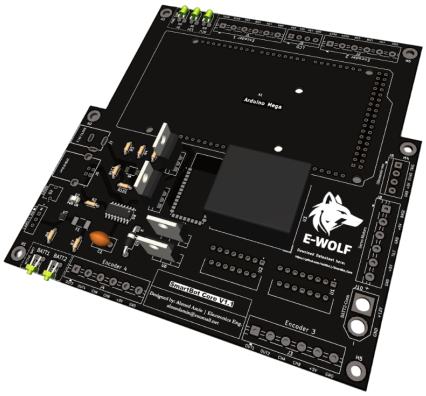

SmartBot Core V1.1

The full SmartBot Core V1.1 project is available at:
https://github.com/void0x11/SmartBot

1 Overview

SmartBot Core V1.1 is a professionally engineered, four-layer control PCB developed to serve as the central brain of modern autonomous or semi-autonomous robots. It combines compact hardware design with advanced electrical protection and power routing mechanisms, making it ideal for both prototyping and final product integration.

This board is designed to handle:

- **Robust power management:** Supports dual battery sources with automatic failover via a built-in Power Multiplexer (MUX), ensuring uninterrupted operation during battery depletion or switching.
- **Reliable communication:** Provides a dedicated USB-B port for serial communication and firmware uploading via a CH340G USB-to-Serial interface, simplifying debugging and integration with development environments like Arduino IDE.
- **Motor and encoder interfacing:** Integrates an L298N motor driver IC and supports up to 3 motor channels with 4 independent quadrature encoder inputs, making it suitable for wheeled mobile robots or robotic arms.
- **Signal clarity and EMI reduction:** Built on a 4-layer FR4 PCB with internal ground and power planes, combined with GND stitching vias for clean signal referencing and noise reduction.
- **User diagnostics:** Equipped with multiple onboard status LEDs for battery selection, voltage rails (12V, 5V, MCU power), and power presence, enabling easy visual diagnostics and field maintenance.
- **Clean expandability:** All interfaces such as I2C, UART, ultrasonic sensor, and user buttons are broken out and labeled clearly, allowing quick connection to external modules without clutter or confusion.

This board is particularly suited for:

- Educational robots used in labs, classrooms, and competitions
- Smart automation prototypes with modular design requirements
- Battery-powered mobile platforms with multiple actuators and sensors
- Research and development kits for embedded systems or motion control

2 Functional Description

- **Power MUX Module:** Automatically selects between two DC sources (BAT1 and BAT2). A dual MOSFET configuration ensures seamless failover in case of main battery failure. Each source is filtered and passed through current-limiting resistors and LEDs for real-time source indication.
- **Power Protection Module:** Implements over-current and over-voltage protection using a surface-mounted fuse and a bidirectional TVS diode. It safeguards downstream logic and motor driver components from power surges up to $18\,\mathrm{V}$ and currents over $1.1\,\mathrm{A}$.
- **USB-B UART Interface:** Provides a direct, external access point to the microcontroller's UART. This allows programming and debugging through a USB-B port routed to a CH340G USB-to-Serial converter.
- **Microcontroller Core:** An ATmega2560 is used as the central processor. It interfaces with 4 encoder inputs, 3 motor channels, and various peripheral I/Os (sensors, buttons, LCD). All key pins are labeled and broken out.
- **Motor Driver Integration:** The L298N IC is directly embedded on the PCB, minimizing layout footprint. It supports up to 3 motor channels. Flyback diodes and current sensing resistors are included for safe operation.
- **GND Shielding:** Multiple plated through holes and vias are tied to the internal GND layer, ensuring low-noise reference planes and shielding critical signals from EMI. A full copper GND shield surrounds the board edges.
- **Indicators:** Three primary LEDs indicate Power status, Battery 1 active, and Battery 2 active. They are connected through 330–470 Ω current-limiting resistors and positioned on the PCB front edge for easy visibility.

