Configuration Study and Analysis of UWB MIMO Antenna Performance

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Abstract

A novel blueprint with a small physical dimension has been proposed and analyzed for Ultra-Wideband (UWB) applications with integration of Multi-Input Multi-Output (MIMO) technique. The configuration study is made on MIMO antenna with the duplication of two single antennas. The preferred typical parameter which reflects to the antennas performance has been conferred in terms of input reflection coefficient, mutual coupling and radiation pattern. The proposed antennas work proficiently for the entire interest band, 3.1GHz to 10.6GHz.

Keywords: Ultra-Wideband (UWB), Multi-Input Multi-Output (MIMO), UWB-MIMO

1. Introduction

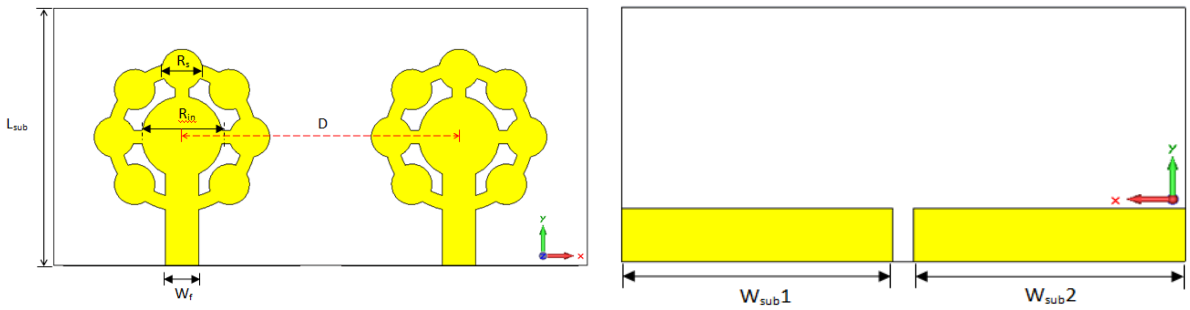
Preliminery studies reported recently a lot of UWB antennas have been developed and established. A novel compact UWB antenna with high bandwidth together with the idea of the rectangular waveguide is been introduced [1]. A planar dipole antenna consists of two semi-elliptical-ended arms connected by a shorting bridge with the ability to enhanced impedance and gain across the UWB operating bandwidth is also studied [2]. The interesting approach of implementing RF switches (PIN diode) at the feed line of planar monopole antenna for the purpose of reconfigurable UWB band to narrowband is presented [3]. A microstrip square-ring slot antenna (MSRSA) is achieved over UWB frequency range by splitting the square-ring slot and optimizes the feeding network [4].

Meanwhile, with the owing of high capacity and high speed wireless communication concentration, many researchers have been performed towards Multi-Input-Multi-Output (MIMO) antenna [5-6]. MIMO techniques use several transmitter and receiver antenna that working simultaneously. However there are few issues and consideration to be tackle for MIMO effectiveness such as very low mutual coupling, low correlation, high diversity gain and low total active reflection coefficient (TARC) [7-9].

This paper presented the novel compaction co-located antenna with replicate of two antenna elements. The proposed antenna is proficient to function for UWB operating frequency with good reflection coefficient. Hence, it demonstrates the purpose of UWB-MIMO antenna for wireless communication applications with advantageous of handy, small in size, high bandwidth, diversity and high capacity. The shortest inter-element spacing with very low mutual coupling is as well attainable for developing MIMO antenna system.

2. Antenna Design

The UWB-MIMO antenna presented consists of combination two identical antennas. Fig. 1 visualized the geometry of the antenna design. The antenna with novelty design is developing with integration of seven small circle with diameter of R_s and inner circle of R_{in}. The feed width is indicating by W_f. The structure of the antenna element has been fabricated on the Taconic TLY-5 substrate with a thickness of 1.5748mm, dielectric permittivity, ε_r of 2.2 and tangent loss, tanδ of 0.0009.



(a) (b)

Figure 1: The proposed UWB MIMO antenna system, (a) front view and (b) back view.

