FACULTY OF ENGINEERING
DEPARTMENT OF ELECTRONICS AND COMMUNICATIONS

GEE336
Electronic Circuits II

Lecture #5
Sawtooth & Staircase Generators

Instructor:
Dr. Ahmad El-Banna

SUMMER 2015

Grading Strategy

Criteria	Marks	Detailed Marks	Description
Attendance	10	5	Attendance
		5	Participation
Mid Term	40	5	Quiz
		5	Assignment
		30	Written Exam
Final	50	10	Assignment
		40	Written Exam

Agenda

- Non-Inverting Integrator
- Staircase Generator
- Sawtooth Generator

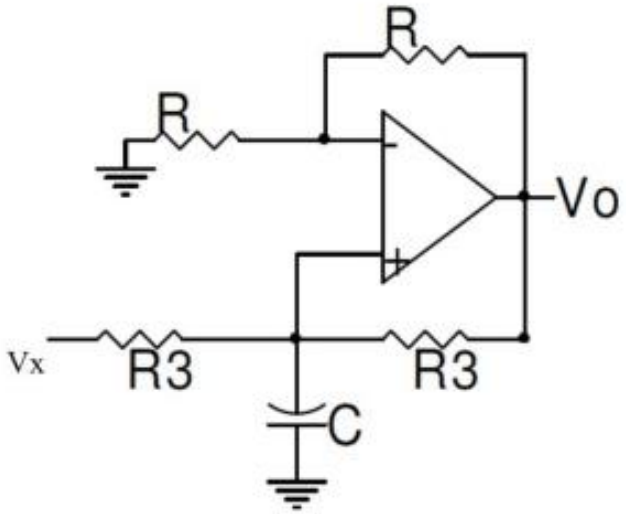
NON-INVERTING INTEGRATOR

Non Inverting Integrator

$V^+ = V^-$

- KCL @ V^-:
  $(V_o - V^-)/R = V^- / R$
  So, $V^- = V_o / 2$

- KCL @ V^+:
  $(V_x - V^+)/R_3 + (V_o - V^+)/R_3 = SC * V^+$
  So, $V^+ = (V_x + V_o) / (2+SCR_3)$



By equating V^+ & V^- we'll get:

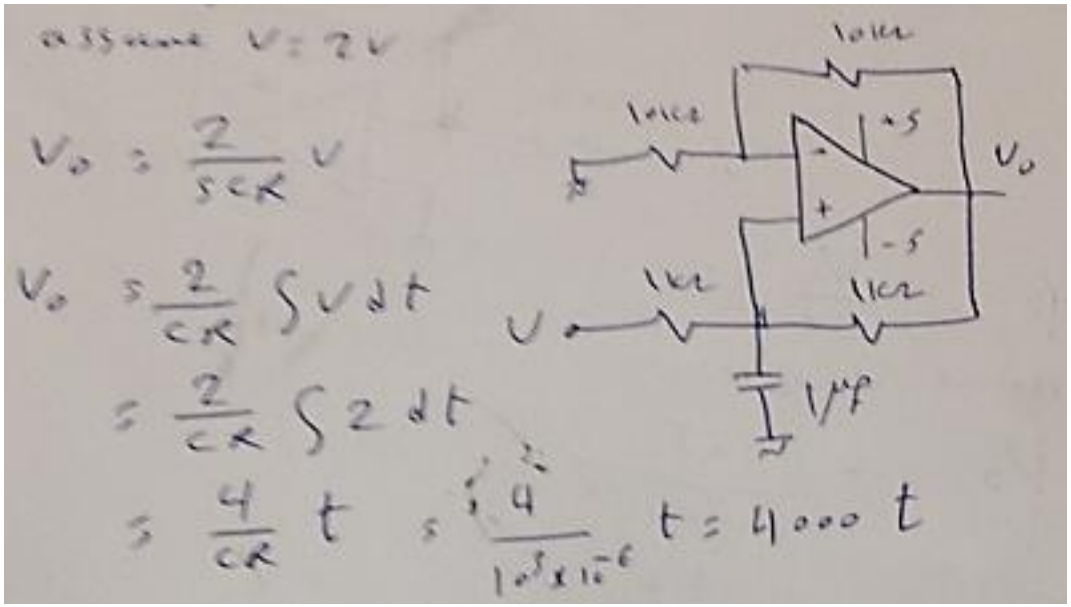
$V_o = (2/SCR_3)\, V_x$ => non-inverting integrator.

