

MSDII Project 22430: Operating Instructions for Walking FBD Suit**I. Introduction**

This document serves to detail the operation and maintenance of MSD project 22430, a free body diagram suit utilizing a pair of gloves and boots outfitted with force sensors to register force interactions from the wearer's environment. Forces are numerically reported on an OLED screen, while calibrated LED panels with configurable color modes indicate the intensity of the force applied.

II. Basic Operation/Initialization

The suit is powered by a set of four nine-volt battery power packs, along with a single rechargeable 5V-6A block. These reside within the backpack of the suit, which houses the core control electronics of the suit. These power sources are visible and accessible on the backpack as indicated in Figure 1

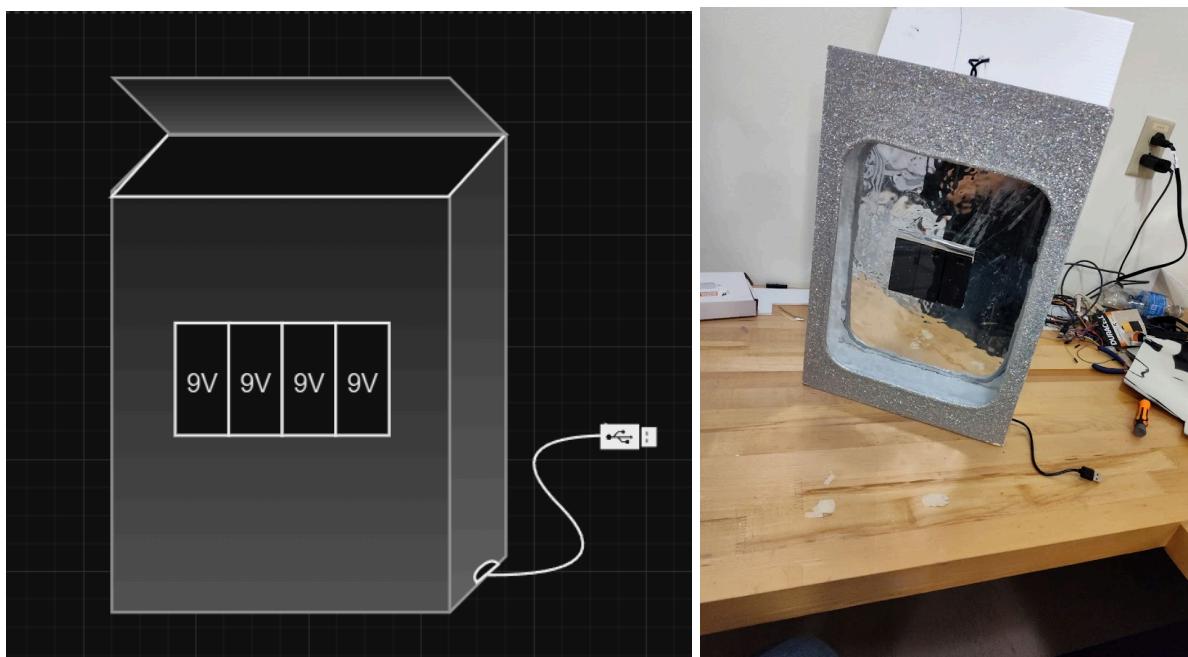


Figure 1. Suit External Power

To power on the suit, each of the four switches on the battery packs must be set to "on" from within the backpack. This is done by opening the lid of the backpack and accessing the front compartment. These battery packs supply power to one of the Arduino microcontrollers and three power module PCBs responsible for controlling the LED displays for the arms, legs, and tie. The remaining two microcontrollers are powered by a rechargeable 5V battery module, which can be recharged through a USB-A connector, as shown in Figure 1.

A diagram detailing the layout of the removable electronics tray is indicated in Figure 2.

