**WALRUS 2.0 PDU BASIC SCHEMATIC**

**DIFF TYPE OF PDU APPROACHES**

**1. Separate PDU for High Voltage (HV) and Low Voltage (LV) Systems**

In this setup, separate PDUs are used for the HV and LV systems. For example:

* **HV PDU:** Supplies power to BLDC motors.
* **LV PDU:** Supplies power to sensors, controllers, and other peripherals.

**Advantages**

* **Isolation:** Clear separation minimizes interference between HV and LV systems.
* **Scalability:** Independent designs allow for easier upgrades or changes to either system.
* **Safety:** Prevents cross-contamination of voltages, reducing risks.

**Disadvantages**

* **Space and Weight:** Requires additional space and may add weight.
* **Cost:** Higher cost due to separate components.
* **Complexity:** More wiring and connectors required.

**Applications**

* Robots with distinct HV and LV requirements.
* Industrial automation bots with heavy-duty actuators and sensitive sensors.

**2. Hybrid PDU (Shared Unit for HV and LV Systems)**

In this setup, a single PDU handles both HV and LV systems with dedicated sections and circuitry for isolation.

**Advantages**

* **Compact Design:** Reduces the overall size and weight.
* **Cost-Effective:** Single unit reduces material and manufacturing costs.
* **Ease of Integration:** Simplifies wiring and reduces system complexity.

**Disadvantages**

* **Interference Risk:** Potential for HV to affect LV operations without proper isolation.
* **Limited Customization:** Design changes to one system might affect the other.
* **Maintenance Difficulty:** Issues in one section could impact the entire system.

**Applications**

* Lightweight robots or drones with limited space.
* Systems with minimal isolation requirements between HV and LV.

**3. Modular PDU (Pluggable/Customizable Units)**

This design allows for modular units that can be swapped or customized for HV or LV systems as needed.

**Advantages**

* **Flexibility:** Modules can be replaced or upgraded independently.
* **Customization:** Tailored to specific requirements for HV or LV.
* **Redundancy:** Faulty modules can be replaced without affecting other parts.

**Disadvantages**

* **Higher Initial Cost:** Customization increases development costs.
* **Complex Design:** Requires a well-thought-out modular system.

**Applications**

* Robots requiring frequent upgrades or different configurations.
* Prototypes or research-based bots.

**4. Intelligent/Active PDU**

This is an advanced type of PDU with integrated microcontrollers, monitoring systems, and communication interfaces for HV and LV management.

**Advantages**

* **Real-Time Monitoring:** Tracks voltage, current, and temperature.
* **Efficiency:** Optimizes power distribution dynamically.
* **Fault Detection:** Identifies issues like overcurrent or overheating.

**Disadvantages**

* **High Cost:** Expensive due to advanced electronics.
* **Complex Maintenance:** Requires skilled personnel for troubleshooting.

**Applications**

* Autonomous robots requiring real-time diagnostics.
* High-performance systems like swarm robots or drones.

**Applications Based on Voltage Systems**

**High-Voltage (HV) System**

* Powering BLDC motors, typically 24V to 48V.
* Requires robust wiring and components for high current demands.

**Low-Voltage (LV) System**

* Powering microcontrollers, sensors, and communication devices (5V or 3.3V).
* Requires precise voltage regulation for sensitive electronics.

**Key Factors for Selection**

1. **Space and Weight:** Compact bots benefit from hybrid or modular PDUs.
2. **Cost Constraints:** Separate PDUs are costlier but more reliable for sensitive systems.
3. **Performance Needs:** Intelligent PDUs suit high-end applications with diagnostic requirements.
4. **Safety Requirements:** Separate PDUs provide better isolation for critical systems.

**PDU BASIC DESIGN SCHEMATIC**

**High-Voltage PDU Design (24V for BLDC Motors)**

**1. Define Requirements**

* Voltage: 24V (nominal)
* Peak Current: Calculate based on the total power draw of 8 BLDC motors. For example: Power per Motor (P)=V×I(given by motor specs)\text{Power per Motor (P)} = V \times I \quad \text{(given by motor specs)} Power per Motor (P)=V×I(given by motor specs) Total Current=Number of Motors×Peak Current per Motor\text{Total Current} = \text{Number of Motors} \times \text{Peak Current per Motor}Total Current=Number of Motors×Peak Current per Motor

**2. Component Selection**

**a. Power Source**

* **Option 1: Lithium Polymer (LiPo) Battery Pack**
  + Pros: High energy density, lightweight, common for robotics.
  + Recommended: 6S LiPo (22.2V nominal, ~25V when fully charged).
* **Option 2: Lithium-Ion Pack**
  + Pros: Safer and longer lifespan compared to LiPo.
  + Recommended: 7S pack (~25.2V fully charged).

