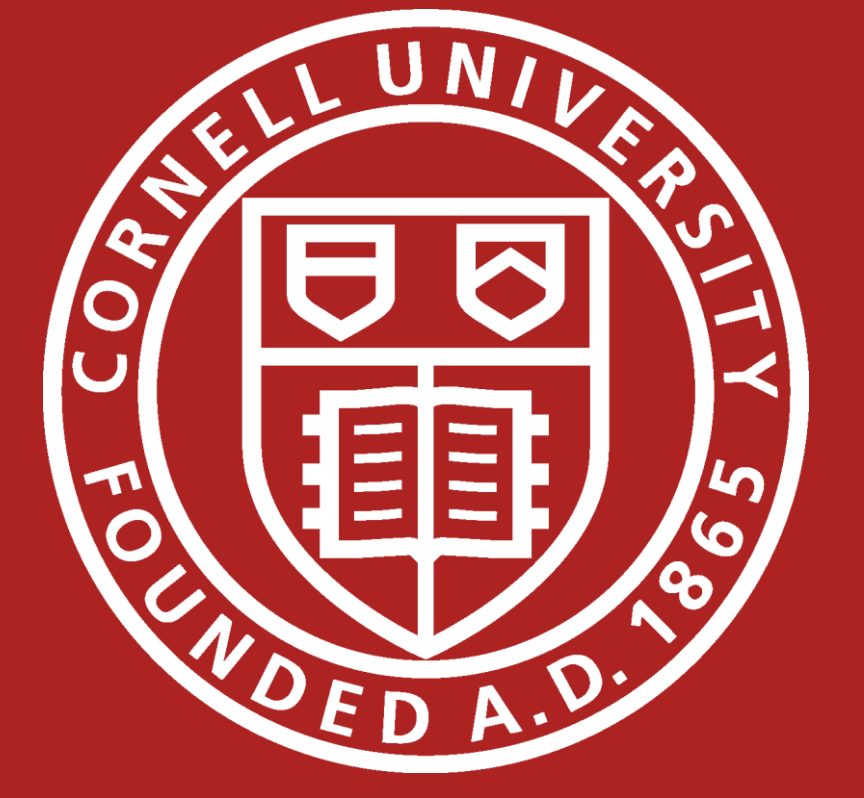# Natural Timers for IoT

Author: Chris Yang   Advisor: Dr. Van Hunter Adams

IoT devices Require Timers but… Polling is Power Inefficient
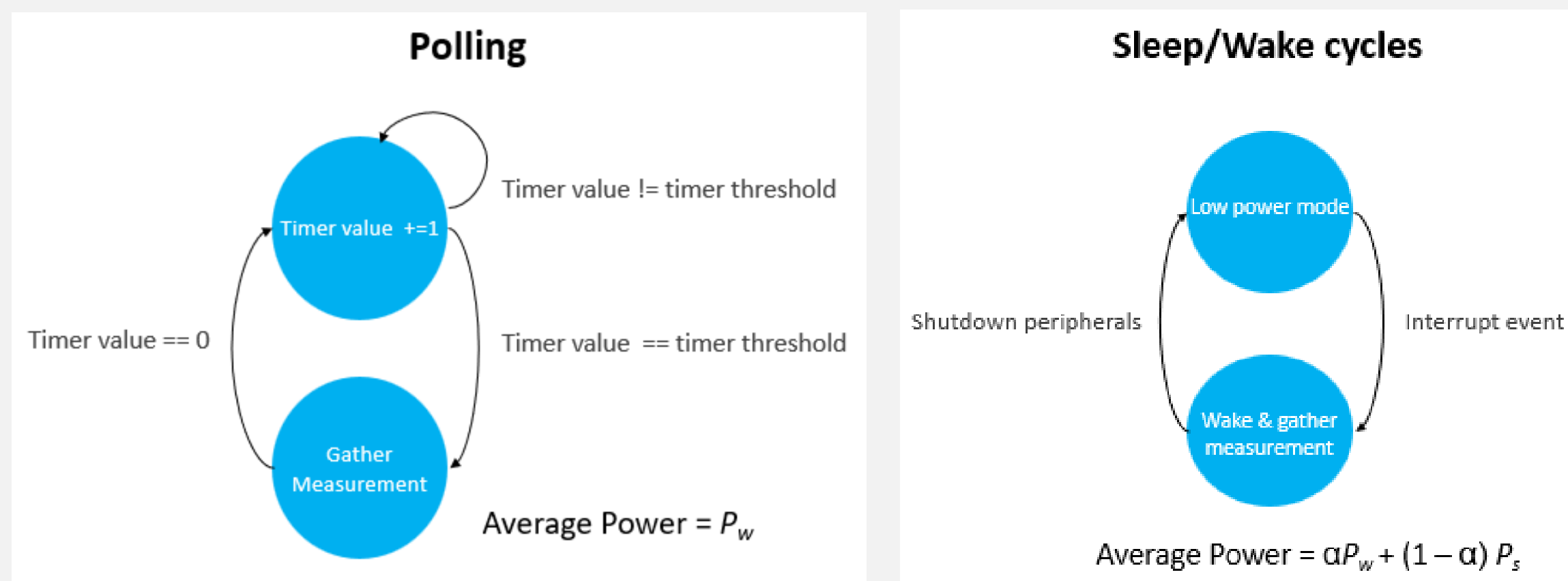

