

**BACHELOR OF SCIENCE IN
ELECTRONIC AND TELECOMMUNICATION ENGINEERING**

**Comparing the effectiveness of several types of dielectric materials
for coaxial cable transmission lines**

Submitted by

Asif Mohammad Mohaimin

T181035

&

Akash Dey

T181038

Supervised by

Abdul Gafur

Associate Professor

Department of ETE, IIUC

Department of Electronic and Telecommunication Engineering
International Islamic University Chittagong
Kumira, Sitakunda, Chittagong – 4314

CANDIDATE DECLARATION

By signing this declaration, it is acknowledged that the work contained in this thesis has not been submitted elsewhere for the conferral of any degree or diploma and does not contain any statements that are illegal.

Abdul Gafur sir, an associate professor in the department of ETE at the International Islamic University in Chittagong, served as the thesis supervisor.

Asif Mohammad Mohaimin

T-181035

Akash Dey

T-181038

RECOMMENDATION

It is a certification that **Asif Mohammad Mohaimin (T181035)** and **Akash Dey (T181038)**, students at International Islamic University Chittagong (IIUC), Department of Electronic and Telecommunications Engineering, successfully completed their thesis on "**Comparing the effectiveness of several types of dielectric materials for coaxial cable transmission lines**" under my supervision and guidance and that it was deemed satisfactory in the university.

Abdul Gafur

Associate Professor

Department of ETE, IIUC

ACKNOWLEDGMENT

In the majesty of Allah, the Most Merciful, the Most Forgiving. All thanks and credit is due to Allah (SWT), who has given us a plethora of opportunities and lavished us with His compassion and direction throughout life. and may Allah provide the Prophet Muhammad (pbuh), a source of wisdom and inspiration for us, peace and blessings. Any type of thesis needs the cooperation of multiple persons to be successfully completed. We have used a number of different sources to help us produce this thesis report. We are now making a tiny effort to show those good people how much we appreciate them.

We are incredibly grateful for what our supervisor **Abdul Gafur**, Associate Professor at the IIUC's ETE Department, has accomplished. Without his patient guidance and knowledgeable comments, this thesis would not have been as effective. His observation and guidance shaped this thesis to be successfully completed at every level.

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ABSTRACT

The kind of dielectric media (Polyimide, Polyethylene, and Teflon) will be covered as the most useful parameter in this thesis.

This evaluation evaluates the performance of dielectric materials with regard to Dielectric losses. To examine the impact of the insulators' (Dielectrics') performance, the research relies on a simple model for coaxial cables. CST (Microwave Studio) is used to simulate this task, and it shows the results in accordance with the coaxial cable's physical parameters, kinds of conductor and dielectric losses, and construction details.

Results that satisfied the requirements for high performance for coaxial cable were achieved.

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CHAPTER 1

Introduction

1.1 Coaxial Cable

A coax cable, ordinarily referred to as coax, may be a variety of transmission line that consists of an inner conductor encircled by a coaxial conducting protect, with the 2 parts separated by a stuff. several homocentric cables additionally embody a protecting outer sheath or jacket. information is transmitted through the middle conductor of a coax cable, and any signal loss (also referred to as attenuation loss) is stopped and EMI is reduced by the shielding layers that surround it. For the purposes of designing effective systems in the disciplines of communication, biology, and material science, there is a strong need for precise material characteristics in the radio and microwave regime. The core conductor and also the outer layers are separated from each other by the primary layer, referred to as the stuff, that additionally acts as some insulation. A transmission circuit that's electrically secure is formed by encompassing one wire with a stuff material, that is then encircled by the second, outer conductor. once the skin conductor of a coax cable is unbroken at ground potential, it acts as an associate magnetic force protect, protective the inner magnetic force signal from outside interference and limiting signal strength to the dielectric's boundaries. Polyethylene, that has robust electrical characteristics, is that the most used stuff material. it's additionally cheap and versatile. As a result, it's the fabric of alternative for cable insulation. PVC has fewer stuff losses than synthetic resin, that is additional moisture-sensitive once exposed to voltage stress.

The phrase "coaxial" refers to the outer shield's shared geometric axis with the inner conductor. The 'skin effect' in telegraph transmission lines was first investigated historically in 1880 by English mathematician Oliver Heaviside. He came to the conclusion that an insular casing boosts the signal's clarity and increases the cable's toughness when it is wrapped around a transmission line. In England following same year, he obtained a patent for the first coaxial wire. An electrical engineering company by the name of Siemens produced the first Coaxial cable four years later, in 1884.

Almost all electromagnetic waves are effectively kept inside a coaxial wire. The coaxial cable may be bent or twisted because of its mechanical characteristics, and it can also be fastened to conductive supports without causing the cable to carry undesired currents. The speed(S) of electromagnetic waves propagating through a dielectric medium is given by:

$$S = c / (\mu_r \epsilon_r)^{1/2}$$

C: the speed of light in a void

μ_r : dielectric medium's relative permeability to magnetism

ϵ_r : relative dielectric permittivity

Polyethylene is the most used dielectric material; it is inexpensive, flexible, and has good electrical characteristics.

As a result, it is a preferred material for coax cable insulation. While PVC is more resistant to moisture under voltage stress (i.e. only at high voltages), Polyethylene has lower dielectric losses than PVC.

1.2 Basics of Coaxial Cable

Usually thought of as a thick electrical wire, coaxial feeder. A variety of components go into making the cable, and when they work together, the

coax cable is able to transport radio frequency signals from one place to another with little to no loss.

The diagram below shows how the coax cable or RF wire is made up of a number of concentric layers, which illustrates its overall architecture. Despite the fact that coax cable comes in a variety of forms, its fundamental design never changes.

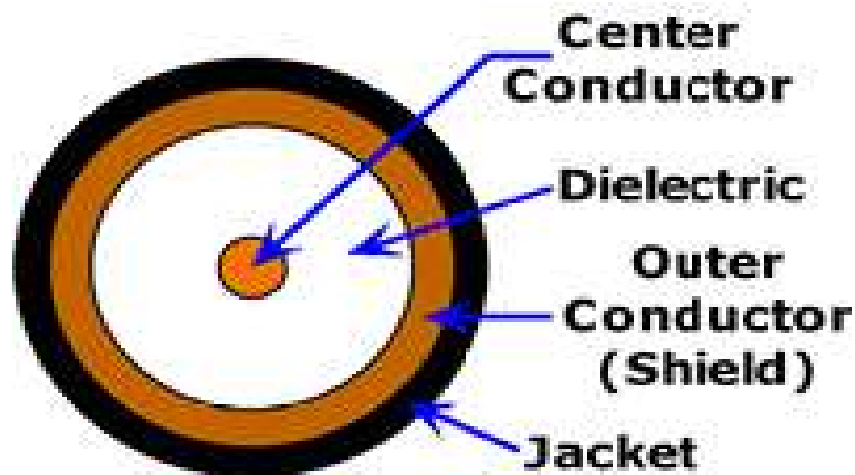


Fig-1.1: Cross section of coaxial cable

1.2.1 Inner Conductor

In virtually all cases, copper serves as the coax's center conductor. In certain RF cables, it may just have one conductor, while in others, it may have numerous strands.

1.2.2 Dielectric

An insulating dielectric is sandwiched between the coax cable's two conductors. Although it is one of the primary causes of loss in practice, this keeps the two conductors apart and in a perfect world would not introduce any loss.

1.2.3 Outer Conductor

Typically, copper braid is used to create the RF cable's outer conductor. Since the outside conductor is no longer solid, the coax cable may be flexible, something it could not otherwise.

1.2.4 Jacket

An outside sheath or final cover for the coax cable is present. The formation of earth loops can be avoided, however this has minimal electrical value. Additionally, the coax cable receives the essential protection needed to stop dirt, moisture, and other mechanical forces from damaging it.

1.3 Coaxial Cable Application

Radio frequency signals are sent using coaxial cable as the transmission medium. It can be used for cable television signal distribution, digital audio (S/PDIF), computer network connections (like Ethernet), and feed-lines that connect radio transmitters and receivers to their antennas.

Video distribution is one of the coaxial cable's many applications. These signals, which range from precise digital signals at a post-production studio to CATV signals in the neighborhood, are routed on 75 ohm coaxial cable. These cables have shields made of a mix of aluminum foil and braided copper-covered steel conductors (outer conductors). High strength, light weight, and cheap cost were considered when designing them for use over 50 MHz.

1.4 Advantages and Disadvantages of Coaxial Cable

Systems that need the transfer of signals from one location to another are connected via transmission lines or networking cables. There are several varieties of cable, each with a unique design intended to fulfill a certain function. A network or system will operate more efficiently if the cables are chosen correctly, whereas improper cable selection will result in signal loss, poor transmission, and subpar performance.

