Dagozilla Electrical and Software Description 2022

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Abstract. In order to participate in the 2022 RoboCup Middle Size League (MSL), **Dagozilla** designed and manufactured a new generation of MSL robots. This paper covers the electrical systems used in the robots and also the software architecture implemented in the robots' system. The electrical systems described in this paper are the power distribution system, locomotion system, dribbler system, kicker system, hardware interface, inertial measurement unit, and expanding system.

Keywords: Middle-size League, RoboCup.

1. Electrical System Overview

The electrical system which the new Dagozilla MSL robots utilize is an improved version from the last generation. The new improvements of the system are the brand new user interface, standalone rotary encoders, and keeper robot's expanding system. The primary computing unit of Dagozilla MSL robots is a custom-built personal computer. The computing unit controls decision-making and environment sensing. A camera is connected to the PC to gather complete information about its surroundings regarding the robot's position and attitude, line detection, ball position, and other robot's position. A Logitech C922 webcam is implemented for this purpose. The microcontroller in this robot handles the interfacing between the PC, sensors, and actuators. For attacker robots, there are four locomotion brushed DC motors, two dribbling mechanisms, brushed DC motors, a kicker system servo, and a solenoid kicker system. The sensors used in the robots are a camera, three standalone rotary encoders, an infrared sensor, and an inertial measurement unit (IMU). The electrical system diagram of the Dagozilla MSL attacker robot is shown in Fig. 1. As for the goalkeeper robot, the actuators are four locomotion brushed DC motors and three stepper motors that are used in expanding mechanisms. The sensors used are a camera, a front additional camera, and an inertial measurement unit (IMU). The electrical system diagram of the Dagozilla MSL attacker robot is shown in Fig. 2.

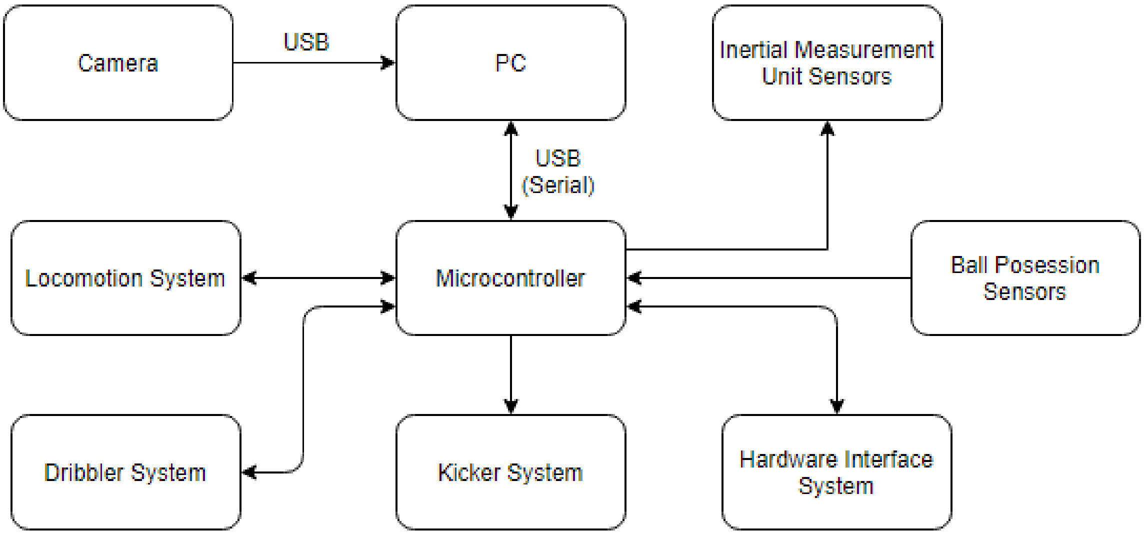


Fig. 1.Attacker Robot Electrical Systems Diagram

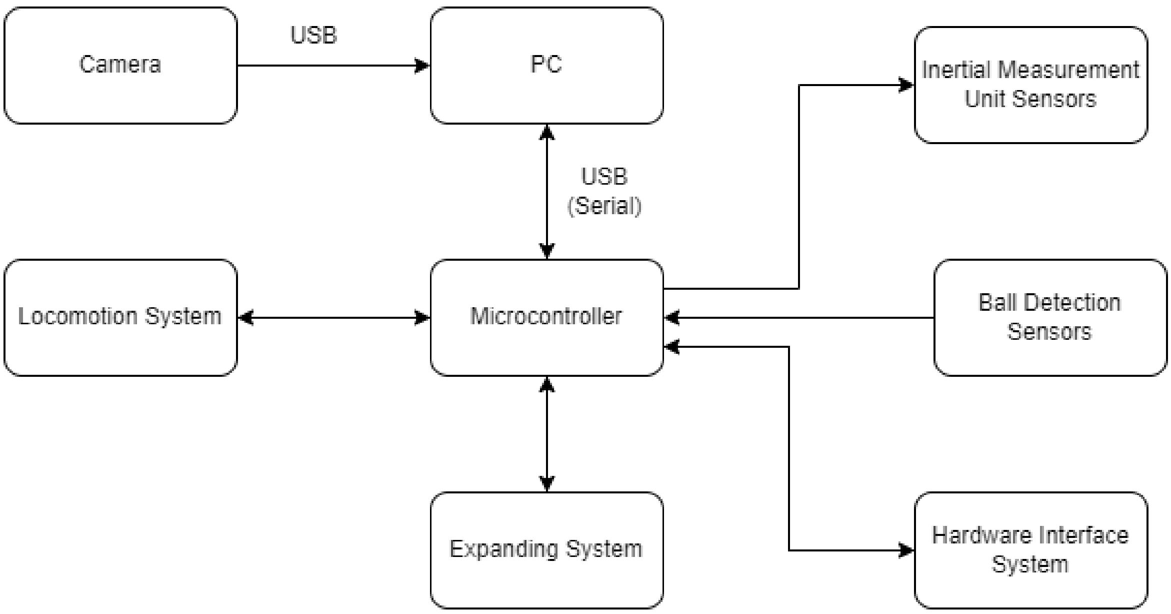


Fig. 2. Goalkeeper Robot Electrical Systems Diagram

2. Microcontroller System

The microcontroller board is a home-designed PCB with STM32 Nucleo F767ZI development board for outfield player robots and an STM32 Nucleo F446RE development board for the goalkeeper robot as the microcontroller. The core of the low-level control of this robot is served by the microcontroller board. This board directly connects the development board pins with the peripherals that consist of actuators and sensors. In order to reduce the amount of cable utilized, microcontroller, locomotion, encoder, and dribbling system boards are merged. Appendix A. Fig. 1 shows the outfield robot schematics and Fig. 2 shows the goalkeeper's schematics.

