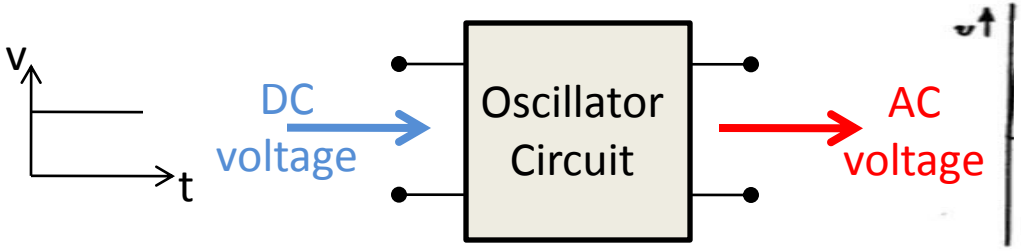
US03CPHY02
UNIT 4
Oscillators Part -1 Oscillator Fundamentals

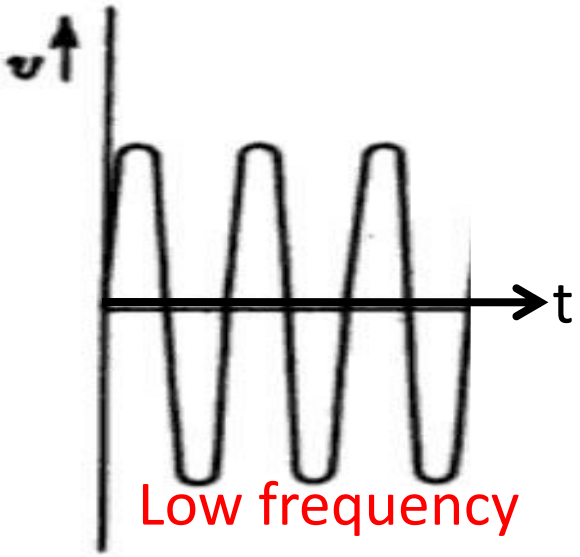
Dr. T. H. Patel
Associate Professor
VP & RPTP Science College
Vallabh Vidyanagar-388120
Gujarat, India.
pateltarunh@yahoo.com

Oscillators

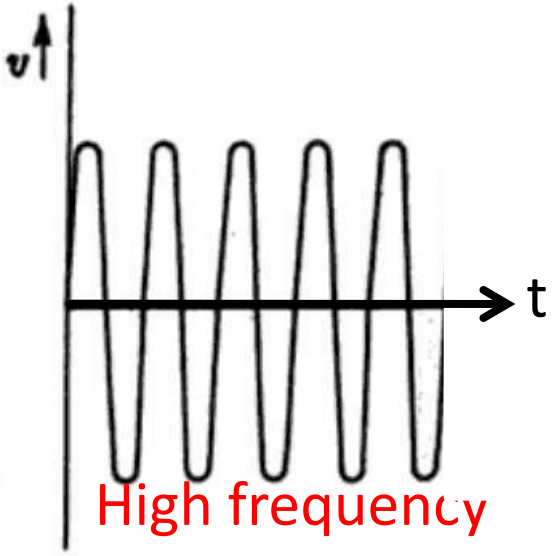
The circuit that generates alternating voltage is called an Oscillator.



Why oscillators are required?: importance



Low frequency AC voltage



High frequency AC voltage

Audio Signal Generator: 20-15KHz

to check the performance of stereo amplifier.