Transverse electromagnetic (TEM) mode is the mode used by coaxial cables to transfer signals. These cables are now commonplace because to their vast variety of utilities and diverse range of applications, including data, video, and voice communication.

A cable's benefits and limits are mostly determined by its design. All the layers of the wire wrapped around one other in a coaxial cable have a common axis, which is particularly intended to reduce outside interference. Depending on the intended purpose, the shielding, protective jacket, and conductor thickness of a coaxial cable can all vary. Waterproof and fire-resistant are two qualities of high-quality coaxial cables.

1.4.1 Advantages

- In compared to twisted pair, coaxial cable is more resistant to EMI and RFI interference. In order to maintain the signal's quality throughout the quick signal transfer, the shielding prevents outside interference. The optimum performance for transmissions over shorter distances is provided by coaxial cables, which offer faster transmission rates.
- Comparatively speaking, compared to twisted pair cables, coaxial cables can carry a significantly wider frequency range.

- The problem of signal leakage is less of an issue with coaxial cables since they are substantially insulated; in a perfect system, there should be no leakage at all.
- Coaxial cables are less expensive than fiber optic cables, making installation cheap and simple. Because the technique is less difficult and the wires are extensible and flexible, they are also very simple to install.
- Durability - Coaxial Cables require less repairs since they are more long-lasting and sturdy while yet being lightweight. The low price makes repairs less expensive when they are necessary. In addition to lowering maintenance costs, this lowers the likelihood of any downtime.

1.4.2 Disadvantages

- At the point of connecting, coaxial cables suffer from signal leakage. F-connectors are the connectors that are most frequently used for gadgets like televisions.
- Long-distance transmissions using coaxial cables are not recommended because of the high data loss that occurs when the distance is increased.
- Unauthorized signal access is a problem as splitters and T-Joints are simple to install and the wires may be quickly tapped.
- In order to avoid interference, it must be grounded.

1.5 Coaxial Cable Specification & Parameter

The requirements for the various criteria must be understood in order to comprehend the coaxial cable's functioning.

1.5.1 Characteristics Impedance

Its characteristic impedance may be one of the characteristics that best describes coax cable. An endless length of wire seems to have this impedance when a signal source looks into it. The total impedance is determined by the cable's size and the chosen dielectric. Ohms are used to measure the resistive nature of this standard.

The most typical impedance values are:

- 50/52 ohms, which is the cable type most frequently used in RF applications for business.
- RF signal leads for televisions and high-end audio equipment typically have an impedance of 75 ohms.
- Many early computers connected displays and the computers themselves via coax that had an impedance standard of 93 ohms. Its low capacitance level made it useful.

The entire cable is in complete opposition or resistance to the transmission of electrical energy. It is a complicated number that is determined by the resistance, capacitance, inductance, and conductance of the cable and represents their combined equivalent value.

1.5.2 Loss

Loss or attenuation is another important factor for coaxial cable. The movement of a signal across a coax cable results in some loss, it is discovered. All cables have this, which is caused by a multitude of variables. Additionally, the duration affects how much it is.

In terms of a loss across a certain length, the coax loss or attenuation parameter is defined. It is often described as a loss expressed in decibels over a particular length, such as 0.5 dB / 10 meters.

1.5.3 Capacitance

The capacitance parameter of the coax cable will be significant for some applications. As is obvious, there is a capacitance between the cable's inner and outer conductors, and this capacitance is related to the cable's length, as well as to the dielectric constant, the inner and outer conductor diameters, and to the length of the cable utilized.

1.5.4 Power rating specification

The power rating may not be crucial for applications using low-level signals, but it may be problematic when carrying larger power levels. The cable's internal heat loss often acts as a limiting factor. Check to make sure the operational voltage is not exceeded if the RF cable's power is going to be pulsed.

1.5.5 Velocity factor specification

A coaxial cable's velocity factor parameters describe how fast the signal travels inside the cable in relation to how quickly it would move outside of it (i.e., at the speed of light). Cable velocity factor numbers are found to be quite comparable.

Because the velocity factor is controlled by the dielectric between the two conductors, this is the case. Velocity factors for cables made of solid

polyethylene dielectric will be approximately 0.66, while for cables made of foam polyethylene, they will be in the range of 0.80 to 0.88.

1.5.6 Maximum voltage

The voltage may reach significant levels in particular applications. The cable may malfunction at a certain voltage, resulting in harm to the cable itself.

High amounts of standing waves and high power levels can result in voltages. Before choosing a certain type of coax, it is important to make sure that it can resist the expected level of voltage.

1.5.7 Coax mechanical dimensions

A number of factors make the coax's mechanical dimensions specification crucial. Coax cables come in a variety of sizes, which is common. The loss levels and power ratings of larger diameter coax cables are frequently lower.

1.6 ATTENUATION FOR COAXIAL CABLE

Attenuation describes the power loss brought on by a coax cable. It has a specified frequency and is measured in decibels per unit of length. However, it is also discovered that the loss is frequency dependent, roughly increasing with frequency, even though the exact degree of loss is not linearly dependent upon the frequency. Obviously, the longer the coax cable, the higher the loss.

Almost all applications require a minimum amount of loss. Several methods exist for the power to be lost:

Resistive loss: The resistance of the conductors causes resistive losses within the coax cable, and heat is lost as a result of the conductors' current flow. The skin effect, which gets increasingly pronounced as the frequency increases, limits the real region through which the current travels in the conductor. Multiple-stranded conductors are frequently utilized to aid with this.

Dielectric loss: Another significant loss that occurs in most coax cables is the dielectric loss. Once more, heat is produced when electricity is lost due to dielectric loss. It is discovered that the dielectric loss increases linearly with frequency but is independent of the size of the RF wire.

Radiated loss: As opposed to the resistive and dielectric losses, the radiated loss of a coax cable is often substantially lower. However, some really inexpensive coax cables could have a very subpar outer braid, and in these situations it might constitute an observable component of the loss.

1.7 Coax Cable Attenuation With Time

Even though many coax cables are flexible, even when bent within the manufacturer's suggested bend radius, the amount of loss or attenuation will rise. This is especially true if the RF wire is bent sharply.

This increase in loss may come from damage to the braid, screen, or dielectric as well as from these disruptions. There may be an increase of one or two decibels at frequencies of 1 GHz when RF cables typically indicate a loss of 10 dB.

CHAPTER 2

Theory and Design Tool

2.1 Several Types of Dielectric Material

In a coaxial cable, the outer shield and inner conductor are separated by an insulating substance (s). In order to preserve stable electrical characteristics and reduce signal loss, this "dielectric" substance is frequently used. The end result is a precise, error-free communication.[8]

The physical size, frequency performance, attenuation, power handling capacity, flexibility, strength, and cost of coaxial cables are all impacted by design decisions. A stranded inner conductor is more flexible than a solid one. The inner conductor could be silver-plated to achieve superior high-frequency performance. The inner conductor of cable used in the cable TV business is frequently made of steel wire that has been copper-plated.

2.2 Dielectric Material

With spacers supporting the inner wire, the insulator that surrounds the inner conductor might be made of solid plastic, foam plastic, or air. Some of the electrical characteristics of the cable are influenced by the dielectric insulator's characteristics. Solid polyethylene (PE) insulators, used in lower-loss cables, are a popular option. Insolely for plenum-rated cables, solid Teflon (PTFE) is utilized as an insulator. [Needs citation] To prevent the inner conductor from hitting the shield, some coaxial lines utilize spacers and air (or another gas).

Copper braided wire serves as the shield in many traditional coaxial cables. Because the braid can't be flat, there are gaps in the shield layer and a tiny variation in the inner dimension of the shield, which makes it possible for the cable to be flexible. The braid can occasionally be coated

with silver. Certain cables include a double-layer shield for improved shield performance. It's possible that the shield only consists of two braids, but nowadays it's more typical to have a wire braid covering a thin foil shield. Some cables may have more than two shield layers, including "quad-shield," which has four alternating layers of braid and foil. For greater performance, other shield designs forgo flexibility; some shields are made of a solid metal tube. [9]

Since electrons are bonded to atoms and molecules in a dielectric, also known as an electric insulating material, there is a high resistance to electric current and zero or almost zero electrical conductivity in the substance. The current electric field liberates the electrons when breakdown occurs. In collisions with neutral atoms or molecules, the liberated electrons may accelerate and release more electrons if the electric field is high enough. The dielectric strength of a material, which is expressed in volts per unit length, must be determined in order to determine how much voltage an insulating material can withstand before degrading. An insulator's use as a material increases with increasing electric strength.