3. Kicking System

The design of the kicking system board revolves around controlling the charge-discharge cycle of the kicking system. It also provides high-voltage protection to the rest of the robot's system. The voltage booster, the capacitor set, the solenoid, and the control circuit connected to the board unite as the whole kicking system. Two parts that are controlled by the kicking system are the capacitor discharge time and the kicking mode. Discharge time control allows the robot to control its kicking power. The kicking mode decides the purpose of the kick (shooting or passing). In order to kick, input high from the main system board is sent to the kicker board. This input will activate the diode that will allow current to flow through solenoid. This current produces a magnetic field that will repel the plunger.

The electrical schematic of capacitor discharge's circuit is shown in Appendix A, Fig. 3, while the kicking mode control is integrated with the main system board (Appendix A, Fig. 1).

4. Locomotion and Encoder System

For the locomotion system, four RS775 with 1:13.9 planetary gear are used together with BTS7960 IBT-2 motor drivers. Each motor has an encoder attached. This robot also uses a standalone rotary encoder. It is used to improve the stability and minimize measurement error. For the goalkeeper, to enhance the modularity and so the electrical parts can fit more compactly, a locomotion and encoder system board is designed. This system board connects the pins from the microcontroller to the motor drivers, the motor encoders, and the standalone encoders. It also reduces the pin amount needed to drive the motor by using a not gate. The electrical schematics of this board can be found in Appendix A, Fig. 4.

5. Dribbling System

The dribbling system uses a pair of high revolutions per minute (RPM) RS775 brushed DC motors coupled with a bevel gear. Similar to the locomotion system, the dribbling system board incorporated in the main board connects the motors with the motor driver which are separated from the locomotion driver board.

6. Power Distribution System

The power distribution system board regulates the power flow from the LiPo batteries to each electrical component on the robot. This board also has fuses to secure the high-current electrical components from over-current. Furthermore, there are 7 LEDs as power flow indicators. To power the PC, two LiPo batteries connected parallel with diodes are used. This configuration is achieved by using a battery switching board. The electrical schematics of the power distribution system can be found in Appendix A, Fig. 5, while the electrical schematics of the battery switching board can be found in Appendix A, Fig. 6.

7. Hardware Interface System

The hardware interface system is aimed to simplify the process of gathering hardware state conditions from the main microcontroller and interfacing them using a Liquid Crystal Display and Pushbuttons. This board is expected to show the hardware conditions such as rotary encoder readings, IMU sensor readings, automatic WiFi PC setup, calibrating the IMU, and starting the motors for debugging purposes. This system is built using an LCD with some push buttons, communicating via I2C to the microcontroller.

8. IMU System

An IMU (Inertial Measurement Unit) board used as an intermediary between the orientation sensor and the microcontroller to obtain orientation data (and localization purposes) of the robot. This orientation data, concurrently with encoder data, is being processed in high-level software. The communication between the orientation sensor and microcontroller is using I2C protocol. The IMU sensor that is used in this system is the BNO055 9-DOF Absolute Orientation Sensor. The electrical schematics of this system can be found in Appendix A, Fig.7.

9. Robot Expanding System

To help the Goalkeeper robot at blocking incoming balls, a new expanding system is developed. Our expanding system utilizes 3 Nema17 stepper motors to move its arm in X-axis (2 motors) and Y-axis respectively. This stepper logic is controlled by Nucleo F446RE as its main controller, while also utilizing a separate stepper board to connect the stepper to the power. The electrical schematics of the stepper board can be found in Appendix A, Fig.8.

10. Software Architecture

The robot's software can be divided into 4 major processes: the vision system, world model, strategy, and control. There is also a process that handles the robot localization using Augmented Monte Carlo Localization method. These processes are implemented as packages, each consisting of several nodes, in a Robot Operating System (ROS) workspace. Each computing unit communicates with each other to share its respective local world model in order to build a distributed global world model as the source of truth for every robot. The communication between computing units is handled using a websocket communication protocol. The diagram of our software architecture can be seen in Appendix B, Fig. 9.

Appendix A Electrical System Schematics

This appendix contains the electrical system schematics or drawings that are used in each of our robots. The schematics start on the next page.

