A Biosensing Device for Posture Correction

A BENG 186B Project

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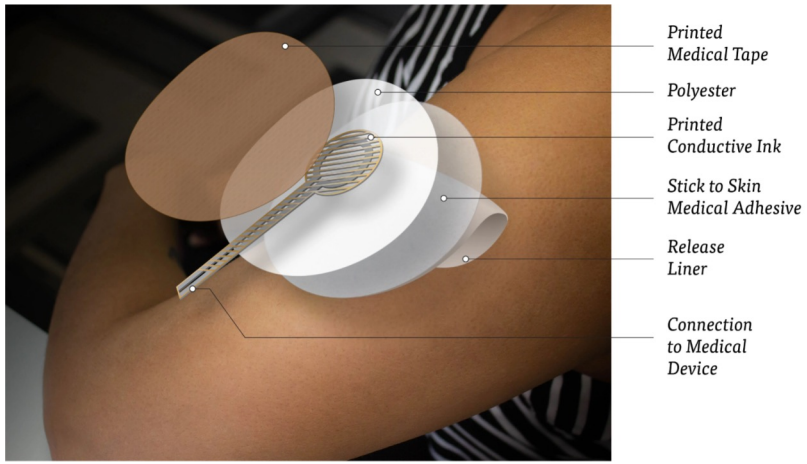
Introduction

Given the **prevalence of improper back posture**, we wanted to create a biomedical device that could alert us if our backs are too slouched. To do this, we use a **strain gauge** to detect if our backs bend too far. Since bending our backs for short durations is tolerable, we decided use a **comparator and RC filter** to have our device alert us after 3 minutes of continuous slouched posture. Lastly, we decided to have our device alert us by warming a heating pad for 2 minutes, which is controlled by a **555 timer**.

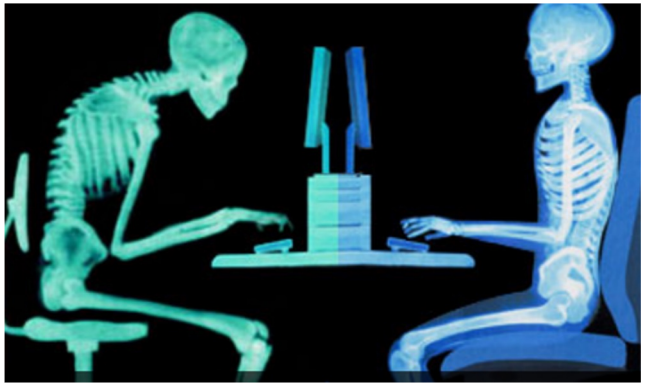
Background

- About 10% of the global population suffers from **lower back pain**.
- Sitting for prolonged periods leads to chronic **muscle deconditioning** and flatness of the lumbar-lordotic curve, which leads to fatigue and discomfort.
- A slouched posture aggravates these problems.



Background

- Lower back pain has a high chance of recurring.
  - Study reported that there was a **33%** of recurring back pain in a 1 year period.
  - Out of that **31.4%** reported needing to go to the doctor for treatment.
  - **9.3%** suffered from lower back pain so severe that it was activity-limiting