3 Technical Specifications

Parameter	Unit	Value
Operating Voltage Range	V	12
Max Continuous Current	A	1.1
TVS Clamping Voltage	V	18
Fuse Rating	A	1.1 (SMD replaceable)
Logic Level Voltage	V	5
Number of Layers	–	4
Board Material	–	FR4 (1.6mm thickness)
Microcontroller	–	ATmega2560
I/O Pins Available	–	54 Digital, 16 Analog
PWM Channels	–	14
ADC Resolution	bits	10
Motor Channels	–	3 (via L298N)
Encoder Inputs	–	4
UART Interfaces	–	1 (USB-B to CH340G)
Protection Features	–	TVS + Fuse + Reverse Polarity
Operating Temperature	°C	-20 to +70
Board Dimensions	mm	TBD
Mounting Holes	–	4 (M3 compatible)

4 Pinout and Indicators

Pin Label	Function
VIN	Main External Power Input (Battery1 Using DG-Jack Connector)
BAT1 / BAT2	Dual battery source terminals (Main and Backup Battery)
GND	Common Ground connection
USB-B Port	UART connection for Arduino programming/debugging
TX / RX	UART Serial interface to MCU
OUT1 – OUT4	Motor driver outputs (up to 4 motors supported)
ENC1 – ENC4 (CHA/CHB/+5V/GND)	Quadrature encoder inputs
LCD (SDA/SCL/+5V/GND)	I2C LCD interface
TRIG / ECHO	Ultrasonic sensor interface
RESET (S2)	Arduino reset button (For clear code)
Power Switch (S1)	Toggle main system ON/OFF
BAT1_LED / BAT2_LED	Indicators for active battery source
PWR_STAT	General system power status indicator
MCU ON / 12V OK / 5V OK	LED indicators for onboard voltage rails

5 Absolute Maximum Ratings

Parameter	Max Value	Unit
Input Voltage (VIN)	18	V
Output Current (OUTx)	1.0	A
Logic Voltage (MCU)	5	V
Storage Temperature	-40 to +85	°C
Operating Temperature	-20 to +70	°C

Note: The maximum input current the circuit is rated for is $1.1\,\mathrm{A}$. If this value is exceeded, the onboard surface-mount fuse will blow to prevent damage to circuit components. The fuse is easily replaceable and can be re-soldered or swapped during maintenance.

6 Layer Stackup

- **Layer 1 (Top):** Surface-mounted signal routing
- **Layer 2:** GND reference and light signals
- **Layer 3:** Power delivery (Main power + auxiliary traces)
- **Layer 4 (Bottom):** Core routing layer (MainCU)

All ground planes are tightly coupled through dense stitching vias and perimeter pad holes, forming a continuous low-impedance ground network. This architecture significantly enhances EMI suppression and ensures consistent signal referencing across the PCB, especially in high-speed or sensitive analog regions.

