SNS COLLEGE OF TECHNOLOGY

(AN AUTONOMOUS INSTITUTION)

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Department of Biomedical Engineering

Course Name: Control Systems

III Year : V Semester

Unit III –Frequency Response

Topic : Nyquist Stability Criterion

Introduction

- The Nyquist criteria help us determine the closed-loop system's stability from the frequency response of the open-loop poles and plot.
- We know that F(s) is a function of s. The polynomial in the numerator and denominator of the system in terms of s can be represented as: $F(s) = (s - z_1)(s - z_2)\ldots(s - z_m)/(s - p_1)(s - p_2)\ldots(s - p_n)$
- The given function has m number of zeroes and n number of poles.
- S in the function is a complex variable, and it is given by $\sigma + j\omega$. Thus, F(s) is also a complex function that can be represented in the form $u + jv$.

Introduction

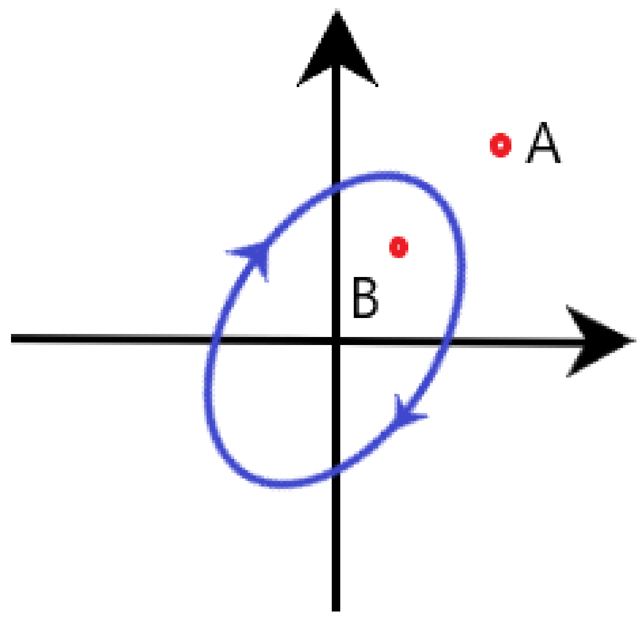
- It means that for every point of s in the s-plane at which the F(s) is analytic, there exists a corresponding point in the F(s) plane. The function f(s) maps into the f(s) plane. There is a contour that maps on the contour on the other side.
- In the Nyquist plot, we will detect the presence of the closed-loop system poles in the right half of the s-plane to determine the system's stability.
- The Nyquist stability criterion works on the principle of argument. It states that if there are P poles and Z zeros are enclosed by the 's' plane closed path, then the corresponding G(s)H(s) plane must encircle the origin P−Z times. So, we can write the number of encirclements N as,

$$N=P-Z$$

Introduction

Encircled:

- If a point is said to lie inside the closed path, it is said to be encircled.



Enclosed:

- If a point lies to the right side of path when the path is traversed in a specific direction, it is said to be enclosed by a closed path.

