Positive Feedback and Relaxation Oscillators

Lecture 2 – Relaxation Oscillators

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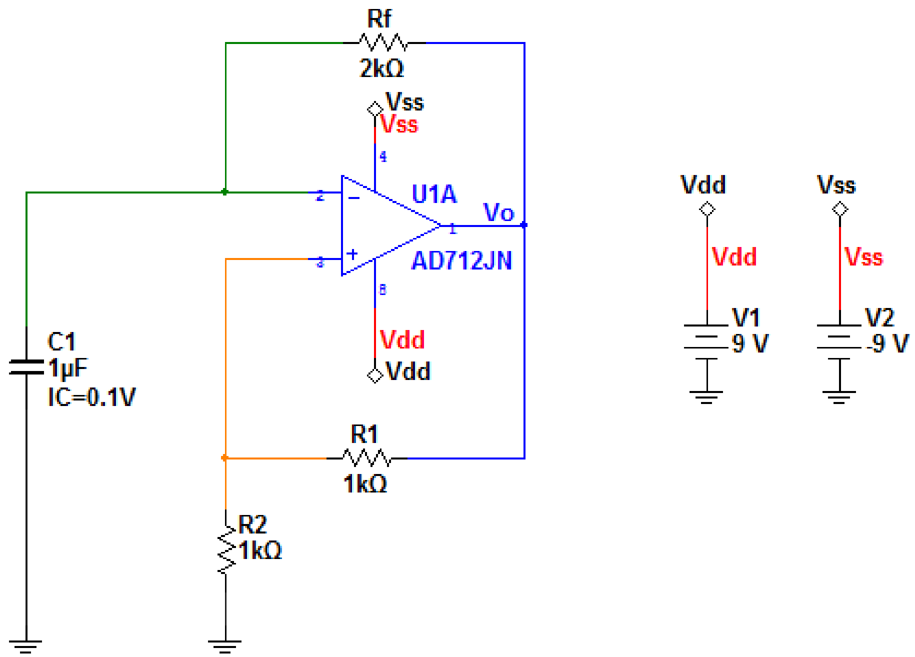
Recall from last lecture…

1. The Schmitt Trigger
2. Instability in the physical Schmitt trigger – the parasitic capacitor

Questions?

Goal of Lecture 2

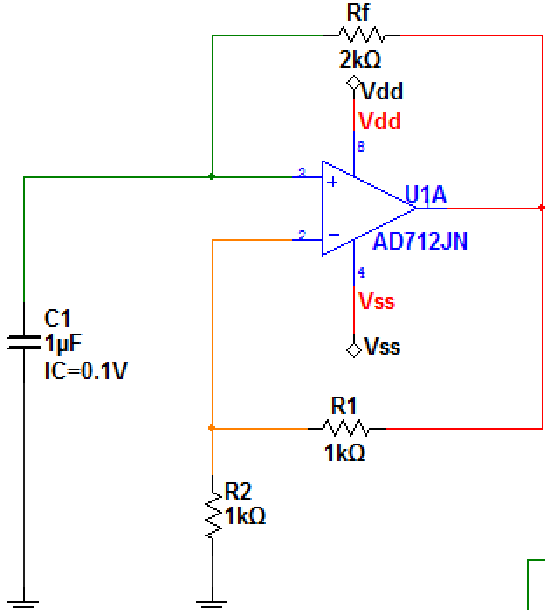
Analyze and simulate circuit shown below. Specifically, sketch Vo(t) in the circuit below. Note: You should realize circuit physically on a breadboard.

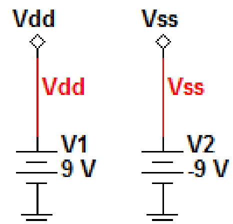


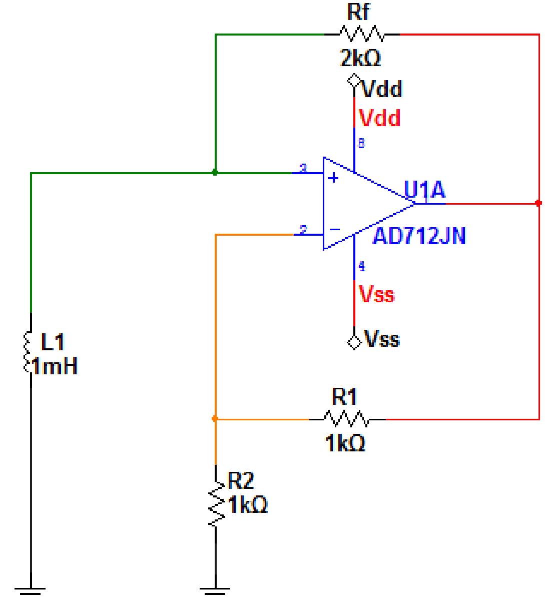
Recall : When you have questions, please ask!

