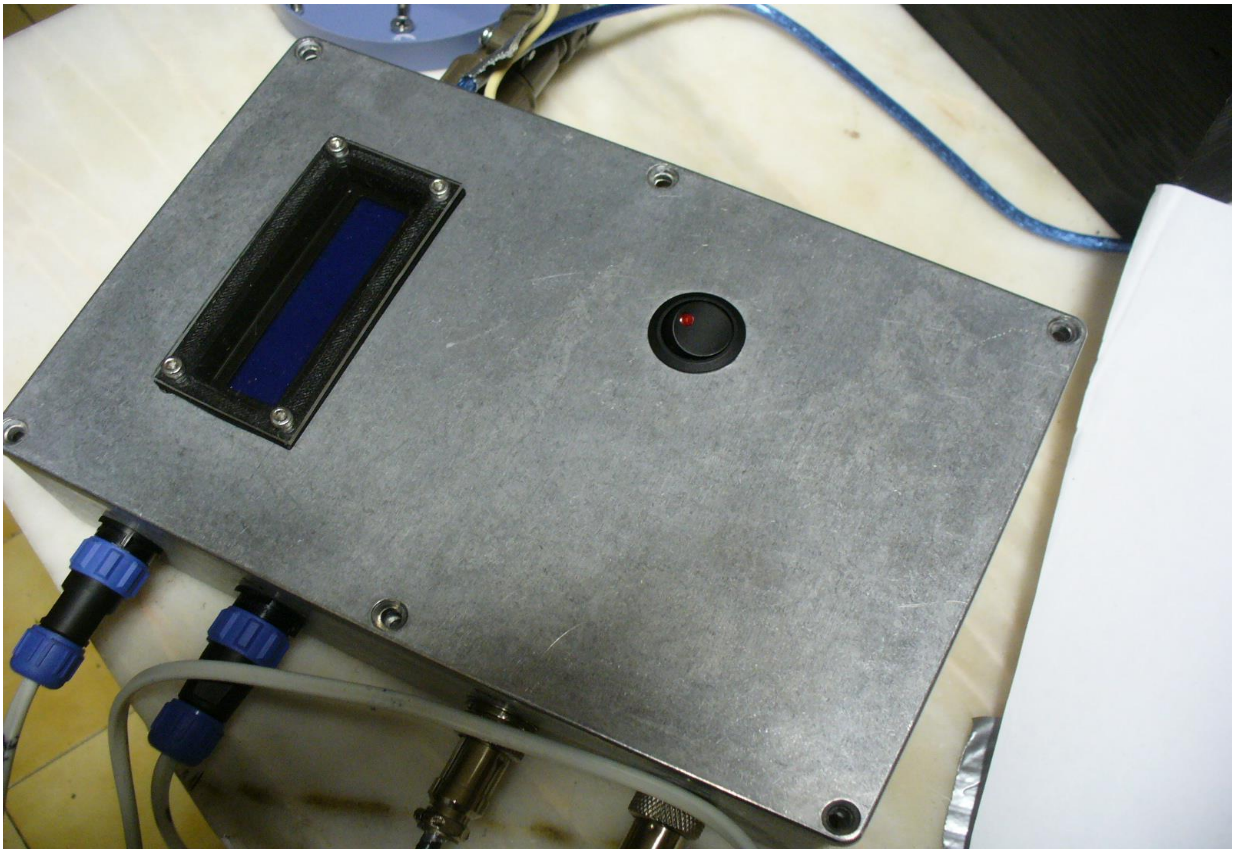
Put the card in the Tracker and follow the menu to set the clock if needed, to select the object, and antenna offset. Wait for the automatic commands…

ARDUINO Diagram connections:

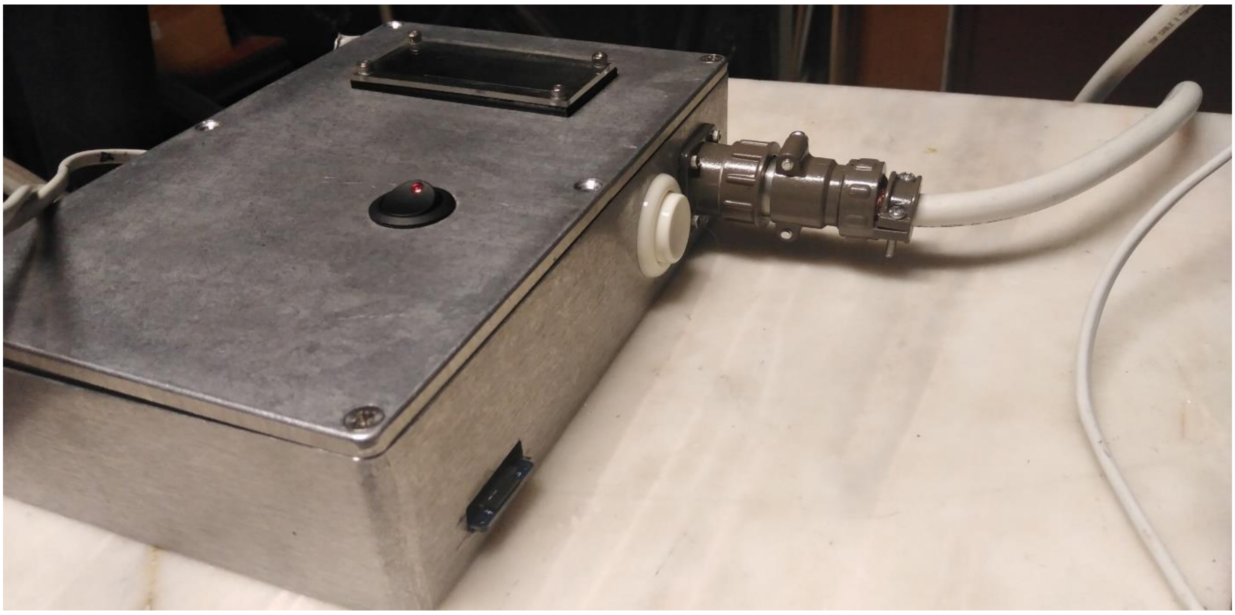




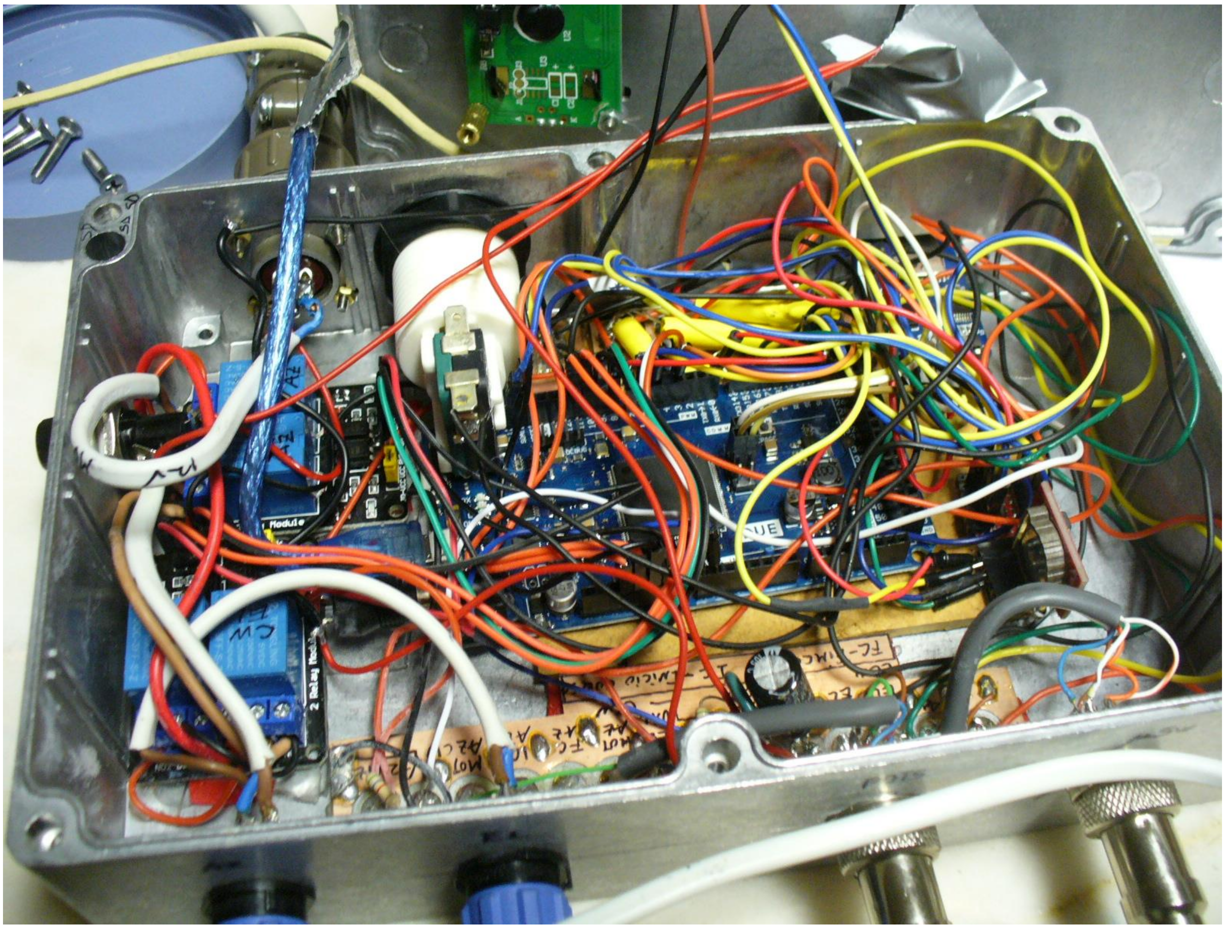
Flow chart Menu



Panel, ON/Off switch AZ/EL and micro-switches connectors



- Connector for ARDUINO 12 V and AC or DC Power for motors
- One robust button for Menu
- Micro-SD Card Slot



Inside the Mule Prototype

Date Time screen

OBJECT Name, OFFSET, Azimuth and Elevation @ the Time of previous screen

3D printing Elevation and Azimuth rotators to test the Tracker.
With this white plate and the rood shadow, it got a zero shadow in one hour of tracking the Sun.

More tests are now underway with a set of two-rotor type CDR Master Rotors @ 24 V AC and a 200 uF condenser without polarity to reverse the moving direction of the synchronous motors.
Good work and 73

CT4BB

Carlos