Communication systems:

- Radio Broadcasting:

Carrier signal frequency from 550 kHz – 22 MHz

- TV Broadcasting:

Carrier signal frequency from 47-230 MHz

Signal Generator

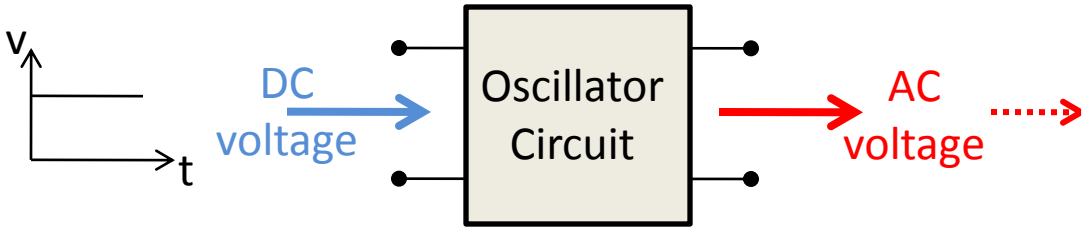
- Radio and TV receivers has oscillator circuits at high frequencies.

Applications of Signal Generator:

- Electronic Lab, Edu. Institute, Research Lab,
- Industrial material heating, Induction & dielectric heating.

Oscillators: Classification

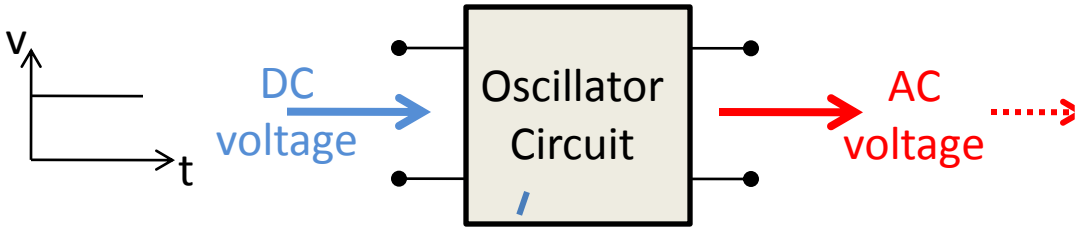
The circuit that generates alternating voltage is called an Oscillator.



*A. Sinusoidal oscillators :*that produces sine waves .

Oscillators: Classification

The circuit that generates alternating voltage i



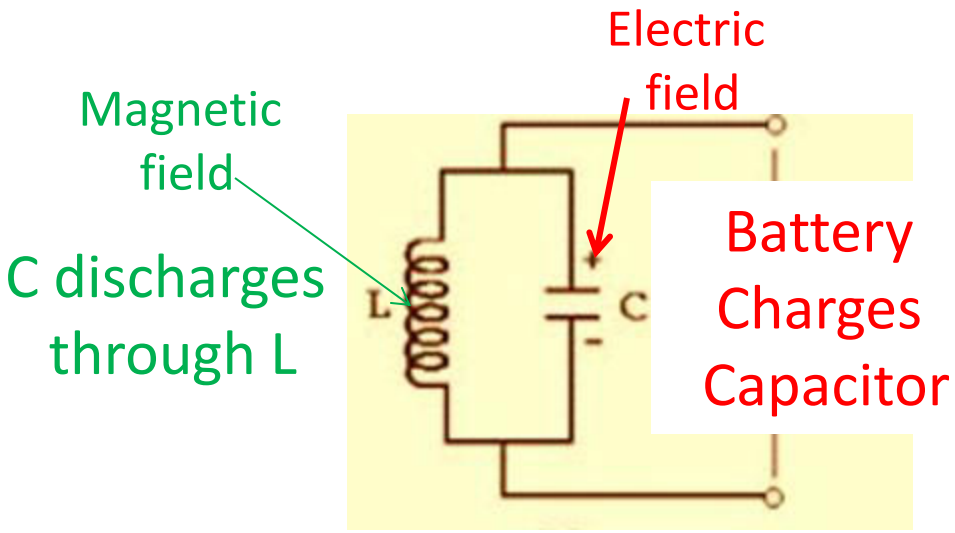
B. Non- *Sinusoidal oscillators:*
that produces non-sinusoidal waves
such as square waves or pulses
also called as *multivibrators*.

1. Tuned Circuit (LC) oscillators.
2. RC oscillators.
3. Crystal oscillators.

Can an alternator (*ac generating machine)* serve this purpose?

