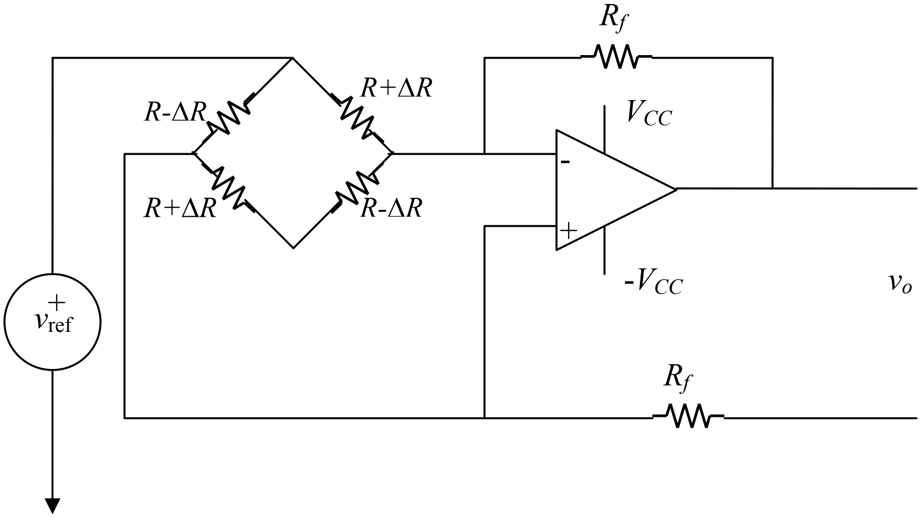
ELG3331: An OP AMP Circuit used for Measuring the Change in Strain Gage Resistance

(Electric Circuits: Nillson and Riedel)

Changes in the shape of elastic solids are of great importance to engineers who design structures that twist, stretch, or bend when subjected to external forces. An aircraft frame is a prime example of a structure in which engineers must take into consideration elastic strain. The application of strain gages requires information about the physical structure of the gage, method of bonding the gage to the surface of the structure, and the orientation of the gage relative to the forces exerted on the structure.



To begin the design process assumes that we have an ideal op amp. Write KCL equations at the inverting and non-inverting input terminals of the op amp

$$\frac{v_{ref}-v_n}{R+\Delta R}=\frac{v_n}{R-\Delta R}+\frac{v_n-v_o}{R_f}$$

$$\frac{v_{ref}-v_p}{R-\Delta R}=\frac{v_p}{R+\Delta R}+\frac{v_p}{R_f}$$

$$v_p=\frac{v_{ref}}{(R-\Delta R)(\frac{1}{R+\Delta R}+\frac{1}{R-\Delta R}+\frac{1}{R_f})}$$

We will assume that the op amp is operating in its linear region, so $v_p = v_n$.

$$v_o=\frac{R_f(2\Delta R)}{R^2-(\Delta R)^2}v_{ref}$$

Because the change in resistance experienced by strain gage is very small, $(\Delta R)^2 \langle\langle R^2$. So $R^2 - (\Delta R)^2 \approx R^2$

$$\boxed{v_o \approx \frac{R_f}{R} 2\delta v_{ref}}$$

Where $\delta = \Delta R/R$

ELG3331: Design of a DC Power Supply

(Microelectronic Circuits: Sedra/Smith)

Design a DC power supply that provides a nominal DC voltage of 5 V and be able to supply a load current I_{load} as large as 25 mA; that is R_{load} can be as low as 200 Ω. The power supply is fed from a 120-V (rms) 60 Hz AC line. Assume the availability of a 5.1-V zener diode having $r_z = 10\ \Omega$ at $I_z = 20$ mA (and use $V_{zo} = 4.9$ V), and that the required minimum current through the zener diode is $I_{z\min} = 5$ mA.

Design Process:

- The 120-V supply is stepped down to provide 12-V (peak) sinusoid across each of the secondary windings using a 14:1 turns ratio for the center-tapped transformer.
- The choice of 12 V is a reasonable compromise between the need to allow for sufficient voltage (above the 5-V output) to operate the rectifier and the regulator.
- To determine a value for R, we may use the following expression

$$R = \frac{V_{C\min} - V_{Z0} - r_z I_{Z\min}}{I_{Z\min} + I_{L\max}}$$

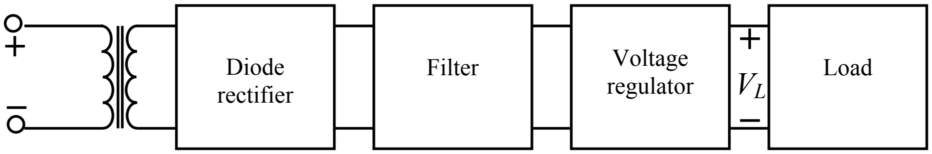
- An estimate for $V_{C\min}$, the minimum voltage across the capacitor, can be obtained by subtracting a diode drop (say, 0.8 V) from 12 V and allowing for a ripple voltage across the capacitor of, say, $V_r = 0.5$ V. Therefore, $V_{Cmin} = 12 - 0.8 - 0.5 = 10.7$ V. Substituting the values in the above equation, we get $R = 119\ \Omega$.

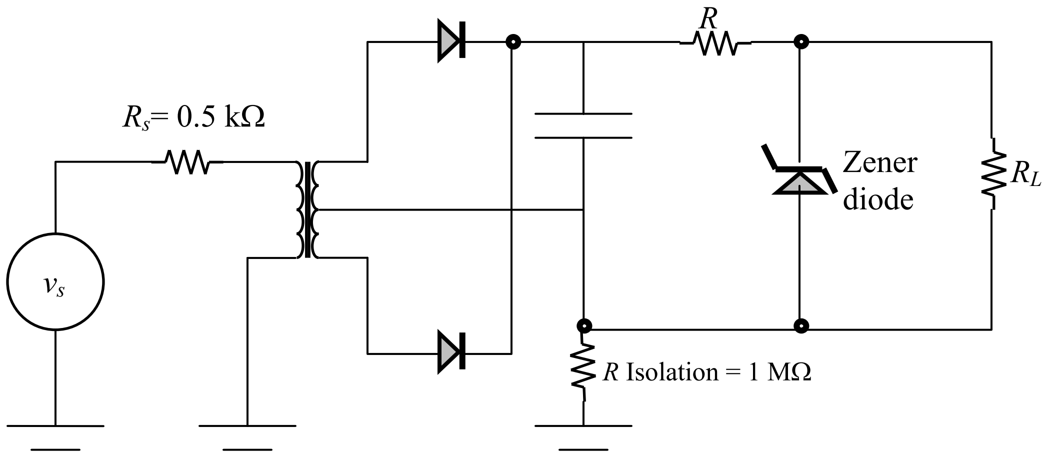
$$R = \frac{10.7 - 4.9 - 10 \times 5 \times 10^{-3}}{5 \times 10^{-3} + 25 \times 10^{-3}} = 191\Omega$$

- Next, we determine C

$$V_r = \frac{V_p}{2fCR}$$

Replace V_p/R by current through 191-Ω resistor. This current can be estimated by noting that the voltage across C varies from 10.7 V to 11.2 V, and therefore has an average value of 10.95 V. Further, the desired voltage across the zener is 5 V. The value of $C = 520$ μF.




R_s= 0.5 kΩ
v_s
R
Zener diode
R_L
R Isolation = 1 MΩ