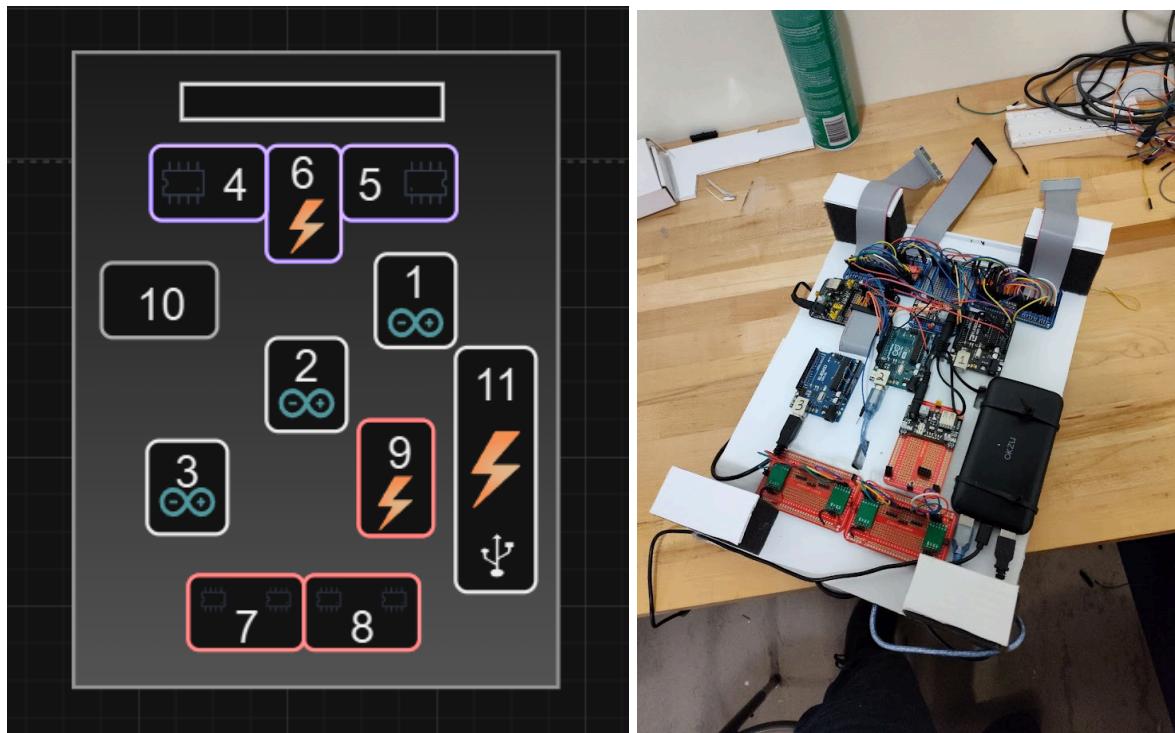


Figure 2. Removable Electronics Display Tray

For the purposes of this section, relevant modules include Module 11, which represents the rechargeable battery used to power Arduinos 2 and 3, as well as Modules 9, 10, 6, and 1, which correspond to the power module PCBs and Arduino, respectively, powered by the 9V battery sources.

The corresponding ribbon cable connections for the right and left arms, legs, and the tie OLED/LED/Button Control connector are shown in Figure 3.

