EE 521: Instrumentation and Measurements

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October 5, 2009

General Circuit

Bridge is excited by an ac supply.

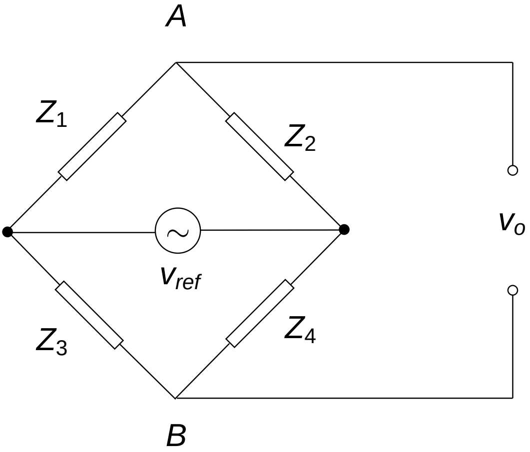

Figure: General impedance bridge

Impedance-bridge output

$$V_o(\omega) = \frac{Z_1 Z_4 - Z_2 Z_3}{(Z_1 + Z_2)(Z_3 + Z_4)} V_{ref}(\omega) \quad (1)$$

Balanced if

$$\frac{Z_1}{Z_2} = Z_3 Z_4 \quad (2)$$

Owen Bridge

See Figure 1. If Z_1=C_1, $Z_2 = R_2$, $Z_3 = R_3 + C_3$, $Z_4 = R_4 + L4$. We can measure both inductance L_4 and capacitance C_3 using balanced bridge method, i.e.,

$$\frac{1}{j\omega C_1}(R_4 + j\omega L_4) = R_2\left(R_3 + \frac{1}{j\omega C_3}\right) \tag{3}$$

Equating real parts:

$$\frac{L_4}{C_1} = R_2 R_3 \tag{4}$$

Equating imaginary parts:

$$\frac{R_4}{C_1} = \frac{R_2}{C_3} \tag{5}$$

Measuring L_4 and C_3

By solving the previous two equations for L_4 and C_3

$$L_4 = C_1 R_2 R_3 \tag{6}$$

and

$$C_3 = C_1 \frac{R_2}{R_4} \tag{7}$$

Wien-Bridge Oscillator

See Figure 1. If Z_1=R_1, $Z_2 = R_2$, $Z_3 = R_3 + C_3$, $Z_4 = R_4||C4$. We can measure both inductance L_4 and capacitance C_3 using balanced bridge method, i.e.,

$$\frac{R_1}{R_2} = \left(R_3 + \frac{1}{j\omega C_4}\right)\left(\frac{1}{R_4} + j\omega C_4\right) \quad (8)$$

Equating real parts:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} + \frac{C_4}{C_3} \quad (9)$$

Equating imaginary parts:

$$0 = \omega C_4 R_3 - \frac{1}{\omega C_3 R_4} \Rightarrow \omega = \frac{1}{\sqrt{C_3 C_4 R_3 R_4}} \quad (10)$$

Linearizing Methods

- Digital software,
- digital hardware, or
- analog circuitry.

Offsetting Circuit

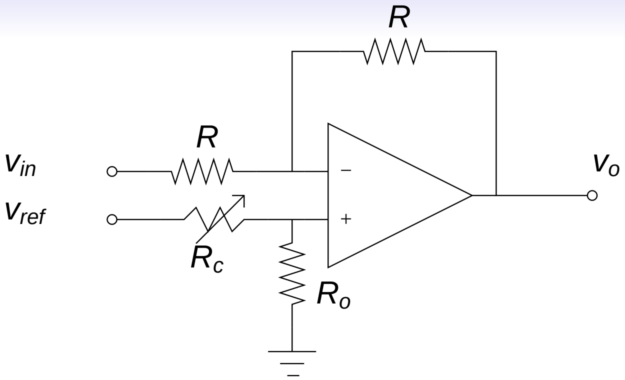

Figure: Offset Compensation

$$v_o = -v_i + \frac{2R_o}{R_o + R_c} v_{ref} \tag{11}$$

Proportional Output Circuit

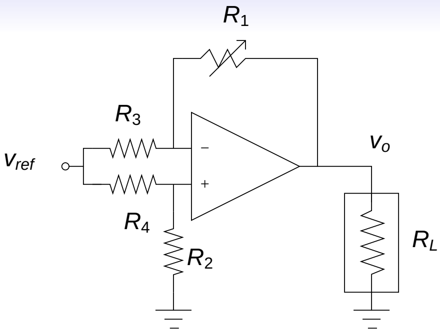

Figure: Proportional output circuit

Assuming $R_1 = R_2 = R_3 = R_4 = R$,

$$\frac{\delta v_o}{v_{ref}} = -\frac{1}{2}\frac{\delta R}{R} \tag{12}$$

Curve Shaping

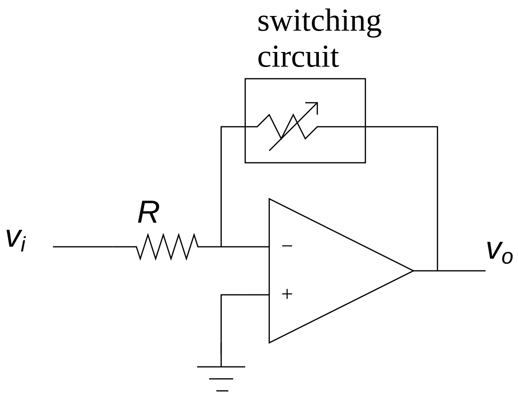

Figure: Curve shaping using resistance switching circuit

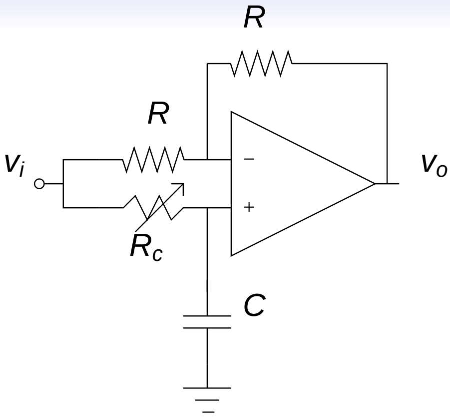

Figure: Simple phase shifter