Data Sheet & User Guide V2 R1

Date: 29 November 2022

by

INDEPENDENCE-X AEROSPACE SDN. BHD.

Version	Release	Remarks	Date
V1	R1	First edition	28 November 2022
V2	R1	• Add datasheet section. • include product information.	

1 Product Information

1.1 Welcome (“Hello World”)

We, from Independence-X Aerospace welcomes you to the world of small satellite. With the advent of advance electronic minitiarization, we have taken the pride and pleasure to develop the world’s smallest satellite. This is to provide educational and industrial opportunities to the vast segment of the world population to have access to cost effective and affordable satellite kit for STEM, and as well to prepare for launch into orbit. The product we develop are in accordance to the ECSS (European Cooperation for Space Standardization). We envision that in the future that every child on the planet will have the opportunity to work on a satellite to improve the scientific cognitive skills and critical thinking.

1.2 Introduction

1.2.1 What’s a femtosatellite?

A femtosatellite is a miniature satellite that is incredibly small and lightweight, weighing less than 100 grams and typically no larger than 10 centimetres in diameter. Despite their small size, femtosatellites are highly capable and can perform a variety of tasks such as remote sensing, communication, and scientific research. They are often deployed in constellations of small satellites that work together to accomplish a specific mission and are relatively inexpensive to build and launch compared to larger satellites.

Femtosatellites are an attractive option for researchers, startups, and universities because they offer an accessible way to conduct space-based experiments without breaking the bank. In addition, they are often used as a tool for education and outreach, allowing students and hobbyists to get involved in space exploration. While femtosatellites are limited in their capabilities compared to larger satellites, they represent an exciting development in the world of space technology and are likely to play an increasingly important role in the future of space exploration.

1.2.2 Purpose of the product

GerhanaSAT is a Femto-class satellite (Femtosatellite) according to mass classification which is lesser than 100g. Independence-X Aerospace plans to launch a constellation of GerhanaSAT into the equatorial low earth orbit for the Internet of Things (IoT)and drone communication services. The mission of the GerhanaSAT is to serve as a communication satellite throughout the equator which contains subsystems such as Attitude Determination Control System (ADCS), Command & Data Handling (C&DH), Electrical Power System (EPS), On-board Computer (OBC), and Communication.

GerhanaSAT kit on the other hand is an educational kit from Independence-X. This satellite in this kit is a mirror of what the real GerhanaSAT is like. But it was design to give an experience of building and operating a small satellite to the student as part of STEM education.

1.3 Nomenclature

ANT : Antenna

BATT : Battery

C&DH : Command and Data Handling

COM : Communication port

COMMS : Communication

CV : Consumer Version

ECSS : European Cooperation for Space Standardization

EEPROM : Electrically erasable programmable read-only memory

EPS : Electrical Power System

EULA : End User license agreement

FPC : Flat printed circuit

GerhanaSAT : Gerhana Satellite

GND : Ground

GPIO : General Purpose Input Output

GPS : Global positioning System

GS : Ground Station

I2C : Inter-Integrated Circuit

IDE : Integrated development environment

IDXA : Independence-X Aerospace

IN : Input

IO : Input Output

LED : Light Emitting Diode

LoRa : Long Range

MaH : Mili-amp Hour

MISO : Master in Slave Out

MOSI : Master Out Slave In

MTR : Motor

NSS : Active-low slave-select

OBC : On-Board Computer

OLED	: Organic LED
PA	: Pin group A
PB	: Pin group B
PC	: Pin group C
PG	: Power good
PWM	: Pulse width modulation
PWR	: Power
RST	: Reset
SCL	: Data line
SDA	: Clock line
SPI	: Serial Peripheral Interface
STEM	: Science, Technology, Engineering and Mathematics
SWCLK	: Serial Wire clock
SWDIO	: Serial Wire Debug Input Output
TX/RX	: Transmit/ receive
UART	: Universal asynchronous receiver / transmitter
UFL	: Radio antenna connector
USB	: Universal Serial Bus

1.3.1 What's included in the package?

Figure 1 item included in the GerhaanSAT kit.

#	Code reference/item	description
A	#A017	• 30 PIN FPC CABLE • 150MAH 1S LIPO BATTERY
B	#M010	• OBC board
C	#M012	• COMMS board • ground station antenna board
D		GROUND STATION MODULE
E	#A010	• Type : Spacer • Pitch : M2 • Length : 8mm • Unit : 4 pieces
F	#A011	• Type : Spacer

		• Pitch : M2 • Length : 7mm • Unit : 4 pieces
G	#A012	• Type : Spacer • Pitch : M2 • Length : 6mm • Unit : 4 pieces
H	#A013	• Type : Spacer • Pitch : M2 • Length : 4mm • Unit : 4 pieces
I	#A014	• Type : Screw • Pitch : M2 • Length : 4mm and 20mm • Unit : 8 pieces and 4 pieces
J	#A015	• Type : Screw • Pitch : M2 • Length : 4mm and 20mm • Unit : 8 pieces and 4 pieces
H	#A013	• Type : Spacer • Pitch : M2 • Length : 4mm • Unit : 4 pieces
K	Antenna	• Frequency : ¼ wave 433Mhz • Unit : 2 pairs
L		micro-USB programming cable
M	Chassis	• M1: front plate • M2: side plate 1 • M3: battery holder • M4: back plate • M5: side plate 2 • M6: top plate • M7: bottom plate

Table 1 item included in the GerhanaSATA kit

1.4 Product Specifications

1.4.1 Specifications for Electronics

Refer to GerhanaSAT one-page datasheet for the electronics specification.

Download link: GerhanaSAT_Datasheet.pdf

1.4.2 Specifications for Software

- *Ground Station Software*

Included with this kit is the ground station software. Please refer to chapter 4 for more information about the software.

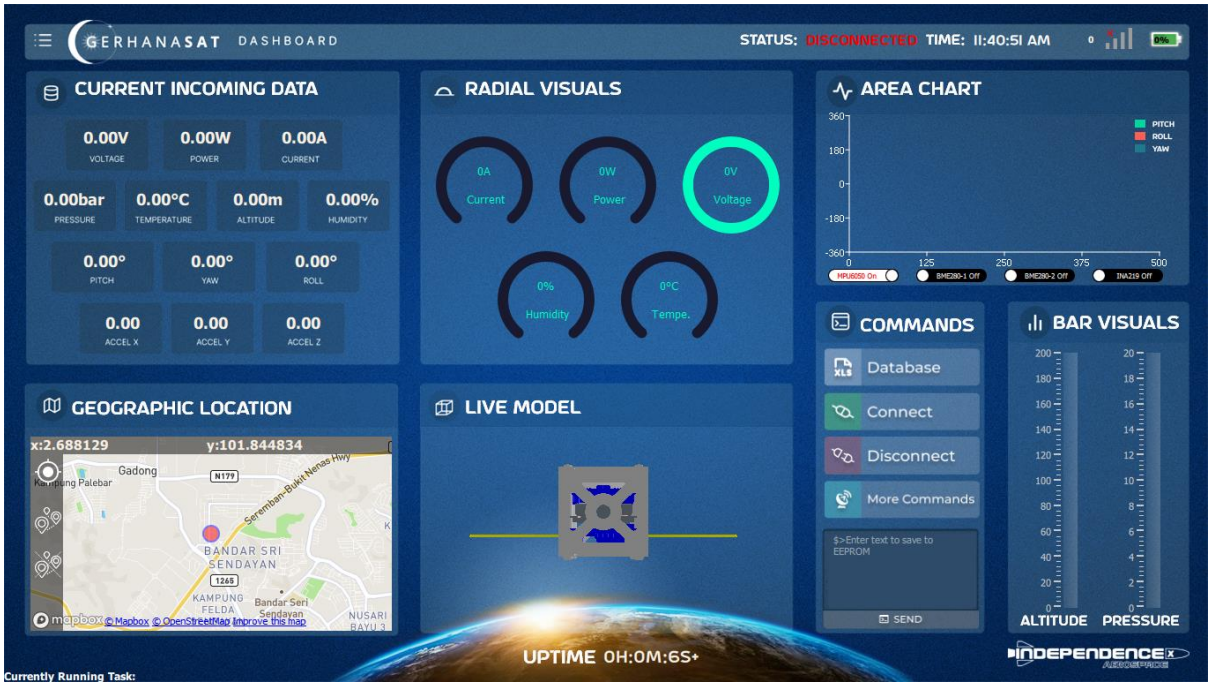


Figure 2 Ground Station software

Download link: GERHANASAT GROUND STATION SOFTWARE V14.14.rar

- *IDE (Integrated Development Environment) Software*

All the boards in the GerhanaSAT kit come pre-loaded with a bootloader that is compatible with Arduino IDE and can be programmed with a micro-USB cable included in the kit.

Download link: https://docs.arduino.cc/software/ide-v1

Figure 3 Arduino IDE.

