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Scenario Y Lab Report

1.Introduction and Aims

The transmission lines are applied widely to transmit information, applications such as communication systems, satellite systems, radar systems and microwave systems can be done due to the structure of transmission lines with inductance and capacitance inside. The coaxial cable is one of the examples of transmission lines that will be used for the experiment.

The aim of the experiment is to investigate the pulse propagation and dielectric constant in the coaxial cables deduced by the speed of wave inside the coaxial cables. Also, the experiment aimed to investigate the reflection inside the coaxial cables, analyzed by the amplitude changes of the voltage.

The report begins with a detailed description of methods followed by a discussion of potential error and limitation. After that, the result will be clearly and fully presented, and errors will be identified and evaluated. Finally, an analysis with relevant theory will be deliberated and conclusion will be given.

2.Methods

First of all, the function generator should be set up to produce a 40ns pulse with very small duty cycle, therefore, a square wave signal with 10kHz frequency and 0.04% duty cycle should be adjusted. Then, the signal from the function generator would be transmitted into oscilloscope via a short coaxial cable connecting with a T junction. After that, connecting the other end of the T junction with 50 Ω coaxial cables with length 6, 10, 15, 20, 25, 30, 35 and 40 meters in open circuit. Also, output the signal from T junction on the screen of oscilloscope. By capturing the trace from oscilloscope and using the 'measure' function, recorded down the phase delay, i.e the time period between two peaks. Following that, plotting the graph with time period in y-axis and double the length of coaxial cable in x-axis because of reflection and finally determine the gradient of the line, the reciprocal of the gradient indicates the speed of wave. Using the equation:

$$\nu = \frac{1}{\sqrt{\varepsilon_0 \varepsilon_r \mu_0 \mu_r}} \tag{1}$$

to find ε_r which is the dielectric constant, where ν is the speed of wave, ε_0 is the vacuum permittivity, $8.85 * 10^{-12}\ Fm^{-1}$, μ_0 is the vacuum permeability, $1.257 * 10^{-6}$ and μ_r is the relative permeability which is normally 1 in the coaxial cable.

Repeat the above steps with replacement of 50 Ω coaxial cables to 75 Ω coaxial cables.

Secondly, set up the function generator with 10kHz frequency, 1Vpp amplitude of voltage and 0.5% duty cycle due to the limitation of previous signal with 0.04% duty cycle which could not display full process of reflection. Then, using T junction at the oscilloscope again with one end connecting to the functional generator via a short coaxial cable with standard impedance 50 Ω. Then connect the 20 meters and 75 Ω coaxial cable followed by 5 meters and 50 Ω coaxial cable in open circuit to the other end of the T connector. After that, outputting the signal on the screen of oscilloscope and make a screenshot. Using the 'measure' function again to record down the pulse duration and notify the amplitude of voltage at each stage. Finally, utilizing the data to draw a 'bounce' diagram.

Due to the situation of imperfect function generator during the experiment, the generated square and pulse waves are defective, especially for the case of distortion. Therefore, it is advised to use coaxial cables with longer length to eliminate the effect of distortion. Also, the coaxial cable connected between function generator and the T junction has a standard impedance of 50 Ω which will cause unwanted effect such as noise and affect the output from the T junction.

3.Results

After following the methods, the constructed circuit is shown below:

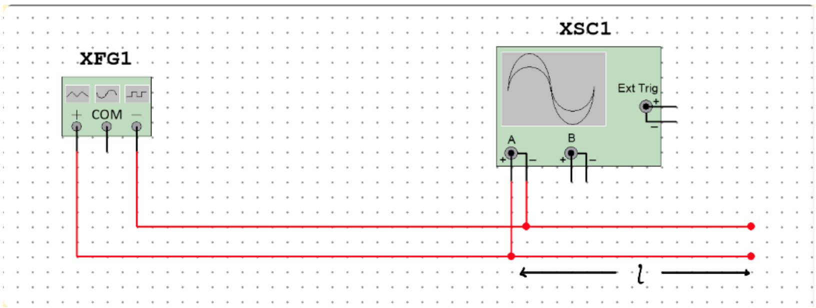

Figure.1 Constructed Circuit 1

The *l* is the length of coaxial cables that are varying, the following table display the data collection when *l* is 6, 10, 15, 20, 25, 30, 35 and 40 with 50 Ω coaxial cables.