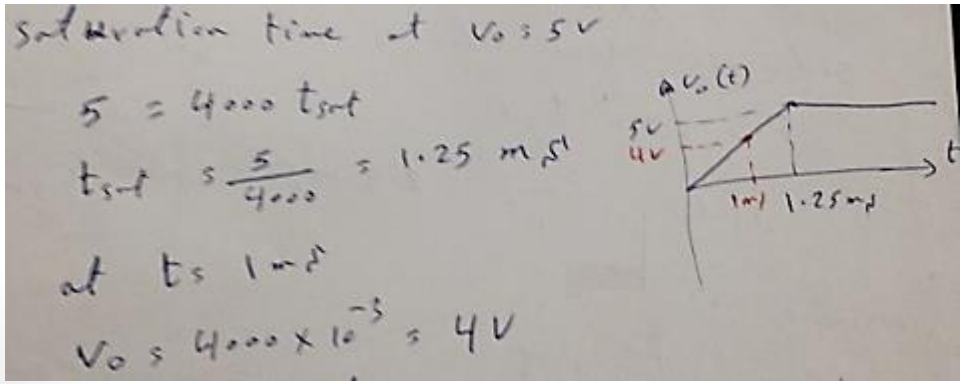
Or

$v_o(t) = (2/CR_3) * \int_0^t v_x \, dt$

Saturation time

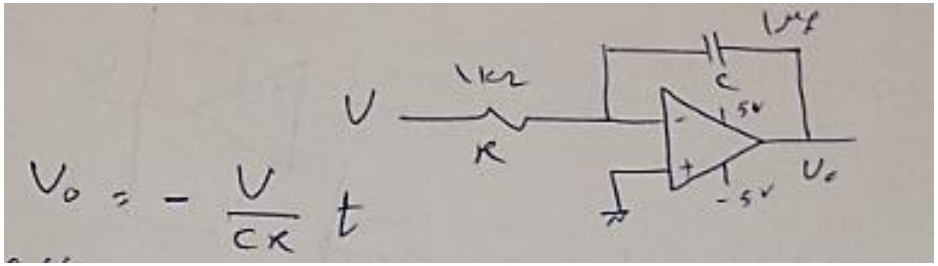
Non Inverting Integrator

