Modelling and control summaries

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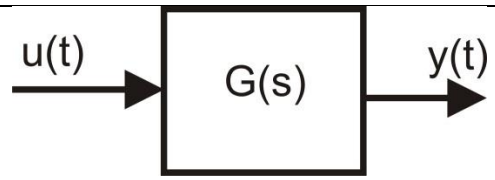
Nyquist 2: Using gain and phase



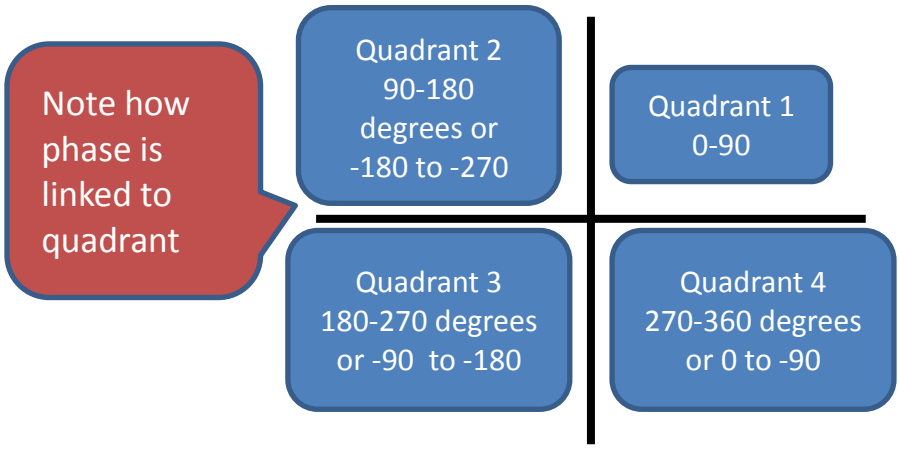
SUMMARY of Frequency response

$$G(jw)$$

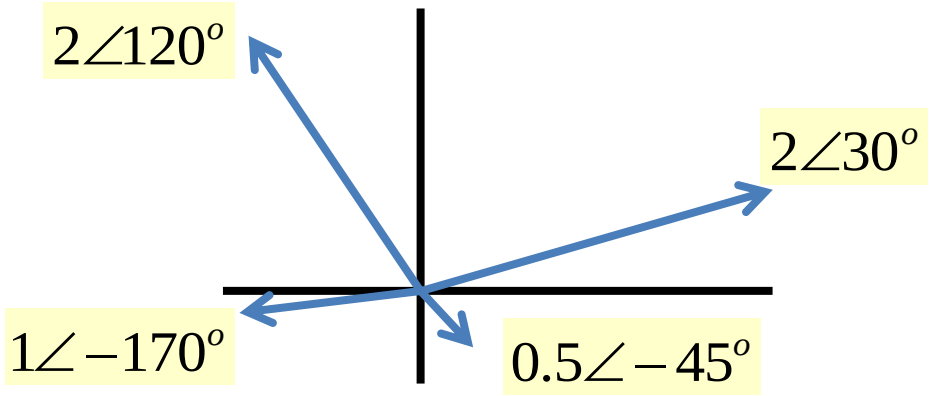
UNDERSTANDING COMPLEX NUMBERS

Students need a clear view on how the gain and phase of a complex number link to a position in the Argand diagram.

GAIN is distance from the origin.



MARK some examples on an Argand diagram



REMARKS:

1. On easy way to sketch a Nyquist diagram is to transcribe gain and phase information.
2. Students may realise that gain/phase is already available in the Bode diagram!

From hereon, assume the Bode diagram is already known.

GUIDELINES FOR QUICK SKETCHES (beginning from Bode)

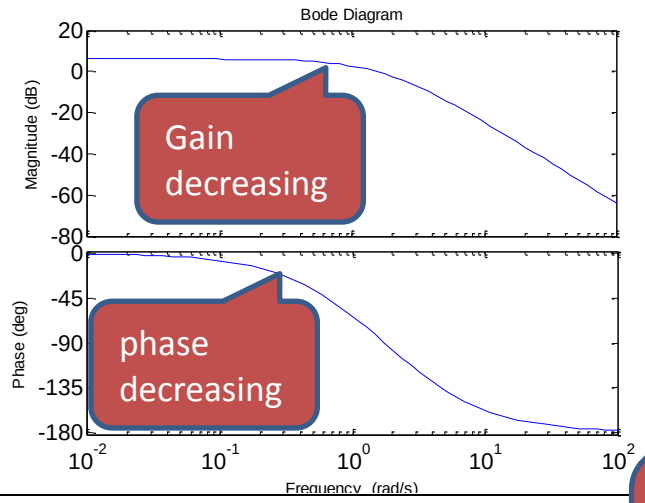
1. **Phase is reducing (or becoming more negative) – plot is moving clockwise.**
2. **Phase is increasing – plot is moving anti-clockwise.**
3. **Gain is reducing – plot is moving towards origin.**
4. **Gain is increasing – plot is moving away from the origin.**

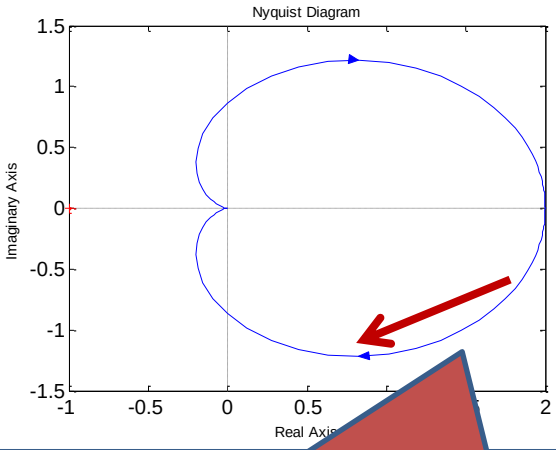
You can use arrows to represent this insight.

$$G = \frac{6}{(s+1)(s+3)}$$

$$|G(jw)| = \frac{6}{\sqrt{(w^2+1)(w^2+9)}};$$

$$\angle G(jw) = -\tan^{-1} w - \tan^{-1} \frac{w}{3}$$





As w increases,
- plot goes closer to origin (gain decreases)
- plot goes clockwise (phase decreases)

INDICATING TRENDS

From any given point, one can deduce the direction of change of a Nyquist diagram and this enables a quick sketch.
Mark arrows for change of phase and change of gain and movement is between these two.