

Introduction

Motivation:

Typical active noise control (ANC) system aims primarily at reducing the acoustic noise over the entire frequency band. However, the following human factors require the capability of tuning the residual noise spectrum in the ANC system:

- ❖ Diversity of individual listening preferences on spectral content;
- ❖ Non-uniform characteristics of human hearing response in frequency domain.

In this work, we attempt to control the spectrum of the residual noise in a similar way as we equalize the music.

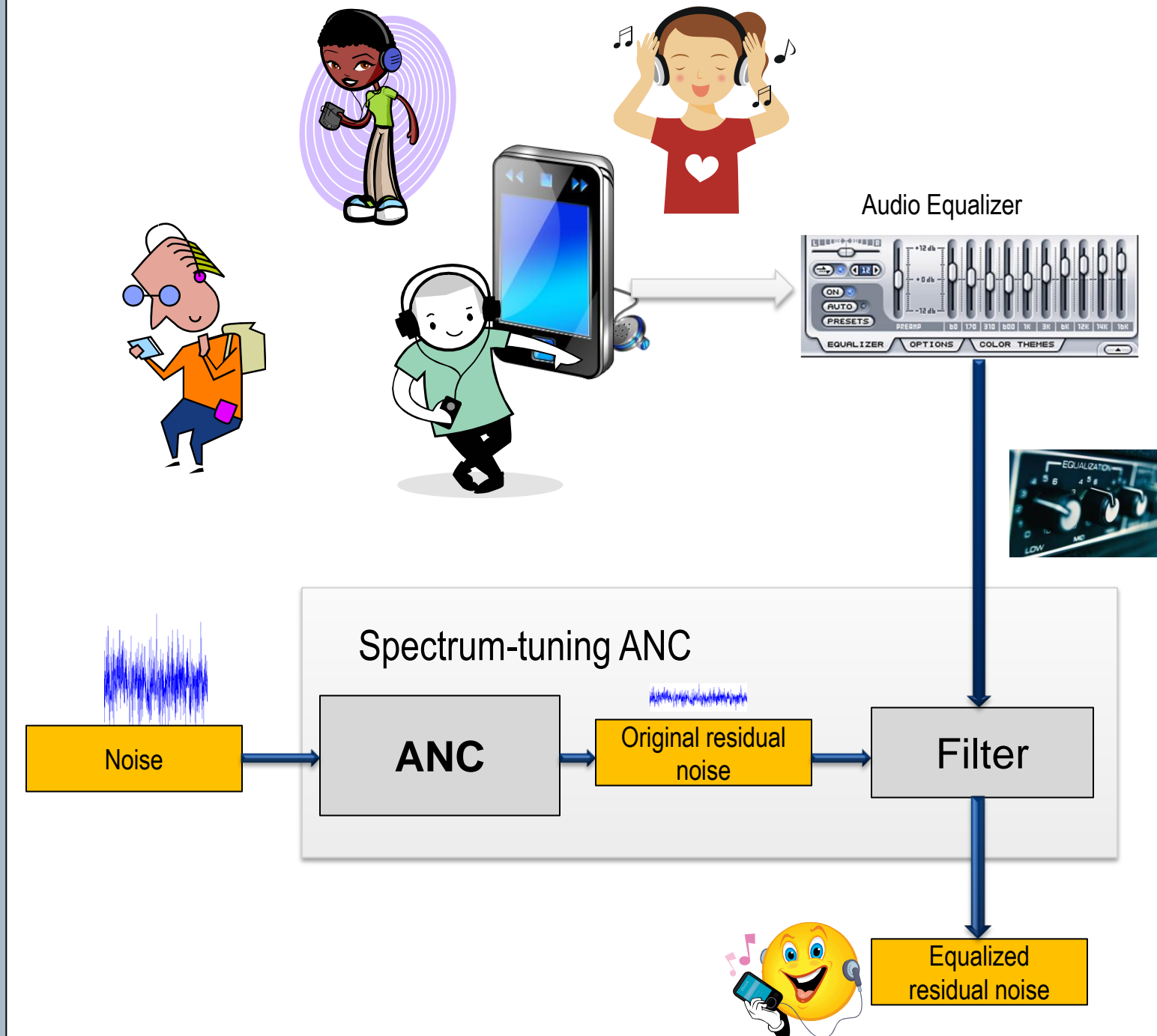
Proposed Work:

We propose a new Spectrum-tuning ANC (STANC) structure based on feed-forward ANC system. The new system possesses good control on residual noise spectrum in the following aspects:

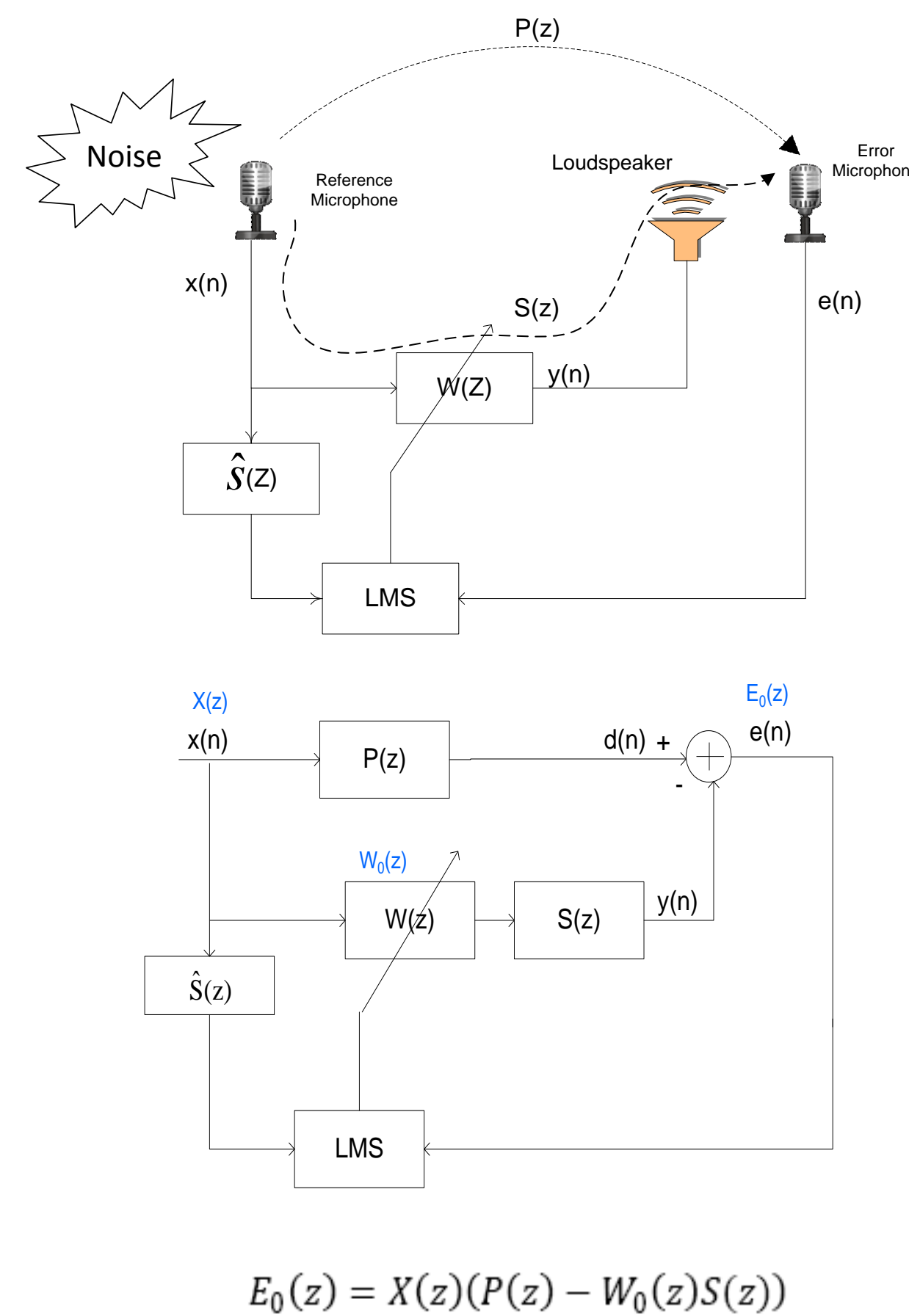
- ❖ The system will feature precise spectrum-tuning;
- ❖ The tuning filter will not influence the system adaptation.

