

# Scanning Tunneling Microscope

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## Summary:

Scanning Tunneling Microscopes (STMs) are used for imaging and research of nanoscale technology. STMs can cost upwards of \$10,000 making it inaccessible to most. Our research is creating an affordable STM utilizing off the shelf components.

## Goals:

- Achieve nanoscale resolution.
- Cost effective and efficient design.
- Develop easy to use software for the STM.

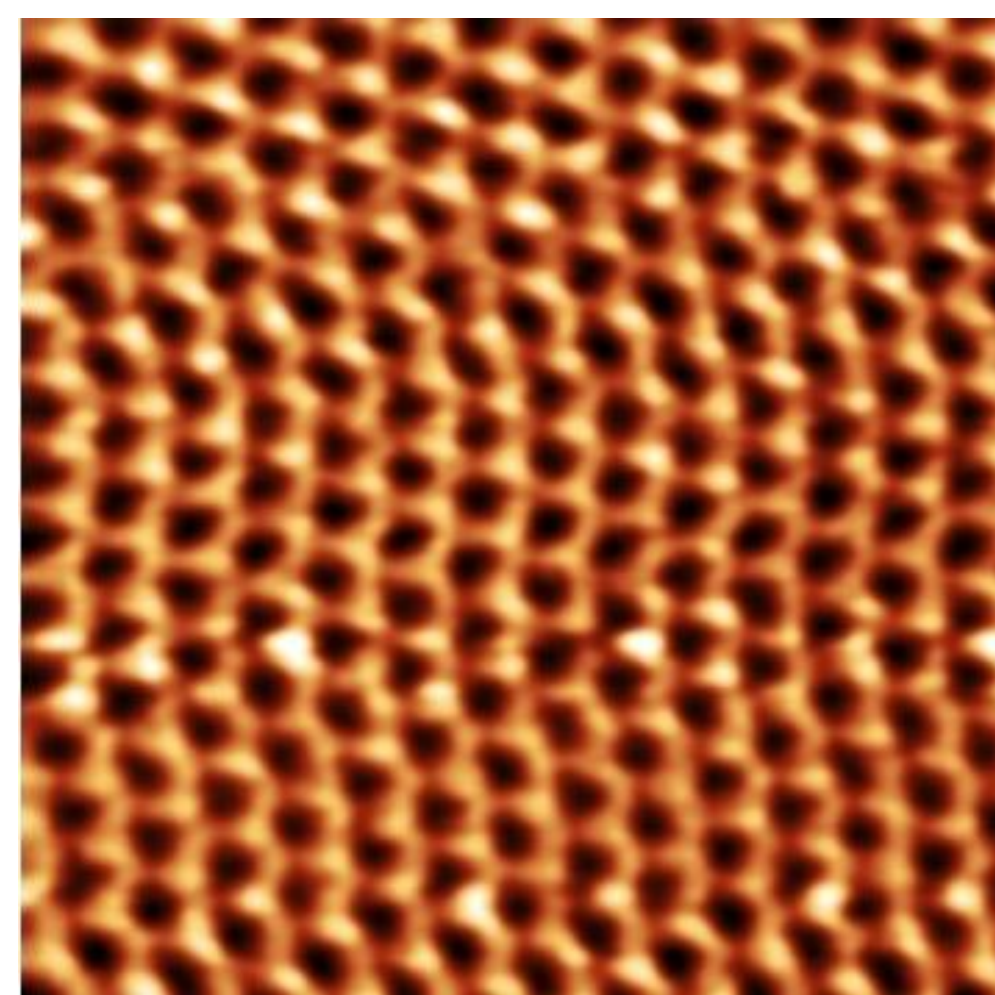


Figure 1 - Atomic STM scan taken from Dan Berard's DIY STM [1]