Figure 1: Comparison of Polling vs. Sleep/wake cycles, Source [1]

Polling

Average Power = P_w

Sleep/Wake cycles

Average Power = $\alpha P_w + (1-\alpha) P_s$

Solution: Nature Offers Periodic Processes

- We can use these processes as timers to wake up our MCU from a low-power state
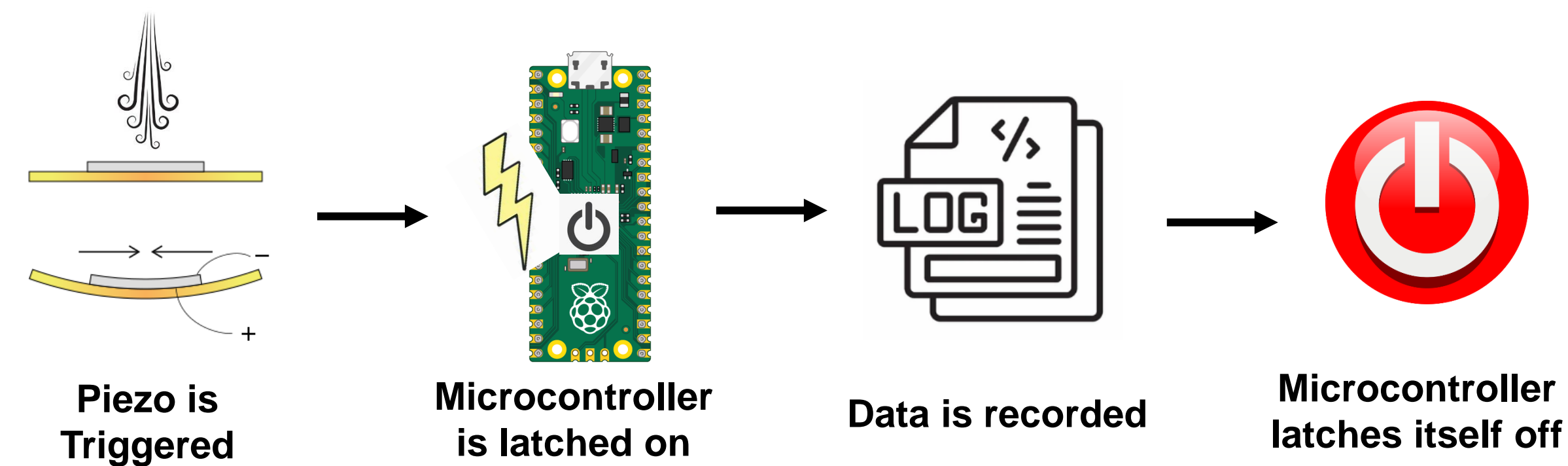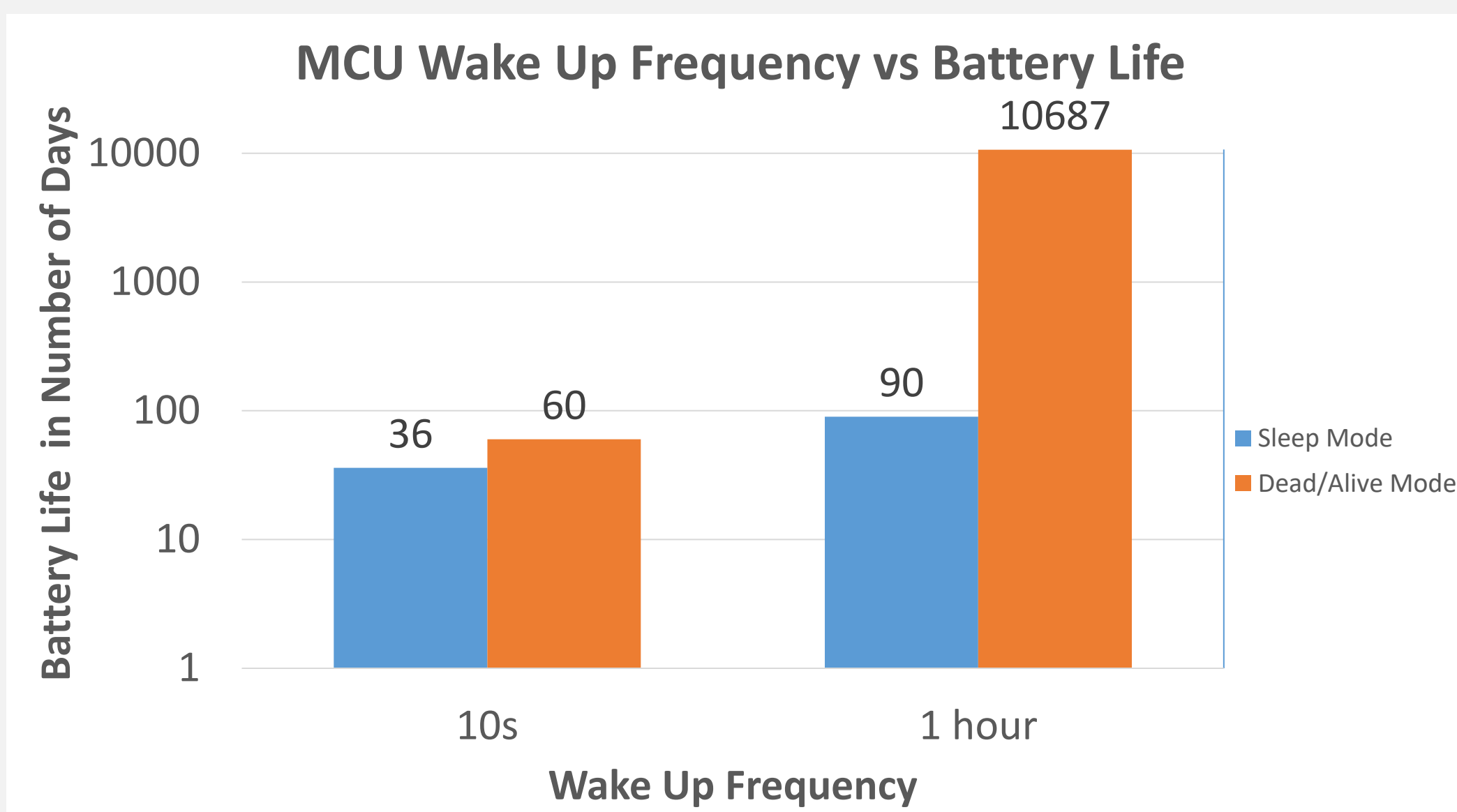
Sleep Mode is Not Much Better

Pico board	VBUS current @5V (mA)		
	Temperature (°C)		
	-25	25	85
Mean	1.4	1.3	1.9

Will only last 91 days!

