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Using hopping technique for interference mitigation in Modulated Scattering Array Antenna system

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Abstract: In modulated scattering antenna array (MSAA) system it has at the receiver side encountered low levels of scattering signals [1, 2] and interferences in addition to the desired signal. In this paper, we propose to utilize the frequency hopping scheme to improve the performance of scattering signals under the influence of narrow band strong interferences. From the numerical results, it concludes that with larger hopping range it improves the ability of anti-interference effects.

Keywords: antenna, array antenna, modulation, hopping, interference, wireless communications

Classification: Microwave and millimeter wave devices, circuits, and systems

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1 Introduction

There are some fundamental problems within the modulated scattering array antenna (MSAA) system [1, 2, 3]. The received signal of the modulated scattering element (MSE) was much smaller than that of the normal antenna [1]. The diversity performance of the MSAA with a compact spacing has been reported and the MSAA system with multiple-input and multiple-out structure (MIMO) has been designed and its performance has been experimentally studied [2]. The spectrum occupied by the MSE could be co-existed with other system and it is therefore possibly suffered the interference from other system signals. Consequently in the design of MSAA system it becomes an important issue of how to mitigate or reduce this kind of narrowband interference. The concept of spread spectrum has been widely used in the anti-jamming consideration and frequency hopping is one of the techniques to approach the spread spectrum environment; its outstanding performance has been recognized and its applications have been applied in various communications systems [4]. In this paper, the technique of frequency hopping will be adopted in our MSAA system when it is suffered from narrowband and strong interferences. The configuration of frequency-hopped MSAA system is constructed and its performance is fully studied.

2 Spectrum

The frequency spectrum of the RF signal, its associated interference signal and the hopping signals under considered at the receiver terminal are shown in Figure 1. In this study the center frequency of the RF signal is set at 2.5 GHz and the hopping signals are uniformly distributed from 2.4 GHz to 2.5 GHz. The narrow band interference is allocated at 2.47 GHz with amplitude 3 dB lower than the desired received RF signal.

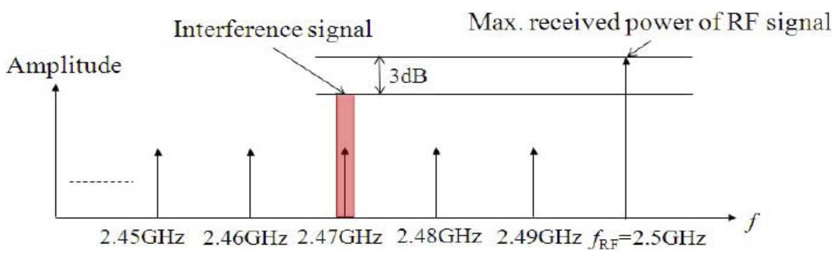

Fig. 1. Spectrum of RF signal, hopping signals and interference signal

3 System configuration of MSAA sequence generation

The system configuration of generating a MSAA sequence when the received RF signal is incident at different incident angles in a loop around the normal receiver antenna is shown in Fig. 2. As shown in the figure, a normal antenna (NA) is constructed closely with the MSE, the spacing between the NA and the MSE is 0.1 wavelength, and it is used to study the system performance

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of the MSAA system when the MSAA is excited by the incident RF signal at certain incident angle., In the figure it is shown a received signal of MSAA is generated by incident paths with azimus angle spacing of 4° and consequently 90 received signals are generated and the system performance will be studied for each received signal. The detailed description of each system element can be referred to [1, 2].

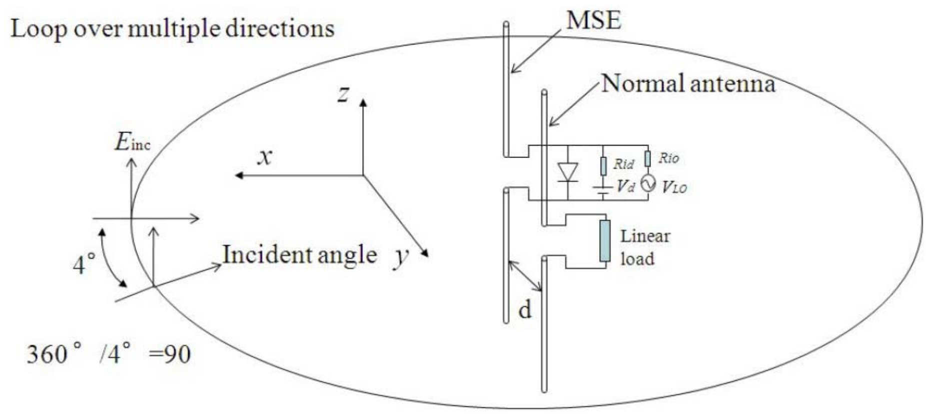

Fig. 2. Analysis Model of MSAA reception

4 Frequency hopping patterns

In the following it lists the frequency hopping parameters to be considered in this study:

· Hopping spacing: 10 MHz
· Hopping Range: 50 MHz or 100 MHz
· Hopping pattern: Sequential or alternative
· Hopping angle spacing or resolution: 8°, 20°, 40°, 60°

In sequential hopping scheme with hopping spacing of 10 MHz in hopping range of 50 MHz or 100 MHz, the frequency hopping patterns will be from 10 MHz to 50 MHz or 100 MHz consecutively with frequency spacing of 10 MHz around the loop with hopping angle resolution of 8. On the other hand for alternative frequency hopping the hopping frequency patterns are selected as 10 MHz, 40 MHz, 30 MHz, 20 MHz, 50 MHz, 40 MHz, and 10 MHz with hopping angle resolution of 8° for 50 MHz hopping rage while the hopping patterns are 10 MHz, 100 MHz, 30 MHz, 80 MHz, 50 MHz, 60 MHz, 70 MHz, 40 MHz, 90 MHz, and 20 MHz. For 100 MHz frequency range with the same hopping angle resolution of 8°.

5 Interference signals

With sequential and alternative frequency hopping patterns in 50 MHz and 100 MHZ hopping ranges the signal strengths of RF signals and their associated MSE modulated interference IF signals have been measured and compared. For example as shown in Figure 3 is a case of the measured RF

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signal and the MSE modulated IF signal in 100 MHz hopping range with alternative hopping and 8° hopping resolution, the RF signals are represented by solid lines while the interference IF signals are expressed by spike-dash-lines pattern. These stronger interference signals will be treated as noises in the system performance evaluation.

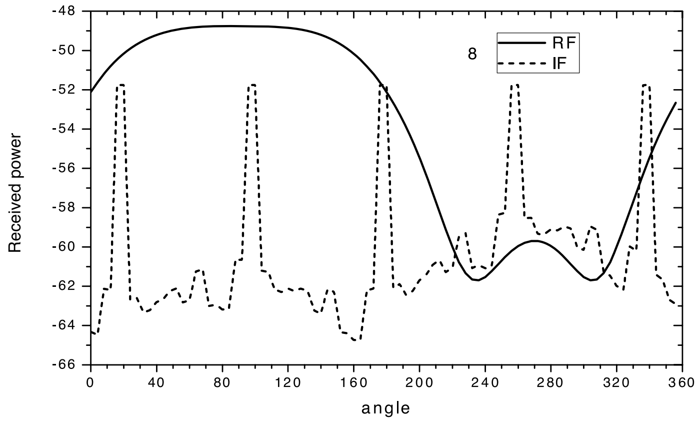

Fig. 3. Alternative Hopping Received Power for the Hopping range 100 MHz and the resolution of 8°

Table I. Probability of Signal Detection Error in 50 (100) MHz Frequency Range in Sequential and Alternative Hopping Patterns

Hopping range	Probability of receiving signal error				
	8°	20°	40°	60°	Average
50 (100)	5/45 (3/45)	2/18 (1/18)	1/9 (0/9)	0/6 (0/6)	0.083 (0.031)
50 (100)	4/45 (3/45)	1/18 (1/8)	1/9 (0/9)	0/6 (0/6)	0.064 (0.031)

6 Observation and conclusion

The MSAA system performance in terms of error probability in the detection of received signals under the influence of narrow band interference for the hopping range of 50 MHz and 100 MHz with sequential and alternative hopping patterns and 8° hopping resolution is listed in Table I. It appears that by utilizing larger hopping range, they have the same error probabilities of 0.031 and 0.031 in 100 MHz hopping rage for both sequential and alternative hopping patterns while they are 0.083 and 0.064 in the sequential and alternative hopping patterns in 50 MHz hopping range respectively. These numerical results conclude that the hopping technique can improve the ability of anti-interference in the MSAA.

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