Length of 50 Ω Coaxial Cable (m)	Time Delay (ns)
6	61.6
10	108
15	152
20	203.2
25	254.4
30	305.6
35	355.6
40	407.2

Table.1 Time Delay for 50 Ω coaxial cable in different length

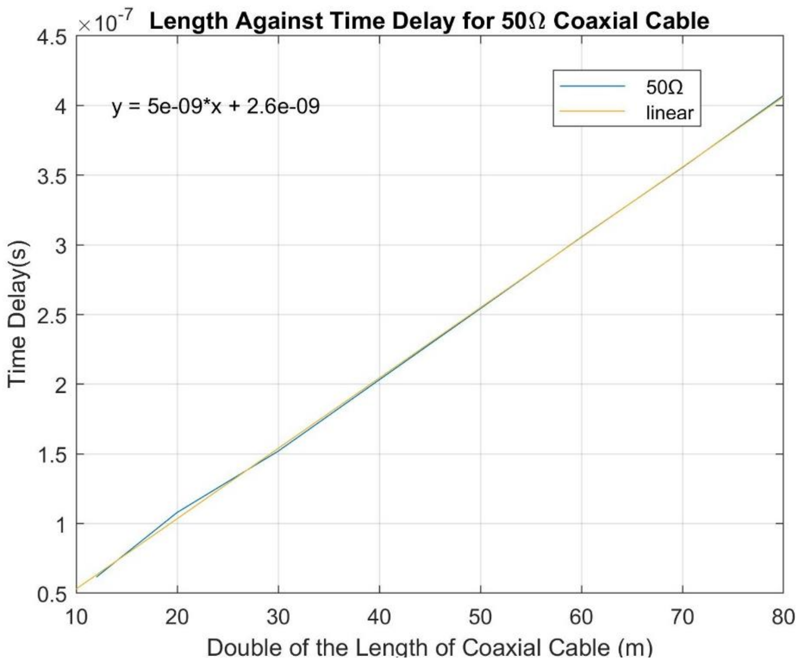

Figure.3 Graph for Table.1

From Figure.3, it can be shown that the gradient of the graph is $5 * 10^{-9}\ sm^{-1}$, by finding its reciprocal which is $\frac{1}{5*10^{-9}} = 2 * 10^{8}\ ms^{-1}$, the speed of wave in 50 Ω coaxial cable can be deduced. Using the equation (1) as shown above, the dielectric constant for 50 Ω coaxial cable is around 2.25 Fm^{-1} to 3 significant figures.

The following table display the data collection when l is 5, 7, 10, 15 and 20 with 75 Ω coaxial cables:

Length of 75 Ω Coaxial Cable (m)	Time Delay (ns)
5	48
7	78
10	103
15	157.3
20	205.8