Insulation normally refers to a substance having low conductivity, even though the phrases dielectric and insulation can be used interchangeably. But the term "dielectric" only applies to insulating materials with strong polarization tendencies. When selecting a cable, dielectric characteristics may be a crucial factor to take into account. The qualities included in these definitions have the power to create or destroy an application's success.[12]

The following are some of the phrases used while talking about dielectrics:

- **Dielectric Breakdown:** When the dielectric is changed and turns conductive, this is known as dielectric breakdown. When high voltage is used and insulation fails, it typically occurs.
- **Dielectric Constant:** The capacity of a dielectric substance to retain electrostatic energy when a specific voltage is applied is determined by a feature known as the dielectric constant. The relative permittivity is another name for the dielectric constant.
- **Dielectric Strength:** The amount of voltage that the insulation can withstand before deteriorating is measured by its dielectric strength. This is a nice attribute since it shows how long the dielectric will last.
- **Dielectric Loss:** This refers to the power loss brought on by the friction in the dielectric. Molecules traveling across an alternating electric field are what cause the friction. Generally speaking, power loss is a bad quality.
- **Dielectric Absorption:** When a dielectric comes into touch with an electric field, it absorbs the electric charges that accumulate there. A problematic aspect of excellent dielectrics is their resistance to the flow of electrons.

Teflon, polyethylene, and polyimide have been chosen so that we may compare how well they work as dielectrics in coaxial cable transmission lines. Details about these dielectrics are explained.

2.3 Teflon

Teflon has a low dissipation factor, a high surface resistivity, and a high dielectric strength across a wide frequency range. The high voltage that an insulating substance can endure before failing is measured by its dielectric strength. The amount of electrical energy that is absorbed and lost when current is applied to an insulating material is measured by the dissipation factor, which the material has a low amount of. When the dissipation factor is low, less heat is produced from the absorbed energy.

The electrical resistance between opposing edges of a unit square on the surface of an insulating material is referred to as the high surface resistivity.[10]

Teflon's loss factor is 0.0003 at 1 MHz, but its dielectric constant is 2.1.

2.4 Polyethylene

Since electrons are bonded to atoms and molecules in a dielectric, also known as an electric insulating material, there is a high resistance to electric current and zero or almost zero electrical conductivity in the substance. The current electric field liberates the electrons when breakdown occurs. In collisions with neutral atoms or molecules, the liberated electrons may accelerate and release more electrons if the electric field is high enough. The dielectric strength of a material, which is expressed in volts per unit length, must be determined in order to determine how much voltage an insulating material can withstand before degrading. An insulator's use as a material increases with increasing electric strength.

Long carbon chains joined by hydrogen atoms make up the strong, reasonably priced polymer known as polyethylene (plastic). Due to its minimal moisture absorption, it has excellent electrical qualities; nevertheless, when the temperature rises, it begins to soften as its

crystallites melt and its dielectric strength will decline. Polyethylene's dielectric strengths range from 18.9 MV/m to 160 MV/m depending on a number of variables. The loss tangent delta value for polyethylene is 0.0002 at 1 KHz, and its dielectric constant is 2.25.

2.5 Polyimide

For coaxial cable transmission lines, polyimide is also employed as the dielectric material. High temperature and radiation resistant polyimide insulated coaxial cable with a 3.4 to 3.5 dielectric constant and manufacturing technique. Low dielectric constant cable is produced by wrapping polyimide with perforations.

2.6 Design Tool

This section contains information about design tool characteristics.

2.6.1 CST Microwave Studio

The 3D electromagnetic simulation of high frequency buildings may be done with excellent results using CST MICROWAVE STUDIO (CST MWS). Antennas, filters, couplers, planar and multi-layer structures, as well as SI and EMC effects, may all be quickly and precisely analysed by the user using CST MWS. There are solutions for both the Time Domain and the Frequency Domain in the program. Filters for the extraction of SPICE parameters and the import of certain CAD files improve design possibilities and save processing time. For the design and analysis of electromagnetic systems, CST provides precise, effective computational solutions.

In order to handle the complete design process of a complicated system, from the initial layout to the ultimate resolution, CST Design Studio

serves as an all-encompassing platform. The behavior of the entire system may be dissectedly examined through the synthesis of fundamental subsystems. The optimization process is greatly sped up as a result of the blocks' ability to keep the most current findings individually and the fact that adjustments often don't affect every block.

The computation of arbitrary variation outcomes is made feasible in CST Design Studio thanks to the usage of global parameters, such as when doing a parameter sweep. An arbitrary number of weighted target functions and arbitrary numbers of parameters may be taken into account during global optimization utilizing the robust built-in optimizer tool. Due to its implementation as an OLE automation server and support for the VBA macro language, CST Design Studio is ideally suited for automation activities.

The boundary conditions of the computation domain that enable both energy absorption and stimulation are represented by waveguide ports. This style of port mimics a structure-connected waveguide that is endlessly long.

CHAPTER 3

Literature Review

3.1 Review Paper

Consequently, for the design and simulation of coaxial cable with better dielectric material and simple construction, the works by other researchers that are related to this thesis, "Comparing the effectiveness of several types of dielectric materials for coaxial cable transmission lines," will be reviewed in this section.

1) Paper on "A Calibration-Free Method for the Dielectric Constant Calculation of Low-Loss Materials."

The author's main points in this paper were: low-loss materials are also needed to create a link between the sample permittivity and the observed wave reflection coefficient. [1]

2) Paper on "Performance Investigation of Coaxial Cable with Transmission Line Parameters Based on Lossy Dielectric Medium."

The author's main points in this paper were: Analyzing the performance of dielectric mediums in terms of dielectric losses and how they affect cable characteristics, dielectrics in relation to characteristic impedance, and attenuation in the coaxial line for various dielectrics. [7]

3) Paper on "Development of new dielectric material to reduce transmission loss."

The author's main points in this paper were: High adherence to copper foil with a flat surface and low dissipation factor for the dielectric materials. [3]

4) Paper on “Broadband Measurement of Dielectric Properties of Substrates up to 67 GHz using a Coaxial Air Line.”

The author's main points in this paper were: Wideband dielectric characterization method with low cost for substrates used in packaging. [2]

5) Paper on “A Calibration-Free Method for the Dielectric Constant Calculation of Low-Loss Materials.”

The author's main points in this paper were: To offer the transition between the sample permittivity and the observed wave reflection coefficient, as well as low-loss dielectrics. [4]

6) Paper on “Dielectric Characterization of Stacked Packaging Substrates Using a Coaxial Transmission Line Technique.”

The author's main points in this paper were: According to the data analysis, thick MUT's dielectric characteristics are close to the specification value across a wideband. For three stacked sections of 9.30 mm thick (0.39) MUT, the observed mean dielectric constant is 2.32 below and 2.22 above 1 GHz, as opposed to the datasheet figure of 2.200.02. [5]

7) Paper on “Quasi-Static Analysis of Multilayer Dielectrics Filled Coaxial Line Using Conformal Mapping Method.”

The author's main points in this paper were: Coaxial line packed with multilayers of dielectric has characteristics of impedance and effective permittivity. [6]

3.2 Summary

In order to establish a connection between the sample permittivity and the measured wave reflection coefficient, low-loss materials are also required. to provide low-loss dielectrics and the transition between the sample permittivity and the measured wave reflection coefficient.

3.3 Motivation

Coaxial cable is more affordable. In coaxial cable, the outer conductor is employed to increase attenuation and shielding efficiency. Compared to twisted pair cable, it is less vulnerable to noise or interference. Coaxial cable with improved shielding materials permits high transmission rates. The signal loss on optical fiber is quite small. Less efficient than coaxial cable. Cost-prohibitive optical fiber requires pricey installation.

3.4 Problem Statement

Depending on the internal design and planned application of the coaxial cabling, mechanical stiffness might vary greatly. High-power cables, for instance, are rigid and frequently manufactured with heavy insulation.

3.5 Objective

- To established the effect of the conductors on the coaxial transmission line
- To investigate the advantages using different kinds of dielectric material
- to determine the impact of high-quality coax on performance.

CHAPTER 4

Methodology

4.1 Methodology

A field of study's approaches are analyzed in a systematic, theoretical way through methodology. It also comprises a theoretical evaluation of the corpus of practices and beliefs connected to a field of study.

Typically, it includes terms like "standard," "theoretical model," "phases," and "quantitative or qualitative methodologies for research."

To notice the improved performance of coaxial cable, we are attempting to compare several forms of dielectric material in this thesis. Teflon, polyethylene, and polyimide are the dielectric materials we have chosen. Teflon, polyethylene, and polyimide, respectively, had relative permittivities of 2.1, 2.25, and 3.5 for the studied dielectrics.

4.2 Water vapor and humidity's impact on coax cables

Water vapor is one of coaxial cable's worst adversaries. It can drastically reduce the performance of a coax cable if it gets inside, necessitating the replacement of the cable.

