Electrical Project Specification

Project Name:	**On-Board Controller (OBC)**
Document Rev:	**06**
Prepared by:	**Sharah Hermiz**
Date:	**December 19, 2023**

Document Revisions

Revision	Date	Change(s)
01	2022/10/11	Initial Release
02	2022/10/26	Updating number of fans and block diagram
03	2022/11/09	Updating PCB Stack-up
04	2022/11/10	Adding new requirements and specifications
05	2022/03/07	Adding Teesny pinout and I2C addresses
06	2023/12/19	Updated block diagram and teensy pinout and added I2C addresses for I2C MUX and fan controller.

Table of Contents

Table of Tables

Table of Figures

0.0 Conventions, Terms, & Reference Documents

0.1 Conventions

"Must" is used to indicate a mandatory requirement.

"Should" is used to indicate an additional nice to have.

"May" is used to indicate an option.

0.2 Terms & Definitions

OBC: On-Board Controller

TSB: Temperature Sensor Board

0.3 Reference Documents

Table 1: Reference documents

RD#	Document	Link
RD1	Temperature Sensor Boards	TSB

1.0 Description

OBC is the main communication hub for all subassemblies in the V2 rover. All communication inside the rover will happen using CAN (as of 10/11/2022). In the event where the team chooses not to go forward with using CAN, we will be using I2C. OBC will use a Teensy 4.1 as the main microcontroller that will be programmed by the software team using MicroROS. OBC will contain GPS and LoRa modules, will power and monitor 4 fans and status/error LEDs, as well as gather temperature data from the temperature sensor boards (RD1). Additionally, it will also have an IMU chip on-board, while also allowing for the use of an external one. It will use ethernet protocol to communicate any necessary data to the Jetson TX2.

1.1 Dependencies

OBC depends on the following systems for operation:

- 12V power from VIPER
- Ethernet connectivity to Jetson

2.0 Requirements & Constraints

Table 2: Requirements & constraints

Requirement ID	Description	Status
OBC-REQ-01	OBC should be powered using 12V	
OBC-REQ-02	OBC must contain a Teensy 4.1 as the main microcontroller	
OBC-REQ-03	OBC must communicate with the Jetson TX2 via ethernet	
OBC-REQ-04	OBC must contain LoRa and GPS modules	
OBC-REQ-05	OBC must have separate power for RF (LoRa, GPS) sections of the board	
OBC-REQ-06	OBC must have CAN, SPI and I2C buses	
OBC-REQ-07	OBC must contain an onboard IMU	
OBC-REQ-08	OBC must be able to connect to external IMU	
OBC-REQ-09	OBC must power and control Status LEDs	
OBC-REQ-10	OBC must power and control the error lights	
OBC-REQ-11	OBC must power and communicate with the Temperature Sensors	
OBC-REQ-12	OBC must power, control and monitor 4 fans	
OBC-REQ-13	OBC should allow for the use of up to 6 fans	
OBC-REQ-14	OBC must always keep the GPS powered	
OBC-REQ-15	OBC must be vertically mounted board	
OBC-REQ-16	OBC must provide access to the SD card on the Teensy 4.1	

3.0 Performance Specifications

Table 3: Performance specifications

Specification ID	Parameter	Min.	Nom.	Max.	Unit
OBC-SPEC-01	Input Voltage	11.8	12	12.2	V
OBC-SPEC-02	Input Current		10.73		A
OBC-SPEC-03	I2C Bus Speed	100		400	kHz
OBC-SPEC-04	SPI Bus Speed	1		16	MHz
OBC-SPEC-05	Ethernet Speed	1		10	Mbps
OBC-SPEC-06	CAN Bus Speed				
OBC-SPEC-07	LoRa Frequency Band				
OBC-SPEC-08	GPS Frequency Band				

OBC-SPEC-09	3V3 Peripheral Output Power				
OBC-SPEC-10	PWM Frequency	3.611		4.482	kHz
OBC-SPEC-11					

4.0 PCB Layout

Table 4: PCB parameters

Parameter	Value	Unit
Number of Layers	4	-
PCB Thickness	1.6	mm
Vendor	JLCPCB	-

Table 5: PCB layer stack-up

Layer #	Copper Weight (oz)	Type
1	1	Signal
2	0.5	Ground
3	0.5	Power
4	1	Signal/Ground

5.0 Mechanical Interfaces

OBC will have an I/O bracket to allow for easy connection to its external modules. It will be mounted vertically to allow for the I/O bracket to be implemented properly.

