Lecture 2 - D

Analog Signal Conditioning

EE 521: Instrumentation and Measurements

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Contents

1 Instrumentation Amplifiers

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

See Figure 1

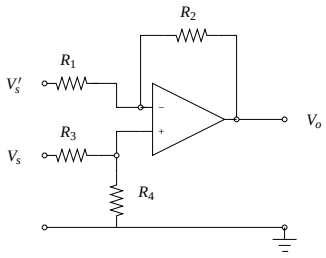

Figure 1: Differential Amplifier Configuration

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.

2 - D.5

Three Op-Amp Configuration

See Figure 2

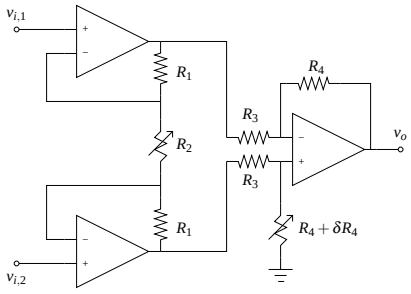

Figure 2: Three op-amp instrumenation amplifier

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

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2 Non-linear Analog Signal Processing

Nonlinear systems

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

2 - D.7

Log

See Figure 3

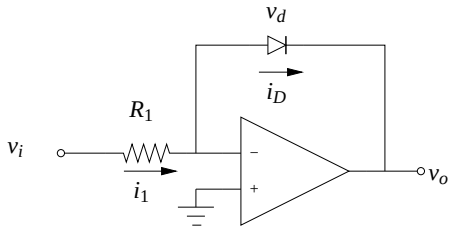

Figure 3: Log circuit

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

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

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

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

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

2 - D.8

Square Root

See Figure 4

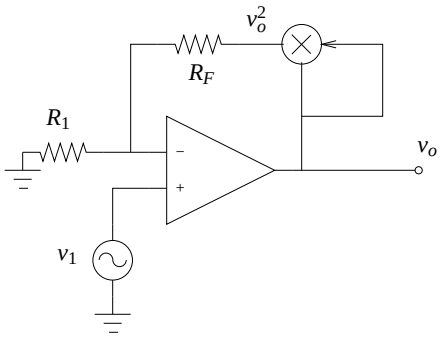

Figure 4: Square root circuit

$$v_1/R_1 = v_o^2/(R_F) \tag{8}$$

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

2 - D.9

Divider

See Figure 5

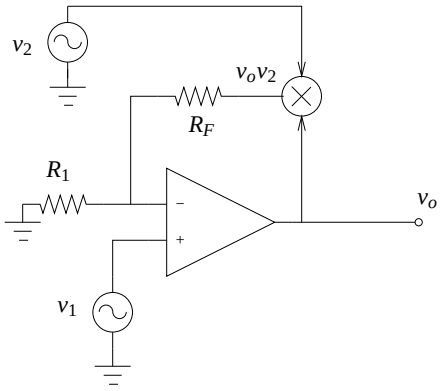

Figure 5: Divider circuit

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

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

2 - D.10

3 Modulation

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. If $A(t)$ varies linearly with the modulating signal (your message to be transmitted), then we have *linear modulation*. If $\phi(t)$ varies with the modulating signal, then we have *angle modulation*. Figures 6, 7 and 8, show modulated signals using *amplitude*

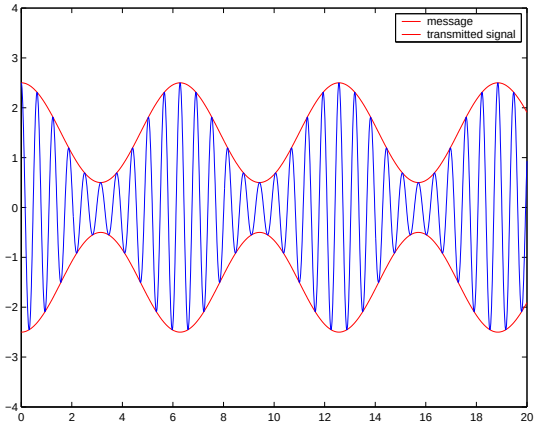

Figure 6: Amplitude modulation

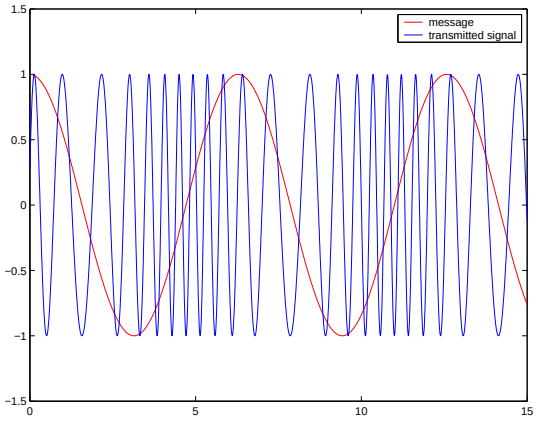

Figure 7: Phase modulation

modulation, *phase modulation* and *frequency modulation*, respectively. As seen in Figure 6, the message signal is modifying the amplitude of the carrier signal, hence the name amplitude modulation. In Figure 7, the oscillation increased or decreased based on the slope of the modulating signal. In Figure 8, the amplitude of the signal is modifying the rate of oscillation of the carrier signal. 2 - D.11

Amplitude Modulation

See Figure 6 2 - D.12

Phase Modulation

See Figure 7 2 - D.13

Frequency Modulation

See Figure 8 2 - D.14

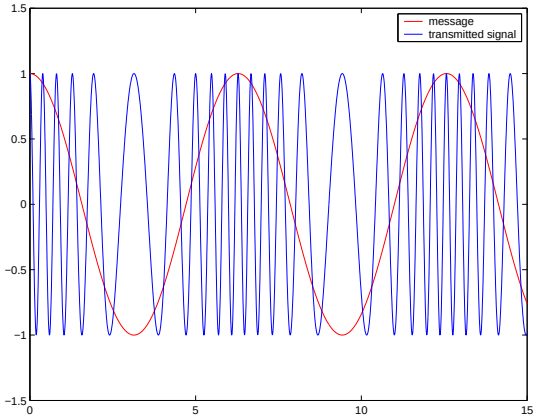

Figure 8: Frequency modulation