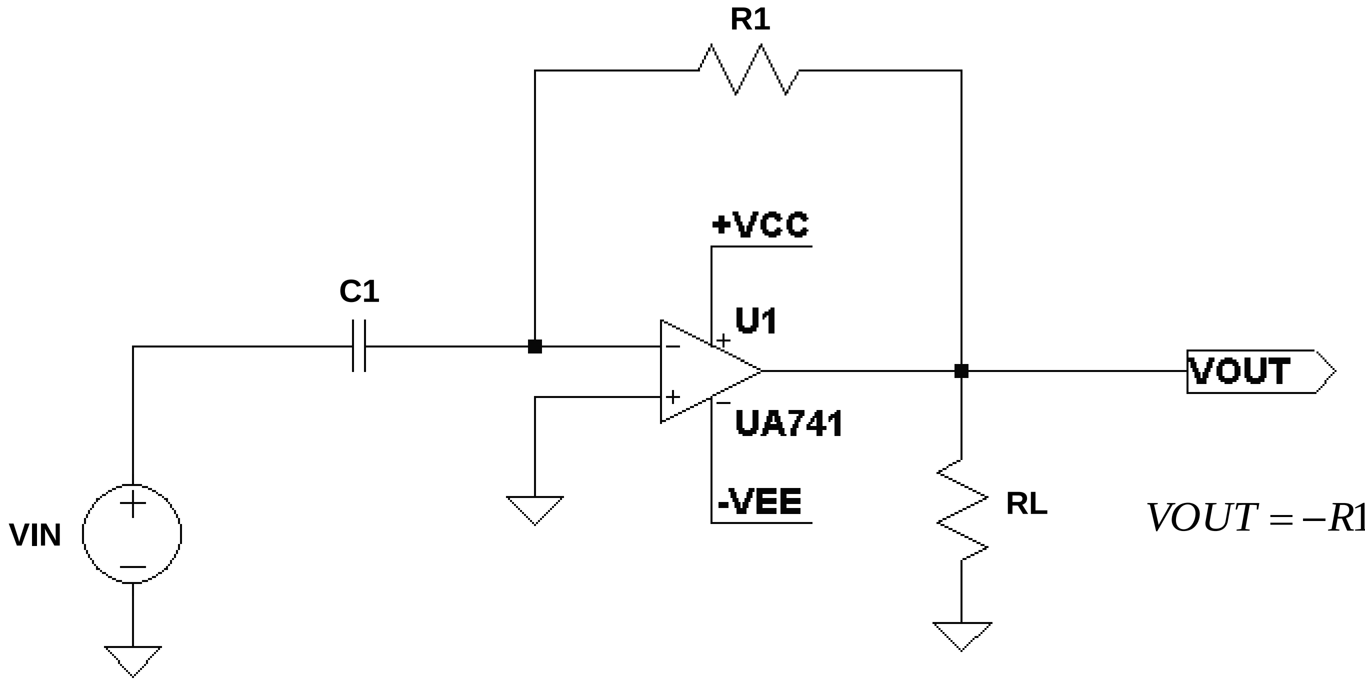
Electronic Circuits Design

Lecture – 5

- *Differentiator*
- *Integrator*

Yeonbae Chung
School of Electronics Engineering
Kyungpook National University

Differentiator



$$VOUT = -R1C1\frac{dVIN}{dt}$$

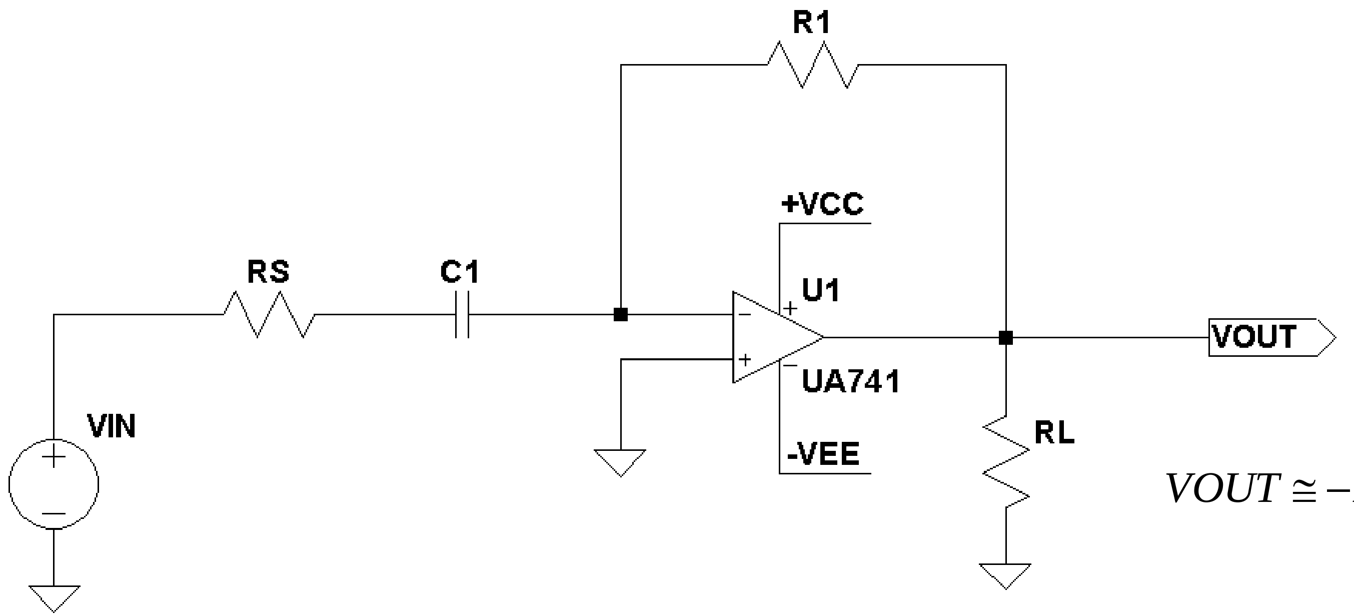
- Unstable
- Very susceptible to high frequency noise

Lab-1: Differentiator

- **Simulation Condition**
  - Op Amp: μA741
  - R1 = 40 kΩ, C1= 10 nF, RL = 5 kΩ
  - +VCC = 15 V, -VEE = -15 V
  - Transient analysis 0 to 10ms

1) **When VIN = $2\sin(2\pi\times10^{3}t)$ V, obtain a plot of VIN and VOUT versus time. VOUT should be $-5\cos(2\pi\times10^{3}t)$ V for all the time. <u>If not, make comments on your result</u>.**
2) **Change R1 to 10 kΩ. When VIN is a symmetrical sawtooth voltage of 4-V peak-to-peak, 0 average, and 2ms-period, which means VIN = PWL(0ms -2V 1ms 2V 2ms -2V 3ms 2V … 9ms 2V 10ms -2V), obtain a plot of VIN and VOUT versus time. VOUT should be a symmetrical square wave of 0.8-V peak-to-peak, 0 average, and 2ms-period. <u>If not, make comments on your result</u>.**

