- Also, for a ***two-pole system***, the ***phase reaches $-180°$ only when the frequency becomes infinite*** (***mathematically***)
  - $\Rightarrow$ ***There is no physically achievable frequency when this can happen***
  - $\Rightarrow$ ***Unconditional Stability***

- ***System With Three (or More) Poles***:
  - ***Actual mathematical analysis quite tedious***
  - It can be shown that as the ***amount of feedback (D) is increased***:
    - ***The highest frequency pole (ω_{p3}) moves outward along the $-\sigma$-axis***

- ***The other two poles (ω_{p1} and ω_{p2}) move towards each other*** (***similar to a two-pole system***)
- As ***D is increased further***, these ***two poles eventually merge***, and then start having ***imaginary components***
- Their ***real part*** also ***keeps on changing with D***, ***keeping the nature of complex conjugacy intact***, and ***moves right in the s-plane***
- ***The path traced out by these poles is known as the root locus***
- ***For a particular value of D***, this ***root locus intersects the imaginary axis of the s-plane at two symmetric points***

- ***Under this condition***, ***sustained sinusoidal oscillation can be achieved***, ***since it now has a complex conjugate pair of poles without any real part*** (ω_{p3} ***will be so large that it will be inconsequential***)
- ***With further increase in D***, the ***root locus enters the RHP*** with the ***poles now having positive real part***

  $\Rightarrow$ ***Potentially dangerous situation in terms of stability***
- ***In terms of phase***, the ***total can be –270°***

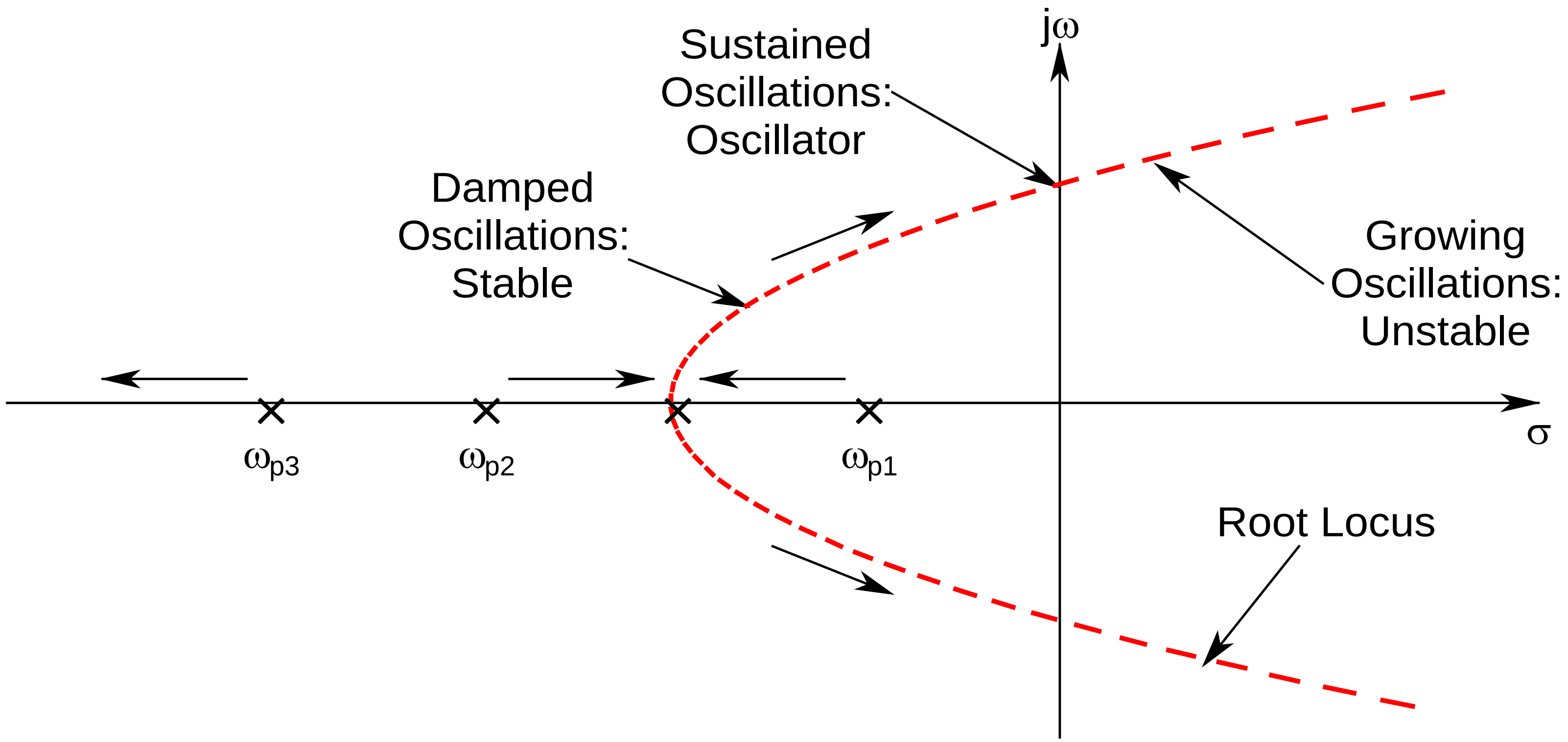
  $\Rightarrow$ ***There exists a particular value of f***, for which the ***phase will become –180°***

