Doppler Ultrasound Monitoring for Feline Surgery

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Generic Surgery Setup for Small Animals

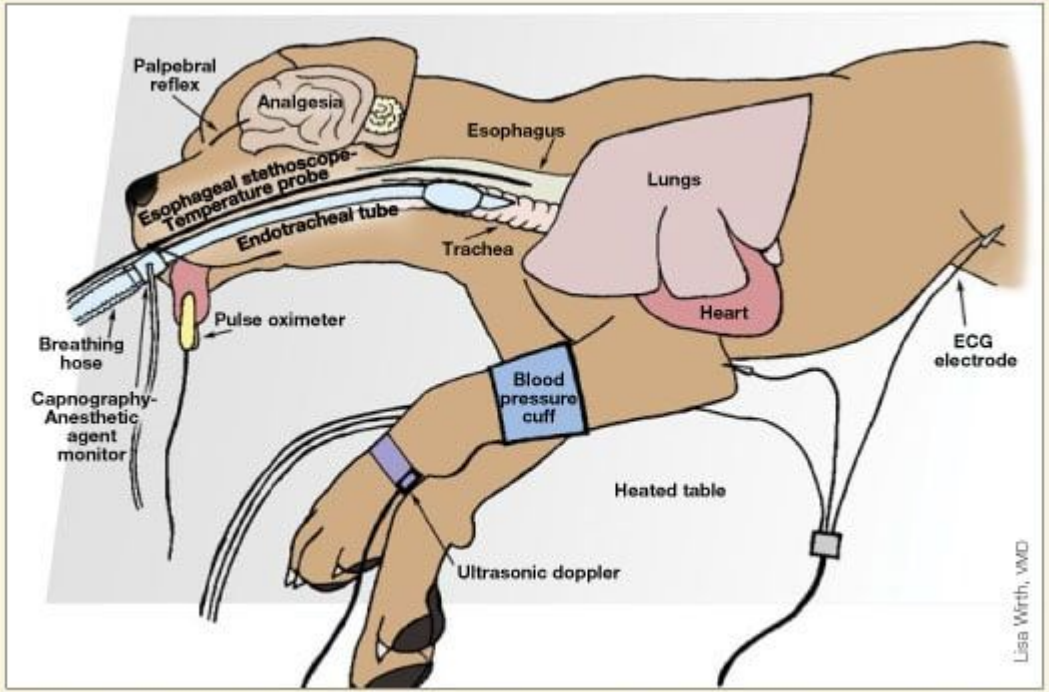


Figure 1. A schematic representation of clinical anesthesia monitoring equipment to ensure proper tissue perfusion with well-oxygenated blood. Continous systemic surveillance can provide an early warning system, prompting immediate intervention.

- Anesthesia monitoring surgery setup is similar for dogs and cats

- Main fundamental aspects of anesthetic monitoring are:
  - Oxygenation
  - Ventilation
  - Circulation

Background

- Pre-surgery considerations
  - General health (Diabetes, asthma, obesity)
  - Age and weight (recommended 2+ lbs, 6-7 months)
  - Fear and stress due to being in an unfamiliar environment
- Anesthesia problems: hypotension, hypothermia, hyperthermia (post-op)
  - Hypotension is the leading complication for cats under anesthesia
- Parameters to monitor
  - Heart Rate
  - Blood Pressure

Motivation and Goal

- Dogs and cats need to undergo anesthesia for every surgery to reduce pain and limit movement during procedures. Due to weaker electrical signals stemming from the heart, it is much harder to use an ECG on small animals as it may obtain inaccurate results.

- Doppler ultrasonography is a utility that can be used to capture both heart rate and systolic blood pressure.

- Our design aims to obtain heart rate and systolic blood pressure data to then notify the surgeon of any abnormalities during surgery.