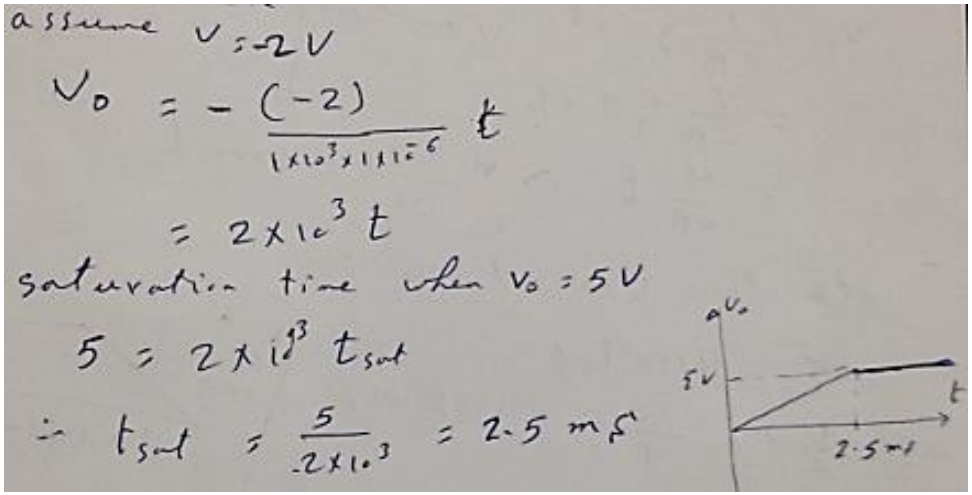




Saturation time

Inverting Integrator

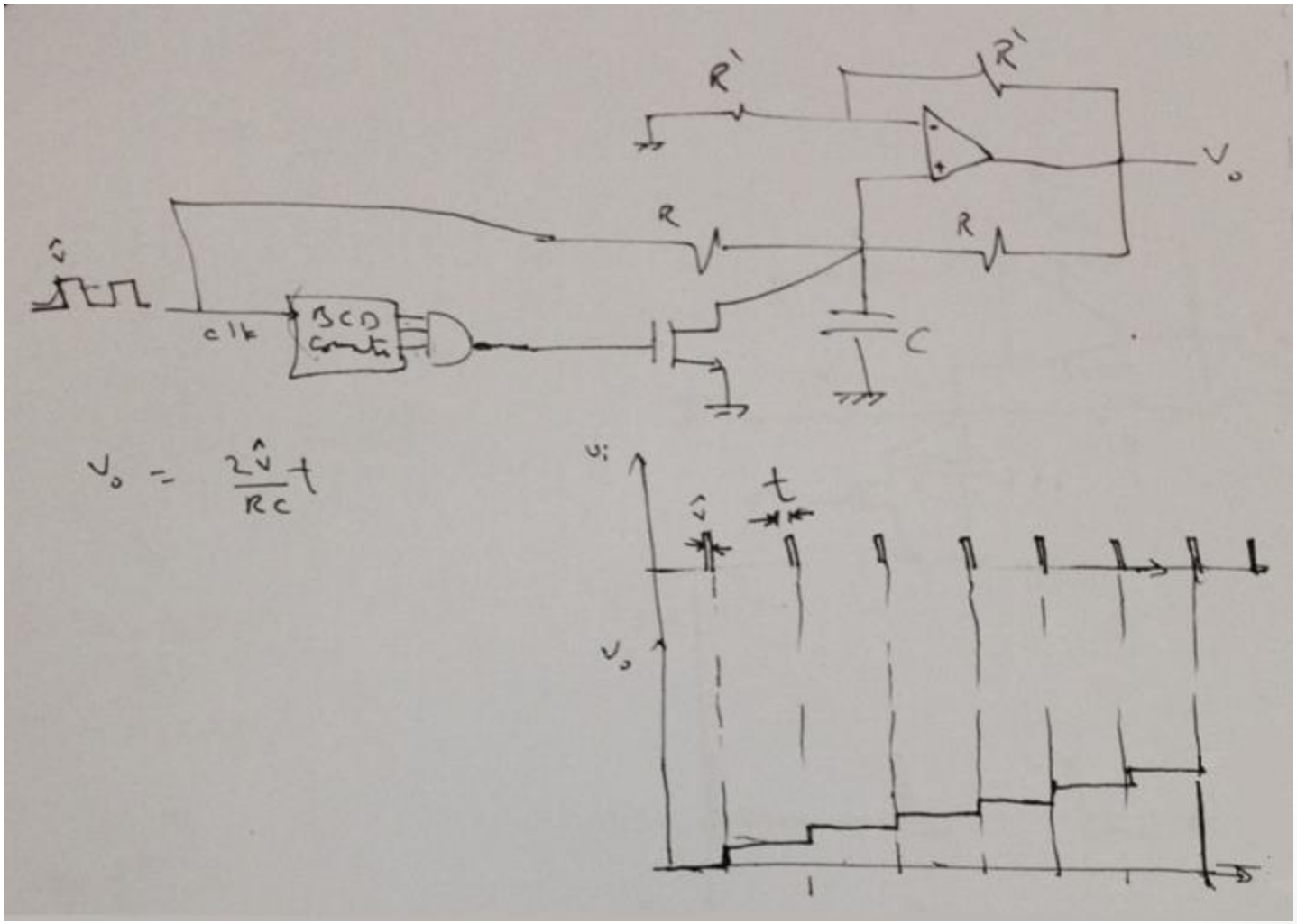




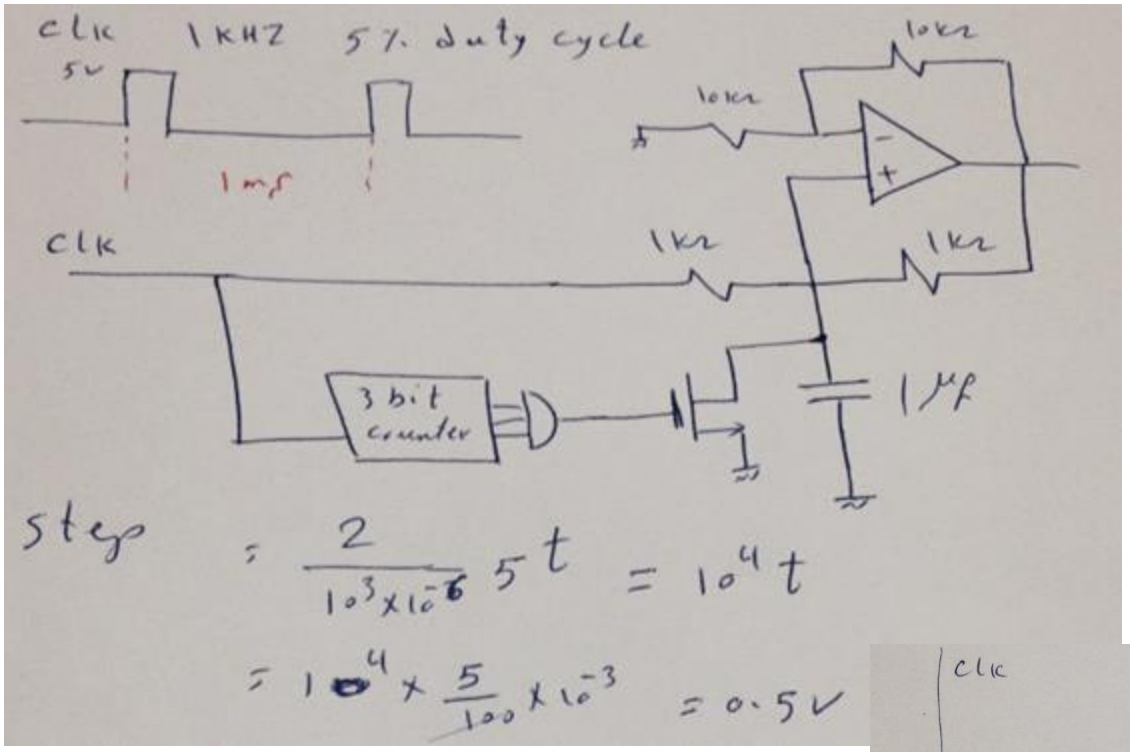
What about v= 2v ?

