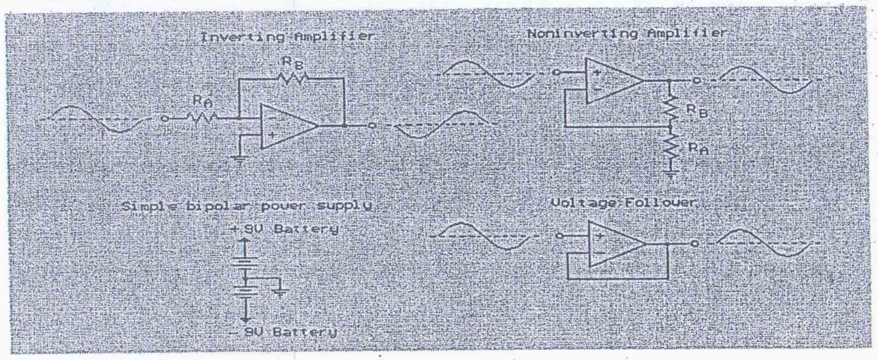
supply the same current through RB and keep the voltage at the inverting input at zero. The voltage gain in this case would be RB/RA or 10K/1K = 10. Note that since the voltage at the inverting input is always zero, the input signal will see a input impedance equal to RA, or 1K in this case. For higher input impedances, both resistor values can be increased.

Noninverting Amplifier:

The noninverting amplifier is connected so that the input signal goes directly to the noninverting input (+) and the input resistor RA is grounded. In this configuration, the input impedance as seen by the signal is much greater since the input will be following the applied signal and not held constant by the feedback current. As the signal moves in either direction, the output will follow in phase to maintain the inverting input at the same voltage as the input (+). The voltage gain is always more than 1 and can be worked out from Vgain = (1+ RB/RA).

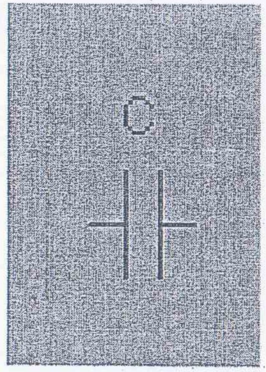
Voltage Follower: The voltage follower, also called a buffer, provides a high input impedance, a low output impedance, and unity gain. As the input voltage changes, the output and inverting input will change by an equal amount.



Unit 7

Section one : Reading comprehension

Capacitance



Capacitance(symbol C) is a measure of a capacitor's ability to store charge. A large capacitance means that more charge can be stored. Capacitance is measured in farads, symbol F. However IF is very large, so prefixes (multipliers) are used to show the smaller values:

- μ (micro) means 10^{-6} (millionth), so 1000000 μF = 1F
- n (nano) means 10^{-9} (thousand-millionth), so 1000nF = 1 μF
- p (pico) means 10^{-12} (million-millionth), so 1000pF = 1nF

Charge and Energy Stored

The amount of charge (symbol Q) stored by a capacitor is given by:

Charge, $Q = C*V$

where: Q = charge in coulombs (C)

C = capacitance in farads (F) V = voltage in volts (V)

When they store charge, capacitors are also storing energy. Energy, $E = \frac{1}{2}CV^2$ where E = energy in joules (J).

Note that capacitors return their stored energy to the circuit. They do not 'use up' electrical energy by converting it to heat as a resistor does. The energy stored by a capacitor is much smaller than the energy stored by a battery so they cannot be used as a practical source of energy for most purposes.

Capacitive Reactance Xc

Capacitive reactance (symbol Xc) is a measure of a cajpacitor's opposition to AC (alternating current). Like resistance it is measured in ohms, but reactance is more complex than resistance because its value depends on the frequency (f) of the electrical

Signal passing through the capacitor as well as on the capacitance.

The reactance Xc is large at low frequencies and small at high frequencies. For steady DC which is zero frequency, Xc is infinite (total opposition), hence the rule that capacitors pass AC but block DC.

For example a 1 μF capacitor has a reactance of 3.2kΩ for a 50Hz signal, but when the frequency is higher at 10kHz its reactance is only 16Ω.

Note: the symbol Xc is used to distinguish capacitative reactance from inductive reactance X_L which is a property of inductors. The distinction is important because X_L increases with frequency (the opposite of Xc) and if both X_L and Xc are present in a circuit the combined reactance (X) is the difference between them.

