

Application Circuits

✓1)

✓2)

✓3)

✓4)

✓5)

✓6)

✓7)

Voltage Comparator

Unity Gain Amplifier/Voltage Follower/Buffer Circuit

Non-Inverting Amplifier

Inverting Amplifier

Scaling Adder

Scaling Subtractor

Instrumentation Amplifier

8)

9)

10)

11)

12)

13)

Integrator

Differentiator

Constant Current Source

Current to Voltage Converter

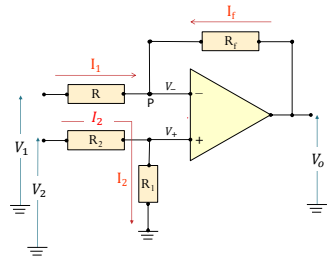
Voltage to Current Converter/Transconductance Amplifier

Output Bounding Circuit

31

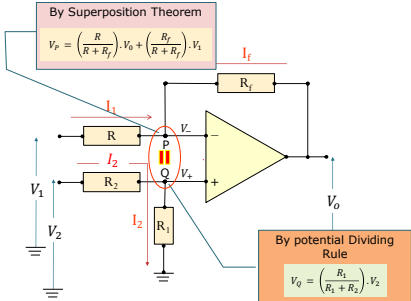
31

6) Scaling Subtractor



32

32



33

33

$$V_p = \left(\frac{R}{R+R_f}\right) V_0 + \left(\frac{R_f}{R+R_f}\right) V_1$$

$$V_q = \left(\frac{R_1}{R_1+R_2}\right) V_2$$

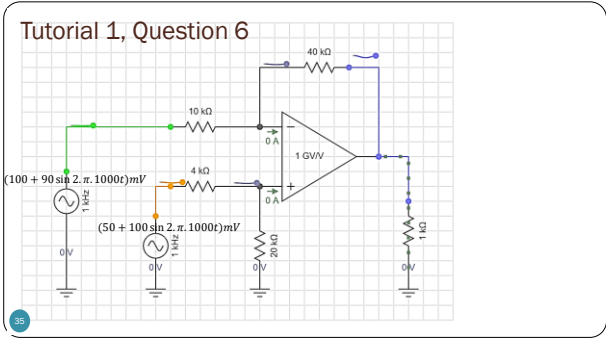
Using the Virtual short circuit principle of the Opamp,

$$V_p = V_q$$
$$\left(\frac{R}{R+R_f}\right) V_0 + \left(\frac{R_f}{R+R_f}\right) V_1 = \left(\frac{R_1}{R_1+R_2}\right) V_2$$
$$\left(\frac{R}{R+R_f}\right) V_0 = \left(\frac{R_1}{R_1+R_2}\right) V_2 - \left(\frac{R_f}{R+R_f}\right) V_1$$
$$V_0 = \frac{R+R_f}{R} \cdot \frac{R_1}{R_1+R_2} V_2 - \frac{R+R_f}{R} \cdot \frac{R_f}{R+R_f} V_1$$
$$V_0 = \frac{R_1}{R} \left(\frac{R+R_f}{R_1+R_2}\right) V_2 - \left(\frac{R_f}{R}\right) V_1$$
$$V_0 = K_2 V_2 - K_1 V_1$$

34

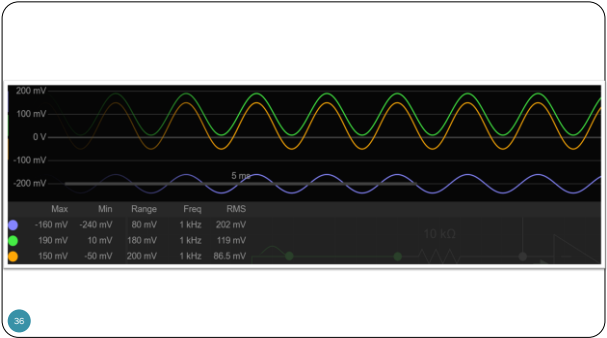
34

Tutorial 1, Question 6



35

35

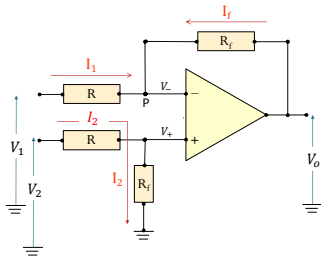


	Max	Min	Range	Freq	RMS
V1	-160 mV	-240 mV	80 mV	1 kHz	202 mV
V2	190 mV	10 mV	180 mV	1 kHz	119 mV
V0	150 mV	-50 mV	200 mV	1 kHz	88.5 mV

36

36

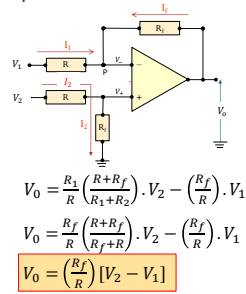
7) Differential Amplifier



37

37

7) Differential Amplifier

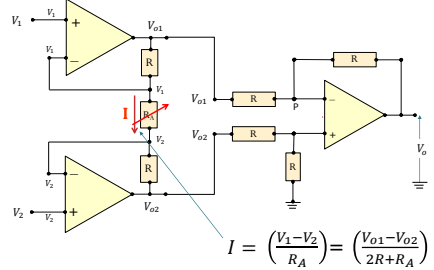


$$V_0 = \frac{R_f}{R} \left( \frac{R+R_f}{R_1+R_2} \right) \cdot V_2 - \left( \frac{R_f}{R} \right) \cdot V_1$$
$$V_0 = \frac{R_f}{R} \left( \frac{R+R_f}{R_f+R} \right) \cdot V_2 - \left( \frac{R_f}{R} \right) \cdot V_1$$
$$V_0 = \left( \frac{R_f}{R} \right) [V_2 - V_1]$$