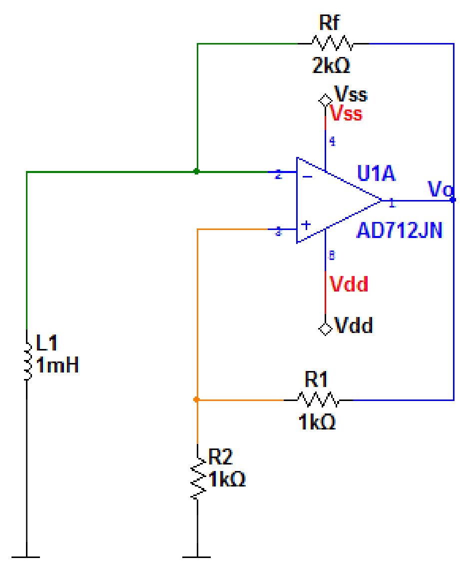
If you have seen this circuit before…

What does each circuit below do (answer in ONE word)?



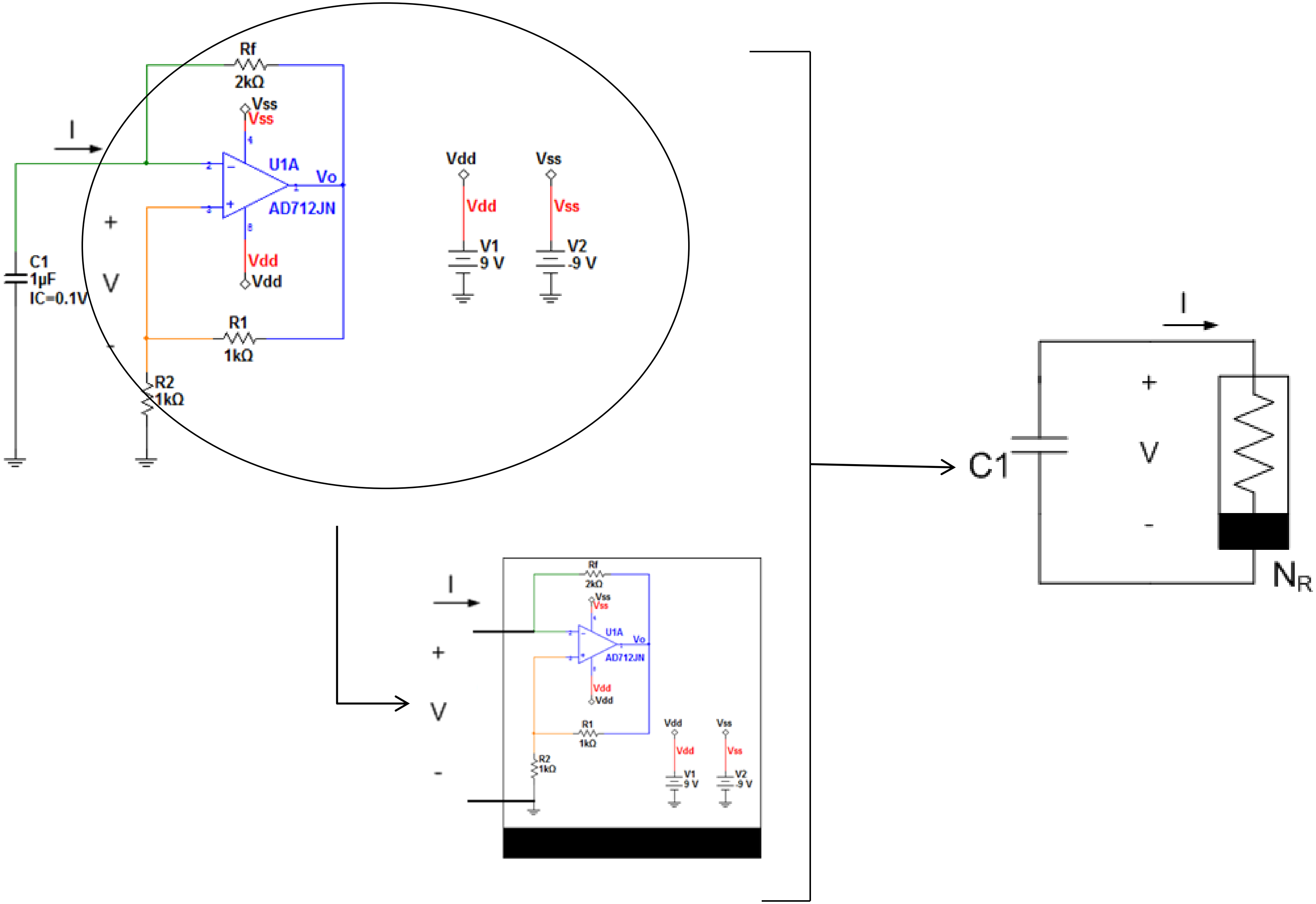