Two basic consequences of moisture increase the amount of attenuation or loss in the cable. The braid or outside conductor of the coax cable experiences an increase in resistance as a result of oxidation, which causes an increase in resistive loss. Increased loss from the dielectric is the second factor.

4.3 Sunlight's impact on coax wires

Coax cable jackets or sheaths are susceptible to the same effects that sunlight has on other materials. The degeneration of the wires is mostly caused by ultraviolet radiation. High molecular weight polythene is used by manufacturers to prolong the life of coax cables. Jackets made with polyvinylchloride (PVC) have a life expectancy that is less than half that of high molecular weight polythene.

4.4 Corrosive vapor's impact on coax wires

A coax cable's lifespan can be shortened more quickly when used close to corrosive liquids and vapors than when used outside. Seagoing warships frequently have salt water issues, and other facilities using coax cables may experience chemical vapors.

4.5 Design & Simulation

Using several dielectric materials, we designed a straightforward coaxial cable using the CST Microwave Studio. First, using a fixed frequency of 2 GHz and permittivities of 2.1, 2.25, and 3.5 for Teflon, Polyethylene, and Polyimide, respectively, we changed the value of the inner and outer diameter of the cable to match the characteristic impedance with 50 ohm. We chose copper (lossy) as the inner and outer conductors before simulating the configuration for these three dielectrics. As we anticipate seeing the loss in metal and dielectric as well as the effective dielectric constant, we have installed ports in both ends to view the desired outcome.

CHAPTER 5

Data Collection and Result Analysis

5.1 Data Table (Teflon)

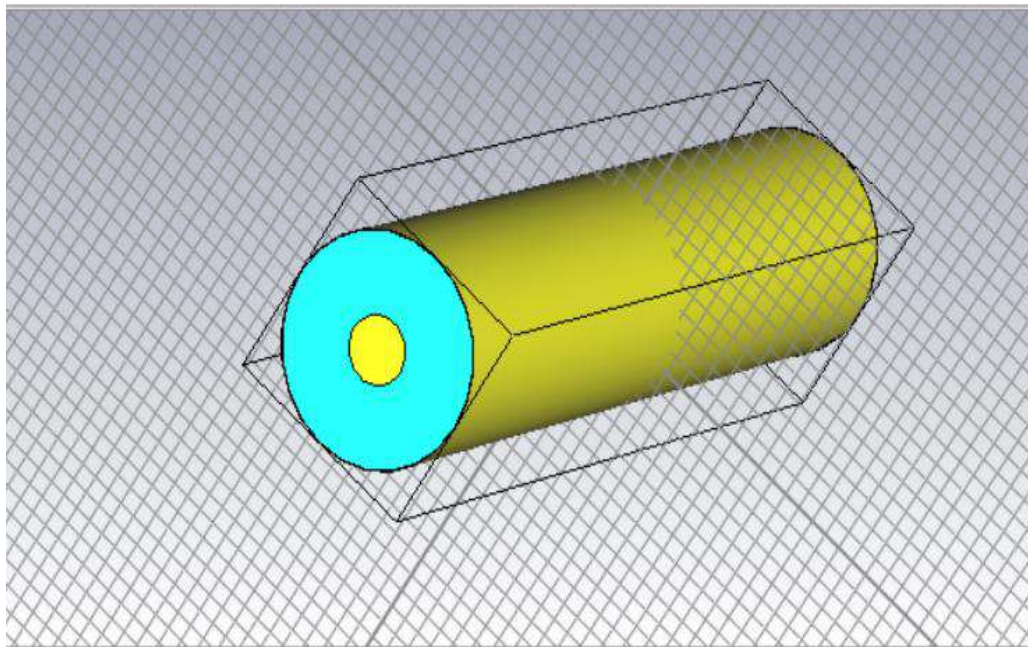
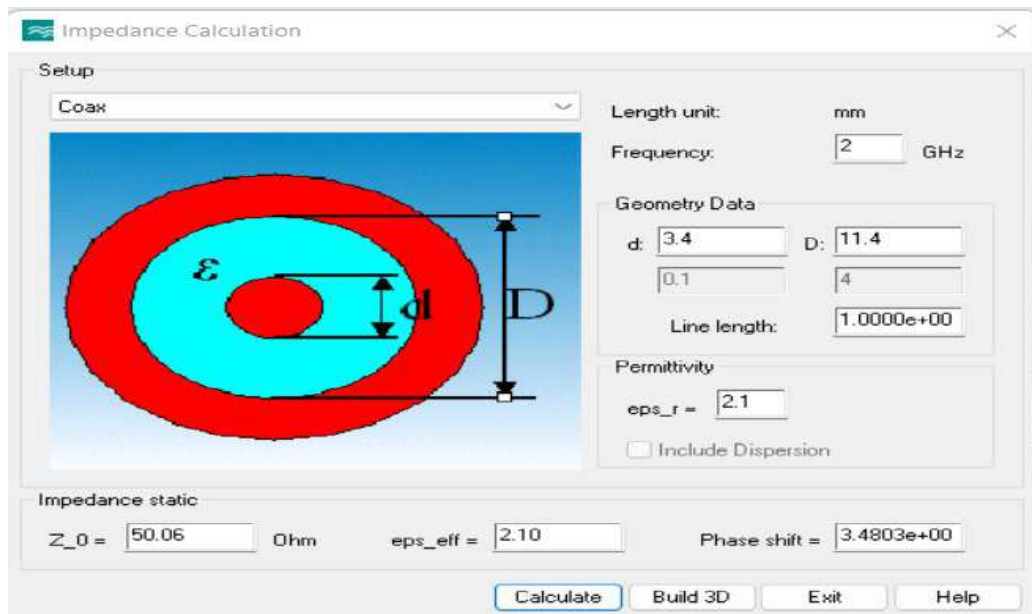


Fig-5.1: Characteristic impedance matching with dielectric (Teflon)

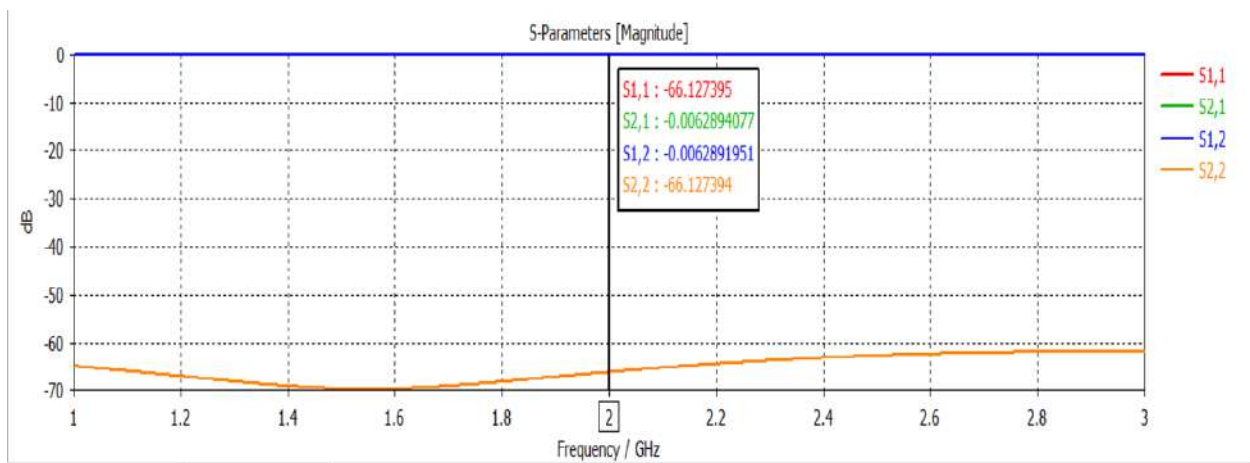
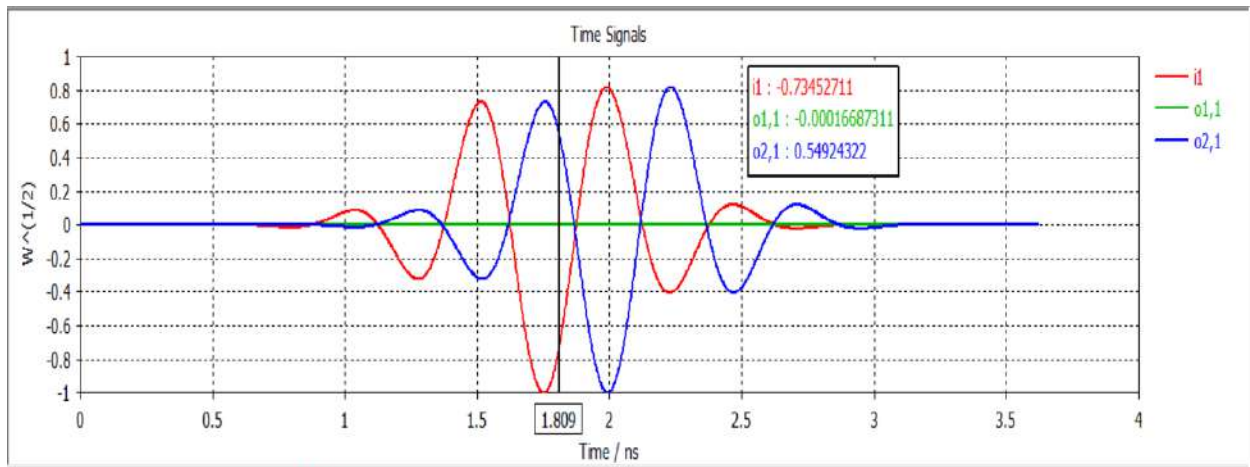


