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Planar pattern reconfigurable UWB antenna array for scanning in personal area network application

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Abstract **– This paper reports novel planar pattern re-configurable UWB antenna array for multidirectional scanning in personal area network (PAN) application. An UWB antenna is designed for 3.1 to 10.6 GHz range and verified experimentally. The coupling between two such antenna elements is measured and a simple technique to suppress it to -20 dB is proposed. Finally, an array of 4 such elements is studied for pattern re-configurability. This is achieved with the implementation of delay line in the feed structure. The pattern reconfigurable UWB array is characterized in both time domain (TD), and frequency domain (FD).**

Index Terms **— UWB, PAN, TD, FD.**

I. Introduction

While UWB antennas are widely reported in literature [1, 2], developing an array of these is a challenge, especially if all elements are printed on a single substrate [3]. There are a few reports but they do not provide desired directional pattern reconfigurability. In a rich multipath environment, it is preferred to have an antenna that can direct the main beam to the desired coverage area while suppressing the unwanted beams in other directions. In this paper, a uniformly spaced linear array comprising planar UWB monopole antennas is studied. Here, pattern reconfigurability of UWB array is achieved, with the implementation of delay line, for enhancing the scanning capability with low interference and high gain.

II. Coupling Effect Suppression In Array

The size of proposed UWB antenna is 40mm × 40mm., and the substrate is 0.508mm thick with $\varepsilon_r = 2.2$. For efficient design of array at UWB range, grating lobe is undesirable [4]. So, spacing has been kept λ_{low} (wavelength at high frequency). This causes prominent coupling effect at lower range of frequencies. This problem is solved by placing a line between two elements and shorting it to ground through via holes. This results in degradation of S_{11}, but significant reduction in coupling is achieved as shown in fig.1.

III. UWB Array

For achieving reconfigurability delay line is implemented in the feed line of antenna. For getting maximum radiation in particular direction, the length of the delay line is calculated, using formula (1) and (2).

The length of the delay line is calculated by following formula. In terms of the ns the length of delay line is

$$\tau = (d^* \sin \theta) / c \quad \text{------ (1)}$$

Length of the delay line on substrate,

$$l = (\tau^* c) / \sqrt{(\varepsilon_{eff})} \quad \text{------ (2)}$$

Where, d = distance between two element
c = velocity of light
θ = 45° direction of reconfigurability
ε_{eff} = Effective dielectric constant of the substrate

Here, radiation pattern is reconfigured between 0° & 45° in azimuth plane but the formula is valid for all the angles from 0° to 360°. Pattern reconfigurability in elevation plane is also possible if the elements are placed along E field and using same delay lines. For simplicity both design configurations were fabricated on separate substrate (as shown in fig.2.). The return loss in both cases is below -9dB. The RF switches used in simulations are realized as metal pads with dimensions 2mm × 2mm. UWB Power divider used here was already reported [5].

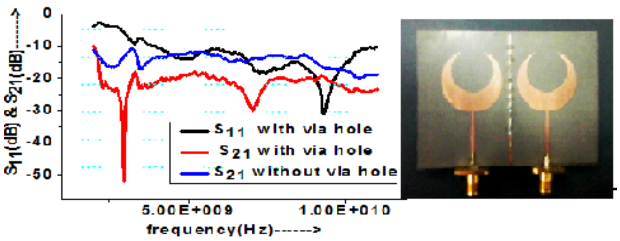

Fig.1.Two element UWB array with via hole and its measured S- parameter

Fig. 2. Fabricated array with maximum radiation at 0^0 and 45^0 respectively

A. Frequency domain analysis

Radiation pattern of the array shows that only H- plane pattern gets modified because the antenna elements are placed along direction of H. The E-plane pattern remains approximately same as monopole UWB antenna. Here, simulated (blue colour) and measured (red colour) results shows good agreement with each other in both cases.