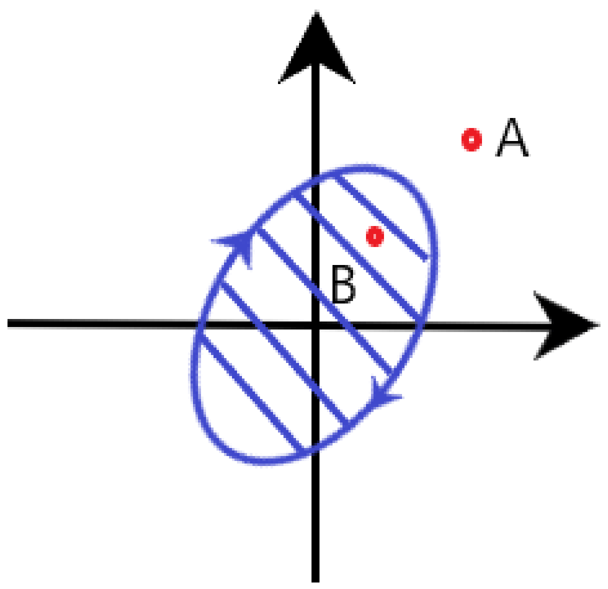


Figure 1

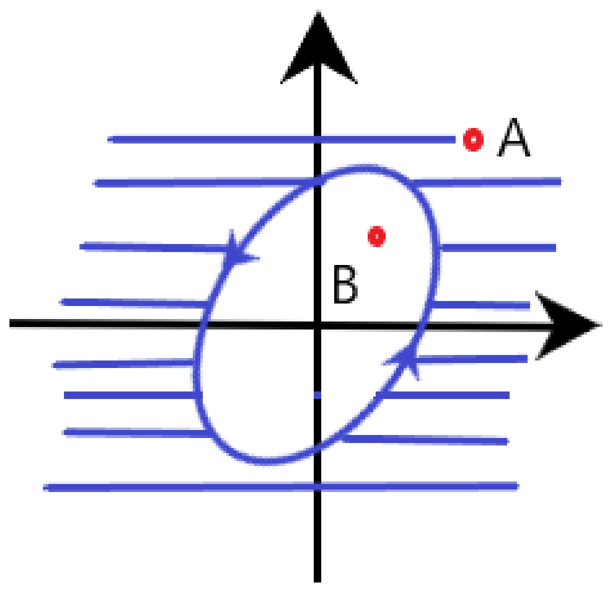
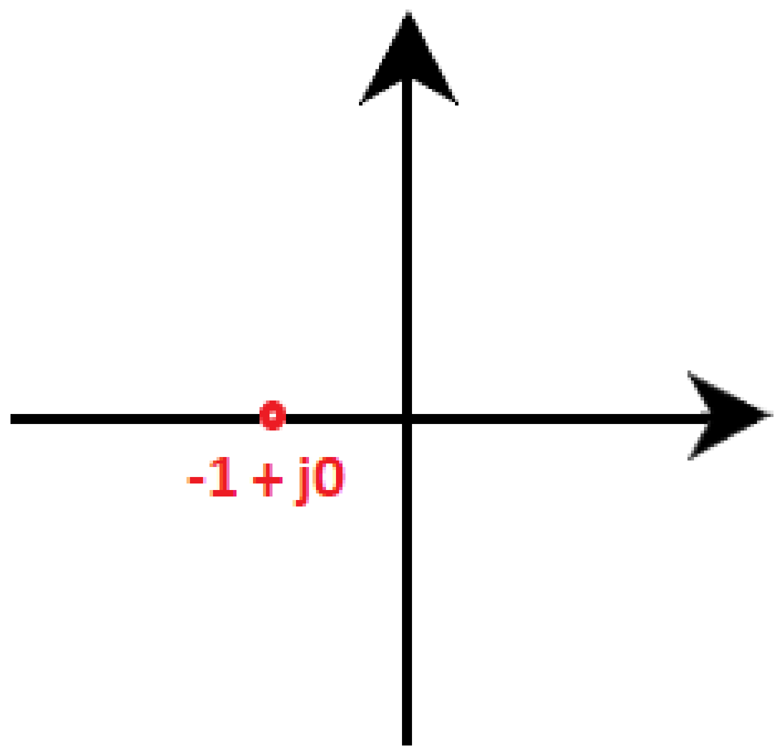


Figure 2

Nyquist Stability

- The Nyquist stability criterion is based on the point -1 + j0 to determine the stability of the closed loop system. It is because the contour of the function F(s) with respect to the origin of the plane is same as the contour of the F(s) -1 plane with respect to the point -1 + j0.



Nyquist Stability

Encirclement of point -1 + j0

- There should be no encirclement of point -1 + j0. We know that the system is stable if the poles are present on the left half of the s-plane. Here, no encirclement means that the system is stable if there are no poles on the right side of the s-plane. The poles present on the right half of the s-plane makes the system unstable.

Anticlockwise encirclements of point -1 + j0

- The anticlockwise encirclements of the point -1 + j0 are equal to the number of poles present in the right half of the s-plane. If such encirclements are not equal to the number of poles, the system becomes unstable.

Clockwise encirclements of point -1 + j0

- There should be no clockwise encirclements of the point -1 + j0 in the Nyquist plot to stabilize the system. If such encirclements are present in the plot, the system is always unstable.