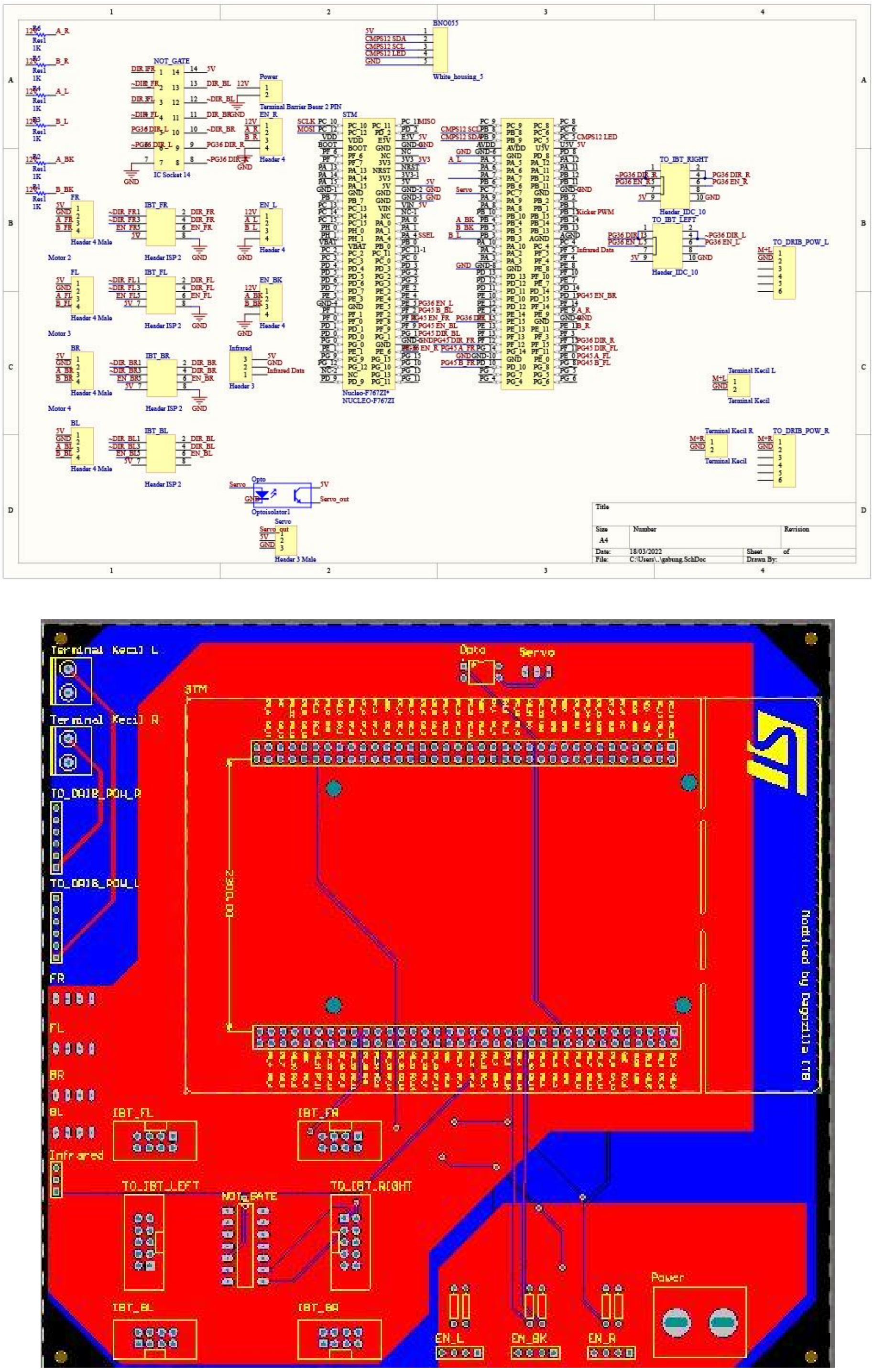


Fig. 1. Outfield Player Robot Main Board Schematic

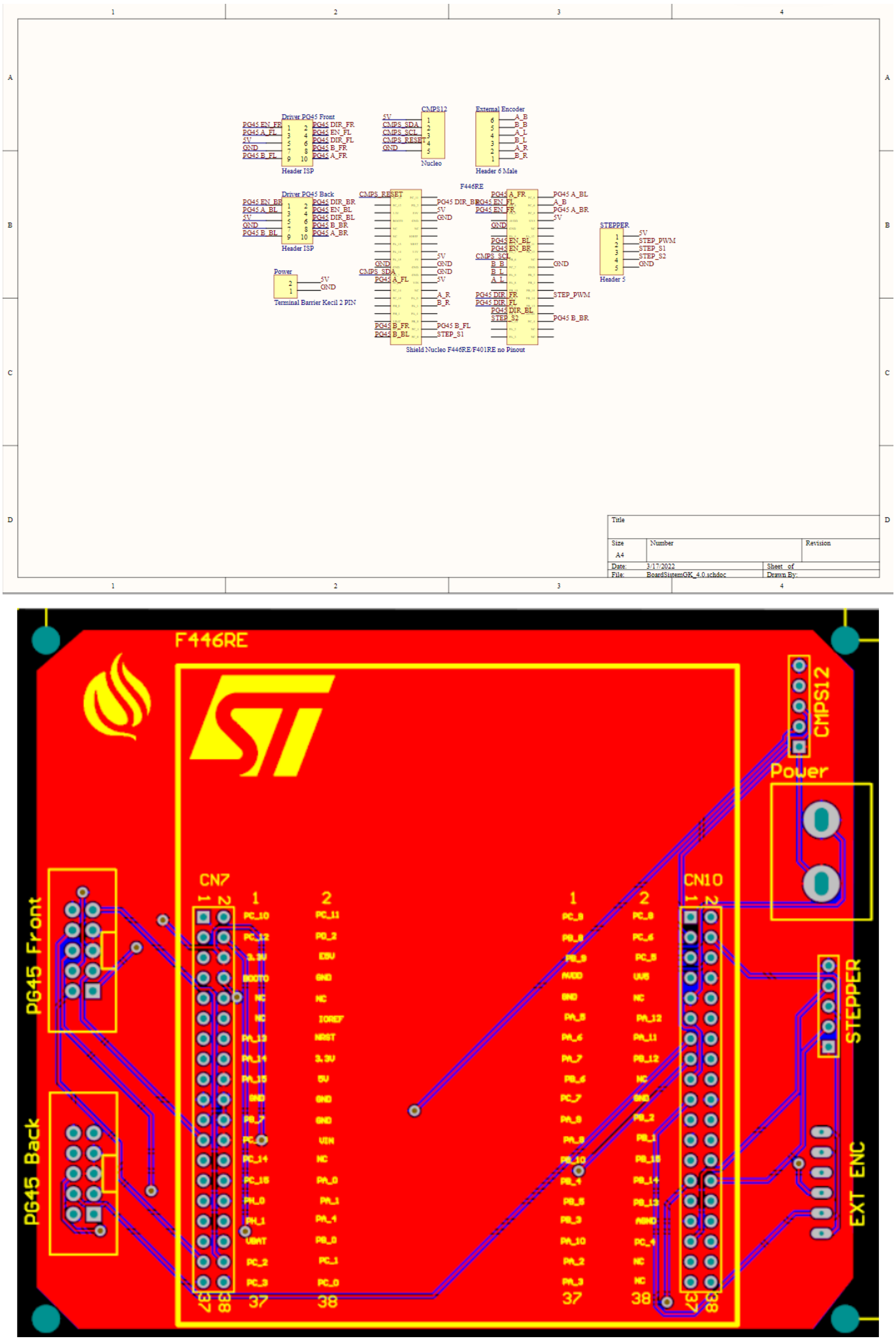