Fig 5.2: Time signal and s-parameter

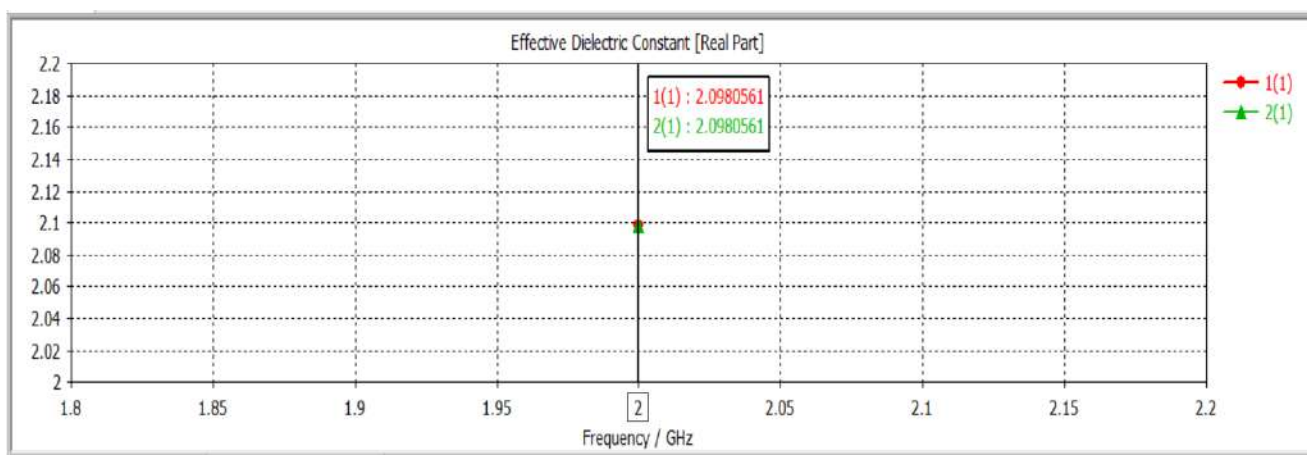
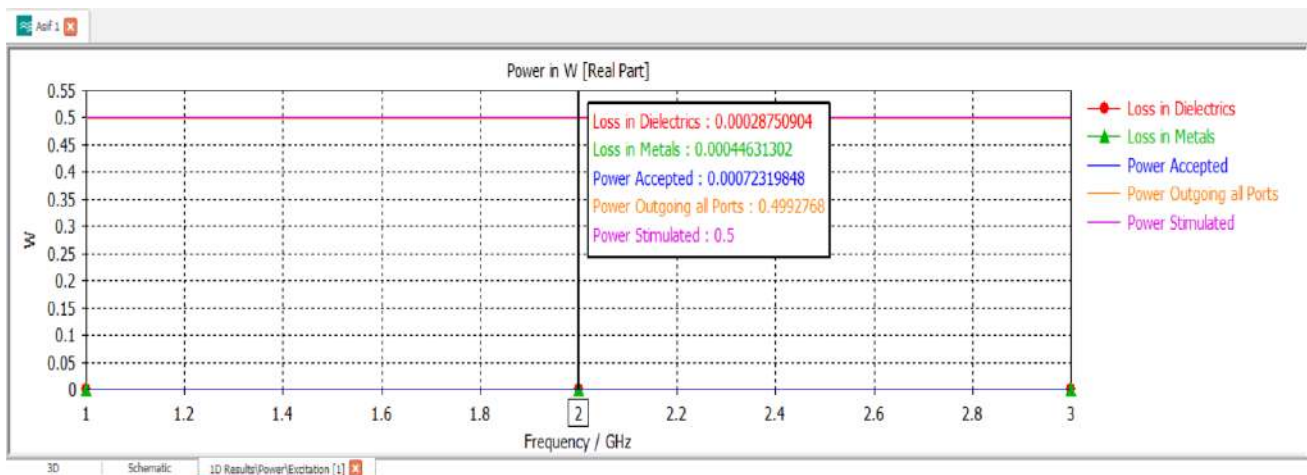
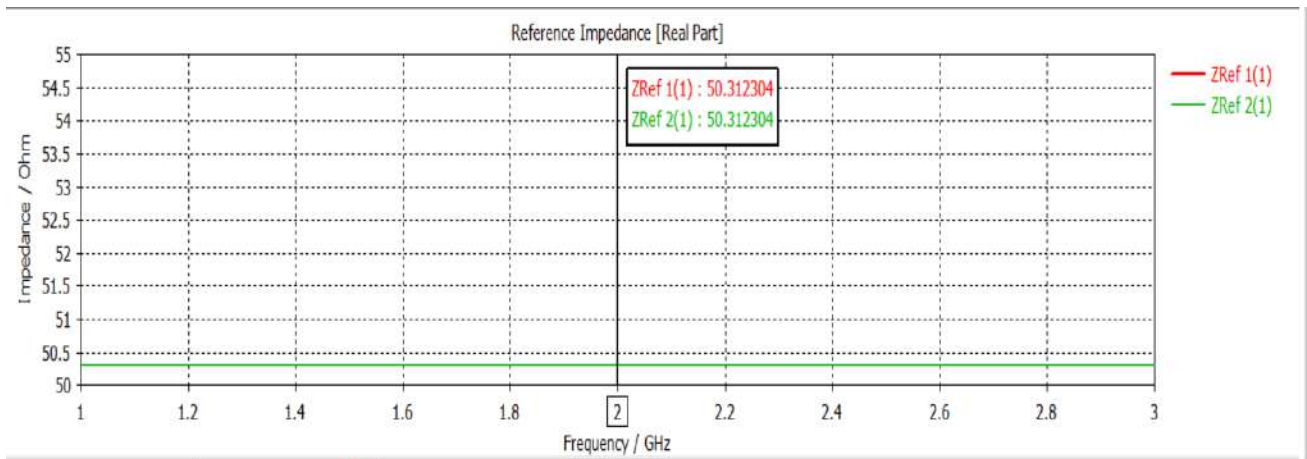