- *Programming and Coding*

Programming and coding for GerhanaSAT is written with Arduino IDE in C++. Please Refer to chapter 3 for detail information on programming the GerhanaSAT.

1.4.3 Specifications for Integration

Maximum chassis size	32mm x 32mm x 32mm
Length with antenna	358mm
Maximum height with screw	34.4mm

Figure 4 Fully integrated GerhanaSAT

Refer to chapter 3 for a complete guide on GerhanaSAT assembly.

1.5 Space Applications

GerhanaSAT main application in space is to provide a communication relay from one remote area to another. GerhanaSAT can save a message, telemetry, or any small data on its on-board EEPROM. This data can be transferred to another GerhanaSAT or to another ground station, thus providing communication between two devices in distance.

1.6 Alternative Applications

GerhanaSAT uses STM32F103 microcontroller as the main controller. Because of the vast variety of libraries available for this microcontroller, GerhanaSAT OBC can also be treated as a generic microcontroller. With this versatility, GerhanaSAT can be modified into other applications. Below are some examples of what GerhanaSAT alternative application.

1.6.1 Drones

With its on board IMU and motor controller, GerhanaSAT can be modified into drones with some tweak of the hardware.

Figure 5 GerhanaSAT reimagine as small drone.

1.6.2 Rover

Also utilizing the on-board motor controller, and using the available GPIO connection, GerhanaSAT can also be turned onto a small rover.

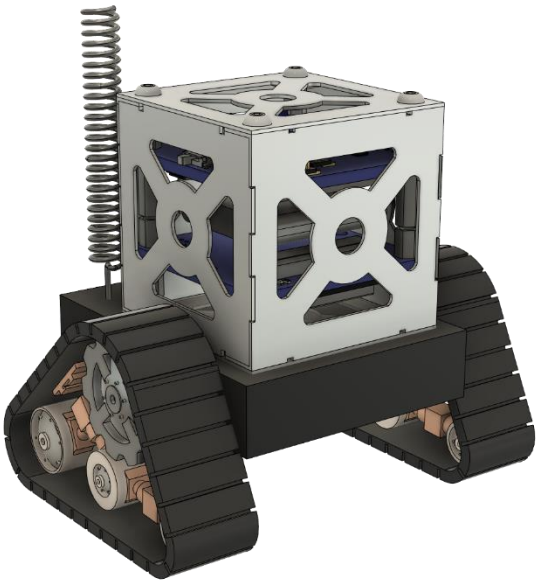


Figure 6 GerhanaSAT reimagine as a rover.

1.6.3 IoT Terminals

IoT devices are becoming more and more crucial in our daily lives, either for our personal smart home or for data collection on a big farm or a factory. With its onboard LoRa connectivity, GerhanaSAT can also be used to be an IoT terminal to increase connectivity on earth surface rather than from space.

1.7 Handling Procedure

There is some procedure that needs to be taken care of while handling the kit, for the safety of the user and the kit.

- When handling the antenna and the chassis, there are some sharp edges that can induce cut if not carefully handled.
- While assembling, make sure there is no shortage between all the chassis, connectors, spacer, and bolt.
- Make sure to turn off or disconnect all power sources while in the assembly process.
- Check for shortage before turning on the board.
- Check the polarity of battery before connecting to the board.
- **DO NOT** turn on COMMS board and Ground Station module **WITHOUT** the antenna.

1.8 Regulations

GerhanaSAT is operating using LoRa modulation on 433Mhz frequency. Most of the countries allow this frequency to be operate freely. But please check with the local authority before operating the GerhanaSAT in the public space.

1.9 End User's License Agreement (EULA)

EULA can be downloaded from the link below.

Download link: GerhanaSAT_EULA_en.pdf

2 Hardware Guide

2.1 Board layout

2.1.1 OBC(#M010) Front view

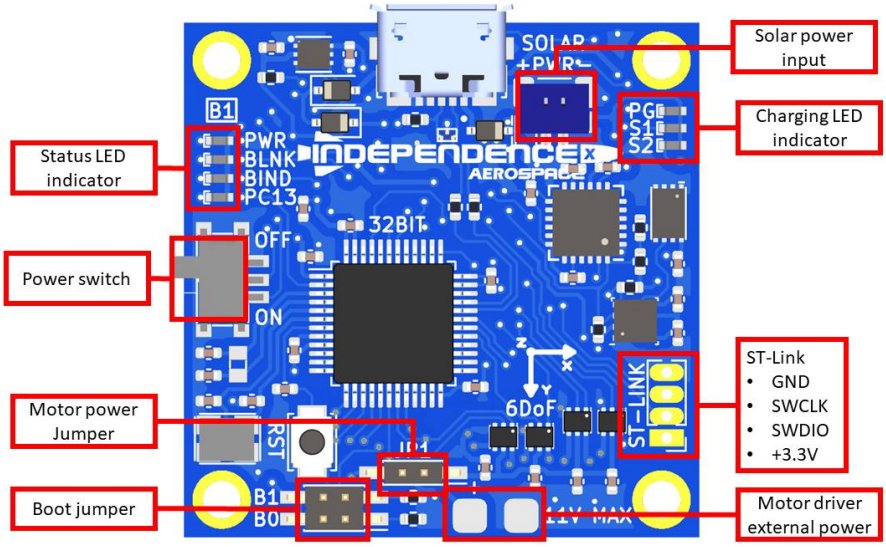


Figure 7 OBC board front view

Status LED

- PWR: power status
- BLINK: Open status LED
- Bind: Open status LED
- PC13: PC13 pin LED

Charging LED

- PG: Power Good status
- Charging: STAT1 on, STAT2 off
- Complete: STAT1 off, STAT2 off

Motor power setup

- Connect motor power jumper to use internal +3.3V(500mA) internal regulator power.
- Disconnect motor power jumper and connect external power to Motor driver external power (MAX:11V, 1.76A per motor driver)

2.1.2 OBC(#M010) Back view

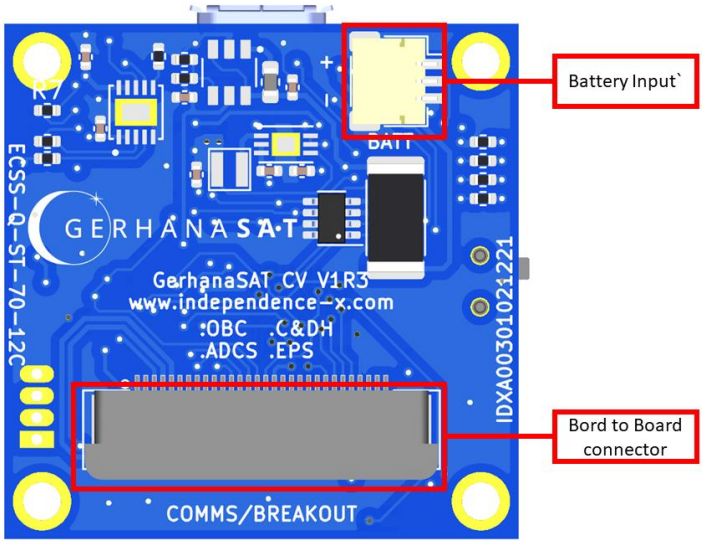


Figure 8 OBC board back view

Battery Input

- 1s LiPo Battery,3.7V.

Board to board connector

- Use 30pin FPC, 0.5mm pitch, opposite side cable (#A017) to connect with Board 2

2.1.3 COMMS(#M012) Front view

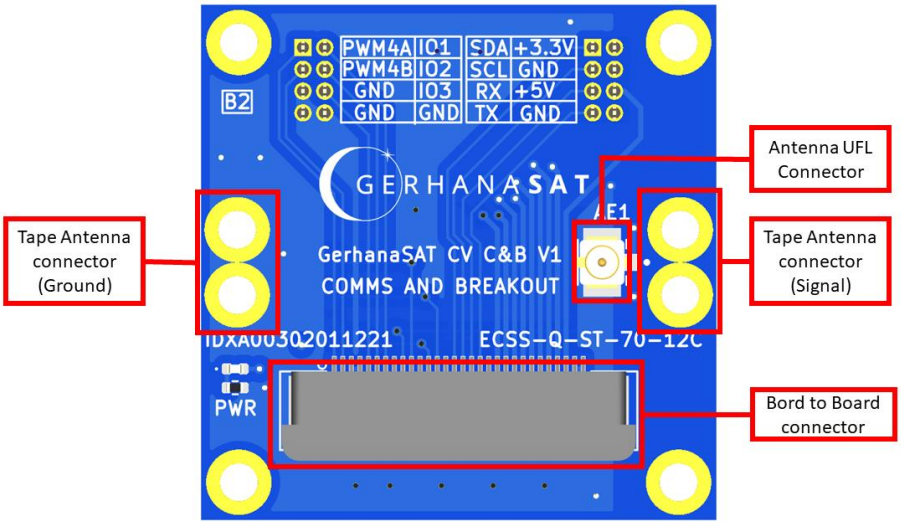


Figure 9 COMMS board front view

- Connect provided tape antenna to the connector using M1.6 button head screw provided.

