Lab Report – Experiment 1: Ramp Generator

Objective

To design, simulate, and experimentally verify a ramp (triangle) wave generator using:

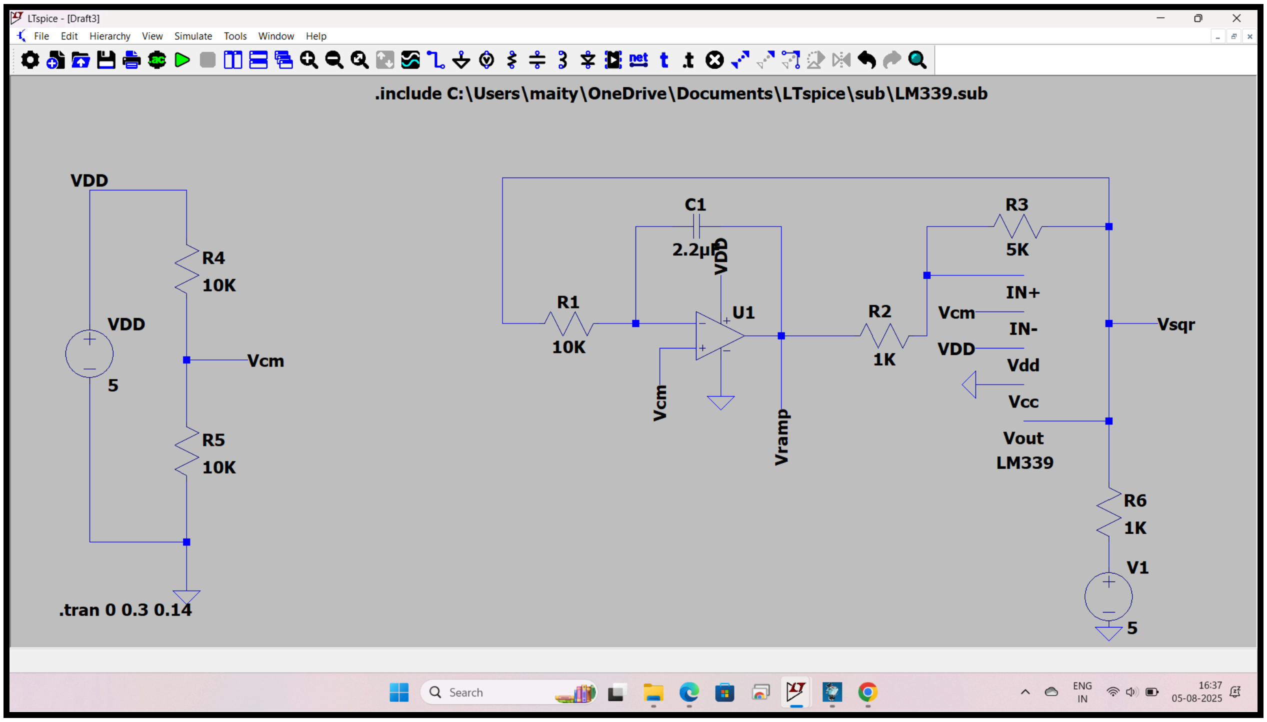
- An **LM324 op-amp** integrator
- An **LM339 comparator** with hysteresis
- A feedback loop that sustains oscillation.

Theory

A ramp generator produces a periodic triangular waveform by integrating a square wave.
In this design:

1. **LM339 comparator**:
    - Configured as a **Schmitt trigger**.
    - Switches output polarity when the ramp crosses defined thresholds.
    - Feedback resistors (R2, R3) set the hysteresis width.
2. **LM324 op-amp integrator**:
    - Converts comparator's square wave into a ramp (triangle wave).
    - Integrates constant high/low levels, producing a rising or falling voltage.
3. **Positive Feedback Loop**:
    - Comparator output → Integrator → Comparator input.
    - Oscillation frequency depends on **R1, C1, hysteresis**.