## Circuits:

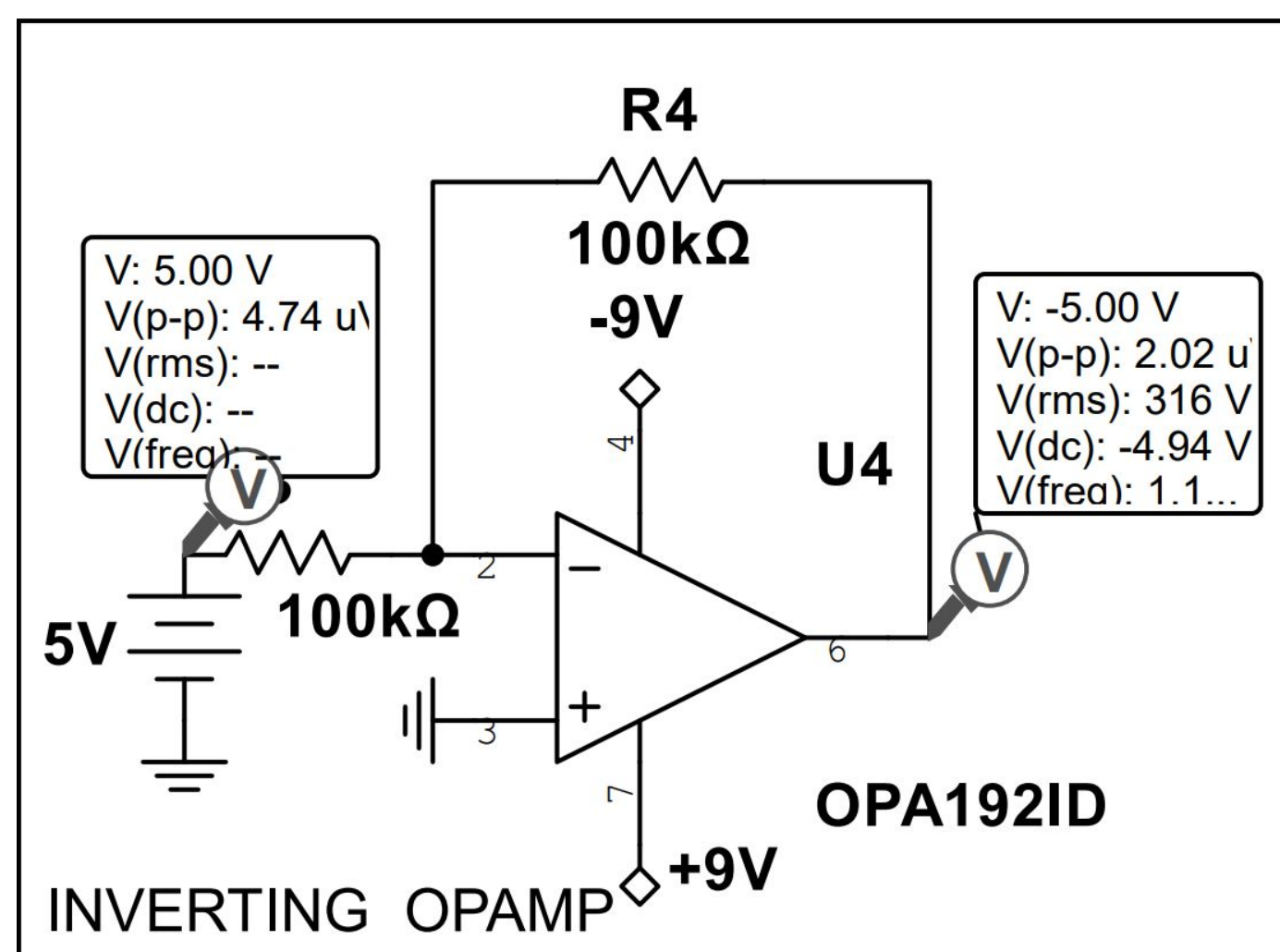


Figure 2 - Inverter circuit for DAC signals representing the  $\pm X$ ,  $\pm Y$ , and  $\pm Z$  axis.

