SOMAIYA
VIDYAVIHAR
K J Somaiya Institute of Technology
(Formerly known as K J Somaiya Institute of Engineering and Information Technology)
An Autonomous Institute Permanently Affiliated to University of Mumbai.

BeliefSat-0

Interface Control Document

Revised Version	Release Date	Change Record	Effective Pages
1.0	25/08/2023	Proposal Submission	12
2.0	27/09/2023	Removal of Camera because of tumbling Platform	12
3.0	05/10/2023	i) Dimensions Changes ii) Addition of Temperature Measure Unit iii) Addition of Short Circuit Protection And Reverse Polarity Protection	18
4.0	18/10/2023	Change in Fuse	18
5.0	01/11/2023	Addition of Frequency Band Details in Design Description	19
6.0	02/11/2023	Typographic mistake in the description of telecommands in Table 1 has been corrected. Frequency Bandwidth changed from 25KHz to 12.5KHz	19

Revision no.	Approval			
	Prepared by	Reviewed by	Verified by	Approved by
6.0	Dhriti Kothari Team Member Student, KJSIT	Sheetal Popat Team Manager Student, KJSIT	Dr. Umesh Shinde Dean, Research Development and Consultancy, KJSIT	Dr. Suresh Ukarande Principal, KJSIT

1. Introduction

1.1 Overview

BeliefSat-0 is developed by students of K. J. Somaiya Institute of Technology to widen the reach of Amateur Radio-operators around the globe. The payload is a part of tribute to 100 years of Amateur Radio in India and meant to be in service to the Amateur radio community worldwide. The payload will perform UHF to VHF FM Voice Repeating and APRS Digipeating on VHF.

1.2 Document Purpose

The interface specifications of Payload are detailed in the document that follows. It provides comprehensive details on the mechanical and electrical interfaces in addition to other important information about the payload.

It will have the following amateur radio payloads onboard:

1. Amateur Band FM voice repeater with 12.5 KHz max bandwidth and 12.5 KHz channel spacing. 67.0 Hz CTCSS tone for uplink.
2. VHF APRS Digipeater with 71.9 Hz CTCSS tone on the uplink.

2. Payload Overview

2.1 Design Description

Payload is developed by students and the Faculty of K. J. Somaiya Institute of Technology to widen the reach of Amateur Radio-operators around the globe with VHF/UHF FM Voice Repeater and APRS Digipeater.

2.1.1 Operational Mode

The operational modes of the payload are:

1. Safe mode (initial mode) : Telemetry once every 30 seconds
2. Digipeater only mode :Telemetry once every 60 seconds and digipeater functionality active
3. Full function mode : Telemetry once every 60 seconds, both digipeater and voice repeater active

Table 1 : Commands for operation mode

Sr. No.	Commands	Description
1.	!MODE_CHANGER@<ModeNumber>	Changes mode between 0,1,2
2.	!VHF_RX_FREQ_CHANGER #<FREQUENCY>	Changes RX frequency of VHF
3.	!VHF_TX_FREQ_CHANGER %<FREQUENCY>	Changes TX frequency of VHF

Note: Detailed command and telemetry formats would be published during frequency coordination

2.1.2 Frequency Bands

	VHF Band	UHF Band
Application	Telemetry, Telecommand, Digipeater uplink, Digipeater downlink, Voice Downlink	Voice Uplink
Frequency Range	144-146 MHz	435-438 MHz
Desired Central Frequency	144.2500 MHz	437.0000 MHz
Bandwidth	12.5 KHz	12.5 KHz
Modulation	FM and AFSK over FM	FM
Encoding	APRS over AX.25 using NRZI line coding and AFSK digital Modulation	No Encoding
Transmitting Power	1W	No Transmit only receive
Area of Operation	Global	Global
Special consideration:	| 3 * VHF Frequency - UHF Frequency | >= 1.5 MHz to prevent feedback loop	

2.1.3 RF Duplexer Design

Payload has two filter circuits which are HPF (high pass filter) and LPF (low pass filter).

1. High Pass Filter (HPF): This filter allows UHF signals to pass through while blocking VHF signals. By placing an HPF between the DRA818U transceiver and the antenna, it isolates the UHF signals associated with this transceiver from the other.