Wait till end of lecture ☺ …

Step 1: Understand Problem



Step 2: Devise a Plan

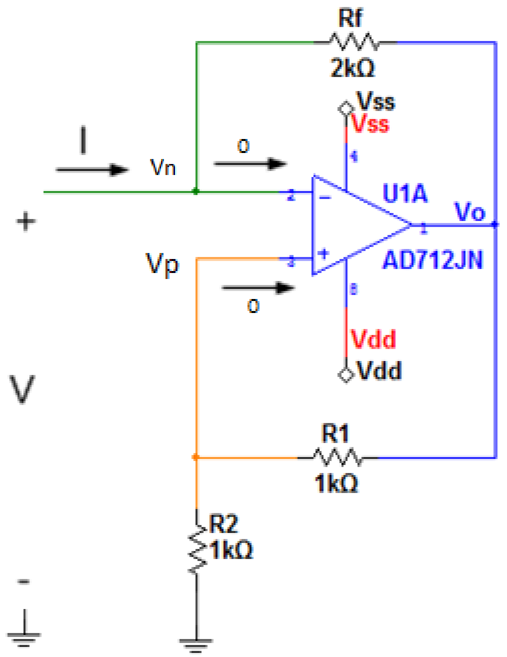
1. Derive i-v graph of $N_R = I(V)$ using op-amp ideas from lecture 1