**b. Power Distribution**

* Use **high-current-rated connectors**:
  + **XT60 or XT90 connectors** for battery input/output.
  + **Bullet connectors** for motor ESCs.

**c. Protection**

* **Fuses**:
  + Add fuses for each motor's Electronic Speed Controller (ESC).
  + Recommended: **Blade fuses** (e.g., automotive ATC/ATO type).
* **TVS Diodes**:
  + Protect against voltage spikes from inductive loads (motors).
  + Recommended: **SM6T24A** for 24V systems.
* **EMI Filters**:
  + Suppress motor-generated noise.
  + Use **LC filters** between the PDU and ESCs.

**d. Voltage Monitoring**

* Add a **voltage divider circuit** with resistors and an ADC pin for your microcontroller to monitor the 24V battery level.
* Alternatively, use a dedicated **voltage monitor IC**.

**e. PCB Design Tips**

* **Trace Width**:
  + Use a PCB trace width calculator to design traces for high-current paths. For example, 2 oz copper thickness can handle ~10A with a 2mm wide trace.
* **Copper Pour**:
  + Use a copper pour for the ground plane and high-current lines.

**3. Recommendations**

* For **protection**, use a combination of blade fuses, TVS diodes, and EMI filters.
* For **connectors**, go with XT90 for main power input and bullet connectors for ESCs.
* Use **6S LiPo batteries** for optimal performance with BLDC motors.

**Low-Voltage PDU Design (Sensors and Controllers)**

**1. Define Requirements**

* Voltage Levels: Likely **5V** (for sensors) and **3.3V** (for microcontroller and logic circuits).
* Current: Estimate total current requirements of all components. Add a 20% margin for safety.

**2. Component Selection**

**a. Voltage Regulators**

* **Option 1: Buck Converters**
  + Efficient for high-current applications.
  + Recommended:
    - **MP1584** (for 5V, adjustable).
    - **LM2596** (more robust, up to 3A output).
* **Option 2: Linear Regulators**
  + Low noise but inefficient for high currents.
  + Recommended:
    - **LM7805** (5V fixed, up to 1A).
    - **LD1117** (3.3V, up to 1A).

**b. Power Input**

* Use a **DC-DC step-down converter** to step 24V down to 12V or 5V as the primary input.
* Recommended: **DROK Adjustable Buck Converter** (wide input range).

**c. Connectors**

* **JST connectors** for low-current devices.
* **Screw terminals** for general-purpose outputs.

**d. Protection**

* **Fuses**:
  + Use **polyfuses** (self-resetting) for low-voltage lines.
  + Example: **200mA to 1A polyfuses** based on load requirements.
* **TVS Diodes**:
  + Protect against ESD and transients.
  + Example: **1N5908** for 5V lines.
* **Decoupling Capacitors**:
  + Place near each sensor or IC to filter noise.
  + Recommended: **0.1µF ceramic capacitors** in parallel with **10µF electrolytic capacitors**.

**e. Monitoring and Feedback**

* Add **current sensors** (e.g., **INA219**) to monitor the current consumption of sensors and controllers.
* Include an **LED indicator** for each power rail.

**f. PCB Design Tips**

* Keep sensitive analog and digital signal traces away from power lines.
* Use **ferrite beads** to filter noise between power rails.

**3. Recommendations**

* For efficient low-voltage regulation, use **MP1584 buck converters**.
* For protection, combine polyfuses, TVS diodes, and decoupling capacitors.
* For feedback, integrate an **INA219 sensor** to monitor voltage and current on low-voltage lines.

**General Recommendations**

**Interfacing High and Low Voltage Systems**

* Use **isolated DC-DC converters** if direct interaction is required between high and low voltage systems.
* Alternatively, employ **optocouplers** for signal-level communication.

**Tools and Resources**

1. **PCB Design Software**:
   * KiCad (free and open-source) or Eagle.
2. **Simulation Tools**:
   * LTspice for testing circuit behavior.
3. **Hardware Debug Tools**:
   * Multimeter, oscilloscope, and thermal camera (for detecting hotspots).