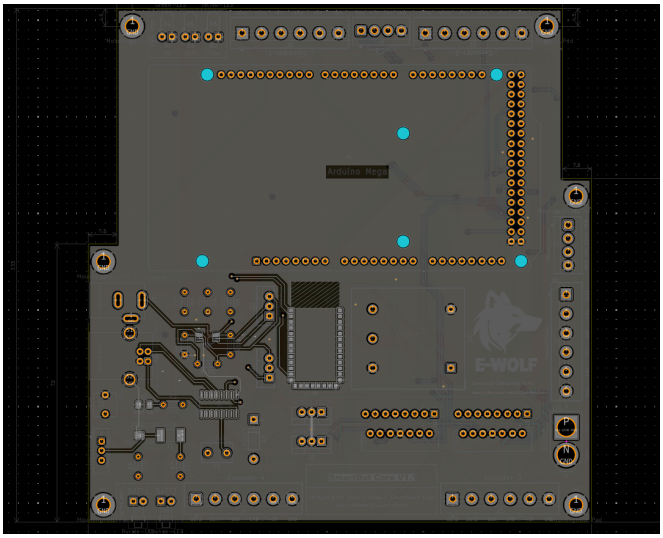

Figure 1: Layer 1: Surface-mounted Signal Routing

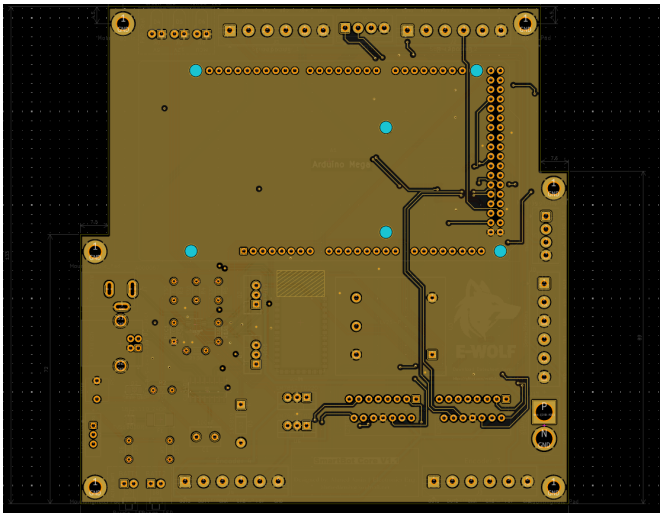

Figure 2: Layer 2: Ground Reference and Signal Traces

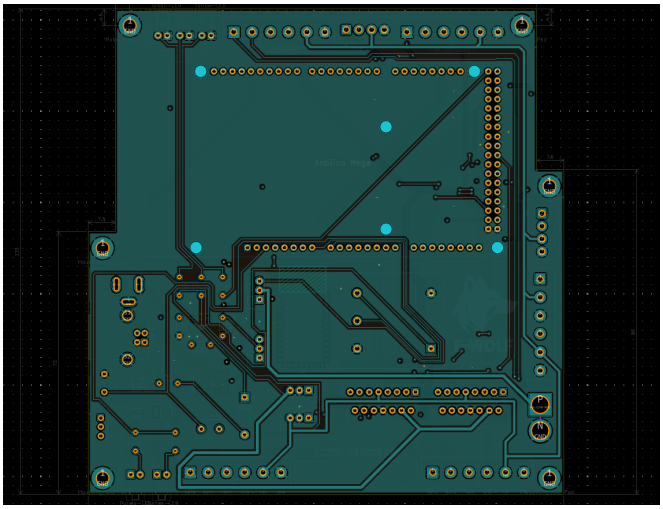

Figure 3: Layer 3: Power Plane and Auxiliary Routes

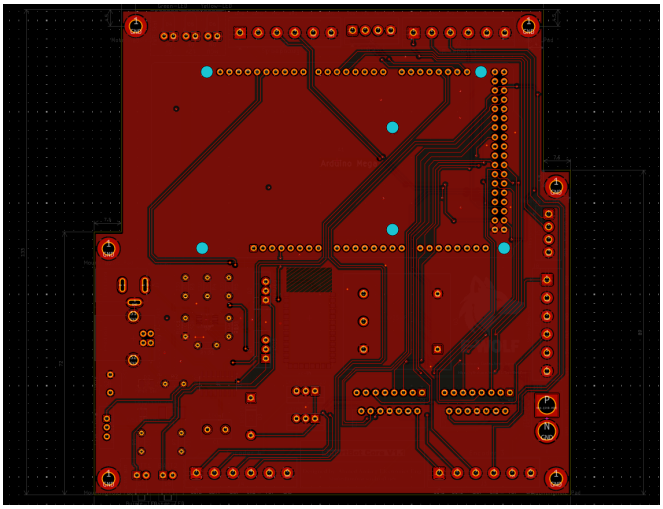

Figure 4: Layer 4: Core Routing Layer

7 Electrical Characteristics

Parameter	Min	Typ	Max
Supply Voltage (VIN)	7	12	18 V
Logic High Level (MCU IO)	2.0	5.0	5.5 V
Motor Output Voltage	VIN - 2.0	–	VIN
UART Baud Rate	–	9600	115200 bps
Encoder Supply Voltage	4.8	5.0	5.2 V