2. Use $I = -C\dfrac{dV}{dt}$ (1) (concepts from circuit theory)

3. Use (1) to find and sketch Vo(t)

Step 3 (a): Carry out the plan

1. Terminology



2. Circuit Equations

$$I = \frac{v_n - v_0}{R_f}$$

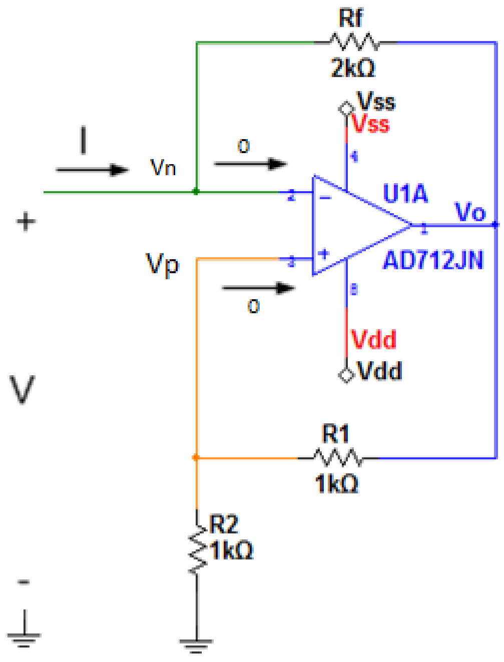
$$= \frac{V - v_0}{R_f} \qquad (2)$$

$$v_p = \frac{R_2}{R_1 + R_2} v_0 \qquad (3)$$

3. Recall three modes of operation for an op-amp : linear region, positive saturation and negative saturation.

