July 26yth order first prototype:

* Develop a PCB board that allows interchange MCU’s (ESP32, STM32, AT mega 32) to reduce the robots form factor to fit under gutter hanger while allowing flexibility scale if a feature is not available in selected test MCU.
  + First PCB board prototype will have EPS32 MCU (cheap), debugger, power management, motor drive with Interface with DC drive motors, interface with DC motor with Encoder
  + Components from Breadboard implementation:
    - Debris removal motor: Brushless DC Motor with Encoder 12V 159RPM. With 5 Line. (1. PWM speed control – logic 0-5V freq - 20~30KHz, 2. Power-/GND, 3. Direction control, 4. Feedback pulse output - rpm readings, 5. Power + Vcc – 12V) | Calculations: Estimated Current draw of 0.384 A.
    - Drive
      * DC Motor Quantity 2 (12V, 200rpm, guessed torque of 98 mNm from Similar motor – G12-N30) | No datasheet Amazon product details
      * Motor driver Sparkfun Board TB6612FNG featuring the TB6612FNG IC with 2 internal h bride and can handle up to 1.2A of constant current. Schematic diagrams shows denoising capacitors on power line VM1 and Vcc. Seem to lack Emf backflow protection though might be internal to the IC.
    - MCU
      * ATmega328P (Arduino nano) operating on 5V logic
    - Battery Lipo
      * DLG 3S RC Lipo Battery,11.1V 1000mAh 20C Battery with Dean's T Plug, for RC car, Boat, Airplane, Helicopter, Truck Models. Dims (73mm x 17mm x 37mm ) | calculation Maximum Discharge Current (A) = 20 .
    - On board programmer, no sure if there is a debugger would like a one

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Connector Type** | **Current Capacity** | **Footprint Size** | **Security** | **Ideal Purpose** |
| **JST (e.g., JST-XH, JST-PH)** | Up to 3A | Small | High (positive locking mechanism) | Sensors, batteries, low-current power |
| **Molex (e.g., Molex KK)** | Up to 11A (depending on series) | Small to medium | High (positive locking mechanism) | Power and signal connections in various environments |
| **Micro Match** | Up to 1.5A | Small | High (vibration-resistant) | Compact designs requiring secure connections |
| **Molex PicoBlade** | Up to 1A | Very small | High (positive locking mechanism) | Small and compact devices |
| **Screw Terminals** | **Up to 20A or more** | **Medium to large** | **Very High** | **High-vibration environments, secure power connections** |
| **Locking Header and Socket** | **Varies** | **Small to medium** | **High (locking mechanism)** | **Connections needing extra security to prevent disconnection** |

**Schematic and Layout**

Based on the above requirements, here’s a high-level schematic layout for the PCB:

1. **Power Input and Regulation**:
   * Input from Lipo battery to a power input connector.
   * Step-down converters from 12V to 5V and 3.3V.
   * Power distribution to different sections of the board.
2. **MCU Section**:
   * Primary footprint for the ESP32 with all necessary connections.
   * Headers for alternative MCUs (STM32, ATmega328P).
3. **Motor Driver Section**:
   * Connections for the TB6612FNG motor driver.
   * PWM, direction control, and feedback connections to the MCU.
   * Power connections to the motor driver.
4. **Motor Connections**:
   * Connectors for brushless DC motor with encoder.
   * Connectors for two DC motors.
5. **Programmer/Debugger Section**:
   * JTAG, SWD, and ICSP headers.
   * Necessary pull-up/pull-down resistors and capacitors for stable operation.

Power Input and Regulation Submodule

A computer screen shot of a program

Description automatically generated A screenshot of a computer program

Description automatically generated

Chain to have create efficient, selected fixed regulator to avoid mistakes.

* LM2596 Step-Down Converter Module (U\_PWR\_1):
  + 12V to 5V (up to 3A)
  + Denoise Capacitors:
    - C\_PWR\_1\_INPUT: 10µF, 25V Electrolytic  
      ()
    - C\_PWR\_2\_OUTPUT: 22µF, 10V Electrolytic  
      ()
* LM7805 Linear Regulator (U\_PWR\_2):
  + (5V to 3.3V)
  + Denoise Capacitors: Low-Pass Filters
    - C\_PWR\_2\_INPUT: 0.33µF, 10V Ceramic  
      ()
    - C\_PWR\_2\_OUTPUT 0.1 µF, 6.3V Ceramic  
      ()

**Power Connections**:

* **12V Input**: PWR\_INPUT\_12V
* **5V Output**: PWR\_OUTPUT\_5V
* **3.3V Output**: PWR\_OUTPUT\_3V3

A diagram of a computer

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A computer screen shot of a circuit board

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A computer circuit board with many wires

Description automatically generated with medium confidence



Protypes delayed. Conduct more research an implementation a more complete board.

