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The Design of An Ultra-Wideband Antenna for Fiber Optic Transceiver

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***Abstract*— The design of an ultra-wideband antenna for fiber optic transceiver is presented in this paper. In designing the ultra-wideband antenna, a high frequency electromagnetic simulation software is used. The proposed antenna is simulated within the operating frequency from 100MHz to 1GHz in order to evaluate the performance and usability for fiber over radio frequency communication system. The operating bandwidth is investigated by variying the radius of the antenna.**

***Keywords*—ultra-wideband antenna, wireless communication**

I. Introduction

Cable television (CATV) is one of the application for the fiber over radio frequency. These systems were called community antenna television. CATV is a system of delivering television programming to subscribers via radio frequency (RF) signals transmitted through coaxial cables or light pulses through fiber-optic cables. Large numbers of television channels is provided in a cost-effective way. FM radio programming, high-speed Internet, telephone service, and similar non-television services may also be provided through these cables. The purpose for cable television was to deliver broadcast signals in areas where they were not received in an acceptable manner with an antenna.

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Designing an ultra-wideband antenna that could be applied onto a fiber over radio frequency communication system would not pose any problem as there are many types of antenna which supports ultra-wideband usage. However, the challenges arise on whether the antenna with high bandwidth and frequency could transmit over a long distance without having much data loses between the transmissions. Currently, ultra-wideband is used in wireless data links and position location over short distance ranges. Although it can transmit a large amount of data at a time, we have to build a lot of ultra-wideband antenna. With the construction of an antenna that could transmit and receive data over long distances and still be able to give and gain the same amount of data with the same speed or better, at the same time reduces the number of antenna used.

II. Design of Circular Printed Patch Antenna

A. Conventional Rectangular Patch Antenna with Coplanar Feed Line

Fig. 1 shows the design of a printed rectangular antenna with coplanar feed line. It is chosen for this work because it is low cost and can be fabricated economically. Although the original design of patch antenna has a narrow bandwidth, it could be overcome by the coplanar-fed and adding some distributed element into the patch as shown in Fig. 1

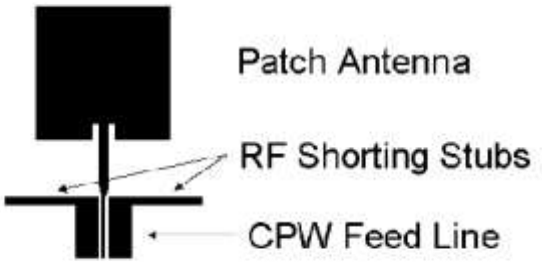

Figure 1. Sketch of a conventional rectangular coplanar patch antenna

In this work, the design of the antenna start with a conventional rectangular patch antenna with coplanar feed line. The patch antenna, transmission feed line and ground plane are made of high conductivity metal and the copper is used practically. The patch is of length (L) and width (W), sitting on top of a substrate which some uses dielectric circuit board of thickness (h) with permittivity or also called dielectric constant (εr). The thickness of the ground plane of the microstrip is not critically important and usually has the same height as the copper of the patch. Typically the height (h) is much smaller than the wavelength of operation but not much smaller than 0.05 of a wavelength [7]. Fig. 2 shows the top view of a conventional patch antenna.

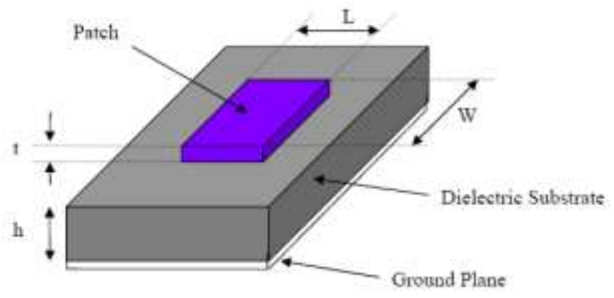

Figure 2. Top view of a conventional patch antenna

The operating frequency of a patch antenna is determined by the length, L and the width, W while the transmission feed line controls the input impedance. Larger widths also can increase the bandwidth. By increasing the width, the impedance can be reduced. However, to decrease the input impedance it requires a very wide patch antenna which takes up a lot of valuable space [7].

B. *Conventional Circular Printed Patch Antenna Design*

The design by using conventional coplanar rectangular printed patch antenna was not a success after it is drawn and simulated using high frequency electromagnetic software. The result of S-parameter gives out a narrow bandwidth and does not satisfies the objective of this project. Hence, we did further research and readings on journals in IEEE website. We found out a research done by J. Sosa-Pedroza, E. Garduno-Nolasco, F. Martinez-Zuniga and M. Enciso from Mexico stated that a patch which has a circular structure would increase its bandwidth. Thus, we carried out the calculation as mentioned in the journal.

