Dissecting the Influence of Parasitic Poles on Compensator Design in Repetitive Control

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Abstract: Repetitive control aims to converge to zero tracking error following a periodic command, or in the presence of a periodic disturbance of known period. It looks at the error in the previous period, and modifies the command in the present period. Zero error is a very ambitions objective, asking for zero error for all frequencies up to Nyquist frequency. It is very unlikely that one has a good enough model up to Nyquist frequency that one can be assured of stability, and if not the convergence process usually appears to be converging, but then starts diverging. When creating a world model, it is common to have some high frequency dynamics that cannot be identified because it is hidden within the noise level. Such dynamics are sometimes called parasitic poles, sometimes residual modes, etc.

To robustify the repetitive control convergence process that iterates with the real world, not our world model, one is forced to cut off the learning at higher frequencies when the model is sufficiently wrong to cause divergence. This cutoff is done with a real-time non-causal FIR filter. The cutoff frequency must be made sufficiently below the residual modes or parasitic poles so that the phase error is within a plus or minus 90 deg tolerance. In the continuous time model one has some understanding of where the phase might get this large for possible parasitic pole locations.

But the repetitive control design must be based on the corresponding discrete time model. The conversion to discrete time introduces a series of distortions at higher frequencies. This paper dissects the influence of these different sources to better understand how the needed cutoff is influenced by the discretization process. The first distortion comes from increasing phase lag of a sampled signal as frequency increases. The second distortion is the result the phase at Nyquist frequency of any discrete time transfer function must be a multiple of minus 180 deg, while in continuous time as frequency goes to infinity it is a multiple of minus 90 deg. The third distortion is the result of the discretization process introducing sample zeros, about half of them outside the unit circle. Parasitic poles influence the sample zeros introduced. This paper studies how each of these effects separately influence the cutoff frequency that must be used in practice.

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