Step 3 (b): Carry out the plan

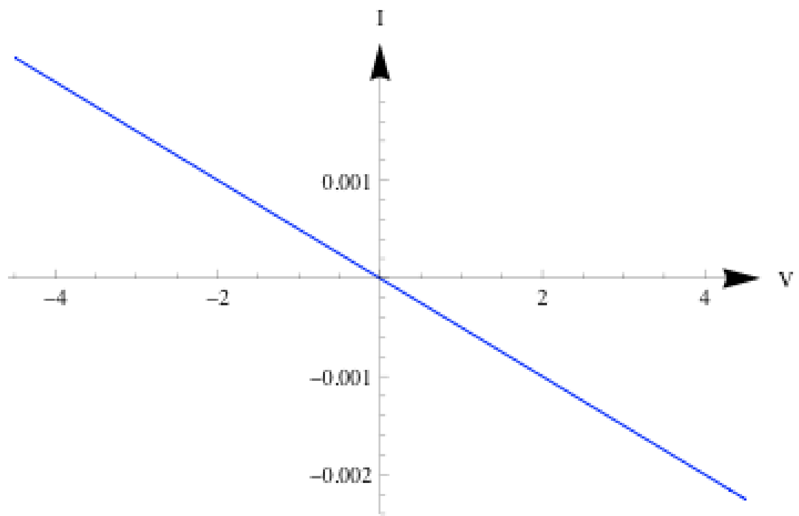
1. Op-amp in linear region



2. Circuit Equations

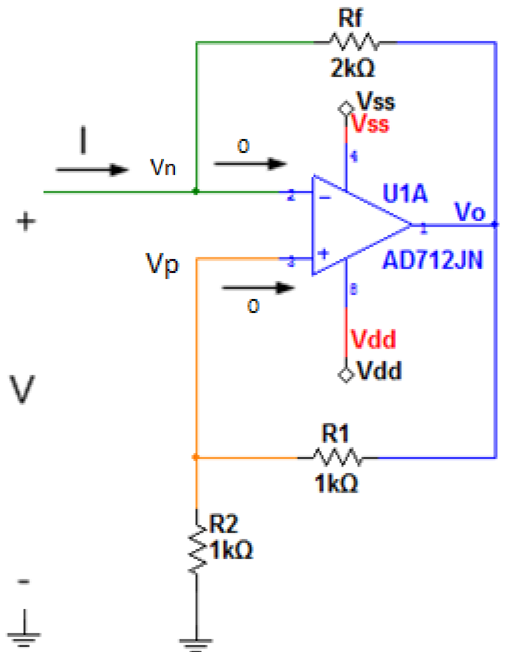
$$I = -\frac{V}{R_f} \qquad (4)$$

3. I-V graph



Step 3 (c): Carry out the plan

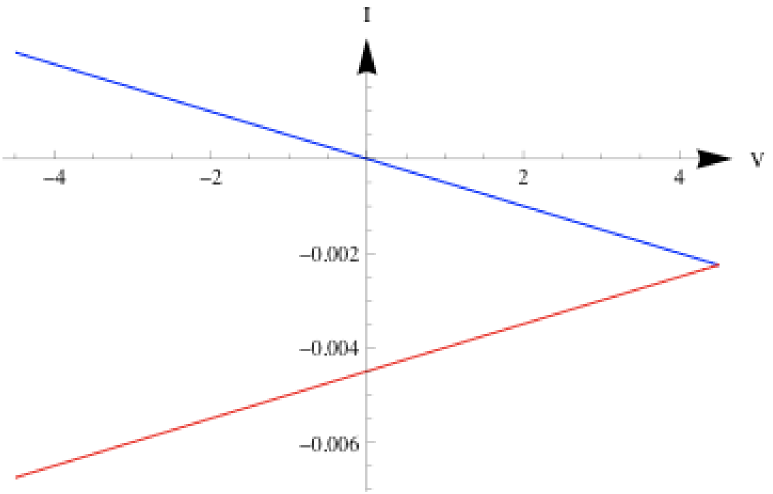
1. Op-amp in positive saturation



2. Circuit Equations

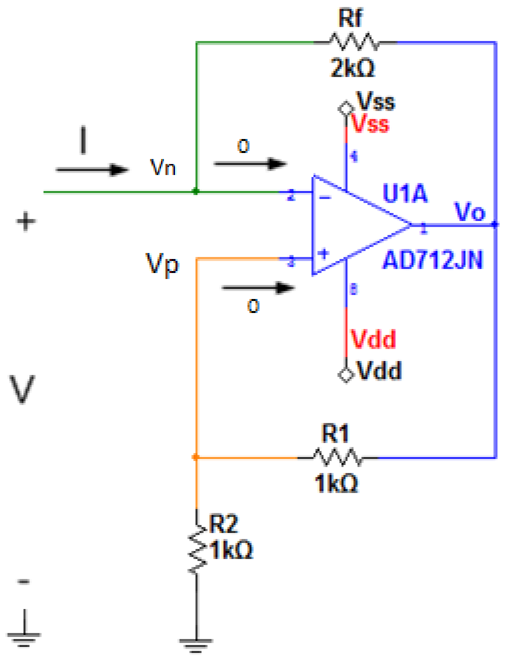
$$I = \frac{V - 9}{R_f} \quad V < 4.5 \text{ volts} \quad (5)$$