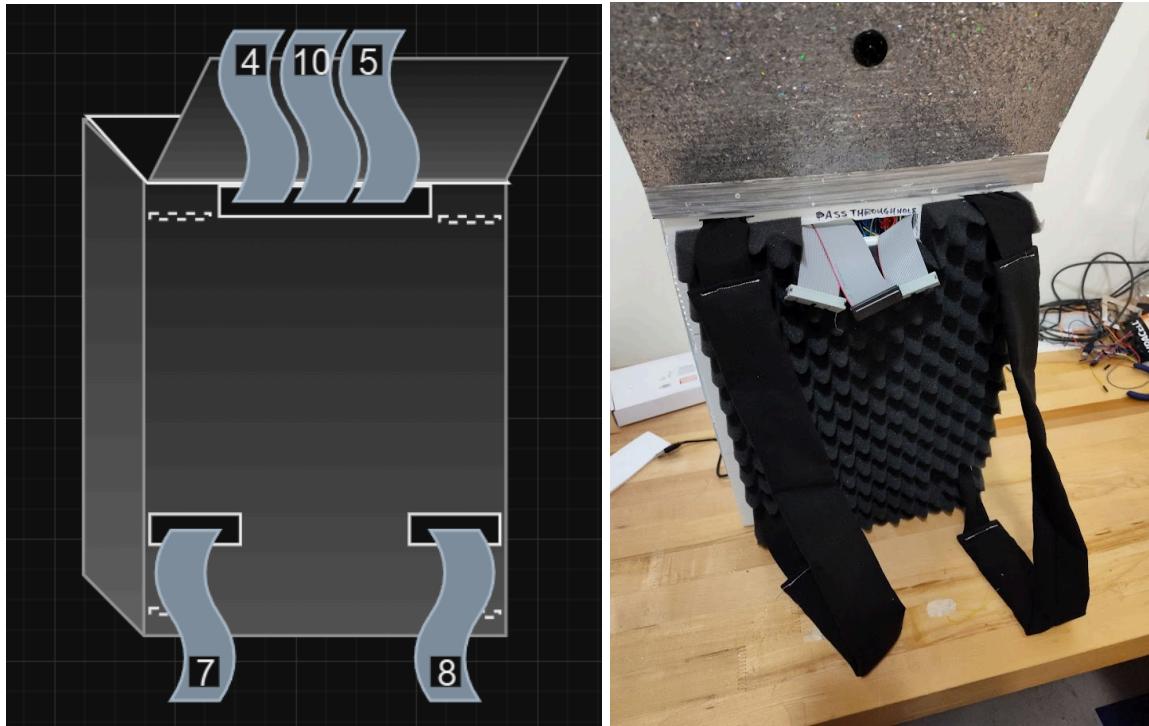


Figure 3. Backpack Ribbon Cable Routing

In the above figure, ribbon cable connectors 4 and 5 correspond to the right and left gloves, respectively, and connect internally to the arm control PCBs. These PCBs are linked to ribbon cables that exit the back of the backpack and are routed through the suit sleeves to the arms. Ribbon connector 10 in Figure 3 connects directly to the tie neck mount. Connectors 7 and 8 correspond to the right and left legs and are joined to ribbon cables routed through the pants.

For all components and connections, ensure that the red line on each connecting cable is aligned between components. For example, verify that the red line on the male connector from the backpack for one arm matches the ribbon cable emerging from the suit for that arm. Then, connect the glove at the opposite end in the same manner.

A representation of the connected components, excluding the LED panels and suit fabric, is provided in Figure 4.



Figure 4. Full Suit Electronic Connections - "Exoskeleton"

Each of the LED panels for the arms, legs, and tie can be connected in the manner elaborated in Figure 5.

