Sampling Gates

* Sampling gates also called linear gates, transmission gates or selection circuits.
  * Output is an exact reproduction of the input during a selected time interval and zero otherwise.

Sampling gates may be unidirectional sampling gates or bidirectional sampling gates.

* Unidirectional sampling gates - which transmit signals of only one polarity.
* Bidirectional sampling gates - which transmit signals of both the polarities.

Basic Operating Principles of Sampling Gates:

* A sampling gate using a series switch.

* As shown above the switch is normally open but is in closed position when the signal is transmitted.
The switches are normally electronic devices, diode (or) transistor.

When device is conducting, it acts as a closed switch and as an open switch when not conducting.

\[ \begin{align*}
R & \quad \text{A sampling gate using a shunt switch.} \\
V_i & \quad \text{As shown above, the switch is normally closed but in an open position when the signal is transmitted.} \\
\end{align*} \]

Unidirectional Diode Gate.

It is a gate which transmits only positive-going input signals.

\[ \begin{align*}
\text{Signal Input} & \quad \text{Gate or control input.} \\
V_i & \quad \text{A}_1 \\
\end{align*} \]
* The gate signal is a rectangular waveform that makes abrupt transitions between two negative levels, \(-V_1\) and \(-V_2\). The gate signal is also called as control pulse, a selector pulse (or) enabling pulse.

* When the gating signal is at lower level \(-V_2\), the diode is heavily back biased and there will be no output.

* When the gating signal is at its upper level \(-V_1\), a time-coincident signal input pulse may be transmitted to the output.

* This gate is not suitable for transmitting a portion of a continuous waveform.

* If input is a pulse of very short duration, the input may be transmitted satisfactorily.

**Advantages:**
1. It is extremely simple.
2. There is very little time delay through the gate.
3. The gate draws no current in its quiescent condition.
4. Can be extended into multi-input OR circuit.
Disadvantages:
1. Interaction between signal source and the control voltage source.
2. Limited use because of slow rise of the control voltage at the diode.

Bidirectional Diode Sampling Gate

- We need two symmetrical gating voltages $+V_c$ and $-V_c$.
- When control signals are at levels $+V_n$ & $-V_n$ than the signal at A is $-V_n$ and signal at B is $+V_n$.
- Both the diodes $D_1$ & $D_2$ are reverse biased hence no signal transmission takes place.
Similarly:

* When the control signals are at levels $V_c$ and $-V_c$ then the signal at A is $+V_c$ and at B is $-V_c$.

* Both the $D_1$ and $D_2$ are on and then a sample of $V_c$ appears at the output.

* Bidirectional diode sampling gate redrawn in bridge network form.

Gain of sampling gate is defined as ratio $V_o/V_x$ during the transmission interval.

$$A = \frac{V_o}{V_x} = \frac{R_c}{R_c+R_2} \cdot \frac{R_L}{R_L+R_3/2}$$
Four-Diode Sampling Gate:

* It is designed to overcome disadvantages of two-diode sampling gate such as:
  1. Its gain is low.
  2. It is sensitive to control voltage imbalance.
  3. \((V_n)_{min}\) may be excessive.
  4. Leakage through diode capacitance.

* A four-diode gate

Operation:

* When the (operation) control voltages are \(V_c\) and \(-V_c\), \(D_3\) and \(D_4\) are reverse biased, because of \(TV\) and \(-V\) diodes \(D_1\) and \(D_2\).
Conduct and the signal source is coupled to the load through $R_2$, $P_1$, and $D_2$.

* When the control voltages are $V_h$ and $-V_h$ the diodes $D_4$ and $D_6$ conduct and points $P_2$ and $P_1$ are clamped to these voltages. So $D_1$ and $D_2$ are reverse biased and the output is zero.

Gain of the gate is given by

$$A = \frac{R_c}{R_c + R_2} \times \frac{R_L}{R_L + (R_2/2)}$$

Six - Diode Sampling Gate:

![Diode Sampling Gate Diagram]
Operation

* When the control signals are at levels $V_n$ and $-V_n$, diodes $D_5$ and $D_6$ conduct. Points $P_1$ and $P_2$ are clamped to these levels.
* Hence, $D_3$ and $D_4$ are back biased and no signal transmission takes place.

* In six-diode gate, the control signals need not be balanced.

* When the control signals are at levels $V_c$ and $-V_c$, the diodes $D_5$ and $D_6$ are off and six-diode gate becomes equivalent to the four-diode gate.

* The change is that control voltages $V_c$ and $-V_c$ are replaced by fixed voltages $V_s$ and $-V_s$. The signal transmission takes place.

Applications of Sampling Gates:

1. Multiplexers.
2. Sample and hold circuits.
3. Digital to Analog Converters.
5. Sampling scope.

* Chopper Amplifier.

\[ R \quad \text{[Diagram]} \quad C \]

**AC amplifier.**

* \( S_1 \) is being driven so that is alternately open and closed.

**Vi** is amplifier input; when \( S_1 \) is open \( v_i = V \)

and when \( S_1 \) is closed \( v_i = 0 \).

* The circuit consisting of \( R \) and \( S_1 \) is called chopper since the \( v_i \) is chopped version of \( v \).

If the frequency of operation of switch is very large compared with the frequency of signal \( v_i \) it may be described as a square wave of amplitude proportional to \( V \) and having an average value that is also proportional to \( V \). This is modulated waveform. Because of this modulation process chopper is often called
a modulator.

* The signal is recovered through mechanism of capacitor c and s2. Switch s2 closes and opens in synchronous with s1.

During T1, negative extremity of v0 is restored to zero, and during T2, the positive extremity is restored to zero.

* As a result, except for an increase in amplitude, the signal v0 across s2 assumes again the form of signal v1.