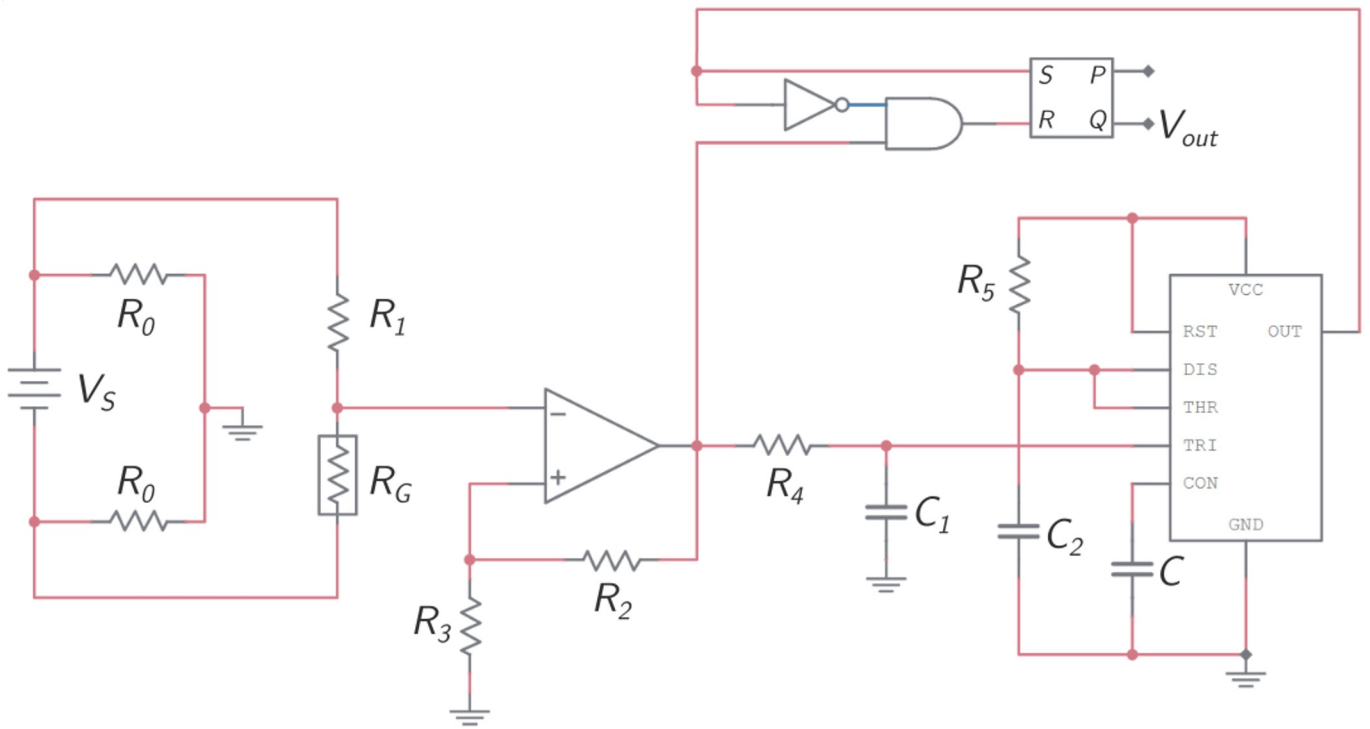
Design Goals

Aim 1:	**Aim 2:**	**Aim 3:**	**Aim 4:**
Measure posture by quantifying curvature of the back	Create a 3-minute delay between initial slouching and device response	Activate a heating pad that warms for 2 minutes	Implement memory into the circuit so that the heating pad can be activated longer than the 555 timer duration
Create a device to measure changes in length using a strain gauge	Use a comparator and low pass filter to create time delay	Use a 555 timer to provide an output voltage once triggered for the heating duration	Use SR latch to retain values

Discussion - Assumptions

1. strain = 0 when not slouching
2. strain ≈ 0.1 when slouching
3. no significant temperature change
4. heating occurs instantaneously

Bioinstrument



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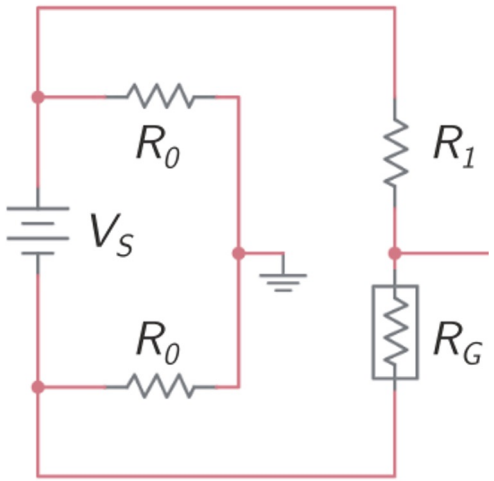
Design Goals - Aim 1: Strain Gauge

Aim 1:

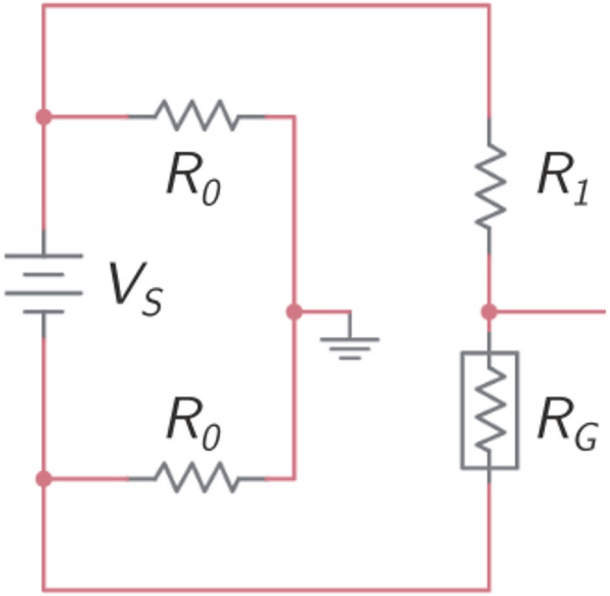
Measure posture by quantifying curvature of the back

