Real-time FPGA-based Platform for Psychoacoustic Evaluation of ANC Headphones Control Algorithms and their Parameters

Piero Rivera Benois, Patrick Nowak, and Udo Zölzer

Dept. of Signal Processing and Communications, Helmut-Schmidt-University, Hamburg
piero.rivera.benois@hsu-hh.de

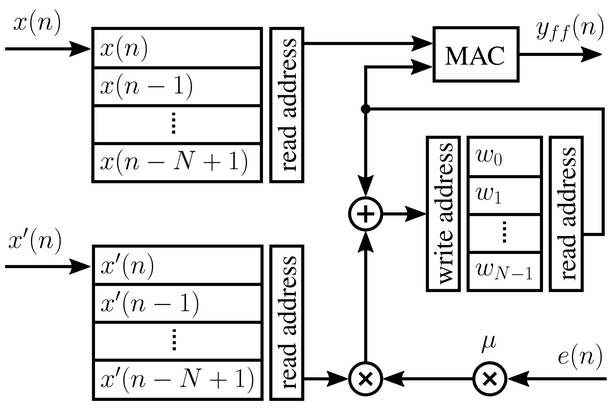
Helmut Schmidt Universität
Universität der Bundeswehr Hamburg

Introduction

Active noise control headphones provide passive and active attenuation of the acoustical pollution present in the environment. For the active attenuation, different control algorithms can be used. In order to choose a control algorithm and generate a satisfactory parameter constellation, engineers have to go through several iterations of design, prototyping, and evaluation. To alleviate and accelerate these tasks, a digital signal processing platform is proposed. The platform enables to switch between control algorithms and to tune their parameters in real-time.

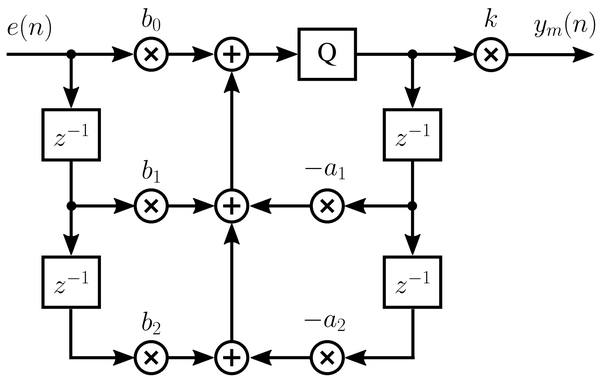
Adaptive Feedforward Controller $W_{\text{ff}}(z)$

The adaption of the feedforward controller is based on a Least Mean Squares (LMS) algorithm. The filtering process and the adaption algorithm are equipped with differentiated inputs, so that an LMS and an FxLMS algorithm can easily be implemented. The controller's coefficients are quantized with a word-length of 64 bit. The accummulator inside of the Multiply-Accummulate (*MAC*) module has an 84 bit word-length. The same module can be utilized for an adaptive feedback system.



Minimum Variance Controller $W_{\text{m}}(z)$

The Minimum Variance Controller (MVC) is generalized as a 2^{nd}-order filter with complex conjugated poles and zeros. The b-coefficients are normalized by the factor g_{norm}, in order to avoid an integer overflow. All coefficients are quantized with a word-length of 24 bit. The quantizer at the output utilizes a word-length of 48 bit. After the filter, the control gain k is applied. The calculation of the coefficients is done by the processor in the *MVC Coeffs Calc* module.



$$\Omega_z = 2\pi f_z / f_s \qquad \Omega_p = 2\pi f_p / f_s$$
$$b_0 = 1/g_{norm} \qquad a1 = -2\, r_p\, cos(\Omega_p)$$
$$b1 = -2\, r_z\, cos(\Omega_z)/g_{norm} \qquad a_2 = r_p^2$$
$$b_2 = r_z^2/g_{norm}$$