3. I-V graph



Step 3 (d): Carry out the plan

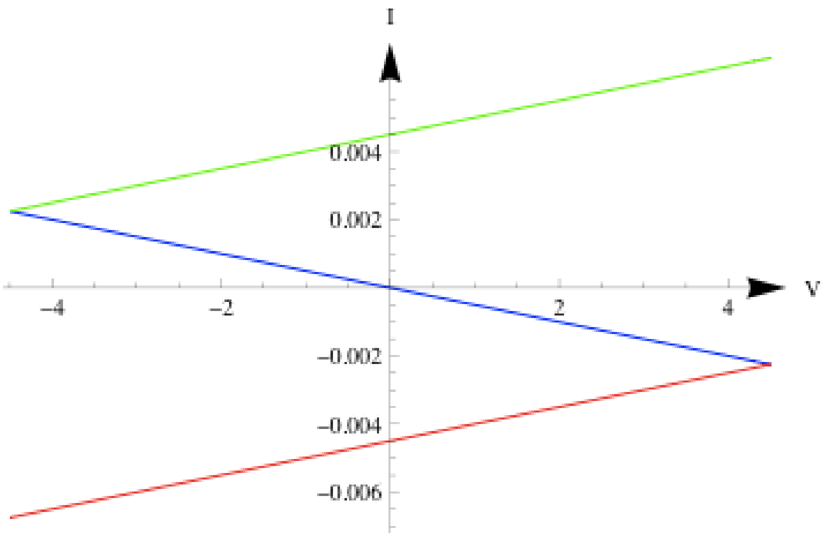
1. Op-amp in negative saturation



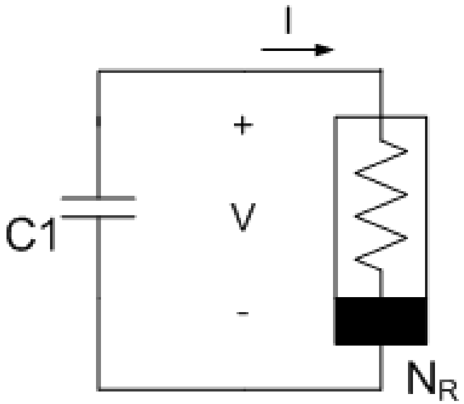
2. Circuit Equations

$$I = \frac{V+9}{R_f} \quad V > -4.5 \text{ volts} \qquad (6)$$

3. I-V graph



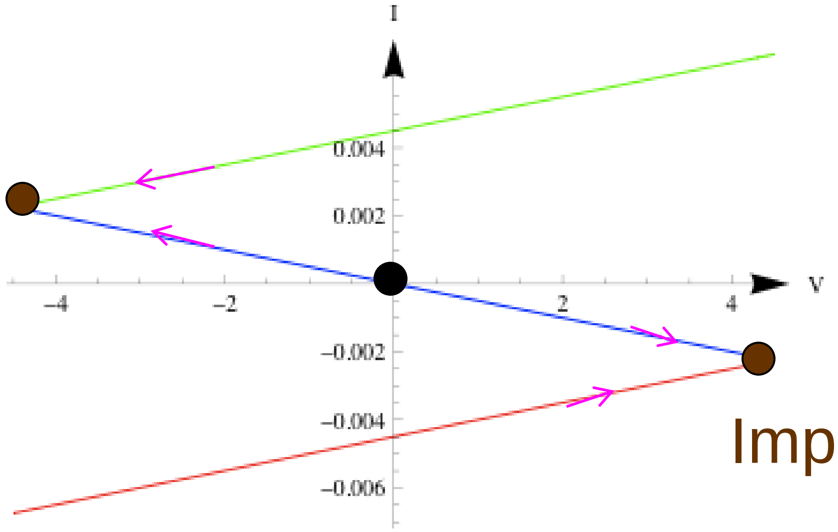
Step 3(e) : Finding Vo(t)



$$I = -C\frac{dV}{dt} \quad (7)$$

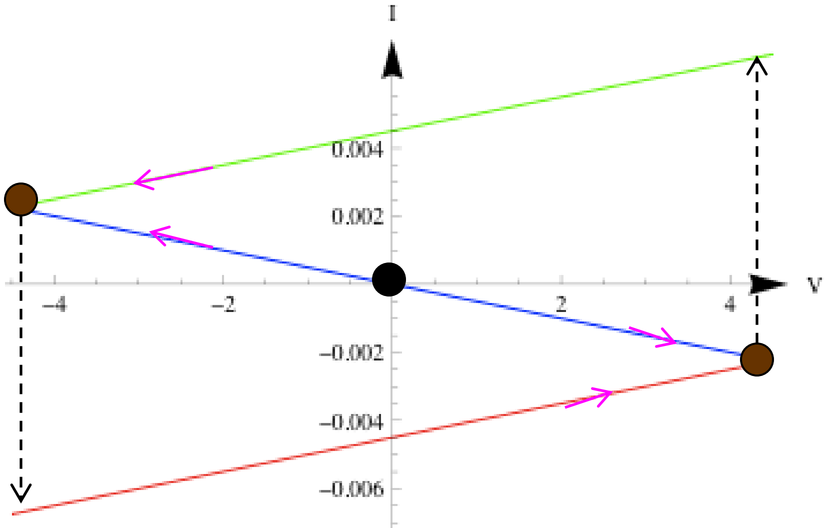
$$\text{Equilibrium points}: \frac{dV}{dt} \triangleq 0 \quad (8)$$

$$\text{Dynamic Route} \triangleq \begin{cases} I > 0 & \dot{V} < 0 \ (C > 0) \\ I < 0 & \dot{V} > 0 \ (C > 0) \end{cases} \quad (9)$$