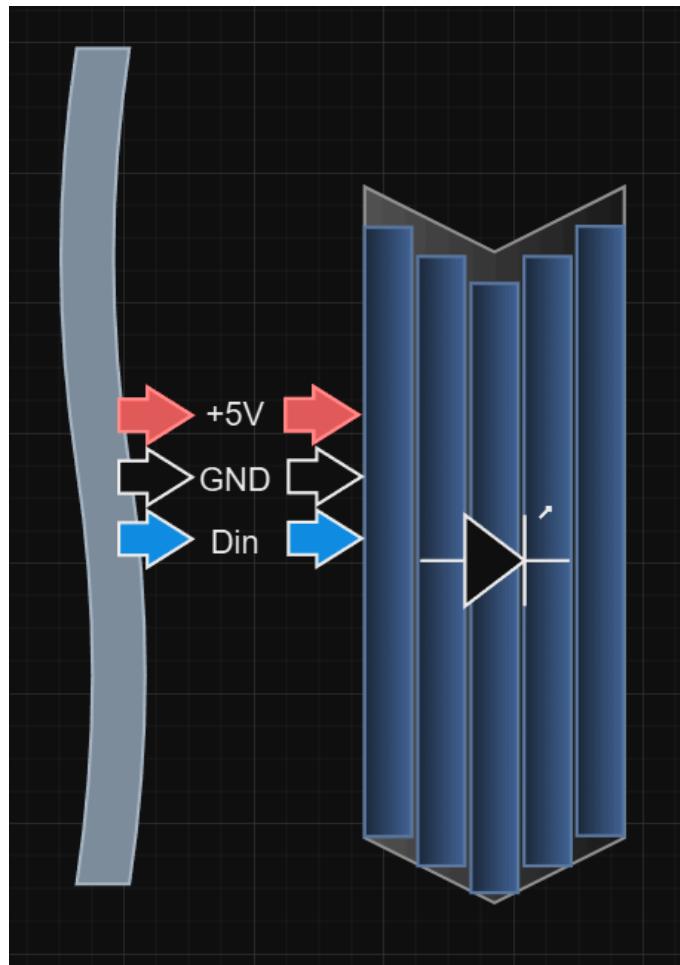


Figure 5. LED Panel Example

The four breakout ribbon cables for the arms and legs, routed through the suit, each include a set of three color-coded wires separated with pins and sockets for connection. Buttonholes by each panel in the suit allow these wires to pass through and connect to the panels, as shown in Figure 5. These wires consist of a power line, a ground line, and a data line, all driven from the control PCBs within the backpack. These same connections can be made for the panel on the tie via the tie's built-in ribbon cable.

After powering the suit, making the proper ribbon cable connections, and mounting the LED panels appropriately, the suit should be ready for use. The central button on the tie calibrates the user's weight vector and initializes the OLED force display. The display gradient on the LED panels can be adjusted for aesthetics using the colored buttons on the tie.

III. Technical Specifications

A complete breakdown of the electronic components of the suit, housed on a removable tray within the suit's backpack, is provided in Figure 6.

1. Right/Left Arm Control Arduino
2. Full Body OLED/LED Display Control Arduino
3. Right/Left Leg Control Arduino
4. Right Glove Control PCB (Multiplexer/Ribbon cable breakout)
5. Left Glove Control PCB (Multiplexer/Ribbon cable breakout)
6. 9V Power Module for Glove Control
7. Right Foot Control PCB (Load Cell Amplifier/Ribbon cable breakout)
8. Left Foot Control PCB (Load Cell Amplifier/Ribbon cable breakout)
9. 9V Power Module for Foot Control
10. Display Control PCB/ 9V Power Module/Ribbon Cable Breakout
11. 5V Arduino Rechargeable Power Supply

