- ***Some Definitions***:
  - ➢ ***Loop Gain*** (L) = fA
  - ➢ ***Return Difference*** (D) = 1 + L
  - ➢ ***Amount of Feedback*** (N) = 20 $\log_{10}$D (dB)
- ***Positive Feedback***:
  - ➢ ***Output fed back to the input through the mixer***, ***but now with a positive sign***

    $\Rightarrow$ ***Feedback signal gets added to the input signal***

- ***Show that under this condition***:

$$A_f(j\omega) = \frac{A(j\omega)}{1 - f(j\omega)A(j\omega)} = \frac{A(j\omega)}{1 - L(j\omega)}$$

- This is a ***general expression***, taking both A and f as ***frequency dependent***
- Note: As $L \to 1$, $A_f \to \infty$
  - ***Implies that output is possible even without any input***
  - This is the ***basic principle of oscillation***

- ***Conditions for Oscillation***:

  Barkhausen's Criteria:

  ➢ ***L becoming unity implies that the signal has completely regenerated itself while traversing once through the loop***

    $\Rightarrow$ ***There is no need for any input any more***, ***since the loop has become self-sustained***!

  ➢ ***Since A and f are frequency dependent***, hence, ***there may exist a frequency*** ω_0, at which:

    $L(j\omega_0) = f(j\omega_0)A(j\omega_0) = 1$

- Since ω_0 is a ***particular frequency***, for which ***this condition holds***, hence, the output will be a ***pure sinusoid*** of ***this frequency***
  - Similar to ***picking out*** f_0 only from a ***Fourier Spectrum***
  - This phenomenon is known as ***Sinusoidal Oscillation***
- German physicist ***Heinrich Georg Barkhausen*** summed this up by ***two conditions***, came to be known as the ***Barkhausen's Criteria***:

1. $|L(j\omega_0)| = 1$ and
2. $\angle L(j\omega_0) = 0°$

- ***Barkhausen's Criteria in words***:

  For a feedback system to oscillate, the magnitude of the loop gain must at least be unity, and the total phase shift around the loop should be 0° or 360°

- ***If these criteria are satisfied exactly***, then the ***oscillations would go on forever***, and ***can be stopped only by shutting the power off for the system***

- However, for ***practical circuits***, the ***exact conditions for oscillations*** are ***very difficult to achieve***

- If |L| becomes ***slightly less than 1***, but $\angle$ L is ***exactly 0°***, then with ***each pass around the loop***, the ***amplitude of oscillation*** would keep on ***going down***, and eventually, it will ***die down*** on its own
  - Thus, ***under this condition***, ***sustained sinusoidal oscillation won't be achieved***
- On the other hand, if |L| becomes ***slightly larger than unity***, but $\angle$ L is ***exactly 0°***, then with ***each pass around the loop***, the ***amplitude*** of the signal will ***keep on growing***
  - Will eventually ***get limited*** by the ***nonlinearities*** present in the circuit

Stability

- ***2 Types of Systems***:
  - ***Stable***
  - ***Unstable***
- ***Stable System***:
  - ***Any transient disturbance would result in a response that will die down with time***
  - ***The system will be able to get rid of the disturbance on its own***

- ***Unstable System***:
  - ***Any transient disturbance would result in a response that will persist or even blow up with time***
    - ***Eventually gets limited by the nonlinearities of the system***
  - ***Positive feedback systems are inherently unstable***
    - ***They are designed as such***, e.g., ***oscillators***
  - ***Negative feedback systems are inherently stable***