LECTURE-42

DIFFERENCE AMPLIFIER

\[ \rightarrow \text{NOT POSSIBLE TO GET HIGH GAIN AND HIGH } R_I \]

INSTRUMENTATION AMPLIFIER

\[ \rightarrow \text{HIGH GAIN AND HIGH } R_I \]

VIRTUAL SHORT THEORY

STAGE 1

STAGE 2

I_1 = \frac{V_{I1} - V_{I2}}{R_1}

I_1 = \frac{V_{01} - V_{02}}{2R_2 + R_1}

V_{01} - V_{02} = \frac{2R_2 + R_1}{n}(V_{I1} - V_{I2})
\[ V_{01} - V_{02} = \frac{2R_2 + R_1}{R_1} (V_{I1} - V_{I2}) \]

\[ V_0 = \frac{R_4}{R_3} (V_{02} - V_{01}) \]

\[ \therefore V_0 = \frac{R_4}{R_3} \left( \frac{2R_2 + R_1}{R_1} \right) (V_{I2} - V_{I1}) \]

* Since input stage is non-inverting, \( R_I = \infty \)

* \( V_0 \) depends on \( R_1 \) → gain is varied using only \( R_1 \)
\[ V_{0} = \frac{1}{sR_{1}C_{2}} V_{I} \]

\[ V_{0} = \frac{1}{sR_{1}C_{2}} \int_{0}^{t} V_{I}(t) \, dt \]

\[ A_{V} = \frac{V_{0}}{V_{I}} = -\frac{Z_{2}}{Z_{1}} = -\frac{1}{sR_{1}C_{2}} \]

\[ s \rightarrow j\omega \rightarrow \text{COMPLEX FREQ.} \]

\[ \frac{d}{dt} \rightarrow s \rightarrow \frac{1}{s} = \int \]

\[ \text{INTEGRATOR} \]

\[ R_{2} \]

\[ C_{2} \]

\[ \text{LOW PASS FILTER} \]

\[ \text{CUTOFF FREQUENCY} \]

\[ Z_{2} = \frac{1}{sC_{2}} = \frac{1}{j\omega C_{2}} \]
**Differentiator**

\[ V_I - \frac{1}{sC_1} \]

\[ V_0 = -\frac{z_2}{z_1} V_I = -s \frac{R_2}{C_1} V_I \]

\[ \frac{d}{dt} v_0(t) = -R_2 C_1 \frac{d}{dt} v_I(t) \]

\[ A_v = -\frac{z_2}{z_1} \]

**High Pass Filter**

\[ f_c = \frac{1}{2\pi R_1 C_1} \]
**HALF WAVE RECTIFIER OP-AMP CIRCUIT**

\[ V_s > 0 \]

**DIODE 2 IS ON, DIODE 1 IS OFF**

CURRENT FLOWS THROUGH \( R_C \)

(NEGATIVE)

\[ V_o^- = -\frac{R_C}{R_A} V_s \]

\[ V_o^+ = 0 \]

\[ V_s < 0 \]

**DIODE 1 IS ON, DIODE 2 IS OFF**

CURRENT FLOWS THROUGH \( R_B \)

\[ V_o^+ = -\frac{R_B}{R_A} V_s \]  (POSITIVE)

\[ V_o^- = 0 \]
**Voltage to Current OP-AMP Circuit**

Since input voltage is given to the negative terminal, $V_s < 0$ (requirement for proper biasing of transistor)

$V_2 = 0$ (Virtual Ground Theory $V_1 = 0$)

$I_1 = \frac{V_s}{R_1}$

$I_2 = \frac{D - V_E}{R_2}$

$I_1 = I_2$

$\frac{V_s}{R_1} = -\frac{V_E}{R_2}$
\[ V_E = -\frac{V_S R_2}{R_1} \]

**KVL BE Loop**

\[-VB + V_{BE(on)} + VE = 0 \]

\[ VB = V_{BE(on)} + VE \]

\[ I_4 = \frac{VE}{R_E} \]

**KCL NODE(A)**

\[ I_E + I_2 = I_4 \]

\[ I_E = I_4 - I_2 \]

**KVL CE Loop**

\[ I_C = \propto I_E \]

\[ V_{CE} = V_{CC} - I_C R_C - VE \]

**Output of Opamp**

**ASSUMING OPERATION IN ACTIVE REGION**