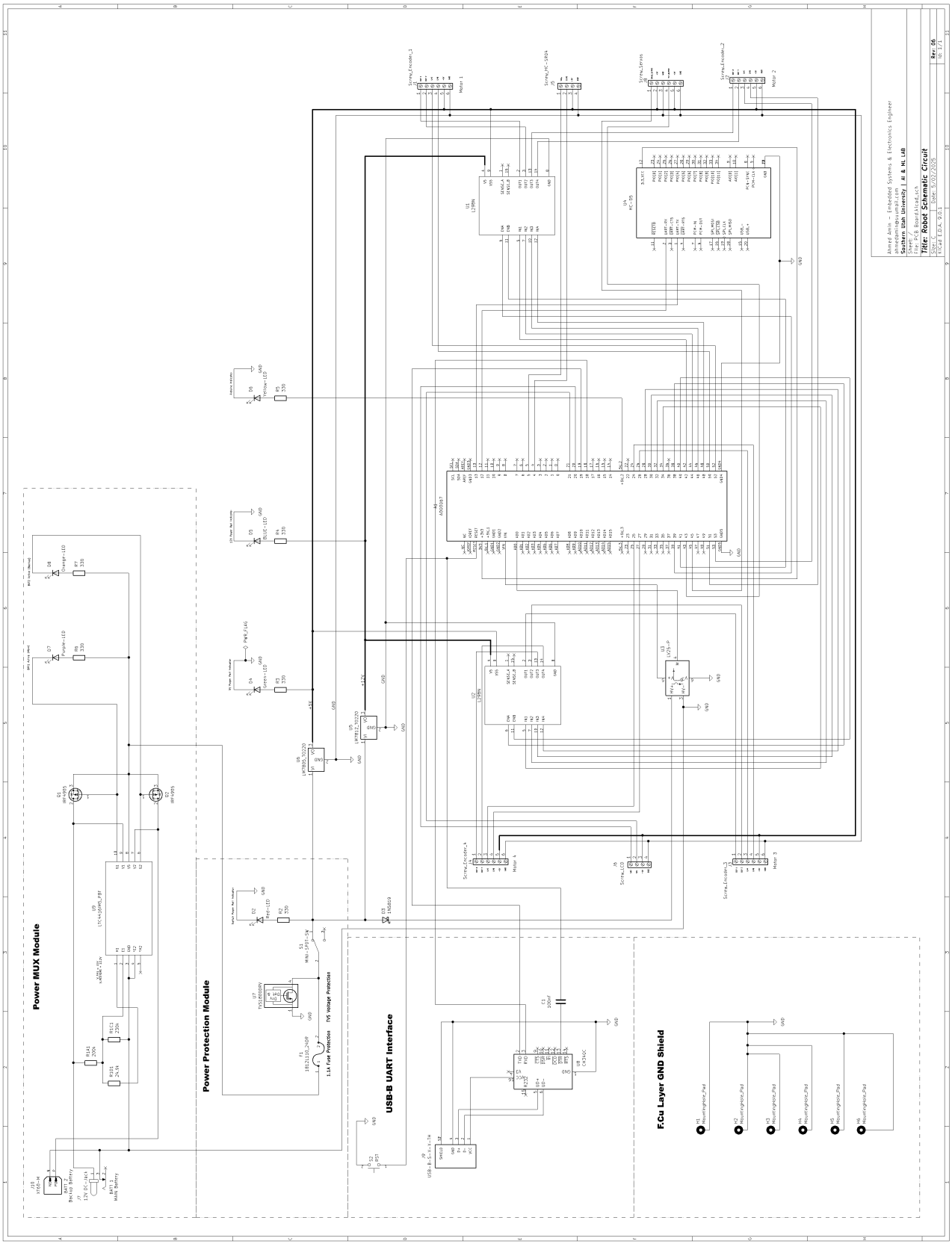

Figure 5: SmartBot Core V1.1 – Full Schematic

Version	Date	Description
V1.0	May 2, 2025	Initial release with basic motor driver and encoder support
V1.01	May 4, 2025	Added USB-B UART external interface
V1.02	May 7, 2025	Integrated Power MUX circuit and LED indicators
V1.03	May 12, 2025	Improved GND shielding and PCB 4-layer restructuring
V1.04	May 20, 2025	Added full encoder input headers and button support
V1.1	May 28, 2025	Final layout with all diagnostics, labels, and protection circuits