- Alternatively, use antenna with UFL connector to connect to onboard UFL connector (UFL antenna is not provided within the kit)
- Connect to board 1 using FPC cable provided using the board-to-board connector

2.1.4 COMMS(#M012) Back view

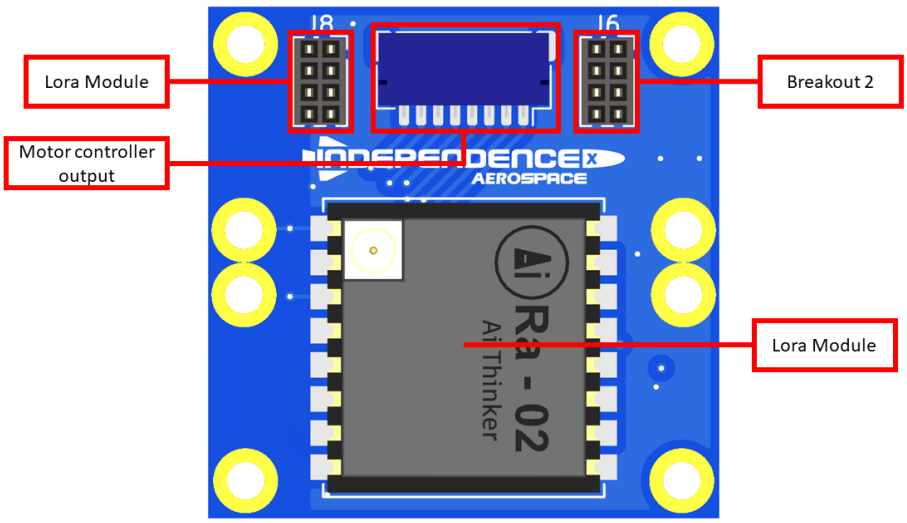


Figure 10 COMMS board back view

J6 and J8 is breakout connection for the board. The connection can be referred to Board 2 front view.

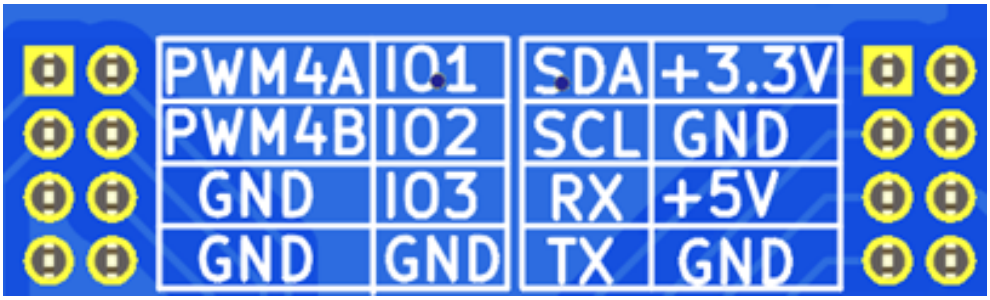


Figure 11 GPIO pinout on the COMMS board.

Motor controller output

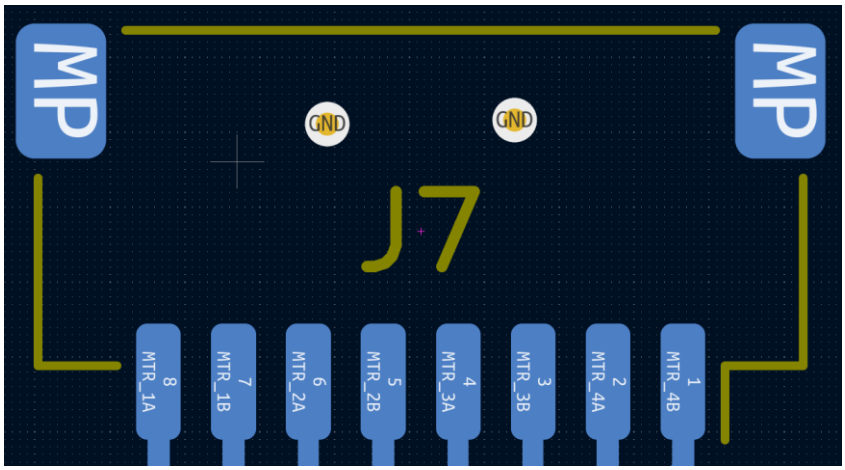


Figure 12 Motor controller output pinout.

2.2 Assembly guide

2.2.1 FPC connection between OBC and COMMS

Figure 13 orientation of FPC, OBC board and COMMS board for assembly.

2.2.2 Antenna assembly

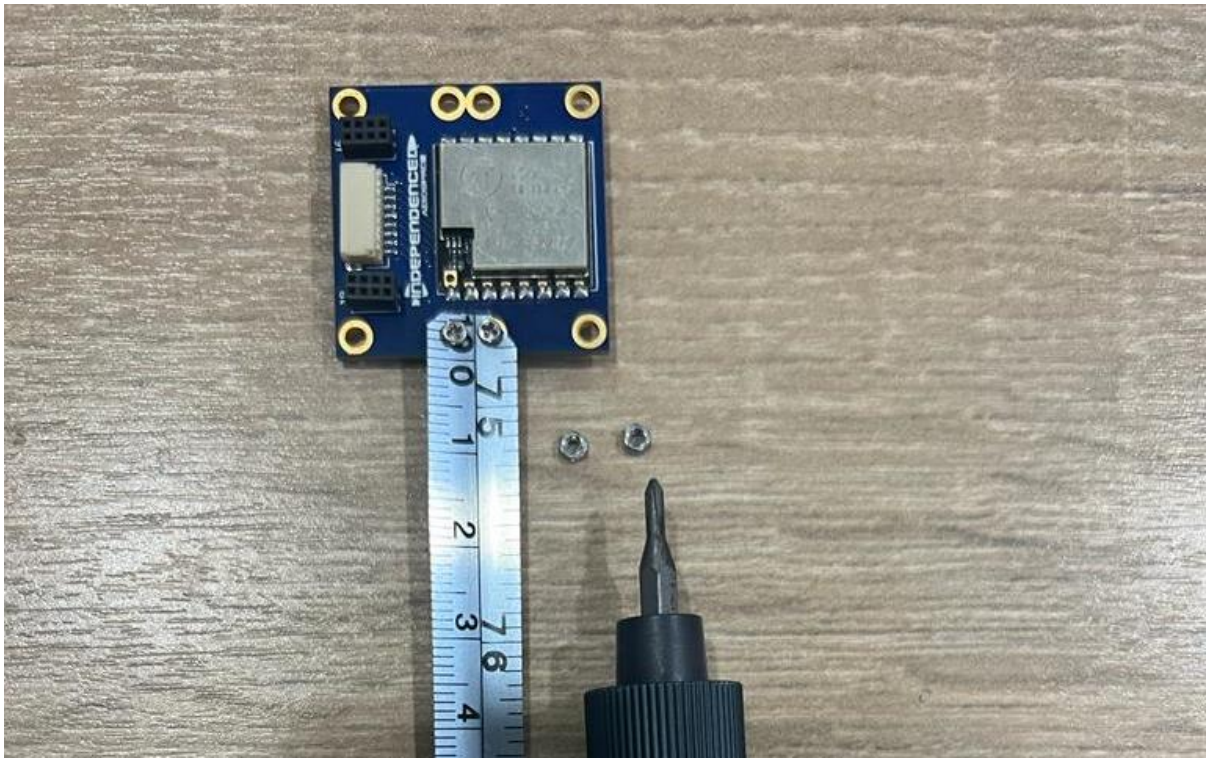


Figure 14 Antenna assembly using M1.6 bolt and nuts(#A015)

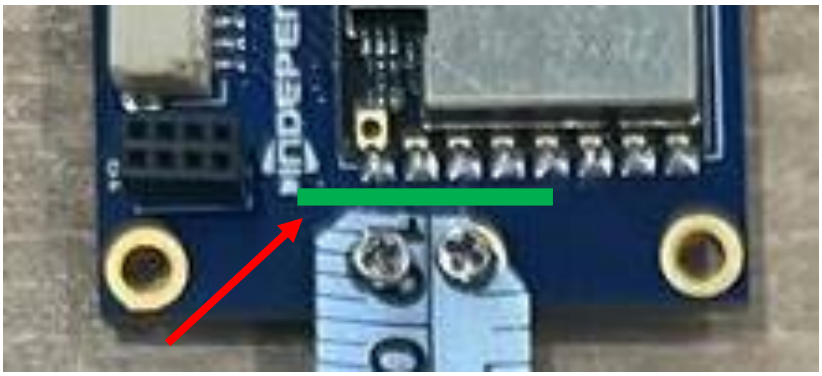


Figure 15 The green line shows where the gap is between antenna and comms module.