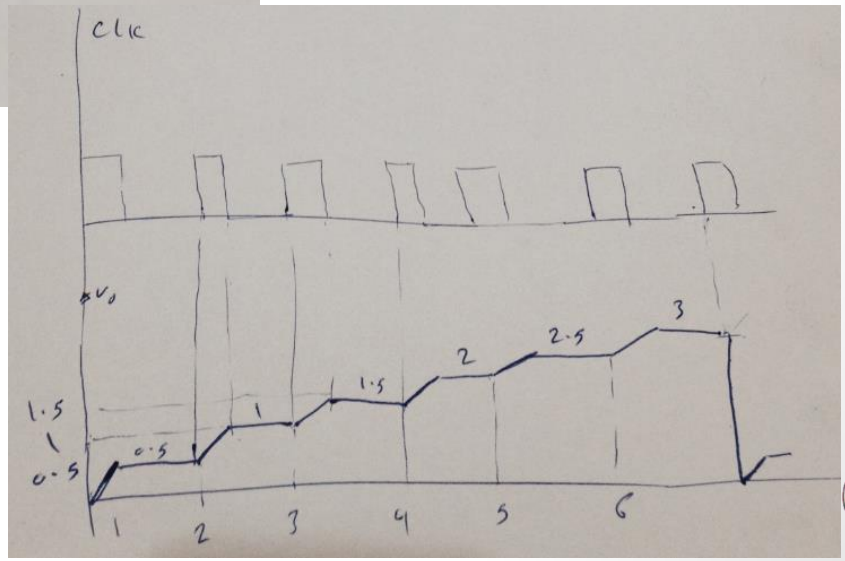
STAIRCASE AND RAMP GENERATOR

Using BCD Counter



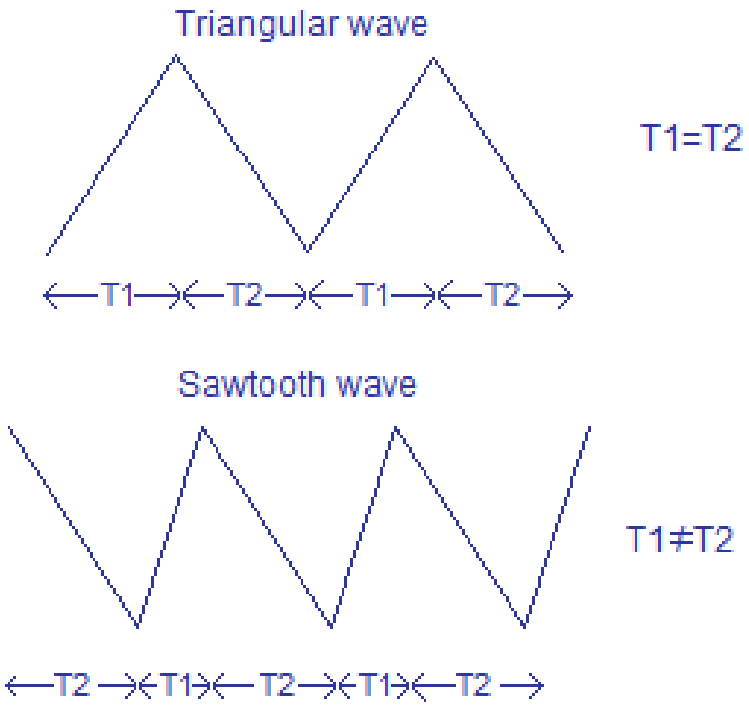
Staircase Example





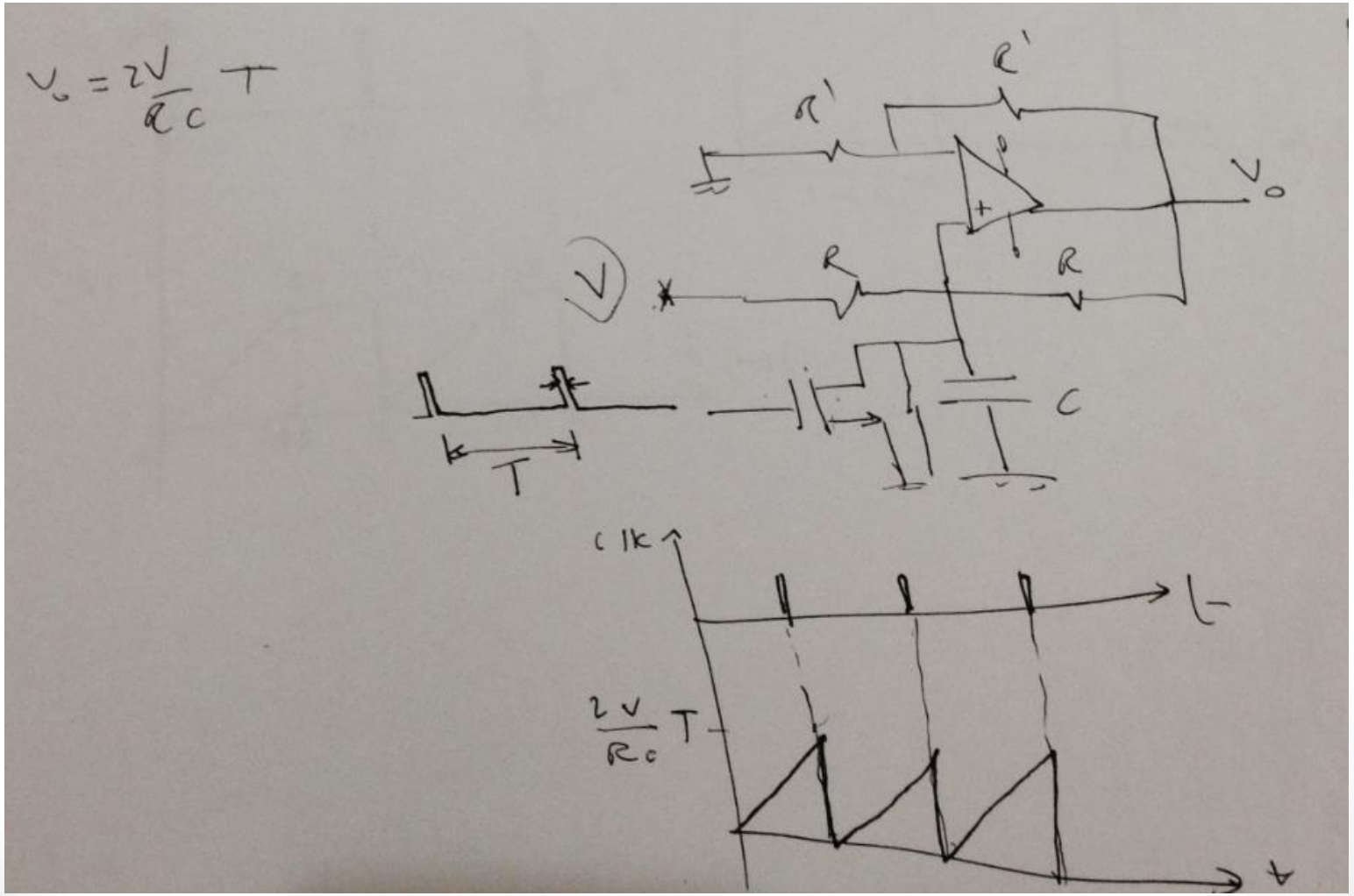
