Analog Design Series

DAC Adjusts Supply Vout

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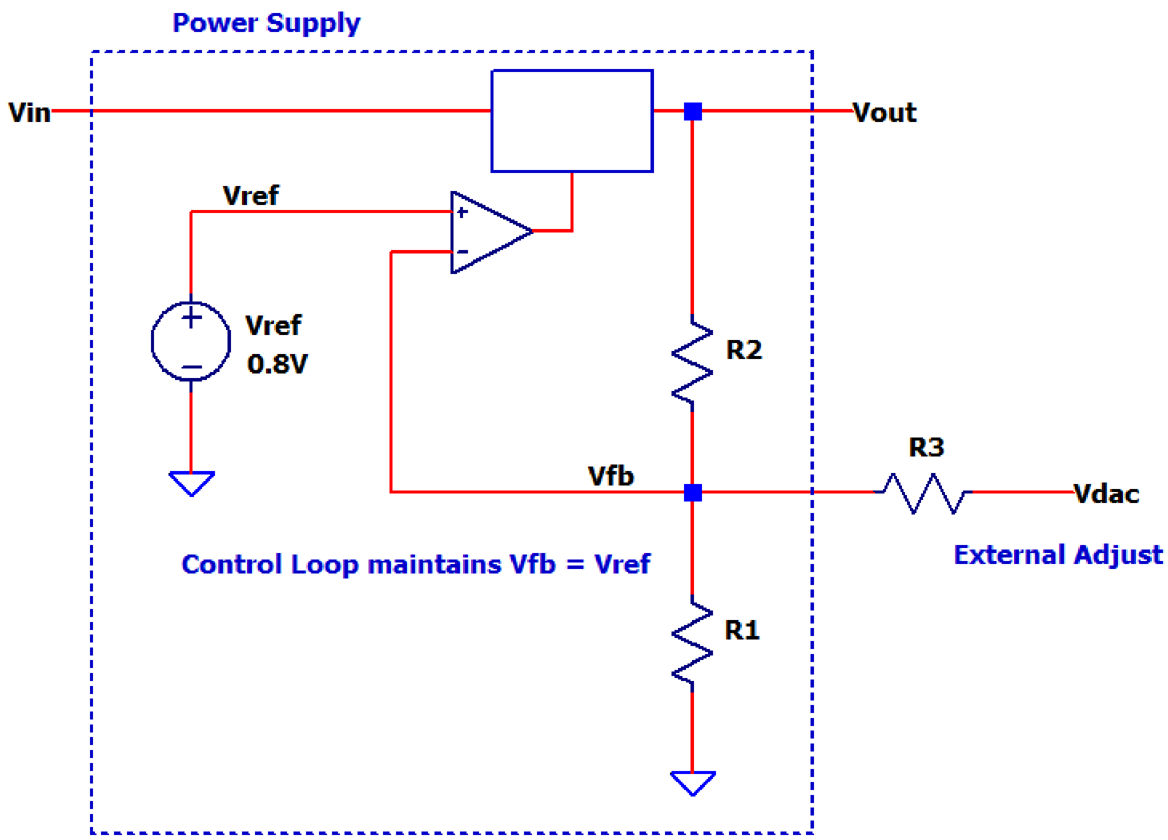
DAC Adjusts Supply Vout

Schematic



Define input (Vdac) and output (Vout) pairs.

$$Vdac0 = 0V \qquad Vout0 = 9V$$

$$Vdac1 = 5V \qquad Vout1 = 3V$$

Transfer Function

Set Vout = 0 and find Vfb versus Vdac.

$$Vfb = Vdac \cdot \left(\frac{R12}{R3 + R12}\right)$$

$$R12 = R1||R2 = \left(\frac{1}{R1} + \frac{1}{R2}\right)^{-1}$$

Then set Vdac = 0 and find Vfb versus Vout.

$$Vfb = Vout \cdot \left(\frac{R13}{R2 + R13}\right)$$

$$R13 = R1||R3 = \left(\frac{1}{R1} + \frac{1}{R3}\right)^{-1}$$

Combine equations

$$Vfb = Vdac \cdot \left(\frac{R12}{R3 + 12}\right) + Vout \cdot \left(\frac{R13}{R2 + 13}\right)$$

Now set Vfb = Vref (control loop action!) and solve for Vout

$$Vout = Vdac \cdot \left(-\frac{R12}{R3 + R12}\right) \cdot \left(\frac{R2 + R13}{R13}\right) + Vref \cdot \left(\frac{R2 + R13}{R13}\right)$$

