EE 521: Instrumentation and Measurements

Aly El-Osery

Electrical Engineering Department, New Mexico Tech
Socorro, New Mexico, USA

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1. Instrumentation Amplifiers
2. Non-linear Analog Signal Processing
3. Modulation

Differential vs Instrumentation Op-amp

Differential Amplifier

One major limitation of this type of amplifier design is that its input impedances are lower compared to that of other operational amplifier configurations.

Input impedance is not matched.

Differential vs Instrumentation Op-amp

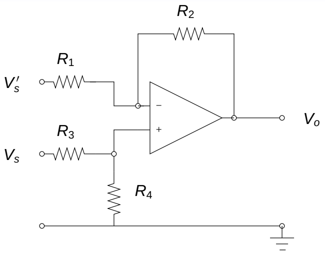


Figure: Differential Amplifier Configuration

Assuming $R_1 = R_3$ and $R_2 = R_4$, then

$$Vo = \frac{R_2}{R_1}(V_s - V_s') \tag{1}$$

Instrumentation Amplifier

To overcome the limitation of the differential amplifier, add a buffer amplifier at each input. This will increase the input impedance of the differential amplifier.

Three Op-Amp Configuration

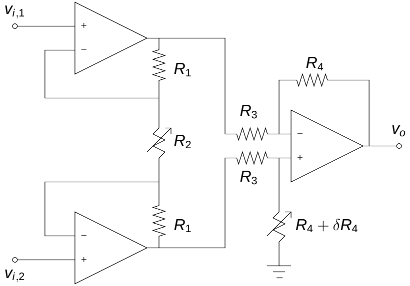


Figure: Three op-amp instrumenation amplifier

$$V_o = \left(1 + \frac{2R_1}{R_2}\right)(R_4/R_3)(v_{i,1} - v_{i,2}) \qquad (2)$$

Nonlinear systems

Non-linear systems don't obey superposition. Many real applications requires the use of non-linear systems.

Log

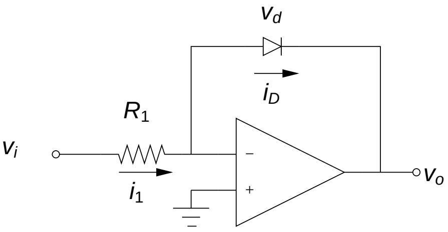


Figure: Log circuit

$$i_D \cong I_s e^{v_D/V_T} \tag{3}$$

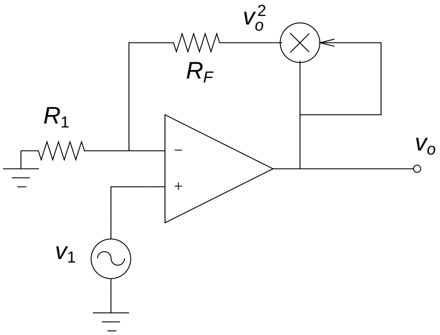
$$i_1 = \frac{v_i}{R_1} \tag{4}$$

$$v_o = -v_D, i_1 = i_D \tag{5}$$

$$i_1 = \frac{v_i}{R_1} = i_D = I_s e^{-v_o/V_T} \tag{6}$$

$$v_o = -V_T \ln\left(\frac{v_i}{I_s R_1}\right) \tag{7}$$

Square Root



$$v_1/R_1 = v_o^2/(R_F) \qquad (8)$$

$$v_o = \sqrt{v_1(R_F/R_1)} \qquad (9)$$

Figure: Square root circuit

Divider

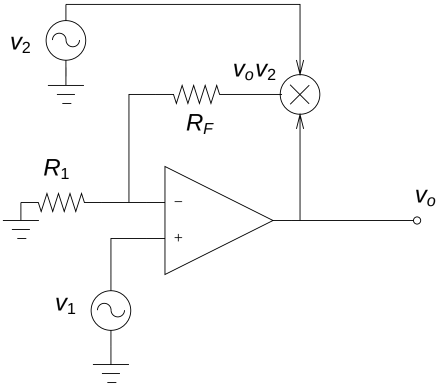


Figure: Divider circuit

$$v_1/R_1 = v_2 V_o/R_F \tag{10}$$

$$v_o = (v_1/v_2)(R_F/R_1) \tag{11}$$

Analog Modulation

Modulation is the modification of some aspect of a carrier signal. Given a signal of the form

$$x_c(t) = A(t)\cos[\omega_c t + \phi(t)]$$

where ω_c is known as the carrier frequency.

Amplitude Modulation

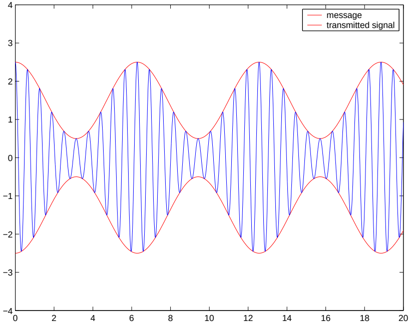


Figure: Amplitude modulation

Phase Modulation

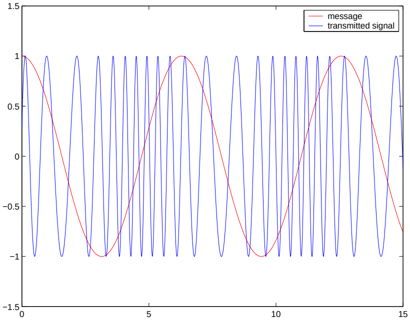


Figure: Phase modulation

Frequency Modulation

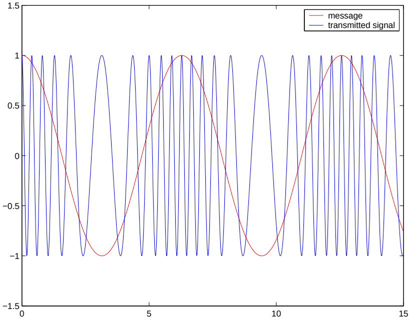


Figure: Frequency modulation