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DOCUMENT NAME: DESIGN DESCRIPTION, RPi 4DIO UPS BOARD.	

DESCRIPTION DOCUMENT FOR *RPi 4DIO UPS BOARD*
HARDWARE REVISION 0.4

Department	Name	Signature	Date
Author			
Reviewer			
Approver			

Revision History

Rev	Description of Change	Effective Date
A	Initial Release with hardware release version 0.1	20/JAN/2018
B	Hardware release version 0.2	15/JUN/2019
C	Hardware release version 0.3	15/DEC/2019
D	Hardware release version 0.4	15/JUN/2020

ABSTRACT:

This document is a detailed product description that describes the effective features of the product. It includes a functional hardware description of the product with its internal block diagram and product images.
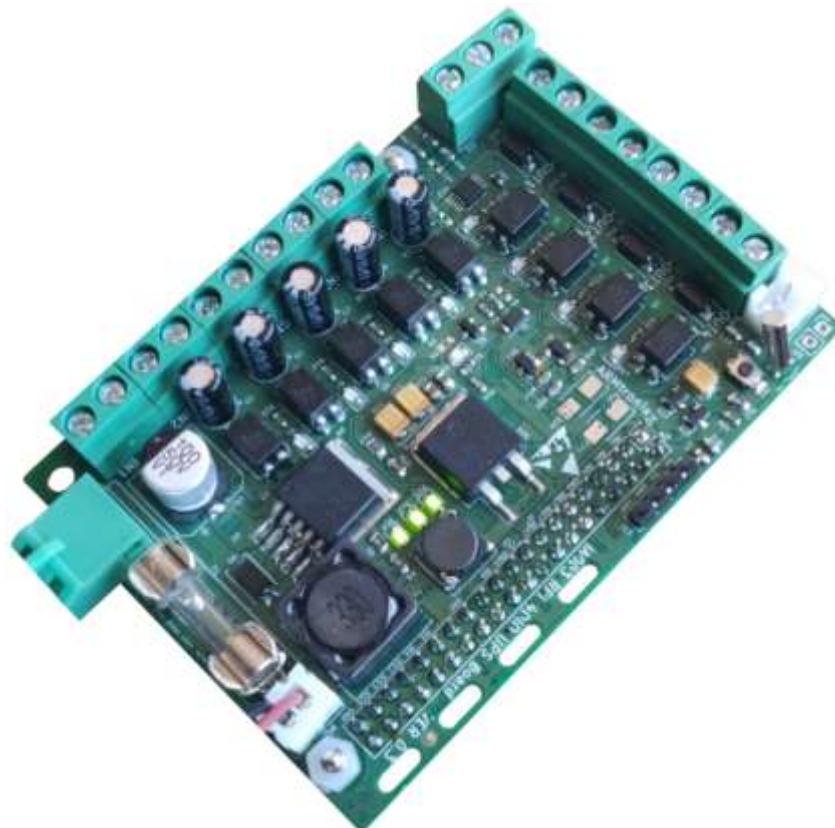
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1. ABBREVIATIONSS

Term	Description
AC	Alternating Current
DC	Direct Current
DGND	Digital Ground
GPIO	General Purpose Input Output
MCU	Microcontroller Unit
Li-Po	Lithium Polymer
PCB	Printed Circuit Board
RPi	Raspberry Pi
RTC	Real Time Clock
UPS	Un-interruptible Power Supply
V	Volts

2. REFERENCES

Company Weblink	https://www.armtronix.in
Youtube Weblink	https://www.youtube.com/channel/UCr3QNs65jDSxKDX4QPc03oQ
Intractable's Weblink	https://www.instructables.com/member/Armtronix/
Github's Weblink	https://github.com/armtronix

3. PURPOSE

The purpose of this document is to outline the design description for the RPi 4DIO UPS BOARD. It provides a high-level summary and technical specification of the product.

4. SCOPE

This document describes system architecture which includes Buck converter, Analog Inputs, Isolated Inputs Isolated Outputs, Li-Po Charger and RTC.