Figure 2: Current Draw of the Raspberry Pi Pico in Sleep Mode, Source [3]

Using Dead/Alive Mode

- Apply the same concept as an interrupt → **let nature be the interrupt trigger!**
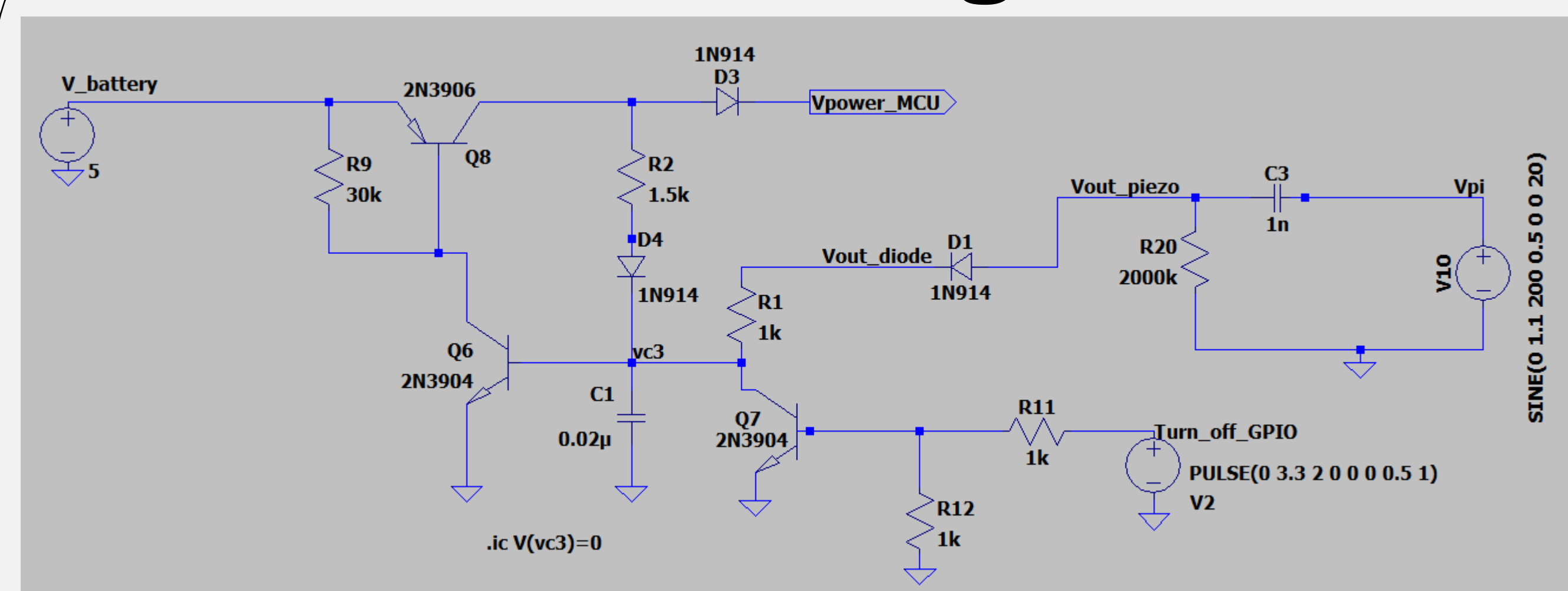- Given a 2850mAh battery, assuming I_{on}= 40mA:

MCU Wake Up Frequency vs Battery Life

- 10s: Sleep Mode 36, Dead/Alive Mode 60
- 1 hour: Sleep Mode 90, Dead/Alive Mode 10687

The Latching Circuit

Piezo is Triggered → Microcontroller is latched on → Data is recorded → Microcontroller latches itself off