Charging a capacitor

The capacitor (C) is being charged from a supply voltage (Vs) with the current passing through a resistor (R). The voltage across the capacitor (Vc) is initially zero but it increases as the capacitor charges.Thecurrent (I) is determined by the voltage across the resistor

Charging current, I = (Vs - Vc) / R (note that Vc is increasing) At firstVc = 0V so the initial current, Io = Vs / R

Vc increases as soon as charge (Q) starts to build up (Vc = Q/C), this reduces the voltage across the resistor and therefore reduces the charging current. This means that the rate of charging becomes progressively slower.

Time constant

The time constant is the time taken for the charging (or discharging) current (I) to fall to $1/e$ of its initial value (lo). 'e' is the base of natural logarithms, an important number in mathematics (like π). e = 2.71828 so we can roughly say that the time constant is the time taken for the current to fall to $\frac{1}{3}$ of its initial value.

After each time constant the current falls by $^1/_e$ (about $^1/_3$). After 5 time constants (5RC) the current has fallen to less than 1% of its initial value and we can reasonably say that the capacitor is fully charged, but in fact the capacitor takes for ever to charge fully!

After 5 time constants (5RC) the capacitor is almost fully charged with its voltage almost equal to the supply voltage. We can reasonably say that the capacitor is fully charged after 5RC, although really charging continues .

Uses of capacitor

- **Timing** - for example with a 555tirner IC controlling the charging and discharging.

Smoothing - for example in a power supply.

Coupling - for example between stages of an audio system and to connect a loudspeaker.

Filtering - for example in the tone control of an audio system.

Tuning - for example in a radio system.

Storing energy - for example in a camera flash circuit.

Capacitor Coupling (CR-coupling)

Sections of electronic circuits may be linked with a capacitor because capacitors pass AC (changing) signals but block DC (steady) signals. This is called capacitor coupling

or CR-coupling. It is used between the stages of an audio system to pass on the audio signal (AC) without any steady voltage (DC) which may be present, for example to connect a loudspeaker . it is also used for the AC switch setting on an oscilloscope.

The precise behaviour of a capacitor coupling is determined by its time constant (RC). Note that the resistance (R) may be inside the next circuit section rather than a separate resistor.

For successful capacitor coupling in an audio system the signals must pass through with little or no distortion. This is achieved if the time constant (RC) is larger than the time_period (T) of the lowest frequency audio signals required (typically 20Hz, T = 50ms).

Comprehension Exercises

A. Answer the following questions orally .

1) What does capacitive reactance X_C means ?

2) What relationship exsists between X_L and X_C ?

3) Define time constant of RC circuit ?

4) How much does it take for a capacitor to be fully charged ?

5) Name same of the applications of capacitors ?

B . Put "T" for true and " F " for false statements.

...... 1) The larger the capacitance of a capacitor is , the more charge it can store .

...... 2) Capacitors do not return their stored energy to the circuit.

...... 3) Capacitors use up electrical energy by converting it to heat as a resistor does .

...... 4) Capacitive reactance depends on frequency .

...... 5) Capacitors pass AC but block DC.

...... 6) The more a capacitor is charged , the more the charging current reduces.

.... 7) After 5 time constants , the voltage at the two ends of the capacitor is almost zero .

C . Multiple choice questions

1) The energy stored by a capacitor is .... The energy stored by a battery.

a) smaller than b) larger than
c) much smaller than d) equal to

2) Capacitive reactance is measured like a ....

a) resistor b) inductor c) capacitor d) none of them

3) The reactance X_C is .... at low frequencies and .... at high frequencies .

a) zero – large b) infinite – small
c) infinite – large d) zero – small

4) A large time constant means the capacitor charges ....

a) quickly b) slowly
c) at first slowly then quickly d) none of them

5) Approximately it can be said that time constant is the time taken for the charging current to fall to .... . Of its initial value .

a) $\frac{1}{2}$ b) $\frac{1}{3}$ c) $\frac{1}{4}$ d) $\frac{1}{\Pi}$

D : Fill in the blanks with the following words.

Load speaker	coupling	rapidly
use- up	build up	distortion

1) For a successful capacitor coupling in an audio system the signals must pass through with little or no ....

2) Inductors and capacitors can not .... their stored energy .

3) At time discharging a capacitor at first the current is large because the voltage is large , so charge is lost quickly and the voltage decreases..........

4) For a .... to have maximum power output impedance must be adapted.