Effect of synchronization error and pseudo-noise on noise suppression system for AM radio

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***Abstract* - Recentry, interference of artificial noises from electrical power transfer becomes large and deterioration of sound quality of AM radio is worried. The authors proposed a noise suppression system for AM radio using quadrature demodulation and PI algorithm. It is expected that the noise suppression effect is reduced when the system has a synchronization error.**

In this paper, an effect of synchronization error on the noise suppression system for AM radio is investigated. Then, a new method using pseudo-noise is proposed to solve the problem.

***Index Terms* — Quadrature demodulation, AM radio, Pseudo-noise, Synchronization error.**

1. Introduction

It is worried that artificial noises caused by semi-conductors in power transformer interfere with AM radio. Thus, the authors proposed a noise suppression system using quadrature demodulation and PI algorithm[1].

In this paper, first, an effect of synchronization error on the noise suppression system for AM radio is investigated. If the system has the synchronization error in quadrature demodulation, the AM signal is leaked to quadrature component. It is expected that the AM signal is cancelled by the leaked AM signal. Then, a new method using pseudo-noise is proposed to solve the problem.

2. Noise Suppression System for AM Radio

Fig. 1 shows a configuration of the proposed noise suppression system using quadrature demodulation and power inversion (PI) algorithm. In the figure, AM signal, carrier, and artificial noise are received. Fig. 2(a) shows a spectrum of the received signal by the antenna. Fig. 2(b) and Fig.2(c) shows the signal of in-phase component and the quadrature component after the quadrature demodulation, respectively. Only the noise signal is included in the quadrature component and it is adjusted based on PI algorithm so as to minimise the output signal. As a result, the noise in in-phase component can be cancelled with the noise in the quadrature component.

3. Effect of Synchronization Error on Suppression Performance

Fig. 3 shows spectrum of the quadrature component when the synchronization error exists in the quadrature demodulation process. We can see that the AM signal leaks to the quadrature component due to synchronization error.

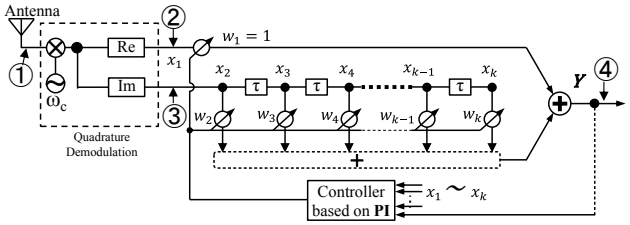
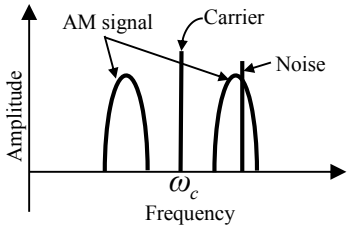
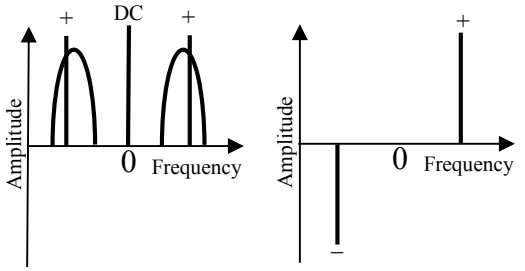


Fig. 1. Noise suppression system based on PI



(a) Received AM signal with interference noise (① in Fig. 1.)



(b) In-phase component (② in Fig. 1.) (c) Quadrature component (③ in Fig. 1.)

Fig. 2. Conceptual figure of signal in the system

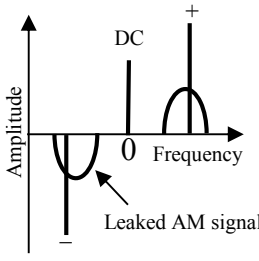
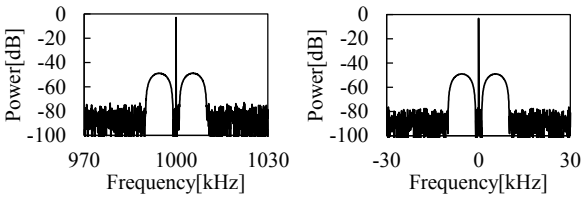


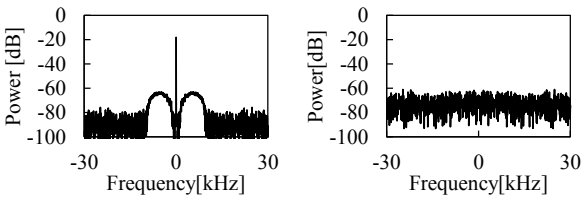
Fig. 3. Conceptual figure of signal on the system with synchronization error (③ in Fig. 1.)

Fig. 4 shows the example of simulation results of the system. The input SIR is ∞ and the synchronization error is 1deg./1snapshot. The input signal(Fig. 4(a)) doesn't include the noise, and the quadrature signal(Fig. 4(c)) include the



(a)Input signal (① in Fig. 1.)