Figure 3: LTSpice Schematic of Latching Circuit

- Piezo is Triggered
- Power for MCU turns on
- GPIO goes high
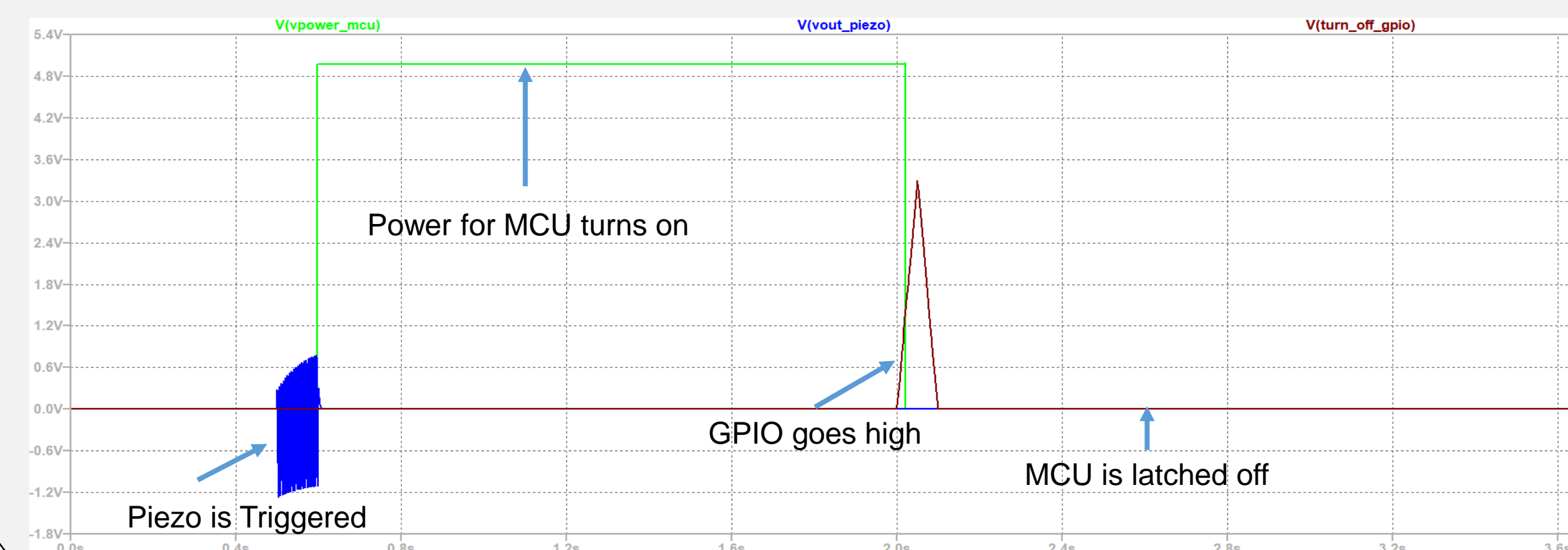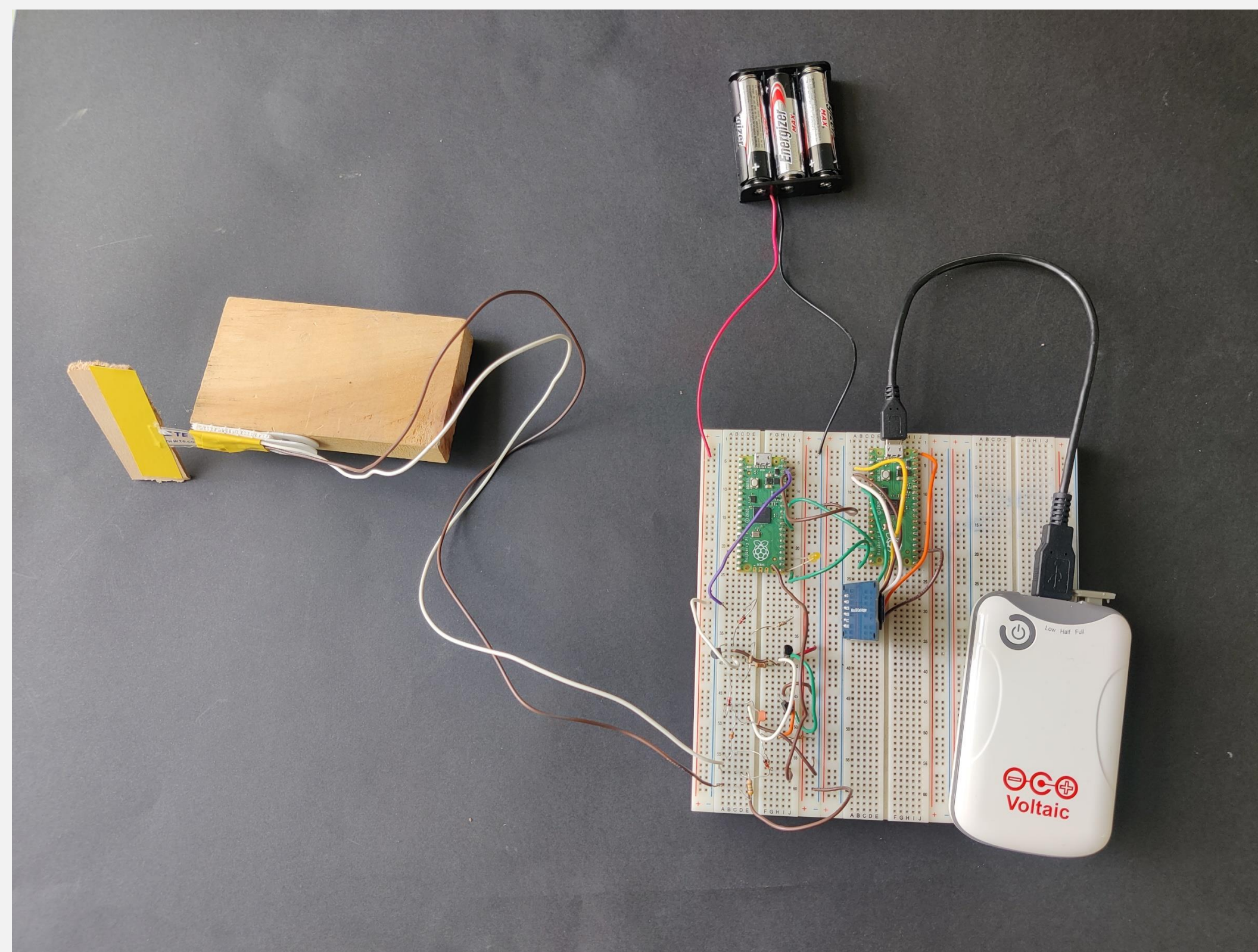- MCU is latched off

