

2.1 BARKHAUSEN CRITERION FOR OSCILLATION

Introduction:

- An oscillator is a circuit which basically acts as generator, generating the output signal which oscillates with constant amplitude and constant desired frequency.
- The feedback is a property which allows to feedback the part of the output, to the same Circuit as its input. Such a feedback is said to be positive whenever the part of the output that is feedback to the amplifier as its input, is in phase with the voltage gain A is shown in figure 2.1.1

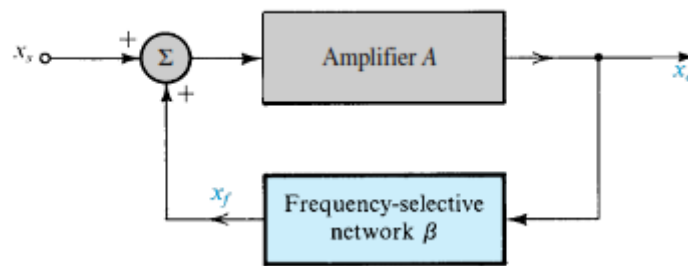


Figure 2.1.1 the basic structure of a sinusoidal oscillator

[Source: microelectronic circuits by sedra & smith, page no: 1337]

- Assume that a sinusoidal input signal V_s is applied to the circuit. As amplifier is non-inverting, the output voltage V_o is in phase with the input signal V_s .
- The part of the output fed back to the input with the help of a feedback network. no phase Change is introduced by the feedback network.
- As the phase of the feedback signal is same as that of the input applied the feedback is called positive feedback.
- The closed loop gain of positive feedback is given by,

$$A_f = \frac{A}{1 - A\beta}$$

- Thus without an input, the output will continue to oscillate hose frequency depends upon the feedback network or the amplifier or both. Such a circuit is called as an oscillator.

Barkhausen criterion

It states that

1. The total phase shift around a loop as the signal proceeds from input through amplifier, feedback network back to the input again, completing a loop, is precisely 0° or 360° or of course an integral multiply of 2π radians.
 2. The magnitude of the product of the open loop gain of the amplifier (A) and the feedback factor β is unity i.e. $|A\beta|=1$
- If satisfying these conditions, the circuit works as an oscillator producing sustained oscillations of constant frequency and amplitude.
 - In reality no input is needed to start the oscillation. In practice $A\beta > 1$ to start the oscillation and then circuit adjust itself to get $A\beta = 1$, finally resulting into self-sustained oscillations.
 - Let us see the effect of the magnitude of the product $A\beta$ on the nature of the oscillations.

1. $|A\beta| > 1$

When the total phase shift around a loop is 0° or 360° and $|A\beta| > 1$, then the output oscillates but the oscillations are of growing type.

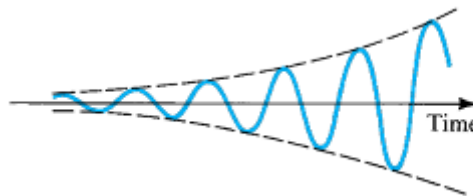


Figure 2.1.2 the growing type oscillation

[Source: microelectronic circuits by sedra & smith, page no: 871]

2. $|A\beta| = 1$

When the total phase shift around a loop is 0° or 360° and $|A\beta| = 1$, then the oscillations are with constant frequency amplitude called sustained oscillations.

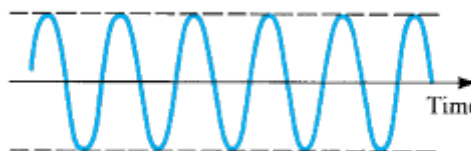
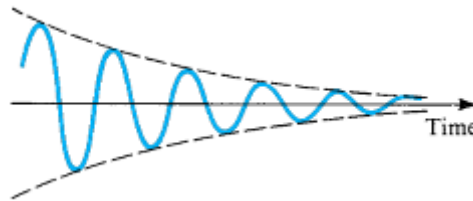


Figure 2.1.3 Sustained oscillation

[Source: microelectronic circuits by sedra & smith, page no: 871]

3. $|A\beta| > 1$

When the total phase shift around a loop is 00 or 3600 and $|A\beta| > 1$, then the oscillations are of decaying type i.e such oscillation amplitude decreases exponentially and the oscillations finally cease.

**Figure 2.1.4 exponentially decaying oscillation**

[Source: microelectronic circuits by sedra & smith, page no: 871]

Starting voltage:

- It is mentioned that no external input is required in case of oscillators.
- Every resistance has some free electrons. Under the influence of normal room temperature, these free electrons move randomly in various directions. Such movements of the free electrons generate a voltage called noise voltage, across the resistance.
- Such noise voltages present across the resistances are amplified. Hence to amplify such small noise voltage and start the oscillations, $|A\beta|$ is kept greater than unity at start.
- The circuit adjusts itself to get $|A\beta| = 1$ and with phase shift of 360° we get sustained oscillations.