5. SAFETY AND WARNING

If you are working with DC power or batteries, please take necessary precautions. Do not short the positive and negative terminals of the power supply, as it may damage the Hardware and may create hazardous to your health. Do not bring AC power in contact with this board, which will damage the hardware and may create hazardous to your health. Please consider disconnecting power supply from the board if you would like to make any changes in connections. Working without safety towards hardware is not advisable.

Fire Hazard: Making wrong connections, drawing more than rated power, contact with water or other conducting material, and other types of misuse/overuse/malfunction can all cause overheating and risk starting a fire. Test your circuit and the environment in which it is deployed thoroughly before leaving it switched on and unsupervised. Always follow all fire safety precautions.

6. PRODUCT FEATURES

- Operates with standard DC power 12V DC - 24V DC.
- On board 24V to 5V converter to power on pi directly.
- Stack-up or FRC compatible for Raspberry Pi.
- Real Time Clock.
- Analog Inputs - 3
- Isolated Digital Inputs – 4
- Isolated Digital Outputs – 4
- Four Input and Four Output Terminal Blocks.
- Two Common Ground Terminals Block for sensor Ground connection.

7. PRODUCT DESCRIPTION

a. PHYSICAL DESCRIPTION

- ➢ Buck Converter
- ➢ Boost Converter
- ➢ Isolated Digital Inputs
- ➢ Isolated Digital Outputs
- ➢ Analog Inputs
- ➢ Real Time Clock