Circuit Parameters Used



Component	Value	Purpose
R1	10 kΩ	Integrator input resistor
R2	1 kΩ	Hysteresis network
R3	5 kΩ	Hysteresis network
C1	2.2 µF	Integrator capacitor
Pull-up resistor	1 kΩ	LM339 output pull-up
Op-amp	LM324	Integrator
Comparator	LM339	Schmitt trigger
VDD	5 V	Power supply

Simulation Results (LTspice)

- **Vramp**: Triangular waveform, peak-to-peak ≈ 0.8 V–0.9 V, centered around ~2.5 V.
- **Vsqr**: Square wave, amplitude ≈ 0–5 V.

- Oscillation period ≈ **40 ms** → frequency ≈ **25 Hz**.

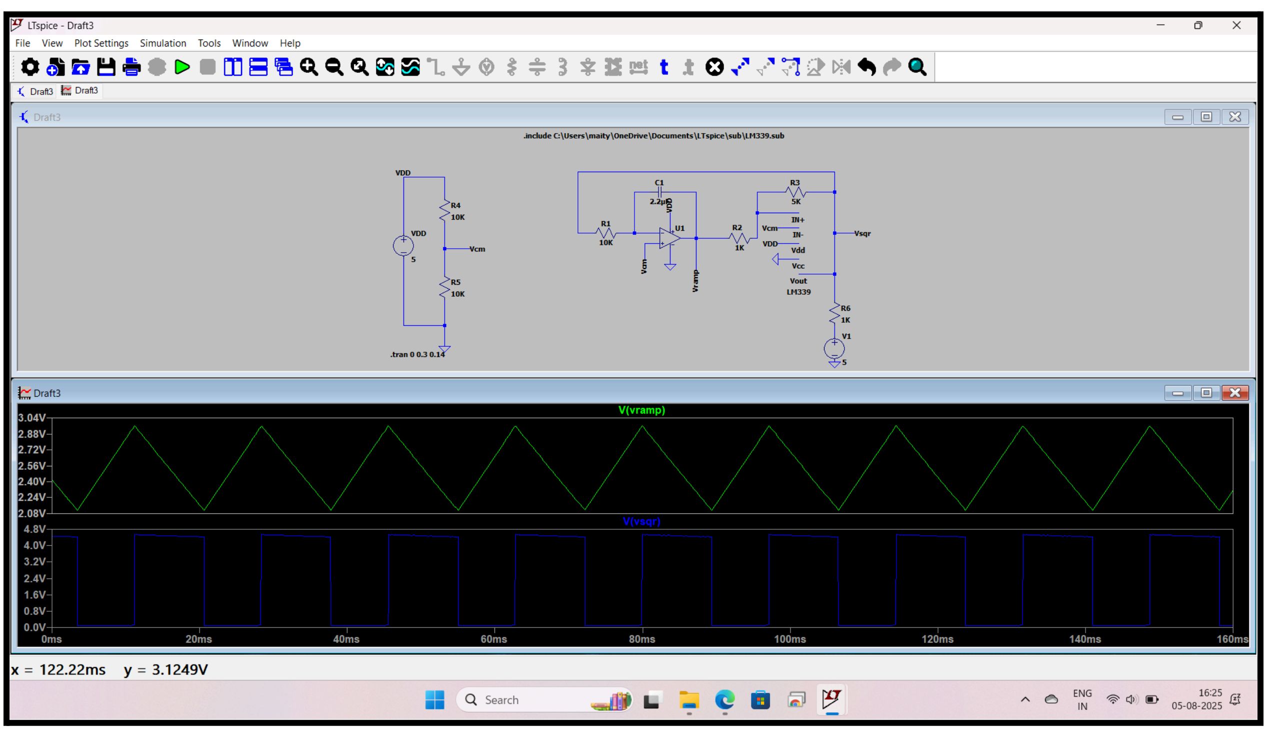
Experimental Results (ADALM1000)

Signal	Waveform Shape	Peak-to-Peak	Average DC
Vramp (Integrator Output)	Triangle	~2.13 V	~2.55 V
Vsqr (Comparator Output)	Square	~4.31 V	~2.41 V

The hardware output matches simulation in **waveform shape** but differs in **amplitude and frequency** due to:

- Larger capacitor (2.2 µF → much slower ramp).
- Low pull-up resistor (1 kΩ → higher load, affecting switching speed).
- Component tolerances.

