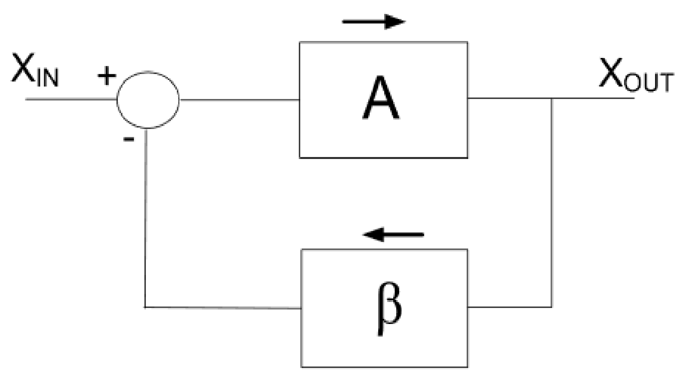
Answer on Question #75507 - Physics - Electric Circuits

Barkhausen Criterion for Sustained Oscillation



$$\boldsymbol{A_{FB}(s) = \frac{A}{1 + A\beta} = \frac{N(s)}{D(s)}}$$

Aβ termed the loop gain

"A feedback amplifier will have sustained oscillation if Aβ = -1."

Stated simply the condition Aβ = -1 at $\omega = \omega_o$ (frequency of oscillation), i.e. the magnitude of loop gain should be one and phase of loop gain should be unity (the feedback network '**β**' introduces 180^o phase shift, the other 180^o phase shift is provided by mixer '**A**') is called Barkhausen criterion.

A closed loop system with negative feedback can be represented by the transfer function $\mathbf{A_{FB}(s)}$. Often feedback network consists of only resistive elements and is independent of frequency, but amplifier gain is a function of frequency. Hence the loop gain Aβ is a function of frequency. There may exist a frequency ω_o at which its magnitude is one and phase is 180^o i.e., Aβ = -1 (Barkhausen criterion). At that frequency overall gain of system is very large theoretically infinite. Noise at the input of amplifier consists of all frequencies with negligible amplitudes. For all frequencies other than the oscillator frequencies the amplifier gain will not be enough to elevate them to significant amplitudes. But at that frequency where oscillator oscillates it provides very large gain and the amplitude of corresponding sine wave will be limited by the nonlinearity of the active device.

Phase-shift Oscillator Circuit

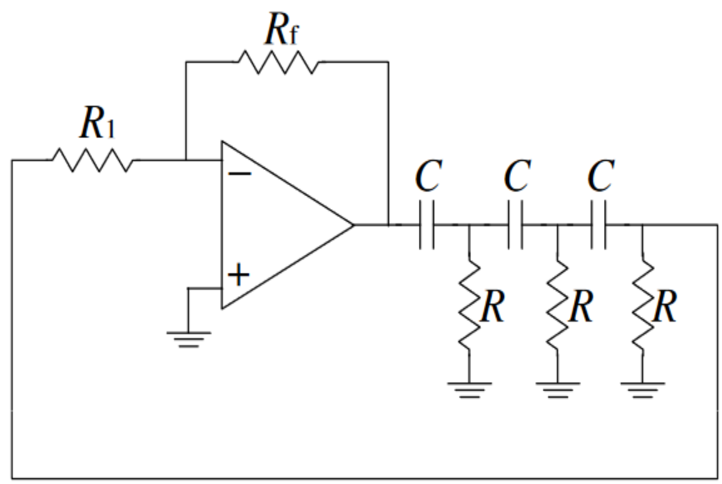


Figure above shows the circuit for a phase shift oscillator, in which the feedback circuit employs three cascaded RC sections to shift the phase by 180°. An additional shift of 180° is obtained by using an inverting amplifier.

Ignoring loading effects, β can be calculated over the feedback betwork, and is given by

$$\beta = \frac{1}{1 - \frac{5}{(\omega RC)^2} + j\left(\frac{1}{(\omega RC)^3} - \frac{6}{\omega RC}\right)}$$

For a phase shift of 180°, the imaginary part is zero, which leads to

$$\omega_o = \frac{1}{RC\sqrt{6}}$$

Then

$$\beta = -\frac{1}{29}$$

And the gain required by the Barkhausen criterion is

$$A = \frac{1}{\beta} = -29$$

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