Alternator suitable up to 1000Hz.
For high frequency, it requires
-More rotations.
-More number of poles.
i.e. impractical

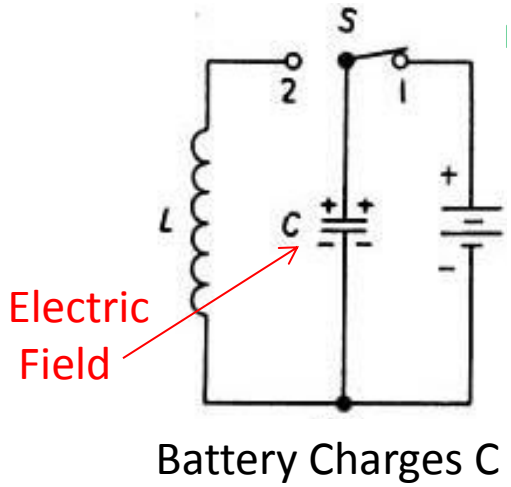
What is a Tuned Circuit or Tank Circuit ?



L and C in parallel forms a tuned or tank circuit.

Tank Circuit is capable to produce sinusoidal oscillations.

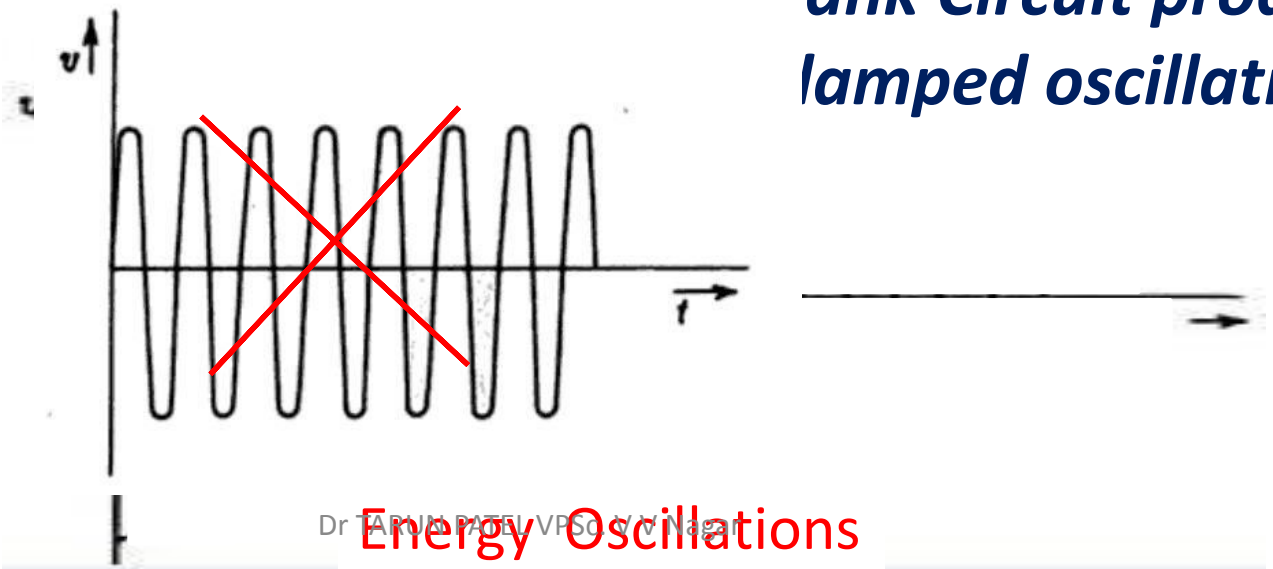
How Tuned/Tank Circuit generates sine waves?