Anesthesia System Assumptions

1. Cat is in good health:
    a. Age: 6 months - 10 years
    b. Weight: 2-12 lbs
    c. No underlying cardiovascular or respiratory disease

2. Cat is not anxious or stressed prior to anesthesia administration (can increase heart rate and breathing)

3. In an anesthetized cat:
    a. Heart rate: 120-160 bpm
    b. Systolic blood pressure: 90-140 mmHg

System Parameters

Heart rate

Systolic blood pressure

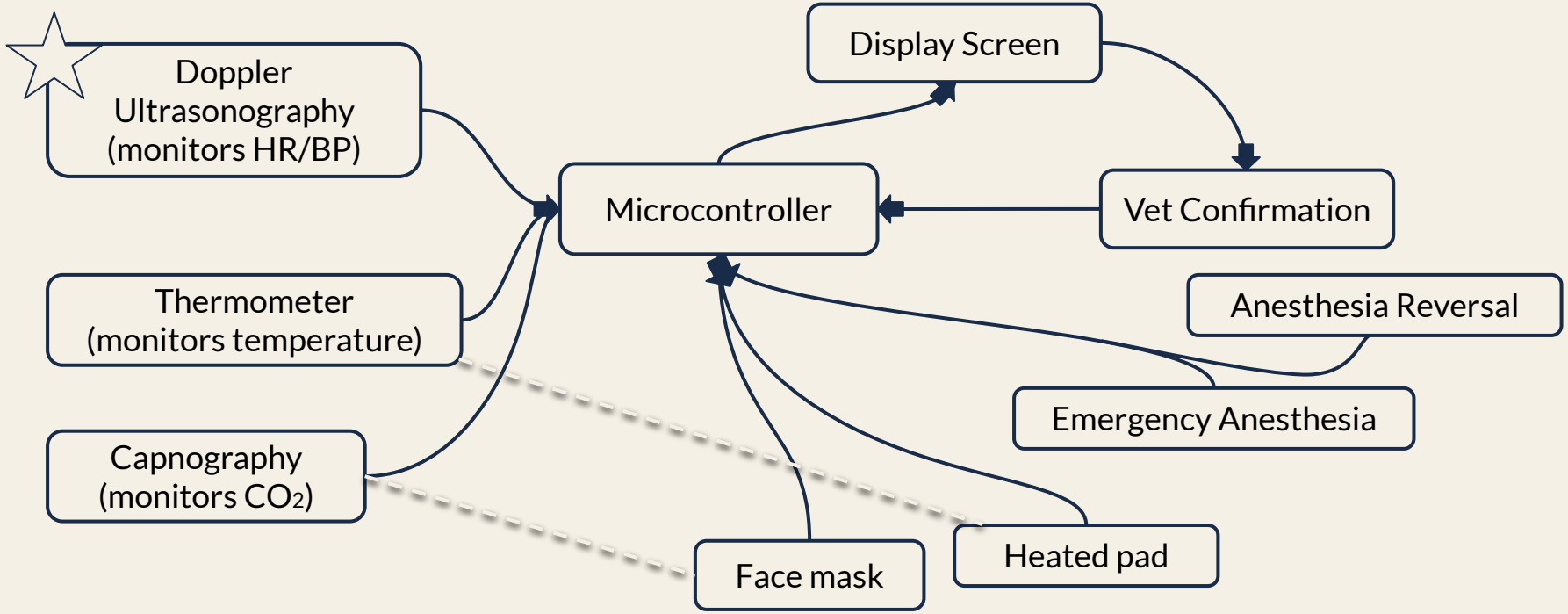
Blood flow velocity

Pressure sampling rate

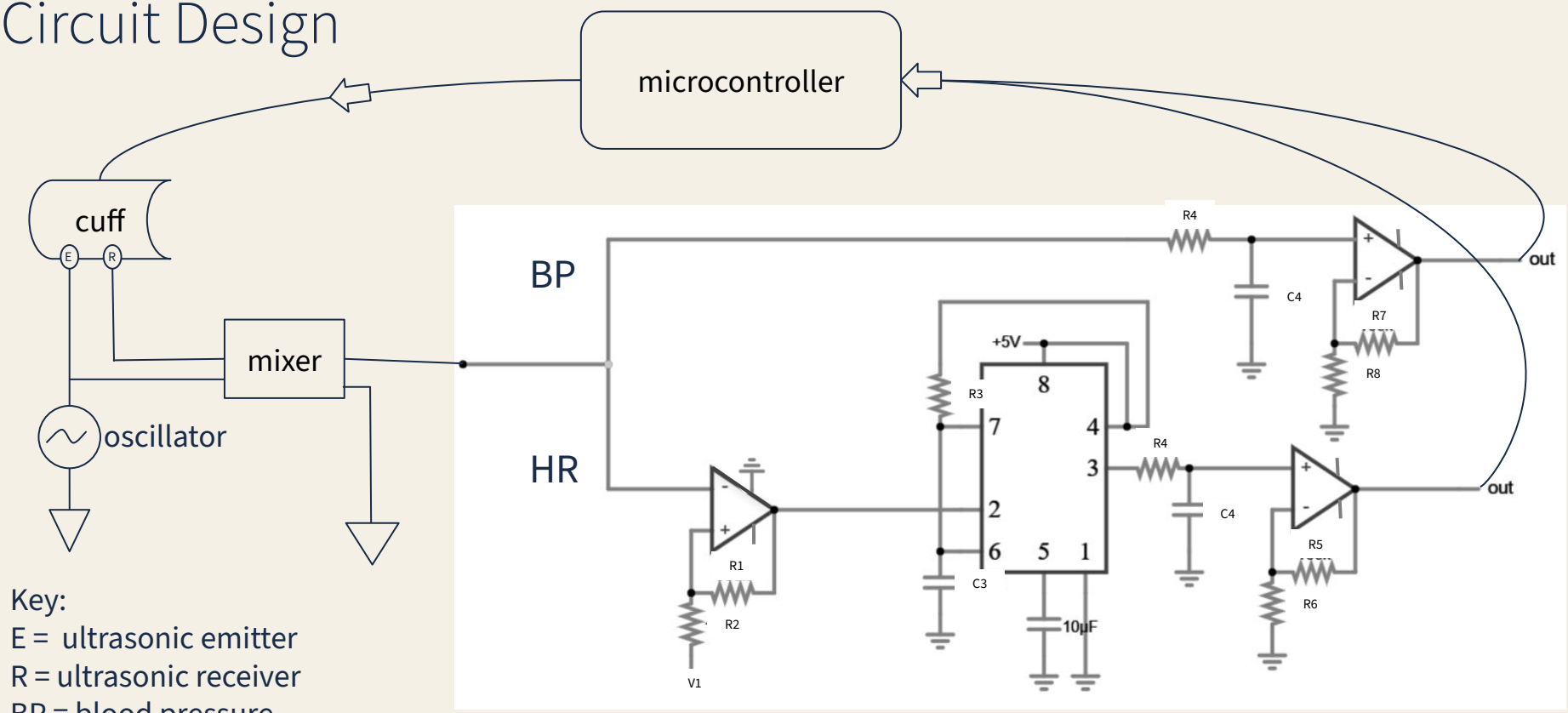
https://journals.sagepub.com/doi/10.1177/1098612X14529123

Mean velocity 23 cm/s

Feline Surgery Anesthesia Setup



Circuit Design



Key:
E = ultrasonic emitter
R = ultrasonic receiver
BP = blood pressure
HR = heart rate

Pseudocode

1. Initialize microcontroller, oscillator, cuff, mixer, low pass filter, and amplifier.
2. Set up microcontroller to control the circuit and handle input/output.
3. Set parameters for ultrasound frequency and signal processing.
4. Loop:
    a. Activate the oscillator to generate ultrasound waves.
    b. Send ultrasound waves through the cuff to the target area.
    c. Receive reflected ultrasound waves back from the target area.
    d. Analyze the output voltage to determine heart rate.
    e. If ‘heart rate’ is less than 120 or greater than 160, alert.
    f. Output the heart rate data through the microcontroller for display.
    g. Repeat loop.
5. Handle any error conditions or exceptions encountered during operation.
6. Shut down the circuit.

(every 2 minutes)

Set cuff pressure to 150 mmHg

Decrease cuff pressure by 2 mmHg per 0.5 s

If sudden increase in velocity:

    Save current pressure as ‘systolic pressure’

Deflate cuff pressure

If ‘systolic pressure’ < 90 mmHg

    Alert and recommend IV dosage or decrease isoflurane

Output ‘systolic pressure’ data through microcontroller for display.