38

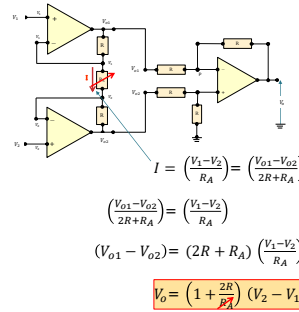
38

8) Instrumentation Amplifier



39

39



$$I = \frac{(V_1 - V_2)}{R_A} = \frac{(V_{o1} - V_{o2})}{(2R + R_A)}$$
$$\frac{(V_{o1} - V_{o2})}{(2R + R_A)} = \frac{(V_1 - V_2)}{R_A}$$
$$(V_{o1} - V_{o2}) = (2R + R_A) \left( \frac{V_1 - V_2}{R_A} \right)$$
$$V_0 = \left( 1 + \frac{2R}{R_A} \right) (V_2 - V_1)$$

40

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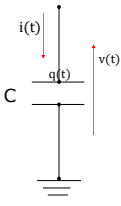
Application Circuits

- ✓ 1) Voltage Comparator
- ✓ 2) Unity Gain Amplifier/Voltage Follower/Buffer Circuit
- ✓ 3) Non-Inverting Amplifier
- ✓ 4) Inverting Amplifier
- ✓ 5) Scaling Adder
- ✓ 6) Scaling Subtractor
- ✓ 7) Instrumentation Amplifier
- 8) Integrator
- 9) Differentiator
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- 11) Current to Voltage Converter
- 12) Voltage to Current Converter/Transconductance Amplifier
- 13) Output Bounding Circuit

41

41

9) Integrator

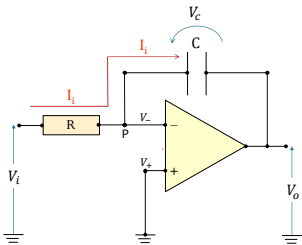


$$q(t) = C \cdot v(t)$$
$$\frac{d[q(t)]}{dt} = C \cdot \frac{d[v(t)]}{dt}$$
$$i(t) = C \cdot \frac{d[v(t)]}{dt}$$
$$v(t) = \frac{1}{C} \cdot \int i(t) \cdot dt$$

42

42

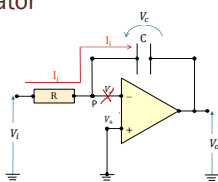
9) Integrator



43

43

Integrator



$$q = C \cdot V_c$$

$$\frac{dq}{dt} = C \cdot \frac{dV_c(t)}{dt}$$

$$I_i = C \cdot \frac{dV_c}{dt}$$

$$V_c = \frac{1}{C} \cdot \int I_i \cdot dt$$

$$V_c = \frac{1}{C} \cdot \int \left( \frac{V_i - V_o}{R} \right) dt$$

$$V_c = \frac{1}{C} \cdot \int \left( \frac{V_i}{R} \right) dt$$

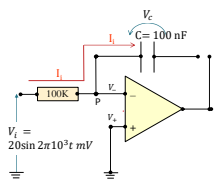
$$-V_o = \frac{1}{RC} \cdot \int V_i \cdot dt$$

$$V_o = \frac{-1}{RC} \cdot \int V_i \cdot dt$$

44

44

Integrator



$$V_i = 20 \sin 2\pi 10^3 t \text{ mV}$$

$$RC = (100 \cdot 10^3) \cdot (100 \cdot 10^{-9})$$

$$RC = 0.01 \text{ S}$$

$$V_o = \frac{-1}{RC} \cdot \int V_i \cdot dt$$

$$V_o = \frac{-1}{0.01} \cdot \int 20 \sin(2\pi 10^3 t) dt$$

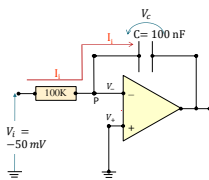
$$V_o = -2000 \cdot \frac{\cos(2\pi 10^3 t)}{2\pi 10^3}$$

$$V_o = -\frac{1}{\pi} \cdot \cos(2\pi 10^3 t) \text{ mV}$$

45

45

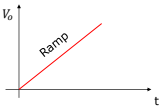
Ramp Generator



$$V_i = -50 \text{ mV}$$

$$RC = (100 \cdot 10^3) \cdot (100 \cdot 10^{-9})$$

$$RC = 0.01 \text{ S}$$



$$V_o = \frac{-1}{RC} \cdot \int V_i \cdot dt$$

$$V_o = \frac{-1}{0.01} \cdot \int (-50) \cdot t$$

$$V_o = 5 \cdot t \text{ Volts}$$

46

46