

EE3122: Analogue Circuit Fundamentals

Oscillator

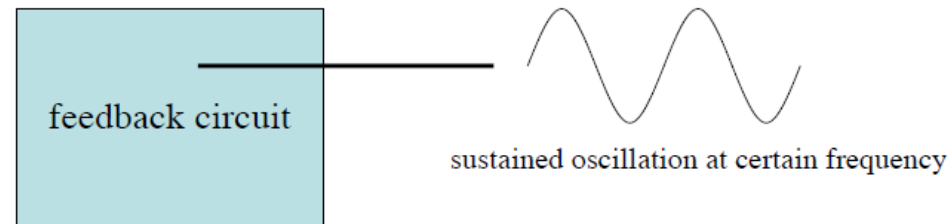
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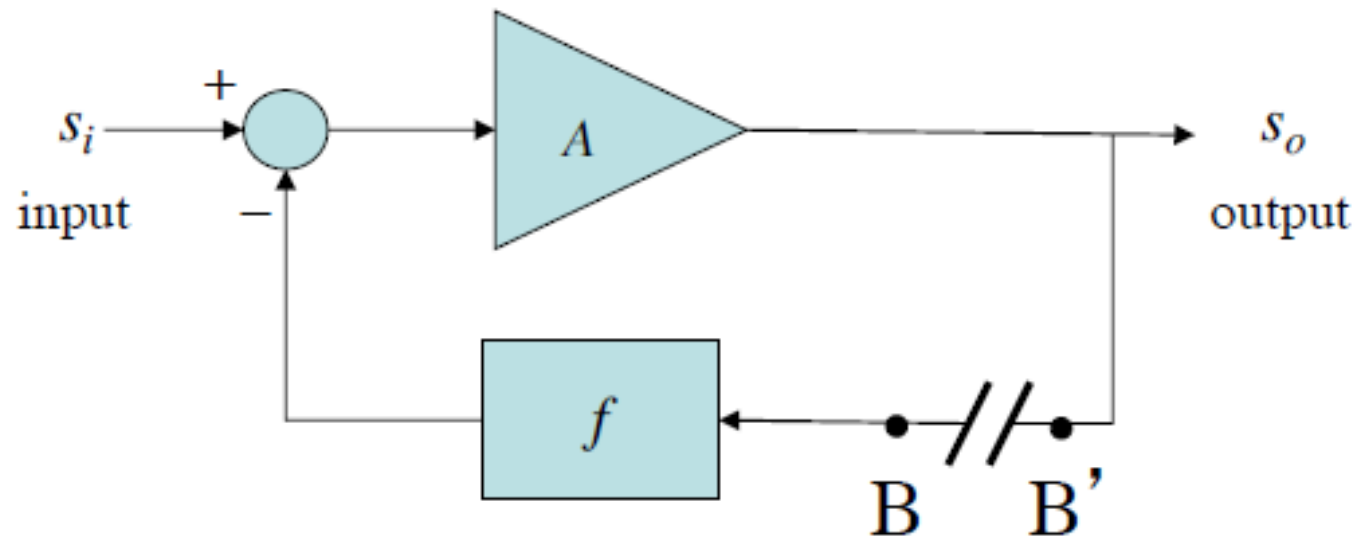
Stability of Feedback Systems

- A feedback system is said to be stable if it does not oscillate by itself at any frequency under a given circuit condition.
- The issue of stability can be investigated in terms of the possibility of sustained oscillation.



Why and How does it Oscillate?

- The feedback system oscillates because of the simple fact that **it has a closed loop in which signals can combine constructively.**



If no input signal:

$$S_{B'} = -A f S_B$$

Signal at B, as it goes around the loop, will be multiplied by f and A , and also -1 .

Why and How does it Oscillate?

- if $S_{B'}$ and S_B are same in magnitude and have a 360° phase difference, then the closed loop will oscillate by itself.
- Oscillation criteria (Barkhausen criteria):