The initial diameter is 22.36mm, calculated by using the formula as in (1),

$$R = \frac{\frac{F}{2h}}{(1 + \sqrt{\pi \varepsilon_{eff} F [ln \frac{F\pi}{2h} + 1.7726]}} \quad (1)$$

where
F= frequncy
h = height of substrate

Fig. 3 shows the design of a conventional circular printed patch antenna with coplanar feed line.

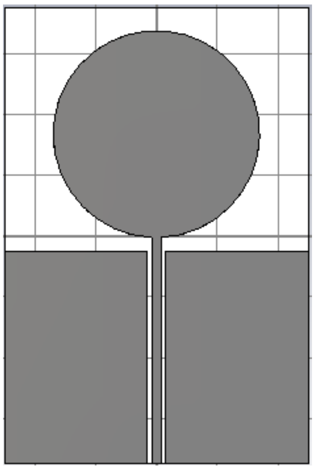

Figure 3. Conventional circular patch antenna with coplanar feed line

However, the above conventional design does not give quite a large bandwidth as needed. In order to reduce size of antenna, a modified circular coplanar printed patch antenna is designed. Fig. 4 shows the complete design of modified circular coplanar printed patch antenna. The antenna is fabricated onto a printed circuit board by using chemical etching.

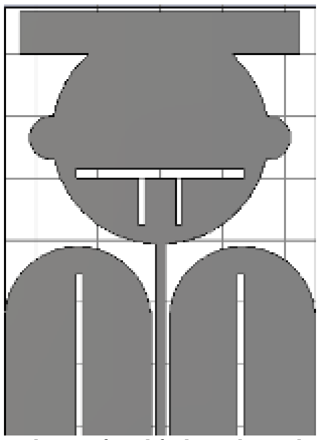

Figure 4. Complete design of modified circular coplanar patch antenna

III. Analysis and Discussions

Many simulations were performed to examine the S-parameter of this circular coplanar patch antenna by varying the patch radius, number of filters, width of coplanar feed and length of filters.

1) Simulation Result for Conventional Circular Coplanar Printed Patch Antenna

For the Fig. 5, the S-parameter from frequency range 0.85Ghz – 1.8Ghz is under -10dB. Hence we can conclude that this antenna has bandwith of 950Mhz.

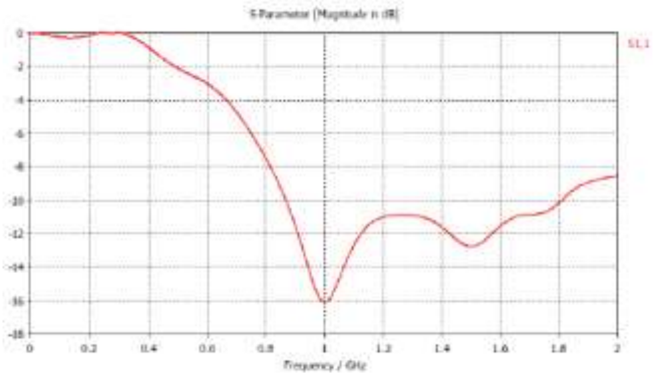

Figure 5. S-parameter of conventional circular coplanar printed patch antenna

2) *Simulation Results for Modified Circular Coplanar* **Printed** *Patch Antenna*

For the Fig. 6, the S-parameter from frequency range 0.81Ghz – 1.60Ghz is under -10dB. Hence we can conclude that this antenna has bandwith of 790Mhz.

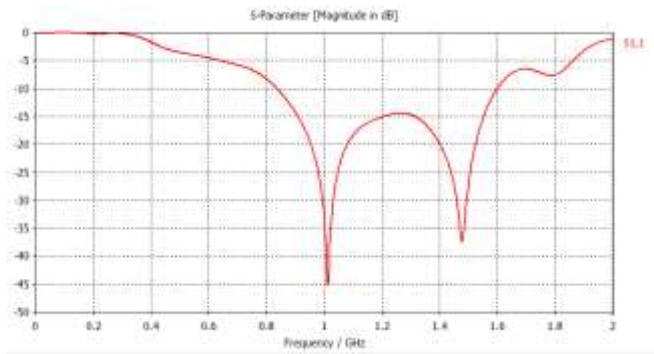

Figure 6. Final result of the modified circular coplanar printed patch antenna

C. *Size of Antenna*

The actual dimensions of an antenna are related to its frequency. Researchers stated that the higher the frequency of an antenna, the smaller the size it will be.