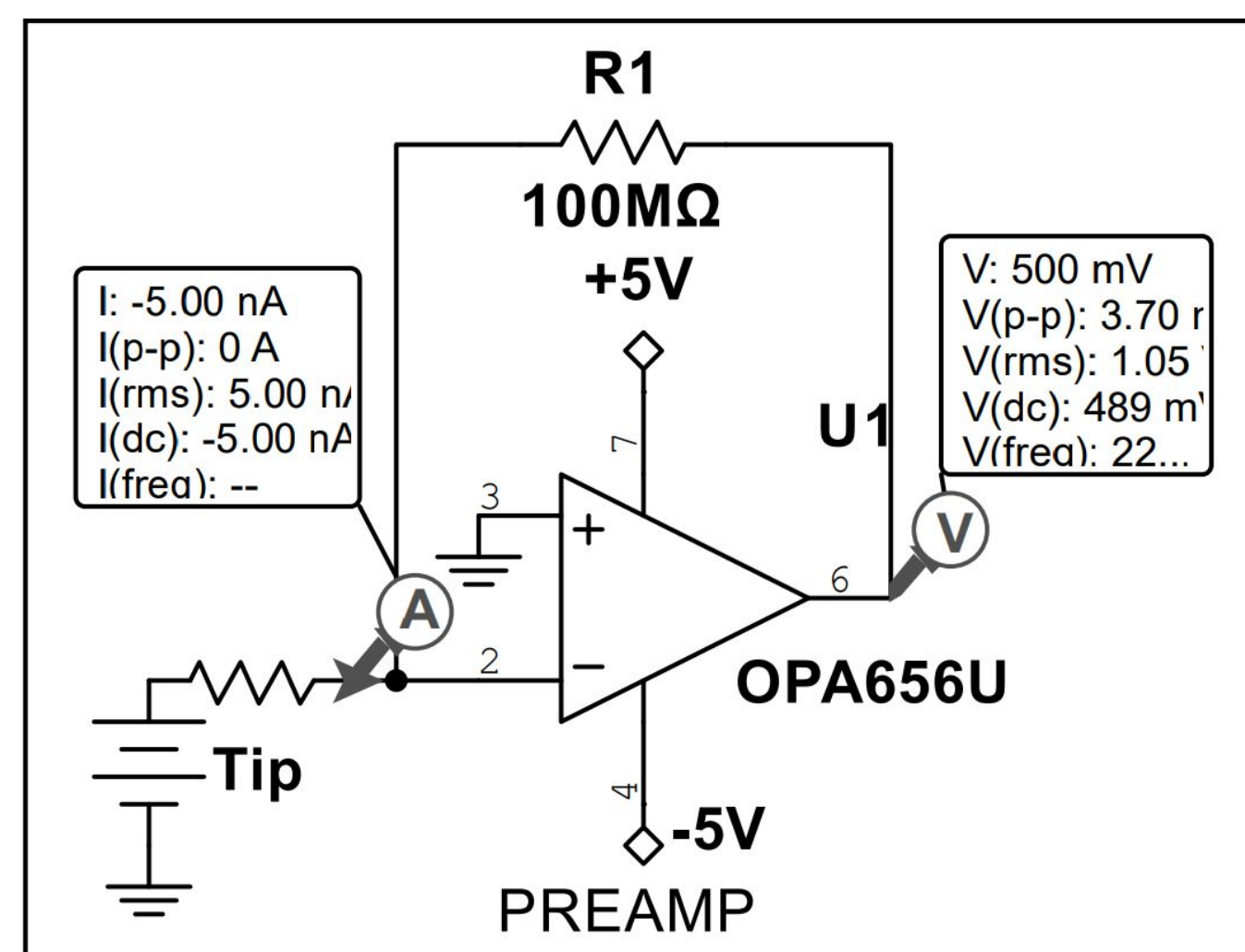


Figure 3 - Preamp circuit with  $-10^8$  amplification for the tunneling current.