Battery Charges C

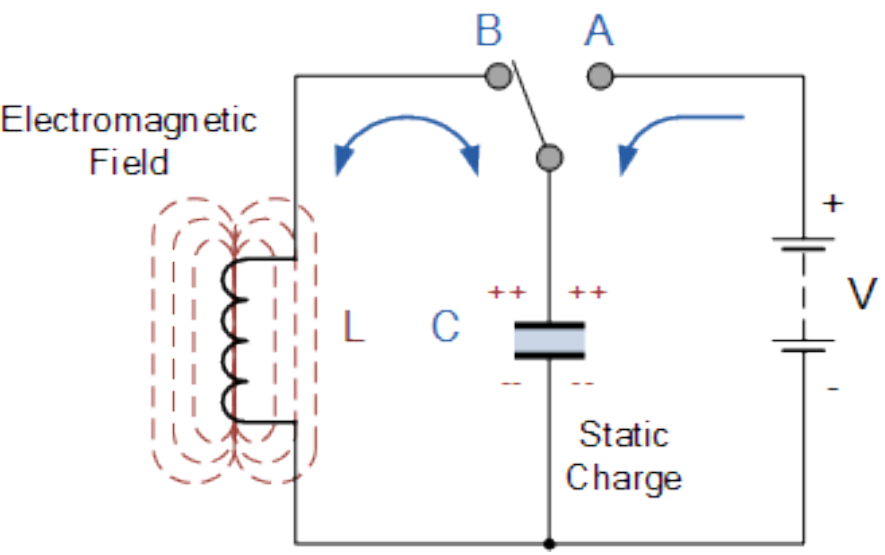
Due to resistive loss in L and dielectric loss in C energy dissipates at each oscillation .

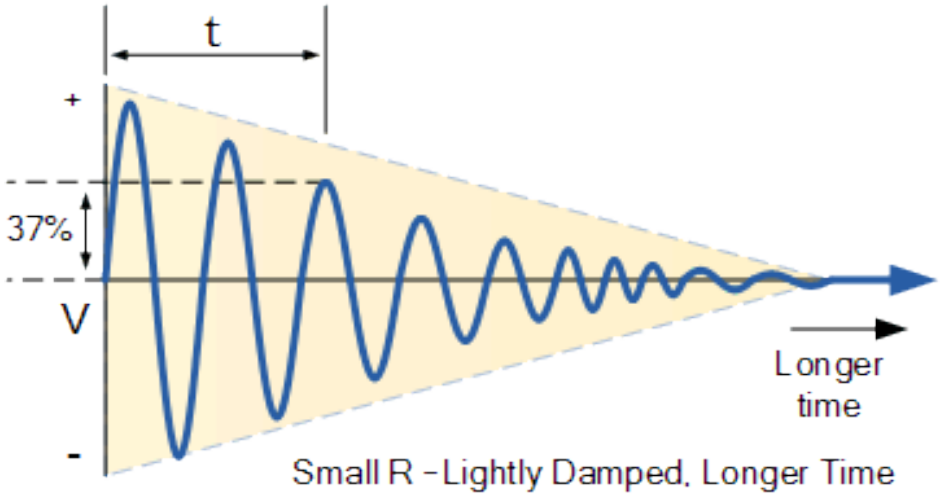
Tank Circuit produce lamped oscillations



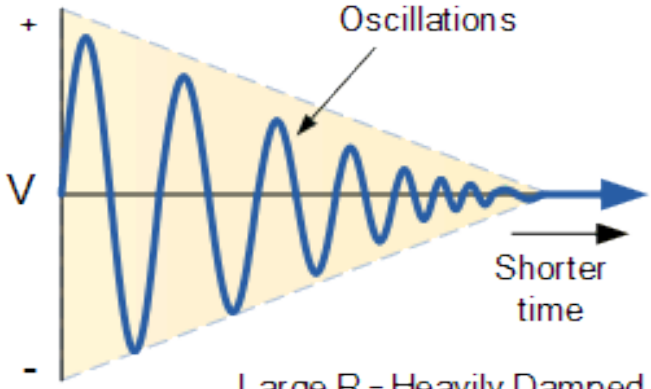
Energy Oscillations

Tuned/Tank Circuit (L and C in Parallel)



