2.1 SIGN CHANGER (PHASE INVERTER)

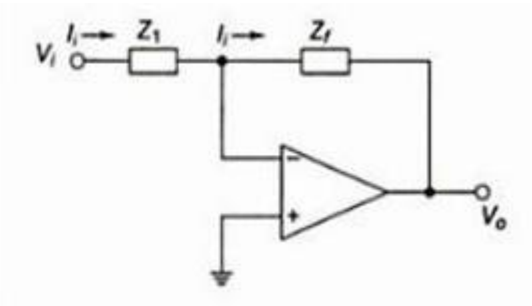

Figure 2.2.1 Basic inverting configuration

[source:"Linear Integrated Circuits"by S.Salivahanan& V.S. Kanchana Bhaskaran, Page-172]

The basic inverting amplifier configuration using an op-amp with input impedance Z_1 and feedback impedance Z_f is shown in figure 2.1.1. If the impedance Z_1 and Z_f are equal in magnitude and phase, then the closed loop voltage gain is -1, and the input signal will undergo a 180° phase shift at the output. Hence, such circuit is also called phase inverter. If two such amplifiers are connected in cascade, then the output from the second stage is the same as the input signal without any change of sign. Hence, the outputs from the two stages are equal in magnitude but opposite in phase and such a system is an excellent paraphase amplifier.

SCALE CHANGER

Referring the above figure 2.1.1, if the ratio $Z_f / Z_1 = k$, a real constant, then the closed loop gain is – k, and the input voltage is multiplied by a factor –k and the scaled output is available at the output. Usually, in such applications, Z_f and Z_1 are selected as precision resistors for obtaining precise and scaled value of input voltage.

PHASE SHIFT CIRCUITS

The phase shift circuits produce phase shifts that depend on the frequency and maintain a constant gain. These circuits are also called constant-delay filters or all-pass filters. That constant delay refers to the fact the time difference between input and output remains constant when frequency is changed over a range of operating frequencies.

This is called all-pass because normally a constant gain is maintained for all the frequencies within the operating range. The two types of circuits, for lagging phase angles and leading phase angles.

PHASE-LAG CIRCUIT

Figure 2.1.2 shown below is the phase lag circuit. Phase log circuit is constructed using an op-amp, connected in both inverting and non inverting modes. To analyze the circuit operation, it is assumed that the input voltage v1 drives a simple inverting amplifier with inverting input applied at (-)terminal of op-amp and a non inverting amplifier with a low-pass filter.

It is also assumed that inverting gain is -1 and non-inverting gain after the low-pass circuit is

$$1+\frac{R_f}{R_1}=1+1=2 \quad \text{Since } R_f=R_1.$$

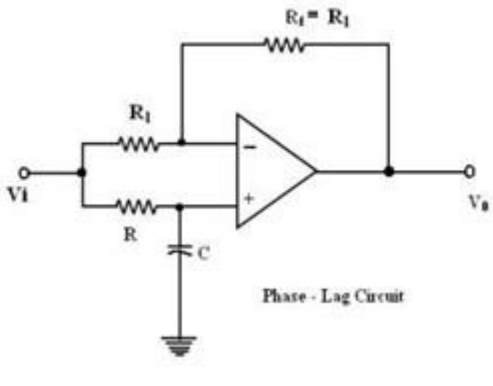

Figure 2.1.2 Phase Lag circuit

[source:"Linear Integrated Circuits"by S.Salivahanan& V.S. Kanchana Bhaskaran, Page-173]

ANALYSIS

$$From\,branch\,C\,, V_B=\frac{1}{C}\int I_1\,dt$$

$using\ Laplace\ Transform$

$$V_B(S)=\frac{1}{SC}I_1(s)----(1)$$

$$From\ branch\ R\quad I_1(s) = \frac{V_i(s) - V_B(s)}{R} ----(2)$$

$sub\ (2) in\ (1) and\ simplifying\ we\ get,$

$$V_B(s) = \frac{V_i(s)}{1 + SCR}$$

$$From\ Branch\ R_1, I_2(s) = \frac{V_i(s) - V_B(s)}{R_1} = \frac{V_i(s) - V_A(s)}{R_1}$$

$$From\ Branch\ R_f, I_2(s) = \frac{V_A(s) - V_o(s)}{R_f} = \frac{V_B(s) - V_o(s)}{R_f}$$