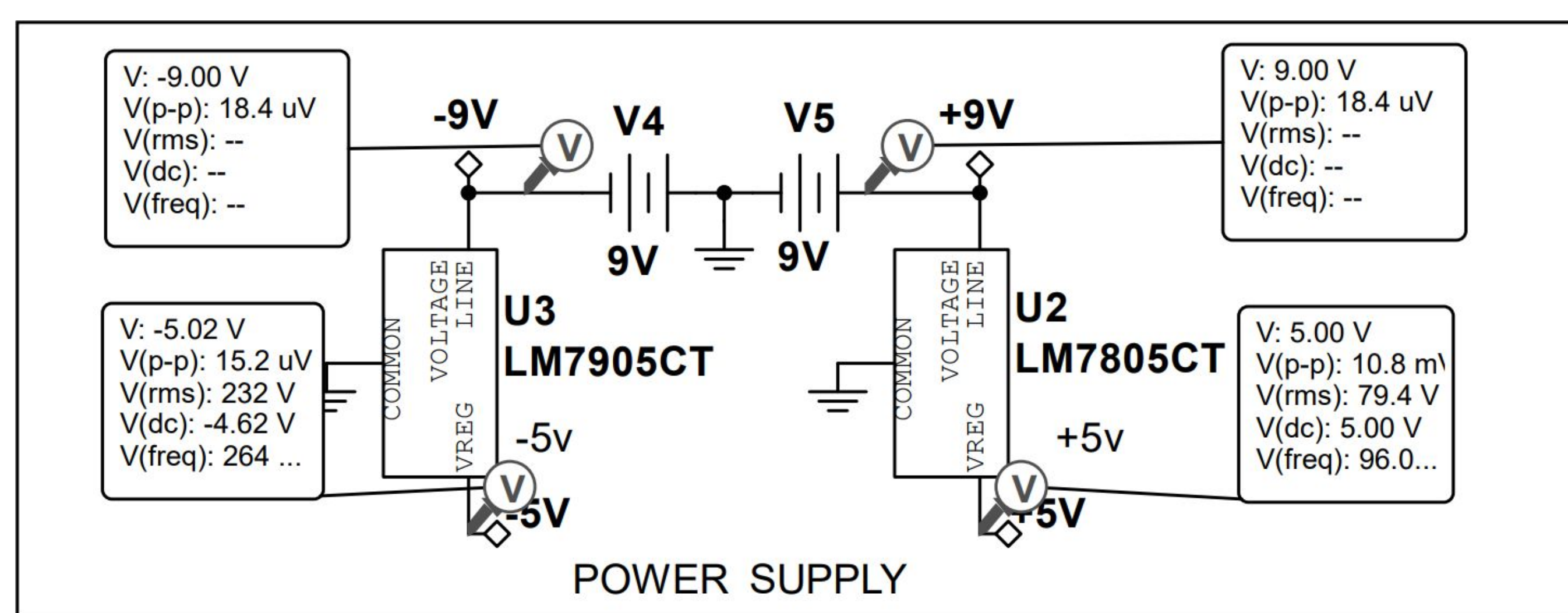


Figure 4 -  $\pm 9V$  and  $\pm 5V$  power supply using 9V batteries and  $\pm 5V$  voltage regulators.