Motivation

Different listening preferences

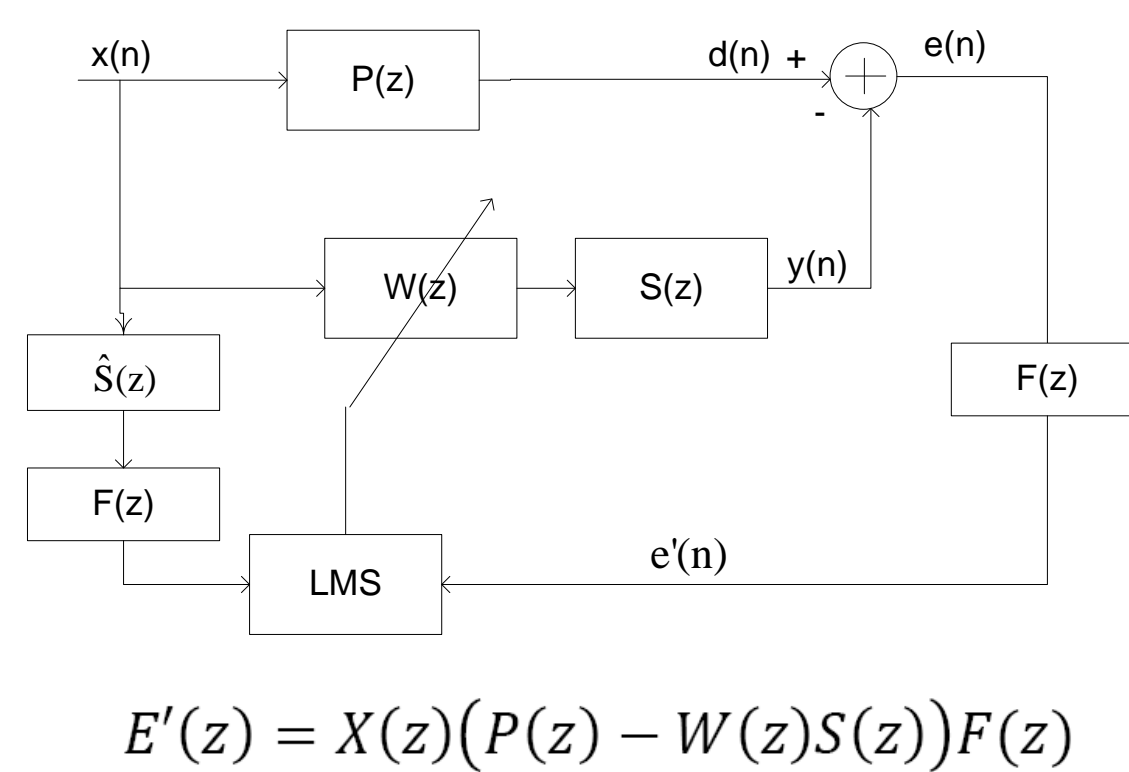