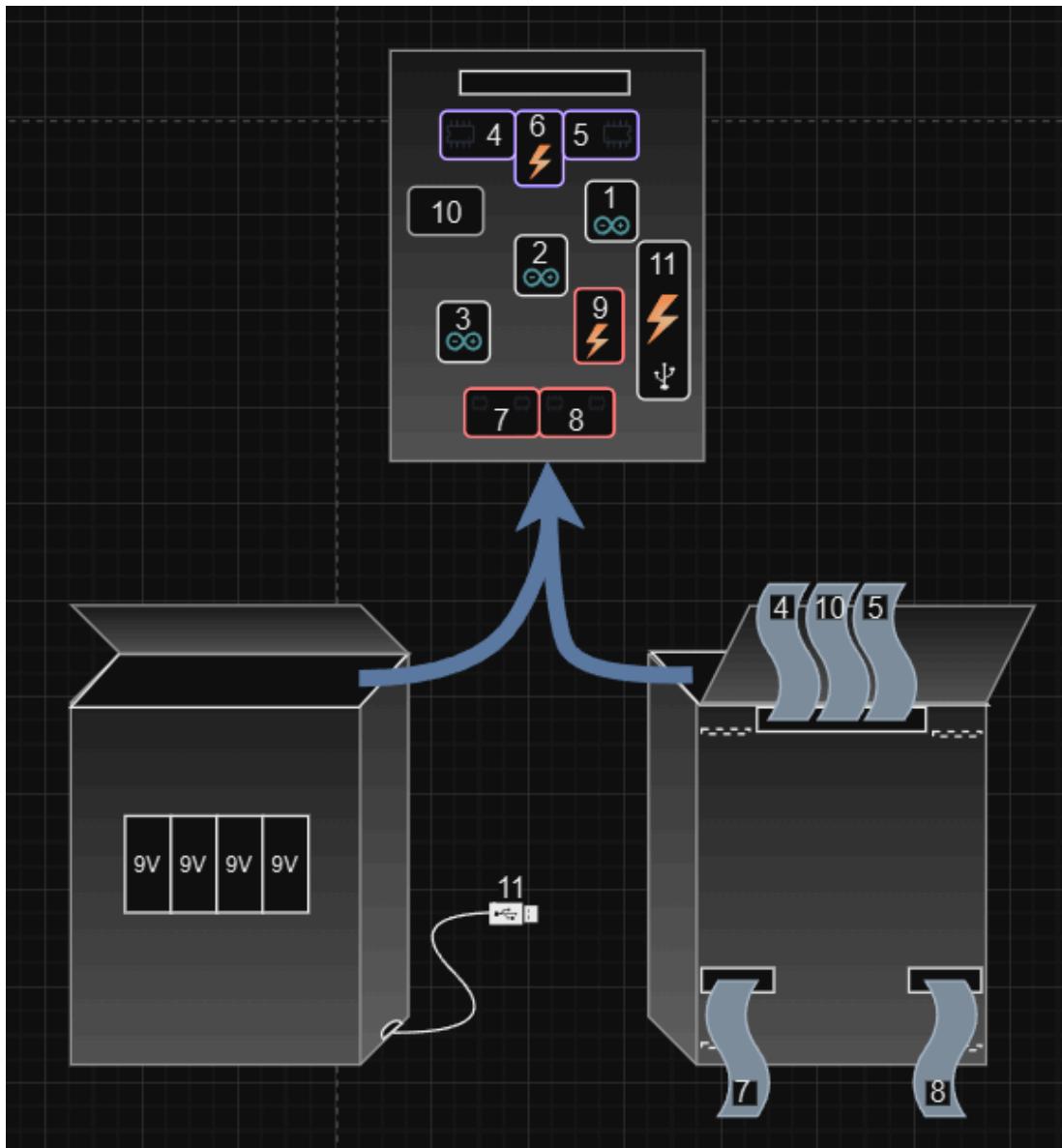


Figure 6. Backpack/Electronics Tray Diagram

IV. Programming, Code Modification, and Debug

All relevant code and documentation is present on the public repository given below.

https://github.com/jrb3982/MSDII_Walking_FBD

Release 1.0.0 is the most current available clonable version. After cloning, code can be viewed/modified/flashed through the Arduino IDE, available for installation here.

<https://www.arduino.cc/en/software>

The following libraries will need to be installed to compile the code used to program the suit. Each of these can be downloaded from the Arduino IDE under Tools->Manage Libraries.

- **FastLED** - Used to configure the WS2812 LEDs on each suit panel
 - **U8G2** - Used to configure the OLED display
 - **HX711_ADC** - Calibrate and configure load cell amplifiers

Arduinos 1, 2, and 3, as shown in Figure 6, can be programmed via the Arduino IDE over a COM port connection using the provided USB-A to USB-B cables. Some of these cables may need to be unplugged from the rechargeable battery source and connected to the host computer running the IDE for programming. The programs that run on each Arduino are available under the Release 1.0.0 folder. They are, respectively:

Arduino 1 - Right/Left Arm Control Arduino:

/Release 1.0.0/Load_Cell_Sensor_Code/read_2x_load_cell/read_2x_load_cell.ino

Arduino 2 - Full Body OLED/LED Display Control Arduino:

/Release 1.0.0/OLED_Data_Processing/OLED_Data_Processing.ino

Arduino 3 - Right/Left Leg Control Arduino:

/Release 1.0.0/Right_Left_Glove_Ctrl/Right_Left_Glove_Ctrl.ino