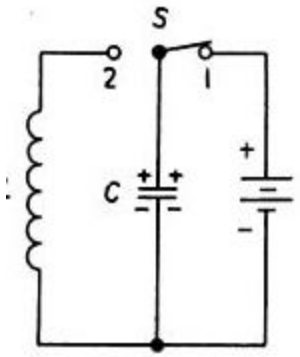


Small R – Lightly Damped, Longer Time

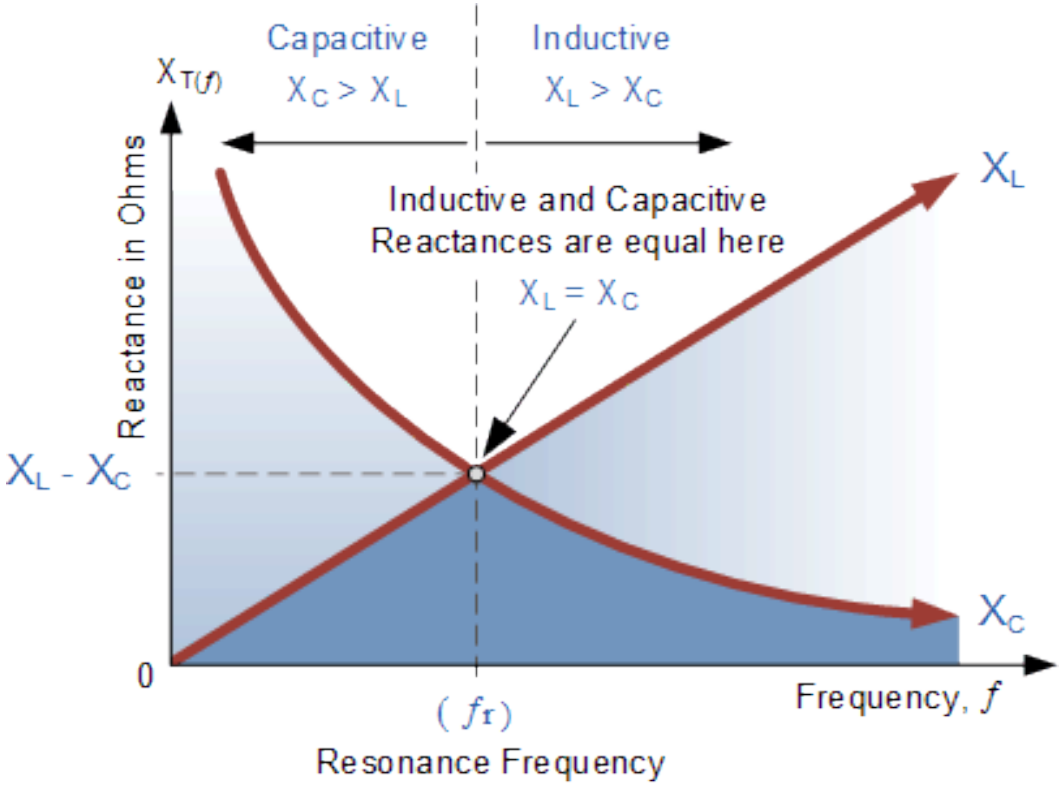


Large R – Heavily Damped, Shorter Time

Frequency of oscillations of a Tuned/Tank Circuit



$$X_L = 2\pi f L \quad \text{and} \quad X_C = \frac{1}{2\pi f C}$$



Frequency of oscillations of a Tuned/Tank Circuit

Example 1

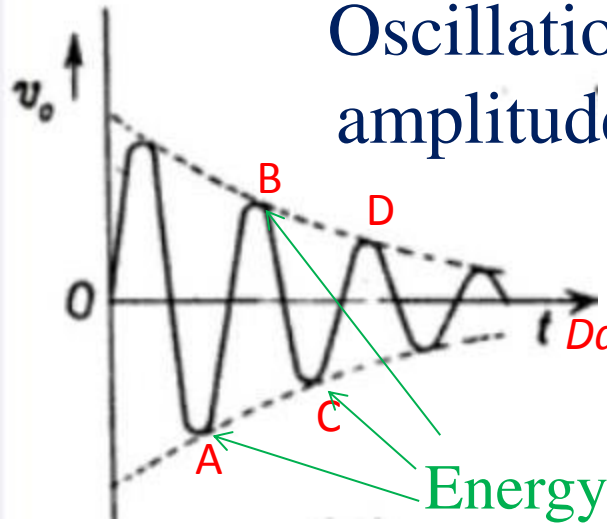
An inductance of 200mH and a capacitor of 10pF are connected together in parallel to create an LC oscillator tank circuit. Calculate the frequency of oscillation.