(b)In-phase signal (② in Fig. 1.)



(c)Quadrature signal (③ in Fig. 1.)

(d)Output signal (④ in Fig. 1.)

Fig. 4. Example of simulation results on the system without pseudo-noise

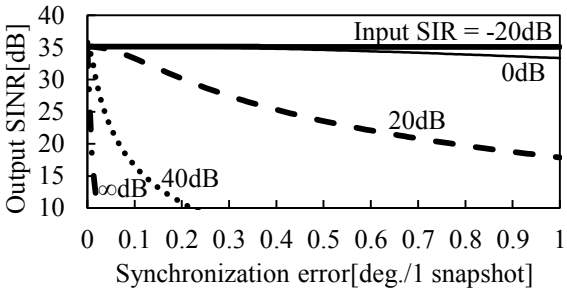


Fig. 5. Relationship between synchronization error and output SINR

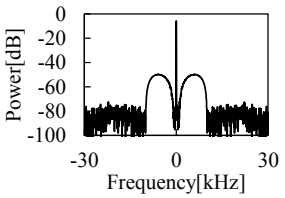


Fig. 6. Example of output signal with pseudo-noise (SPR=0dB) (④ in Fig. 1.)

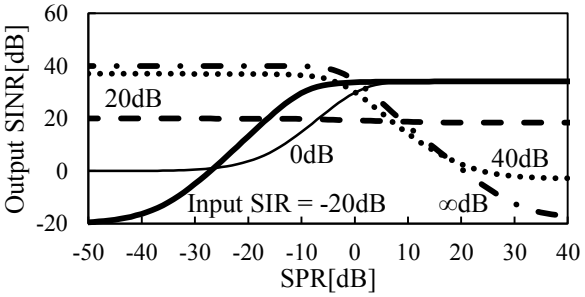


Fig. 7. Relationship between SPR and output SINR

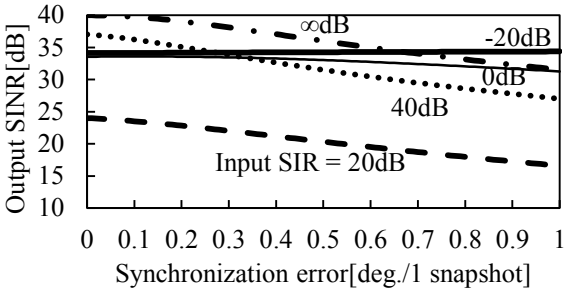


Fig. 8. Relationship between synchronization error and output SINR with pseudo-noise

leaked AM signal. It is found from Fig. 4 (d) that the AM signal is cancelled by the leaked signal.

Fig. 5 shows a relationship between synchronization error and output Signal to Interference plus Noise power Ratio;SINR. The parameter is input SIR. It is found from Fig. 5 that the output SINR falls sharply when the system have synchronization error. The reason is that AM signal is cancelled by leaked AM signal, which is adjusted based on PI algorithm.

4. Effect of Pseudo-Noise on Suppression Performance

It is well known that the suppression performance is reduced by pseudo-noise[2]. Thus, we introduce the pseudo-noise on the PI algorithm in Fig. 1. The pseudo-noises are added on the diagonal elements of input correlation matrix in PI algorithm[2].

Fig. 6 shows the output signal(④ in Fig. 1) of the system with pseudo-noise. We can see that the AM signal is not cancelled by the system by pseudo-noise.

Fig. 7 shows relationship between Signal to Pseudo-noise power Ratio;SPR and output SINR. The parameter is input SIR. It is found that the output SINR is improved by pseudo-noise when input SIR is more than 20dB and SPR is more than 0dB, namely pseudo-noise is larger than AM signal. The reason is that AM signal is not cancelled by reducing the suppression performance due to the pseudo-noise. The output SINR is improved on all input SIR when SPR is about 0dB.

Fig. 8 shows relationship between synchronization error and output SINR when SPR=0dB. The output SINR in Fig. 8 is considerably improved compared with Fig. 5.

5. Conclusion

Effect of synchronization error and pseudo-noise on the noise suppression system was studied. As a result, it was shown that suppression effect was fallen sharply by synchronization error, because AM signal is cancelled by leaked AM signal. It was also shown that suppression effect was improved by pseud-noise when SPR is about 0dB. Namely, the problem of synchronization error in the noise suppression system was solved by effect of the pseudo-noise.

References

[1] S.Ito, et.al, "Consideration of Noise Suppression System for AM signal using Quadrature Demodulation and PI Algorithm," IEICE Technical Report, A・P2015-101, Oct. 2015. (in Japanese)

[2] K.Takao and N.Kikuma, "Tamed Adaptive Antenna Array," *IEEE Trans*, vol. AP-34, no. 3, pp. 388-394, Mar. 1986.