Practical Differentiator



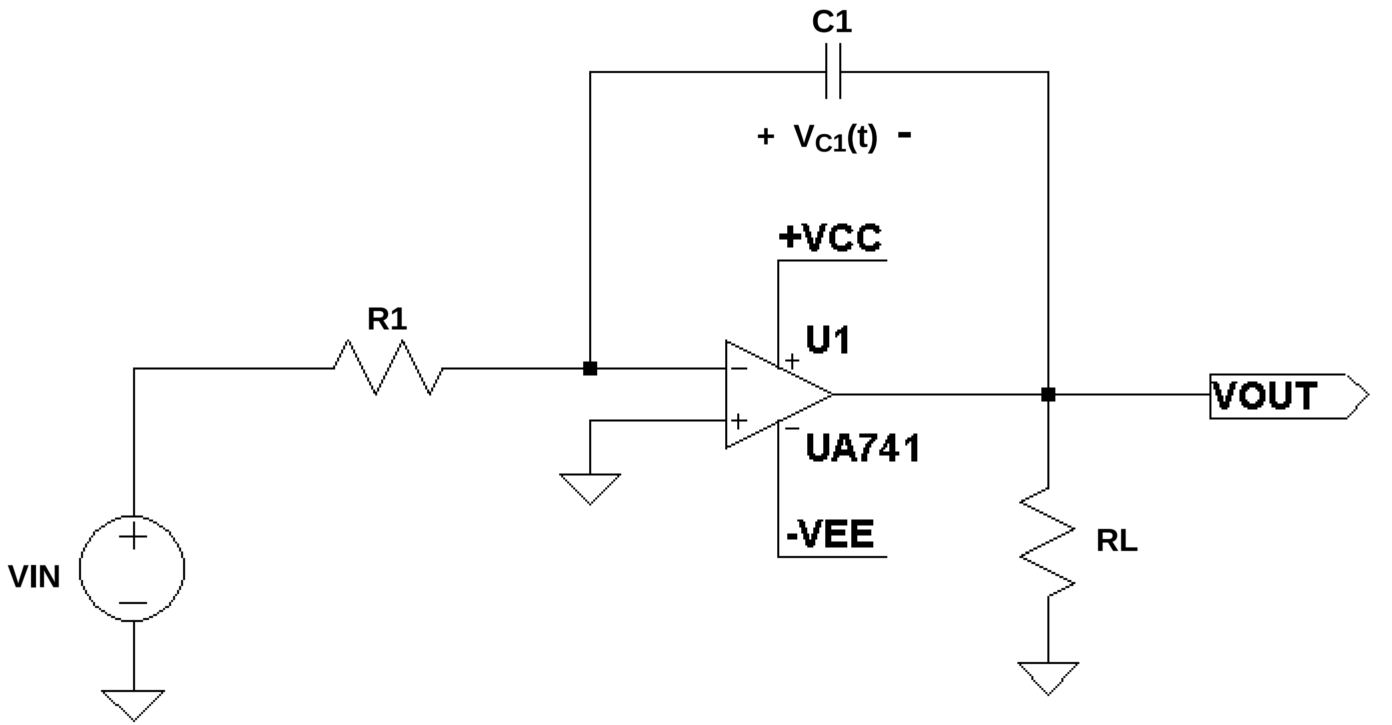
$$VOUT \cong -R1C1\frac{dVIN}{dt}$$

Lab-2: Practical Differentiator

❖ **Simulation Condition**
  - **Op Amp: μA741**
  - **RS = 100 Ω, RL = 5 kΩ**
  - **+VCC = 15 V, -VEE = -15 V**
  - **Transient analysis 0 to 10ms**

1) **When VIN = $2\sin(2\pi\times 10^3 t)$ V, design the differentiator to provide VOUT = $-6\cos(2\pi\times 10^3 t)$ V. <u>Make comments on your design if you need</u>.**
2) **When VIN is a symmetrical sawtooth voltage of 4-V peak-to-peak, 0 average, and 2ms-period, which means VIN = PWL(0ms -2V 1ms 2V 2ms -2V 3ms 2V … 9ms 2V 10ms -2V), design the differentiator to provide VOUT of a symmetrical square wave of 10-V peak-to-peak, 0 average, and 2ms-period. <u>Make comments on your design if you need</u>.**