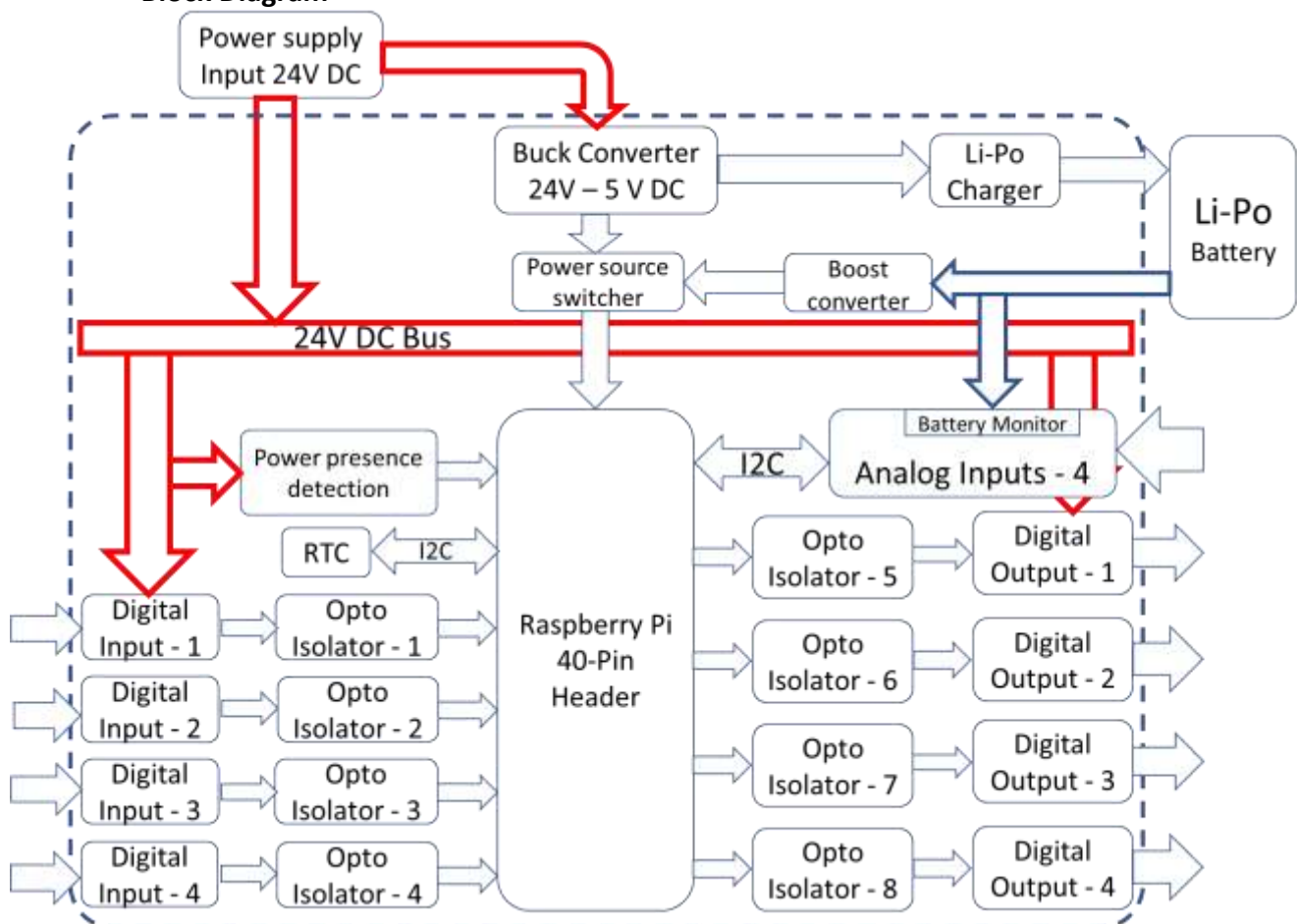### b. FUNCTIONAL DESCRIPTION

Block Diagram

Figure 1: Block Diagram

8. **Description:**

This device is made specially for Raspberry Pi, it functions as UPS to pi. It can take 12-24V DC wide range of power input and regulates it to required voltage for raspberry pi, that means user can use industry standard 24V DC to powerup the Pi using this board. It also has li-po/li-ion charger on-board to charge a single Li-Po/li-ion cell, the same can act as power backup to Pi. It has special feature of RESTART button onboard and also can be connected using RMC externally. It has few salient features like mains power input presence detection and battery voltage monitoring. It has an RTC with its dedicated button-cell to help logging data with time stamp for the purpose of analysis.

The main advantage of this board is, along with its UPS feature it also has a special circuit to auto reboot the pi when in ups mode in case of mains power recycle.

Example scenario:

Consider you are using Raspberry Pi for your industrial automation application and powered it using external power source via 24VDC to 5VDC pi-hat.

Problem-1: If the power fails randomly or abrupt disconnection of power by user, then the OS or other files of Pi may be corrupted due to this, your stored data may be lost and system will call for maintenance. To bring back the system to normal state, a new memory card has to be bought, new image has to be loaded, which may consume sufficient amount of your precious time as well as money on redoing this again and again.

Problem-2: If pi is in turned off condition and power supply is present due to any reason, the power source has to be plugged out and connected back to boot/reboot.

Solution: To solve the above stated problems, we have come up with this hardware which acts as UPS to the pi, so that you can save the data and softly auto shutdown the pi, in case of mains power failure. Even though the power via battery is present due to UPS feature, it will reboot the pi, if power returns and it will continue its task and user need not to worry of manually power booting.

This board comes in 2 variants mentioned below. Variant can be chosen while purchasing based on your application and planned way of implementation. It has 4 isolated digital inputs to monitor 4 digital sensors, has 4 isolated digital outputs to control 4 digital outputs like relays and 3 analog 4-20mA current inputs. All the inputs and outputs can be monitored and controlled simultaneously.

Board has 2 variants as mentioned below:

1. Variant 1

   Board with suitable special 40Pin male-female header soldered from the bottom side of the board to stack up on Raspberry Pi. So that user can directly plug it on to Pi and use it for their application. Will need less space (length or width) but more height or depth.

2. Variant 2

   Board with 40 Pin Male header and respective FRC with box header to connect with Raspberry pi, instead of stack up. This will be useful where users cannot stack up on to Pi, they opt for this option. This variant connection will need more space (length or width) but less height or depth.

9. SYSTEM OVERVIEW

1. Buck Converter:
   The DC-DC converter on board is used to regulate voltage from 24 V DC to 5 V DC to supply power to Raspberry-Pi.