Conclusion

Advantages:

- Non-invasive blood flow monitoring is a powerful tool in assessing vascular health.
- Doppler ultrasonography works well with small patient size, unlike ECG where small patient size means less electrical activity.

Limitations:

- The stated assumptions made within the study may not be applicable to the true situation, with variations in overall health possibly affecting the system's performance.
- Only systolic pressure is recorded, so hypertensive cases due to high diastolic pressures may be overlooked.

Future improvements:

- This model may be further developed using components to measure temperature and CO_2 levels, covering other common issues such as hypothermia, hyperthermia, and airway obstruction.
- Values and fittings may be adjusted in the future for other smaller/larger animals undergoing anesthesia.

References

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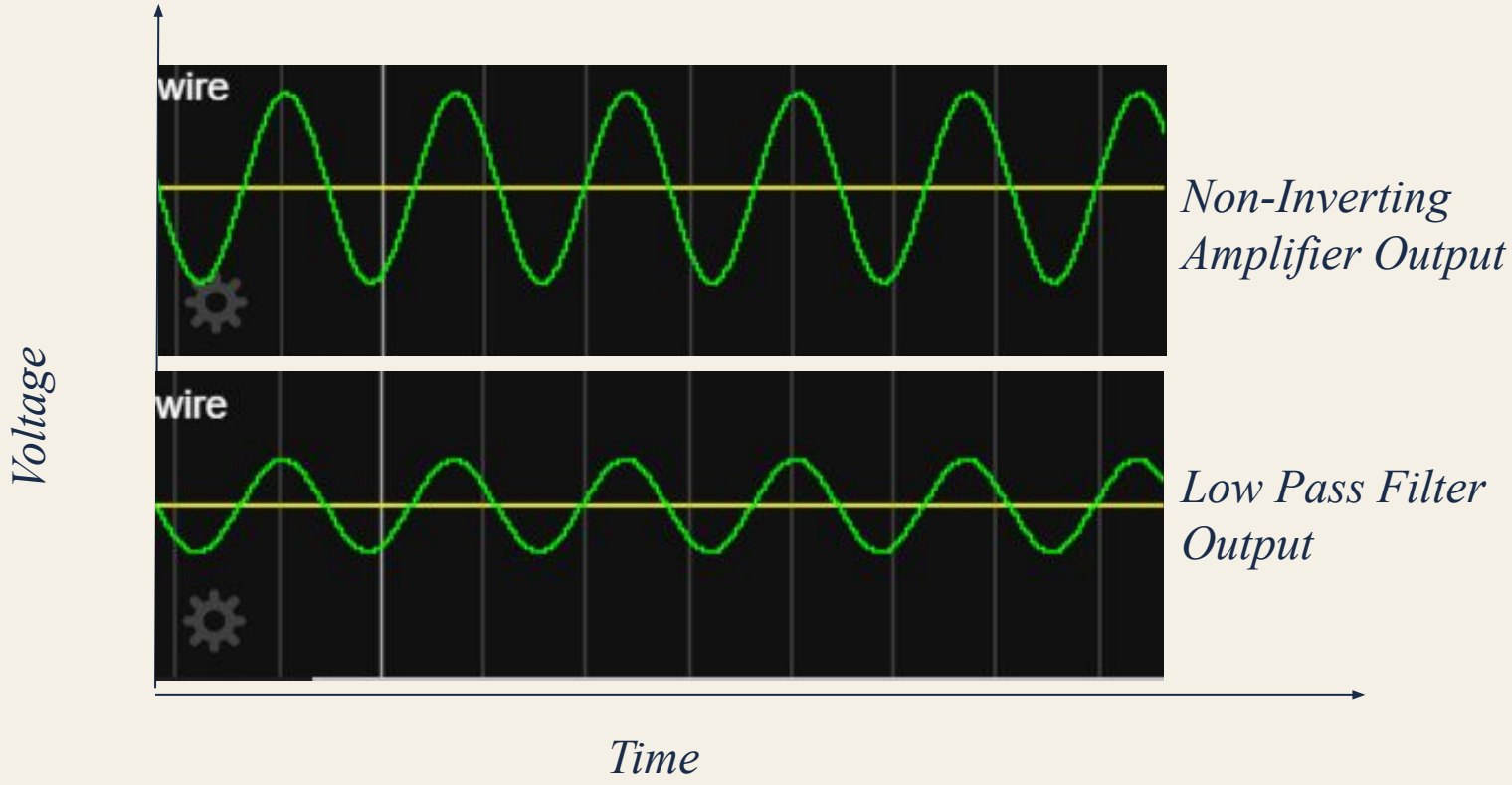
Yutong’s

