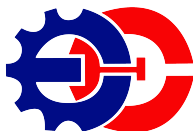


Operational Amplifier: Dependent Sources

TE201414 - Rangkaian Elektronika 2

Program Studi Teknik Elektro



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Electrical Sources

In Electric Circuit course we have experienced with several type of electrical sources, that are: independent sources and dependent sources. the independent sources can generate power without any variable which makes its outputs changed (amplitude, frequency, phase, etc.). contrary with the independent one, dependent sources has variable that affect its outputs.



Voltage source



Current Source



Controlled Voltage Source

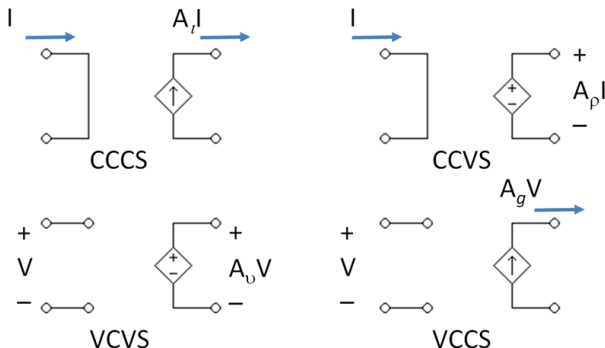


Controlled Current Source

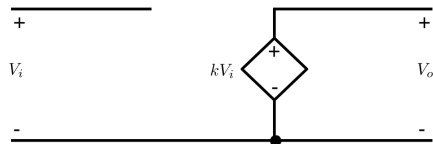
Electrical Sources

Dependent sources:

- Current Controlled Current Source (CCCS/ICIS)
- Current Controlled Voltage Source (CCVS/ICVS)
- Voltage Controlled Voltage Source (VCVS)
- Voltage Controlled Current Source (VCCS/VCIS)



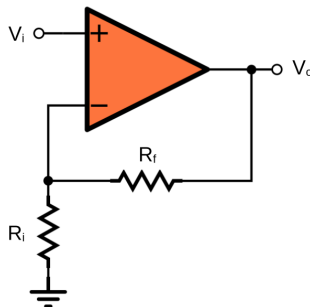
Voltage Controlled Voltage Source



$$V_o = kV_i$$

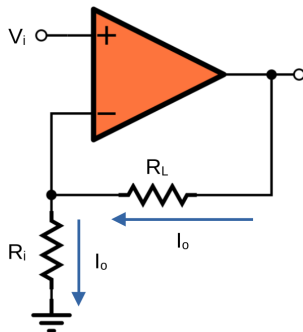
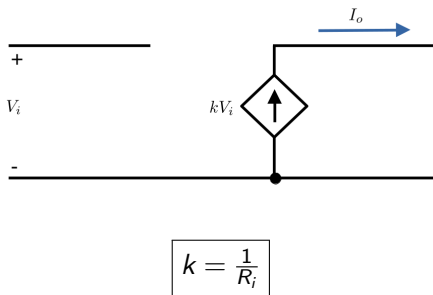
equivalent circuit of VCVS is identical with non-inverting amplifier that which Hi-Z input. the amplification factor of the VCVS can be defined as the transfer function of non-inverting amplifier $k = \frac{R_f}{R_i} + 1$.

Non-inverting amp:



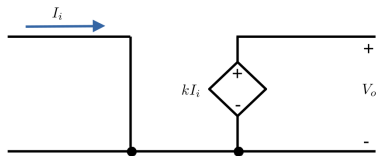
Voltage Controlled Current Source

equivalent circuit of VCCS/VCIS is identical with VCVS, so the circuit can be approached with non-inverting amplifier as well. the difference between VCVS and VCCS is the load R_L location. VCVS locates load resistor (R_L) at output voltage, whereas VCCS locates its load resistor as feedback resistor.



Current Controlled Voltage Source

the equivalent circuit of CCVS is identical with inverting amplifier which has low input impedance due to virtual ground at its inverting input. the amplification factor k of CCVS is equivalent with feedback resistor.



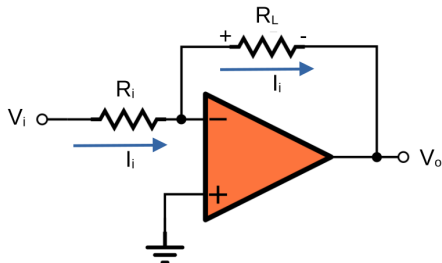
$$V_o = kI_i$$

where,

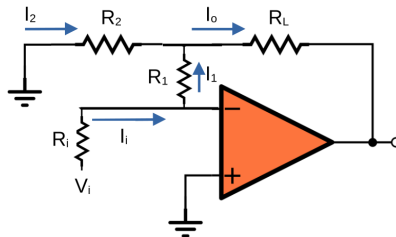
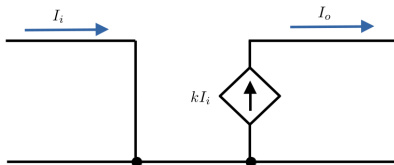
$$I_i = \frac{V_i}{R_i}$$

and,

$$k = -R_L$$



Current Controlled Current Source



$$I_o = I_1 + I_2$$

$$I_2 = \frac{I_1 R_1}{R_2}$$

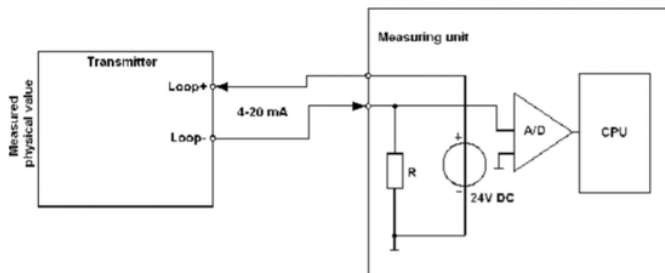
$$I_o = \left(1 + \frac{R_1}{R_2}\right) I_1 = \left(1 + \frac{R_1}{R_2}\right) I_i$$

$$k = \left(1 + \frac{R_1}{R_2}\right)$$

similar with CCVS, CCCS can be approached by putting input current at op-amp inverting input.

Application of Dependent Sources: 4-20 mA

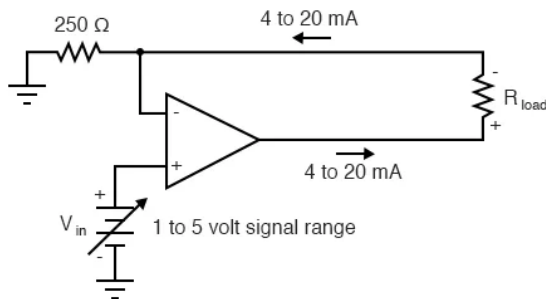
4-20mA is used to transmit analog signal in industry. the advantages of using this protocol is lossless signal during transmission.



2 wire, 4-20 mA transmitter connection

Application of Dependent Sources: 4-20 mA

the output sensor commonly can be modeled as voltage source. to transmit analog signal as current, VCCS circuit is used as transmitter. Load resistor of VCCS takes role as receiver which converts current into voltage. then, voltage can be sampled with Analog to Digital Converter (ADC) for further processing.



References

Floyd,T.L., Fundamentals of Analog Circuits, Prentice Hall, .

Malvino,A., Electronic Principle, McGrawHill, 2016.

Boylestad, R.L., Nashelsky,L., Electronics Devices and Circuit Theory, Pearson, 2014.

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