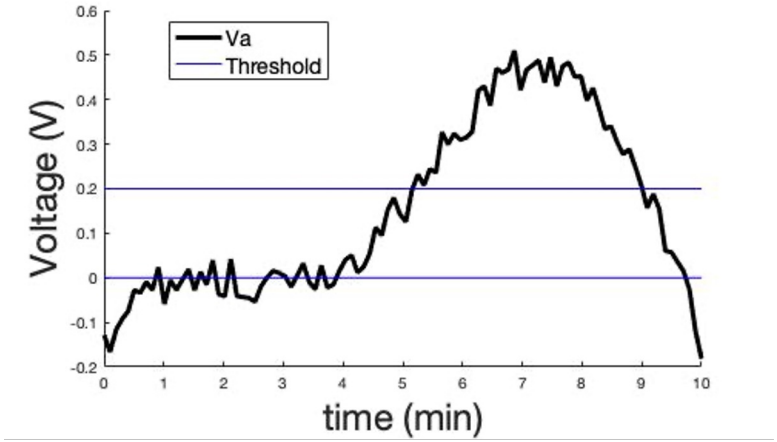
Create a device to measure changes in length using a strain gauge



- Strain = ΔL / Lo
- Estimated by looking at strain in a 2-cm long resistor, ε ≈ 0.1
- G = 8
- R_{nom} = 1 kΩ
- $R_G = R_{nom}(1+ G\varepsilon) \approx 1.8$ kΩ at stretch
- R_1 = 1.2 kΩ
- No stretch: V = -0.14 V
- Stretched: V = 0.3 V

Design Goals - Aim 1: Strain Gauge





Design Goals - Recap

Aim 1:
Measure posture by quantifying curvature of the back

Create a device to measure changes in length using a strain gauge

Aim 2:
Create a 3-minute delay between initial slouching and device response

Use a comparator and low pass filter to create time delay

Aim 3:
Activate a heating pad that warms for 2 minutes

Use a 555 timer to provide an output voltage once triggered for the heating duration

Aim 4:
Implement memory into the circuit so that the heating pad can be activated longer than the 555 timer duration

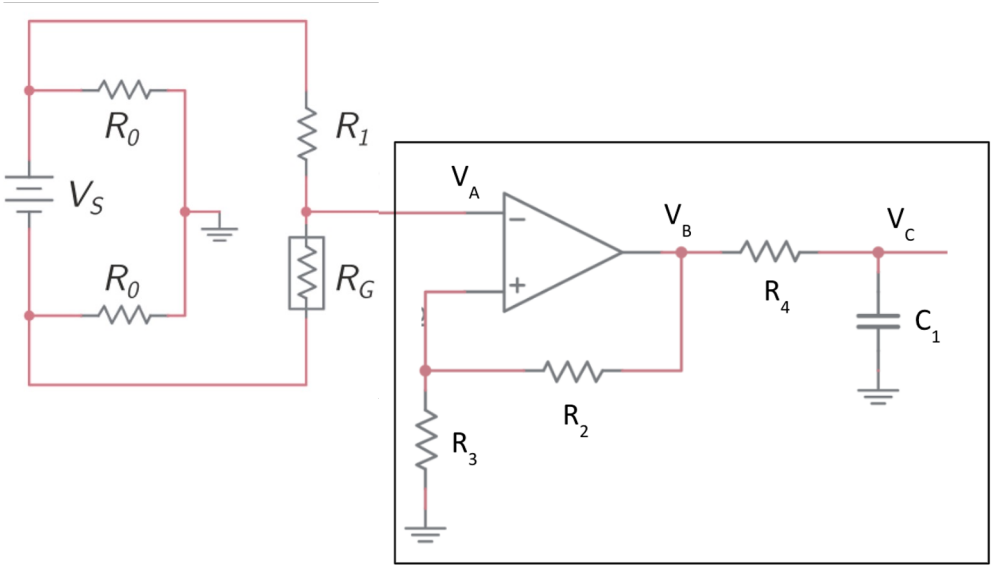
Use SR latch to retain values

Design Goals - Aim 2: Comparator and Charging

Aim 2:

Create a 3-minute delay between initial slouching and device response

Use a comparator and low pass filter to create time delay



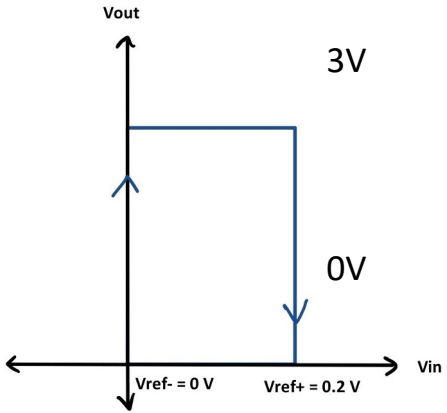
Design Goals - Aim 2: Comparator Input and Output

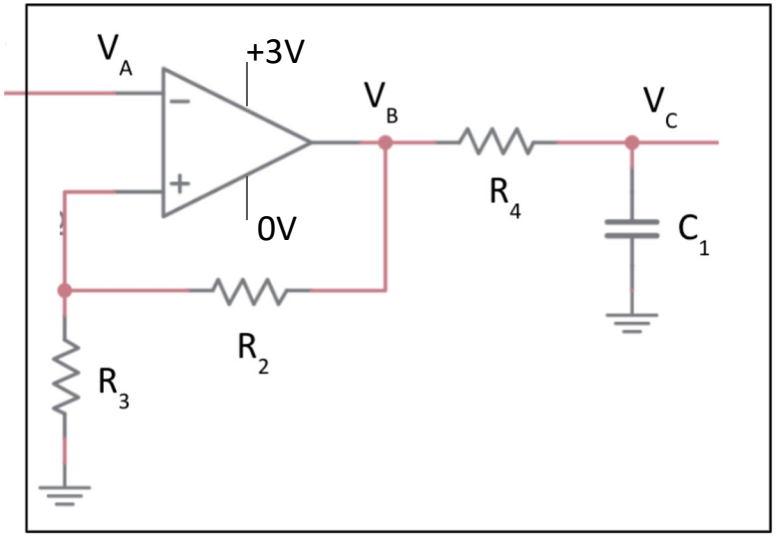
- The two threshold voltages for the comparator will be

$$V_{In,Low} = 0.0V$$
$$V_{In,High} = 0.2V$$

- With output voltages

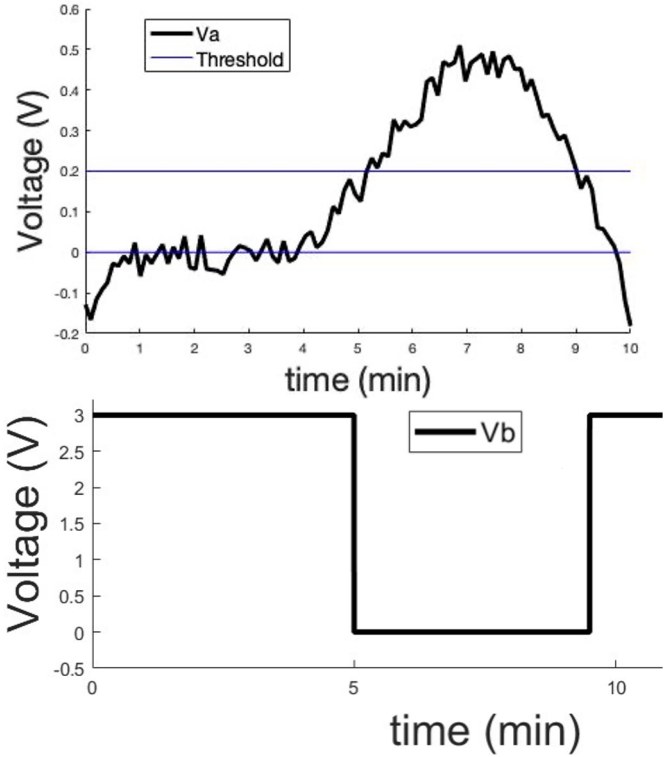
$$V^{-}_{Out} = 0V$$
$$V^{+}_{Out} = 3V$$