Integrator



$$VOUT = -\frac{1}{R1C1}\int_0^t VIN(t)dt - V_{C1}(t=0)$$

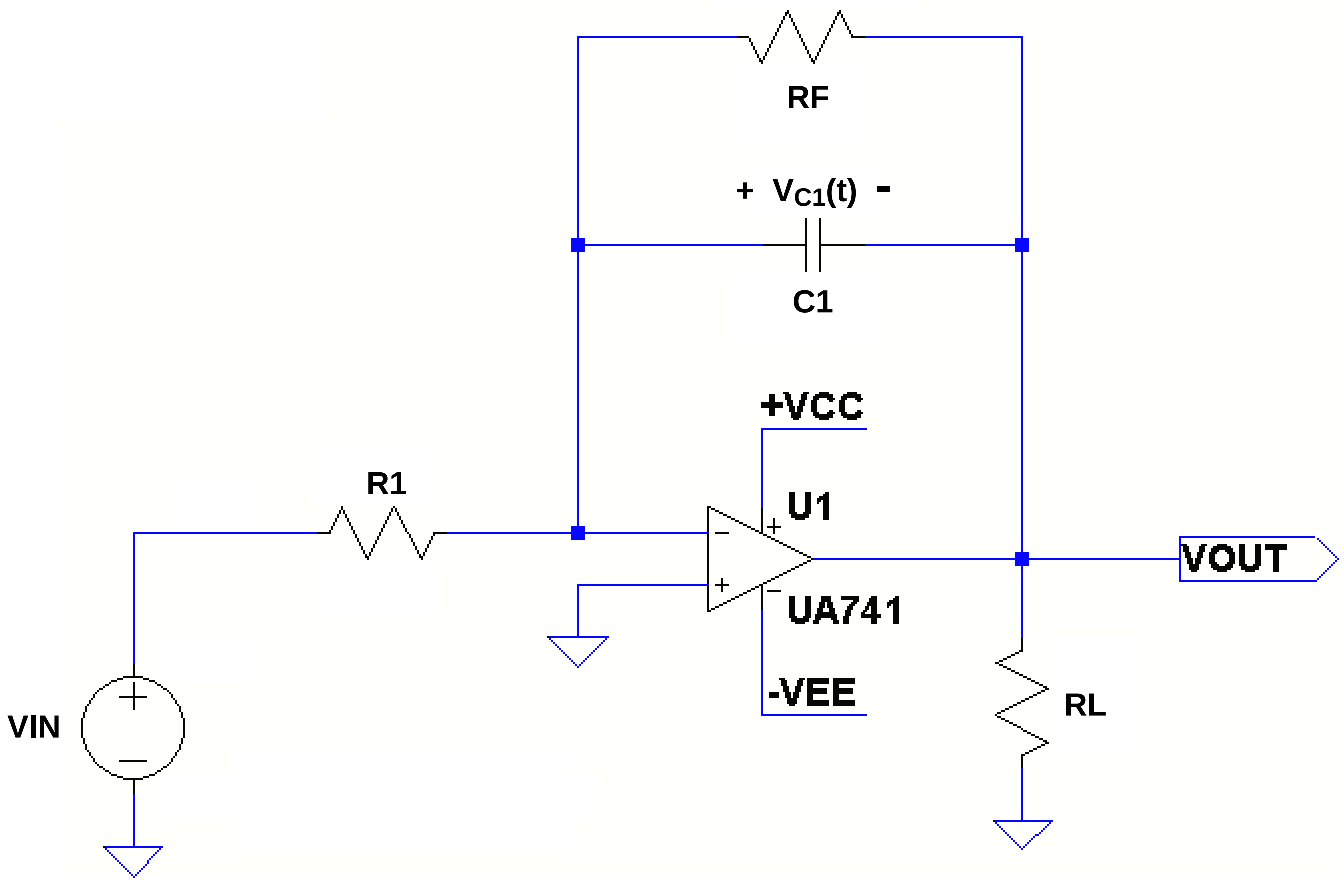
- Any tiny DC component makes the output to saturate
- At t = 0, input offset voltage and part of input current charging C1 produce the error voltage at the output

Lab-3: Integrator

- **Simulation Condition**
  - **Op Amp: μA741**
  - **R1 = 4 kΩ, C1= 10 nF, RL = 5 kΩ**
  - **+VCC = 15 V, -VEE = -15 V**
  - **Transient analysis 0 to 10ms**

1) When VIN = $\sin(2\pi\times 10^3 t)$ V, obtain a plot of VIN and VOUT versus time. VOUT should be $4\cos(2\pi\times 10^3 t)$ V. <u>If not, make comments on your result</u>.

Practical Integrator



$$VOUT \cong -\frac{1}{R1C1}\int_0^t VIN(t)dt - V_{C1}(t=0)$$

Lab-4: Practical Integrator

- **Simulation Condition**
  - Op Amp: μA741
  - RF = 200 kΩ, RL = 5 kΩ
  - +VCC = 15 V, -VEE = -15 V
  - Transient analysis from 0 to 20ms

1) **When VIN = $1\sin(2\pi \times 10^3 t)$ V, design the integrator to provide VOUT = $4\cos(2\pi \times 10^3 t)$ with a negligible phase difference after t = 10ms. <u>Make comments on your design</u>.**
2) **When VIN is a symmetrical square voltage of 2-V peak-to-peak, 0 average, and 1ms-period, which means VIN = PULSE(-1V 1V 0.5ms 1ns 1ns 0.5ms 1ms), design the integrator to provide VOUT of a symmetrical sawtooth wave of 12-V peak-to-peak, 0 average, and 1ms-period after t = 10ms. <u>Make comments on your design</u>.**
3) **When VIN = PULSE(1V -1V 1ms 1ns 1ns 1ms 2ms), design the integrator to provide VOUT of a symmetrical sawtooth wave of 8-V peak-to-peak, 0 average, and 2ms-period after t = 12ms. <u>Make comments on your design</u>.**