Reduction of Frequency Shift Error on Periodical Noise Suppression System

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***Abstract* –The artificially generated noise from the appliances has a periodicity in frequency domain. A noise suppression system, which is based on the PI(Power Inversion) algorithm and using frequency shift, has already been proposed. However, the system has a significant problem that the suppression effect can not be obtained when the frequency shift is not accurate. In this paper, reduction method of frequency shift error is proposed. Numerical results show that frequency shift error is reduced by the proposed method when the number of snapshots and the interval of sampling are set appropriately.**

***Index Terms* —Frequency shift, Periodical Noise.**

I. INTRODUCTION

In recent years, it is worried that noises caused by semiconductors in power transformer interfere with wireless communication systems[1]. The noises have periodicities in the frequency domain because signals are periodically switched by the inverter or converter. The authors have proposed a noise suppression system for periodical noises using PI algorithm and frequency shift[2]. However, the suppression effect is not obtained when frequency shift has error.

In this paper, a frequency error reduction method for the noise suppression system is proposed. In the method, correlation matrix in PI algorithm is utilized for reducing the frequency error. Numerical results show that the frequency shift error is reduced by this system when number of snapshots and the interval of sampling are adjusted appropriately.

II. NOISE SUPPRESSION SYSTEM

A. Noise Suppression System using Frequency Shift

Fig.1 shows the configuration of the noise suppression system using frequency shift. In the system, the signal received at the antenna is divided into two signals. Then, the frequency of one of the divided signal is shifted. The shift frequency is set at the frequency interval of the artificially generated noises. And the shifted signal is weighted based on PI algorithm. As a result, two noises in the same frequency are cancelled.

B. Problem due to Frequency Shift Error

Fig.2 shows the effect of frequency shift error on output SINR. Input SNR is 35dB.

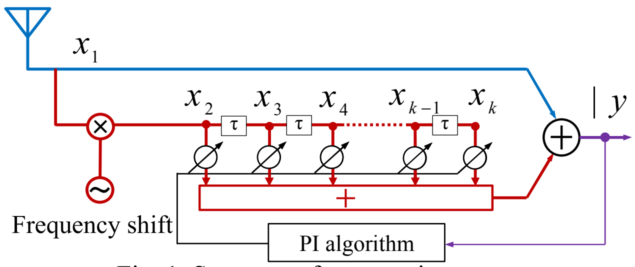
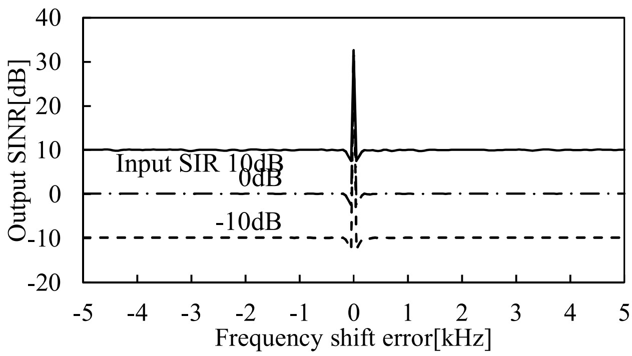


Fig. 1. Structure of suppression system using frequency shift



The parameter in the figure is input SIR. In Fig.2, excellent suppression effect is obtained when there is no frequency shift error. However, the suppression effect is extremely decreased when the system has only the few frequency shift error. Therefore, it is necessary to reduce the frequency shift error.

III. REDUCTION METHOD FOR FREQUENCY SHIFT ERROR

A. Signal Modeling

The input signal in Fig.1 is expressed in vector format as

$$X(t) = [x_1 \quad x_2 \quad \dots \quad x_k]^T \tag{1}$$

The correlation matrix R_{xx} is expressed as Eq.(1).

$$R_{xx} = E[X(t)X^H(t)] = E\begin{bmatrix} x_1x_1^* & x_2x_1^* & \cdots & x_kx_1^* \\ x_1x_2^* & \ddots & & \\ \vdots & & \ddots & \\ x_1x_k^* & & & x_kx_k^* \end{bmatrix} \tag{2}$$

Here, superscript H and * denotes hermitian conjugate and complex conjugate, respectively. $x_2x_1^*$ in 1st row 2nd column in Eq.(2) correspond to the correlation value the input signal and the frequency shifted signal. Therefore, It is expected that the correlation value is large when frequency shift error is small. Frequency shift error is reduced using this characteristics.