SAWTOOTH GENERATOR CIRCUITS

Triangular vs. Sawtooth



Sawtooth circuit

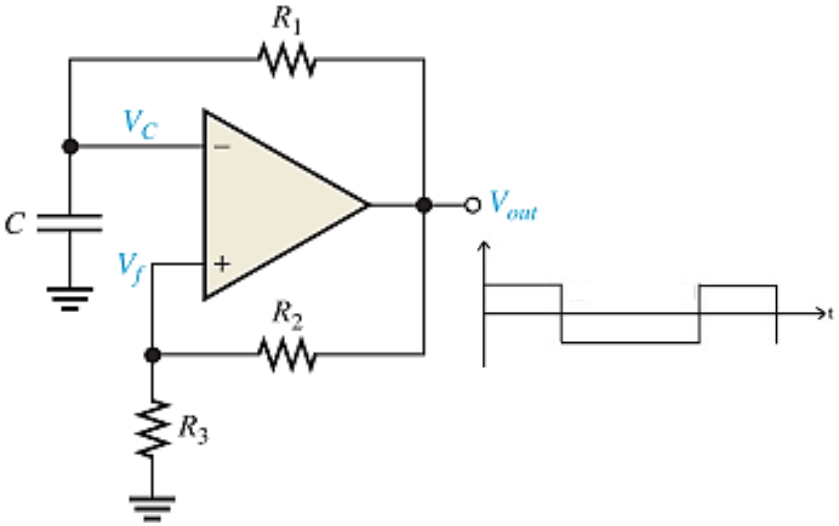
Using non inverting Integrator



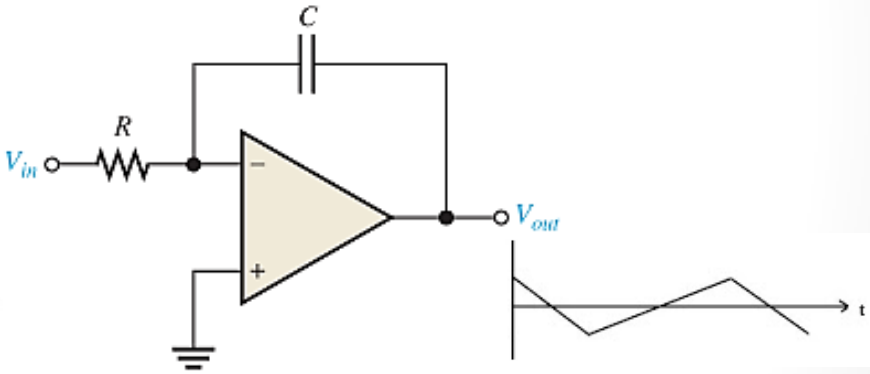
Sawtooth circuit..