R_2=100Ω, R_3=1400Ω, R_4=1.64MΩ, C_1=100µF

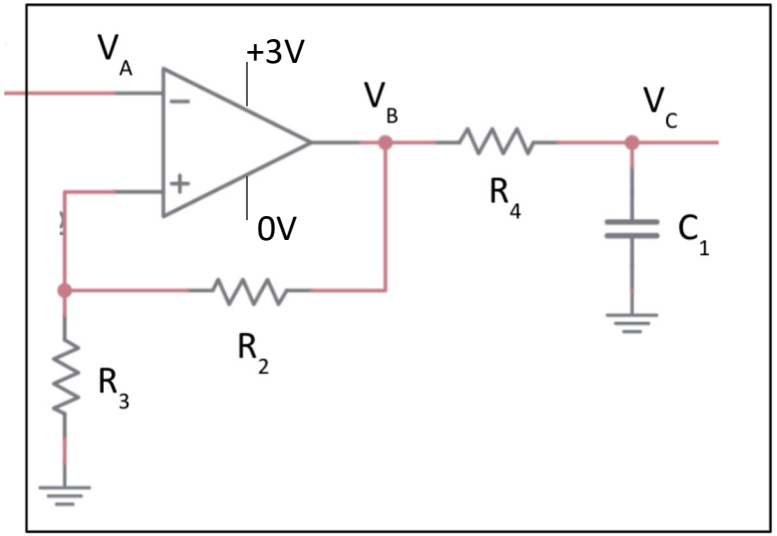
Design Goals - Aim 2: Voltage graphs



- Once the voltage reaches the threshold voltage, the comparator **drops from high to low voltage**
- The comparator returns to high after straightening the back
- Low voltage will begin **“discharging”** the capacitor which will activate the 555 timer

Design Goals - Aim 2: Comparator and Charging

- The comparator provides a threshold so the device will have steady charging in a “bent” or “straight” state
- If the back is bent, the comparator will have an output voltage of **3V and will start the “discharging” process**
- If the back is straight, the comparator will have an output voltage of **0V and will “charge” the capacitor**
- The time constant of the low pass filter is such that it will take **3 minutes** to reach the trigger voltage of the 555 timer



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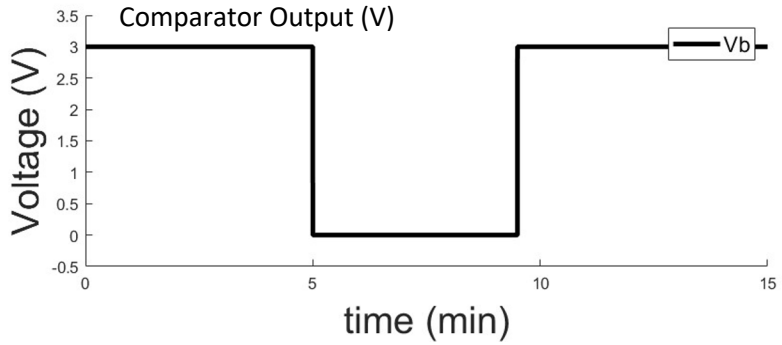

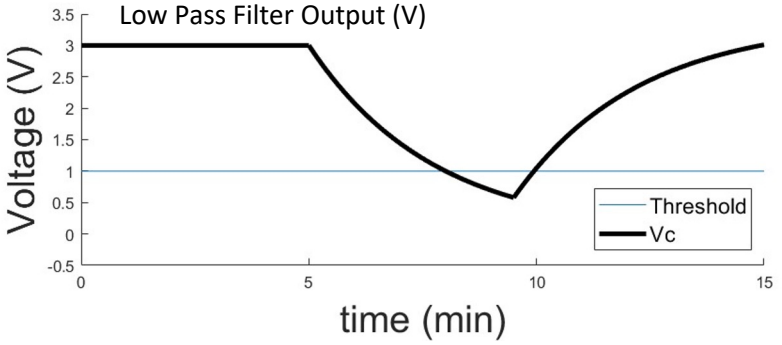

The time constant to discharge to the trigger voltage of 1V:

$t = \ln(3) R_4 C_1 =$ **3 minutes**

-Once voltage is reached, **555 timer is activated**

-The time delay allows one to make **daily adjustments** in the back and only starts the 555 timer when **persistent** slouching occurs