B. Relation between Correlation Value and Frequency Shift Error

Fig.3 shows relation between frequency shift error and correlation value $< x_2x_1^* >$. Here,<•> denotes operation of expectation. The parameter in Fig.3 is the sampling interval I_s as shown in Fig.4. The number of snapshots is 2000. In Fig.3, It is found that the correlation value is largest when frequency shift error is 0 because phase difference between x_2 and x_1 doesn't change in time domain. Correlation value is small when frequency shift error is large because phase difference varies in time domain. The frequency width that the correlation value is larger than 0 is defined as f_{width}. It is found that f_{width} is large when I_s is short. f_{width} is expressed as

$$\frac{2}{m \times I_s} = f_{width} \quad (3)$$

C. Proposal of Reduction Method

The peak of correlation value is found easy by hill-climbing method because the correlation value in f_{width} monotonically increases toward the peak from 0. Therefore, the peak finding system utilizing hill-climbing method is easy process as shown in Fig.5. In Fig.5, F is the shift frequency, T is the value of adjust for frequency shift, C is correlation value, V is value to choose addition or subtraction, and k is the number of iteration.

IV. Effects of Hill-climbing Method on Frequency Shift Error

Fig.6 shows relation between the number of iteration and frequency shift error. The parameter is frequency shift error of first iteration. The number of snapshots is 2000 and the time of I_S is 200ns. Then, f_{width} is 5kHz from Eq.(3). The dashed lines show null point of correlation value in Fig.3. Frequency shift error is converged at 0 by hill-climbing method when first frequency shift error is in the range between dashed lines. However, frequency shift error is converged at inappropriate point when the first frequency shift error isn't in the range between the dashed lines. Therefore, it is necessary to adjust the interval I_s so as to set the f_{width} between dashed lines.

V. Conclusion

Frequency shift error reduction method using correlation value and hill-climbing method was proposed. It was shown that the relation between frequency shift error and correlation value was affected by the interval of sampling. Reduction effects of the frequency shift error using hill-climbing method was confirmed.

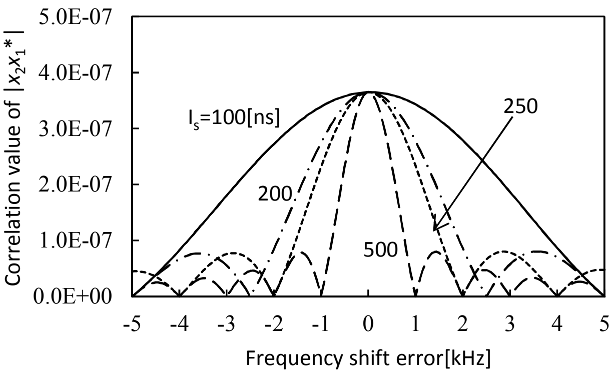


Fig. 3. Relation between frequency shift error and correlation value

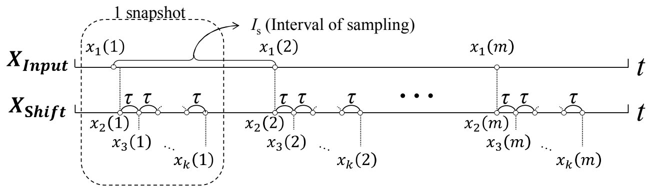


Fig. 4. Timing of sampling

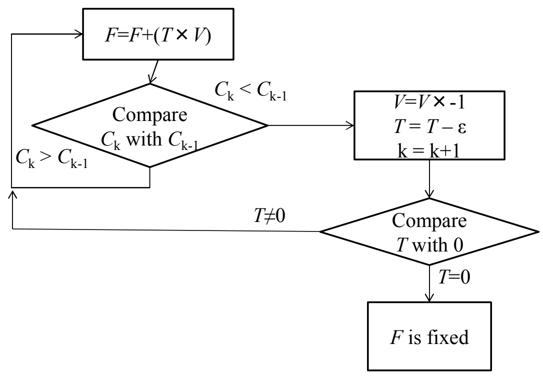


Fig. 5. Flow of hill-climbing method

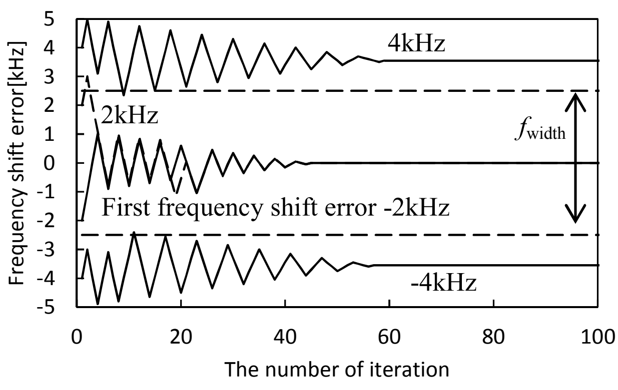


Fig. 6. Relation between the number of iteration and frequency shift error using hill climbing method

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