Make sure the antenna assembly did not touch the comms module pin. Insert the heat shrink included in the antenna for the COMMS board, in the position as in the red circle in Figure 16 and apply heat to set the heat shrink.

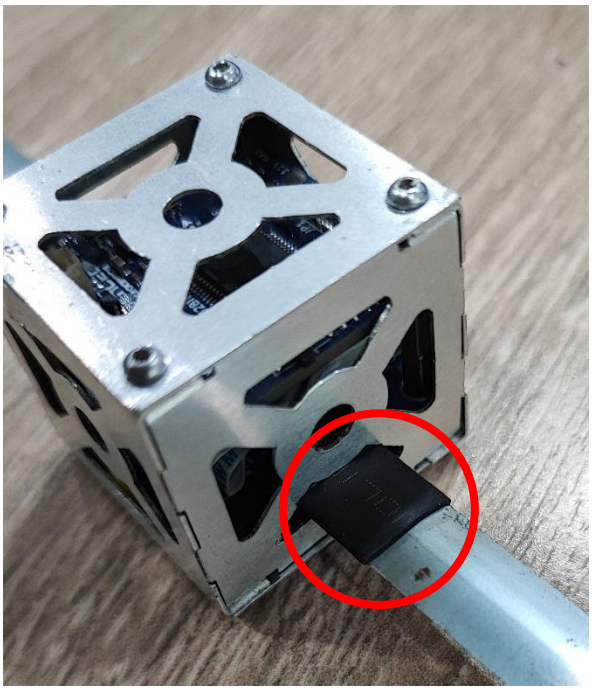


Figure 16 heat shrink position on the antenna.

2.2.3 Battery assembly

From Figure 8, u can see the location of battery connection. Insert the battery included (#A017) into the battery connector according to correct polarity as seen in Figure 17. Please be carefull of the small capacitor in front of the battery connector as seen in Figure 18, as you connect and disconnect the battery.

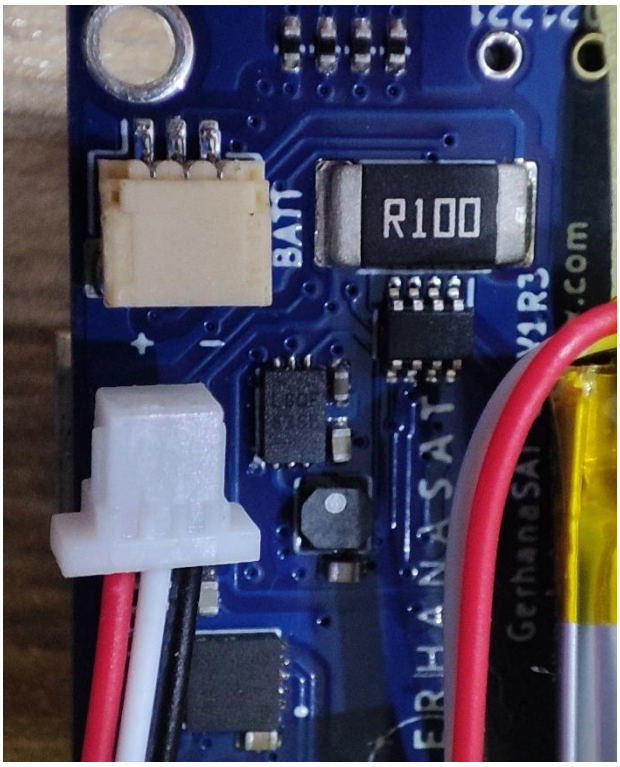


Figure 17 Battery connection polarity.

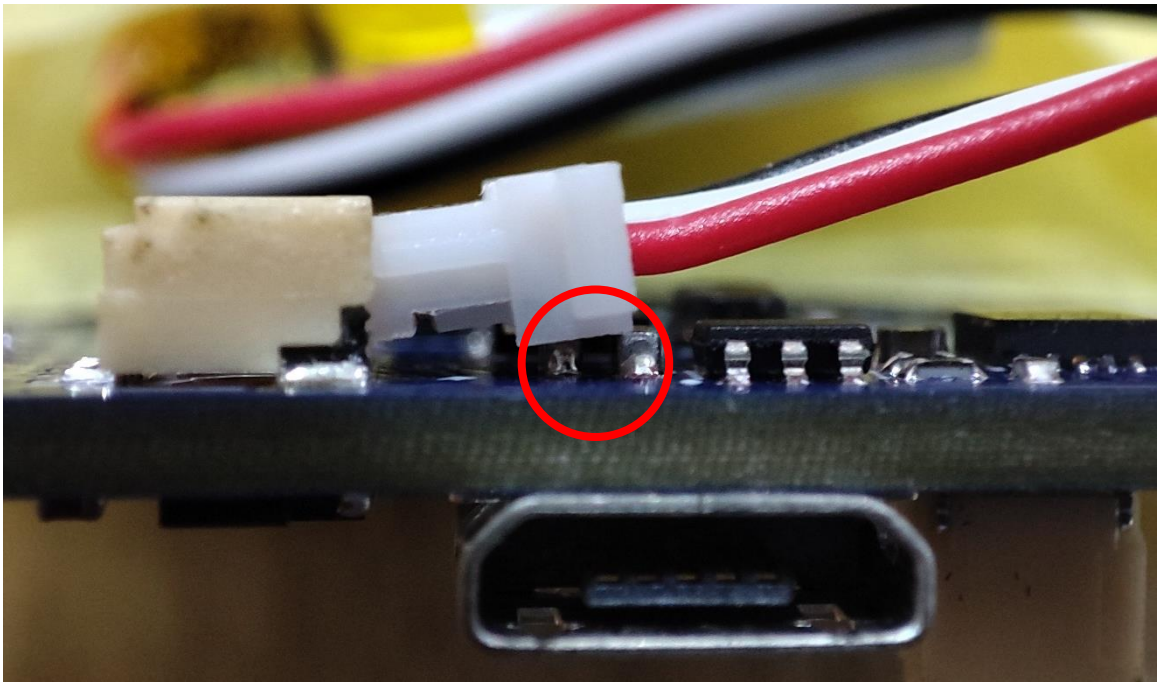


Figure 18 small capacitor in front of battery connector.

