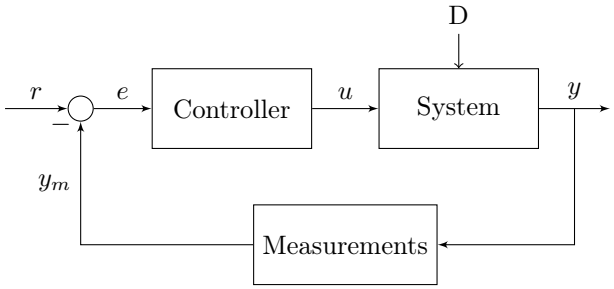
Block Diagram in LaTeX Tikz

CBCO

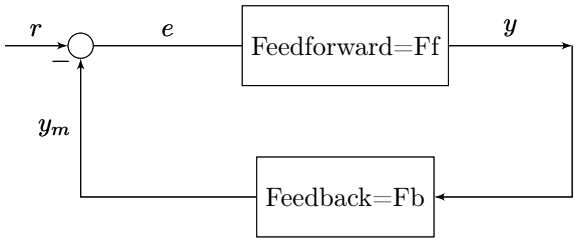
March 29, 2024

1 Block Diagrams

The typical control system diagram in Figure 1 was drawn using Tikz. The Figure 1 (a) was basic control system. The Figure 1 (b) was the simplification of Figure 1 (a).



(a)



(b)

Figure 1: Block diagram

Consider Figure 1 (b). The following equations were noted. Note that the negative sign in sum means negative feedback.

$$e = r - y_m \tag{1}$$

$$y_m = F_b y \tag{2}$$

$$y = F_f e \tag{3}$$

Eliminating e, and ym

$$y = F_f \left(-F_b y + r\right) \tag{4}$$

$$y \left(F_b F_f + 1\right) = F_f r \tag{5}$$

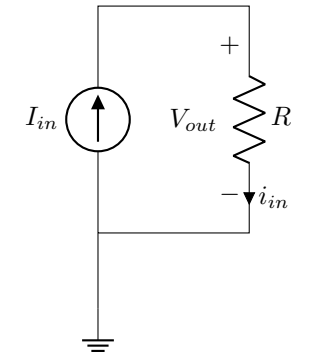
$$y = \frac{F_f r}{F_b F_f + 1} = \frac{r}{F_b + \frac{1}{F_f}} \tag{6}$$

$$y \approx \frac{1}{F_b} r \quad for 1 << F_f \tag{7}$$

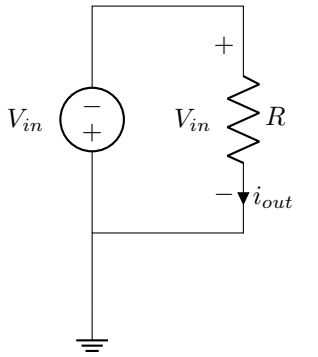
The open loop gain was feedforward. The close loop gain was reciprocal of feedback. If Fb = 1, then y=r. It was called unity feedback. Current mirrors made used of unity feedback.

2 Block Diagrams of Schematic Passive Circuit Components

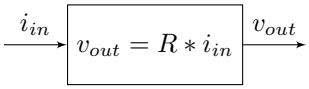
2.1 Resistor



(a)



(c)



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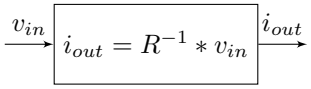


(d)

Figure 2: Resistor Circuits schematic to Resistor blocks diagram

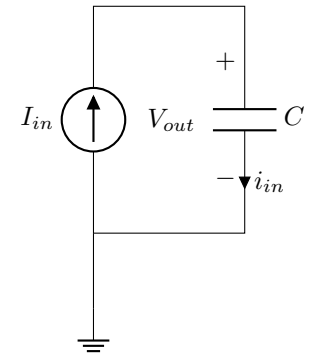
The resistor schematic circuit diagram was shown in Figure 2 (a). It had a current source as input. Its block diagram was shown in Figure 2 (b). The resistor schematic circuit diagram with voltage source as input was shown in Figure 2 (c).

The equations of Resistor in time domain were the following.