- ***Under this condition***, ***if the magnitude of the loop gain is exactly unity***, ***then the system will break out into spontaneous oscillation***, however, ***the amplitude will be controlled***

  $\Rightarrow$ ***Sustained sinusoidal oscillation***

- ***This particular value of f is known as the critical feedback factor (f_{crit}) for oscillation***
  - For $f < f_{crit}$, the ***system will be stable***
  - For $f > f_{crit}$, the ***system will be unstable***

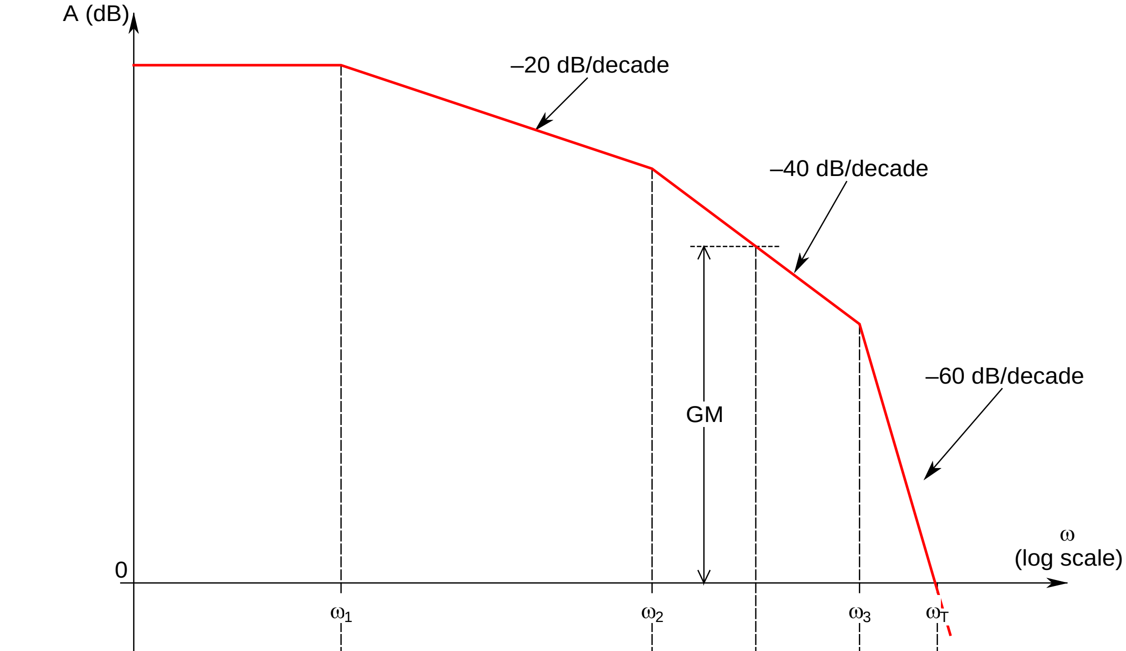
- Thus, the system is ***NOT Unconditionally Stable***, but ***stable only till a specific value of f***
  - Known as ***Conditionally Stable System***



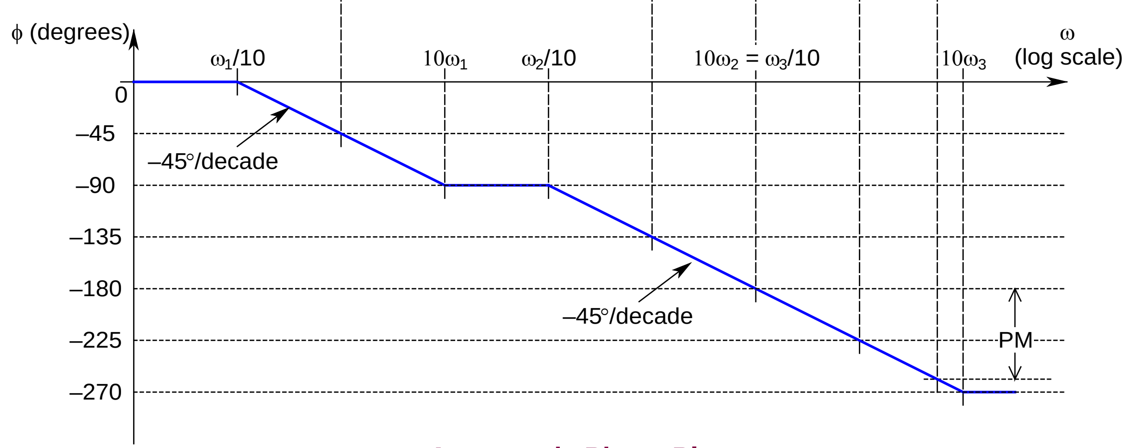
Root Locus of the Poles of a Three-Pole System as D is Increased

Stability Study Using Bode Plot

- The ***most convenient*** and the ***most useful***
- ***Recall***: ***Single- and Two-Pole Systems are unconditionally stable***
- Consider a ***Three-Pole System***, with the ***pole frequencies*** at ω_1, ω_2, and ω_3, with $\omega_3 = 100\omega_2$, and $\omega_2 > 100\omega_1$
- ***Note***: ***$A = L$ if $f = 1$*** (***100% feedback***)
- Refer to the next slide (***Bode Plot***)



Asymptotic Gain Plot



Asymptotic Phase Plot