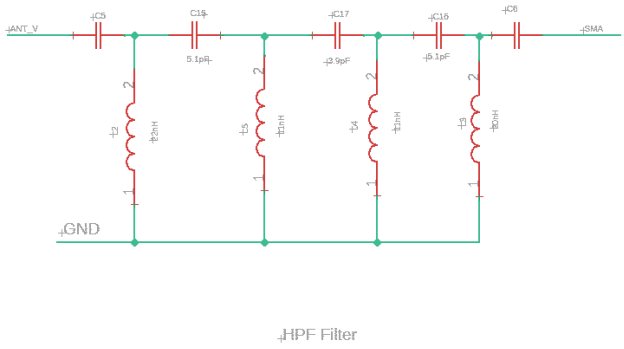

Fig. 1:High Pass Filter (HPF)

2. Low Pass Filter (LPF): Conversely, an LPF allows VHF signals to pass through while blocking higher-frequency signals. Placing an LPF between the other DRA818 transceiver and the antenna, this helps to isolate the lower-frequency signals associated with that transceiver.

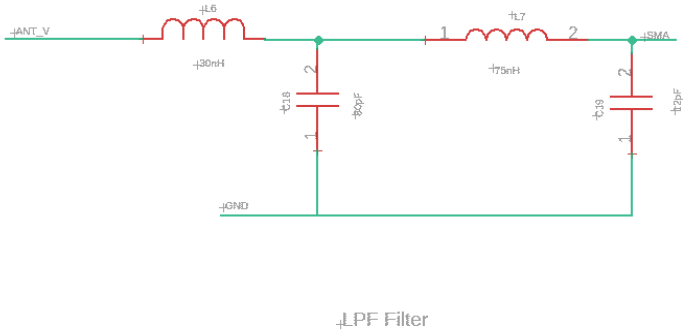

Fig. 2: Low Pass Filter (LPF)

2.1.4 Power Circuit Design:

As per the interface specifications outlined for POEM experimental payloads, the power supplied falls within the range of 24-36 volts in its raw form. To meet these requirements, we have integrated an LM2575S DC to DC buck converter into the system. This converter efficiently transforms the input power into a stable voltage of 3.3 volts while delivering a maximum current output of 2 amperes.

In the implementation of this specific buck converter, two essential protective components have been incorporated. Firstly, a 500mA 125V DC fuse (datasheet included in references) is included to prevent short-circuits effectively. Secondly, a Schottky diode has been employed to ensure reverse polarity protection.

Please refer the provided image below:

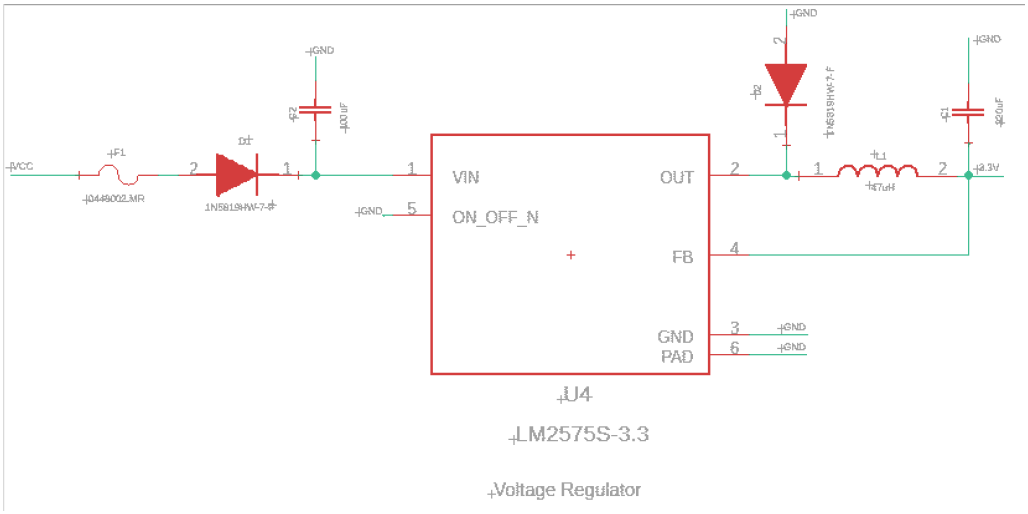

Fig. 3: Power Circuit Design

2.1.5 Temperature measurement unit:

Payload consists of two thermistors (Thermistor 100k NTC) to measure the internal circuit temperature and body temperature. To measure the body temperature one thermistor is fixed to the body using kapton tape and another one fixed on the electronic circuit to measure the circuit temperature.

