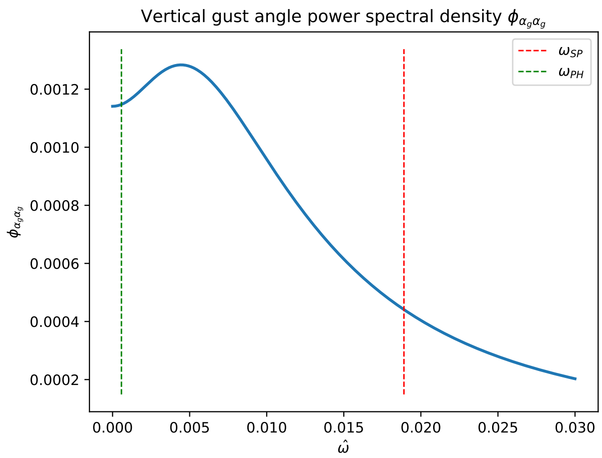
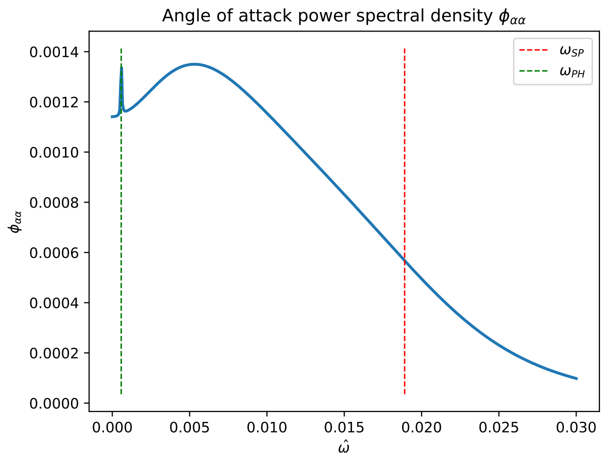
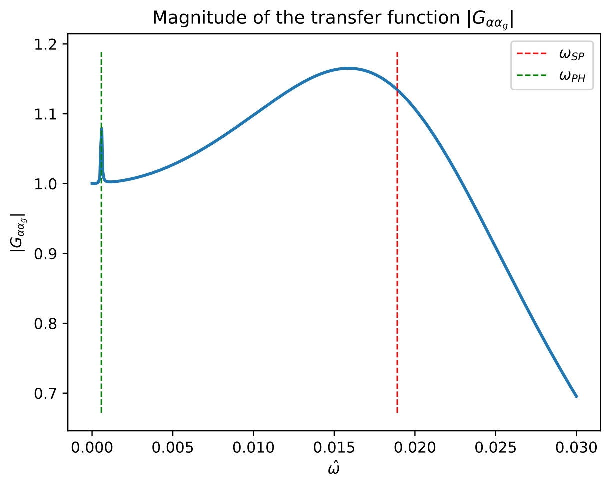
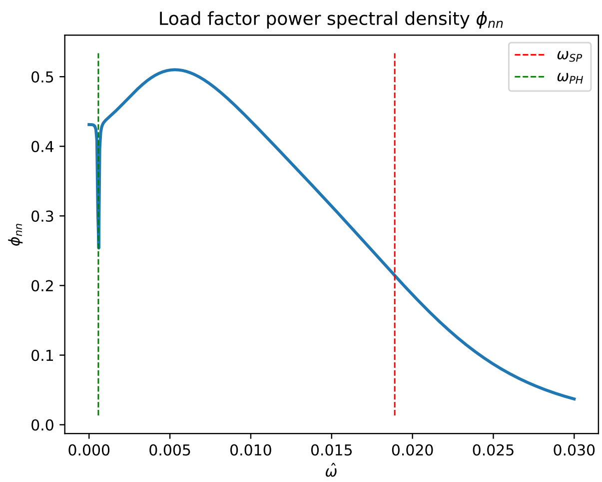
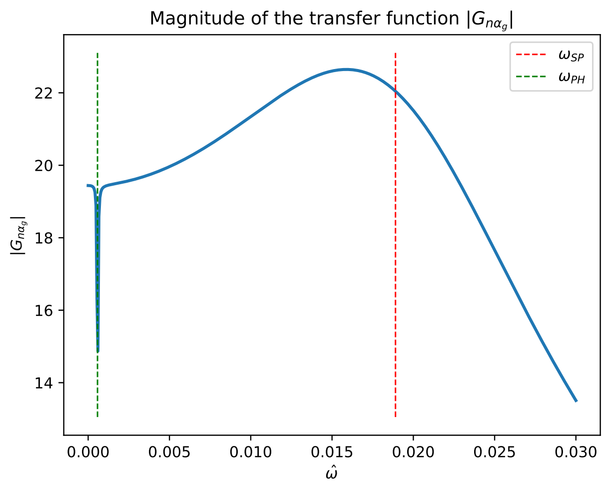
Spectral response to vertical gust











The power spectral density describes how the signal energy is distributed across different frequency components. From the input spectrum, it can be observed that turbulence exhibits a higher energy content at low frequencies, indicating a slow variability of the vertical wind, with a maximum around $\hat{\omega} = 0.005$. As the frequency increases, the energy content progressively decreases, becoming negligible beyond the short-period mode frequency. This indicates that most of the wind energy is concentrated in long-duration events rather than in rapid fluctuations.
The power spectral density of the angle of attack, $\Phi_{\alpha\alpha}$, shows an overall behavior similar to that of the input spectrum, with the presence of a peak at the phugoid-mode frequency. This behavior is consistent with the fact that the magnitude of the transfer function exhibits a relative maximum at the same frequency. At higher frequencies, although the magnitude of the transfer function slightly increases, the power spectral density decreases due to the reduced energy of the input turbulence.
The power spectral density of the load factor, Φ_{nn}, also follows the trend of the input spectrum, but exhibits a relative minimum at the phugoid-mode frequency. This feature is associated with a strong reduction in the magnitude of the transfer function at that frequency, resulting from the combination with opposite signs of the transfer functions composing $\hat{G}_{n\alpha_g}$, namely $\hat{G}_{V\alpha_g}$ and $\hat{G}_{\alpha\alpha_g}$. Similarly, at higher frequencies the power spectral density decreases due to the lower energy content of the turbulence.