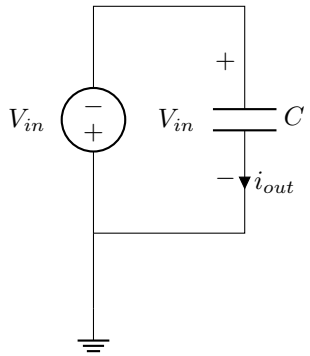
$$v_{out}(t) = Ri_{in}(t) \tag{8}$$

$$i_{in}(t) = \frac{v_{out}(t)}{R} \tag{9}$$

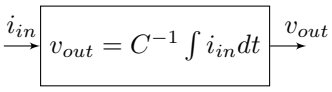
2.2 Capacitor



(a)



(a)



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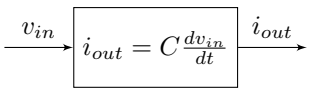


(d)

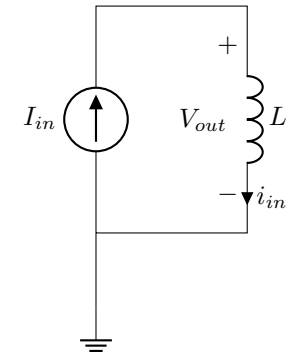
Figure 3: Capacitor Circuits schematic to Capacitor blocks diagram

The schematic circuit diagram of capacitor with current source as input was shown in Figure 3 (a). Its block diagram was shown in Figure 3 (b). Its schematic circuit diagram with voltage source as input was shown in Figure 3 (c). Its block diagram was shown in Figure 3 (d). The capacitor equations were expressed as follows.

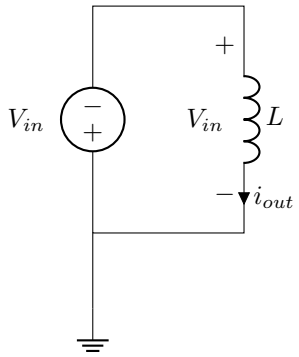
$$v_{out}(t) = \frac{\int i_{in}(t)\, dt}{C} \tag{10}$$

$$i_{in}(t) = C\frac{d}{dt}v_{out}(t) \tag{11}$$

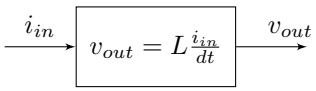
2.3 Inductor



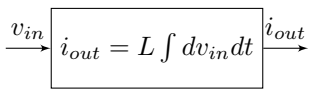
(a)



(a)



(b)



(d)

Figure 4: Inductor Circuits schematic to Inductor blocks diagram

The schematic circuit diagram of inductor with current source as input was shown in Figure 3 (a). Its block diagram was shown in Figure 3 (b). Its schematic circuit diagram with voltage source as input was shown in Figure 3 (c). Its block diagram was shown in Figure 3 (d). The inductor equations were expressed as follows.