Table.2 Time Delay for 70 Ω coaxial cable in different length

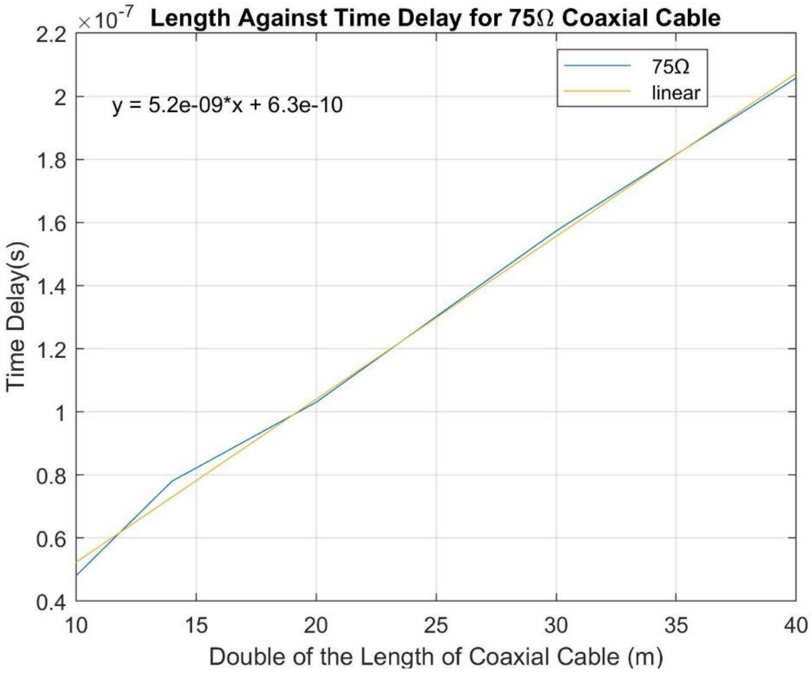

Figure.4 Graph for Table 2

From Figure.3, it can be shown that the gradient of the graph is $5.2 * 10^{-9}\ sm^{-1}$, by finding its reciprocal which is $\frac{1}{5.2*10^{-9}} = 1.92 * 10^{8}\ ms^{-1}$, the speed of wave in 75 Ω coaxial cable can be deduced. Using the equation (1) as shown above, the dielectric constant for 75 Ω coaxial cable is around 2.43 Fm^{-1} to 3 significant figures.

After the previous testing, the circuit is constructed as shown as Figure.5:

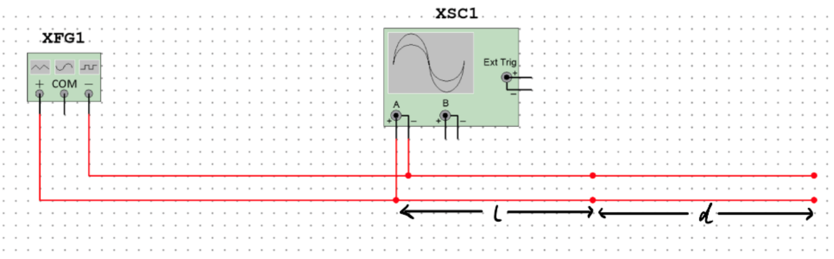

Figure.5 Constructed circuit 2

The *l* is the 20 meters coaxial cable with 75 Ω impedance and *d* is the 10 meters coaxial cable with 50 Ω impedance. The outputting data from the T junction is shown as Figure. 6:

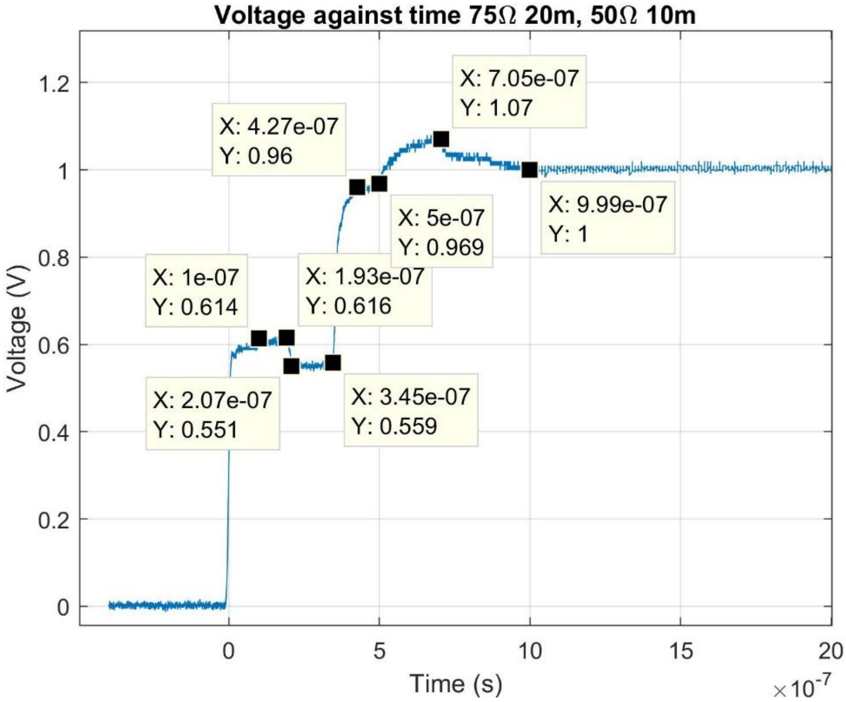

Figure.6 Output from T Junction

The 'bounce' diagram generated from Figure.6 is shown as Figure.7:

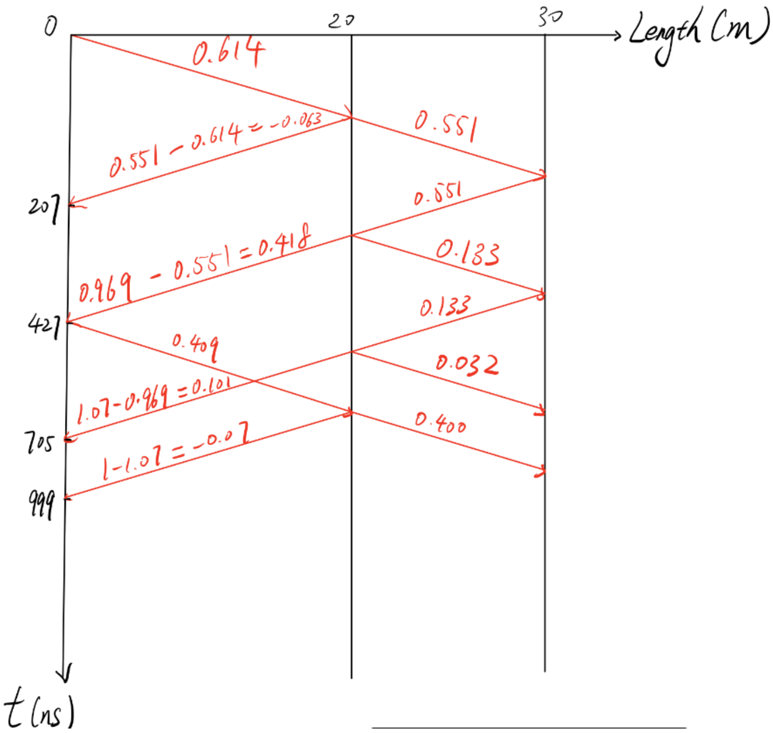

Figure.7 'Bounce' Diagram from Figure.6

4.Analysis and Conclusion

Comparing the speed of wave and dielectric constant between 50 Ω and 75 Ω coaxial cables, there are 4% and 8% difference, respectively. It could be deduced that the speed of wave is not affected by the impedance of the coaxial cables, also, due to the equation (1) as shown above, the difference in dielectric constant are caused by the difference from speed of wave. Theoretically, the result of speed of wave from the experiment is acceptable, as the speed does not exceed and is a fraction of the speed of light. However, based on the theory, the speed of wave and dielectric constant should be the same in coaxial cables with same material, same inner conductor diameter and same inner coaxial cable shield diameter. After further research and measurement, it was discovered that the length of the cables has ± 5% of error which could cause the error and the noise. The improvement can be applied into radio network which could eliminate the effect of noise and prevent signal leakage.

The experiment with connection of 75 Ω and 50 Ω coaxial cables prove the following equation about reflection coefficient:

$$r = \frac{Z_L - Z_o}{Z_L + Z_o}$$

where Z_L is the load impedance and Z_o is the reference impedance and in the experiment situation, they are 50 Ω and 75 Ω, respectively. Therefore, the reflection coefficient is negative as it has been proved from the decline between the time 207 to 345 ns in Figure.6 due to the negative reflection back at the boundary between 75 Ω and 50 Ω coaxial cables as shown in Figure.7. However, from Figure.7, the magnitude of reflection coefficient is unexpected and questionable, as it does not match the theoretical result which should be 0.2. After further research, the unexpected magnitude of reflection could be caused by distortion in both function generator and coaxial cable which cause transient in some parts of the result. The effect can be reduced with better function generator or placing longer coaxial cables for longer time for reflection and response. The improvement could be used in television network to prevent distortion.

Overall, the experiment was successful, as the aims had all achieved and the results had been analysed and confirmed by the theory.