Component Analysis and Suitability for BID4R Project

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EE 421

October 2024

1- Mini 3-Layer Round Robot Chassis Kit - 2WD with DC Motors

- **Main Specifications**:
    - **Drive Motors Voltage**: 3-6V DC.
    - **Current Draw**: 200-400mA (normal), 1.5A (stall).
    - **Material**: Aluminum alloy chassis.
- **Responsibility**:

The chassis provides the **physical structure** and **mobility** for the robot. The two **DC motors** attached to the wheels are responsible for movement, allowing the robot to drive forward, backward, and turn.

- **Suitability**:

The chassis is lightweight, providing enough space for mounting all components and wiring. The motors' voltage range of 3-6V allows them to be powered directly by the **3.7V LiPo battery**, though they will operate with lower performance compared to 6V. The motors' current draw is manageable, but the **stall current of 1.5A** requires protection (fuses).

- **Considerations**:

The stall current could damage the motor driver if not limited.

- **Solution**:

Install **1.5A fuses** in series with the motors to prevent overcurrent from damaging the driver and the system.

2- Adafruit DRV8833 DC/Stepper Motor Driver Breakout Board

- **Main Specifications**:
    - **Voltage Range**: 2.7V to 10.8V.
    - **Continuous Current**: 1.2A per channel (2A peak).
- **Responsibility**: The motor driver acts as the **interface between the Arduino and the motors**. It translates the **PWM control signals** from the Arduino into power for the motors, allowing for precise control of speed and direction.

- **Suitability**: The motor driver is well-suited to control the robot's DC motors, as it supports a wide voltage range (compatible with the 3.7V battery). However, it can only handle **1.2A continuously**, which means it's close to its limit during stall conditions. This makes the use of fuses essential.
- **Considerations**: The driver must not exceed its current rating, especially during motor stall conditions.
- **Solution**: Use **1.5A fuses** to protect the motor driver and consider adding **heat sinks** to manage heat under heavy loads.

3- Arduino Nano 33 IoT

- **Main Specifications**:
    - **Operating Voltage**: 3.3V (logic), 5V via VIN for power.
    - **Processor**: ARM Cortex-M0+ SAMD21.

- **Responsibility**: The Arduino Nano 33 IoT is the **brain of the robot**. It processes sensor inputs, executes decision-making logic, and sends control signals to the motor driver to manage the robot's movement. It also handles wireless communication via **Wi-Fi and Bluetooth** if needed.
- **Suitability**: The Arduino Nano is perfectly suited for this project because of its **small form factor** and low power consumption, making it ideal for battery-powered robots. It operates on **3.3V logic**, which is compatible with the sensors. The PowerBoost 1000C can provide the necessary 5V to power the Arduino through the VIN pin.
- **Considerations**: Ensure that the sensors connected to the Arduino are compatible with its **3.3V logic**.

4- Pixy2 Smart Vision Sensor

- **Main Specifications**:
    - **Power Supply**: 5V.
    - **I2C Logic Level**: 3.3V I2C logic.
- **Responsibility**: The Pixy2 sensor provides the robot with **vision capabilities**, such as object and color detection, which can be used to guide the robot's movement (e.g., following a line or tracking a specific object).

- **Suitability**: The Pixy2 sensor is highly suitable for the project due to its ability to communicate using **3.3V I2C logic**, making it compatible with the **Arduino Nano 33 IoT** without requiring an I2C level shifter. The **5V power requirement** can easily be supplied by the PowerBoost.
- **Considerations**: No level shifter is needed as the sensor communicates using 3.3V logic.

5- Universal Qi Wireless Receiver Module

- **Main Specifications**:
  - **Output Voltage**: 5V.
  - **Output Current**: 1A max.
- **Responsibility**: This module enables the robot to **charge wirelessly** by receiving power from the wireless charging transmitter. It converts the received energy into **5V** to charge the **LiPo battery** via the PowerBoost 1000C.
- **Suitability**: The Qi receiver module is well-suited for enabling **autonomous charging** without the need for physical connectors, providing the necessary 5V to charge the battery.
- **Considerations**: Proper alignment between the receiver and transmitter is essential for efficient charging.

