Study on an Extension of Generalized Repetitive Control to Variable Speed Region Based on Oppenheim's Frequency Transformation

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1 Introduction

Generalized Repetitive Control(GRC) proposed in [1] has an excellent performance to reject periodic disturbances. This controller is designed by convex optimization, and it makes the difficulty to re-design GRC online. In motor drive applications, disturbance frequency changes according to the rotation speed. Therefore, it is needed to re-design the GRC controller online. In this paper, we propose a new algorithm which enables us to re-design GRC online. This method is based on FIR re-designing method proposed in [2].

2 FIR Redesigning Method

When GRC is added to the loop, the frequency characteristics of the modifying sensitivity function is expressed as

$$M_S(z) = 1 - X(z) \tag{1}$$

$$X(z) := \sum_{k=K_1}^{K_2} X_k z^{-k} \tag{2}$$

This research objective is to transform the frequency characteristics of the modifying sensitivity function by the transformation of the frequency characteristics of $X(z)$. $X(z)$ is designed as a linear phase FIR filter to which FIR redesigning method proposed in [2] is applied.

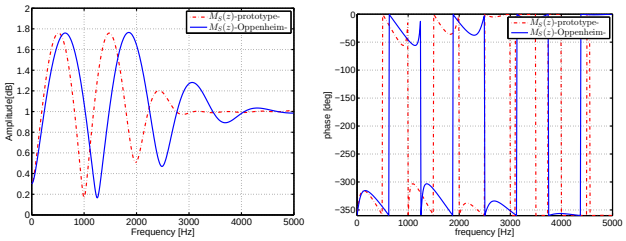
Firstly, $X(z)$ is expressed in the form

$$\begin{aligned} X_0(z) &= z^{-N_d} \sum_{k=-N}^{N} a_k z^k \\ &:= H_{0:\mathrm{p}}(z) H_{0:\mathrm{a}}(z) \end{aligned} \tag{3}$$

$$H_{0:\mathrm{p}}(z) := z^{-N_d} \tag{4}$$

$$H_{0:\mathrm{a}}(z) := \sum_{n=0}^{N} A_n \left(\frac{z+z^{-1}}{2} \right)^n \tag{5}$$

The amplitude of $H_{0:p}(z)$ is 1 and there is no phase delay in $H_{0:a}$. The characteristics of $H_{0:p}(z)$ and $H_{0:a}(z)$ is designed separately to achieve desirable frequency characteristics. The phase characteristics are stretched by adding delay operators to $H_{0:p}(z)$. Noting that the amplitude characteristics of $H_{0:a}$ is a polynomial function of $\cos\Omega$, the amplitude characteristics is transformed by distorting the frequency axis. Such a transformation is realized by the substitution of variables



(a) amplitude (b) phase

Figure 1: Simulation Result of FIR Redesigning Method

$$\frac{z+z^{-1}}{2} = K_0 + K_1 \left(\frac{Z+Z^{-1}}{2} \right) \tag{6}$$

The property of this linear mapping is decided by the parameters K_0 and K_1. These parameters should be set according to the relationship between prototype frequency response $H_{0:a}(z)$ and the transformed frequency response $H_{1:a}(z)$. In this paper, the parameters which equalize the properties of $H_{1:a}(z)$ and $H_{0:a}(z)$ at zero and cutoff frequency are selected. Figure 1 demonstrates this re-designing method.

3 Conclusion

In this paper, a new algorithm which enables to re-design GRC online is proposed. It is our next step to update the filter coefficients dynamically to achieve dynamic loop shaping.

References

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