$$v_{out}(t) = L\frac{d}{dt}i_{in}(t) \tag{12}$$

$$i_{in}(t) = \frac{\frac{d}{dt}v_{out}(t)}{L} \tag{13}$$

3 Emitter Follower

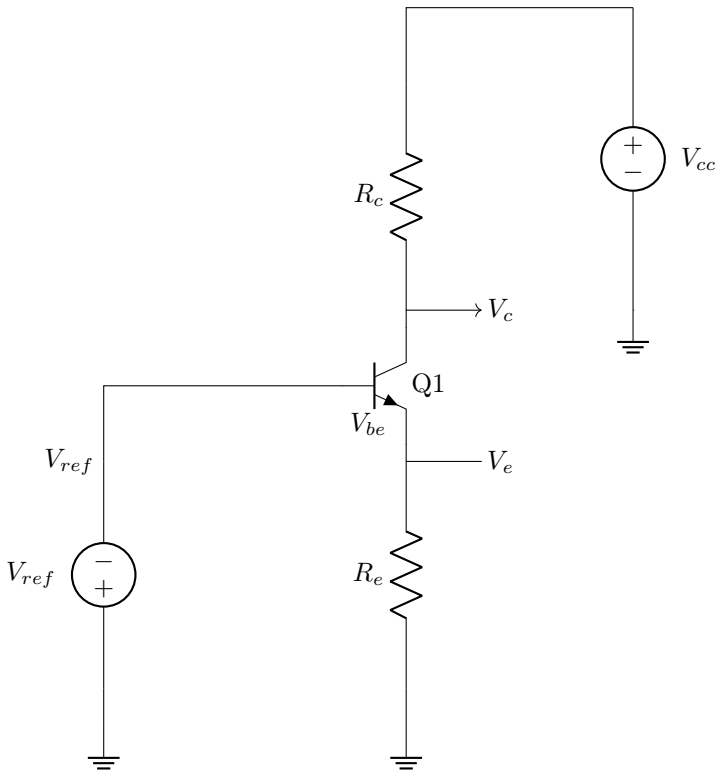


Figure 5: Schematic Circuit diagram of emitter follower

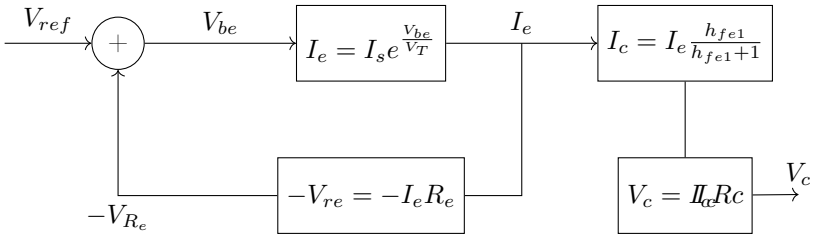


Figure 6: Control System Block Diagram of Emitter Follower Circuit of Figure 8

4 Block Diagram of current Mirrors

4.1 Widlar Current Mirror

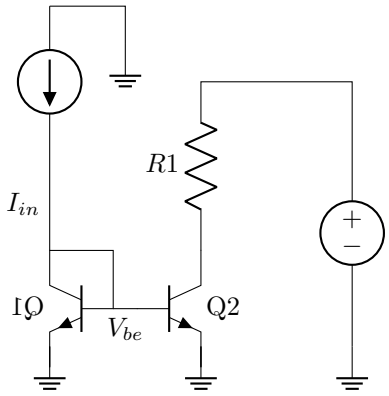


Figure 7: Widlar current mirror schematic diagram

4.2 Wilson Current Mirror

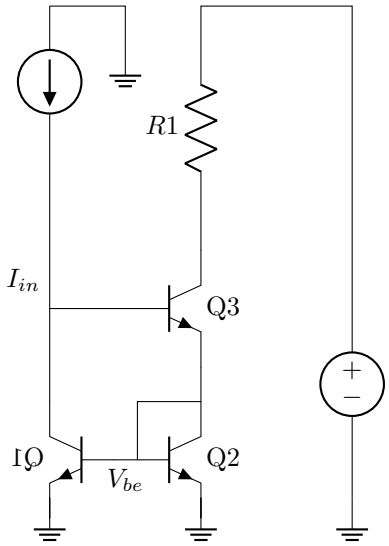


Figure 8: Wilson current mirror schematic diagram

5 Exercises

1. Write the Equations of Widlar current mirror. (5)

2. Draw the Widlar block diagram. (5)

3. Write the equations of Wilson current mirror. (5)

4. Draw the block diagram of Wilson current mirror. (5)

5.There is a portion of Wilson current mirror that is Widlar current mirror. Draw the block diagram of Wilson current mirror incorporating a block that is the Widlar currrent mirror. (5)

References

[1] Daniel Braun Tim Hoffmann (TeXstudio) Pascal Brachet (Texmaker) Luc Buant (QCodeEdit) Joel Amblard (html conversion) Benito van der Zander, Jan Sundermeyer. Textstudio 2.12.10. *Source Forge*, Copyright © 2018. download from `https://sourceforge.net/projects/texstudio/`.

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[5] Clement J. Savant Jr Gene H. Hostetter Raymond T. Stefani, Bahram Shahian. *Design of Feedback Control Systems*. Number ISBN 0-19-514249-7. Copyright © Oxford University Press, Inc, 200.