   The main power input 24V DC supply is also used to provide limited power to isolated outputs.

2. Boost Converter:
   This board can be powered ON using external Li-Po battery. Pi works on 5V DC whereas we get only 4.2 V maximum from Li-Po battery. To convert this li-po battery output to required supply voltage for Pi, this booster circuit is included in this board. The booster we have used in this product is MT3608, it can boost battery output to required power for Pi.

3. Li-Po Battery Charger:
   This boards contains single-cell fully integrated Li-Ion/Li-Po charge management controller. It employs Constant-current/constant voltage charge algorithm. This charger can pump charge to Li-Ion or Li-po battery at the maximum rating of 500mA of current.

4. Isolated Digital Inputs – 4 Numbers:
   There are four number of optically isolated inputs given accessible to user to monitor sensors or read any digital inputs with voltage level between 12V DC – 24V DC. The optical isolation is used to protect the hardware from any electrical hazardous at/from external interfaces to the board like sensor push buttons or any other respective inputs. Refer to Table-2 for GPIOs used for Digital Inputs.

5. Isolated Digital outputs – 4 Numbers:
   There are four number of optically isolated outputs given accessible to user to control low power consumption loads with voltage level between 12V DC – 24V DC. The optical isolation is used to protect the hardware from any electrical hazardous at/from external interfaces to the board like solenoids, relays or any other respective outputs. Refer to Table-2 for GPIOs used for Digital Outputs.

6. Analog Inputs – 3 Numbers:
   As mentioned above, this board also supports for Analog input measurement for monitoring sensors with analog output from 4-20mA DC. The ADC used in this board is ADS1115 from Texas Instruments. Communication between Pi and this ADC is I2C. AIN0 ADC is used for Li-Po battery voltage monitoring purpose. Remaining 3 AINs are given access user to read 4-20mA DC current input. For more information on this ADC, please refer to it technical datasheet from its manufacturer at http://www.ti.com/lit/ds/symlink/ads1115.pdf

7. Real Time Clock.
   Real Time Clock on this board is DS1307 from Maxim Semiconductor. Communication between Pi and this RTC is I2C. CR1220 button cell holder is given on the board for ease of installation of RTC battery. For more information on this RTC, please refer to it technical datasheet from its manufacturer at https://datasheets.maximintegrated.com/en/ds/DS1307.pdf.

10. TECHNICAL SPECIFICATION

a. ELECTRICAL SPECIFICATION

Input Specifications				
Description	**Min**	**Typ**	**Max**	**Unit**
Voltage DC	3.3	5	5.5	Volts
Current DC (Standby)	-	10	-	uAmps

Isolated Outputs Specifications (Maximum)				
Description	**Min**	**Typ**	**Max**	**Unit**
Voltage DC	-	-	24	Volts
Current DC	-	-	0.3	Amps
Power DC	-	-	0.72	Watts

Isolated Inputs Specifications (Maximum)				
Description	**Min**	**Typ**	**Max**	**Unit**
Voltage DC	-	-	24	Volts
Current DC	-	-	0.03	Amps

Li-Po Battery Specification				
Description	**Min**	**Typ**	**Max**	**Unit**
Voltage DC	-	-	4.2	Volts
Current DC	2000	-	3000	mAh

RTC Battery Specification				
Description	**Min**	**Typ**	**Max**	**Unit**
Voltage DC	-	-	3	Volts