At first, the single antenna with dimension of L_{sub} x $W_{sub}1$ is developing. The impedance matching of the microstrip feed line is fix to 50Ω. Once the single element has met the agreement of UWB application, the second antenna is drawn by replicate the first antenna structure on the same substrate. With few optimization routine, the final geometric results are; L_{sub}=38mm, W_f=5mm, R_{in}=12mm, R_s=6mm, $W_{sub}1$=38mm and $W_{sub}2$=38mm. The distance between both antenna design symbolize by D will be analyze in the sense of getting the minimum mutual coupling and low reflection coefficient, conserve UWB frequency band standard. All the design and analyzes has been made using CST Microwave Studio simulation software.

3. Antenna Performance: Result and Discussion

3.1 Input Reflection Coefficient ($|S_{11}|$)

The performance of the single element (before combination) and MIMO antenna (after combination) are monitored. Fig. 2 obviously illustrated the reflection coefficient of both elements under the acceptable return loss less than 10dB is achievable for the entire UWB frequency. The return loss of the MIMO antenna has depreciated especially for frequency 3.15GHz and 6.2GHz approximately compared to single antenna. This is in due to the effect of the adjacent element and also the increase of the substrate dimensions in terms of width and length.

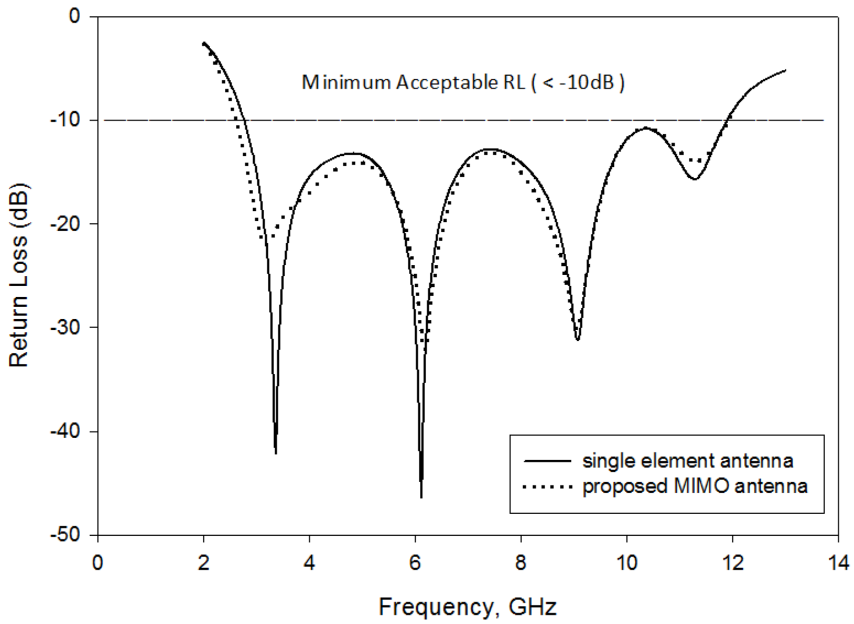


Figure 2: The returns loss of the presented antenna

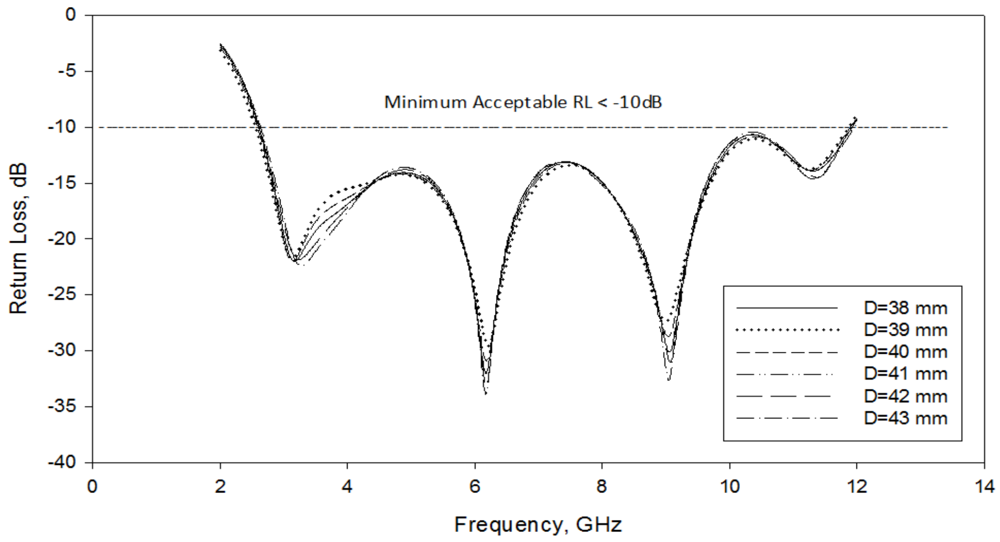


Figure 3: The returns loss of the MIMO antenna inter-element spacing

A study on the consequence of inter-element spacing represent by D has been carried out on the effect to the input reflection coefficient. Fig. 3 visualized the return loss of the MIMO antenna with various D values (38, 39, 40, 41, 42 and 43: mm). When D is 38mm, the impedance matching at particular frequency 6GHz is the optimum compared to others. Meanwhile, the higher the D values the more perfect match happen at the 9GHz frequency resonant. Yet to all the D values studied, the MIMO antenna still capable to operate at 3.1GHz to 10.6GHz. Due to antenna compaction plus antenna performance constraint, this paper has determined the value of D is equal to 38mm.

