Improving Vaccine Efficacy via Wearable Bandage

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PROJECT STATEMENT

Our objective is to create a wearable "bandage" device that utilizes electroporation to enhance cellular absorption of vaccines. Our product is a compact, battery-powered device designed to generate multiple levels of Pulsed Electric Fields (PEFs). It incorporates an automated testing feature that confirms proper exposure and delivers a simple pass/fail result. This technology addresses a key challenge in vaccine delivery—improving cellular uptake—allowing cells to absorb vaccines more efficiently and enhancing overall vaccine effectiveness.

DESIGN & DISCOVERY

- DC to DC Power Conversion – 300 V_{DC} maximum output with 24 V_{DC} Input
- Application of Pulsed Electric Fields (PEF) through fine needle electrodes
- Eight pulse PEF Generation with target intensity between 400 – 1200 V/cm
- Successful electroporation response detected through drop in DC resistance
- Programmable logic control (Prototype – PLC, Final Concept – Field Programmable Gate Array (FGPA))
- Finite Element Analysis (FEA) verification using COMSOL™ multi-physics analysis software

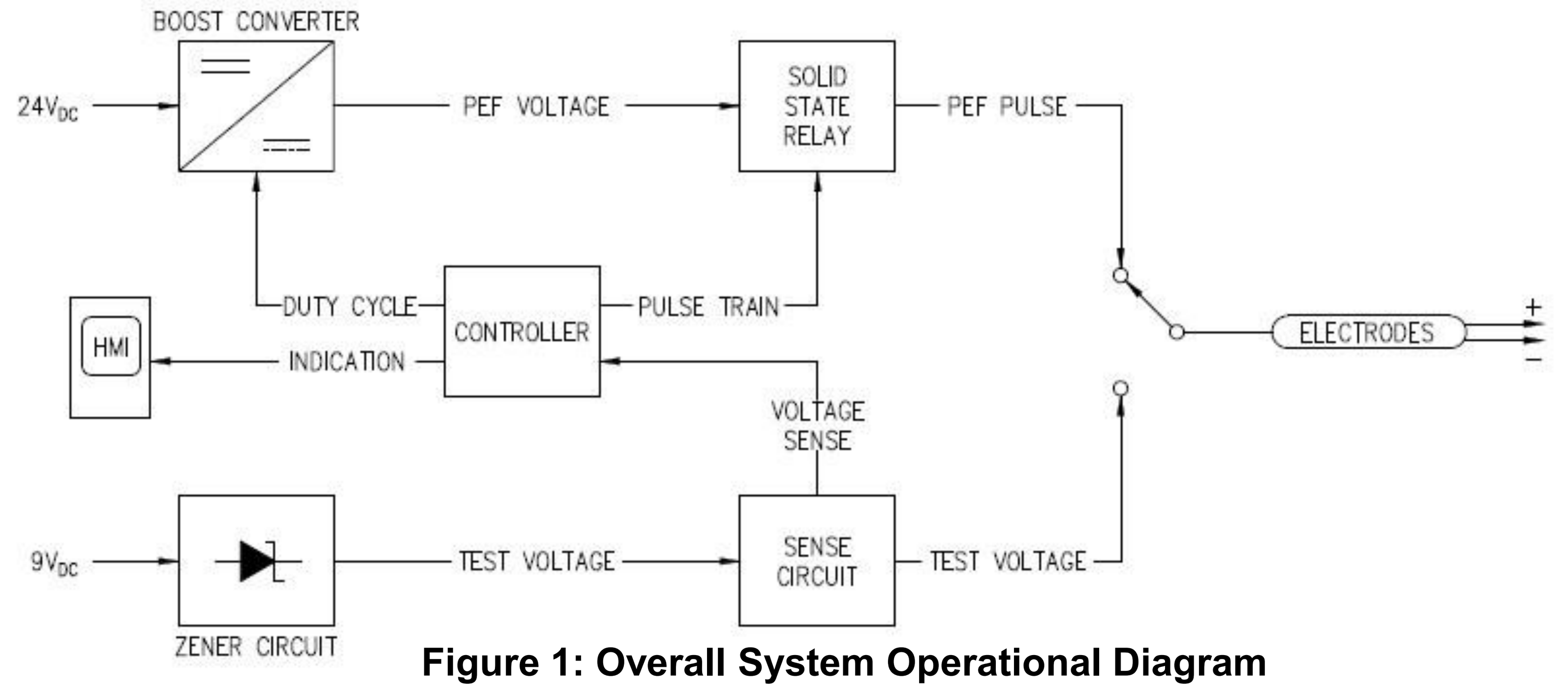

Figure 1: Overall System Operational Diagram

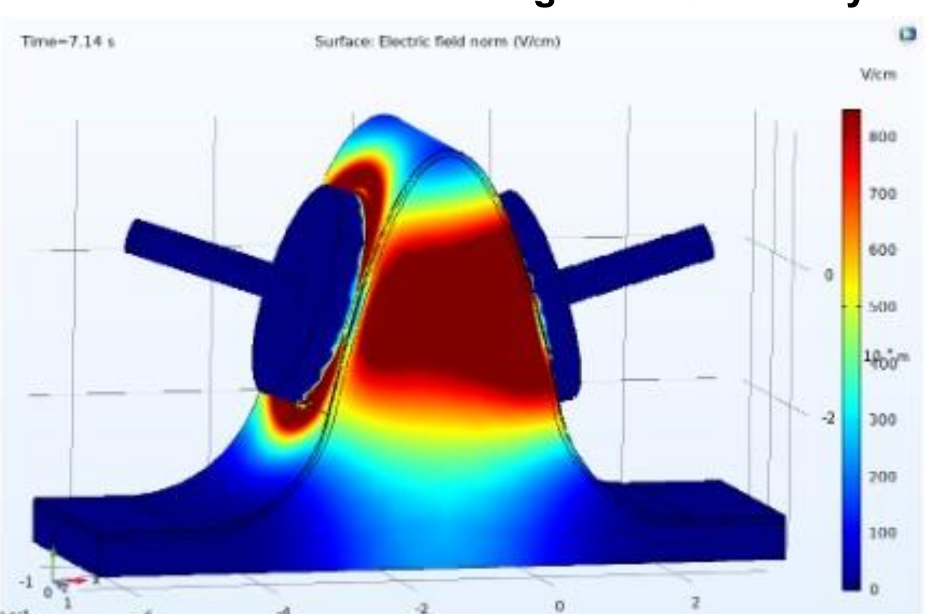

Figure 2: COMSOL "Pinched Skin" with Electrodes

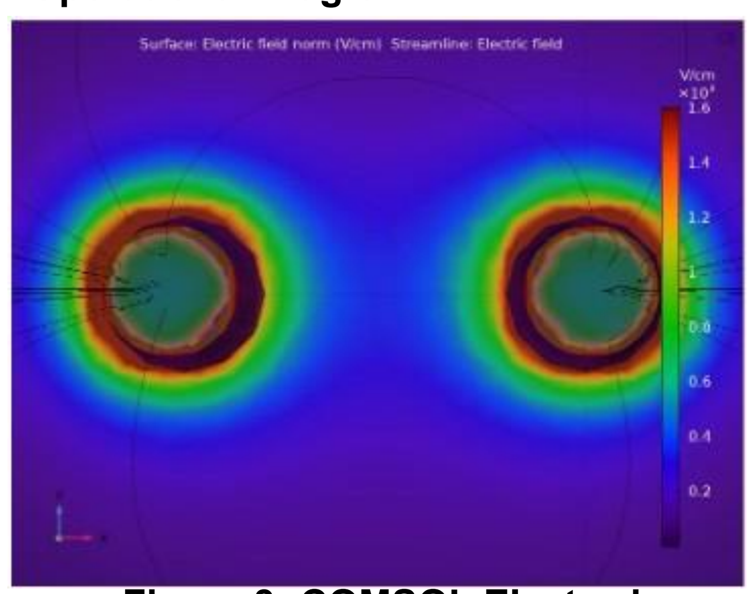

Figure 3: COMSOL Electrode Electric Field Result

TEST BENCH SETUP

- Boost converter is powered by a 24 V power supply
- Gate signal is driven using a signal generator
- Oscilloscope to measure the output and gate signals
- Zener test circuit that is powered by a 9V battery
- Programmable logic control unit that switches between the test and boost circuit

