NANOENERGY LETTERS

Performance Evaluation of Stochastic Resonance Receiver for the Multi Carrier Detection

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***Abstract*—Stochastic Resonance (SR), known as a noise-enhanced phenomenon, can improve the performance of communication systems. By applying SR in the receiver, it is possible to detect a weak signal that is not detectable in the traditional linear receiver. In the SR systems, the input of multi-carrier has not ever been discussed. So this paper proposes the SR receiver for multi-carrier detection and evaluates its Bit-Error-Rate (BER) performance.**

I. INTRODUCTION

In wireless communication systems, the noise has been treated as a nuisance degrading the performance. On the other hand, in SR system, the noise can improve the signal detection [1], [2]. By applying this remarkable phenomenon to the communication systems, the noise can improve its performance.

SR has been studied theoretically and observed in a large variety of systems. As an application of SR in engineering, weak signal detection using SR has been proposed [3]–[5]. In wireless communication, however, the practical method of applying SR to signal detection is not clear. Consequently, to authors' knowledge, a practical application of SR to the communication system has not been performed. Motivated by this, we have been studying the SR receiver [6].

We focus on two critical conditions that conventional linear receiver cannot detect signal; the received signal is buried in noise and the received signal is below receiver sensitivity. For the former situation, a non-linear receiver performs better than the conventional linear receiver when noise is non-Gaussian [7]. In most case in wireless communication systems, channel noise is Gaussian. On the other hand, conquering receiver sensitivity lights up new and attractive challenge in wireless communication systems. The receiver sensitivity based on an IEEE 802.11 wireless LAN standard is approximately -80 dBm [8]. If we could lower the receiver sensitivity, then we could lower transmission power and simultaneously interference to other users will be reduced. The reduction of interference in wireless LAN and cellular systems can enhance system capacity. We also note that the reduction of power consumption will increase battery life.

In this paper, we propose an SR receiver for the detection of multi-modulated signal called multi-carrier, and show its effectiveness. In applying the SR receiver to the wireless communication systems, a multiple access system that can support simultaneous access from different users must be considered.

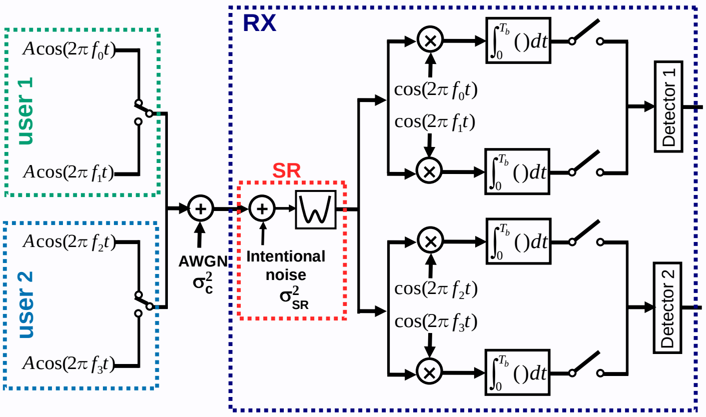


Fig. 1. System model of the two users.

However, this situation has not ever been discussed in SR systems. This paper shows the BER performance in multi-carrier case and evaluates the effectiveness of the proposed system.

II. SYSTEM MODEL

System model of two users case is shown in Fig. 1. In the transmitter, each user transmits a modulated signal given by

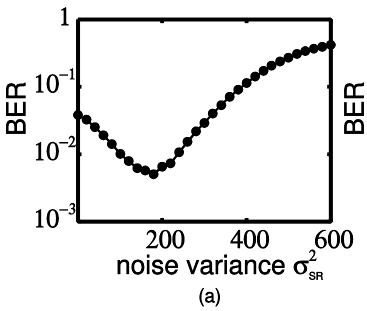
$$s(t) = A\sum_{k=-\infty}^{\infty} g(t-kT_b)\cos(2\pi f_k t), \quad (1)$$

where A is the signal amplitude, k is the index of time, T_b is the signal duration, $g(t)$ is the bi-polar pulse $g(t)$ = 1 in $0 \le t < T_b$ and otherwise $g(t)$ = 0. This is a frequency-shift keying signal in that the messages are transmitted by signals that differ in frequency. And, $f_k \in f_0, f_1, f_2, f_3$ are the frequencies of the symbol k in each user, and their spacing is $1.0/T_b$. At the channel, the background noise $n_c(t)$ assumed to be zero-mean white Gaussian noise with variance σ_c^2 is added, where the signal to noise ratio (SNR) of the received signal(= 10 log($A^2/2\sigma_c^2$)) is assumed to be 0dB. And then the received signal composed of $s(t)$, $n_c(t)$ and intentional noise $n_{SR}(t)$ is fed into the SR process expressed by

$$\frac{dy(t)}{dt} = ay(t) - by(t)^3 + s(t) + n_c(t) + n_{SR}(t), \quad (2)$$

TABLE I
PARAMETER SETTINGS FOR THE COMPUTER SIMULATION.