Astable Multivibrator & Integrator

Stage #1



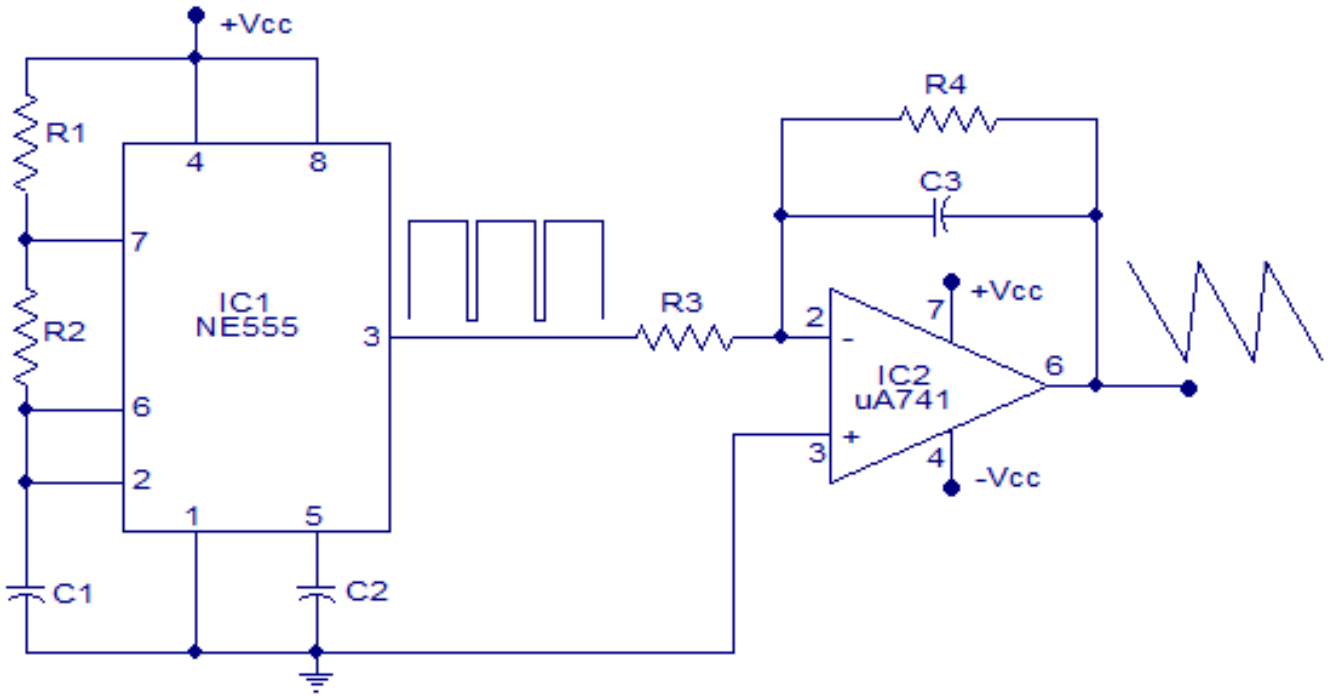
Stage #2



- Duty Cycle of the Astable Waveform indicates the rise and fall time of the sawtooth waveform i.e. positive or negative ramp.

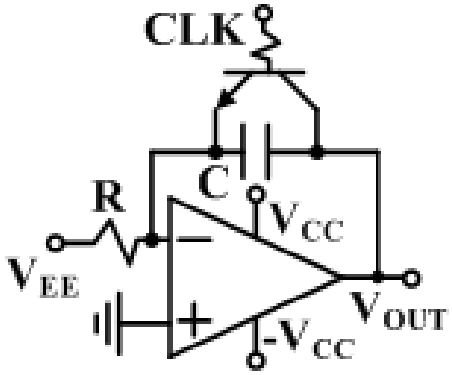
Sawtooth circuit…

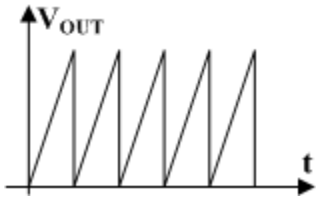
Astable Multivibrator & Integrator

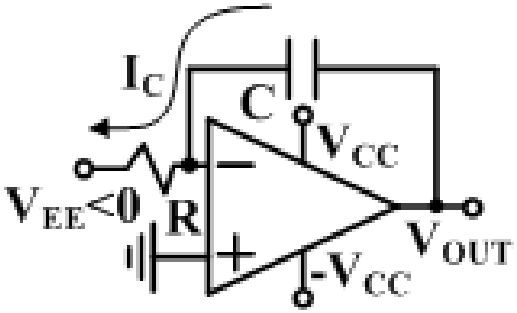