$$f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{200\,\text{mH} \times 10\,\text{pF}}} = 112.5\ \text{kHz}$$

What are Sustained Oscillations?

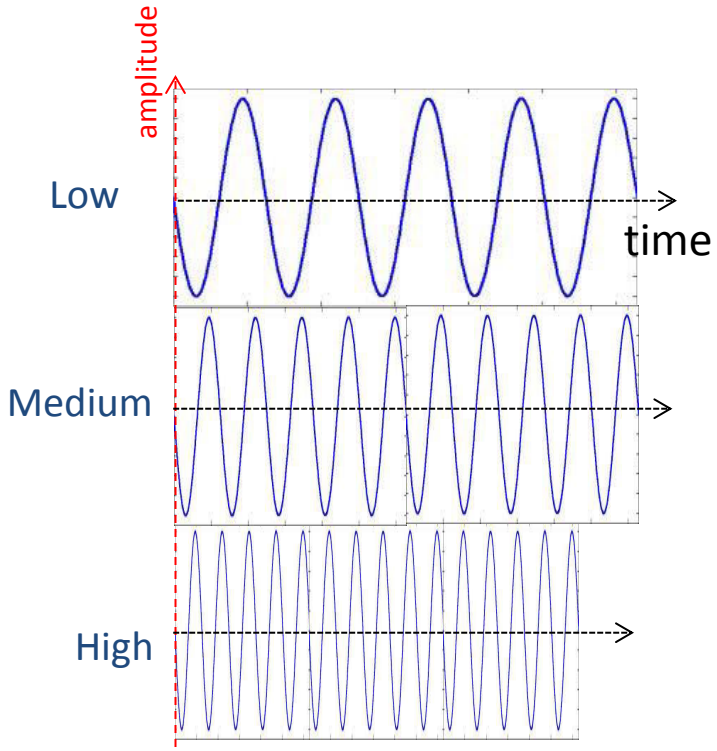
Hence by supplying energy at regular proper time interval, oscillations of constant amplitude of desired frequency can be obtained.

Oscillations of a certain freququncy at constant amplitude are called as *Sustained Oscillations.*



Damped oscillations of LC circuit

Energy supply (spurt)