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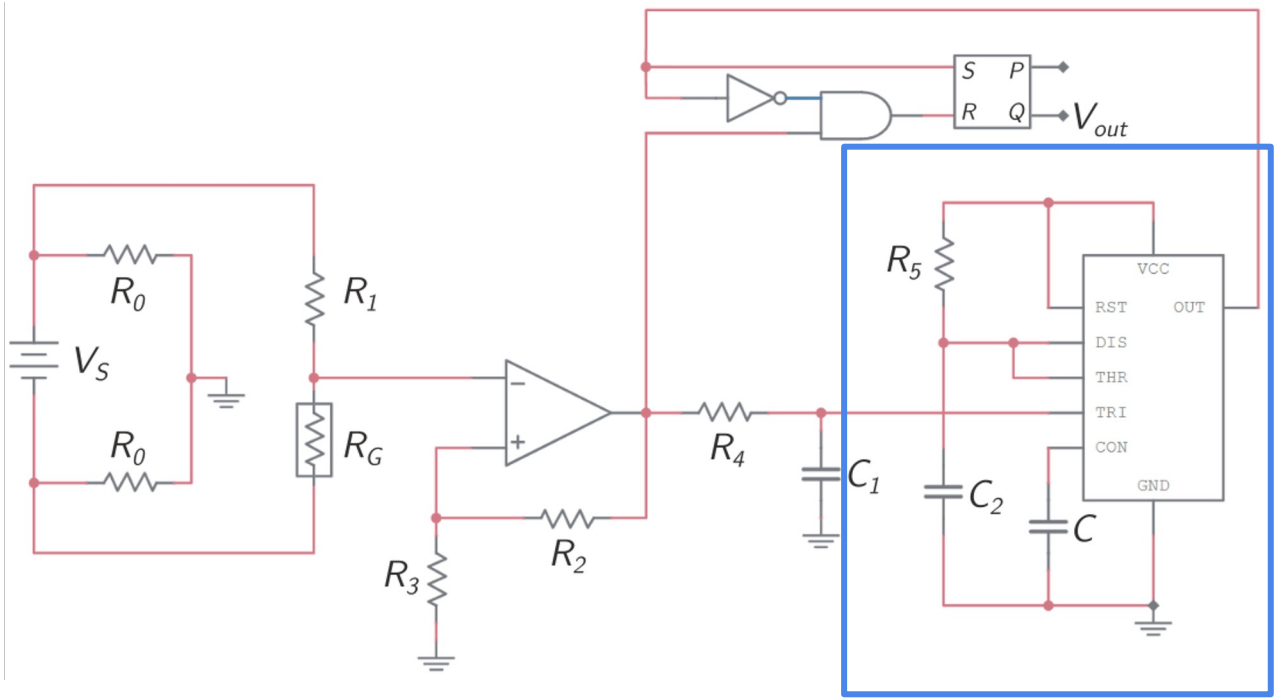
Design Goals - Aim 3: 555 Timer

Aim 3:

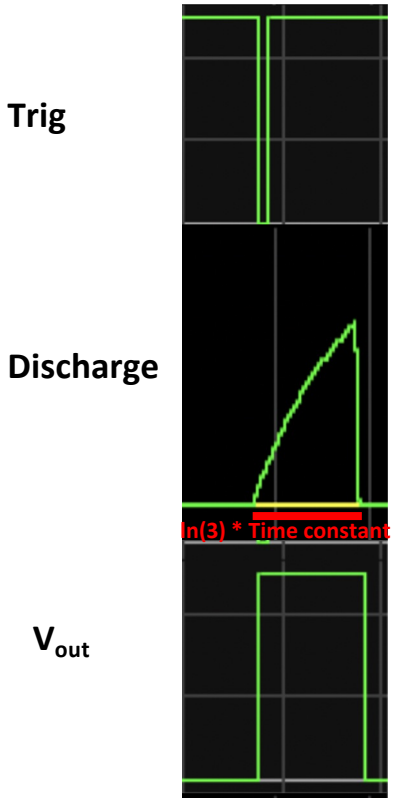
Activate a heating pad that warms for 2 minutes

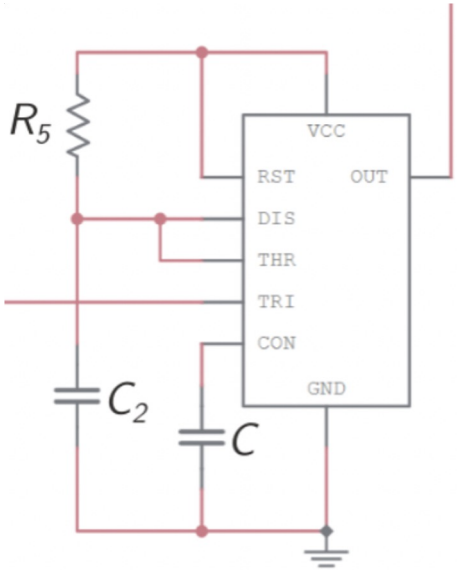
Use a 555 timer to provide an output voltage once triggered for the heating duration



Design Goals - Aim 3: 555 Timer

- When our circuit is activated, we want our heating pad to be on for **2 minutes**. To do this, we use a 555 timer in **monostable** mode with a time constant of 2 minutes
- To do this, set
  $\ln(3)R_5C_2 = 120$ seconds
  which gives us:
  $R_5 = 1.1\ M\Omega$
  $C_2 = 100\ \mu F$