6- Universal Qi Wireless Charging Transmitter

- **Main Specifications**:
  - **Input Voltage**: 5V (typically via USB).
  - **Output Power**: 5W.
- **Responsibility**: The transmitter is responsible for **wirelessly providing power** to the Qi receiver, enabling the robot to recharge its battery without manual intervention.
- **Suitability**: The transmitter works seamlessly with the Qi receiver to provide power for charging the robot's battery. It ensures the robot can charge autonomously when placed on the charging pad.
- **Considerations**: Ensure that the charging station is designed for proper alignment between the transmitter and receiver.

7- 4x 3.7V Lithium LiPo Battery (3000mAh)

- **Main Specifications**:
    - **Voltage**: 3.7V.
    - **Capacity**: 3000mAh.
- **Responsibility**: The **battery provides the main power supply** for the motors, Arduino, and sensors, by supplying 3.7V to the PowerBoost 1000C, which converts it to 5V.
- **Suitability**: The battery has a high enough capacity (3000mAh) to power the system for an extended period. It can also handle the current demands of the motors and other components. The **PowerBoost** converts the battery's 3.7V to the required 5V for the Arduino and other components, making it well-suited for the robot.
- **Considerations**: A **BMS (Battery Management System)** is essential to protect the battery from over-discharge, overcharge, and short circuits.

8- VCNL4010 Proximity/Light Sensor

- **Main Specifications**:
    - **Power Supply**: 3.3V to 5V.
    - **I2C Logic Level**: 3.3V to 5V compatible.
- **Responsibility**: The proximity sensor provides **environmental feedback** by detecting obstacles, enabling the robot to avoid collisions. It also measures ambient light, allowing for light-based decisions.
- **Suitability**: The sensor is compatible with the **3.3V I2C logic** of the Arduino Nano 33 IoT, making it easy to integrate without a level shifter. Its low power requirements make it ideal for use in battery-powered robots.
- **Considerations**: Ensure proper placement for effective obstacle detection.

9- PowerBoost 1000C

- **Main Specifications**:
    - **Input Voltage**: 3.7V (from LiPo battery).
    - **Output Voltage**: 5V.
    - **Output Current**: 1A continuous.

- **Responsibility**: The **PowerBoost 1000C** is responsible for converting the 3.7V output from the LiPo battery into a stable **5V supply** to power the Arduino Nano 33 IoT, sensors, and other 5V components.
- **Suitability**: The PowerBoost 1000C is perfectly suited for this project as it provides a continuous **1A** at 5V, which is sufficient for powering the entire system. The total current draw of the components (including sensors, camera, and Arduino) does not exceed the **1A** limit, ensuring safe and efficient operation.
- **Considerations**: Ensure the total current draw remains within the 1A limit and consider spreading the load or using an additional PowerBoost if future components increase the current requirements.

10- APA106 LEDs (Addressable RGB LEDs)

- **Main Specifications**:
  - **Power Supply**: 5V.
  - **Current Draw**: 20mA per LED.

- **Responsibility**: Provides **visual feedback** for the robot, useful for signaling or status indication.
- **Suitability**: The PowerBoost 1000C provides 5V for powering the LEDs.
- **Considerations**: If you use 50 LEDs, the total current draw will reach 1A, leaving no room for other components.
- **Solution**: Limit the number of LEDs or use an additional power supply if more LEDs are needed.

11- Resistors

- **Main Specifications**:
  - **Resistance Value**: 330Ω for APA106 LEDs.
  - **Power Rating**: 1/4W.
- **Responsibility**: Regulates the current flow to the LEDs, preventing damage from voltage spikes.
- **Suitability**: The 330Ω resistor is suitable for protecting the APA106 LEDs' data line.
- **Considerations**: Place a 330Ω resistor on the **data line** of the first LED to prevent damage.