## STM Architecture:

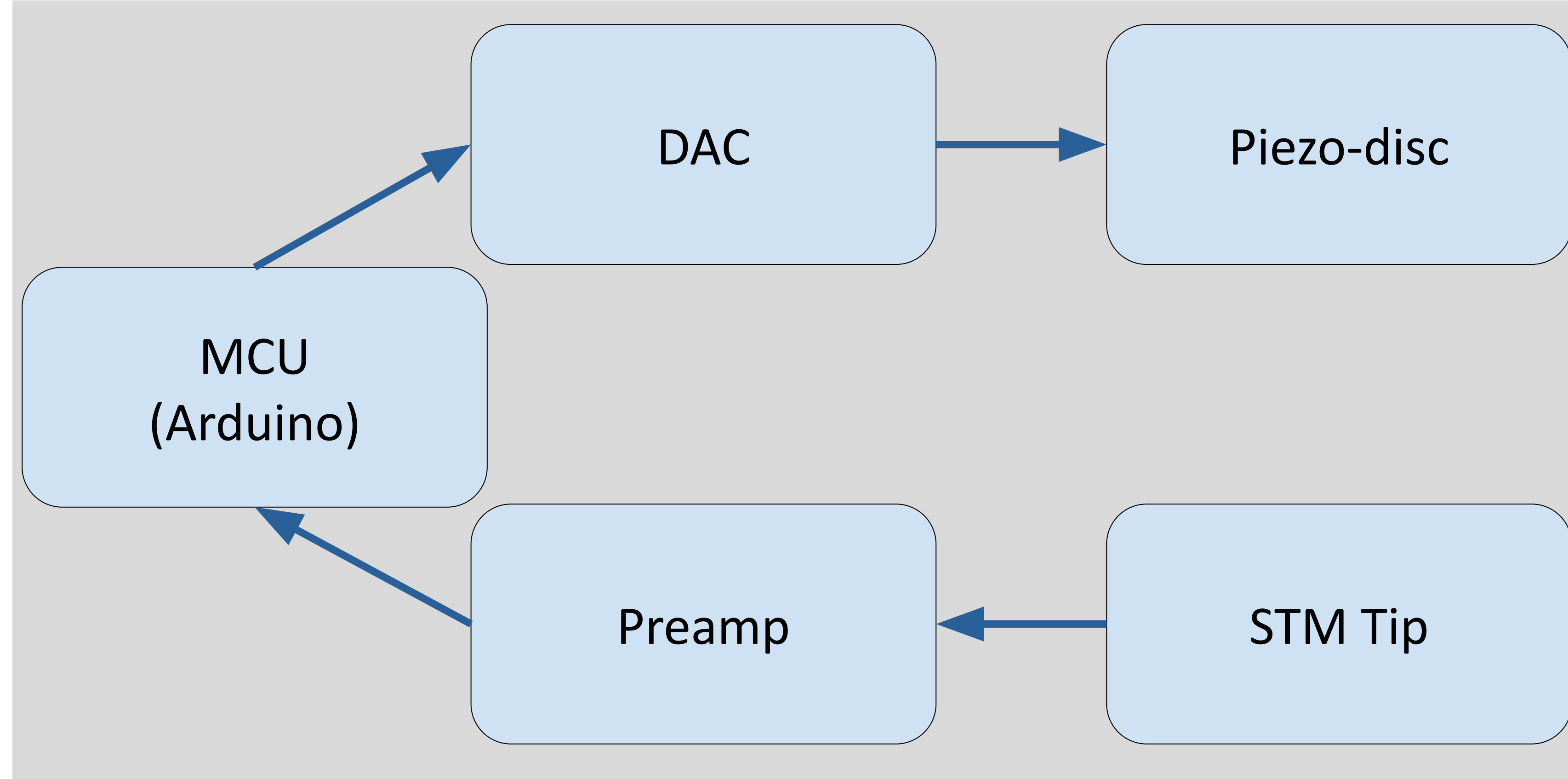


Figure 5 - Flow chart of the STM architecture

## STM Vibration Damping