Design of Multimode Linear Array Antenna for the Interference Mitigation

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***Abstract*- In this paper, we propose a multimode linear array antenna to maximize the number of the array elements for the interference mitigation by integrating a loop patch and a monopole antenna. The loop patch and the monopole antennas had maximum gains of 5.2 dBi and 1.6 dBi in the upper hemi-sphere pattern. The nulling performances are observed to demonstrate the interference mitigation, and the results shows a pattern null width of 13° and a null depth of 66.2 dB.**

***Index Terms* — Interference mitigation, Multimode antenna, Array antenna.**

I. Introduction

In recent years, multiple antennas are integrated and mounted on a small platform in order to receive various signals simultaneously, and thus antennas often suffer from having low received signal strengths (RSSs) for desired signals due to external and internal signal interferences. Such interference signals can be mitigated by beamforming and nulling using an array antenna. Furthermore, when an N-element array antenna is used in a nulling system, N-1 interference signals can be handled using conventional signal processing methods such as power inversion (PI) and least means square (LMS) algorithms [1]-[3]. Because of this feature, if more array elements are used in the nulling system, then more unwanted signals can be reduced while maintaining high reception reliability for the desired signals. However, the restricted platform size is not physically large enough to incorporate a large number of array elements. To overcome this limitation, challenging researches have been conducted by placing seven array elements on a 5-inch ground [4] and four array elements on a 3-inch platform [5]. Although the resulting array antennas provide good impedance matching and gain performances, these array antennas still have problems of mutual coupling between adjacent elements, high pattern correlation, and limitations on the maximum number of array elements.

In this paper, we propose a multimode linear array antenna to maximize the number of the array elements for interference mitigation. In this array, the multimode antenna is integrated with a loop patch and a monopole antenna, where the antennas have radiation patterns with different modes even if they are placed almost at the same place. Three sets of the multimode antennas are linearly arrayed for having a null steering pattern to reduce the unwanted signal strength. To demonstrate the interference mitigation, we use the LMS algorithm to obtain weights for all array elements that result in high null depth and narrow null width performances.

II. Proposed Array Antenna & Nulling Performance

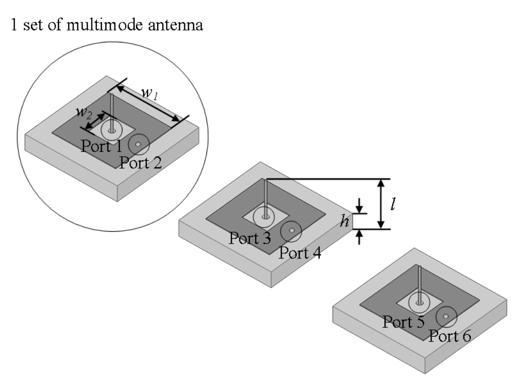

Fig 1. Geometry of the proposed multimode array antenna.

Fig. 1 presents the proposed linear array that consists of three sets of the multimode antennas. Each multimode antenna is integrated by the loop patch and monopole antenna with two direct feeding ports. The loop patch antenna is printed on the FR-4 substrate (ε_r = 4.5, $tan\delta$ = 0.018) with a height (h) of 10.92 mm, and the radiator has outer (w_1) and inner (w_2)

widths of 41.2 mm and 14.2 mm. In addition, the monopole antenna designed with a length (l) of 47.7 mm is located at the center of the multimode antenna sharing the ground with the loop patch antenna. The three multimode antennas are linearly arrayed with an array distance of a half wavelength at 1.6 GHz to have a null steering pattern. The proposed array antenna has the same physical space that can incorporate three conventional patch antennas, but it can handle up to five interference signals due to the six array elements.

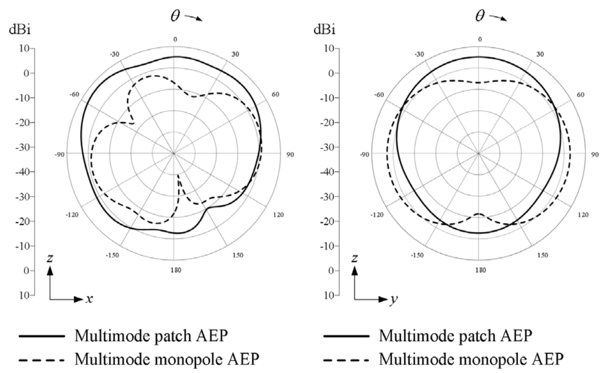

Fig 2. 2D radiation patterns of the proposed multimode array antenna.

Fig. 2 shows the active element patterns (AEPs) for the first set of the multimode antenna in *zx*- and *zy*- planes, where solid and dashed lines indicate the loop patch and monopole AEPs, respectively. The loop patch and monopole antennas have the maximum gain performances of 5.2 dBi and 1.6 dBi in the upper hemi-sphere radiation pattern.

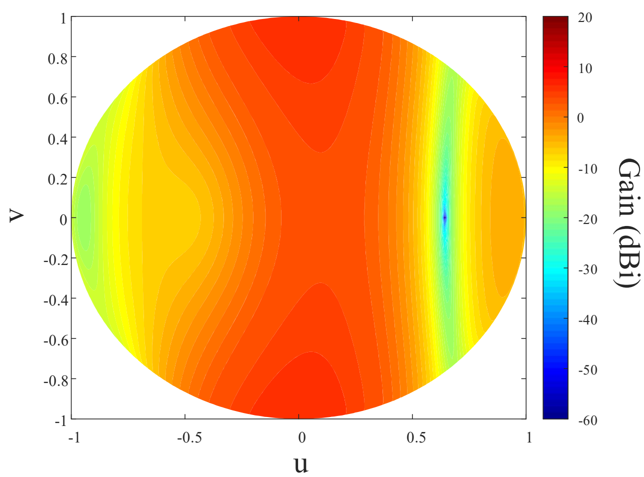

Fig 3. A null steering pattern of the proposed multimode array antenna.

Fig. 3 represents the null steering pattern according to the *uv*-plane when an incoming interference source of a chirp signal is located at $\phi = 0°$ and $\theta = 40°$. The proposed array antenna has good nulling performance with a pattern null width of 13° and a null depth of 66.2 dB.

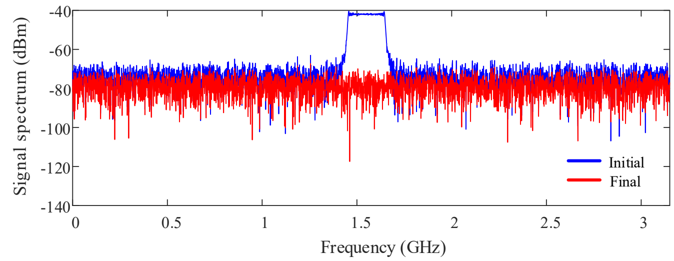

Fig 4. Power spectrum before and after the interference mitigation.

Fig. 4 illustrates the power spectrum in the frequency domain. The blue line indicates the spectrum with the chirp interference signal before the interference mitigation, and the red line specifies the result of the interference mitigation that reduces the interference signal strength under the noise level.

III. Conclusion

The multimode linear array antenna was proposed for the interference mitigation. Each multimode antenna was designed by integrating the loop patch and the monopole antenna. The loop patch and monopole antenna had gains of 5.2 dBi and 1.6 dBi, respectively. The nulling performances were observed to confirm the interference mitigation, and the results showed a pattern null width of 13° and a null depth of 66.2 dB.

Acknowledgment

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