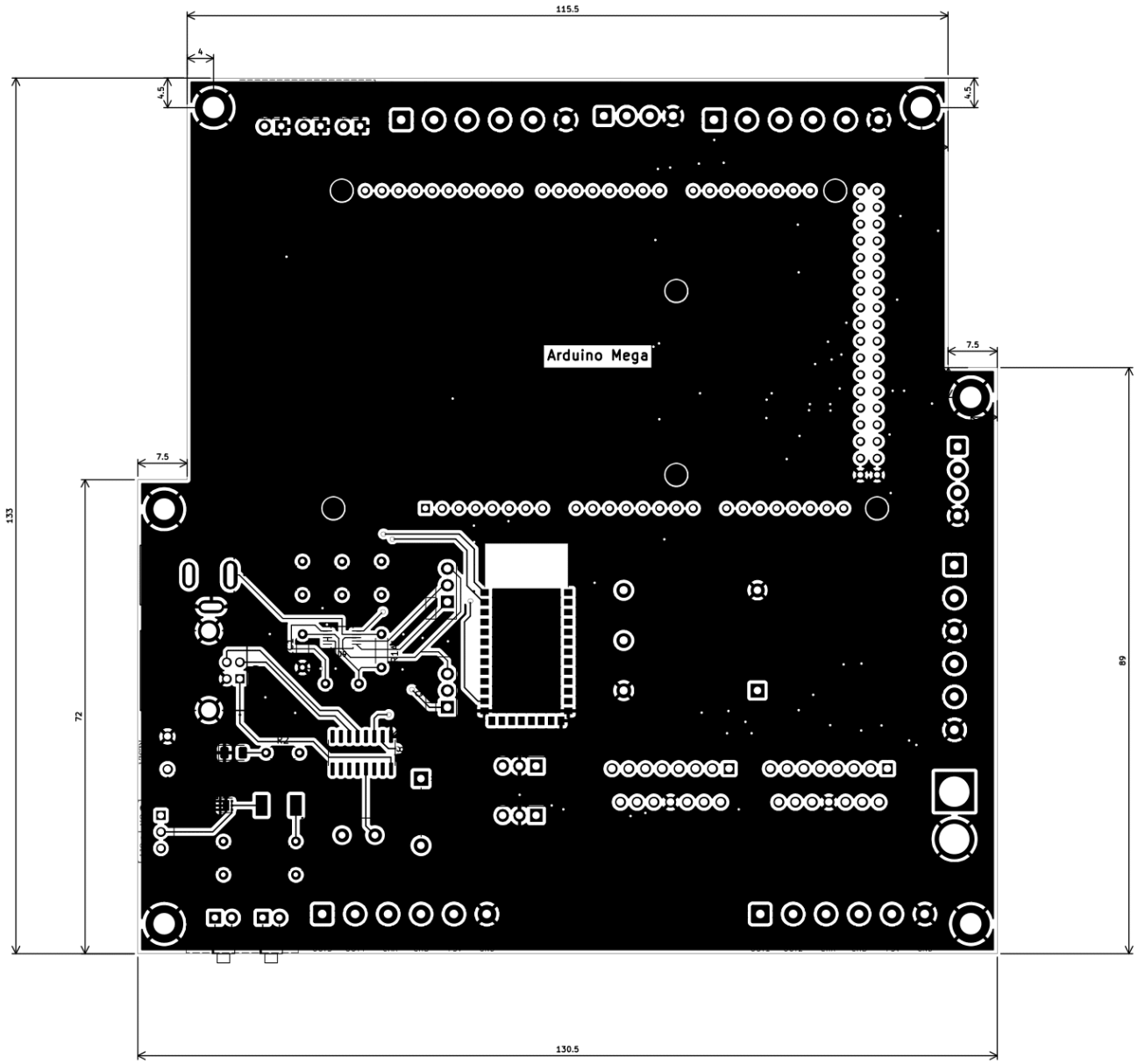

Figure 6: SmartBot Core V1.1 – Board Dimensions

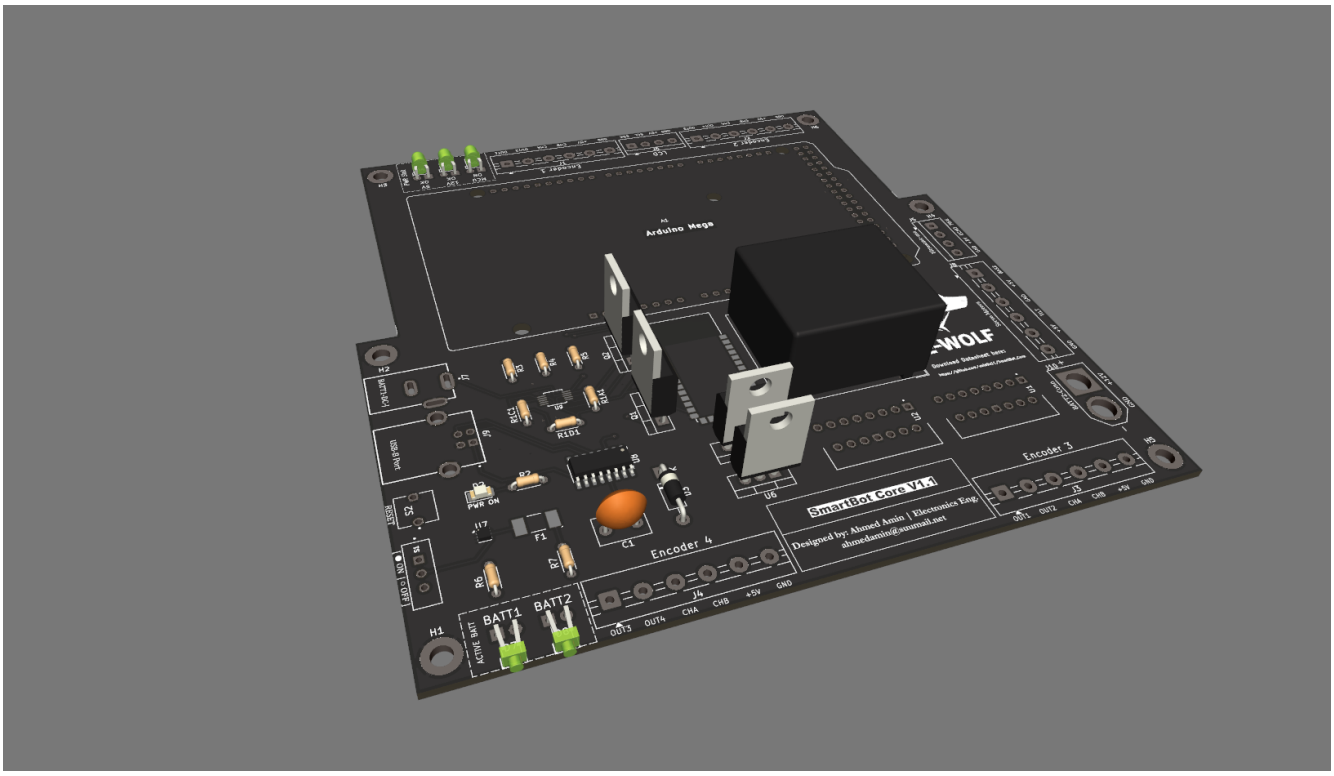