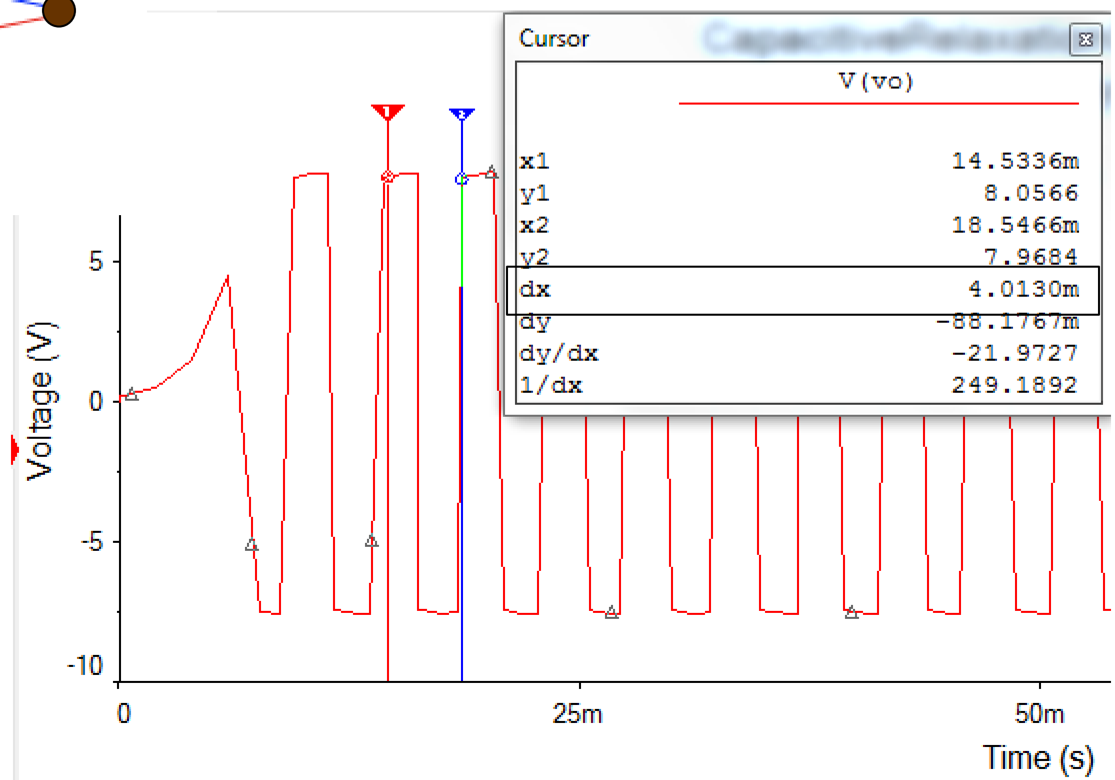


Impasse Points

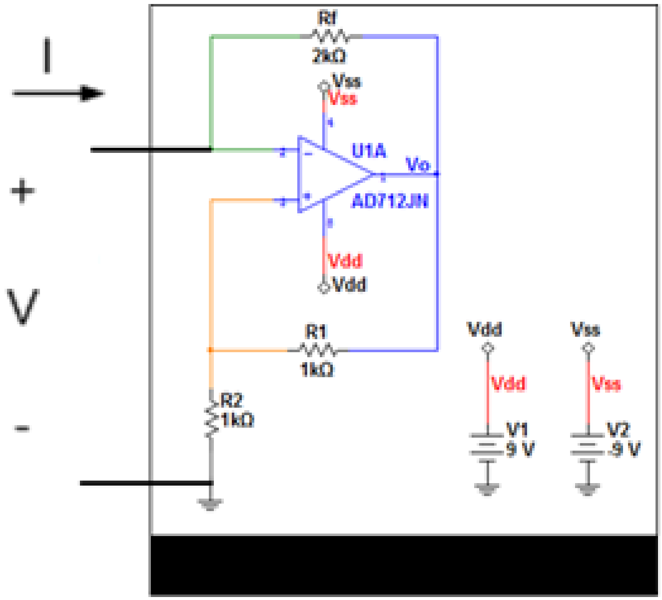
Step 3(e) : Sketching Vo(t)