Fig. 2 Goalkeeper Microcontroller Schematic

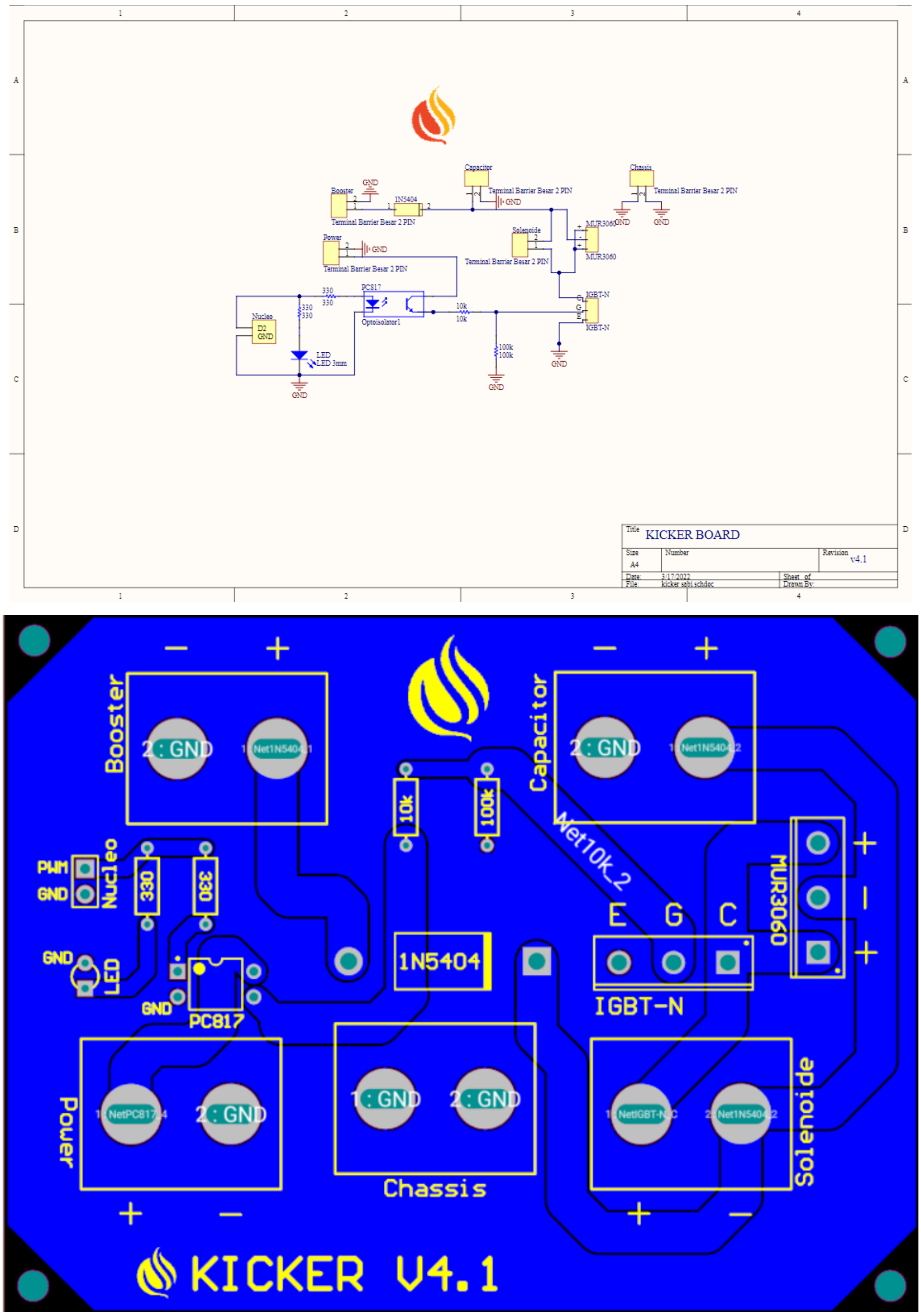


Fig. 3. Kicking System Schematic