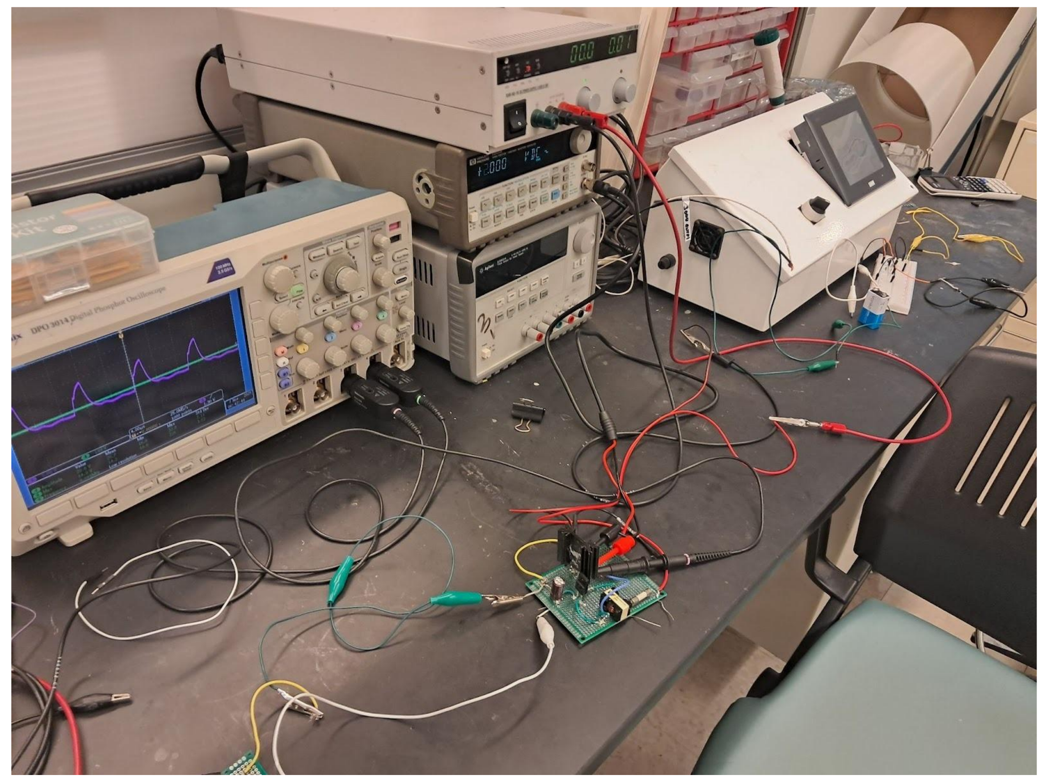

Figure 4: Complete Lab Setup

DATA COLLECTION/TROUBLESHOOTING

- Fixed continuity issues through soldering
- Used proper signal generator that is sufficient to drive the MOSFET gate
- Used heatsink combined with thermal paste to reduce heat