Figure 7: Typical Application: Full PCB Shape 90 degree left

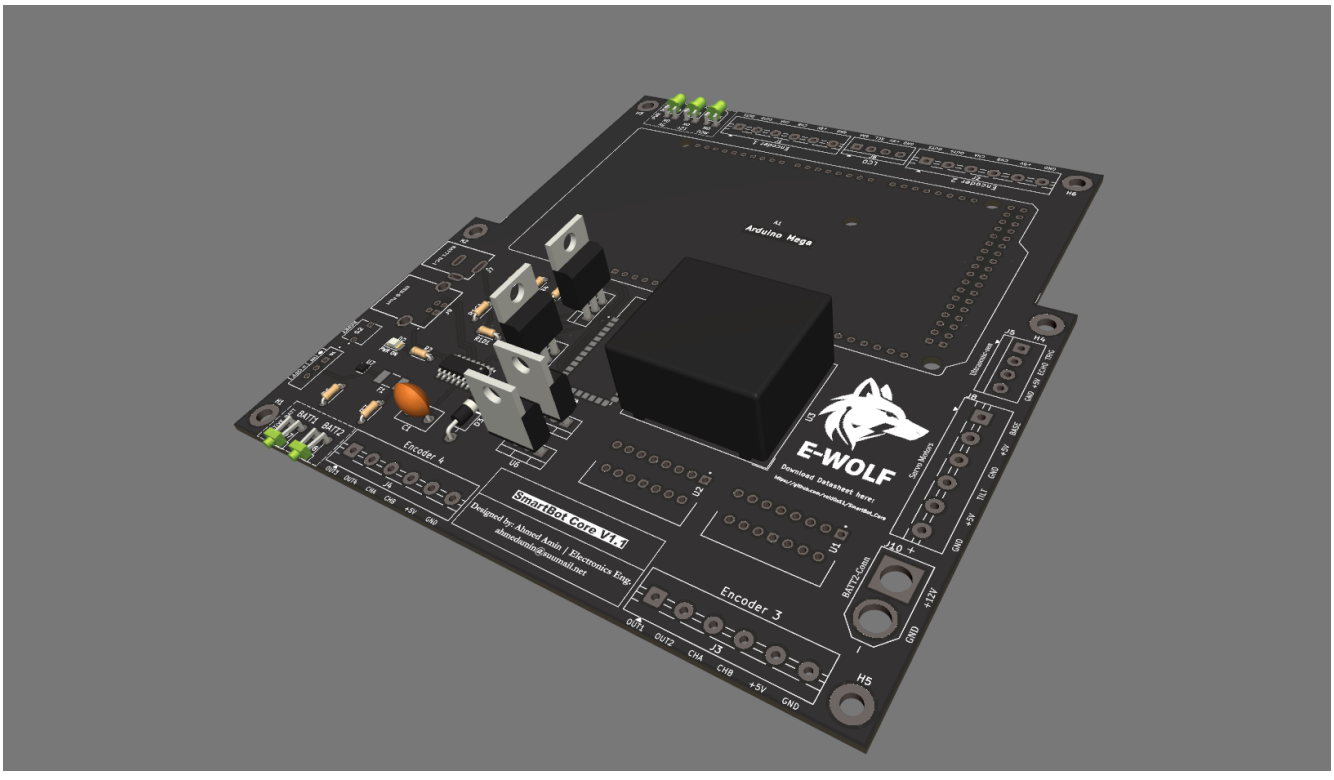

Figure 8: Typical Application: Full