Hence, we simulate by using different size of antenna .Fig. 7 below show the S-parameter simulation results by using the original size of the antenna.

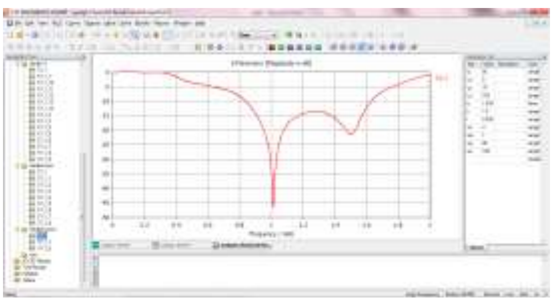

Figure 7. S-parameter simulation result of the conventional circular coplanar patch antenna

When the size of the antenna is increased from its original size, the result is as shown in Fig 8.

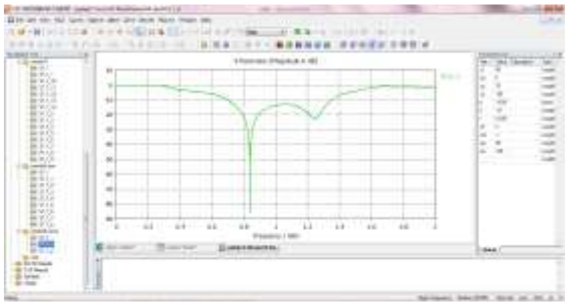

Figure 8. S-parameter simulation result of the conventional circular coplanar patch antenna when the size is transformed 1.5 times from its original size

Fig. 9 below shows S-parameter simulation result of the conventional circular coplanar patch antenna when the size is transformed twice its original size.

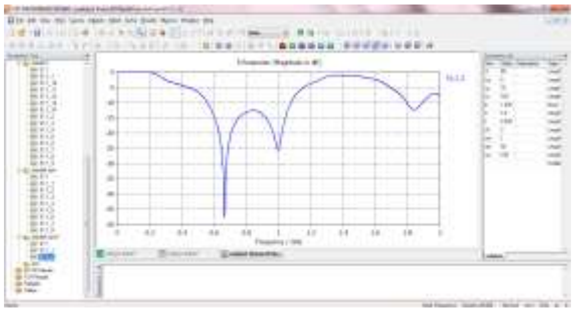

Figure 9. S-parameter simulation result of the conventional circular coplanar patch antenna when the size is transformed twice its original size

To prove the theory, the higher the frequency of an antenna, the smaller the size, all the simulation results was combine to shows the difference of frequency range.

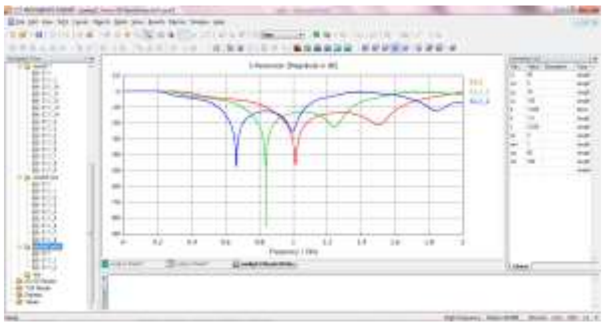

Figure 10. Combination of S-parameter simulation result for all sizes

The original conventional circular coplanar printed patch antenna runs from the frequency range of 0.838GHz to 1.63GHz. However, after the size is increased 1.5 times from its original size, the frequency range decreases to run from 0.698GHz to 1.348GHz. In the other hand, when the size is again magnified to twice of the original size, the antenna could operates at the frequency range of only 0.556GHz to 1.076GHz.

Furthermore, the bandwidth of the antenna also changed as the size changed. The original size antenna gives a bandwidth of 0.792GHz but after the size is increased 1.5 times its original size, the bandwidth decreased to 0.65GHz. For the size which is twice the original size of the conventional circular coplanar patch antenna, the bandwidth is only 0.52GHz. They act inversely proportional from each other in which as the size increases, the bandwidth decreases.In conclusion, the size of antenna should be reduced to obtain higher frequency range.

Fig 11 below show the fabricated antenna onto a printed cicuit board by using chemical etching.

Figure 11. Printed circular coplanar patch antenna with connector soldered to the port

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