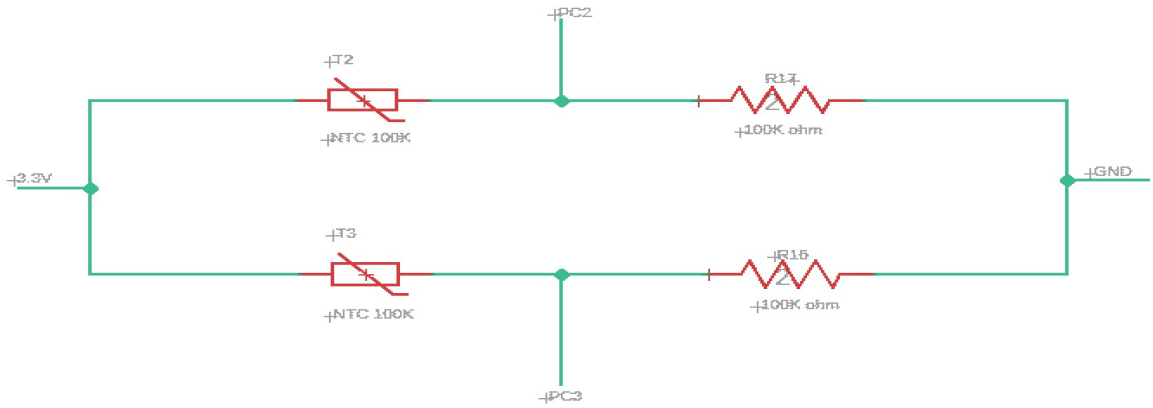

Fig. 4: Temperature measurement unit

2.2 General System Requirements

1. The system includes the necessary electrical and mechanical interfaces with respect to the Launch Vehicle specifications.
2. The payload should be securely connected with the launch vehicle, and is required to receive a continuous power supply within the range of 24V-36V(raw) throughout the entire duration of journey.
3. The payload does not need telemetry and telecommand (TM and TC) requirements from the launch vehicle. Therefore, no communication is required from the platform, except for power supply.

2.3 Payload Design Parameters

ID	Parameter	Unit	Specification
Mechanical			
1.	Maximum Estimate Mass of the payload	g	500
2.	Payload Volume(Excluding Antenna)	mm^3	150x118x34
3.	Payload Volume (Including Antenna)	mm^3	150x118x512
4.	Antenna Length (Nagoya NL-770S VHF/UHF High Gain Mobile Antenna)	mm	480
5.	Payload mechanical interface		6x M5 HEX steel bolt
Electrical			
6.	Payload electrical interface	-	On Payload: M24308/23-25F D-Sub Mil Spec Connectors R/A RCP ASSY 9 POS SER 109 (Refer Appendix B for pictorial information) From Platform: The expected connection is a male DB9 D-sub connector (9 Pin)
7..	Power requirement from PS4-OP	-	Nominal: 2 W Peak: 10 W

2.4 Coordinate System:

The coordinate system of the payload can be seen in the figure below. The base of the payload is in the XY plane and the antenna is along the Z-axis.

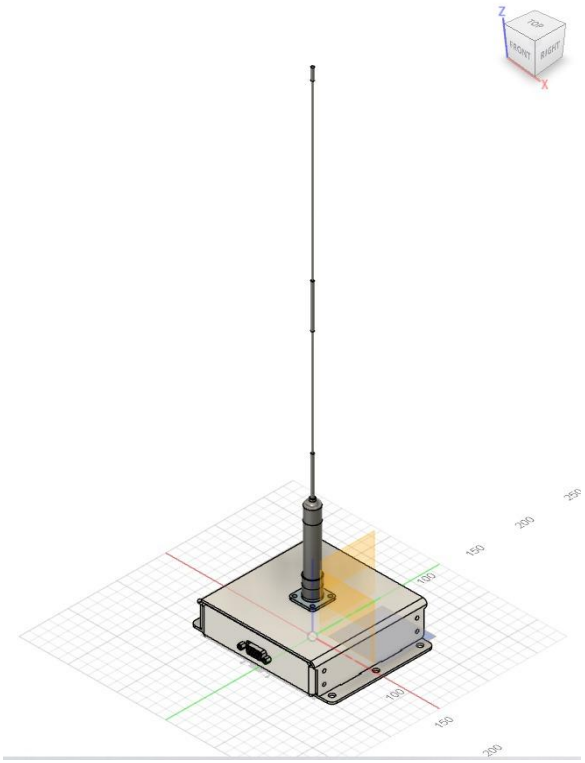

Fig. 5: Coordinate system

3. Physical Interfaces

3.1 Mechanical Interfaces

i) The external structure is constructed using Aluminum 8011. The payload is to be mounted on the platform with the help of 6 x M5 HEX steel bolts (See *Fig. 4*).

