Lecture 2 - F

Analog Signal Conditioning

EE 521: Instrumentation and Measurements

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Aly El-Osery, Electrical Engineering Dept., New Mexico Tech

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1 Impedance Bridge Circuits

General Circuit

See Figure 1.
Bridge is excited by an ac supply.

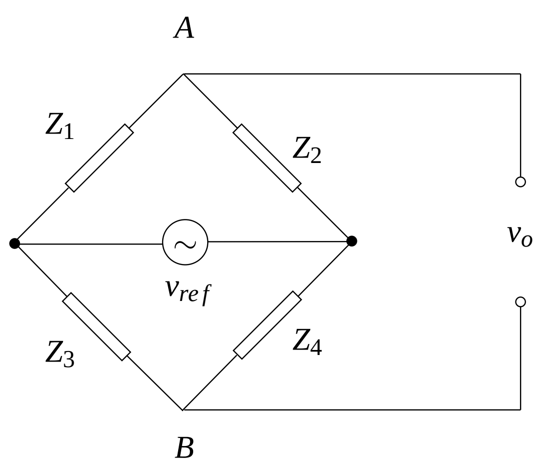

Figure 1: General impedance bridge

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Impedance-bridge output

$$V_o(\omega) = \frac{Z_1Z_4 - Z_2Z_3}{(Z_1+Z_2)(Z_3+Z_4)}V_{ref}(\omega) \tag{1}$$

Balanced if

$$\frac{Z_1}{Z_2} = Z_3 Z_4 \tag{2}$$

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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:

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

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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

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

2 - F.6

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.,

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

Equating real parts:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} + \frac{C_4}{C_3} \tag{9}$$

Equating imaginary parts:

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

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2 Linearizing Devices

Linearizing Methods

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

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Offsetting Circuit

See Figure 2.

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

2 - F.9

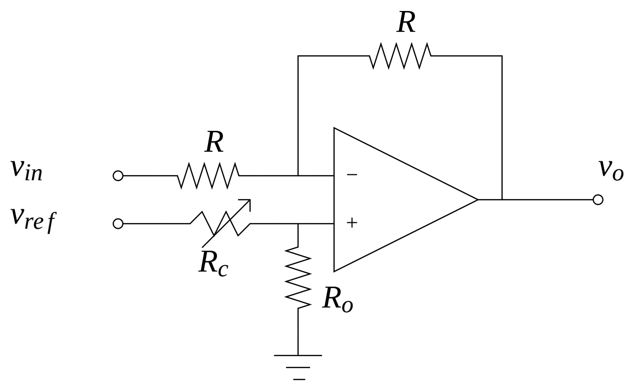

Figure 2: Offset Compensation

Proportional Output Circuit

See Figure 3.

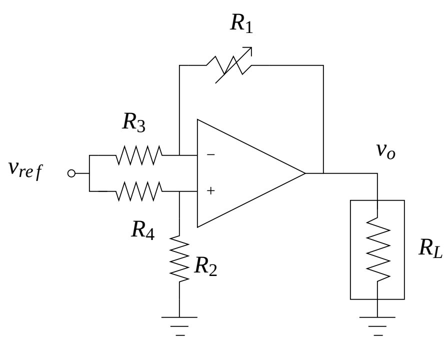

Figure 3: Proportional output circuit

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

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

Sensitivity of the proportional output circuit is $1/2$ as compared to $1/4$ of the Wheatstone bridge. 2 - F.10

Curve Shaping

See Figure 4. 2 - F.11

3 Phase Shifter

See Figure 5. 2 - F.12

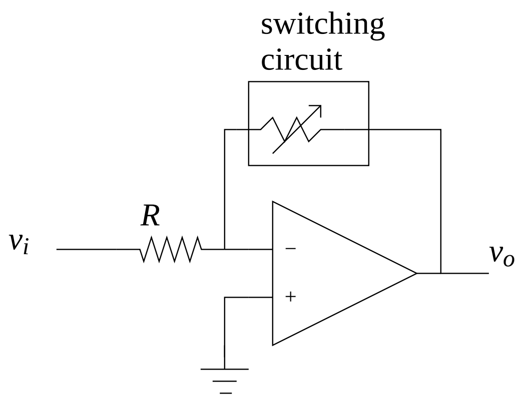

Figure 4: Curve shaping using resistance switching circuit

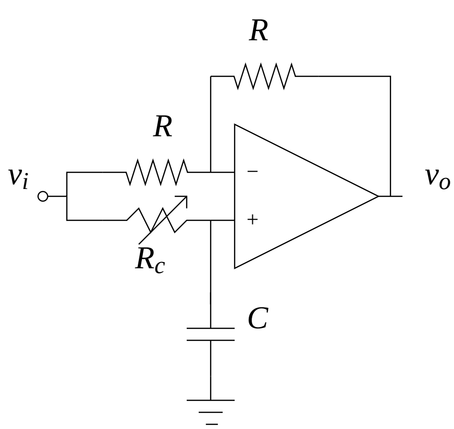

Figure 5: Simple phase shifter