$$Af = -1$$

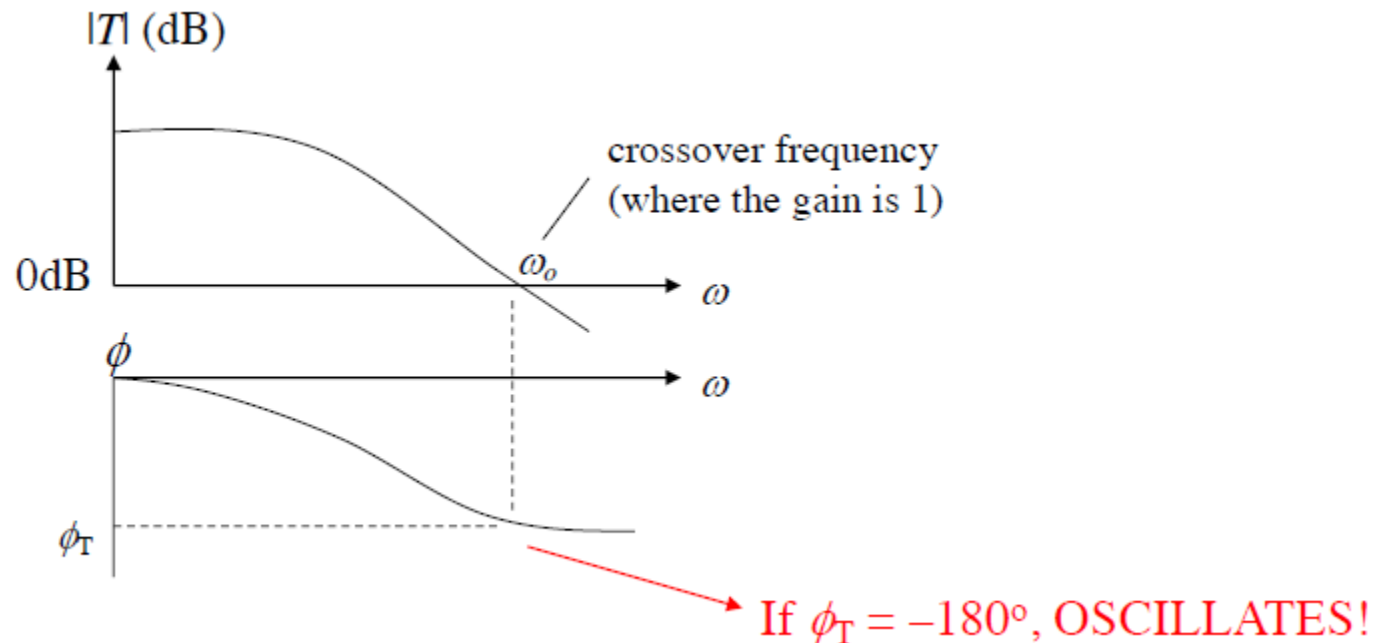


$$\begin{cases} |Af| = 1 \\ \phi_A + \phi_f = (2n + 1)\pi \quad (n \text{ is integer}) \end{cases}$$

- If the signal, after making a round trip through A and f , has a gain of 1 and a phase shift of exactly 360° , then it oscillates.
- But, in the negative feedback system, there is already a 180° phase shift.
- Therefore, **the phase shift caused by A and f together will only need to be 180° (or $(2n+1) * 180^\circ$) to cause oscillation.**

Loop Gain & Stability Criteria

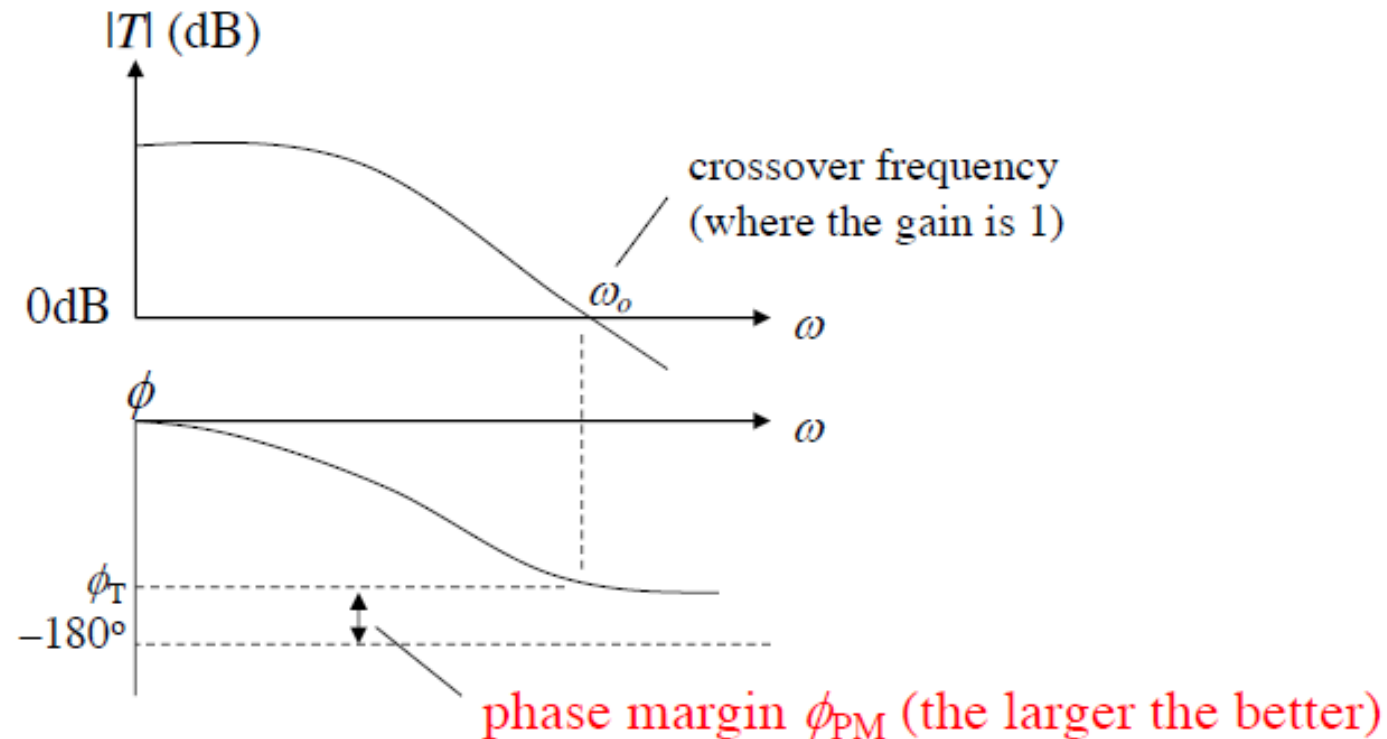
- An important parameter to test stability is the loop gain, usually denoted by T ($T = Af$).