Angela’s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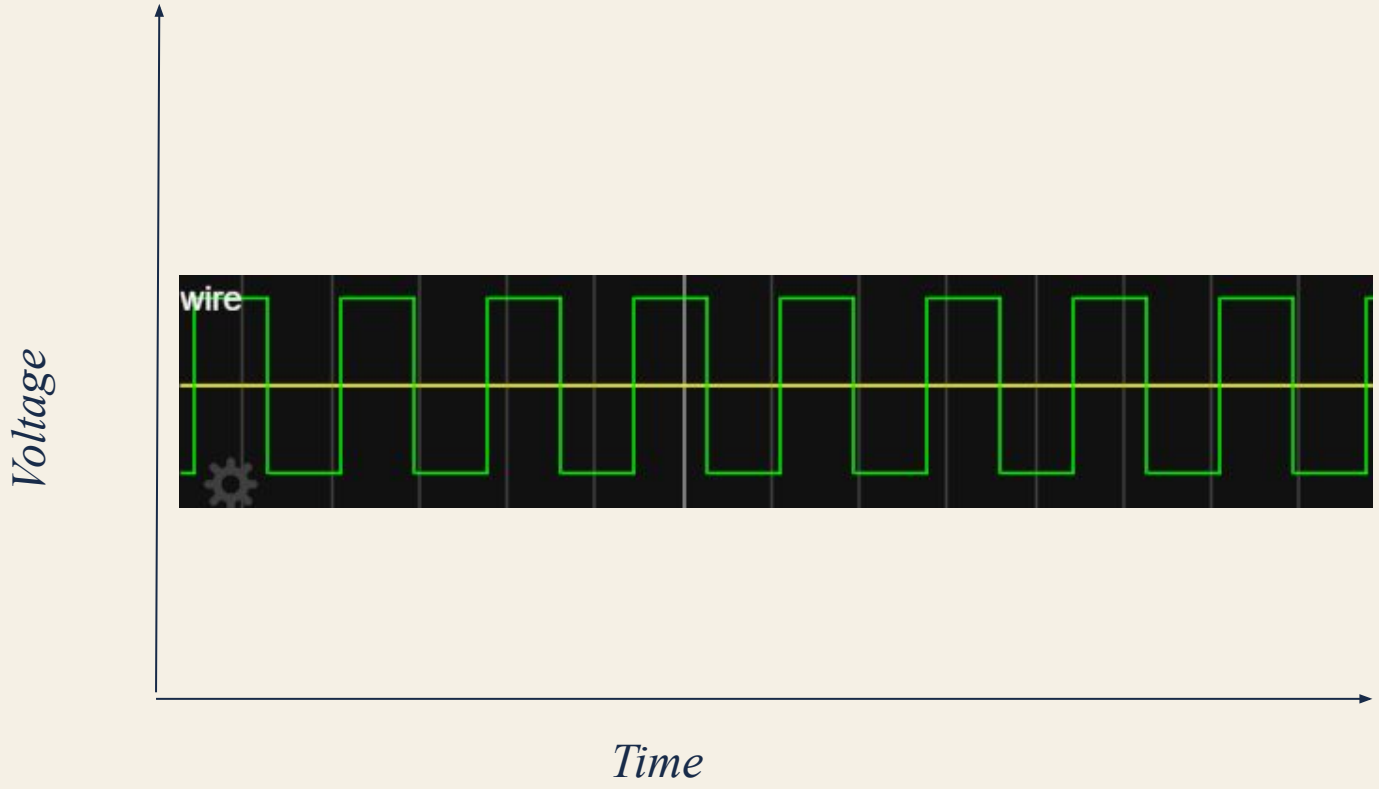
Voltage
Time
Non-Inverting Amplifier Output
Low Pass Filter Output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