PCB Shape 90 degree right

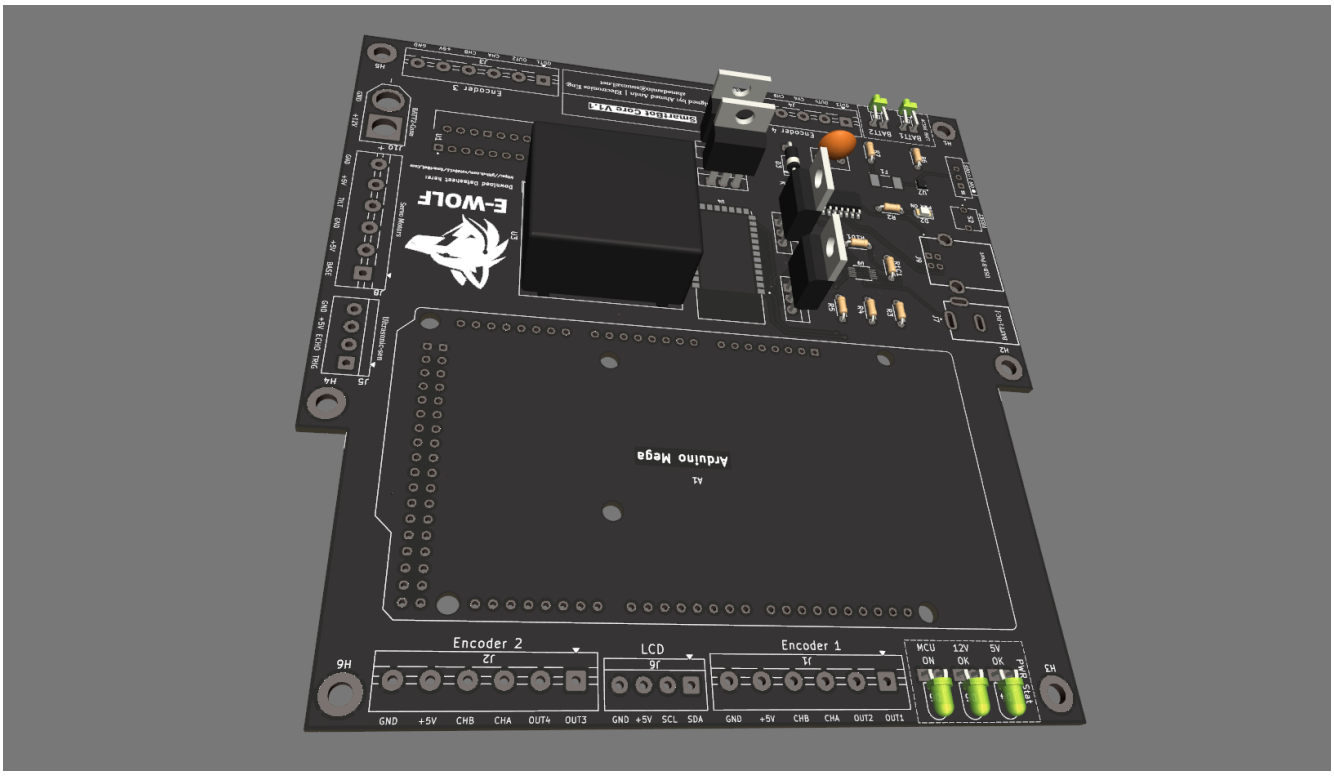

Figure 9: Typical Application: Full PCB Shape centered