Conventional ANC System



FELMS System

FELMS: Filtered-Error Least-Mean-Square

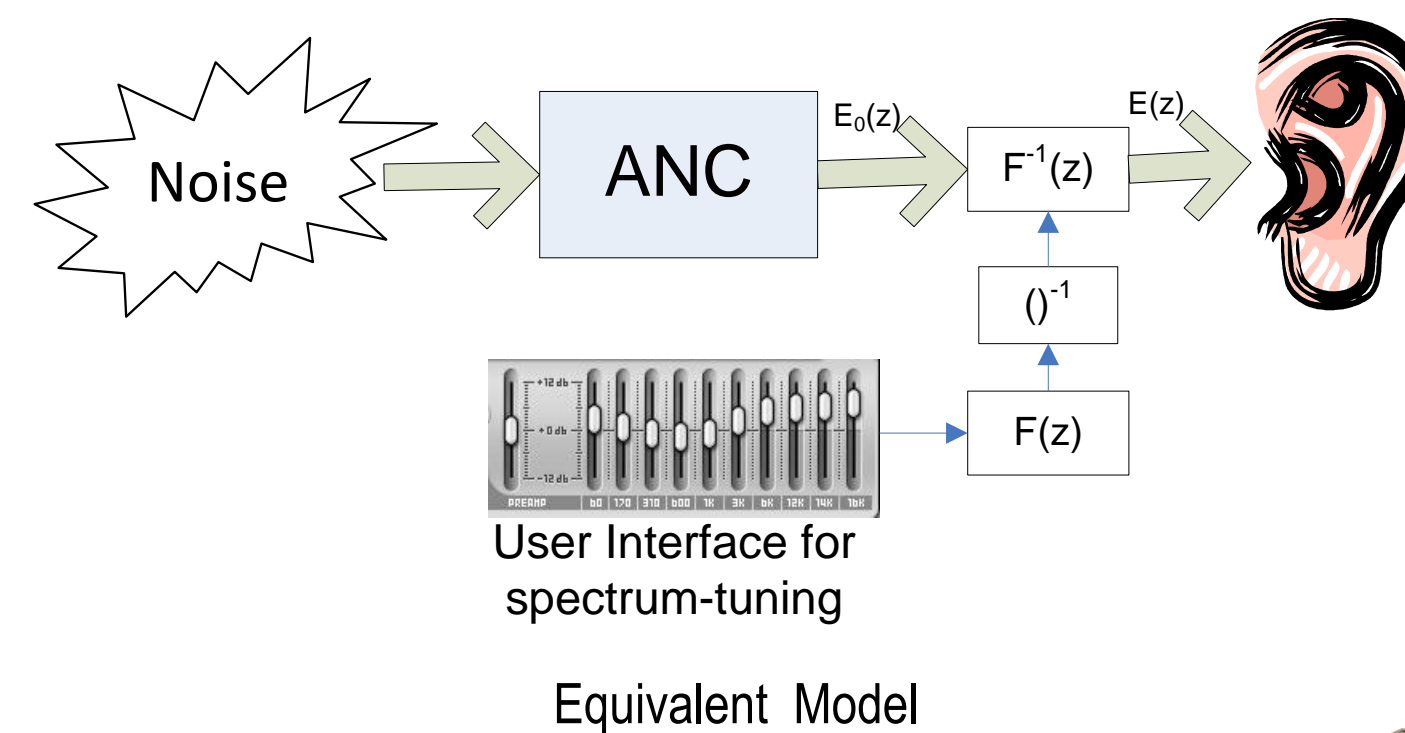
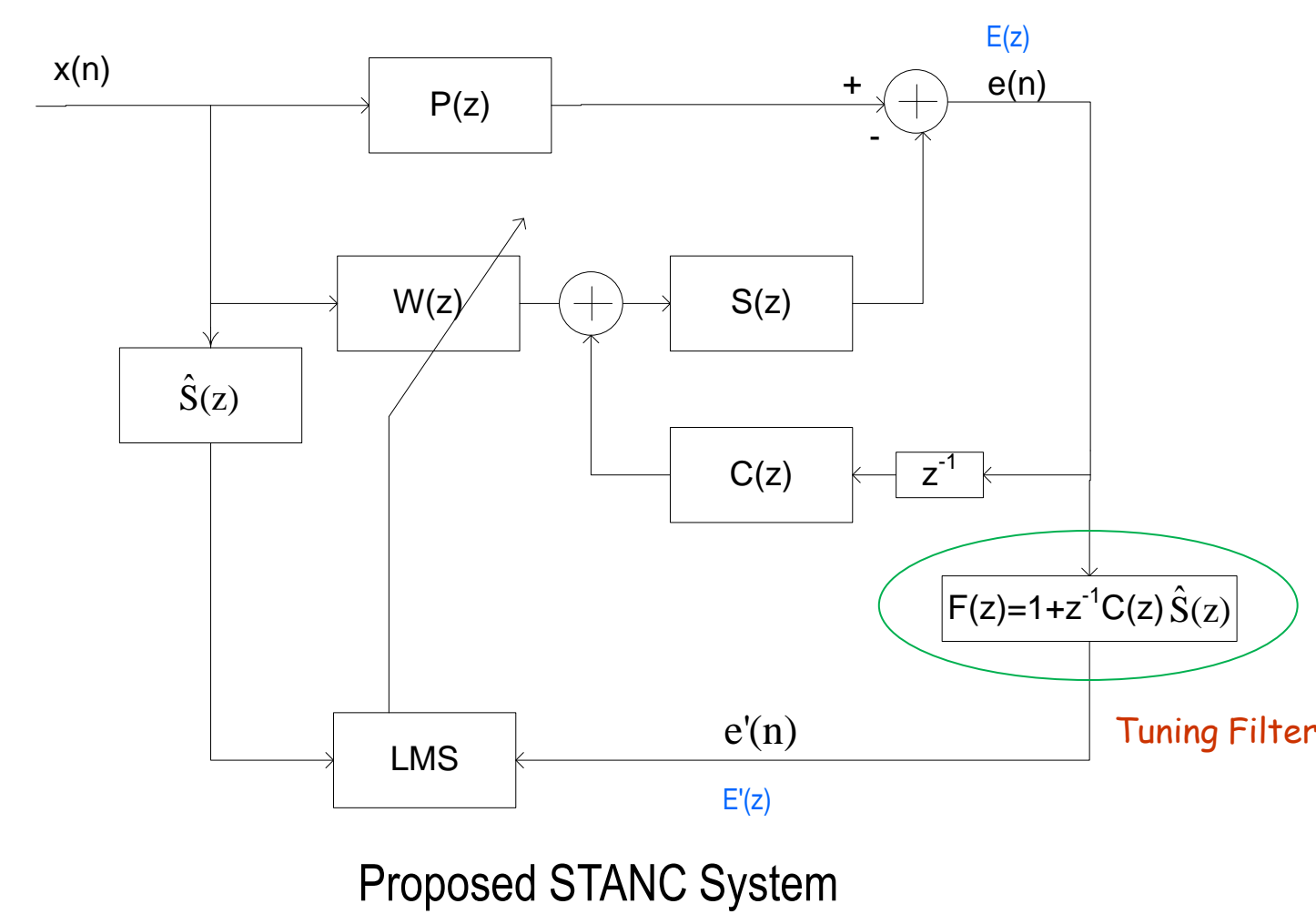