ned oscillations

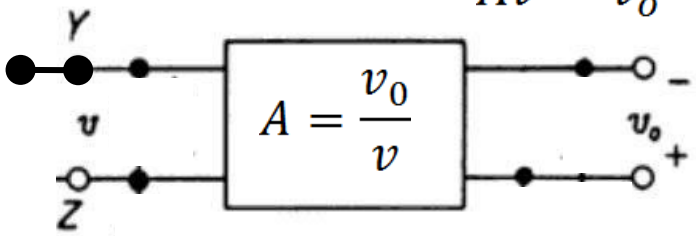
Sustained oscillations

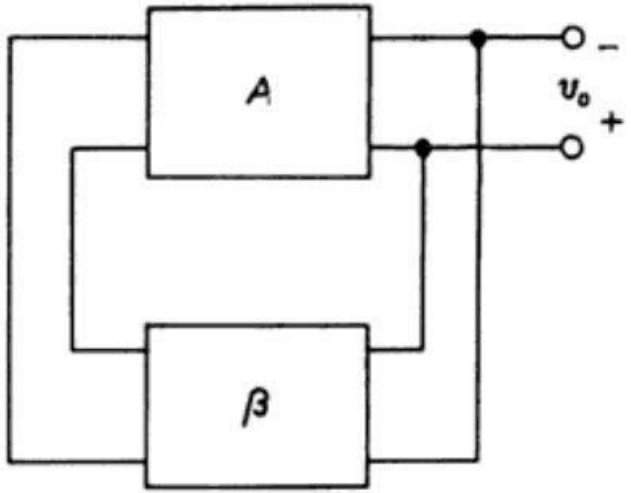
LC oscillator circuit: Features.

1. Must contain an amplifier (with active device like transistor or tube).
2. The amplifier must use positive feedback.
3. The amount of feedback must be sufficient to overcome the losses (resistive and dielectric).

Positive Feedback Amplifier as an oscillator.

$$Av = v_o$$





$$v_f = \beta v_0 = A\beta v$$

$$v_f = \beta v_0 = A\beta v$$

Positive Feedback Amplifier as an oscillator.

$If\ A\beta < 1, then\ \ A\beta v < v$

so, every time feedback volatge will be less than the input voltage v and so output voltage decreases.

Hence oscilattions dies out (damped oscillations)

$If\ A\beta > 1, then\ \ A\beta v > v$

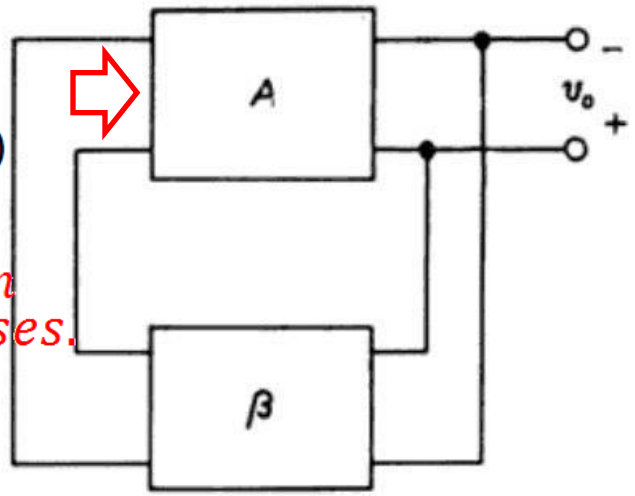
so, every time feedback volatge will be more than the input voltage v and so output voltage increases.

Hence, growing oscillations are obtained.

$If\ A\beta = 1, then\ \ A\beta v = v$

so, every time feedback volatge will be same as the input voltage v and so output voltage remains constant

Hence sustained oscilattions are obtained.



$v_f = \beta v_0 = A\beta v$

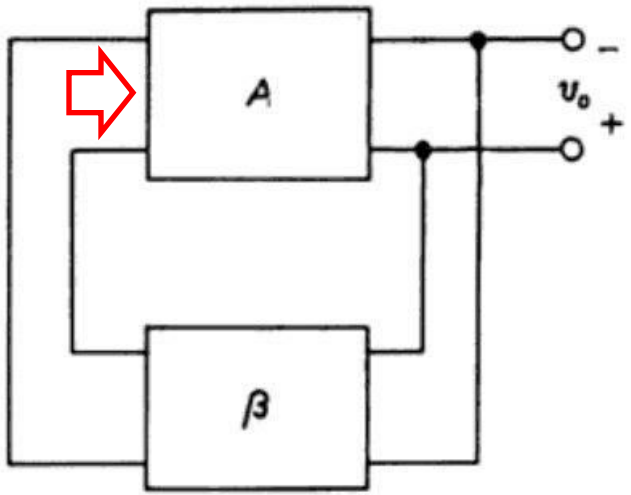
Positive Feedback Amplifier as an oscillator.

Hence, for sustained oscillation $A\beta = 1$.