Features

* ESP32 S3 Wroom Module (Wi-Fi, Bluetooth, etc.)
* SD Card
* USB 2.0 with Type C connect for MC Programming and Debugging (UART| JTAG). Add Diode IC for Protection
* Battery Monitor for the 3 cell Lipo Battery with over and undercurrent protection - Connect to MC via I2C
* 6 Axis IMU – Connected to MC Via SPI 2
* H Bridge Motor drive to control the Differential drive Wheels
* SPI Interface intend to add a camera. [lock in connectors] ( 4 lines )
* Moter interface for a DC Brushless motor with an encoder ( 3 cables for the controls )

Submodules

* Power Management
  + LM2596 Step-Down Converter Module - Fixed 5V output 3A
    - C\_in = 680 micro F | C\_out = 220 mirco F ( Both polarized ) :
      * Place these capacitors as close as possible to the input/output terminals of the LM2596. The goal is to keep the input path short to minimize the loop area, which helps in reducing electromagnetic interference (EMI). While providing a low impedance path for the switching currents, which improves transient response and minimizes output voltage ripple.
    - 33 micro-H inductor
    - Dicode 1N5824
    - 12->5 A lot **energy dissipation** and **high switch Freq 150-kHz**| Two Available Packages TO-220, TO-263. Thermal data is unclear thus will assume large area better heat dissipation. (TO-220,5 Area > TO-263 Area, 5)
    - Trace and placement {Assume 3A}
  + LM3940 1-A Low-Dropout Regulator for 5-V to 3.3-V Conversion
    - C\_in = 0.47 micro F | C\_out = 33 mirco F ( Both polarized ) The minimum output capacitance required to maintain stability is 33 μF (this value may be increased without limit). Larger values of output capacitance will give improved transient response.
    - TO-220 has the best thermal Dissipation. As no size requirement for prototype
  + BQ76940 Battery Management
    - BQ769x0 | Package TSSOP (20) | body 6.50 mm × 4.40 mm | supports up to 5-series cells or typical 18-V packs.
    - I2C interface with the MC, Alert pin to MC (R\_Alert = 1 MΩ)
    - No using internal LDO. Max current draw = + R\_θJA Junction-to-ambient thermal resistance is 93.7 °C/W
    - Over and undervoltage protection
      * Depending on R\_sns | if 5mΩ and the current is 20A P\_d = 20^2 = 0.005 = 2W - Battery Max discharge rate is 20 A
      * Q1, Q2: IRLZ44N (N-channel MOSFET, 55V, 47A, 22mΩ RDS(on) at Vgs = 10V. Power Dissipation : P= 20^2 \* 0.022 = 8.8W
      * Q3: IRF9540N (P-channel MOSFET, 100V, 23A, 117mΩ RDS(on)
      * R1, R2, R2\*: 1MΩ, 1/4W, 1% tolerance resistors
      * Rds: 0.01Ω, 3W sense resistor
      * Diode: 1N5819 (Schottky diode, 40V, 1A)
      * Zener Diode: 1N4733A (5.1V Zener diode)
    - Sense resistor
      * R\_SNS = 5mΩ, 5W, 75 ppm/°C
      * R\_FILT = 1kΩ resistor To filter the sense input and provide accurate readings to the coulomb counter
    - Additional values taken from typical application
      * Rc = 100 Ω, Cc =1 µF, Rf= 100Ω, REGOUT loading capacitance Cl =4.7 µF, REGSRC CCap = 1 µF, External thermistor nominal resistance R\_TS 10K Ω

LM2596

A diagram of a buck regulator

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LM3940

A diagram of a device

Description automatically generated

BQ76940 Overview Circuit

A diagram of a circuit board

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BQ76940 Protection Circuit Details

A diagram of a circuit

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**Q1 and Q2 (N-channel MOSFETs)**:

* **Purpose**: These are used as the main switching elements for the CHG and DSG paths.
* **Recommendation**: Low RDS(on) N-channel MOSFETs that can handle the required current and voltage for your application. Check the MOSFET's VDS and IDS ratings to ensure they match your battery pack's requirements.

**R1 (1MΩ resistor)**:

* **Purpose**: This resistor drops the voltage when the PACK- pin is pulled high and limits the current going into the CHG pin.
* **Recommendation**: A 1MΩ resistor with a suitable power rating (typically 1/4W or higher depending on the application) and a tolerance of 1% for accuracy.

\**R2 and R2* (1MΩ resistors)\*\*:

* **Purpose**: These resistors ensure the gates of Q1 and Q2 are pulled down when the CHG or DSG pins are turned off. This helps to turn off the FETs reliably.
* **Recommendation**: 1MΩ resistors with a similar power rating and tolerance as R1.

**Rsns**:

* **Purpose**: This is the sense resistor used to measure the current flowing in and out of the battery pack.
* **Recommendation**: Choose a sense resistor with a low resistance value (typically in the milli-ohm range) and a power rating that can handle the maximum expected current. The exact value depends on the sensitivity and range of current measurement required by the BQ769x0.

**Q3 (P-channel MOSFET)**:

* **Purpose**: This FET keeps the CHG pin from being exposed to high voltages when PACK- is at a higher potential.
* **Recommendation**: A low-cost P-channel MOSFET with adequate voltage and current ratings for your application.

**Diode**:

* **Purpose**: The diode across CHG pin is used to pull the Q1 gate high.
* **Recommendation**: A Schottky diode with a low forward voltage drop and adequate current rating to protect the gate of Q1.

**Zener Diode** (optional):

* **Purpose**: This may be used to prevent Q1 from turning on too quickly due to a transient spike.
* **Recommendation**: A Zener diode with a breakdown voltage suitable for your application, usually around the Vgs threshold of Q1.

MOSFETS

**RDS(on)**, or "Drain-Source On Resistance," is a key parameter of a MOSFET. It represents the resistance between the drain and source terminals when the MOSFET is fully turned on (i.e., in the "on" state). This resistance determines how much voltage drop and power dissipation occurs within the MOSFET when current flows through it.

Lower RDS(on): Results in lower power dissipation and higher efficiency, as less power is converted to heat within the MOSFET.

Higher RDS(on): Results in higher power dissipation and potentially more heat generation.

**Microcontroller**