2.2.4 Screw configuration

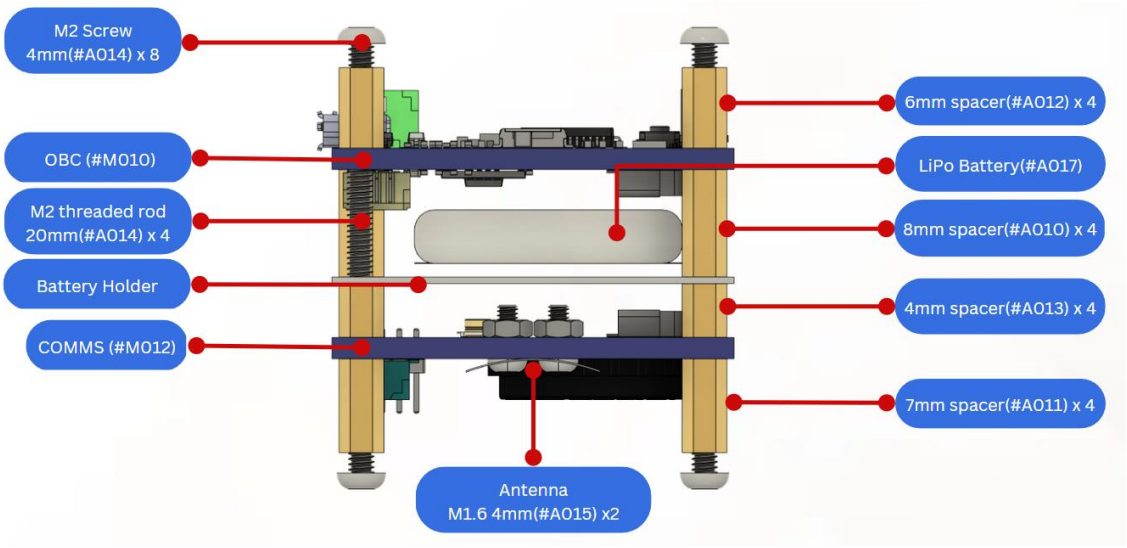


Figure 19 Screw configuration for assembly

2.2.5 Chassis configuration

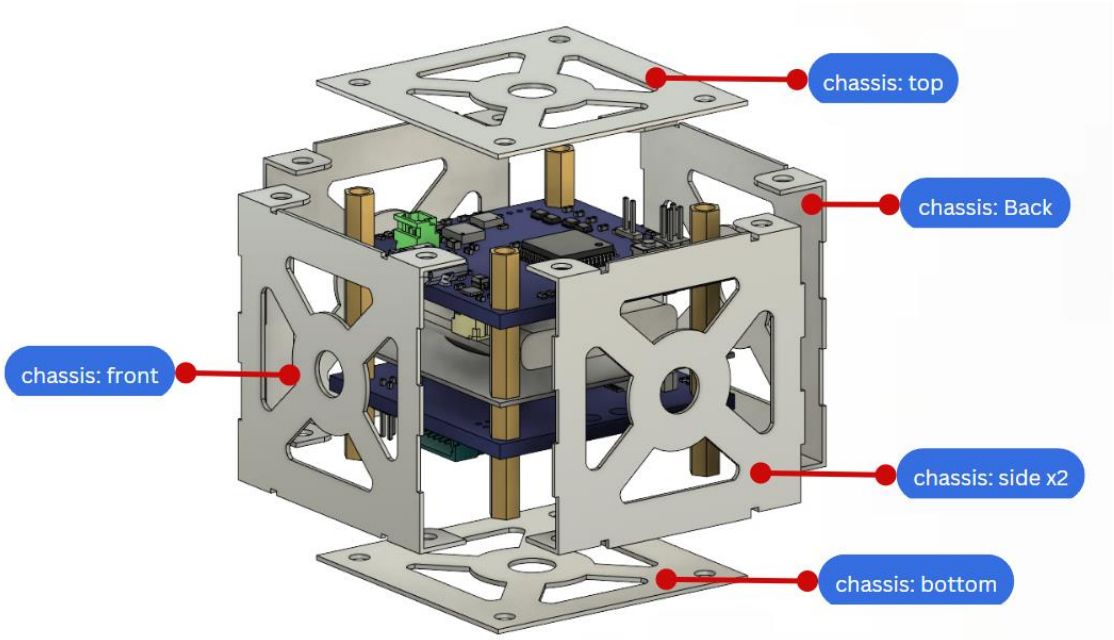


Figure 20 Chassis configuration for assembly

2.2.6 Assembled view.

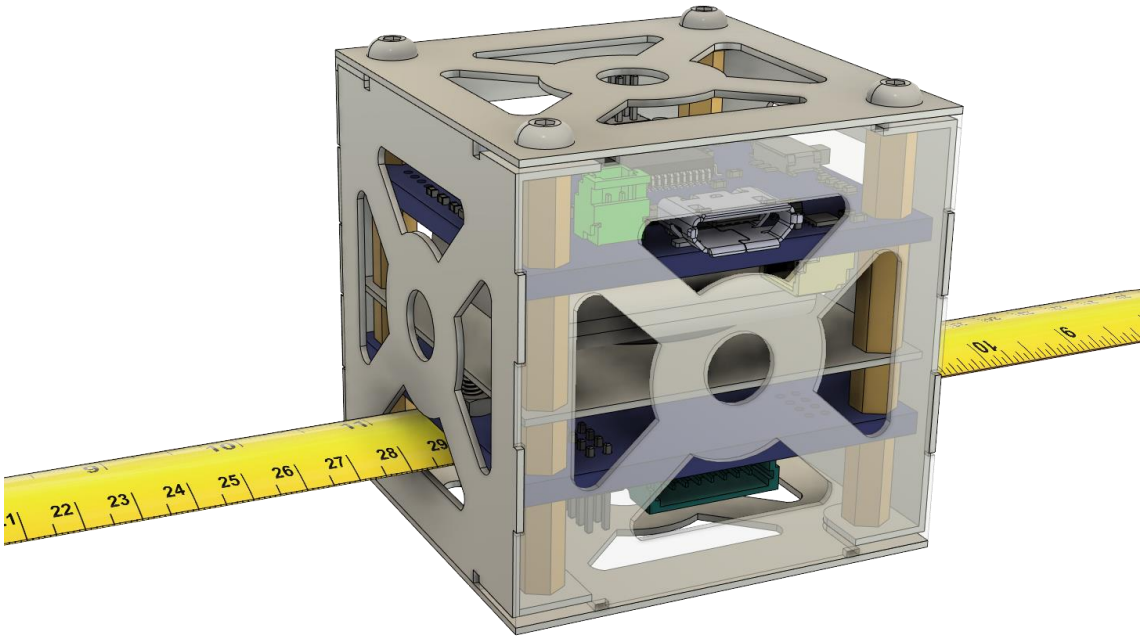


Figure 21 Fully assembled GerhanaSAT

2.2.7 Ground station assembly

The Ground station come with the kit pre-assembled. But the user need to assemble the antenna board and install the antenna board in the ground station module.

- Antenna board assembly.

Use M1.6 bold and nuts from package #A015 to secure the antenna on the antenna board.

Figure 22 Antenna Board assembly.

- Antenna board installation into ground station module.

The step-by-step installation instruction is explained from Figure 23 Insert the antenna board into the M.2 connection on the right of the module.Figure 23 to Figure 25.

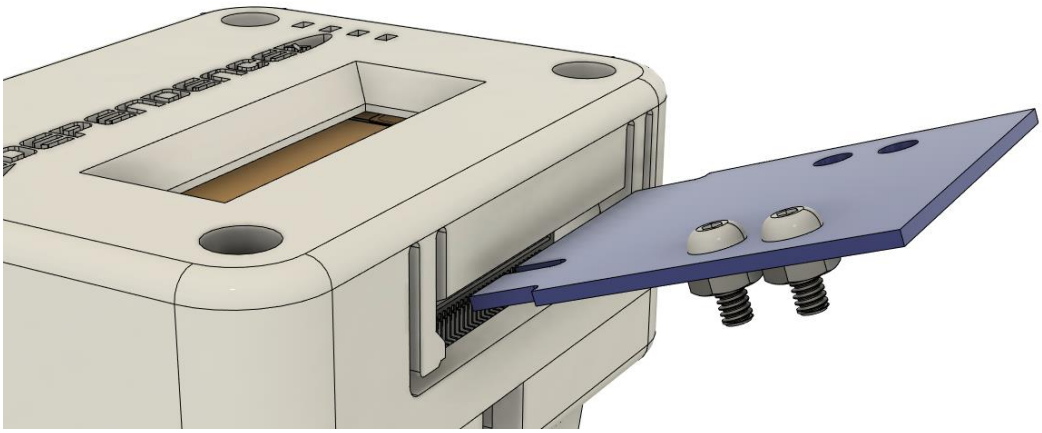


Figure 23 Insert the antenna board into the M.2 connection on the right of the module.

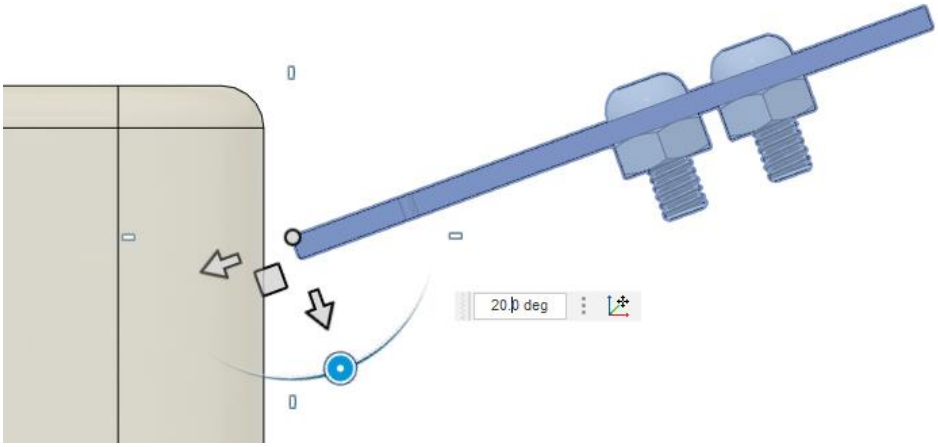


Figure 24 insert the antenna board at 20-degree angle all the way in.