Sawtooth circuit….

Integrator & rapid discharge element





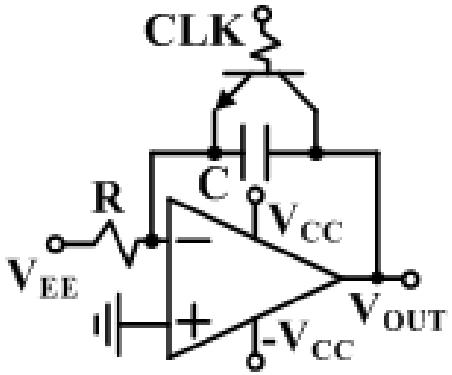


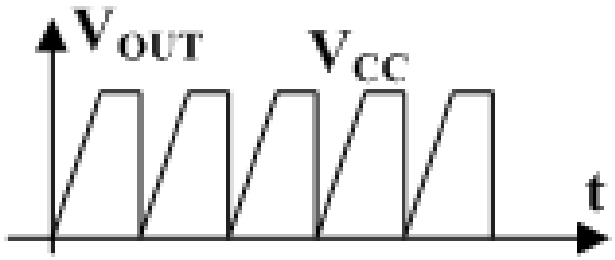
$$I_C = -\frac{V_{EE}}{R}$$

$$V_{OUT} = -\frac{V_{EE}}{RC}T = -\frac{V_{EE}}{RCf}$$

Trapezoidal Generator circuit

If output voltage reaches V_{CC} during time T, op-amp sawtooth generator goes to saturation, and output voltage is **trapezoidal**.