Phase Margin

- Phase margin is an important parameter to evaluate how stable the system is.

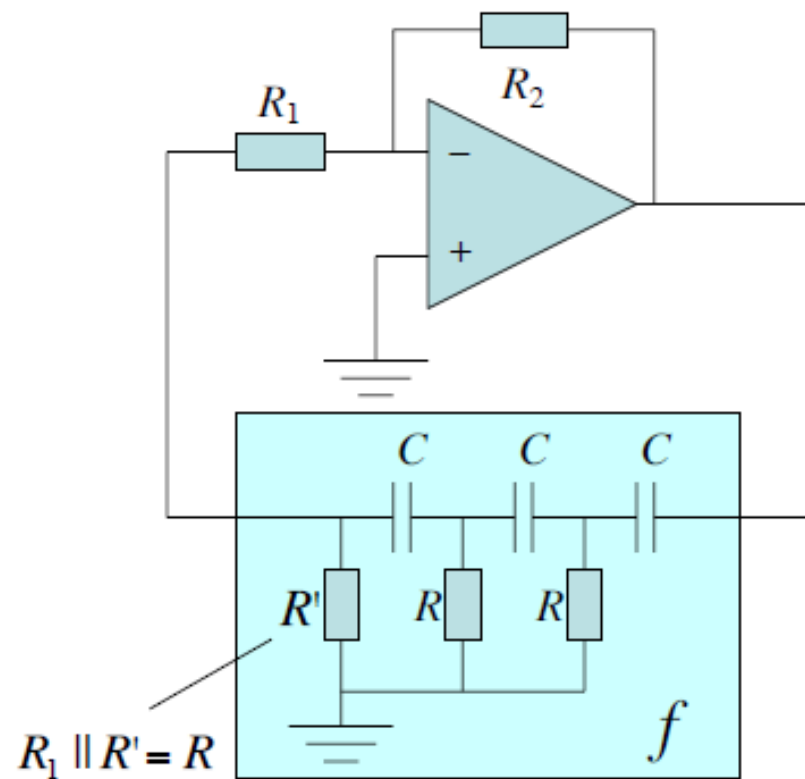
$$\text{Phase margin } \phi_{\text{PM}} = -180^\circ - \phi_T$$



Oscillation

- In designing feedback amplifiers, we want to make sure that oscillation does not occur, that is, we want stable operation.
- However, oscillation is needed to make an oscillator.
- The same feedback structure can be used to make an oscillator. In other words, we construct a feedback amplifier, but try to make it satisfy the **Barkhausen criteria**.
- **In practice, T is a function of frequency, and the **Barkhausen criteria** is satisfied for one particular frequency. This frequency is the oscillation frequency.**

Phase Shift Oscillator



- The phase-shift network consisting of resistors and capacitors in a ladder network.
- The feedback network 'shifts' the phase of the amplifier output by 180 degrees at the oscillation frequency to give positive feedback.
- Phase-shift oscillators are often used at audio frequency as audio oscillators.

Appendix

Sustained oscillation (Self-oscillation)

- There are two problems!
 - How does oscillation start? **Noise!**
 - How can oscillation be maintained? If $|T|$ is slightly bigger than 1, oscillation amplitude will grow and go to infinity. But if $|T|$ is slightly less than 1, oscillation subsides.

Sustained oscillation (Self-oscillation)

- We need a control that changes $|T|$ continuously. Typically, this is done by a *nonlinear amplitude stabilizing circuit*, for example, an amplifier whose gain drops when its output increases, and rises when its output decreases.

