OP-AMPS

Integrators and Differentiators

Integrator

- Integrators produce output voltages that are proportional to the running-time integral of the input voltages. In the running time integral, the upper limit of integration is t.

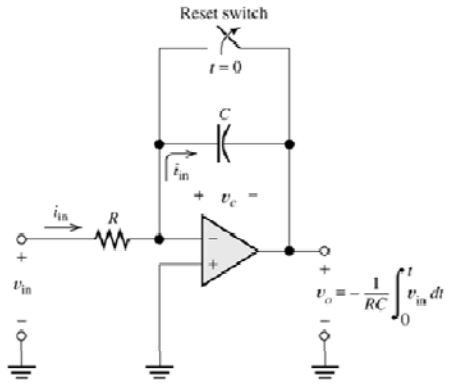
Integrator Applications

- Instrumentation
  - Acceleration signal may be integrated to get signal proportional to velocity
  - Velocity signal may be integrated to get signal proportional to displacement
- Extraction of information from digital signals corrupted by noise
  - Voices – digital phones

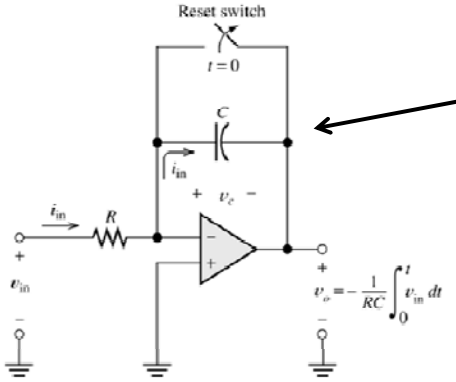
Integrator Applications

- Control systems
  - Temperature control
    - Integrate error term
      - Error term – difference between set-point and actual temperature
      - Want error term to become zero
- With integration the error term is sum of instantaneous error over time

Integrator – assume ideal op amp



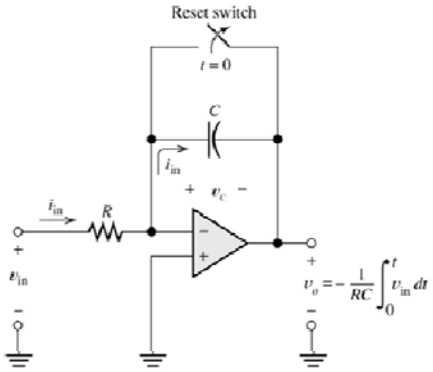
Integrator



Negative feedback through Capacitor

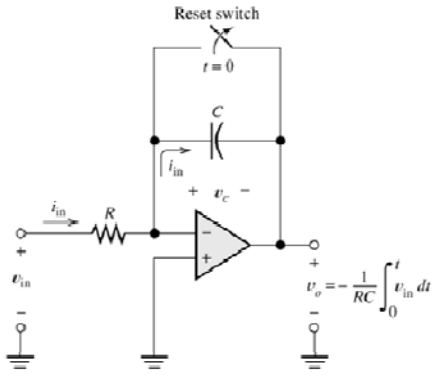
- What is i_{in}? $i_{in}(t) = \frac{v_{in}(t)}{R}$

Integrator



- What is the capacitor voltage at t = 0? 0 V
- We know $V_- = V_+ = 0$ V
- $V_o(t) + V_c(t) = 0$ => $v_o(t) = -\frac{1}{RC}\int_0^t v_{in}(t)dt$

Integrator



$$v_o(t) = -\frac{1}{RC}\int_0^t v_{in}(t)dt$$

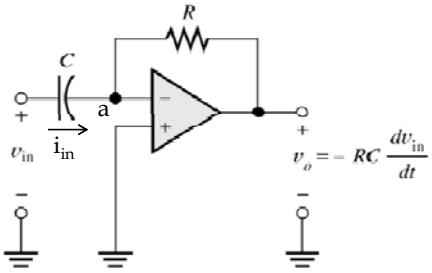
- V_o is -1/RC times the running integral of the input voltage
- Choose R and C with gain and bias current in mind
- Add inverting amplifier if want positive gain

Differentiator

- Differentiators produce output voltages that are proportional to the time derivative of the input voltages.

- Applications
  - Controls
    - Gives slope of error term over time
    - Slows the rate of change (reduces overshoot from integrator)
    - Amplifies noise

Differentiator



- Know $V_a = V_+ = 0$ V
- KCL at node a: $i_{in} - \frac{0 - V_o}{R} = 0$

$$V_o = -R * i_{in} = -RC\frac{dv_{in}}{dt}$$

Summary

- Integrators - output voltages proportional to running-time integral of input voltages.
- Differentiators - output voltages proportional to time derivative of input voltages.
- Applications
  - Instrumentation
    - Acceleration ⇔ Velocity ⇔ Displacement
  - Control systems