For Positive feedback amplifier, we have

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

$$If\ A\beta = 1, \qquad A_f = \frac{A}{1-1} = \frac{1}{0} = \propto$$



Hence, gain becomes infinity i.e.

"Output is obtained without any input".

The amplifier is now becomes an *oscillator.*

The condition

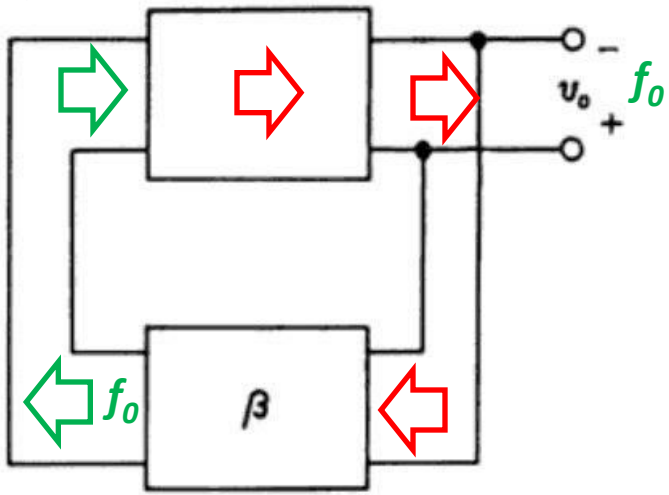
$$A\beta = 1$$

is known as *Barkhausen Criterion of oscillations*.

Starting Voltage in oscillator.

The random motions of electrons in the circuit generates sinusoidal noise voltage signals of small amplitudes of various frequencies.

Such signals are amplified ,reaches at the output and appear at the input of the feedback network and drive it.



$$v_f = \beta v_0 = A\beta v$$

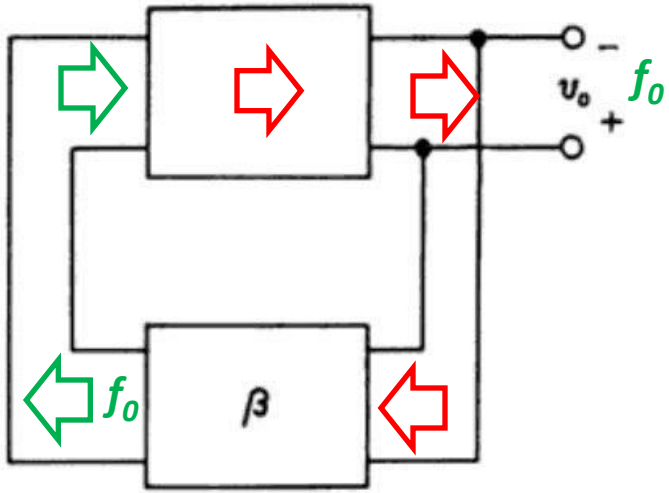
Since the feedback network is either a resonant circuit or a phase shift network the feedback voltage $A\beta v$ is maximum only at a frequency of resonance f_o.

In addition, the phase shift required for positive feedback is correct at this frequency f_o only.

Hence the output of the oscillator contains only one sinusoidal frequency f_o.

How oscillations obtained at the output of oscillator ?

1. Switch ON the circuit.
2. Initially keep Aβ > 1, i.e. positive feedback so oscillations can built-up.
3. At suitable level decrease the gain of *amplifier to unity i.e. 1 so that sustain oscillations start.*



$$v_f = \beta v_0 = A\beta v$$

What are requirements of oscillator Circuit ?

1. There must be Positive feedback.
2. Initially loop gain Aβ > 1.
3. At desired level loop gain must decrease to Aβ = 1 for sustained oscillations .

Oscillators: Types

LC Oscillators:
1. Hartley oscillator
2. Colpitts oscillator

RC Oscillators:
1. Phase-shift oscillator
2. Wein Bridge oscillator

Crystal Oscillators:
1. Piezoelectric oscillator

Oscillators: Part-2