b. MECHANICAL SPECIFICATION

- Mechanical Dimensions of PCB are 85 x 60 x 12 mm (Length x Width x Height)
- For more details on dimension of the board shown in figure 2.
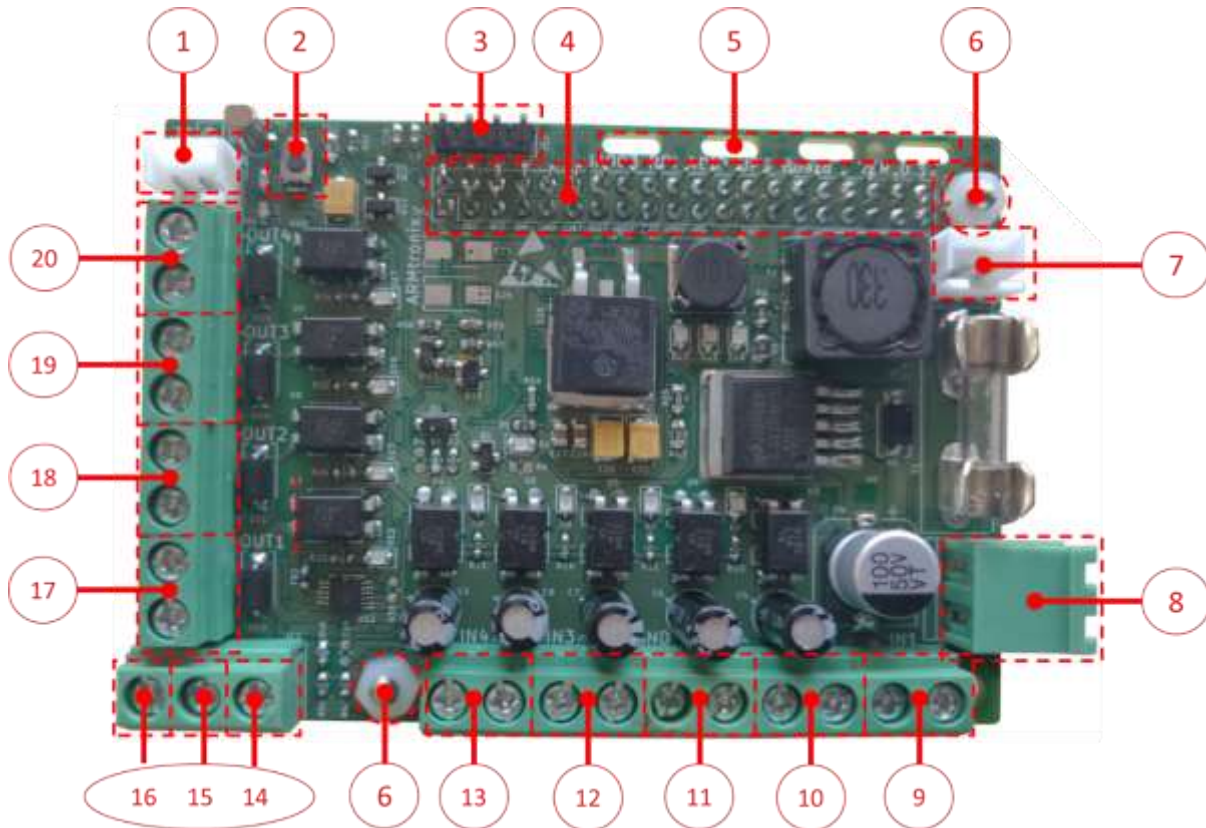
11. ELECTRICAL CONNECTIONS

Figure 2: Header Details

Description of Headers shown in Figure 3:

1. BT1   RTC Battery Connector
2. SW1   RESTART switch
3. J13   External display power supply 5V DC header
4. J11   Raspberry Pi Compatible header.
5.   Battery tie notches
6.   Mounting hole
7. BT2   Connector for 1-cell Li-Po Battery.
8. J2   24 V DC power Input supply connector to board.
9. J3   Digital Input -1
10. J4   Digital Input -2
11. J1   GND
12. J5   Digital Input -3
13. J6   Digital Input -4
14. AIN-1   Analog Input -1
15. AIN-2   Analog Input -2
16. AIN-3   Analog Input -3
17. J7   Digital Output -1
18. J8   Digital Output -2
19. J9   Digital Output -3
20. J10   Digital Output -4
21. J15   Connector for external RESTART Switch or jumper for auto reboot.
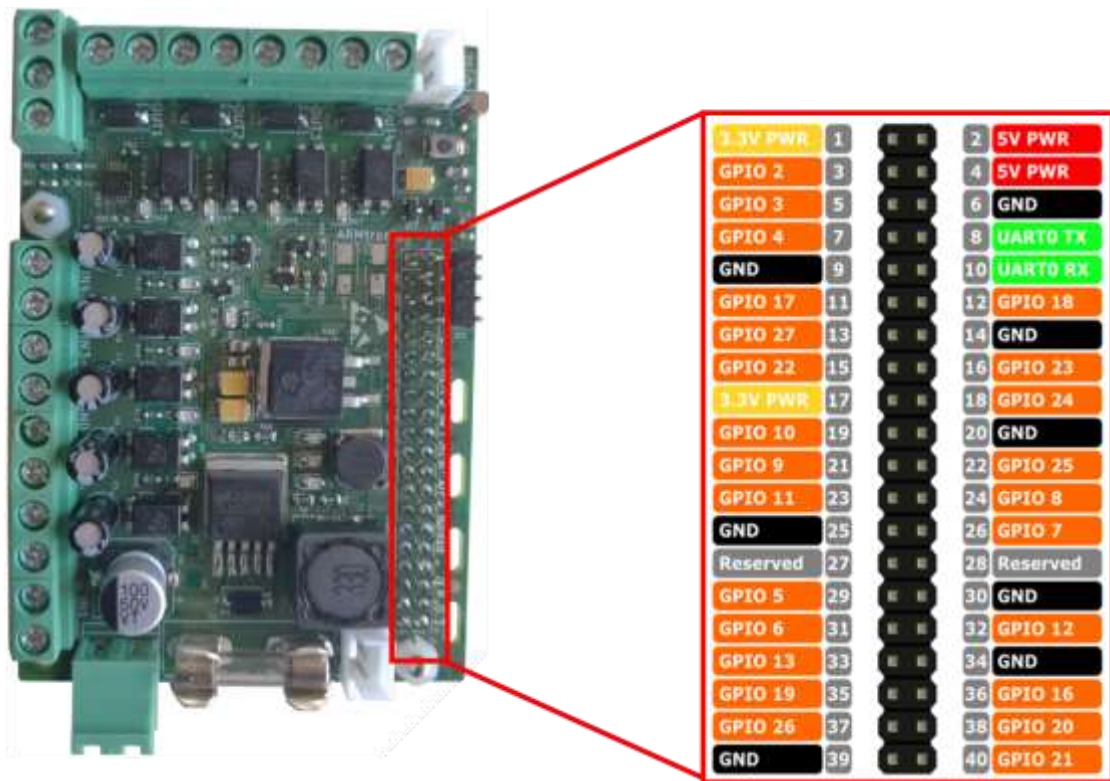
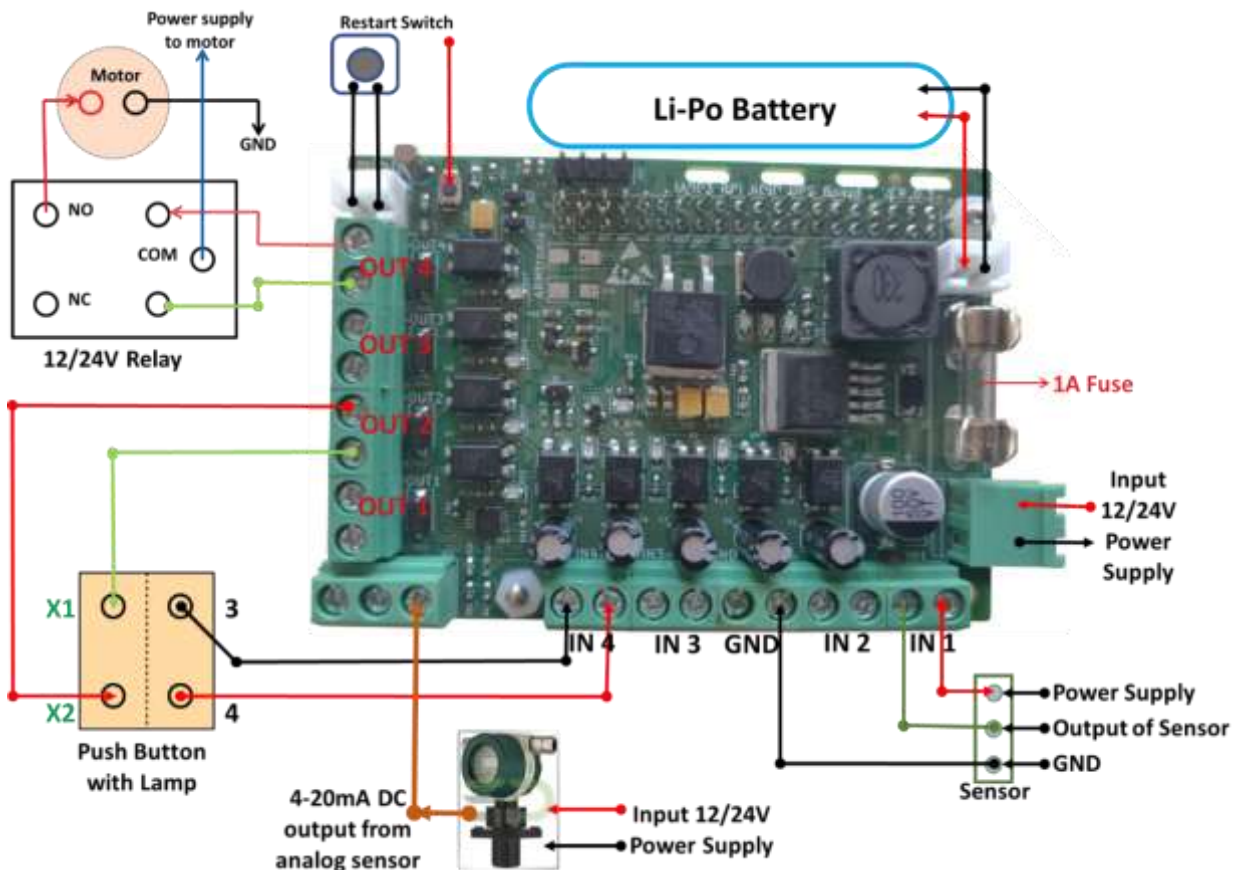**Figure 3: Header Pin number references**