Final Considerations and Solutions:

Component	Responsibility	Solution	Quantity	Links
Fuses (1.5A)	Protects motors and motor driver from overcurrent.	Use fuses to prevent overcurrent from damaging the motors and driver.	2	https://www.amazon.com/1-5AMP-10PCS-LITTELFUSE-31301-5-DELAY/dp/B0CCWRKQ3B
BMS	Protects LiPo battery from overcharging /discharging.	A **BMS** is essential for safe battery management and ensuring battery health.	1	https://bmsbatteries.com/product/daly-smart-bms-4s-12v-60a-lithium-ion-battery-protection-module/

The Additional Component Analysis and Suitability for BID4R Project

12- Littelfuse 1.5A Slow-Blow Fuse (31301.5)

- **Main Specifications**:
  - **Current Rating**: 1.5A.
  - **Type**: Slow-blow (time delay).
  - **Voltage Rating**: 250V.
  - **Dimensions**: 5mm x 20mm.
- **Responsibility**: The Littelfuse 1.5A slow-blow fuse is responsible for **protecting the motors and the motor driver** from overcurrent by interrupting the circuit if the current exceeds 1.5A for an extended period. This fuse type can tolerate brief current surges (such as motor startups) but will blow if a motor **stalls** and continuously draws a high current.
- **Suitability**: This fuse is well-suited for the setup because:
  - The motors in the **Mini 3-Layer Round Robot Chassis Kit** have a **stall current of 1.5A**, making the 1.5A fuse ideal for protecting them.
  - The **DRV8833 motor driver** provides 1.2A continuously, so the fuse ensures that if the motors draw more than 1.5A (due to stalling), the circuit will break, protecting the motor driver from damage.
  - The **slow-blow characteristic** ensures that the fuse will not blow immediately during short surges (like motor startup), which momentarily increases the current.
- **Considerations**:
  - In this setup, the fuses should be installed **between the motor driver and each motor**. This way, if one motor stalls and draws too much current, only the fuse for that motor will blow, while protecting the motor driver and other motor from overcurrent.
  - Ensure the physical size of the fuse (5mm x 20mm) is appropriate for the setup and that you use a compatible fuse holder if necessary.

13- DALY Smart BMS 4S 12V 60A Lithium-Ion Battery Protection Module

- **Main Specifications**:
  - **Battery Type**: 4S (4 cells in series) for **12V Lithium-Ion or LiPo batteries**.
  - **Max Current**: 60A.
  - **Protection Features**: Overcharge, over-discharge, overcurrent, short circuit, and balancing.
  - **Communication**: UART and Bluetooth optional for real-time monitoring.

- **Responsibility**: The DALY Smart BMS provides **comprehensive protection** for the **LiPo battery** used in the robot. It ensures the battery operates safely by protecting against overcharging, over-discharging, short circuits, and excessive current. It also handles **cell balancing**, ensuring that all cells in the battery pack are charged evenly, extending the battery life.

- **Suitability**: This BMS is well-suited for the setup because:
    - It matches the **4S LiPo battery configuration** (total voltage of 14.8V from 4x 3.7V LiPo cells).
    - It provides the necessary protection for both the battery and the connected components (motors, motor driver, Arduino).
    - The **60A rating** ensures it can handle high-current draws from the motors or other components without triggering false protections.
    - The optional **UART and Bluetooth** communication allows you to monitor the battery's status in real-time, which can be useful for displaying battery conditions through LEDs or on a display.
- **Considerations**:
    - Ensure that the **BMS is installed correctly** between the battery and the load (PowerBoost, motor driver, etc.). The battery leads from the BMS should be connected directly to the LiPo battery, and the output leads from the BMS should go to the load.
    - Proper cooling might be necessary if the current draw approaches the BMS's 60A limit for prolonged periods.

References

[1] "Utilizing Fuses for Overcurrent Protection," eepower.com, [Online]. Available: https://eepower.com/technical-articles/utilizing-fuses-for-overcurrent-protection/. [Accessed: 12-Oct-2024].

[2] D. Andrea, "Battery Management System for Overcharge Protection," *Applied Sciences*, vol. 7, no. 12, p. 1314, 2017. [Online]. Available: https://www.mdpi.com/2076-3417/7/12/1314. [Accessed: 12-Oct-2024].

[3] "Overcharging Lithium-ion Polymer Batteries," Grepow.com, [Online]. Available: https://www.grepow.com/blog/overcharging-lithium-ion-polymer-batteries.html. [Accessed: 12-Oct-2024].