OBC will power and control the status and error LEDs. These must be visible and properly weatherproofed.

6.0 Detailed Description (Theory of Operation)

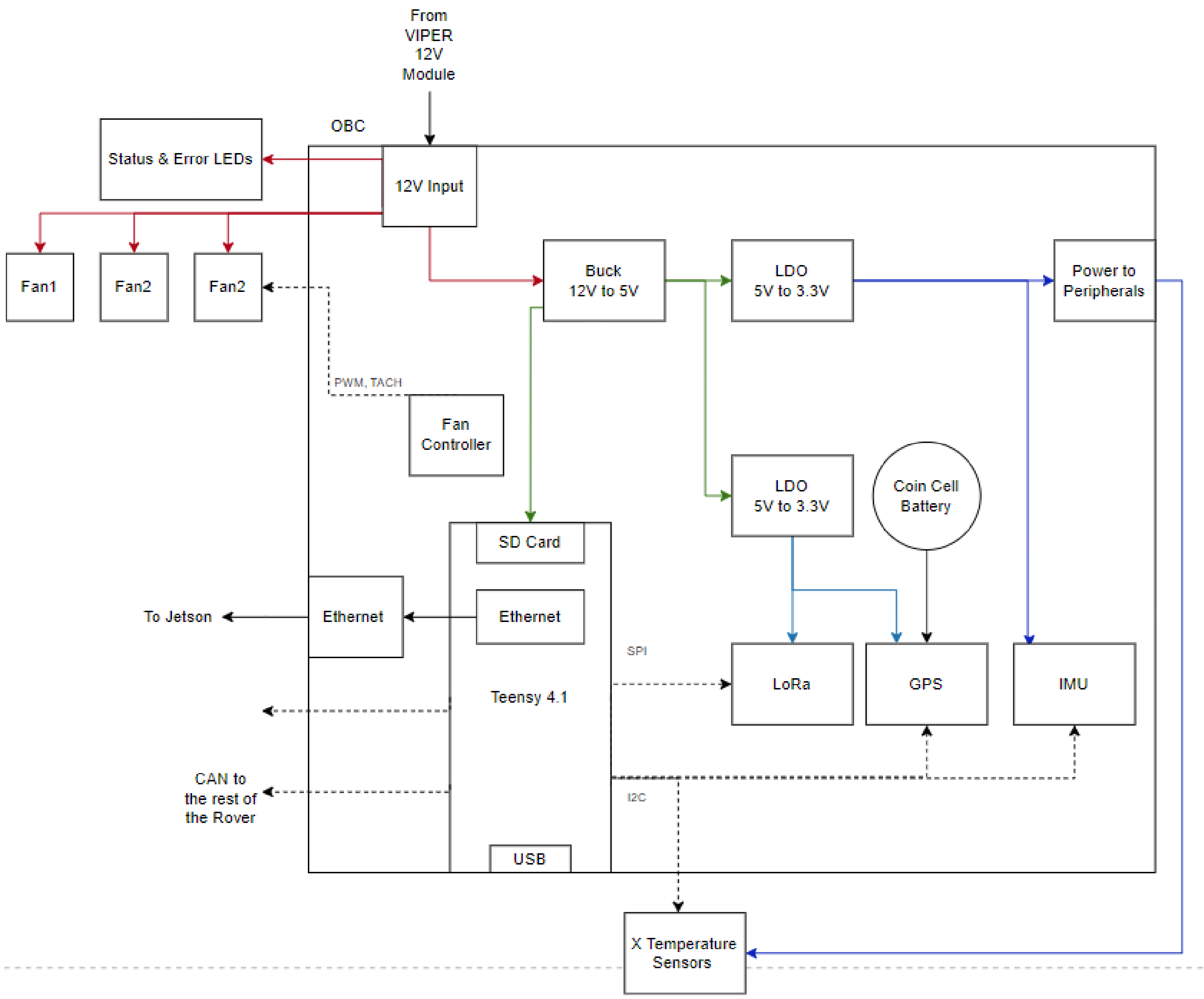

Figure 1: OBC Block Diagram

OBC will be powered via 12V from the VIPER modules.