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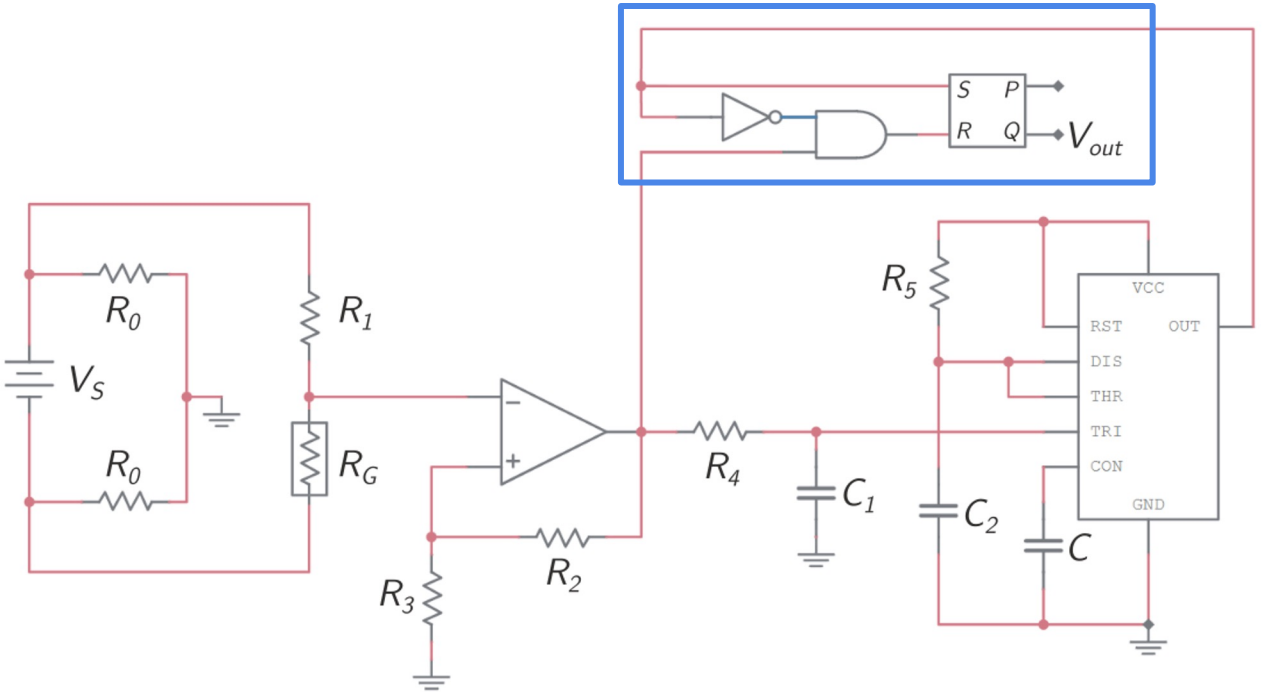
Design Goals - Aim 4: Memory

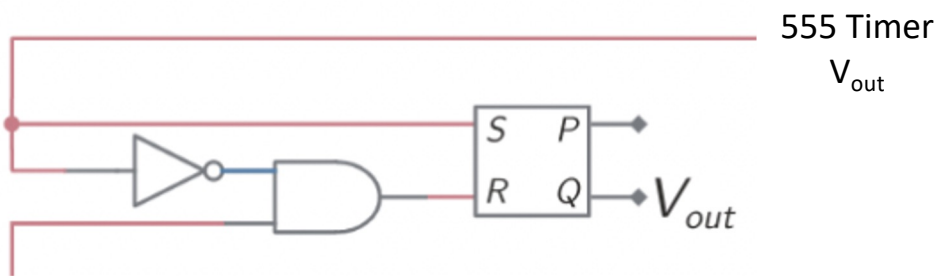
Aim 4:
Implement memory into the circuit so that the heating pad can be activated longer than the 555 timer duration

Use SR latch to retain values



Design Goals - Aim 4: Memory

We can use an **SR latch** to help us retain memory about the state of the output. In particular: if the output went from high to low but the individual is **still slouching**, set V_{out} to high.