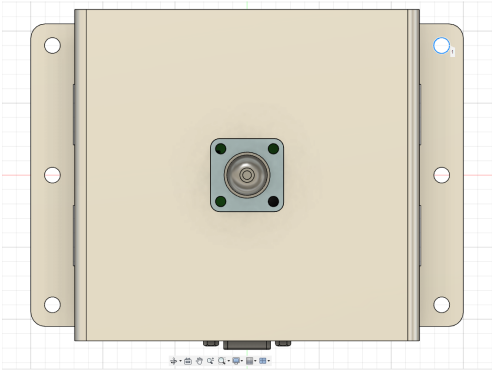

Fig. 6: 6 M5 holes for mounting

ii) The distance between the center of the mounting hole to the side- wall of the payload is 7.75 mm (See *Fig. 5*).

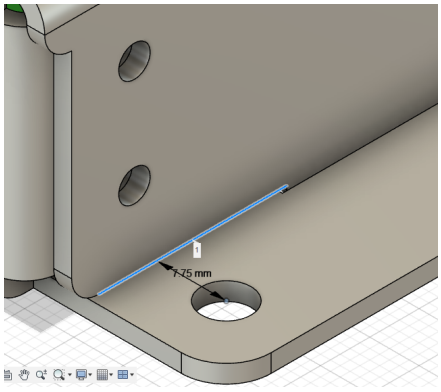

Fig. 7: Side-wall to mounting hole dimension

iii) Thermal insulating sheet, typically made from material like PEEK, is employed to separate the base from the platform.

3.2 Mass properties

Mass, Moment of Inertia and Centre of Mass information is provided in the table below. The values are provided for reference purposes only and it can be used as a baseline input for initial sizing calculations. The following assumptions were taken to generate mass properties:

1. The Moment of Inertia given in the table below is given with respect to the Centre of Mass as well as the Origin position.

Parameter		**Value**
Mass (g)(Approx.)		500
Centre of Mass (mm)	$X\ (mm)$	-2.324
	$Y\ (mm)$	-2.309
	$Z\ (mm)$	27.299
Moment of Inertia (At Centre of Mass) $(g\ mm^2)$	Ixx	1.995×10^6
	Iyy	2.027×10^6
	Izz	1.318×10^6
Moment of Inertia (At Origin) $(g\ mm^2)$	Ixx	2.563×10^6
	Iyy	2.595×10^6
	Izz	1.327×10^6

4. Electrical Interface

4.1 Payload - Launch Vehicle Interface

The interface connector details are provided in the table given below:

CONNECTOR TYPE	D-sub 9 Pin Connector
On payload	RECEPTACLE-TYPE (female) (Refer **Appendix B** for pictorial information)
On Launch Vehicle	PIN-TYPE (male)
Location	On the side plate, which is situated in the XZ plane (along negative Y axis)

4.2. The pinouts of DB-9 connector are given in the table below (we require only VCC and GND from the platform):

Pin Number	Name	Description
1	TX_VHF	NC
2	RX_VHF	NC
3	TX_UHF	NC
4	RX_UHF	NC
5	**GND**	**Ground**
6	RESET_DB9	NC
7	TX_DB9	NC
8	RX_DB9	NC
9	**VCC**	**Power Supply**

The schematic diagram of the DB -9 connector is given in Appendix C (Electrical Interface Schematics).