Rewrite as linear transformation: Scale (m) and Shift (b)

$$Vout = Vdac \cdot m + b$$

$$m = \left(-\frac{R13}{R2 + 13}\right) \cdot \left(\frac{R2 + R1}{R1}\right)$$

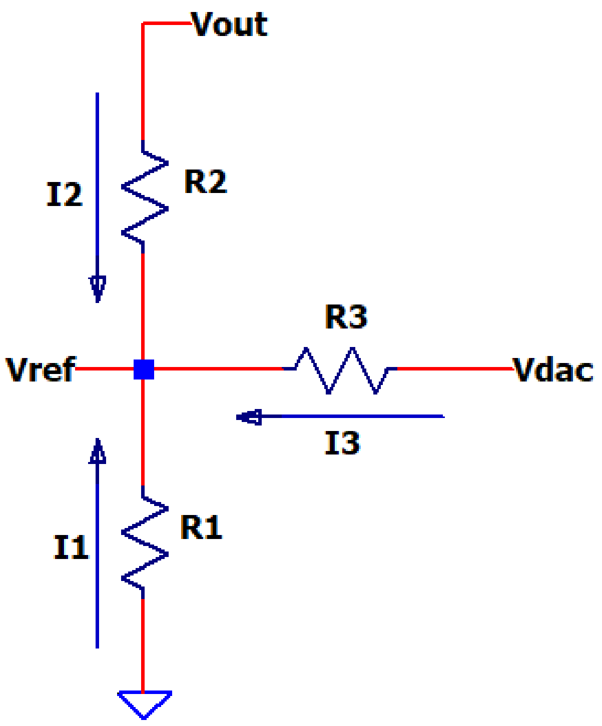
$$b = Vref \cdot \left(\frac{R2 + R13}{R2}\right)$$

Find Vdac need for Vout

$$Vdac = \frac{Vout - b}{m}$$

R1, R2, R3 Derivation

Schematic for Analysis



Servo loop maintains Vfb at Vref.

$$Vfb = Vref$$

Nodal Analysis

$$I3 + I2 + I1 = 0$$

$$\left(\frac{Vdac - Vref}{R3}\right) + \left(\frac{Vout - Vref}{R2}\right) + \left(\frac{-Vref}{R1}\right) = 0$$

Define input (Vdac) and output (Vout) pairs.

$$Vdac0 = 0V \quad Vout0 = 9V$$

$$Vdac1 = 5V \quad Vout1 = 3V$$

R1, R2, R3 Derivation

Nodal Analysis (repeated)

$$\left(\frac{Vdac - Vref}{R3}\right) + \left(\frac{Vout - Vref}{R2}\right) + \left(\frac{-Vref}{R1}\right) = 0$$

Collect terms and simplify

$$\frac{Vdac}{R3} + \frac{Vout}{R2} = Vref \cdot \left(\frac{1}{R3} + \frac{1}{R2} + \frac{1}{R1}\right)$$

Input / Output pair 0

$$\frac{Vdac0}{R3} + \frac{Vout0}{R2} = Vref \cdot \left(\frac{1}{R3} + \frac{1}{R2} + \frac{1}{R1}\right)$$

Input / Output pair 1

$$\frac{Vdac1}{R3} + \frac{Vout1}{R2} = Vref \cdot \left(\frac{1}{R3} + \frac{1}{R2} + \frac{1}{R1}\right)$$

If right sides equal, then so are left sides.

$$\frac{Vdac0}{R3} + \frac{Vout0}{R2} = \frac{Vdac1}{R3} + \frac{Vout1}{R2}$$

Choose R3, and **Solve for R2**.

$$R2 = \frac{(Vout0 - Vout1)}{\left(\frac{Vdac1}{R3} - \frac{Vdac0}{R3}\right)}$$

Solve for R1 in input/output pair 0 or 1.

$$R1 = \frac{Vref}{\left(\frac{Vdac0}{R3} + \frac{Vout0}{R2} - \frac{Vref}{R2} - \frac{Vref}{R3}\right)}$$

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- Check out topic on eCircuit Center.
  - https://ecircuitcenter.com/Circuits/dac_adjust_PS/dac-adjust-supply-vout-1.htm
- Analog Topics with SPICE and Excel
  - https://ecircuitcenter.com/Circuits.htm
- Instructables Article: DAC Adjusts Supply Vout using the Arduino
  - https://www.instructables.com/circuits/arduino/projects
- What do you find useful? Other comments?
  - https://ecircuitcenter.com/contact.htm