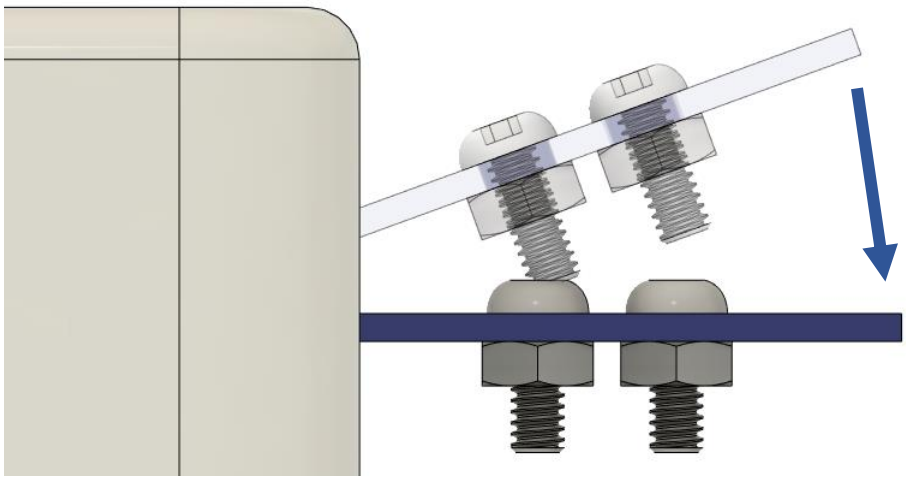


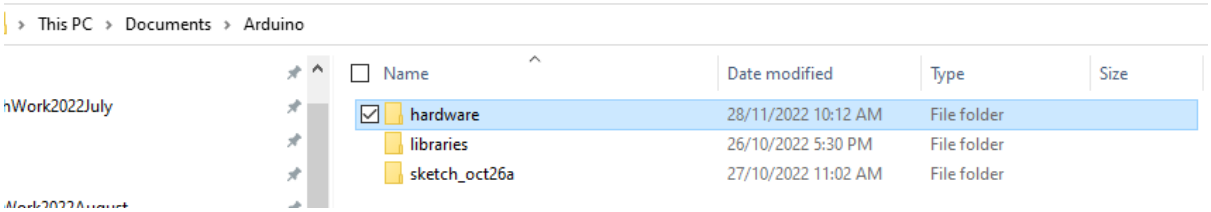
Figure 25 push down the antenna board from its outer end until its parallel with the ground station board and it is secure in place.

3 Firmware and Software guide

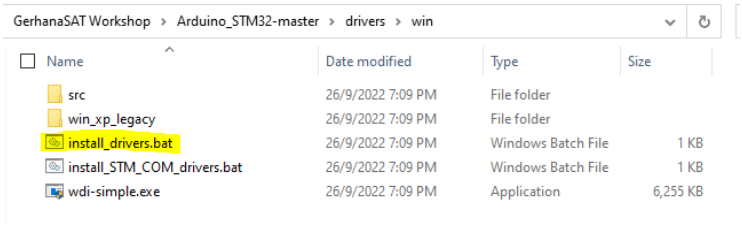
3.1 Arduino IDE STM32 Driver and Board

Download Arduino IDE at https://www.arduino.cc/en/software

Copy the Arduino_STM32 folder to My Documents/Arduino/hardware (Note: if the hardware folder doesn't exist you will need to create it).

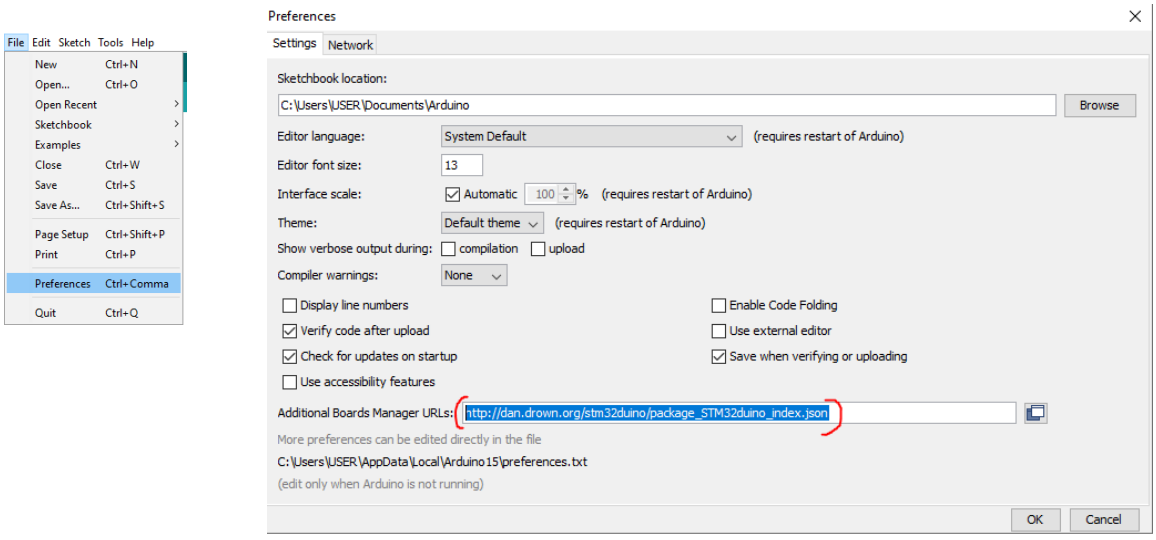


If using Maple or Maple mini, you need to install drivers for the Serial and DFU (upload devices). Navigate to the folder: /drivers/win/ and run: install_drivers.bat.



After Installing the Drivers

Navigate on the Arduino IDE to File > Preferences



Paste link below in Additional Boards Manager Urls as above picture in Arduino preferences
http://dan.drown.org/stm32duino/package_STM32duino_index.json

Restart the Arduino IDE, and select the appropriate board from the "Tools" -> "Board menu", and select the appropriate Com port for your Maple mini or serial upload device.

Once done, on the Tools > Port should have COM(Maple).

3.2 Libraries to Include

To use the components on GerhanaSAT, there are libraries need to be included in the IDE. Below is the list of libraries that can be used with GerhanaSAT.

Download link: [GerhanaSAT.rar]

libraries to be include to program the GerhanaSAT

Name	Date modified	Type	Size
Adafruit_GFX_Library.zip	4/11/2022 4:05 PM	WinRAR ZIP archive	352 KB
Adafruit_GPS_Library.zip	4/11/2022 3:58 PM	WinRAR ZIP archive	74 KB
Adafruit_INA219.zip	4/11/2022 3:58 PM	WinRAR ZIP archive	266 KB
Adafruit_SSD1306.zip	4/11/2022 3:58 PM	WinRAR ZIP archive	35 KB
arduino-LoRa-STM32-master.zip	4/11/2022 3:48 PM	WinRAR ZIP archive	97 KB
i2cdetect.zip	4/11/2022 3:57 PM	WinRAR ZIP archive	4 KB
LIBRARIES TO INCLUDE.txt	4/11/2022 4:00 PM	Text Document	1 KB
MPU6050_light.zip	4/11/2022 3:57 PM	WinRAR ZIP archive	194 KB

You can also use your own libraries or specifically use wire.h to access the sensors onboard. These libraries are for ease of use and have been tested to be able to use with GerhanaSAT.

INA219 library is for the power sensor.

SSD1306 library is for the **OLED** display on the ground station.

LoRaSTM32 library is for the lora communication.

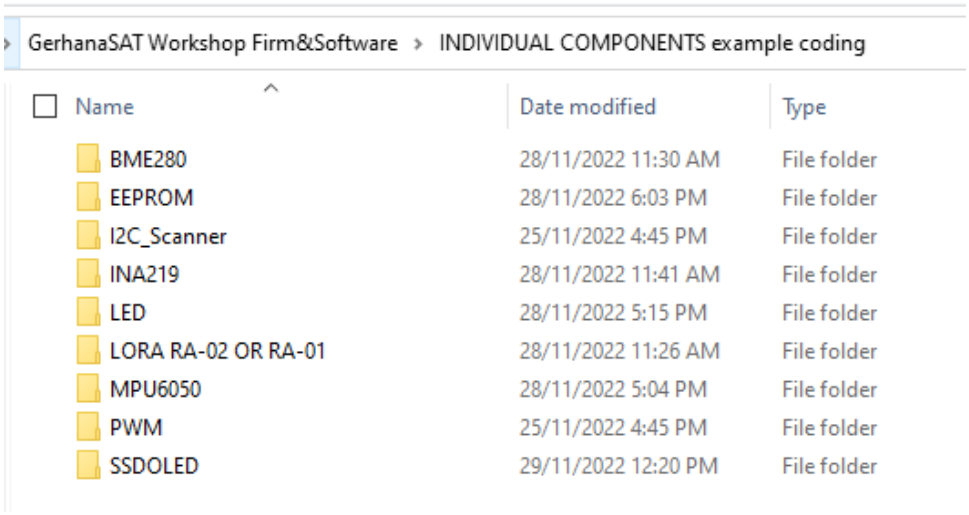
MPU6050 is for the inertial measurement unit sensor.

BME280 library is for the temperature, altitude and humidity sensor.

GPS library can be used by connecting a GPS externally via **I2C** or **UART** depending on the type of GPS used.

3.3 Individual Components

3.3.1 Coding Examples



This folder directory shows code examples on how to interact with the sensors and the pins on the GerhanaSAT as well as the LoRa module for receiving and sending.

3.4 Pin Reference

Pin reference for types of pins.

Table 2 GerhanaSAT Pinout guide.