5. Appendix A: Overall dimensions of Payload

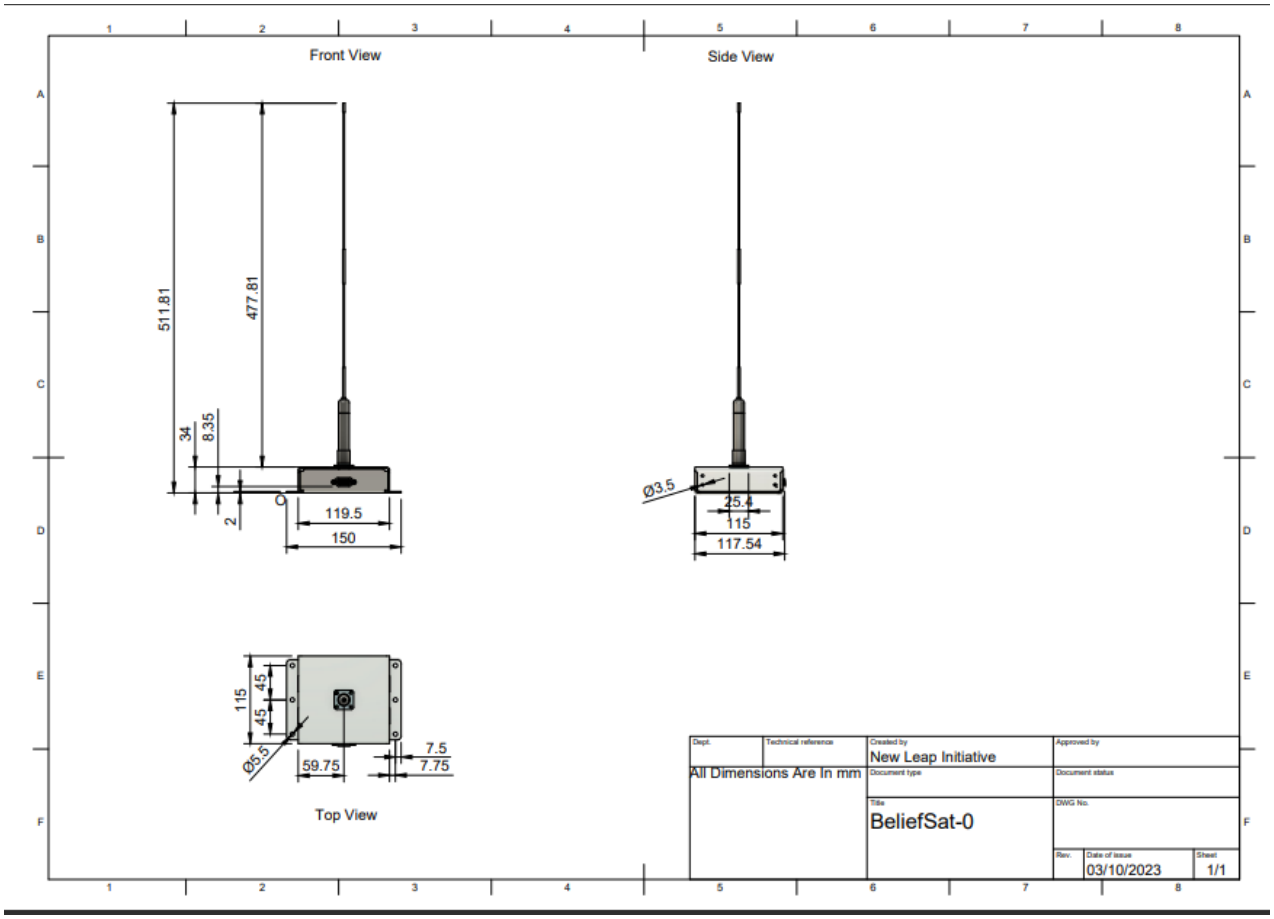

Fig. 8: Dimensions of Payload (in mm)

6. Appendix B: Overall dimensions of Connector Used For Electrical Interface

Fig. 9: M24308/23-25F D-Sub Mil Spec Connectors

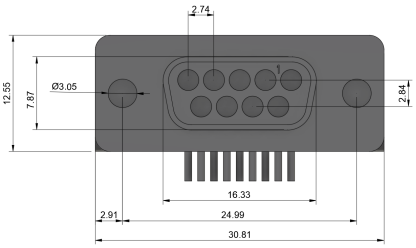

Fig. 10: DB9 Connector Dimensions

The base of the DB9 connector is positioned at a distance of 10.24 mm above the payload base, while the screws are situated 14.19 mm above the payload base.