- Person slouches for more than 3 minutes; heating pad turns on:

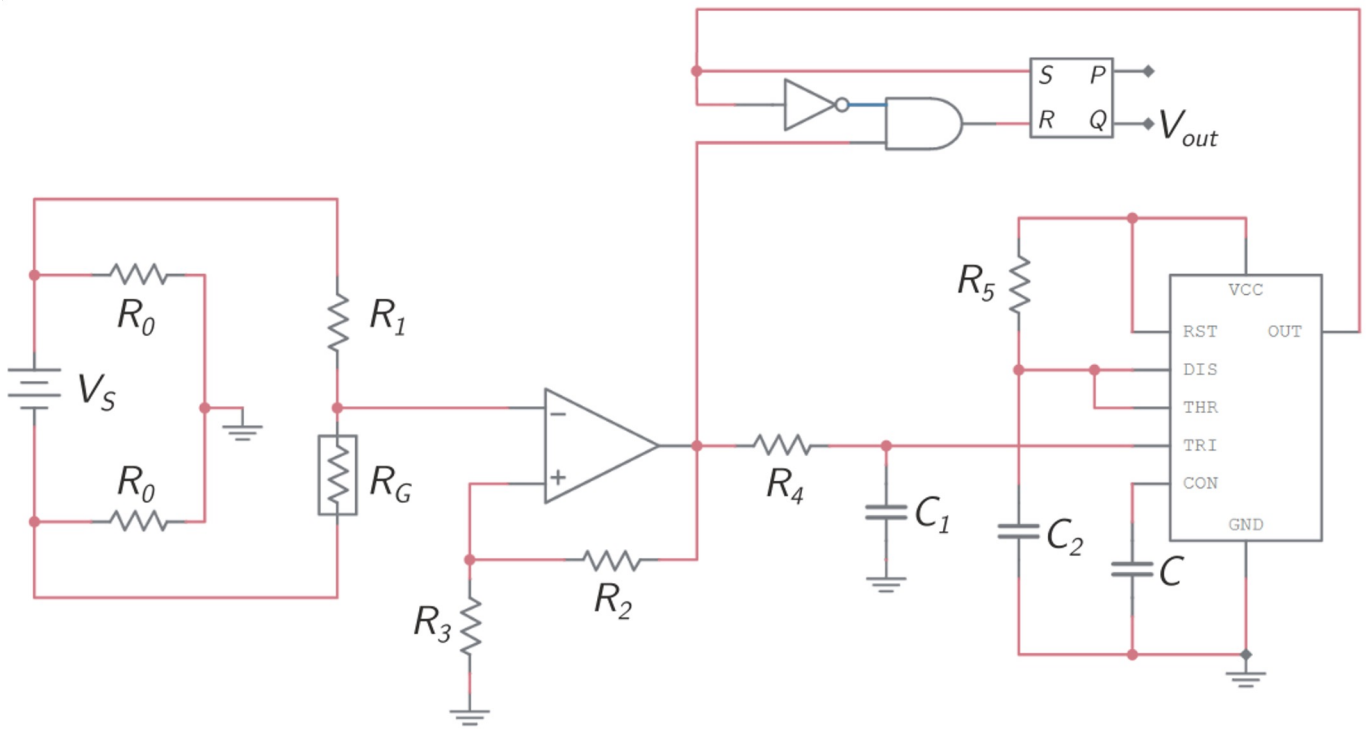
  SR = 10 → heating pad ON

- Heating pad activates for a minute; 555 timer turns off and person is still slouching

  SR = 00 → heading pad is previous state of ON

S From 555 Timer	*R* From Op Amp	Output *Q* To Heating Pad
0	0	Previous state
0	1	0
1	0	1
1	1	Invalid

Bioinstrument



Discussion - Advantages and Limitations

Advantages:

- Does not require **signal processing** or software
- Passive design will help with ease of use and **“gentle” heating** will not induce stress/frustration
- Use of threshold voltages make output steady and consistent

Limitations:

- May **not be comfortable** on the body or not at appropriate heating strength
- **No method of user feedback** or adjustable input
- Does not have a “reset” button for strain gauge so cannot be re-calibrated
- Large capacitance needed for 3-minute charging time

Discussion and Future Applications

- Posture correction can act as conservative treatment option for **scoliosis patients** (either those who can't or don't wish for surgical correction).
- Implement additional **digital data processing** techniques to monitor the users' health data for long term considerations

Considerations:

1. Comfortable Design
2. Realigns Spinal Position
3. Simple to Use
4. Safe For Every Body Type

Acknowledgements

Would like to thank Professor Cauwenberghs and Teaching Assistants Samira Sebt, Vikrant Jaltare, and Adyant Balaji for all their work this quarter!

References

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Thanks for Listening