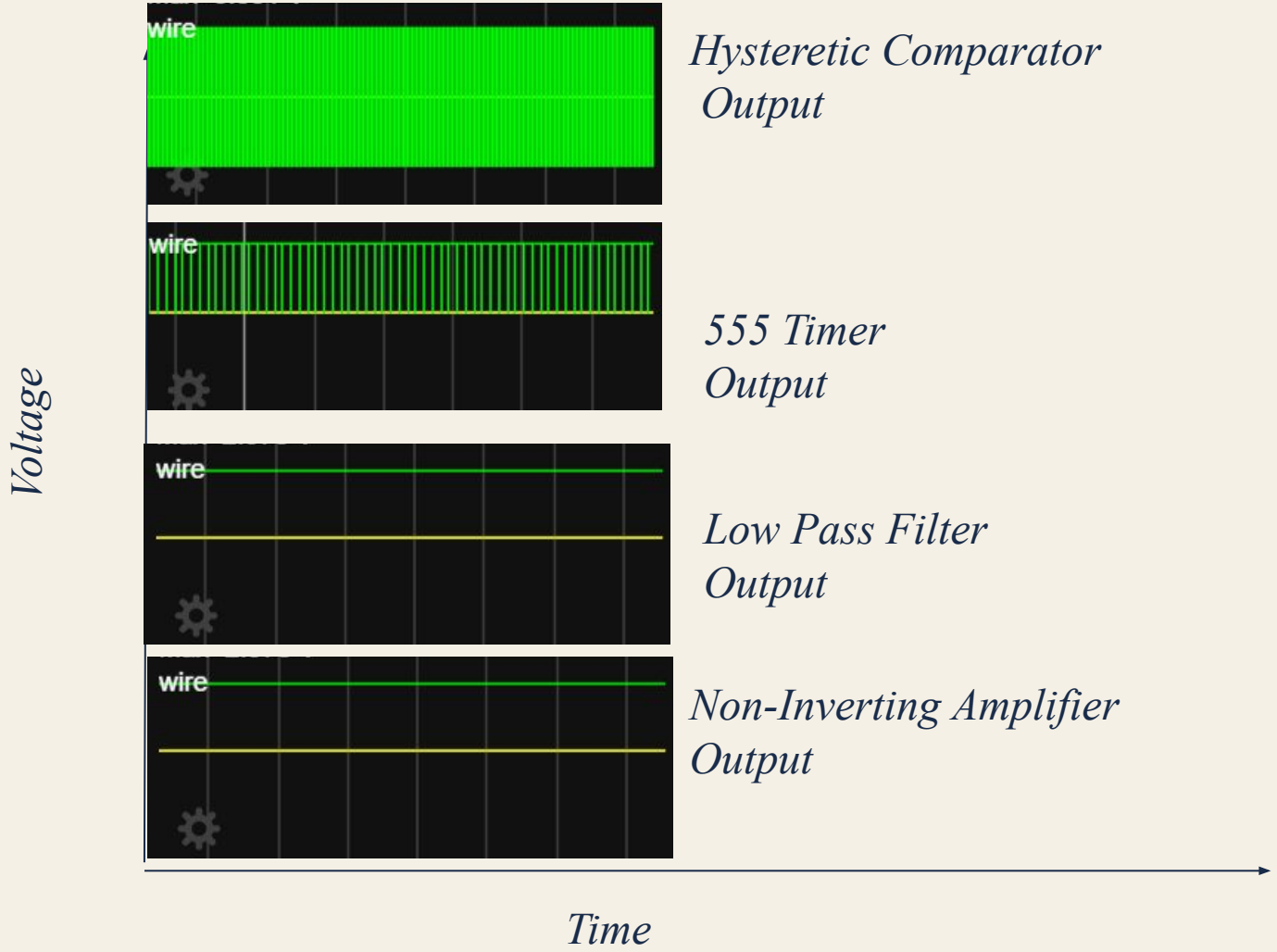
Voltage
Time


wire
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Hysteretic Comparator Output
555 Timer Output
Low Pass Filter Output
Non-Inverting Amplifier Output
Voltage
Time