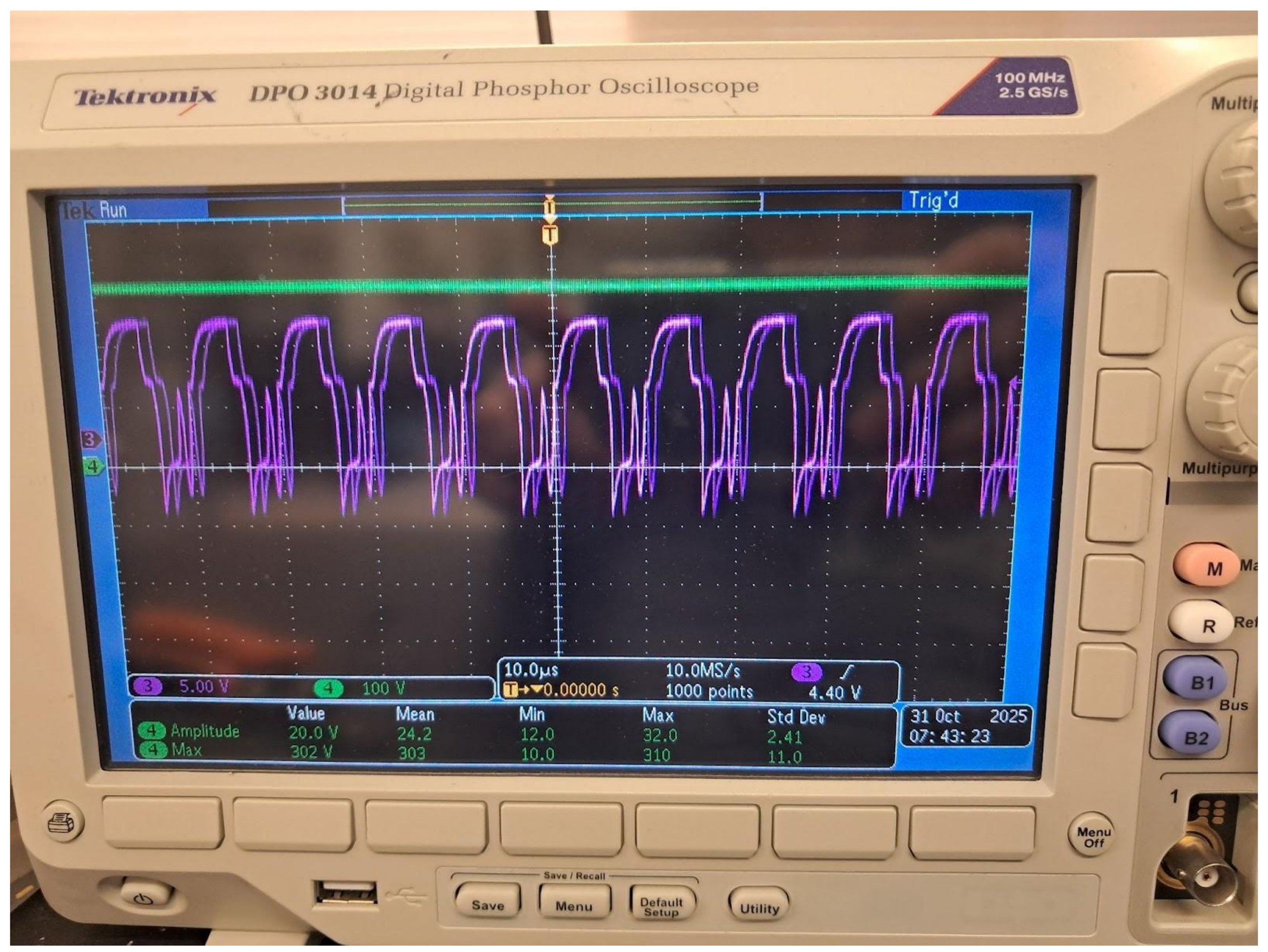

Figure 5: Pulse Wave Signal Generation of Boost Converter to MOSFET Gate

HARDWARE CONTROL LOGIC

Figure 6: Logic Controller with Touchscreen Interface

The system integrates a PLC controller with a Human-Machine Interface (HMI) to combine boost converter functionality and resistance testing into a single unit. It includes:

- Power Supply: Converts 120–240 VAC to 24 VDC
- Relay: 24 VDC logic NO, NC, and common relay with a switching capacity of 6A at 250V
- Solid-State Relay (SSR): 3–32 VDC logic, switching capacity of 10A at 660V
- PLC: Equipped with voltage input and output cards
- Disconnect Switch: Isolates the load from the main distribution block (limit: 10A at 600VAC)
- Human-Machine Interface (HMI): Touchscreen interface

CONCLUSION & LOOKING AHEAD

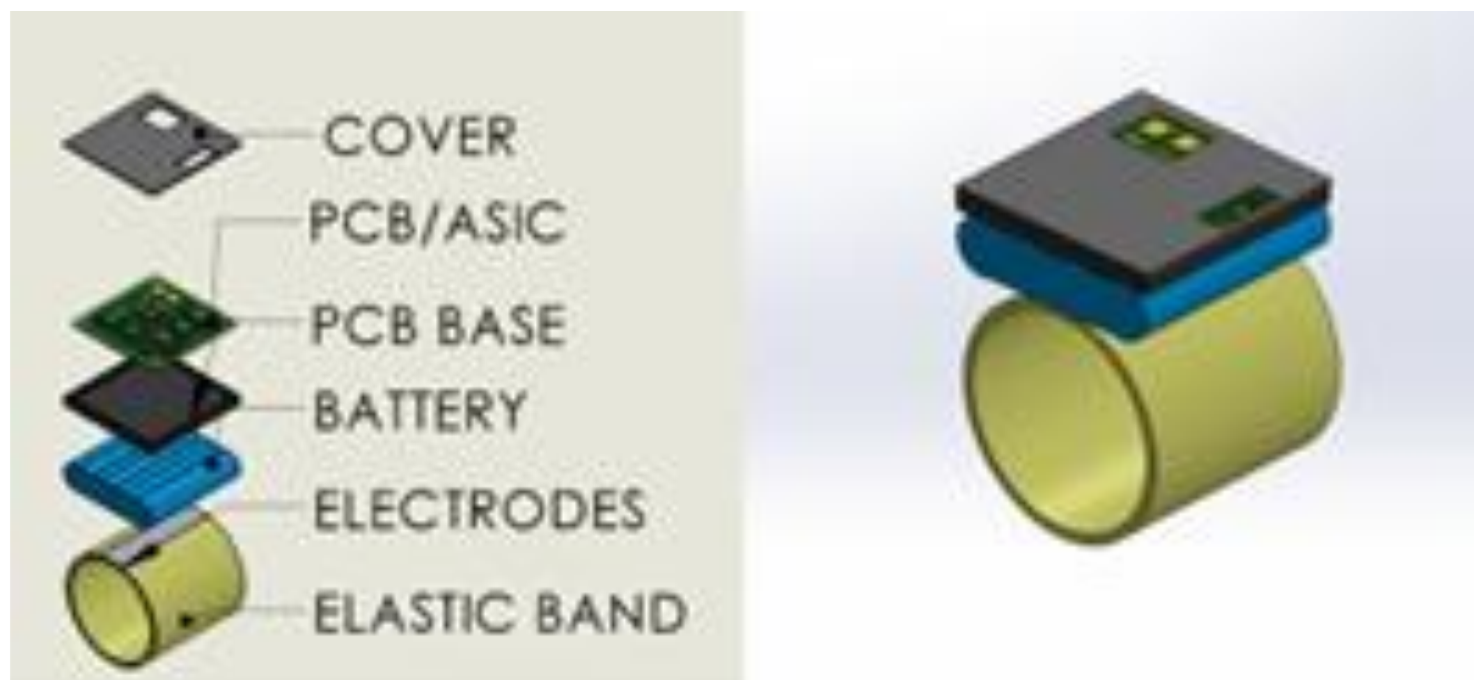

Figure 7: Initial Wearable Unit Prototype Design

The initial wearable unit concept includes:

- Elastic band for secure placement
- Electrodes for EP
- Battery pack for power supply
- PCB integrating core components
- Protective housing for durability and usability
- Prioritizes mobility, modularity and ease of integration