3.2 Mutual Coupling

The mutual coupling is the effect which exists due to the electromagnetic (EM) interaction between the adjacent antenna elements. The high value of mutual coupling will result to less efficiency of the antenna. Mutual coupling can be determined from the forward transmission coefficient, S_{12} and reverse transmission coefficient, S_{21} [8, 13]. In paper [8], [10] and [13], they show that the mutual coupling is less than -14dB, -11dB and -9.5dB respectively.

Fig.5 demonstrates the case study on the effect of different D values towards the S_{12} and S_{21}. From the result in fig.5, the mutual coupling is always less than -11.5dB for the entire UWB frequencies. With D is equal to 38mm, the S_{21} and S_{12} is overlapping to each other. As compared D is 38mm (no gap between elements) to other D's, the mutual coupling is reducing as inter-element spacing is increasing except for frequency operating 2GHz to 3GHz.

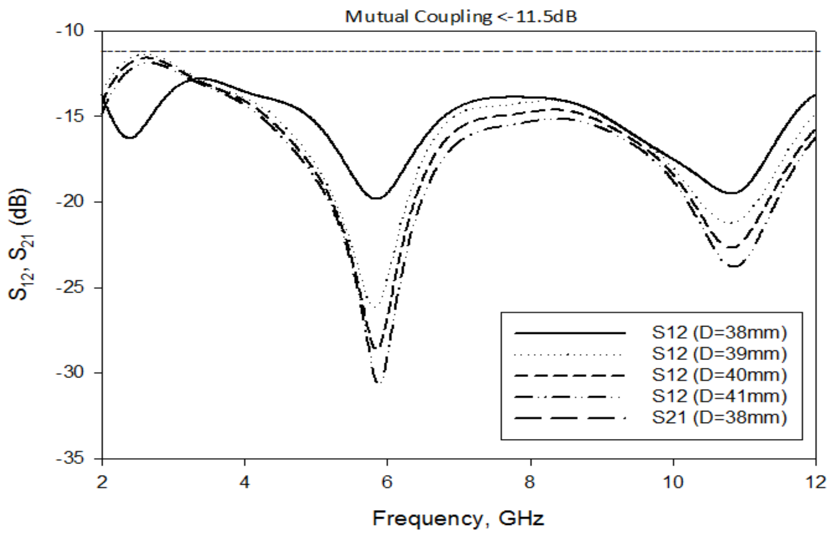


Figure 5: The mutual coupling against frequencies

4. Conclusions

In this paper, a novel design of 2x2 MIMO antennas with identical design operating for UWB is presented. Besides, a comparable study has been made towards the single element antenna (before combination) and MIMO antenna (after combination). The characteristic design of the MIMO antenna which reflects to antenna performance has been analyzed. The paper accessible a MIMO antenna with minimum input reflection coefficient of -10dB as well as low mutual coupling (<-11.5dB). A further study will be made on the low correlation coefficient and acceptable UWB impulse response. These indicate that the proposed antenna is fit for UWB-MIMO application. Additionally with a compaction in size, it is potential to be commercialized as future communications devices.

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