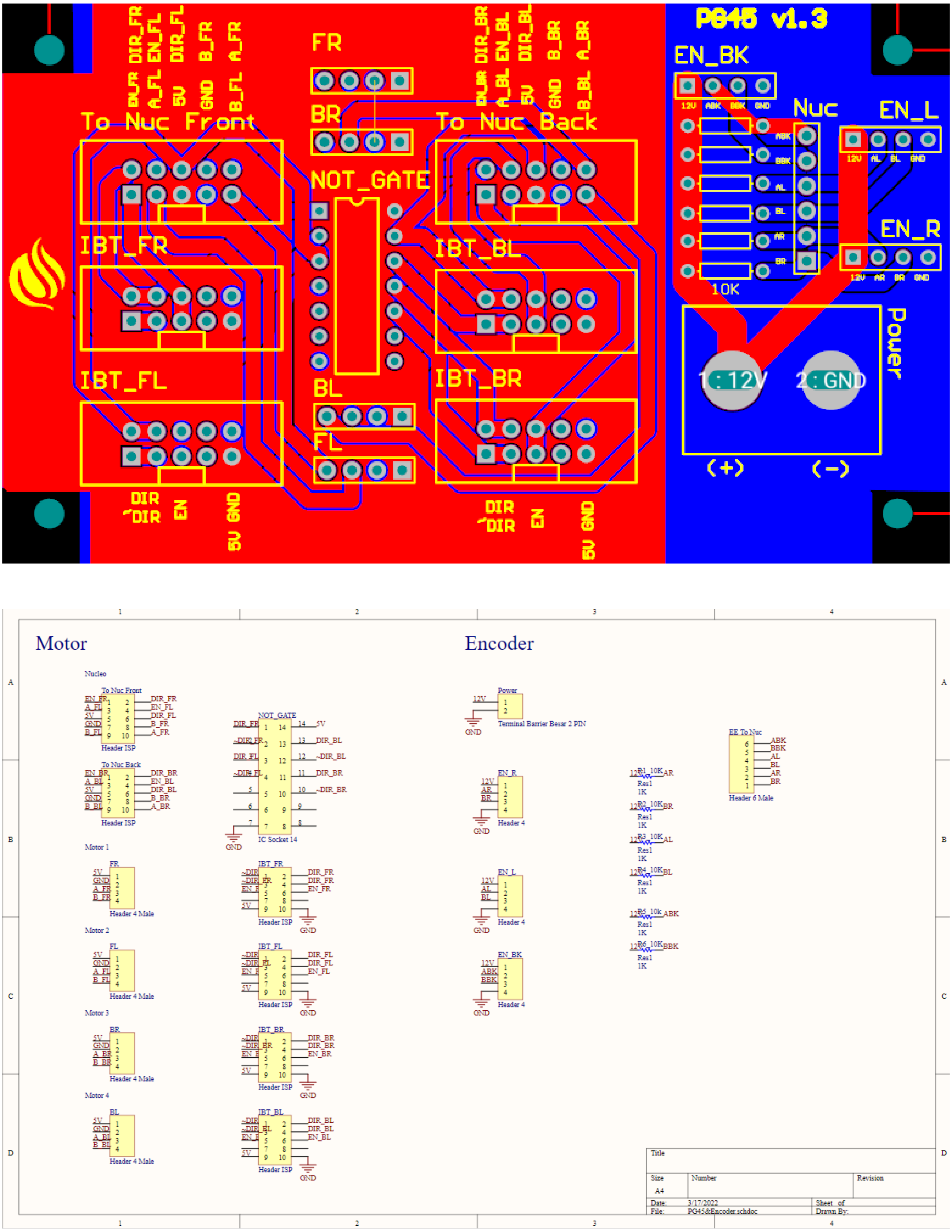


Fig. 4. Locomotion and Encoder System Schematic