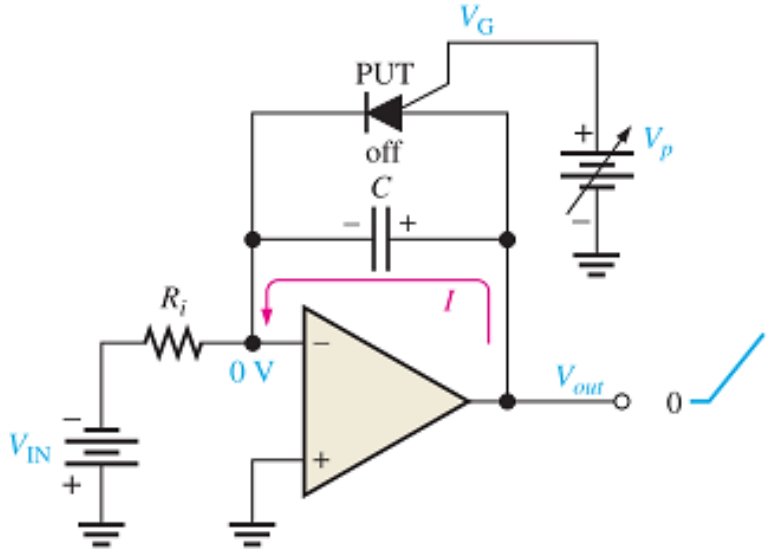




Sawtooth Voltage-Controlled Oscillator (VCO)

- VCO is a relaxation oscillator whose frequency can be changed by a variable dc control voltage.
- VCOs can be either sinusoidal or nonsinusoidal.
- One way to build a sawtooth VCO is with an op-amp integrator that uses a switching device (PUT) in parallel with the feedback capacitor to terminate each ramp at a prescribed level and effectively "reset" the circuit.
- The PUT is a programmable unijunction transistor with an anode, a cathode, and a gate terminal.

- Operation:

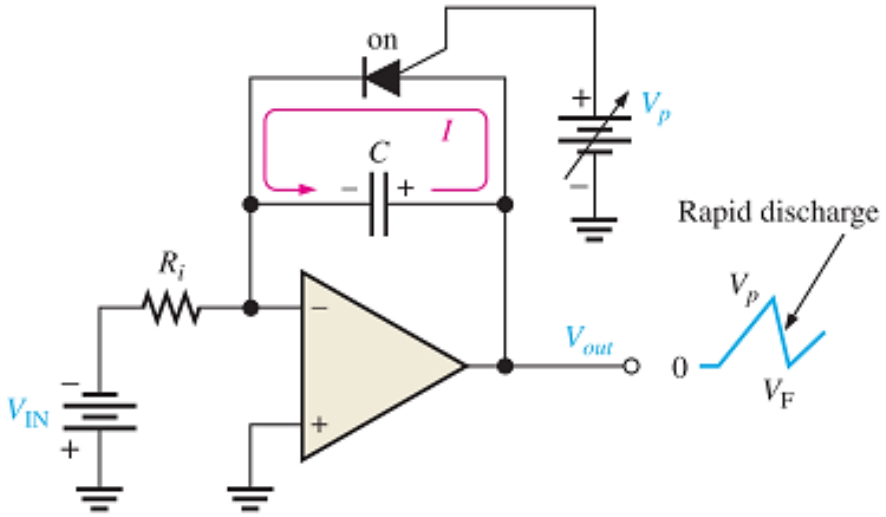


(a) Initially, the capacitor charges, the output ramp begins, and the PUT is off.

N.B.

For more details regarding PUT, refer to ch. 11

Sawtooth VCO..



(b) The capacitor rapidly discharges when the PUT momentarily turns on.

T, of the sawtooth waveform: $$T = \frac{V_p - V_F}{|V_{IN}|/R_iC}$$

f =1/T, gives $$f = \frac{|V_{IN}|}{R_iC}\left(\frac{1}{V_p - V_F}\right)$$

Assignment

- Design a sawtooth generator to provide a sawtooth waveform with the following specs:
  - frequency from 1 KHz to 1 MHz
  - amplitude from 0.5 Vpp to 6Vpp.

- For more details, refer to:
  - Chapter 16, T. Floyd, **Electronic Devices**, 9th edition.
  - Online tutorials on Sawtooth, Staircase generators.
- The lecture is available online at:
  - http://bu.edu.eg/staff/ahmad.elbanna-courses/12884
- For inquires, send to:
  - ahmad.elbanna@feng.bu.edu.eg