Solution:

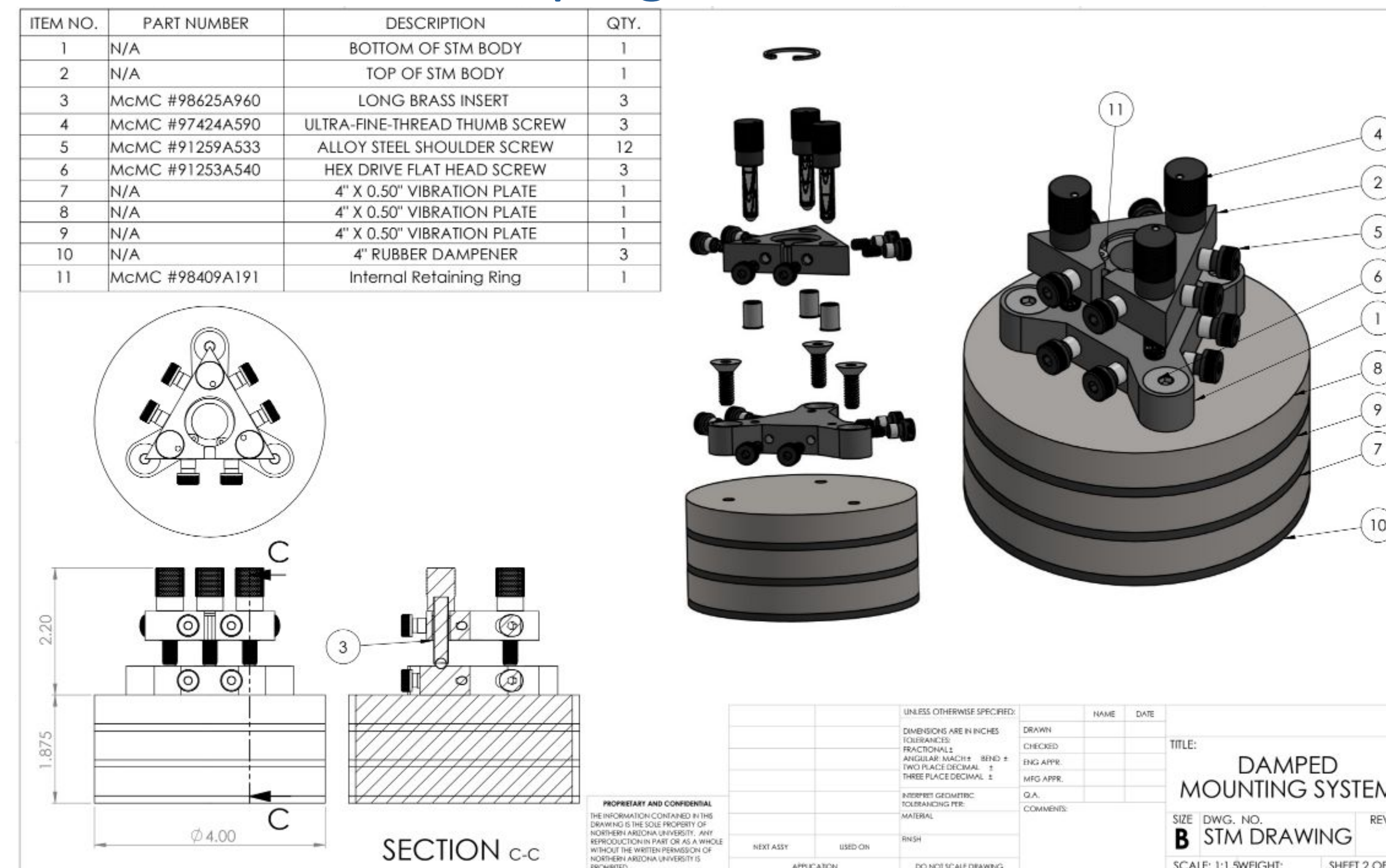


Figure 6 - STM vibration damping solution created by the mechanical engineering team.

