Bill of Materials (BOM) Explanation

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Introduction

This document provides an explanation of the Bill of Materials (BOM) we want to use in the project. Each component listed in the BOM is described in detail, including its purpose and other relevant specifications.

Component Overview

The table below outlines the components used in this project along with their purpose and additional information.

Table 1: Component Descriptions for the Project

Component	**Description**	**Purpose**	**#**	**á price (price per robot) SEK**
DF45L024048-A	Brushless direct current (BLDC) motor with integrated hall sensors for the wheels	Used to spin the wheels of the robot.	4	830.4 (3273.60)
Hobbywing FPV XRotor 3110 900KV	Brushelss DC motor	High revolutions per minute (RPM) motor used to control the dribbler.	1	175.20 (175.20)
B-G431B-ESC1	BLDC motor driver	Motor driver with embedded μController current sensing and hall sensing to form a closed-loop control algorithm	5	208.96 (1044.8)

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NUCLEO-H723ZG	μController	Computational power and real-time processing capabilities, supports μROS	1	322.58 (322.58)
Raspberry Pi 4 Model B/8GB	Single-board computer	Processing camera input and performing local path planning	1	979 (979)
SX1280IMLTRT	Radio frequency (RF) transceiver	Used to transmit data over 2.4Ghz network	1	75.44 (75.44)
SKY66122-11	Integrated front-end-moduel (FEM)	Simplified integration with the RF circuit	1	40.48 (40.48)
6s 1300mAh - 120C - GNB HV XT60	LiPo-battery	Used to power the robot	1	351.20 (351.20)
LT3750	Charging controller for the capacitors of the kicker	Charge controller for the kicker circuit	1	146.93 (146.93)
iC-PX2604 + PX01S 26-30	Wheel encoders	Will be used for odometry of the robot	4	224.40 (897.60)
WSEN-ISDS 6 Axis IMU	6-DoF IMU	Well be used for odometry of the robot	10	N/A
Raspberry Pi Kameramodul 3	Camera	Provide images in front of the robot to detect the ball and obstacles	1	369 (369)
IR Break Beam Sensor - 5mm LEDs	Infrared (IR) sensor	Used to detect if the ball is close to the robot	1	99 (99)
JST 6B-PH-K-S	Connector	Hall sensor connector from the motor	4	3.85 (15.4)
JST B5P-VH	Connector	Motor connector	4	4.06 (16.24)

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Connectors	Passive component	Supplied by Würth	N/A	N/A
Shaft hub with clamping bracket 4mm	Coupler	Couple the wheels with the motor shaft	4	139 (556)
Bearings	Bearings	Make the roller spin (dribbler)	2	18 (36)
Resistors	Passive component	Supplied by Würth or 326	N/A	N/A
Capacitors	Passive component	Supplied by Würth or 326	N/A	N/A
Voltage regulators	DC/DC buck converters	Supplied by Würth	N/A	N/A
Solenoid	Solenoid	Supplied by MDU	1	N/A
PCB	Printed circuit board (PCB)	The students will supply any custom PCB designed	2	N/A
Total price for 1 robot	**8398.47**			

Reason for component choice

DF45L024048-A

The BLDC motor has a high torque at low speeds and can reach high revs per minute (RPM). This is necessary to ensure fast acceleration at low speeds. In order to have precise control of the motors, positional feedback of the magnets position and the phase current can be used to form a closed-loop PID system. The μController would only need to send the desired velocity to the ESC and the closed-loop control will make sure the desired speed is met. On the contrary, using a BLDC motor without sensor feedback, additional components would be required, for example external hall sensors and external current sensing iCs. This would add complexity and introduce integration issues. We also have to take the size of the motor into account. Having to large footprint on the motors would cause the kicker (solenoid) to not fit in the chassi. Sensored BLDC motors are mainly used for RC cars, where positional accuracy is required for low speeds and they have a larger footprint and cheaper alternatives compared to the DF45L024048-A did not exist.

Hobbywing FPV XRotor 3110 900KV

The requirements for the dribbler motor is that it can reach high RPM (around 10000 RPM). Positional accuracy for the dribbler motor does not have to be as precise compared with the motor for the wheels. Since we have current feedback for each phase we can calculate the RPM of the motor.

B-G431B-ESC1

The chosen electronics speed controller (ESC) has an STSPIN32F0A system in package chip which has an integrated STM32 with hall sensor decoding logic and current sensing capabilities. This makes this ESC a good fit with the DF45L024048-A BLDC motor. The PID system can be run on this chip for each motor offloading computational loads from the μController and allow for precise movement and rapid acceleration which is critical to make quick directions changes and dribbling. The hall sensor feedback support enables accurate rotor position allowing for good torque control at low speeds. The size and weight of the ESC does also have to be taken in consideration, the B-G431B-ESC1 has a small footprint with a relatively low weight 286g. With all the components integrated on one board it will make the assembly process easier and reduce any external components e.g. current sensing or hall sensing. The programming for the integrated STM32 is done using STM32 Motor Control Software Development Kit which is a graphical programming environtment from ST.

Table 2: Pros and Cons of the B-G431B-ESC1 Motor Driver in the Robot Setup

Category	**Pros**	**Cons**
Integration and Control	- Integrated microcontroller for closed-loop control. - Built-in current sensing and Hall sensor feedback for precise, closed-loop control. - Smooth low-speed operation ideal for motor control.	- Requires familiarity with STM32CubeIDE for firmware development, but extensive documentation and community support make learning manageable.
Compatibility with Motors	- Direct support for Hall-effect sensors in BLDC motors, perfect for **DF45L024048-A** motors. - Capable of handling high-speed applications, like the dribbler motor (**Hobbywing FPV XRotor 3110**).	- Limited to one motor per ESC, but its compact size allows for easy integration of multiple units in the robot.
Power Handling	- Supports up to 48V, making it fully compatible with the **6s 1300mAh** LiPo battery.	- Potential heat buildup under heavy loads, but simple heat sinks or airflow can mitigate this for sustained performance.

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Category	Pros	Cons
Size and Integration	- Compact design simplifies installation in space-constrained robots. - Reduces the need for additional wiring and external controllers, leading to cleaner and more reliable assembly.	- Using multiple ESCs requires careful layout, but it results in a modular design

NUCLEO-H723ZG

The NUCLEO-H723ZG μController is chosen because of its high computational abilities which is based of the STM32H7237G chip. The μController will be required to collect the data from the sensors, perform calculations with the data, send the data to the team server.

Raspberry Pi 4 Model B/8GB

SX1280IMLTRT + SKY66122-11

iC-PX2604 + PX01S 26-30

WSEN-ISDS 6 Axis IMU

Raspberry Pi Kameramodul 3

IR Break Beam Sensor - 5mm LEDs

Connectors

Shaft hub with clamping bracket 4mm

Bearings

Resistors

Capacitors

Voltage regulators

Solenoid

PCB

Conclusion

This document serves as a reference for understanding the role of each component in the project. For any further technical details, please refer to the respective datasheets provided by the manufacturers.