Fig 5.3: Reference impedance, power and effective dielectric constant

5.2 Data Table (Polyethylene)

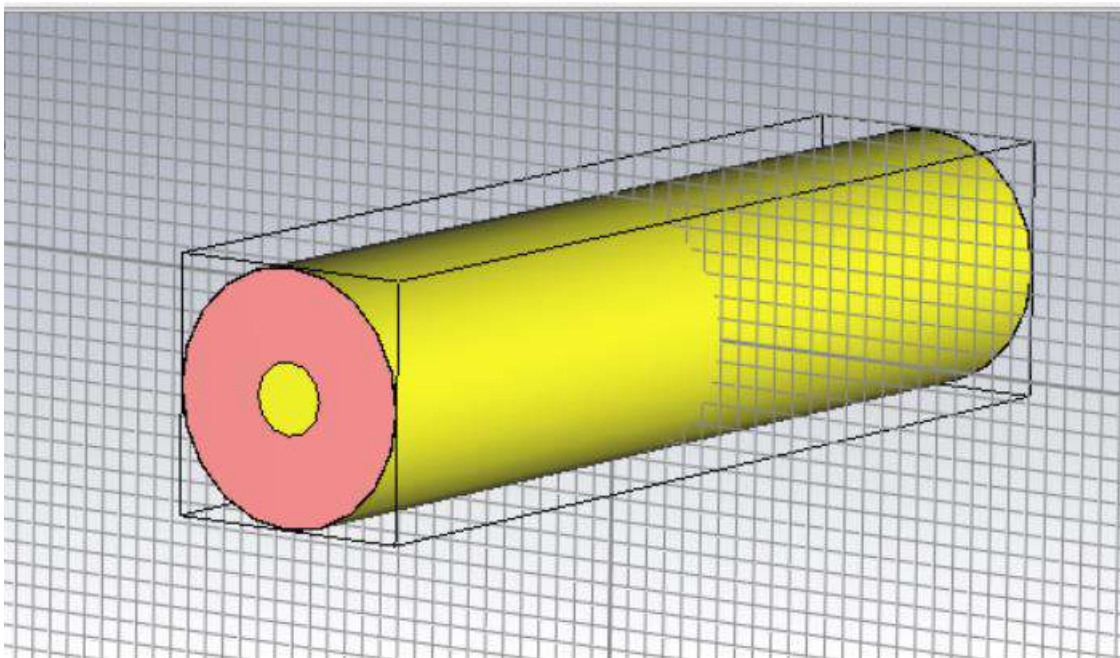
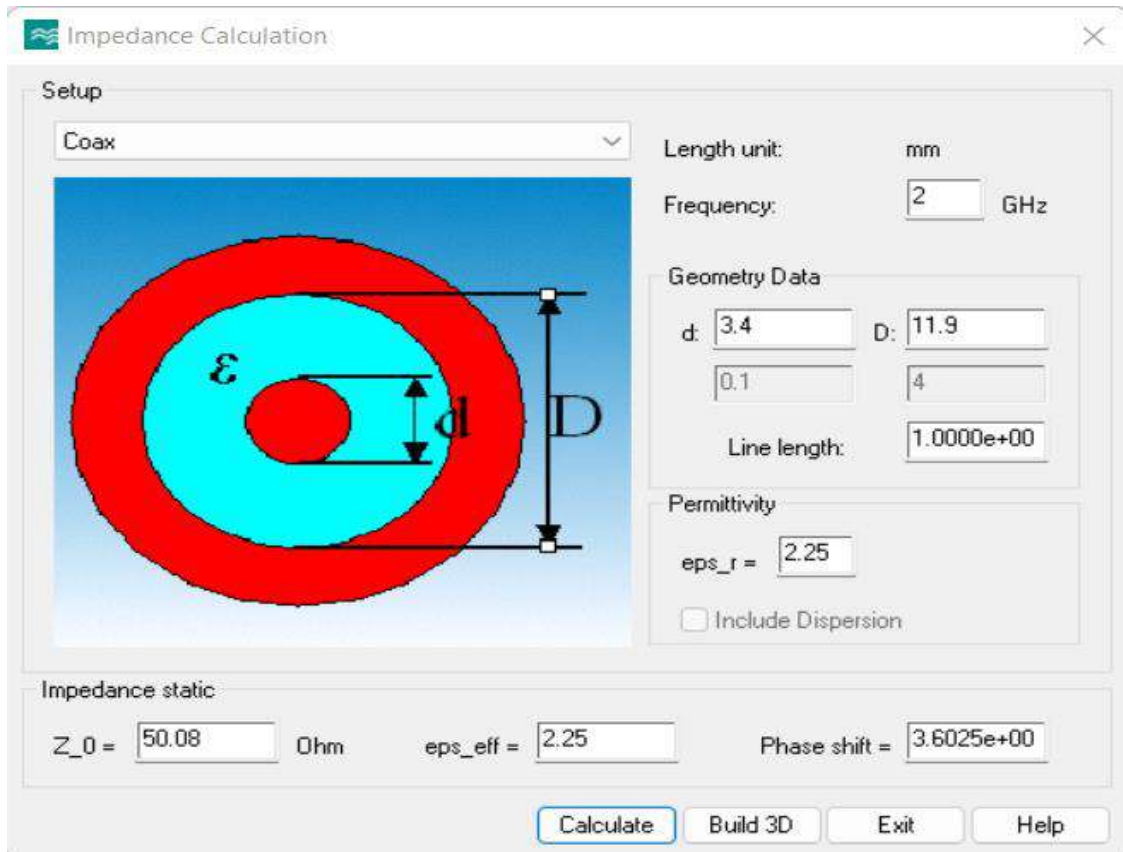


Fig 5.2.1: Characteristic impedance matching with dielectric (Polyethylene)