Case1 – H- plane radiation pattern at 3.1GHz, 5GHz, 8GHz and 10.6GHz of the array [A] without delay line (fig.3)

Case2- H –plane radiation pattern at 3.1GHz, 5GHz, 8GHz and 10.6GHz of the array [B] with delay line of 45 ° (fig.4)

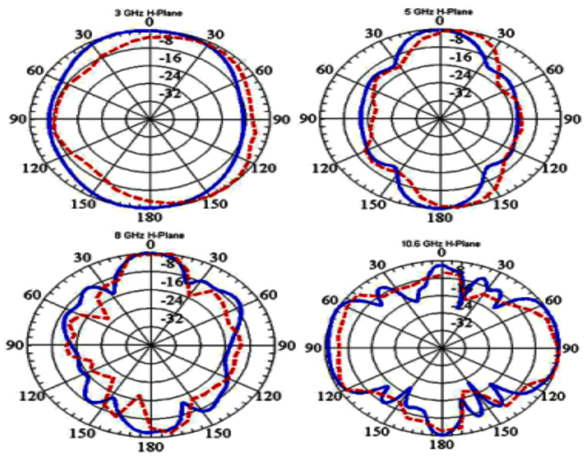

Fig. 3. Radiation pattern of array [A] at 0°

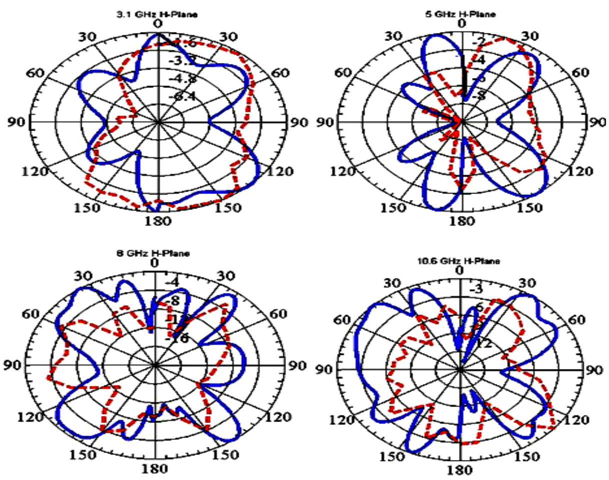

Fig. 4. Radiation pattern of array [B] at 45°

B. Time domain analysis

For TD analysis, Gaussian pulse is chosen as input signal s(t) because its spectrum satisfies the UWB range. T(f) is channel transfer function, which has been extracted from VNA and multiplied with Fourier transform of input signal s(t). The output is R(f), which is inverse Fourier transformed to get received signal r(t).

Case1 – When Tx- UWB array antenna and Rx -monopole UWB single antenna, the received signal is as shown in fig.5.

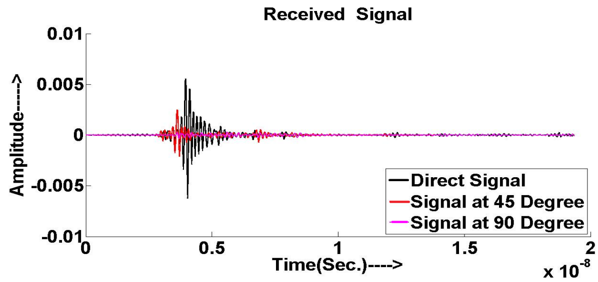

Fig. 5. Amplitude of received signal radiated by array (A)

Case2- When Tx- UWB array antenna with delay line and Rx -monopole UWB single antenna, the received signal is as shown in fig.6.

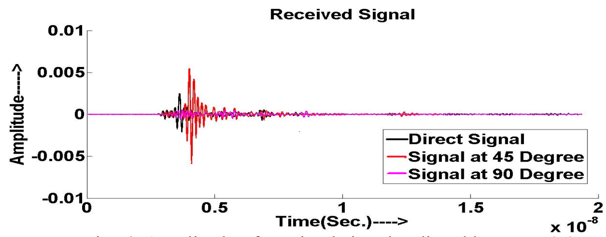

Fig. 6. Amplitude of received signal radiated by array (B)

In FD, measured result shows that array [A] & [B] have maximum radiation at 0° and 45°. And in TD, Gaussian signal transmitted by array [A] & [B] is received by single monopole UWB antenna have maximum amplitude of received signal at 0° and 45° respectively. These measured results, in both TD and FD, verify that the proposed array has reconfigured at two directions.

IV. CONCLUSION

With the above measured result in both cases, the radiation pattern in FD and received signal in TD, it is clear that the reconfigurability of the UWB array is achieved. Here, reconfiguration of pattern is achieved between two directions. Moreover, the same formula will be applicable to get reconfiguration of pattern in multiple directions in both elevation and azimuth plane. Due to its desired directional reconfigurability, easy design configuration and fabrication, the proposed UWB antenna array can be promising candidate for commercial ultra wide band wireless communication to achieve multidirectional scanning in PAN applications.

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