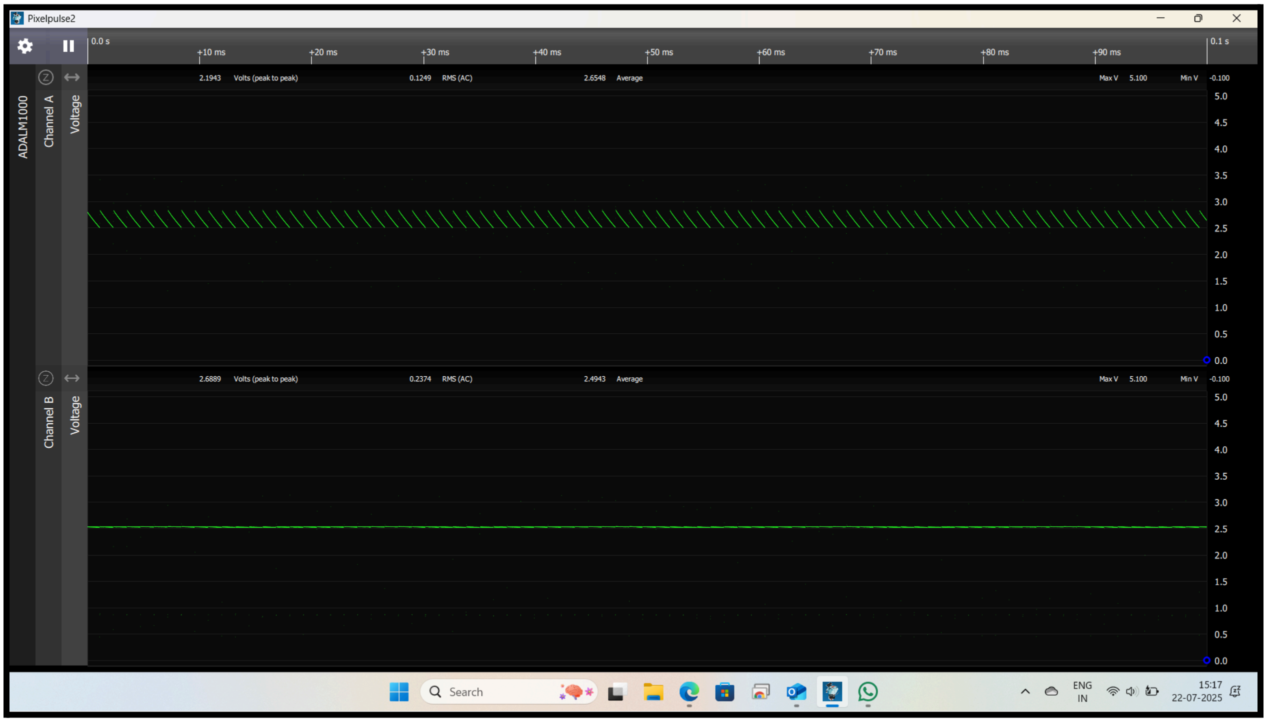
Waveforms



Simulation – LTspice

- Vramp: Green triangular wave.
- Vsqr: Blue square wave.

Experimental – ADALM1000 (Pixelpulse2)



- Channel A (Vramp): Triangular wave, ~2.13 Vpp.

- Channel B (Vsqr): Square wave, ~4.31 Vpp.

Observations

1. Increasing C1 → lowers oscillation frequency (slower ramp).

2. Low-value pull-up resistor (1 kΩ) → increases current draw and may distort output.

3. Hysteresis network (R2/R3) determines amplitude of Vramp.

4. The integrator output average remains close to VCM ≈ 2.5 V.

Conclusion

The ramp generator using LM324 + LM339 works as expected:

- Simulation and hardware results both show proper triangular and square waveforms.
- Differences in frequency/amplitude are due to selected component values (especially C1).
- This confirms the theory that an integrator + Schmitt trigger can sustain oscillations and produce ramp signals.