論文の要旨

題 目　Design of Noise Shaping Filters in ΔΣ Modulators for Quantization Error Reduction

(量子化誤差削減のためのΔΣ変調器のノイズ整形フィルタの設計)

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Optimal finite impulse response (FIR) and infinite impulse response (IIR) noise shaping filters for delta-sigma (ΔΣ) modulators are designed based on the system norms. We incorporate the weighting function, connected to the output of the ΔΣ modulator, into our design problem. Then, we minimize the weighted norms of the quantization noise in the output of a ΔΣ modulator, which corresponds to the minimization of the system norm. Three norms, the H_2 system norm, the H_∞ system norm, and the l_1 norm of the impulse response of the system, are adopted. The H_2 system norm can be used to calculate the mean squared error of quantization noise. On the other hand, the H_∞ system norm gives us the worst case gain, while the l_1 norm of the impulse response can minimize the maximum error. The optimization problems for three types of FIR noise shaping filters are evaluated by using linear matrix inequalities (LMIs) and then solved numerically via semi-definite programming. For IIR noise shaping filters, the design problem becomes non-convex, which is hard to solve numerically. To solve the non-convex optimization problem, we propose the extended LMI technique, FIR approximation techniques, the hybrid technique and an iterative LMI algorithm to obtain good IIR noise shaping filters. Design examples are provided to demonstrate the effectiveness of our proposed methods over the existing methods.