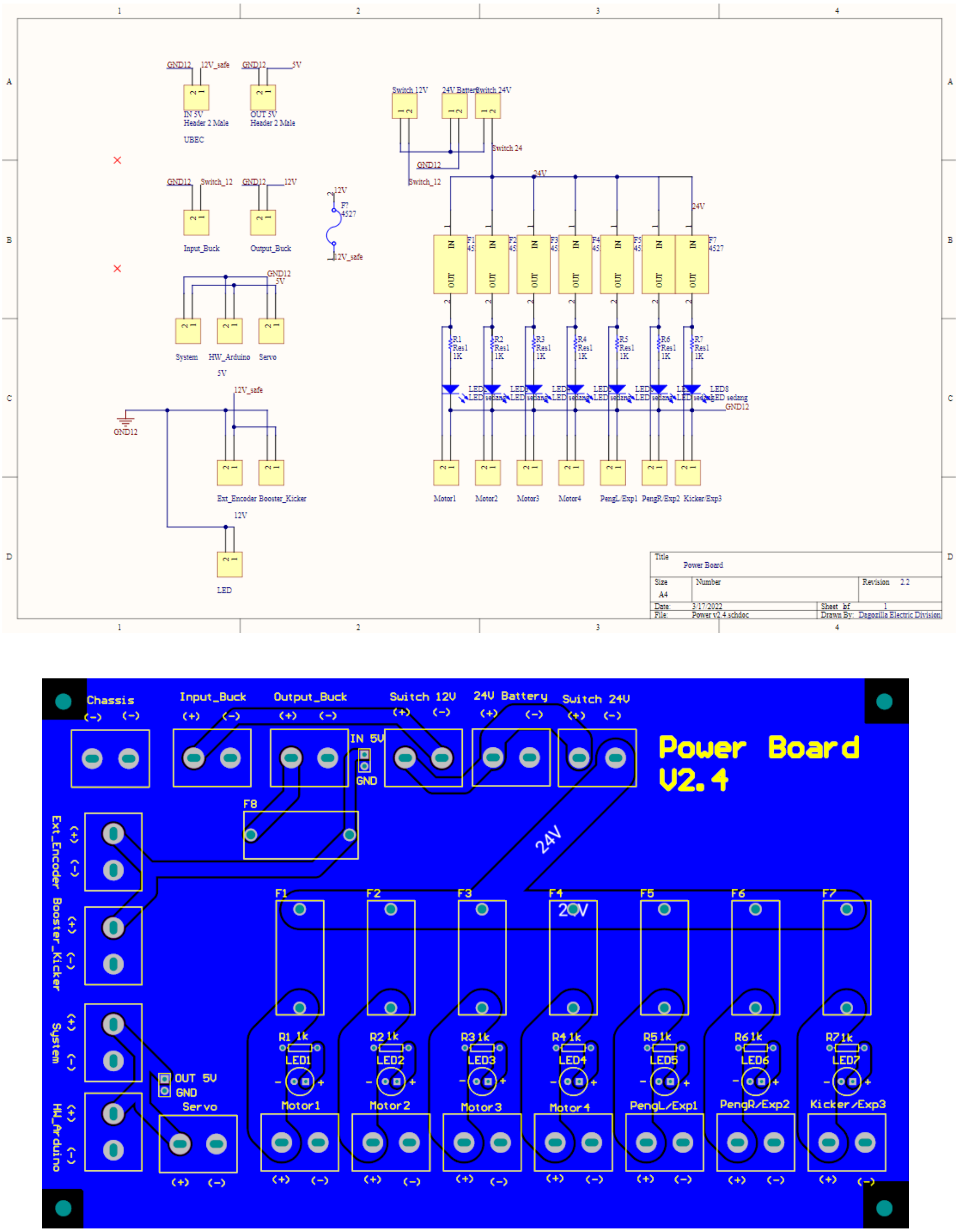


Fig. 5. Power Distribution System Schematic

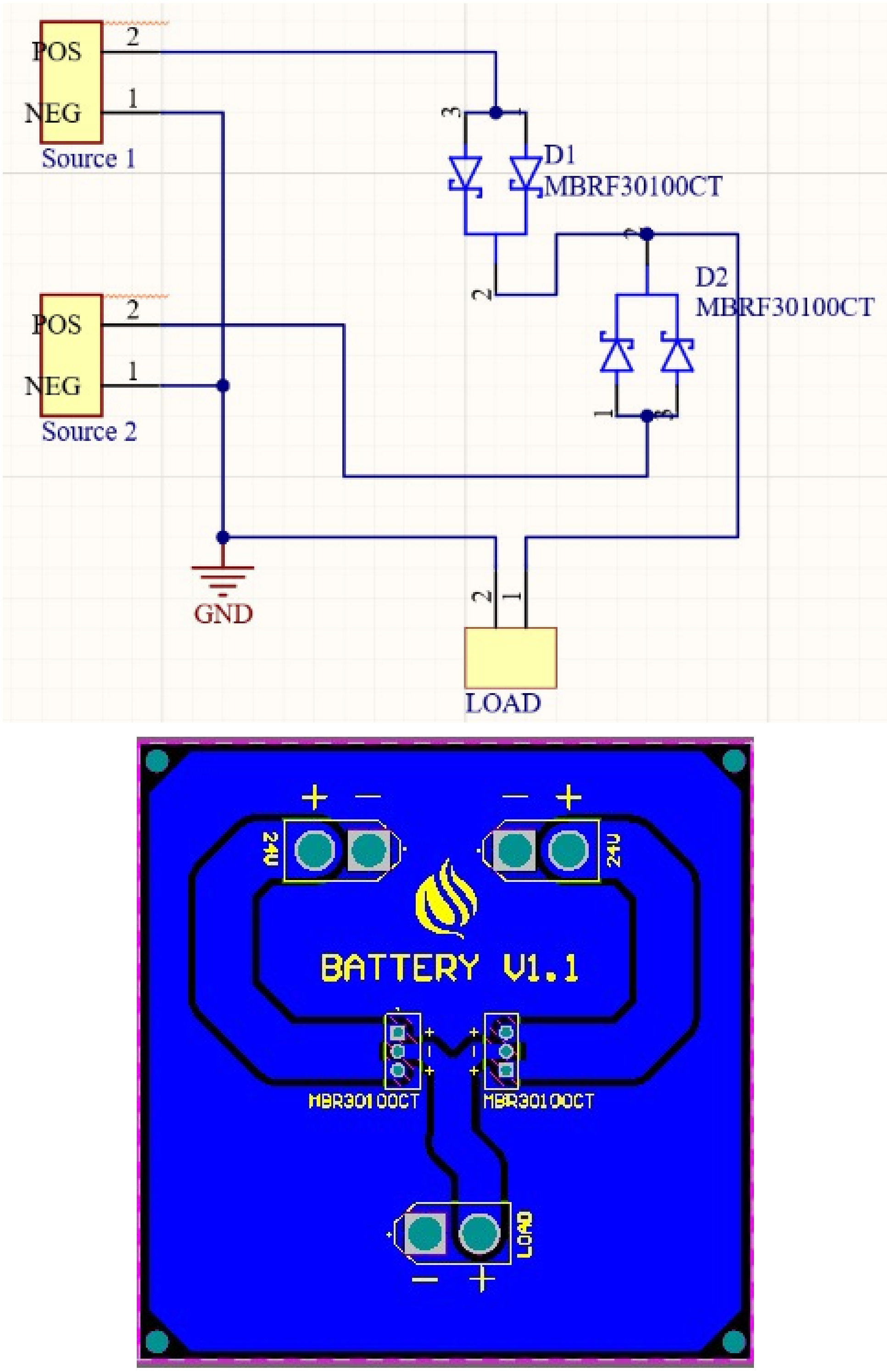