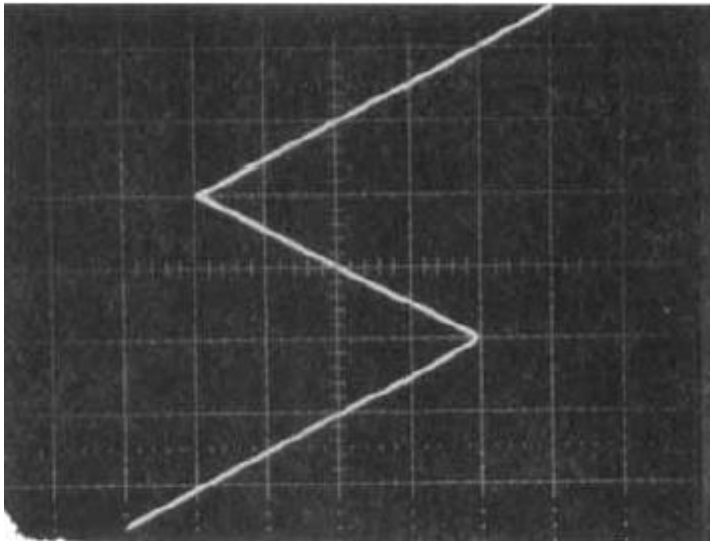


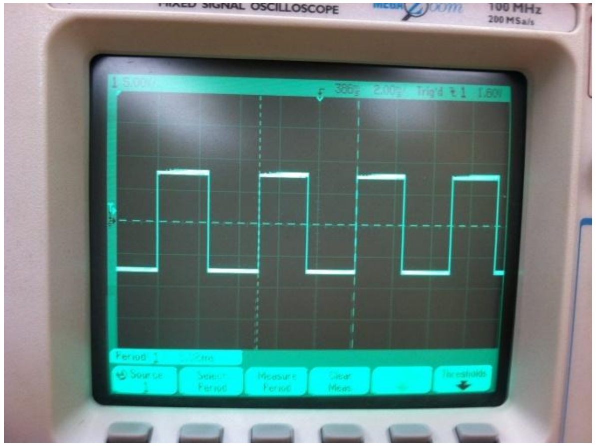
Period will be computed in next lecture



Step 4: Check your answer

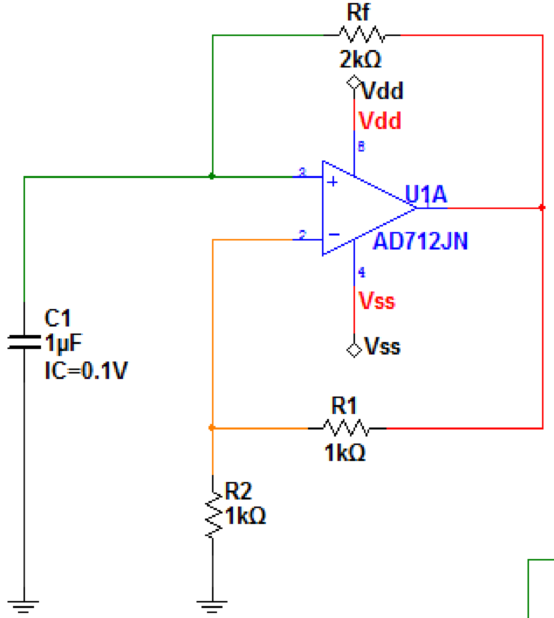


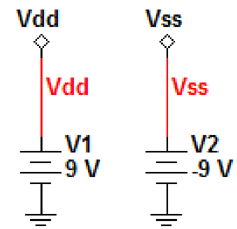


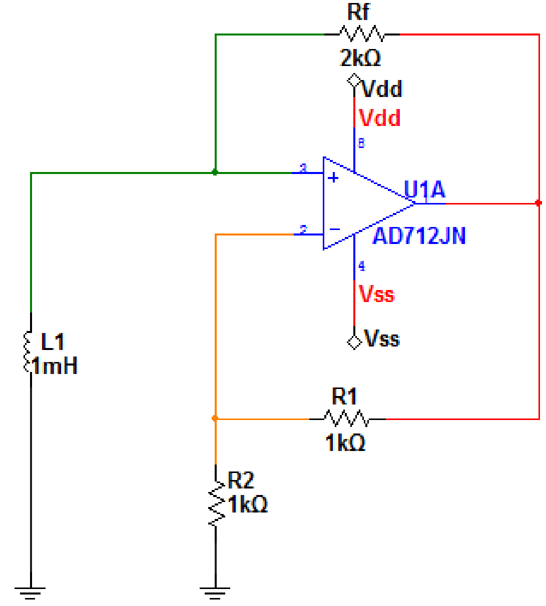


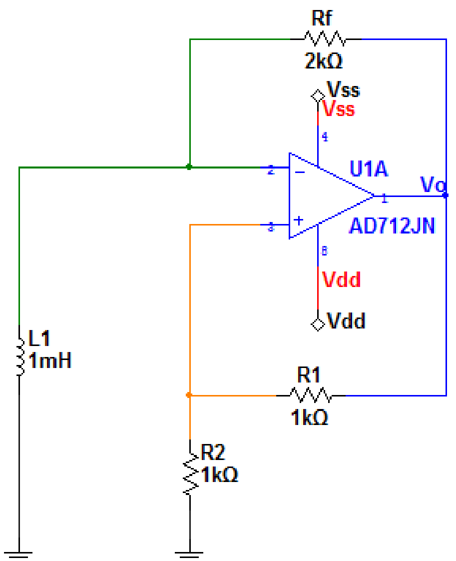
Remember us ☺?

What does each circuit below do (answer in ONE word)?









Question : Only one of them is an oscillator, which one?

Hint : Refer to the reading for this lecture!