$$Simplyfing\ we\ get, \frac{V_o(s)}{V_i(s)} = \frac{1 - SCR}{1 + SCR}$$

$$Sub\ S = j\omega$$

$$\frac{V_o(j\omega)}{V_i(j\omega)} = \frac{1 - j\omega CR}{1 + j\omega CR}$$

$$Magnitude = 1\ hence\ \left|V_o\right| = \left|V_{in}\right|$$

$$Phase\ \theta = -\tan^{-1}(\omega RC) - \tan^{-1}(\omega RC)$$

$$\theta = -2\tan^{-1}(\omega RC)$$

$Case\ (i)\ \omega = 0\ \ then\ \theta = 0$

$Case\ (ii)\ \omega = \infty\ \ then\ \theta = -180°$

$$\theta = -2\tan^{-1}(2\pi fRC)$$

$$\theta = -2\tan^{-1}(\frac{f}{f_o})$$

$$f_o = \frac{1}{2\pi RC}$$

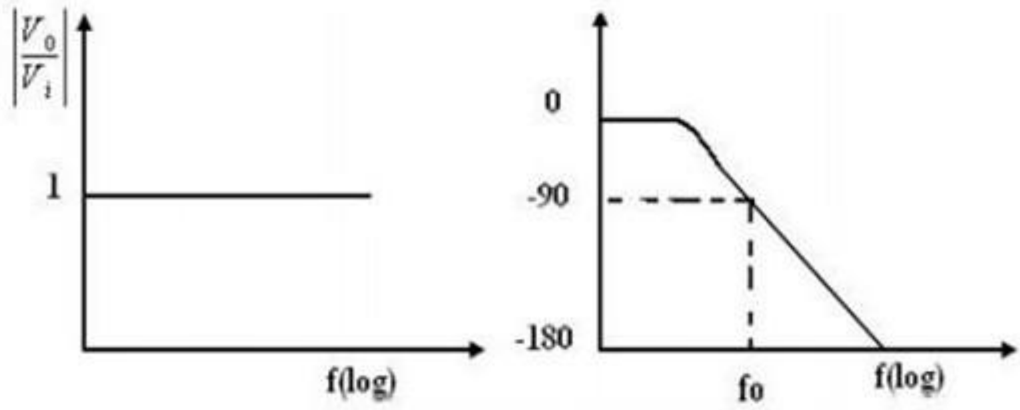

Figure 2.1.3 Bode plot of phase lag circuit

[source:"Linear Integrated Circuits"by S.Salivahanan& V.S. Kanchana Bhaskaran, Page-173]

The relationship is complex as defined above equation and it shows that it has both magnitude and phase.Figure 2.1.3 shows the bode plot of phase lag circuits. Since the numerator and denominator are complex conjugates, their magnitudes are identical and the overall phase angle equals the angle of numerator less the angle of the denominator.

PHASE-LEAD CIRCUIT

The phase-lead circuit is in which the RC circuit forms a high pass network. The output voltage is expressed as.

$$\frac{V_O(jw)}{V_i(jw)} = -\frac{(1 - jwRC)}{(1 + jwRC)}$$

$$\theta = 180^\circ - 2\ \tan^{-1} RC\omega$$

Figure 2.1.4 shown below is the phase lead circuit and figure 2.1.5 is the bode plot of phase lead circuit.

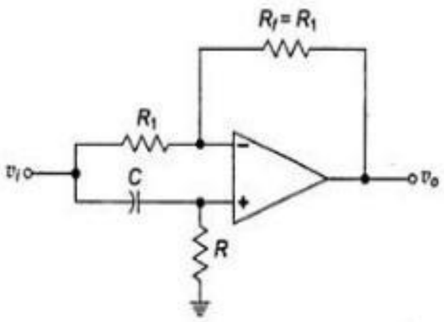

Figure 2.1.4 phase lead circuit

[source:"Linear Integrated Circuits"by S.Salivahanan& V.S. Kanchana Bhaskaran, Page-175]

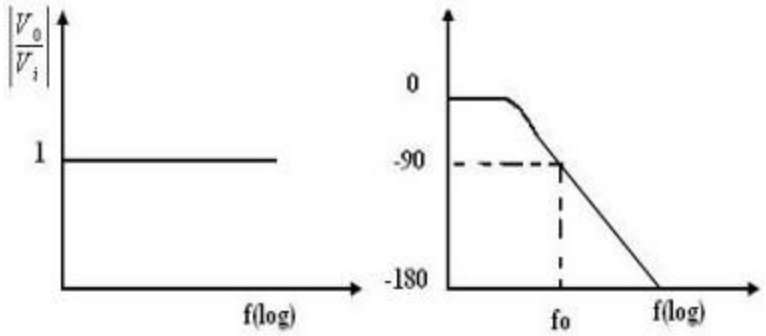

Figure 2.1.5 Bode plot of phase lead circuit.

[source:“Linear Integrated Circuits”by S.Salivahanan& V.S. Kanchana Bhaskaran, Page-175]

VOLTAGE FOLLOWER

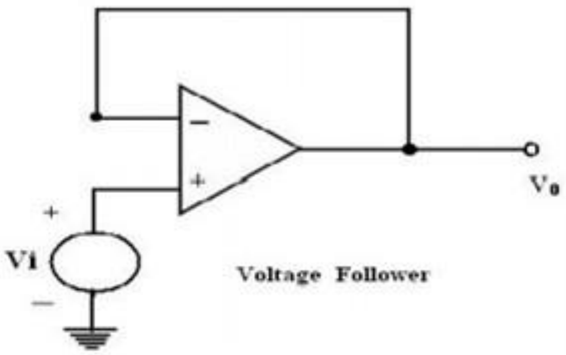

Figure 2.1.6 Voltage Follower

[source:“Linear Integrated Circuits”by S.Salivahanan& V.S. Kanchana Bhaskaran, Page-175]

If $R_1=\infty$ and $R_f=0$ in the non-inverting amplifier configuration. The amplifier act as a unity-gain amplifier or voltage follower. Figure 2.1.6 shown above is the circuit diagram for a voltage follower.

The circuit consists of an op -amp and a wire connecting the output voltage to the input, i.e. the output voltage is equal to the input voltage, both in magnitude and phase. $V_0=V_i$.Since the output voltage of the circuit follows the input voltage, the circuit is called voltage follower. It offers very high input impedance of the order of MΩ and very low output impedance.

Therefore, this circuit draws negligible current from the source. Thus, the voltage follower can be used as a buffer between a high impedance source and a low impedance load for impedance matching applications.