Team 8: Electron Tunneling Microscope

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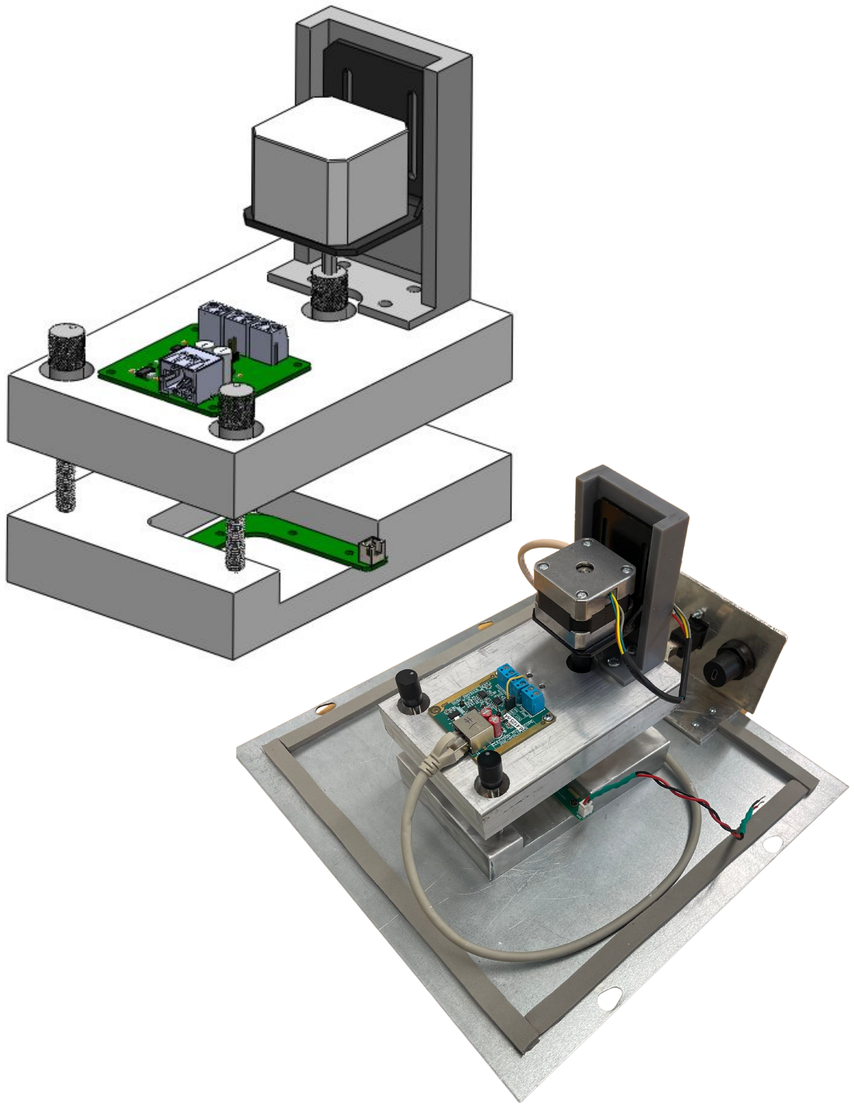
Purpose & Background

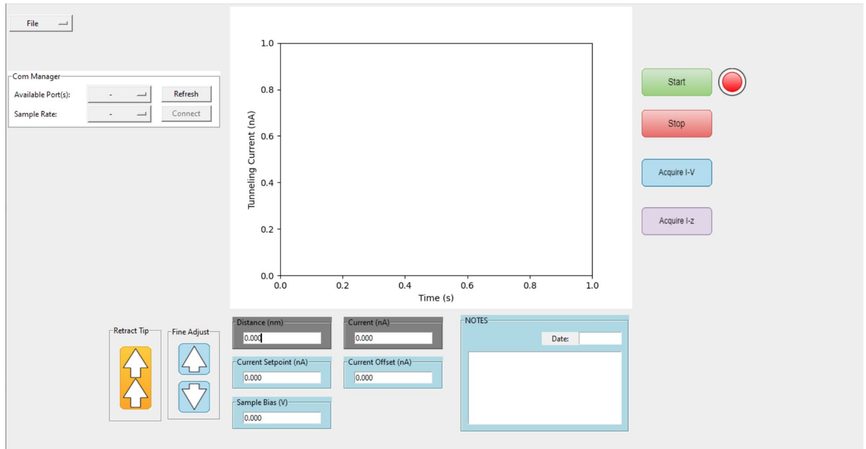
Professors in Grand Valley State University's Physics Department first introduced a novel design for a single-axis electron-tunneling microscope in 2022. Following a further design iteration, the GVSU DOER Center produced several functioning prototypes that have been used in the laboratory by advanced undergraduate physics students. The GVSU DOER Center, in cooperation with the Physics Department, has sponsored a senior design project to revise an electron tunneling microscope with the intent to:

(1) Improve the speed of data acquisition
(2) Reduce the cost per unit
(3) Reduce the set-up time.

Key Specifications

- Installing the tip ≤ 10 minutes.
- Moving tip to a user-defined tunneling distance ≤ 5 minutes.
- The tip shall be capable of moving in Δz steps ≤ 0.10 nm.
- Hardware shall measure currents in the range of +/- 10nA with a precision of 1pA.
- Hardware shall supply a bias voltage ranging from -10V to 10V with a minimum precision of +/- 2.0mV.
- The device shall use a distance control algorithm to automatically control the tip's approach to the sample.
- A GUI capable of displaying currents, voltages, and approach distances to the sample.
- The GUI shall allow the user to manually adjust the tip-sample distance and abort the control algorithm.
- The total cost of all five devices ≤ $5000.





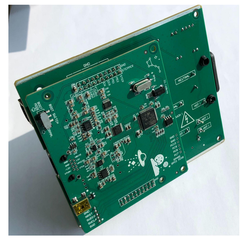
GUI HOMEPAGE

Notable Challenges

- Testing the driver code to operate ADC/DAC peripherals.
- Defining a command and data protocol.
- Designing and fine tuning the hardware.
- Programming serial communication between the PC and microcontroller.

Key Features

- High-gain preamplifier circuit, enabling accurate measurement of picoamp (pA) levels.
- Precision 18-bit differential analog-to-digital Converter (ADC).
- Precision dual channel 16-bit digital-to-analog converter (DAC).
- Three levels of positional adjustment: micrometer screws (coarse), stepper motor (fine), and piezoelectric actuator (ultra fine).
- STM32 microcontroller with 80MHz clock speed.
- Convenient USB communication.
- Custom GUI and firmware.
- Shielded enclosures and shielded cables.
- New tip assembly.



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