Fig.6. Battery Switching System Schematic

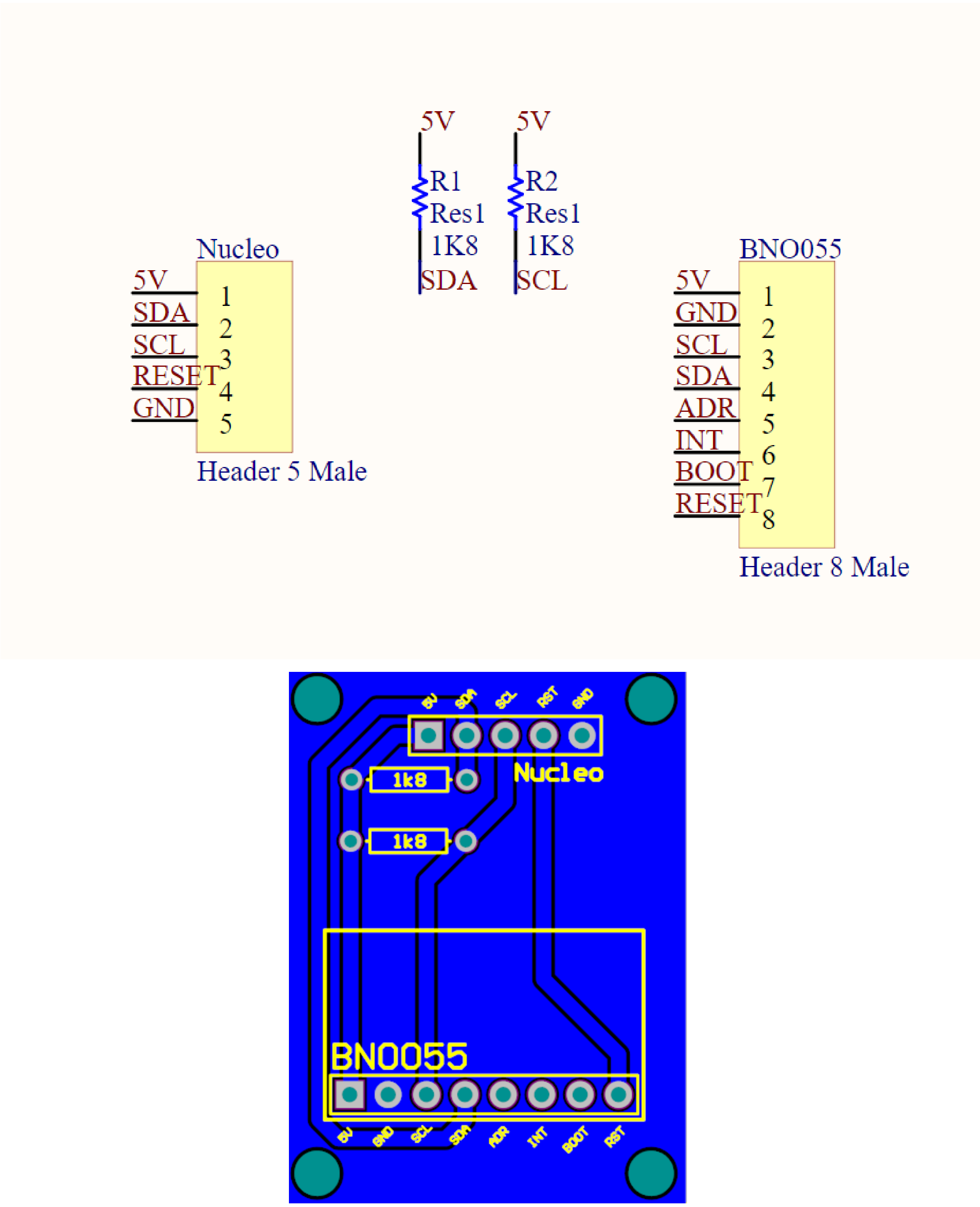
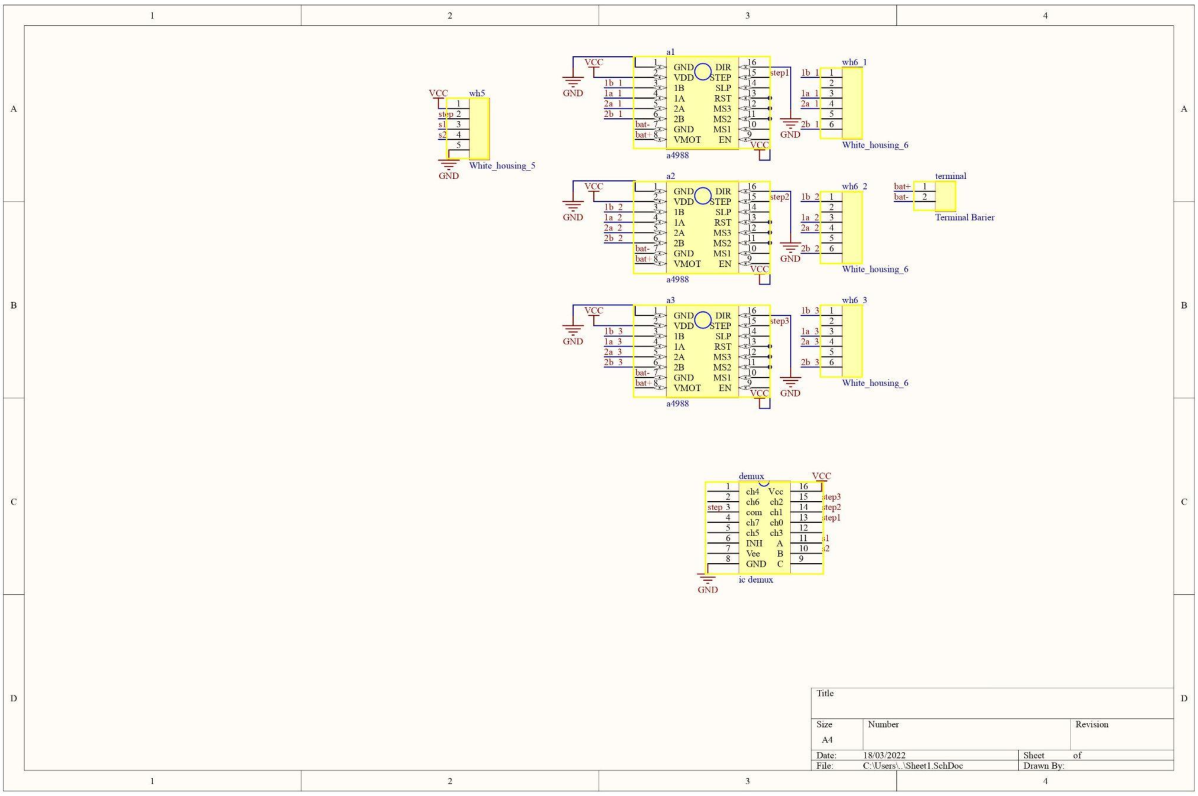