Figure 4: LTSpice Simulated Results of Latching Circuit

Circuit Implementation with a Piezo Sensor

Experiment on May 2, in Ithaca, NY


```
Pressed Thursday 2 May 14:47:52 2024
Pressed Thursday 2 May 14:47:53 2024
Pressed Thursday 2 May 14:47:53 2024
Pressed Thursday 2 May 14:47:54 2024
Pressed Thursday 2 May 14:47:54 2024
Pressed Thursday 2 May 14:47:54 2024
Pressed Thursday 2 May 14:47:54 2024
Pressed Thursday 2 May 14:47:55 2024
Pressed Thursday 2 May 14:47:56 2024
Pressed Thursday 2 May 14:47:56 2024
Pressed Thursday 2 May 15:10:02 2024
Pressed Thursday 2 May 15:10:03 2024
Pressed Thursday 2 May 21:10:27 2024
Pressed Thursday 2 May 21:10:28 2024
Pressed Thursday 2 May 21:10:28 2024
Pressed Thursday 2 May 21:10:28 2024
Pressed Thursday 2 May 21:10:29 2024
Pressed Thursday 2 May 21:10:29 2024
Pressed Thursday 2 May 22:32:08 2024
Pressed Thursday 2 May 22:32:08 2024
Pressed Thursday 2 May 22:32:08 2024
Pressed Thursday 2 May 22:32:08 2024
```
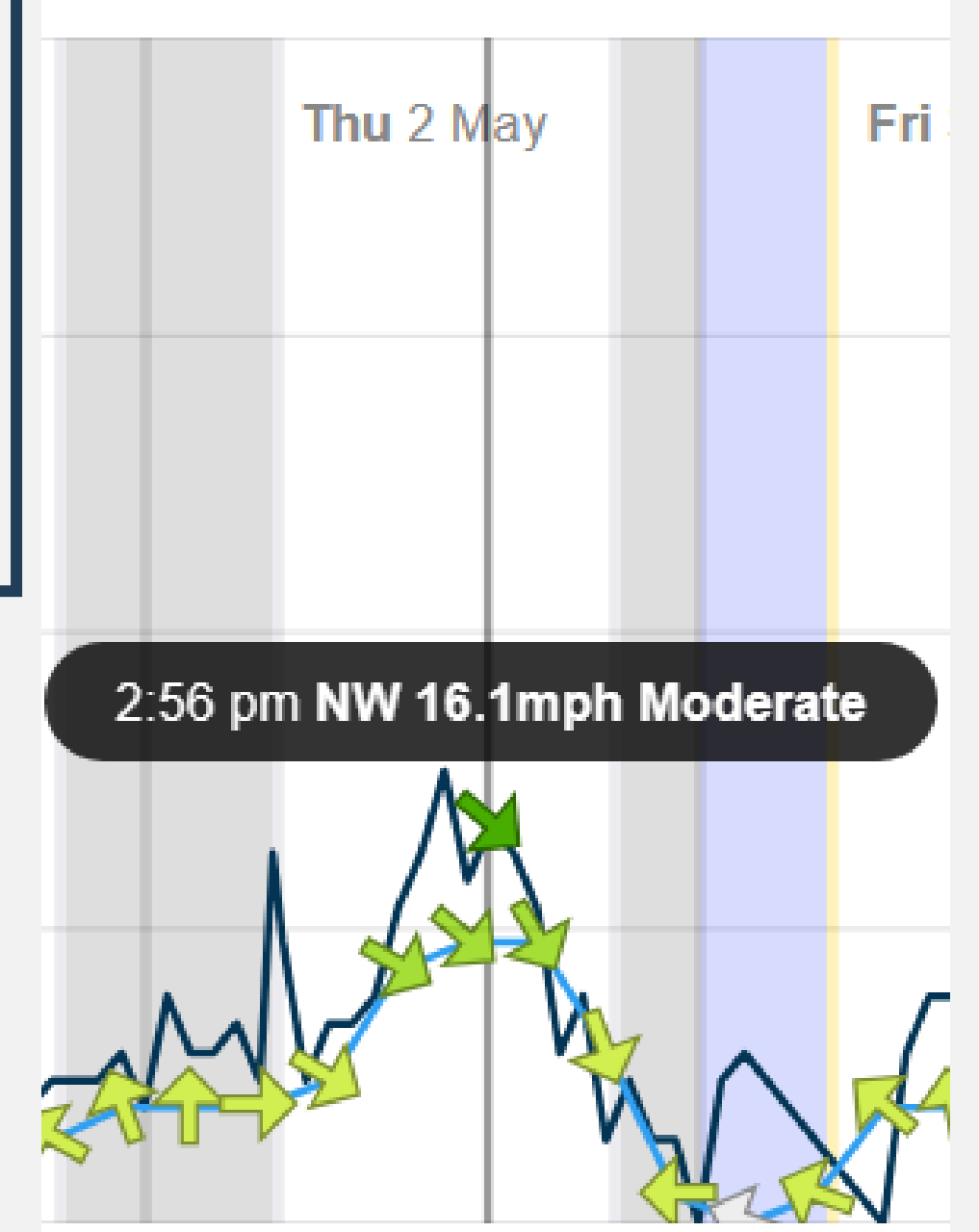
2:56 pm NW 16.1mph Moderate

Figure 5: SD Card Log File   Figure 6: Wind Speed in Ithaca, May 2

Further Discussion

- My focus this semester was getting a piezo sensor to work with the circuit
- This circuit will most certainly need to be modified for other natural current sources
- This project will likely be continued in following semesters to integrate Wi-Fi/ Bluetooth data communication to a server on a natural event trigger
- The power consumption are simply estimates. The actual power consumption of the circuit will likely be higher if more features are added after the microcontroller wakes up

References

[1] https://www.youtube.com/watch?v=Er8fSoeaZD0
[2] https://vanhunteradams.com/Talks/IoT_Energy.pdf
[3] Raspberry Pi. (2021, January 21). Raspberry Pi Pico Datasheet. Raspberry Pi Datasheets Retrieved November 15, 2023, from https://datasheets.raspberrypi.com/pico/pico-datasheet.pd
[4] https://cdn.sparkfun.com/datasheets/Sensors/ForceFlex/LDT_Series.pdf
[5] https://www.sparkfun.com/datasheets/Sensors/Flex/MSI-techman.pdf

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