Pro: The spectrum of the residual noise can be shaped

Cons:

- It is difficult to shape the residual noise spectrum to a desired curve
- The change of $F(z)$ will cause the change of the adaptive filter $W(z)$

Proposed STANC System



Analysis

$$E(z) = X(z)(P(z) - W(z)S(z)) - z^{-1}E(z)C(z)S(z)$$

$$E(z)[1 + z^{-1}C(z)S(z)] = X(z)[P(z) - W(z)S(z)]$$

$$F(z) = 1 + z^{-1}C(z)S(z)$$

$$\hat{S}(z) = S(z)$$

$$E(z)F(z) = X(z)[P(z) - W(z)S(z)]$$

$$E'(z) = E(z)F(z)$$

$$E'(z) = X(z)[P(z) - W(z)S(z)] \quad \text{Conventional ANC: } E_0(z) = X(z)(P(z) - W_0(z)S(z))$$

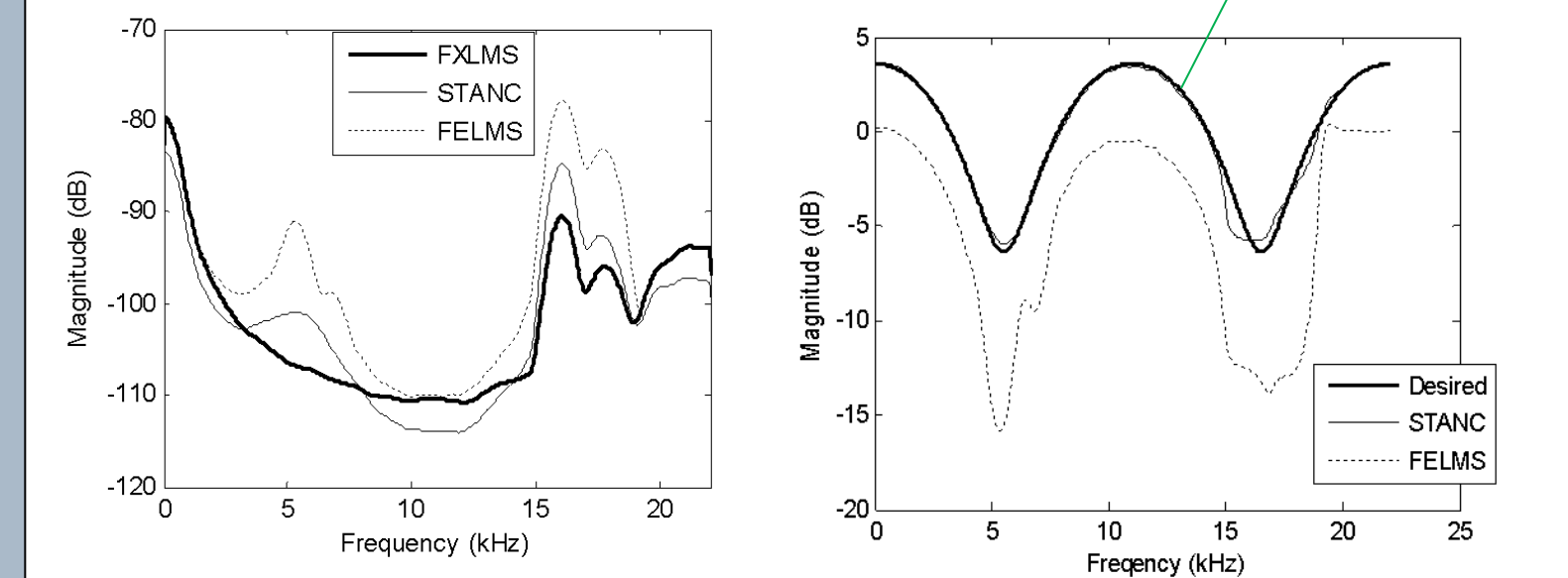
$$E(z) = E_0(z)F^{-1}(z) \quad E'(z) = E_0(z) \quad W(z) = W_0(z)$$