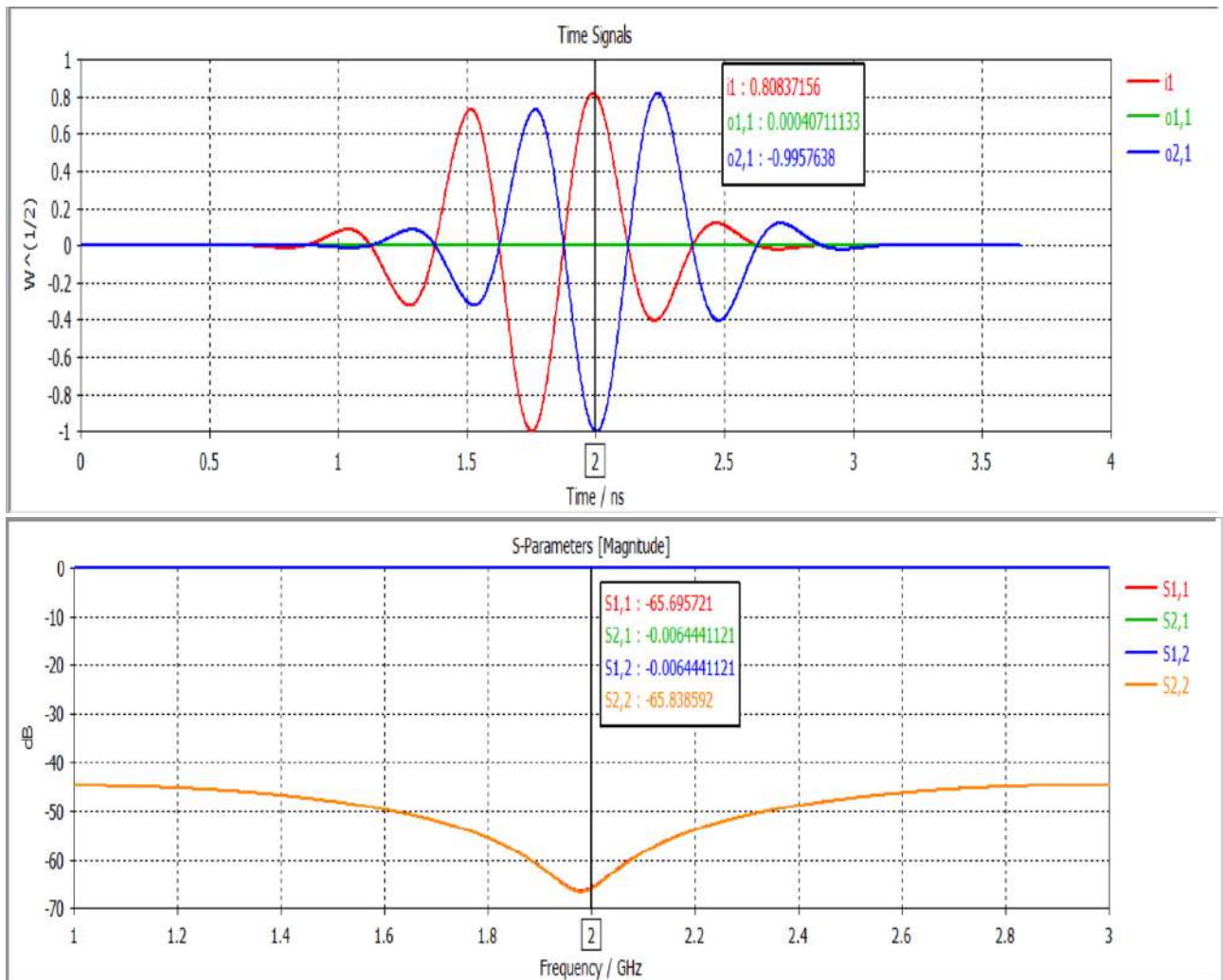


Fig 5.2.2: Time signal and s-parameter

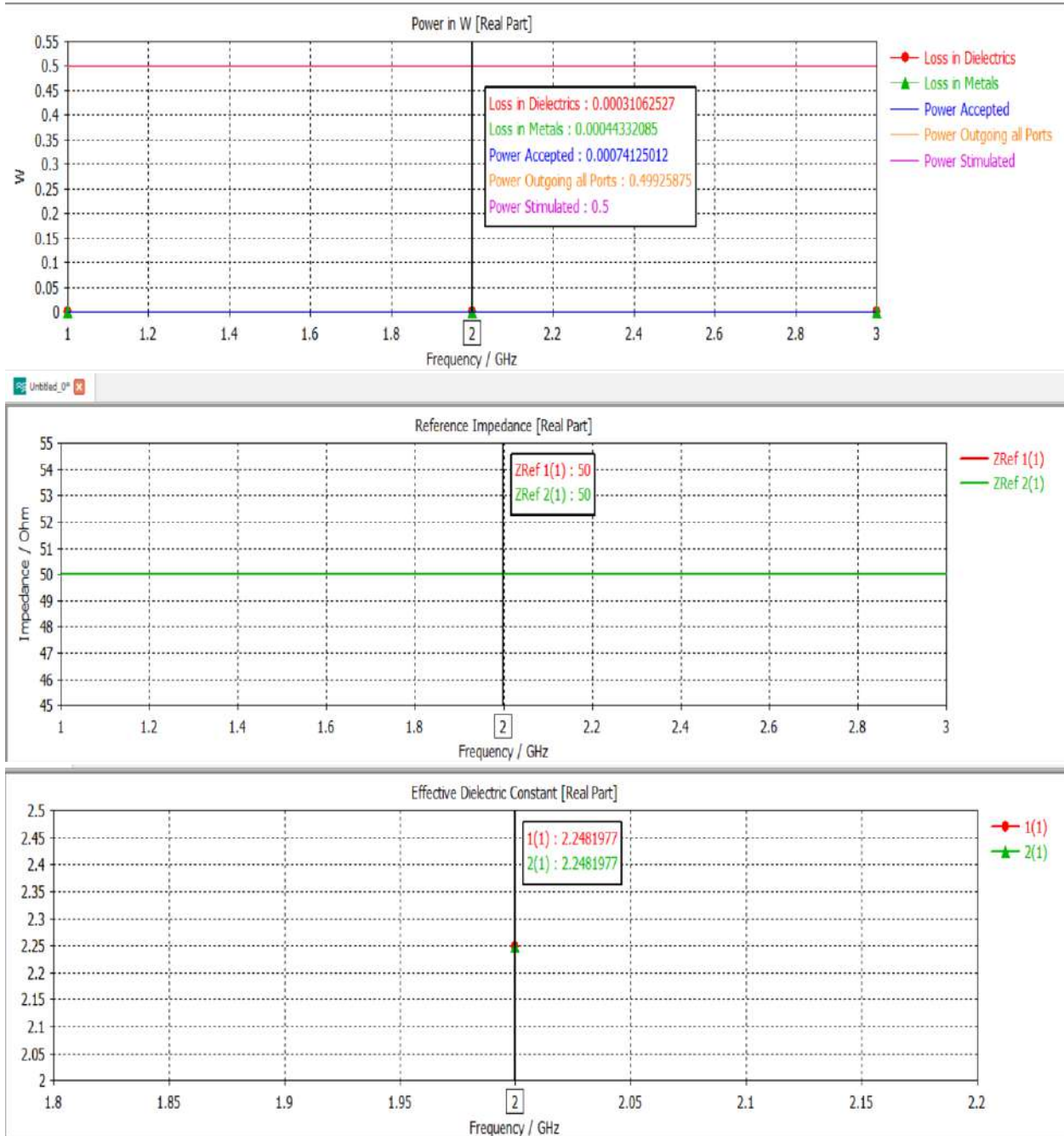


Fig 5.2.3: Reference impedance, power and effective dielectric constant

5.3 Data Table (Polyimide)

Impedance Calculation

Setup

Coax

Length unit: mm

Frequency: 2 GHz

Geometry Data

d: 2.5 D: 11.9

0.1 4

Line length: 1.0000e+00

Permittivity

eps_r = 3.5

Include Dispersion

Impedance static

Z₀ = 50.01 Ohm eps_eff = 3.50 Phase shift = 4.4931e+00

Calculate Build 3D Exit Help

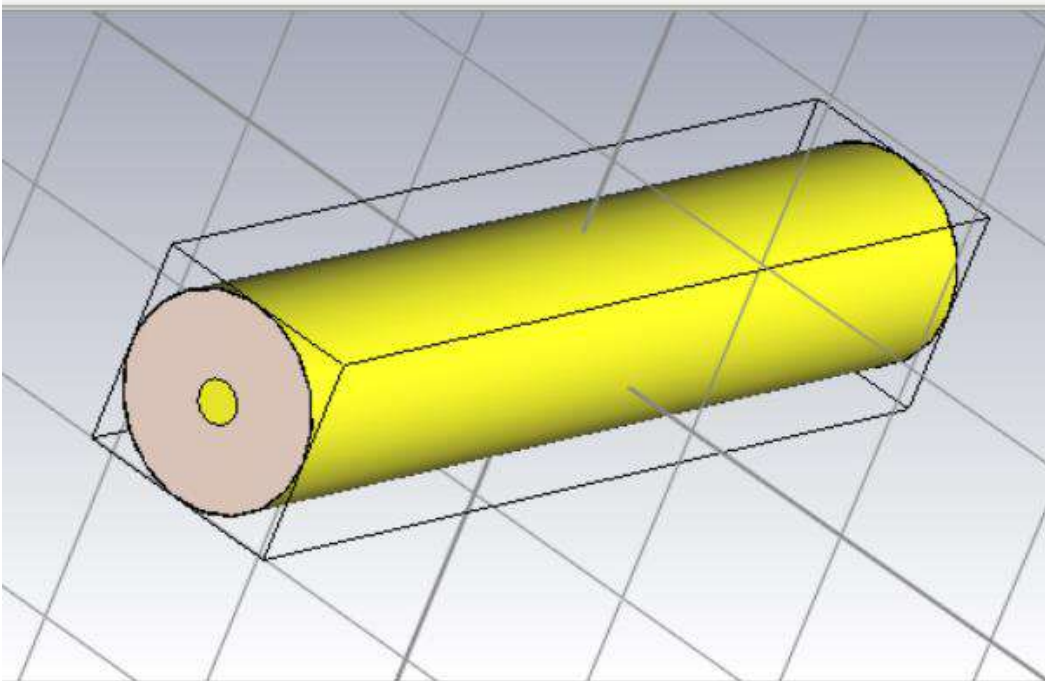
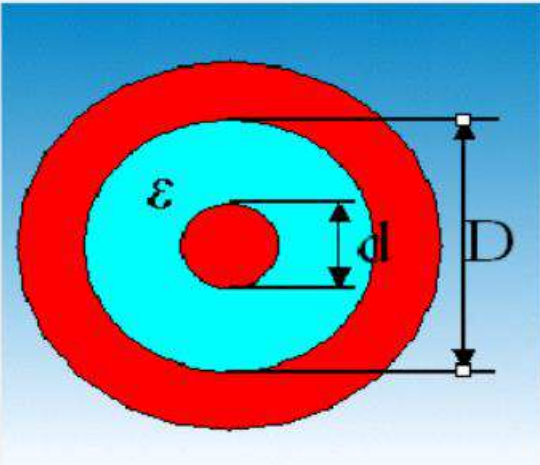


Fig 5.3.1: Characteristic impedance matching with dielectric (Polyimide)