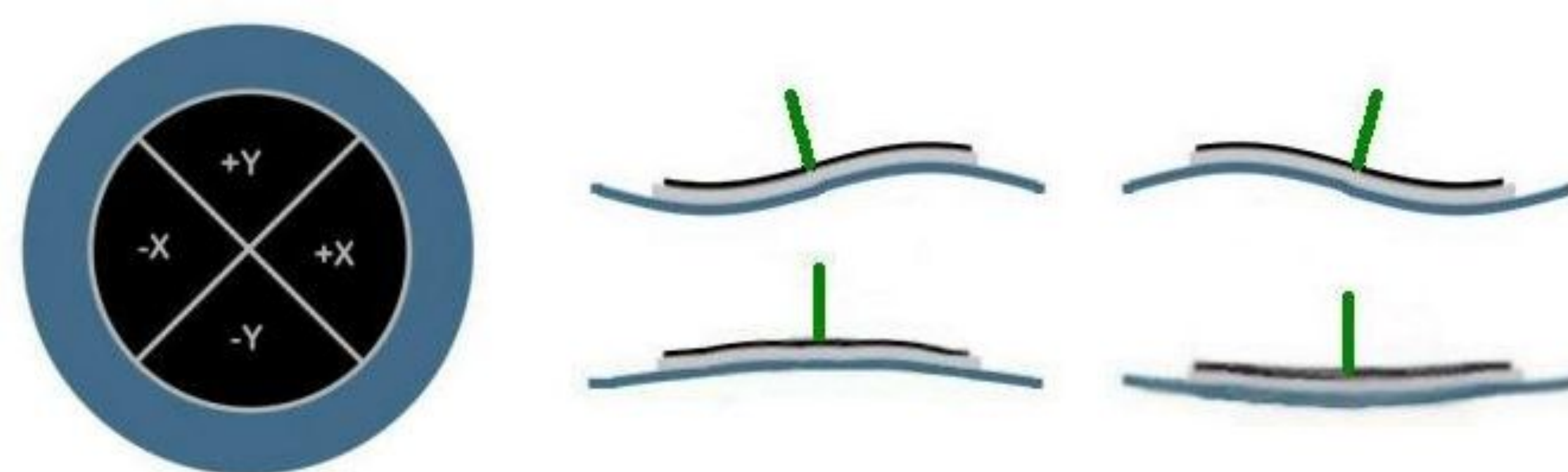


Figure 7 - Picture of piezoelectric disc quadrants and how it flexes [2]

## STM Tip:

The STM tip will allow us to measure a tunneling current between the tip and surface giving us data points for an image.

## Preamp:

The tunneling current is in nano ( $10^{-9}$ ) amps, so we use a transimpedance amplifier to take nA and output an amplified signal in volts.

## Microcontroller (MCU):

The Arduino will compile 65,536 data points and plot them. Additionally, it will send signals to the DAC to control the piezoelectric disc.

## Digital-Analog Converter (DAC):

The DAC will take signals from the Arduino and output a voltage to the piezoelectric disc to flex and control the scan.

## Piezoelectric Disc:

Piezoelectric devices take electrical energy and turn it into mechanical flex. The flex of our disc will drive the movement of our scan head, allowing us to take images.

## Conclusion & Future Work:

- So far we have done the following:
  - Circuit design, simulation, assembly, and testing
  - STM tip fabrication and tip holder assembly
- Future work includes the following:
  - Implement tip feedback loop and approach tip
  - Finalize the piezoelectric driver
    - DAC implementation and software
  - Acquire and analyze data from Arduino
  - Optimize noise isolation and STM performance

## References:

- [1] D. Berard, "Electronics," Dan Berard, 29-Dec-2021. [Online] Available: <https://dberard.com/home-built-stm/electronics/>. Accessed 12-December-2023.
- [2] J. D. Alexander, "Disk Scanner," Disk\_Scanner\_EXP, 2000. [Online]. Available: [https://john-alexander42.github.io/simple-stm-webpage/Disk\\_Scanner\\_Exp.htm](https://john-alexander42.github.io/simple-stm-webpage/Disk_Scanner_Exp.htm). [Accessed: 12-December-2023].