Figure 4: Example Application Diagram

a. HEADER PIN CONFIGURATION

i. HEADER J2

Header Pin Number	Pin Name
1	DC GND / 0V
2	24V

Table 1: DC Input power supply Connector

ii. DIGITAL INPUTS

Description	Pin Name	RPi Header Pin #
DIN-1	GPIO26	37
DIN-2	GPIO19	35
DIN-3	GPIO13	33
DIN-4	GPIO6	31

Table 2: Digital Inputs GPIO Configuration

iii. DIGITAL OUTPUTS

Description	Pin Name	RPi Header Pin #
DOUT-1	GPIO22	15
DOUT-2	GPIO27	13
DOUT-3	GPIO17	11
DOUT-4	GPIO4	7

Table 3: Digital Outputs GPIO Configuration

iv. ANALOG OUTPUTS

Description	ADS1115 Pin Name
AIN - 1	AIN1
AIN - 2	AIN2
AIN - 3	AIN3

Table 4: Analog Inputs ADC Pin configuration

v. UPS BATTERY CONNECTOR

Header Pin Number	Pin Name
1	Battery +ve
2	Battery -ve

Table 5: UPS Battery Connector

vi. UPS BATTERY CONNECTOR

Header Pin Number	Pin Name
1	Battery +ve
2	Battery -ve

Table 6: UPS Battery Connector

vii. LED STATUS

LED D1	LED D18	LED D23	Power Supply	Battery
OFF	ON	ON	PRESENT	PRESENT
OFF	OFF	ON	PRESENT	LOW/ABSENT
OFF	OFF	ON	PRESENT	LOW/ABSENT
ON	ON	ON	LOW/ABSENT	PRESENT

- RTC backup battery should be of 3V DC.

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