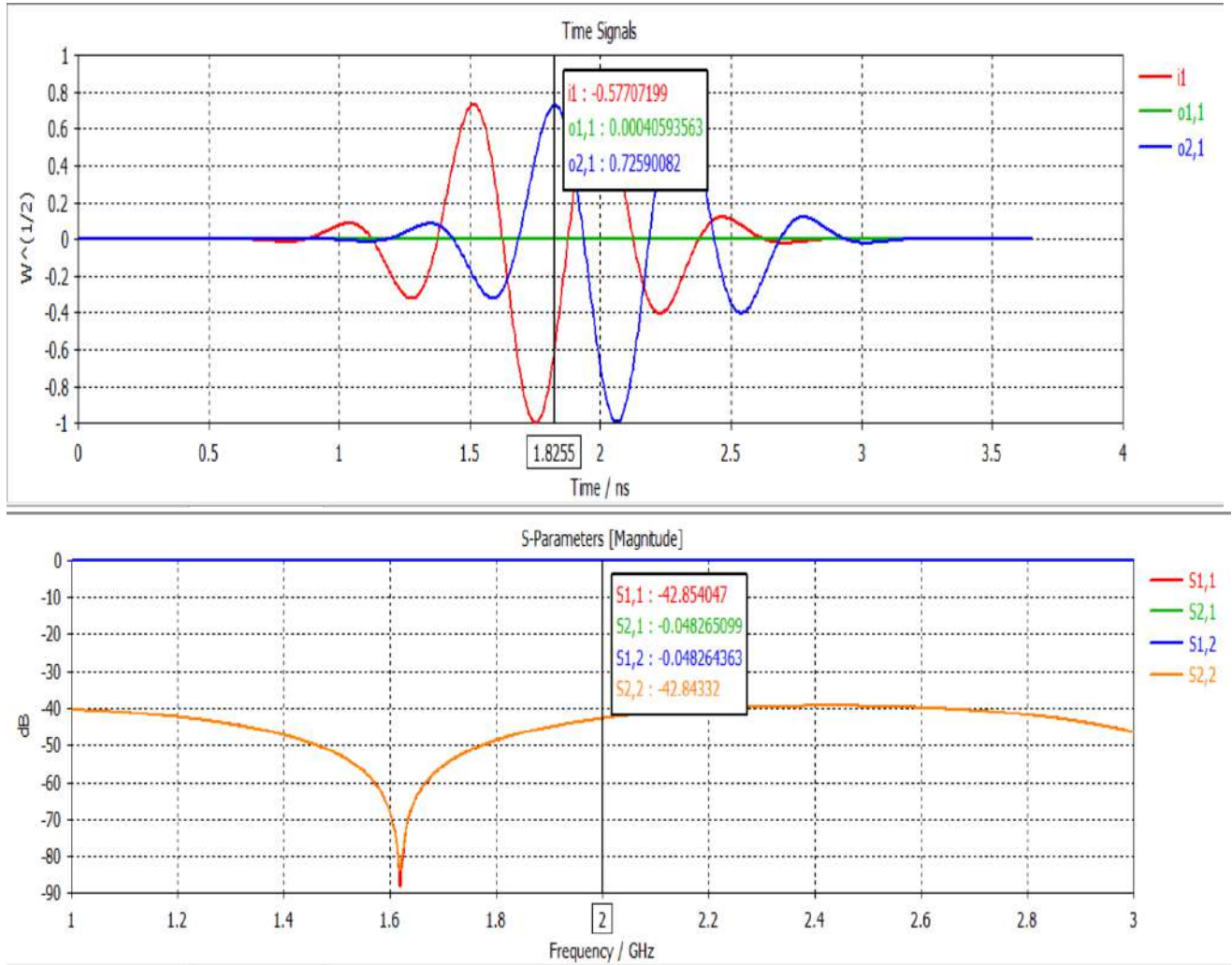


Fig 5.3.2: Time signal and s-parameter

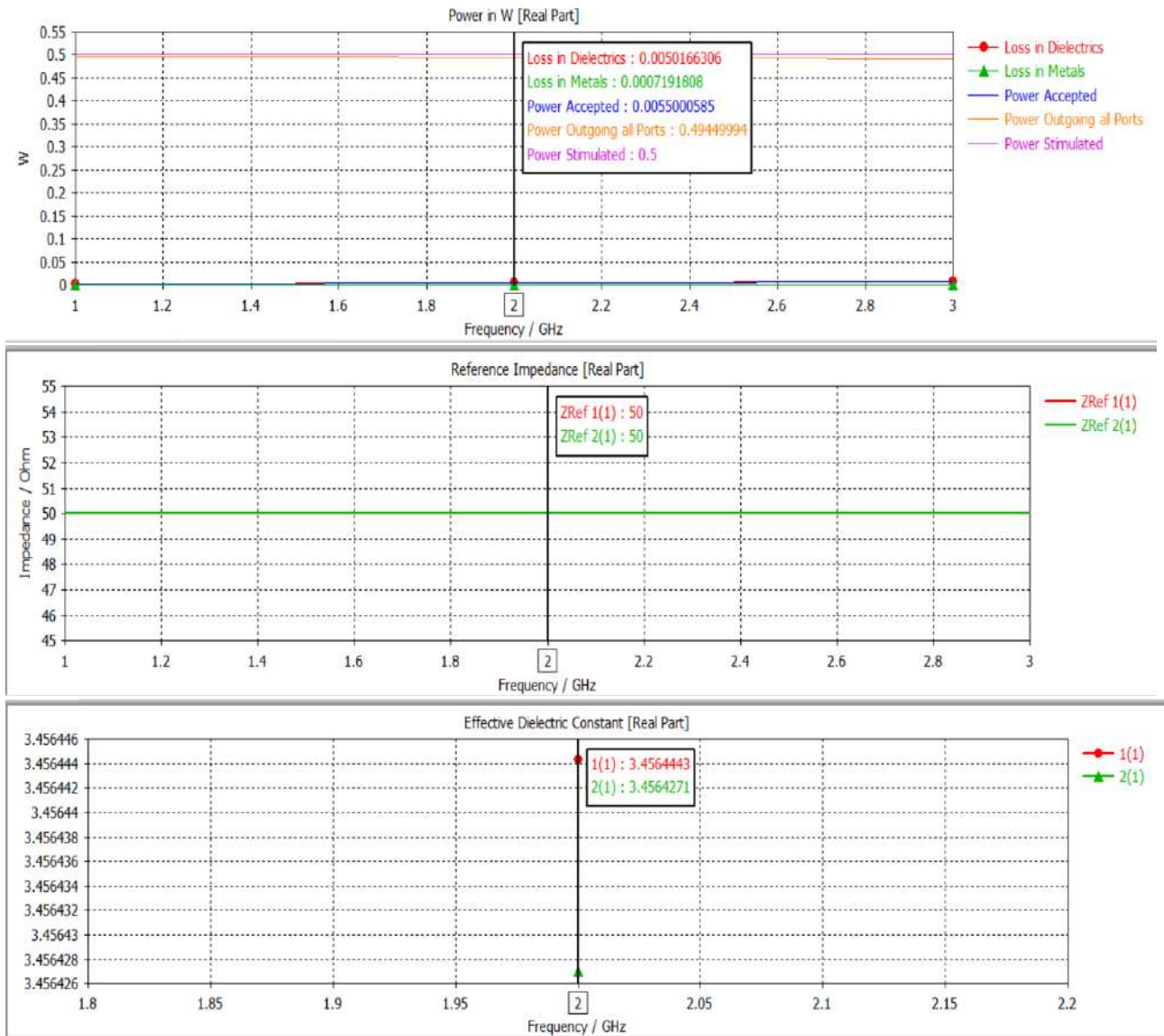


Fig 5.3.3: Reference impedance, power and effective dielectric constant

5.4 Result

Parameter	Teflon	Polyethylene	Polyimide
S1,1	-66.127395	-65.695721	-42.854047
S2,1	-0.0062894077	-0.0064441121	-0.048265099
S1,2	-0.0062891951	-0.0064441121	-0.048264363
S2,2	-66.127394	-65.838592	-42.84332
Loss in Dielectric	0.00028750904	0.00031062527	0.0050166306
Loss in Metal	0.00044631302	0.00044332085	0.0007191808
Effective Dielectric Constant	2.098	2.248	3.456

5.5 Result Analysis

When the dielectric changed, we saw several changes in the results. And we can observe that dielectric loss is really little and varies with different dielectrics. According to the findings, Teflon exhibits lower dielectric loss than Polyethylene and Polyimide. Compared to the other two studied dielectrics, polyimide exhibits more dielectric loss. Additionally, metal loss varies with dielectric. The effective dielectric constant was practically the same as the input, as can be shown. For the

simulation, our lowest and maximum frequencies were 1 GHz and 3 GHz, respectively. In order to better comprehend the results, we set the frequency at 2 GHz.

CHAPTER 6

Conclusion

6.1 Conclusion

Teflon, polyethylene, and polyimide are the dielectric materials that we employ. Teflon, polyethylene, and polyimide, in that order, have relative permittivities of 2.1, 2.25, and 3.5, respectively. Nearly the same as its real value, the dielectric constant. Teflon and polyethylene have reduced and virtually comparable conductivity loss compared to polyimide, which is greater. To fit the 50 ohm characteristic impedance, the inner and outer diameters were modified. In the results for the s-parameter and in the loss in the metal and dielectric, we have seen certain modifications. With a change in frequency, we noticed certain variations in performance. The greater the frequency, the bigger the magnitude in the parameter. Magnitude change with regard to frequency change. Greater frequency will result in losses of a larger size. With regard to higher frequency, dielectric loss will rise. Regarding frequency shift, both the power that can be used and the power that can be output increase. Dielectric material and metal both experience extremely little loss. Therefore, we may conclude that the coaxial cable's conductor is effective. Additionally, the impedance matched the parameters at about 50 Ohm. Polyethylene is the most used dielectric material; it is inexpensive, flexible, and has good electrical characteristics. As a result, it is a preferred material for coax cable insulation. When exposed to voltage stress, polyethylene is more moisture-sensitive than PVC and has smaller dielectric losses.

6.2 Coaxial Cable Usage in Modern Times

Around the world, cable operators, phone companies, and internet service providers often employ coaxial wire. Customers may communicate with you via phone, video, and data. It has also been widely applied in residences. It offers the benefits of precise and dependable communication.

It is often used by cable TV companies to connect client homes and businesses to their satellite antenna installations.

6.3 Making Use of Research Findings

In comparison to twisted pair cable, it is less vulnerable to noise or interference (EMI or RFI). Compared to twisted pair, it allows for the transmission of signals at high bandwidths. Since coaxial cable has stronger shielding materials, it enables greater transfer speeds.

6.4 References

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