Designing Anti-Aliasing-Filters for control loops of mechatronic Systems regarding the Rejection of aliased Resonances

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Abstract

The design of anti-aliasing filters in control loops is a trade-off between the rejection of signals above the Nyquist frequency and the introduced phase lag. The introduced phase lag will reduce the performance of the control loop in terms of disturbance rejection. However, insufficient rejection of signals above the Nyquist frequency can cause severe stability and performance problems.

In practice anti-aliasing filters of control loops are often designed by rule-of -thumb or even omitted. This paper wants to give guidance to a proper design. It introduces the concept of equivalent delay to quantify the phase lag added by the filter and to balance it with the rejection of the filter. Thereby it supports e.g. the choice of the order and cut-off frequency of the filter. Further, approaches to reduce the control loops total phase lag are given.

Commonly, aliasing is associated with the aliasing of signals. However, in discrete-time control systems aliasing can also be found as aliasing of systems. In particular, this is in critical for weakly damped resonances of the sampled discrete-time plant above the Nyquist frequency. These resonances mirror at the Nyquist frequency equally to signals above the Nyquist frequency and appear blow the Nyquist frequency. This can harm the performance of the control loop or even cause instability. However, it is often disregarded in the design process. The effect of aliasing-of-resonances caused by reconstruction and sampling of the analogue signal is explained in the paper as well as the purposeful modelling of the effect, in order to consider it early in the design of the control loop.