LED	PC13	PC13	GERHANASAT STM32F103			
MTR DRV4 IN1	PWM_4B	PB0		PA0	PWM_2A	MTR DRV2 IN1
MTR DRV4 IN2	PWM_4A	PB1		PA1	PWM_2B	MTR DRV2 IN2
	BOOT1	PB2		PA2	PWM_3A	MTR DRV2 IN1
	GPIO1	PB3		PA3	SPI_RST	LoRa Module
	GPIO2	PB4		PA4	SPI_NSS	
	GPIO3	PB5		PA5	SPI_SCK	
	I2C_SCL	PB6		PA6	SPI_MISO	
	I2C_SDA	PB7		PA7	SPI_MOSI	
MTR DRV1 IN1	PWM_1A	PB8		PA8	PWM_3B	MTR DRV2 IN2
MTR DRV1 IN2	PWM_1B	PB9		PA9	UART1_TX	
LoRa Module	GPIO4	PB10		PA10	UART1_RX	
		PB11		PA11	D-	
		PB12		PA12	D+	
LED	C_BIND	PB13		PA13	SWDIO	
LED	c_BLINK	PB14		PA14	SWCLK	
		PB15		PA15		

4 GerhanaSAT Ground Station Software

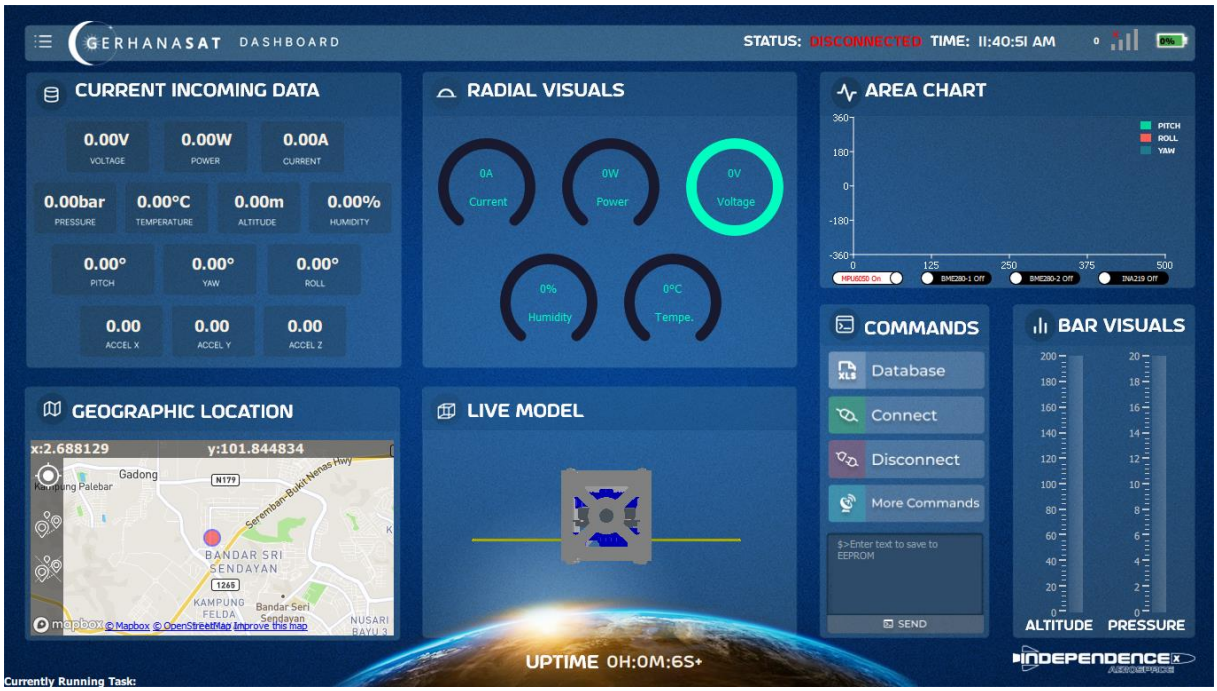


Figure 26 GerhanaSAT Ground station software

GerhanaSAT Ground Station software is proprietary software made specifically for GerhanaSAT. This will take all the raw data from GerhanaSAT and display it in a very user-friendly view. This way the data is presented in a readable manner, can be recorded, and analyzed.

System Requirements

Operating System: Windows 7 and above

Working resolution: 1360 x 768

The format of data given received by the software is as follows:

TIME	TEMPERATURE	PRESSURE	HUMIDITY	ALTITUDE	ROLL	PITCH	YAW	X_ACCEL	Y_ACCEL	Z_ACCEL	VOLTAGE	CURRENT	POWER	MAPVOLTAGE	LATITUDE	LONGITUTE

TIME: time stamp in second

TEMPERATURE: temperature reding by sensor

PRESSURE : pressure reading by sensor

HUMIDITY : humidity reading by sensor

ALTITUDE : Altitude reading by IMU

ROLL : Roll reading by IMU

PITCH : Pitch reading by IMU

YAW : Yaw reading by IMU

X_ACCEL : X-axis acceleration

Y_ACCEL : Y-axis acceleration

Z_ACCEL : Z-axis acceleration

VOLTAGE : Regulated voltage reading

CURRENT : Current consumption reading

POWER : Power consumption reading

MAPVOLTAGE: Battery level reading

LATITUDE : GPS latitude value

LONGITUDE : GPS longitude value

Steps to use:

1. Plug-in GerhanaSAT Ground Station via USB.
2. Switch on GerhanaSAT Satellite.
3. Press “Connect” on the dashboard to connect to the Ground Station
4. When connected, the status will change to “Connected” and the data will start streaming.
5. The Ground Station module can be mounted on laptop screen or any rigid thin structure.

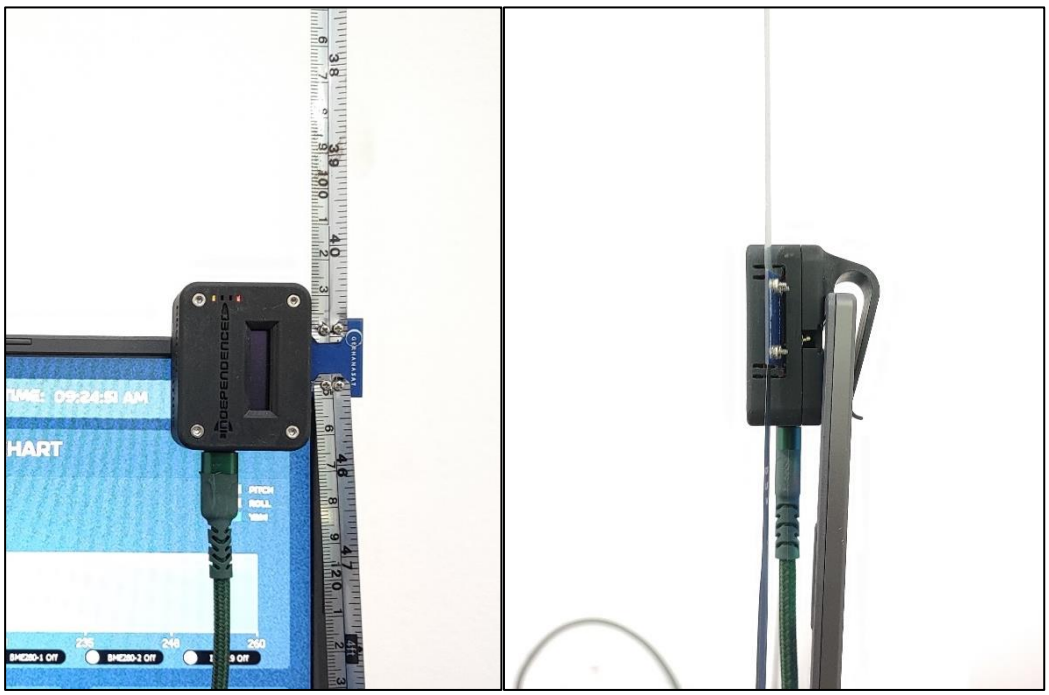


Figure 27 ground station module mounted on a laptop (front and side view)

1.1 Data value Display

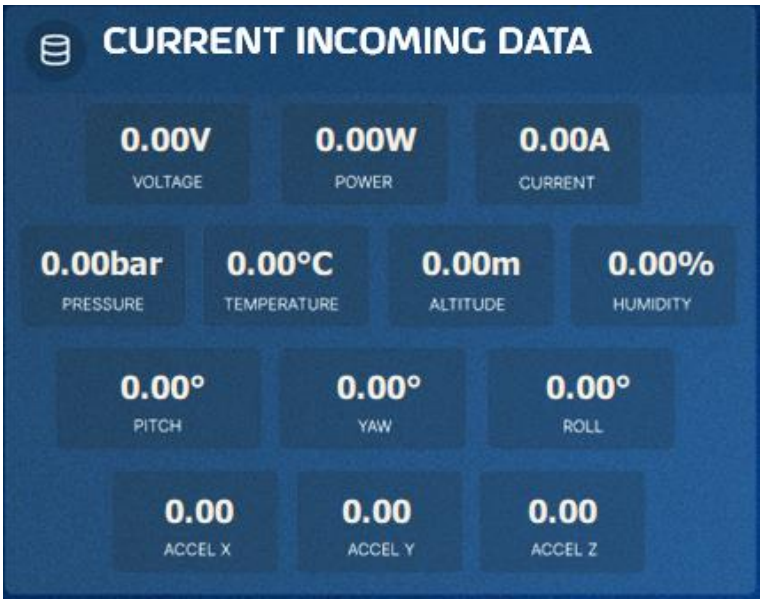


Figure 28 current incoming data display

This window will display all the data from the satellite's on-board sensors. The value will change with real-time data received from the satellite.