The Teensy 4.1 is the main microcontroller used, which allows for the implementation of CAN, I2C, and SPI interfaces. It also allows for the use of ethernet which will be used to communicate necessary data to the Jetson, and SD card which can store any necessary data.

All subassemblies in the rover will be communicating via CAN. Therefore, OBC will contain a CAN bus that will deliver and receive data to and from other boards such as VIPER, BATMAN, MCS, RAD and SMRCC.

OBC will be responsible for powering, controlling, and monitoring the Fans & Temperature Sensors. It will be powering the fans using the 12V rail and controlling them through the use of Fan Controller ICs. It will be powering the Temperature Sensors using the 3.3V rail and gathering temperature data by using I2C.

OBC will control the status and error LEDs. There will be three lights to indicate the status of the rover:

- Red: autonomous operation
- Blue: teleoperation
- Flashing Green: successful arrival at a post or passage through a gate

OBC will have a yellow error LED which will communicate any errors when received from other boards/subassemblies in the rover.

OBC will also contain LoRa and GPS modules. The GPS module contains I2C and UART interfaces whereas the LoRa module contains only SPI. Since they are RF modules, they will have their own power source. The GPS sensor must always be on as to not lose its data, therefore it will always be powered using a coin cell battery.

The EEPROM chip will be programmed to store the CAN address of OBC.

There is an onboard IMU used to determine the rover acceleration, tilt, etc. at any point in time. It will also allow for the connection to an external one.

6.1 Teensy Pinout

Pin Number	Function	Notes
0	ALERT0 from TSB1	Timer: FlexPWM1.0, Refer to RD1
1	IMU Interrupt 2/MDRDY	Timer: FlexPWM1.0
2	LED for testing	
3	NC	
4	*MISC*	
5	*MISC*	
6	PWM for Fan 3	
7	NC	
8	ALERT2 from TSB2	Timer: FlexPWM1.3, Refer to RD1
9	ALERT3 from TSB3	Timer: FlexPWM2.2, Refer to RD1
10	SPI CS (LoRa)	
11	SPI MOSI	
12	SPI MISO	
13	SPI SCK	
14	PWM Control for LED1(1)	Timer: QuadTimer3.3
15	PWM Control for LED2	Timer: QuadTimer3.2
16	I2C SCL MASTER	MUX
17	I2C SDA MASTER	
18	PWM Control for LED3	Timer: QuadTimer3.1
19	PWM Control for LED4	Timer: QuadTimer3.0
20	UART TX	
21	UART RX	
22	*MISC*	
23	IMU Interrupt 1	Timer: FlexPWM_4.1
24	ALERT1 from TSB1	Timer: FlexPWM1.2, Refer to RD1
25	*MISC*	
26	GPS Timepulse	
27	GPS Extint	
28	NC	
29	NC	
30	CAN RX	
31	CAN TX	
32	NC	
33	*MISC*	
34	LoRa RXEN	
35	LoRa TXEN	
36	*MISC*	
37	*MISC*	
38	*MISC*	
39	LoRa BUSY	
40	LoRa NRST	
41	*MISC*	

(1) The PWM signals are created by hardware timers. PWM pins common to each timer always have the same frequency, so if you change one pin's PWM frequency, all other pins for the same timer change.

6.2 I2C Addressing

IC	Address	Notes
IMU	1101011b To read: 11010111 (0xD7) To write: 11010110 (0xD6)	The address of the slave is in the first 7 bits and the eighth bit tells whether the master is receiving data from the slave or transmitting data to the slave
GPS	0x42 1000010	I got this from line 430 of this code. I could not find it in the datasheet or integration manual.
EEPROM	101011(A8)b To read: 101011(A8)1 To write: 101011(A8)0	
Fan Controller	Controller1: 0101110(R/W) Controller2: 0101100(R/W) Read:1 Write:0	Address is configurable based on value of resistor present at pin 4. The fan controllers use SMBUS communication.
I2C MUX	11100001 (read) 11100000 (write)	