Figure 10: Typical Application: Full PCB Shape zoomed

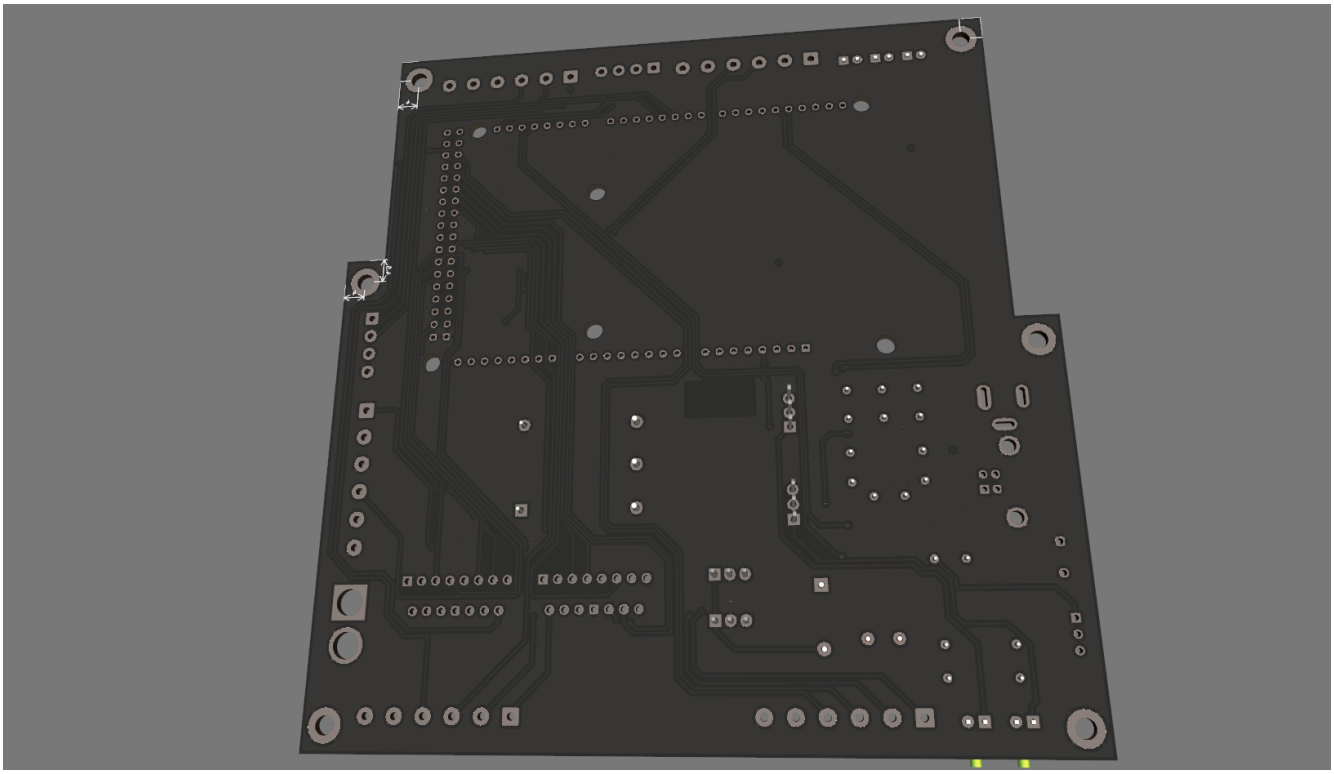

Figure 11: Typical Application: Full PCB Back Traces