Propagation Measurement on 2.5 mm NYAF Cable Using Load Matching and TDA

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Abstract. In this work, we propose measuring the propagation speed on the transmission medium in the form of a 2.5mm NYAF cable. The method used is load matching and time difference of arrival (TDA). The load matching method uses the same load as the characteristic impedance of the cable. While the TDA method measures two points on the cable with a capacitive load on the output side. From the results of the study, it was found that on the load impedance method, the average propagation speed on a 2.5mm NYAF cable is 1.9×10^8 m/s or 0.63 c. Meanwhile, in the time difference of arrival (TDA) method, the average propagation speed on a 2.5mm NYAF cable is 0.5×10^8 m/s or 0.17 c.

Keywords: Propagation Speed; Load Matching; Time Difference of Arrival

1 Introduction

Transmission media in the world of communication is used as a liaison between the sender and receiver to exchange data. Some electronic equipment requires a transmission medium to be able to receive data such as telephone, computer, television, radio, and so on. One type of transmission media used is the cabling system. This system has advantages such as high data transmission speed, stable cable network, can be connected to various electronic equipment and is more pocket friendly.

In communication, there is the term propagation or wave propagation that can predict the average signal power used to exchange data. Some studies on propagation are [1-20]. In this research, we used the transmission medium in the form of fiber cable with a 2.5mm NYAF type. The purpose of this research is to measure the speed of signal propagation through cable media using Load Matching and Time Difference of Arrival (TDA) methods.

2 Materials and Method

This section describes the materials and methods used in this study, including propagation speed, the description of matching impedance, and the time difference of arrival (TDA) method.

2.1 Propagation Speed

The speed of the wave propagation depends on the medium through which it travels, this is known as the speed of propagation. The highest propagation speed occurs in a vacuum medium which is often referred to as the speed of light ($c = 3 \times 10^8$ m/s). In the air, the speed of propagation of electromagnetic energy ranges from 95 – 98% of its speed in a vacuum. On the cable, the speed ranges from 60-85%.

2.2 Matching Impedance

Impedance adjustment is important in the microwave frequency range. A transmission line that is loaded with the same characteristic impedance has a standing wave ratio (SWR) equal to one and transmits a certain amount of power without reflection. Transmission efficiency is optimum when no power is reflected.

Matching in transmission lines has a different meaning from that in circuit theory. In-circuit theory, maximum power transfer requires a load impedance equal to the source complex conjugate. This kind of matching is called conjugate matching. In transmission lines, matching has the meaning of providing a load equal to the characteristic impedance of the line.

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2.2.1 Conjugate Matching

Fig. 1. Conjugate Matching

Used generally in the source section. This matching maximizes the power delivered to the load but does not minimize bounce (unless real Z_s).

2.2.2 Load Matching

Fig. 2. Load Matching

Generally used in the load section. This matching minimizes bounce but does not maximize the power delivered unless Z_0 is real. The following figure shows a “matched” transmission line system.

Fig. 3. "Matched" Transmission Line System

Impedance adjustment circuits generally use reactive components (capacitors and inductors) to avoid losses.

2.3 Time Difference of Arrival (TDA)

TDA is a two-point measurement method as shown in Figure 4. The propagation time measured by this technique has the same problem as the TDR method, where the TDR method is better because it observes one direction of propagation between two ends (A to B ends) of the cable. In the test, high-frequency current transformers (HFCT) are used as current measuring devices, and can also be used to record signals directly on a digital oscilloscope.

Fig. 4. TDA Measurement Implementation

This method raises some questions because it takes measurements at both ends. In the case of pulse signals, measurements are made at both ends with individual systems. Measurement of propagation delay time requires accurate timing with synchronization at both ends. This makes the technique more sensitive and error-prone. The synchronization problem has been eliminated for laboratory measurements using the configuration shown in Figure 4.

The TDA method can work well for shorter sections of the cable to minimize errors that occur. However, in practical applications with longer cables such as underground cable networks, where the accuracy of the fault point is important, it is important to consider the accuracy of the method used.

3 Results and Discussion

In this research, two methods were used to obtain the propagation speed on transmission media, especially cables. The first method used is load matching, this method uses a load with a characteristic impedance of the cable as shown in Figure 5. The second method used is Time Difference of Arrival (TDA), this method measures two points on the cable as shown in Figure 6.

Fig. 5. Test Series with Load Matching

Fig. 6. Test Series with TDA

Based on the observations on the load impedance method, when the input load is made at least or equal to zero and the output load is assigned a random value, the results obtained are graphs that are similar in shape to the input signal (box signal) but because of the load on

the output side, the signal has an additional signal. What is not desired apart from the length of the cable is from the output load itself so that the results obtained are a noisy box signal as in Figure 7.

Fig. 7. Zin is Minimum

Then when the output load is made to a minimum and the input load is made to a maximum (5kΩ) then the graph results obtained are only input signals which are not intact due to the large load on the input side. The output signal does not appear because there is no load so that the cable channel becomes an open channel as shown in Figure 8.

Fig. 8. Zout is Minimum

Furthermore, when the input and output loads are maximized (5kΩ), the graph results obtained are signals that are close to the sine signal. This is because the load on the output side is too large so that the output signal is close to a pure signal, namely a sinusoidal signal as shown in Figure 9.

Fig. 9. Zin and Zout are Maximum

Then when the input load and output load are made the same, the expected graph result is the same signal as the input signal and there is no time delay (delay) and

there is no noise. But the results obtained in this practicum are signals that have noise and delay as shown in Figure 10, this is because to get results that do not have noise and delay it is necessary to consider the cable selection and determine the characteristic impedance of the cable.

Fig. 10. Zout > Zin

Based on observations on the time difference of arrival (TDA) method, when the input signal is given a frequency of 10 kHz, 50 kHz, and 100 kHz, the same output signal is obtained in the form of a noisy box signal with a propagation delay of ± 840 ns. So it was found that in the TDA method, a change in frequency from 10 kHz to 100 kHz does not affect the propagation speed on the channel and the measurement of the propagation delay time requires accurate timing with synchronization at both ends. This makes the technique more sensitive and error-prone.

Furthermore, from the results of each observation can be calculated propagation speed. In the load impedance method, the average propagation speed of a 2.5mm NYAF cable is 1.9×10^8 m/s or 0.63 c. Meanwhile, in the time difference of arrival (TDA) method, the average propagation speed on a 2.5mm NYAF cable is 0.5×10^8 m/s or 0.17 c.

4 Conclusion

In this study, the following conclusions can be drawn:

1. The load matching method is a method that uses the same load as the characteristic impedance of the cable.
2. The Time Difference of Arrival (TDA) method is a method that measures two points on a cable with a capacitive load on the output side.
3. In the load impedance method, the average propagation speed of a 2.5mm NYAF cable is 1.9×10^8 m/s or 0.63 c.
4. In the time difference of arrival (TDA) method, the average propagation speed of a 2.5mm NYAF cable is 0.5×10^8 m/s or 0.17 c.

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