Custom PCB for Robotic Arm with ESP32 and Stepper Motor Control

Project Overview:

We are developing **Armold 4.0**, a compact and powerful 6-axis robotic arm. This project requires the creation of a **custom PCB** to integrate multiple electronic components, including **ESP32 DEVKITV1 modules, A4988 stepper drivers, servo motors, and cooling fans**. The PCB will serve as the central controller, efficiently managing the power, communication, and coordination of the robotic arm's six NEMA 17 stepper motors, magnetic encoders, and additional peripherals. Future support for a **camera** module is required, so extra pins must be easily accessible.

The goal of this PCB is to make the system **as compact and organized as possible** while ensuring that the power is properly distributed across the components.

Deliverables:

- **Compact PCB design** (with Gerber files) optimized for the following components.
- **Complete documentation** with pin assignments, schematics, and wiring diagrams.
- **Bill of Materials (BOM)** for sourcing components.
- **Guidelines** for board assembly and soldering.

Connected Components and Features:

1. **ESP32 DEVKITV1 Modules (x2):**
    a. **One ESP32** will control **4 stepper motors** (base motor + joints 2, 3, and 4).
    b. **The second ESP32** will manage the remaining **2 stepper motors, 1 servo motor, and 2 cooling fans**.
    c. The **two ESP32s must share the load** and communicate efficiently.
2. **A4988 Stepper Motor Drivers (x6):**
    a. Each A4988 driver will control a NEMA 17 stepper motor.
    b. The **STEP, DIR, and ENABLE** pins of the drivers will be connected to the ESP32s.
    c. Ensure proper **voltage regulation** to supply the motor drivers with **12-24V**.

3. **NEMA 17 Stepper Motors (x6):**
    a. **37mm NEMA 17 motors** for the first four joints, **23mm NEMA 17 motors** for the top two joints.
    b. The drivers must be capable of providing **sufficient current and torque** to handle the payload.
    c. Each motor will use **AS5600 magnetic encoders** for position sensing.
4. **AS5600 Magnetic Encoders (x6):**
    a. These will be mounted at the back of each stepper motor for precise angle measurement.
    b. Encoders will communicate via **I2C**, so ensure an I2C bus is correctly routed.
5. **Micro Servo Motor:**
    a. The servo will control the **gripper** at the end of the robotic arm. It requires a **PWM pin** and **5V power**.
6. **Cooling Fans (x2):**
    a. Each fan will be controlled through **MOSFETs** for on/off control via the ESP32.
    b. Ensure sufficient **cooling for the electronics and stepper drivers**.
7. **Future Camera Integration:**
    a. Spare pins must be routed for **SPI or I2C camera** support.
    b. Include an option for a **camera mount near the gripper**.
8. **Power Supply and Regulation:**
    a. **Barrel Jack Input:** 12-24V input power supply to power the entire board and motors.
    b. **Voltage Regulation:** Provide appropriate regulation for **3.3V logic (ESP32)** and **5V for fans and the servo**.

Design Considerations:

- **Compact Layout:** Keep the PCB as small as possible to fit within the robotic arm's base.
- **Pin Accessibility:** Provide easy access to **spare pins** for additional sensors or peripherals.
- **Heat Dissipation:** Ensure space for heatsinks or cooling mechanisms for the A4988 drivers.
- **Communication between ESP32s:** The ESP32s should be able to **synchronize movements** via UART or I2C.
- **Reset Button:** A single **reset button** for the entire system, accessible from outside the arm.

Expected Deliverables:

1. **Gerber Files** for PCB fabrication.
2. **Schematics and Pin Mapping** for ESP32, stepper drivers, and encoders.
3. **Wiring Diagrams** showing how each component connects to the PCB.
4. **Recommendations for Assembly** (mounting options, enclosure suggestions, etc.).