parameter	value
channel and intentional noise	AWGN
signal amplitude A [V]	20.0
signal duration T_b [s]	100.0
carrier frequency f_0 [Hz]	1.0
potential parameter a	32.0
potential parameter b	1.0
total numbers of transferred bits	10000



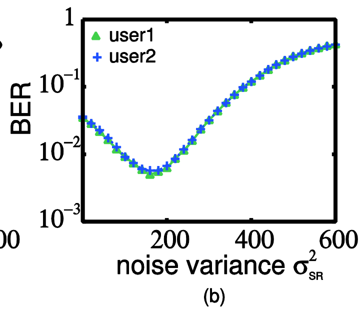


Fig. 2. BER performance of the stochastic resonance receiver: (a) one user, (b) two users.

where $y(t)$ is the output of SR, $n_{SR}(t)$ is zero-mean white Gaussian noise with variance σ_{SR}^2. Then, the SR output is multiplied by $\cos(2\pi f_k t)$ and the message is recovered by the integrated and dump circuit and a threshold decision in each user.

III. NUMERICAL RESULTS

The proposed system is evaluated with BER by computer simulation. BER is the number of bit errors divided by the total number of transferred bits during signal duration. Table. I shows simulation parameters. These parameters value are chosen to have SR effect.

Figure 2(a) shows the BER performance versus the noise variance σ^2_{SR} in 1 user. As we see from Fig. 2(a), the BER curve is improved by an increase in σ^2_{SR}, and then slightly degrades depending on a further increase in σ^2_{SR}.

Figure 2(b) shows the BER performances versus the noise variance σ^2_{SR} in two users. As we see from Fig. 2(b), the BER curves show the SR effect, and achieve the same performance as in one user. This shows the effectiveness of the SR receiver for more than one carrier.

Figure 3 shows the BER performances versus the noise variance σ^2_{SR} in the number of users N = 1, 10, 20, 30. The frequency spacing is $1.0/T_b$. As we see from Fig. 3, the BER curve is shifted left with the increase of users. This is because the signals from other users become the interference; consequently they behave like the noise equivalently. And each BER curve shows the SR effect. This shows the effectiveness of the SR receiver for multi-carrier.

IV. CONCLUSION

In this paper, we have proposed the SR receiver for multi carrier detection and evaluated its BER performance. In the results of computer simulation, the effectiveness of stochastic resonance in multi user has been shown in the given parameter.

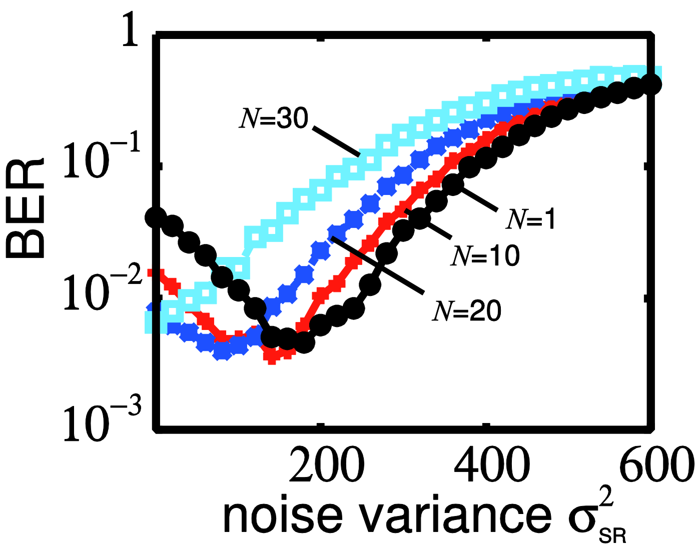


Fig. 3. BER performance as a parameter of the number of users N.

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