No influence on system adaptation

Spectrum-tuning Or Equalization

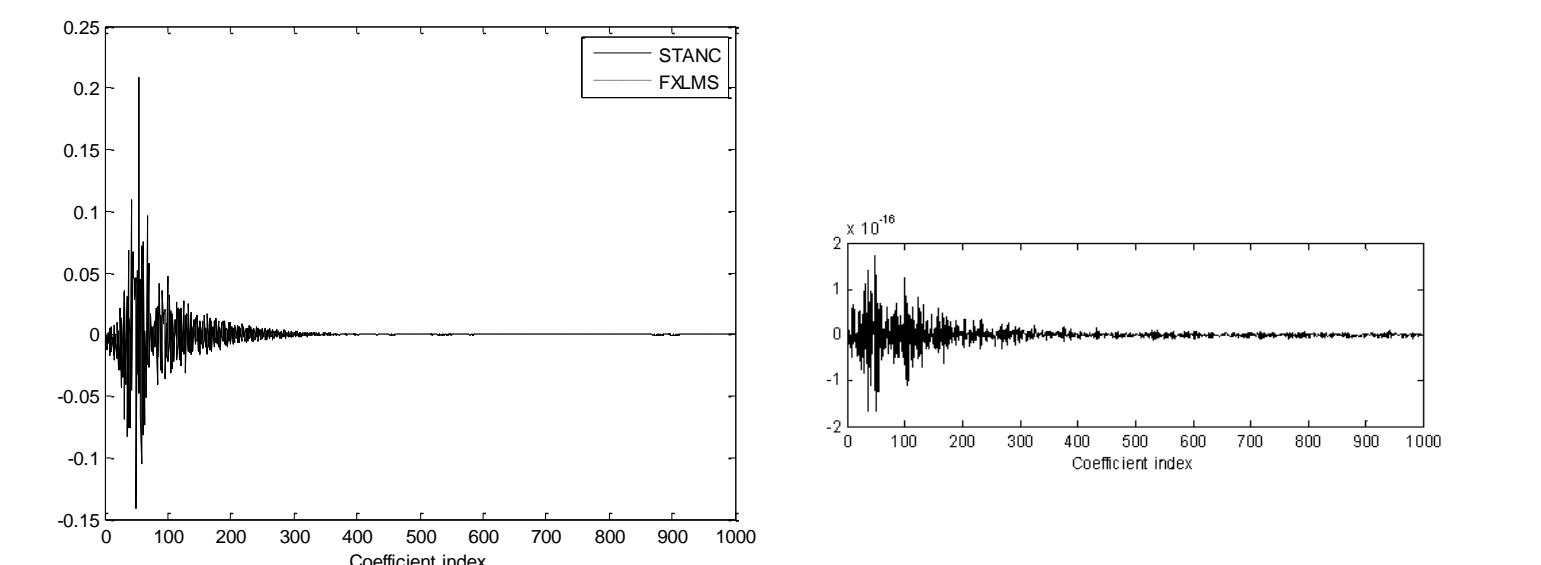
Results

- Noise source: white noise
- Tuning filter $F(z)$ is arbitrarily chosen as
 - $F(z) = 1 + 0.5184z^{-1}$ Poles: $[0.6, \pm 0.6j], [-0.6, \pm 0.6j]$
 - $C(z)$ is not calculated explicitly
 - $z^{-1}C(z)S(z)$ is ideally treated as $F(z) - 1$
- Performance is evaluated by comparing power spectrum and adaptive coefficients for FXLMS, STANC and FELMS systems



Power spectrums of residual noises after convergence in ANC systems of FXLMS (thick line), STANC (thin line) and FELMS (dash line)

Comparison of desired tuning shape (thick line) and tuning effects of STANC (thin line) and FELMS (dash line)



Adaptive filter coefficients comparison: (a) coefficients of STANC (solid line) and FXLMS (dot line) and (b) their difference

Conclusions

Contributions

- ✓ A new ANC structure (STANC) is proposed for spectrum-tuning of residual noise.
- ✓ The new system achieves precise spectrum-tuning.
- ✓ The new system keeps the adaptive behavior the same as the conventional FXLMS system.
- ✓ Experimental results validate the effectiveness of the new system.

Future Work

- Automatic design of tuning filter according to the input of human listening preference considering
 - system stability
 - noise robustness
- Evaluation of influence from estimation error of secondary path transfer function.
- Real-time prototype development.