Fig. 7. IMU System Schematics



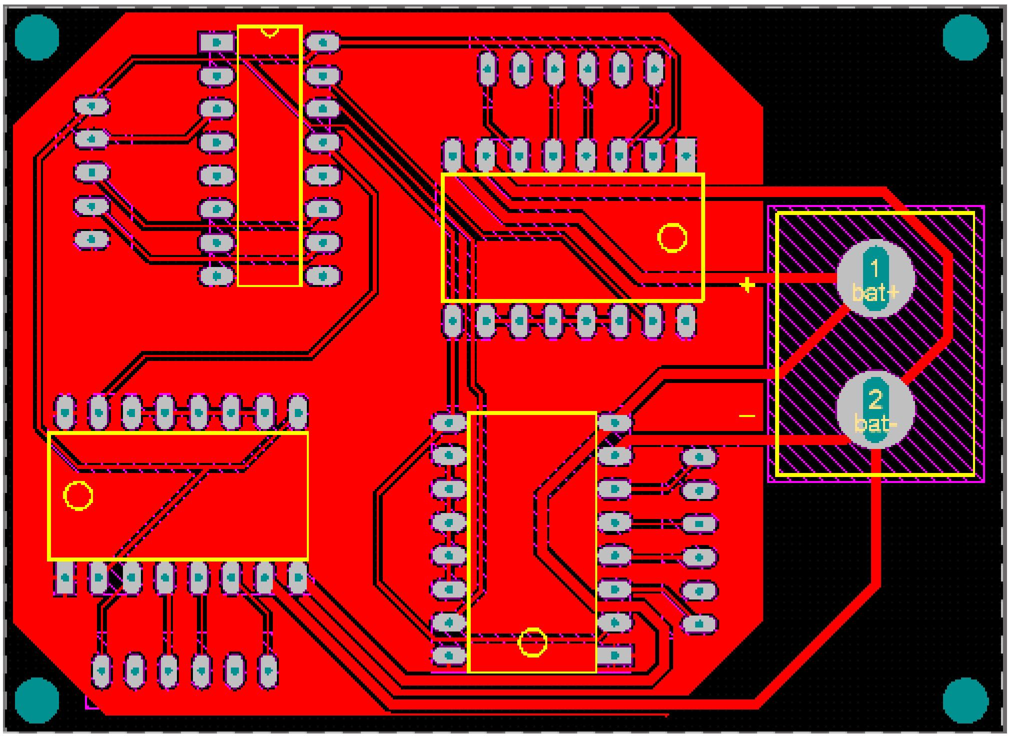


Fig. 8. Stepper System Schematics

Appendix B Software Description

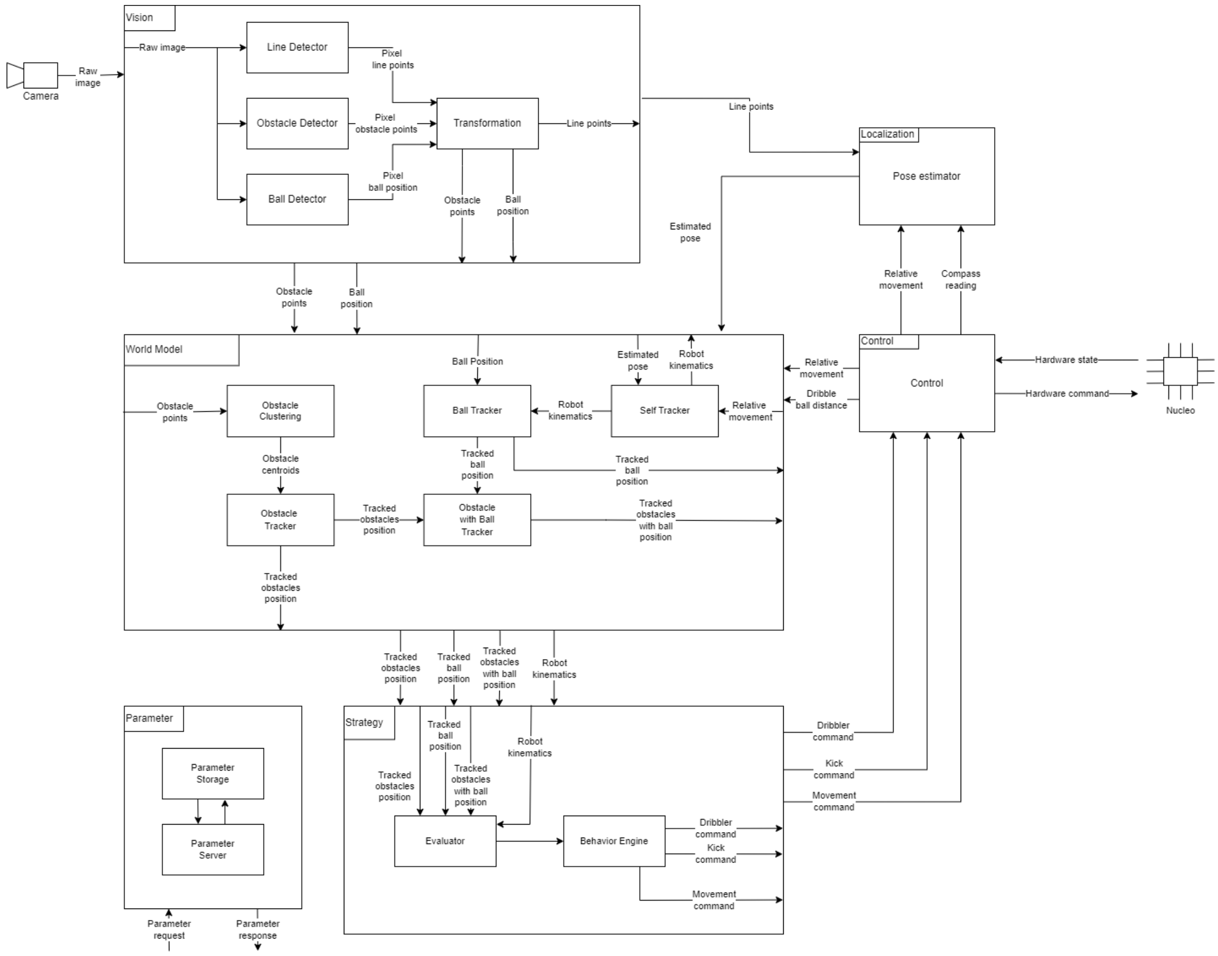


Fig. 9. Generalized Robot's Software Description