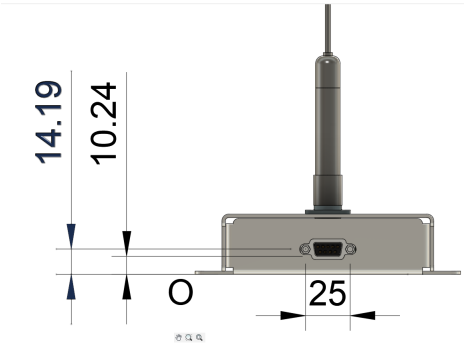

Fig. 11: DB9 Connector Location on Package

7. Appendix C: Electrical Interface Schematics

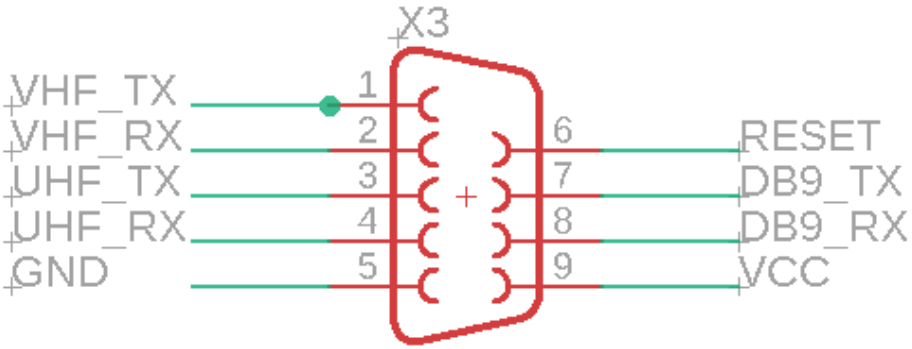

Fig. 12: DB9 Connector Schematic

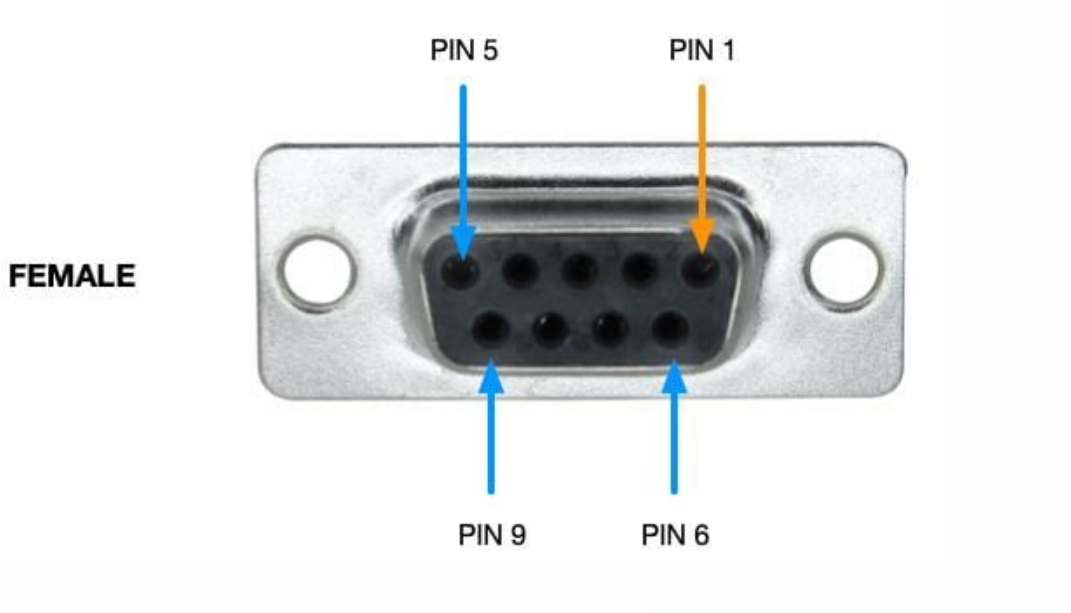

Fig. 13: DB9 Connector Pin Locations

8. References :

i. Microcontroller datasheet (Atmega328P-PU)
https://www.mouser.in/datasheet/2/268/ATmega48A_PA_88A_PA_168A_PA_328_P_DS_DS40002061B-3050139.pdf

ii. DC to DC Buck Converter (LM2575S IC REG BUCK 3.3V 2A TO263-5L)
https://mm.digikey.com/Volume0/opasdata/d220001/medias/docus/5011/LM2575-LM2575HV.pdf

iii. Fuse (LITTELFUSE 0451.500MRL)
https://drive.google.com/drive/folders/1YPhIgdw0xbcl2YF_EygH_6NI25DQiTfl

iv. Schottky Diode (DIODES INC. 1N5819HW-7-F)
https://in.element14.com/diodes-inc/1n5819hw-7-f/diode-scky-recti-1a-40v-sod123/dp/1773475

v. DB9 connector (M24308/23-25F)
https://www.mouser.in/datasheet/2/418/8/TYEL_S_A0000703600_1-2524337.pdf