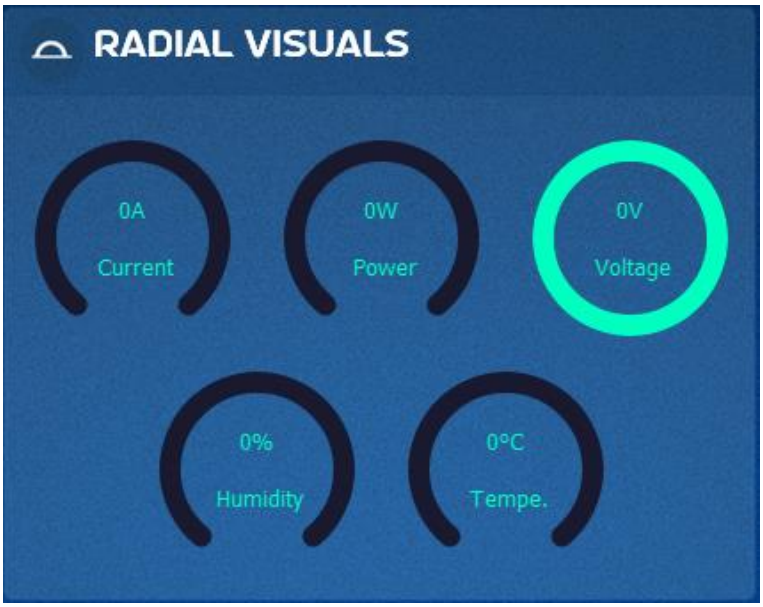


Figure 29 radial visual display

This window will display current, power, voltage, humidity, and temperature data on a radial display.

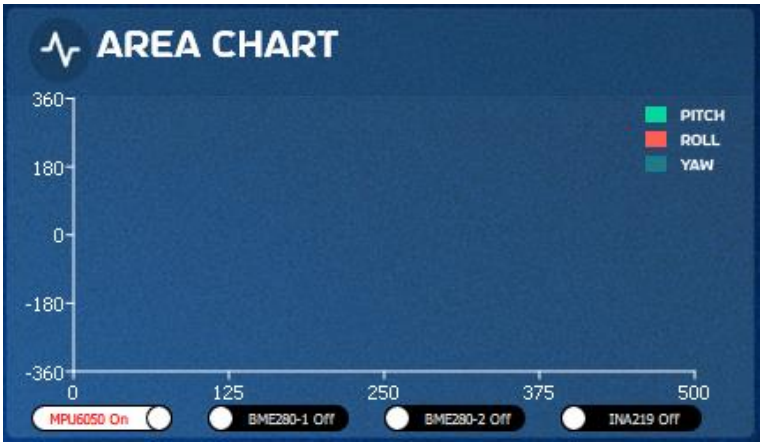


Figure 30 Area chart display

This window will display all the data in a line chart. The button at the bottom of the display will toggle the data display on the chart.

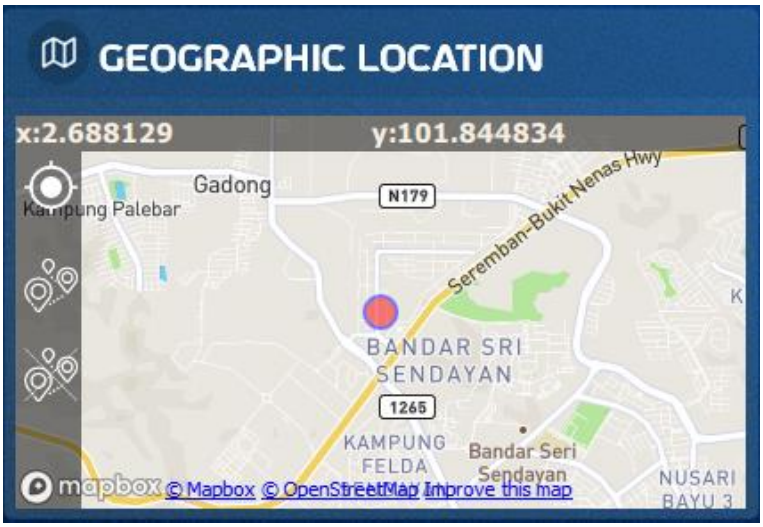


Figure 31 location display

This window will display the location of the satellite in a map (GPS module is not included in the kit)

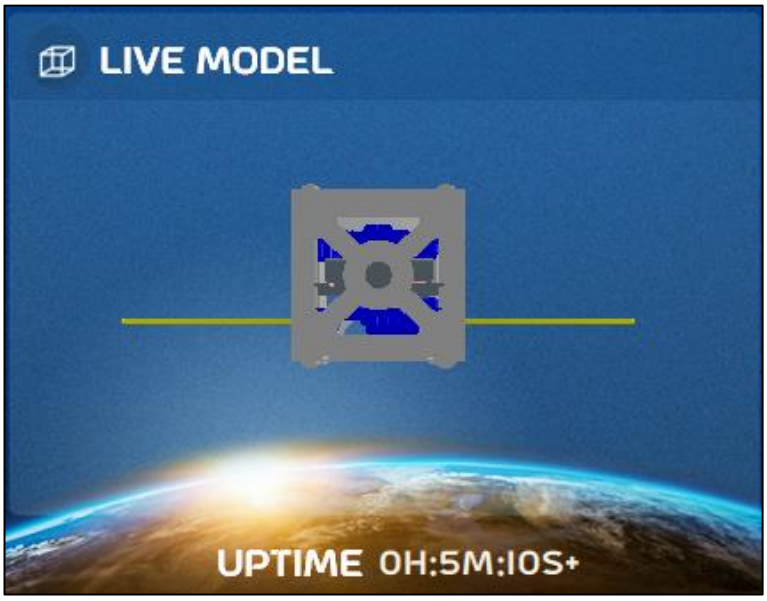


Figure 32 live 3D model and uptime display

This window will display live 3D-model of the satellite. The model will move in correspond with the live IMU data from the satellite. The timer at the bottom of the window is showing how long the satellite has been running.

Figure 33 command display

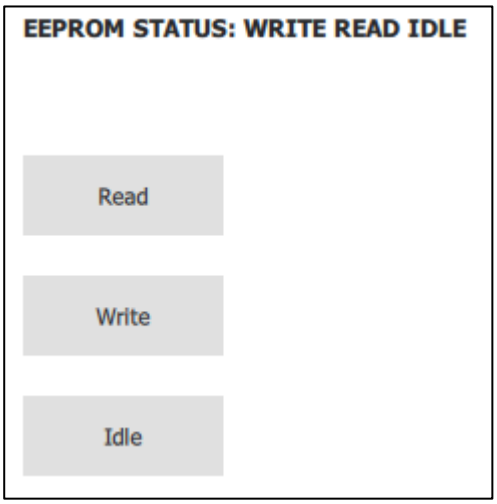


Figure 34 EEPROM command display

This is the command display. The button function is as follows:

Database: this button will save the recorded data in csv format to the local drive

Connect/ disconnect: these buttons will connect or disconnect the ground station with the satellite.

More command: this button will open another window for EEPROM command where user can read, write, or idle the EEPROM.

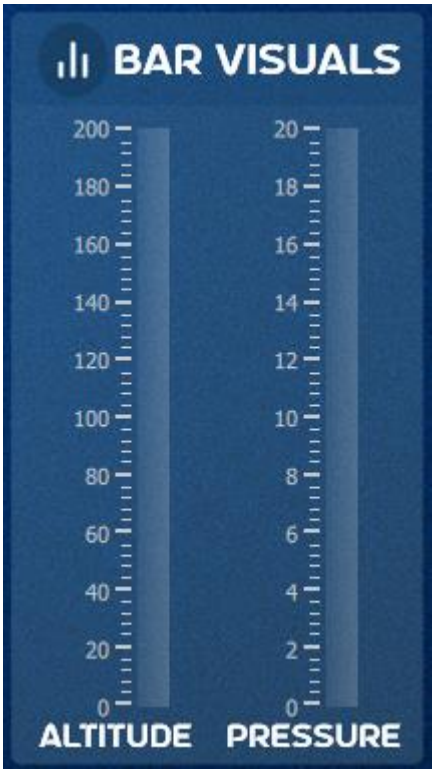


Figure 35 Bar Chart display

This window will display altitude and pressure with a more suitable bar chart.

Thank you for using our product. We are here to serve you better.

If you have any questions or comments, please write to us at the contact information below:

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