IMPLEMENTATION OF COMPLEX NUMBER CONCEPT ON ROUTER SIGNALING PROCESS (CASE STUDY OF AN-NUR DORMITORY)

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ABSTRAK

Pemrosesan sinyal pada router merupakan aspek penting dalam jaringan komunikasi. Penelitian ini bertujuan untuk menerapkan konsep bilangan kompleks secara kontekstual dalam analisis sinyal raouter di Asrama An-Nur Wangandowo. Router di Asrama An-Nur ditempatkan pada dua titik strategis yang memungkinkan cakupan sinyal yang optimal. Penelitian ini menggunakan metode pendekatan kualitatif yang akan digunakan untuk memahami konteks dan pengalaman praktis yang terlibat dalam penggunaan sinyal router dengan melibatkan wawancara, observasi, atau analisis dokumen untuk mendapatkan wawasan yang komprehensif. Hasil penelitian ini berupa model matematika pemrosesan sinyal pada router di Asrama An-Nur Wangandowo, yaitu untuk memberikan pemahaman yang lebih mendalam tentang bagaimana konsep tersebut dapat diterapkan dalam lingkungan praktis dan menunjukkan bagaimana konsep bilangan kompleks secara efektif diterapkan dalam analisis sinyal router. Hal ini melibatkan pemetaan sinyal ke dalam domain bilangan kompleks dan analisis hasilnya. Hasil implementasi bilangan kompleks menghasilkan pada pemrosesan sinyal analog dengan menggunakan rumus konvolusi, transformasi fourier, dan transformasi Laplace serta pada pemrosesan sinyal digital dengan domain ruang dan waktu, domain frekuensi, dan transformasi Z. Implikasi penelitian ini akan menunjukkan bagaimana konsep bilangan kompleks dapat diterapkan dalam analisis sinyal router di lingkungan yang nyata dan kontekstual. Ini akan memberikan wawasan yang berharga tentang efektivitas konsep ini dalam meningkatkan pemahaman dan pengelolaan sinyal router.

Kata kunci *:* sinyal router, bilangan kompleks, *mathematical modeling*

ABSTRACT

Signal processing on routers is an important aspect in communication networks. This research aims to apply the concept of complex numbers contextually in the analysis of raouter signals at An-Nur Wangandowo Dormitory. The routers at An-Nur Dormitory are placed at two strategic points that allow for optimal signal coverage. This research uses a qualitative approach method that will be used to understand the context and practical experiences involved in the use of router signals by involving interviews, observations, or document analysis to gain comprehensive insights. The result of this research is a mathematical model of signal processing on the router at An-Nur Wangandowo Dormitory, which is to provide a deeper understanding of how the concept can be applied in a practical environment and show how the concept of complex numbers is effectively applied in router signal analysis. This involves mapping the signal into the complex number domain and analyzing the results. The implementation of complex numbers results in analog signal processing using convolution formula, Fourier transform, and Laplace transform as well as digital signal processing using space and time domain, frequency domain, and Z transform. The implications of this research will show how the concept of complex numbers can be applied in router signal analysis in a real and contextual environment. This will provide valuable insight into the effectiveness of these concepts in improving the understanding and management of router signals.

Keywords: *router signals, complex numbers, mathematical modeling*

INTRODUCTION

Along with the rapid development of information and communication technology. The need for internet connectivity, especially Wi-Fi is in great demand by internet service users, because WiFi technology is relatively easy to implement in work and lecture environments. In addition, WiFi provides freedom to its users to be able to access it anytime and anywhere through the device. This can be seen from the variety of mobile devices such as note books, laptops, and Android smartphones. Signals have really helped us in the development of technology, especially communication technology, such as telephone, internet, cellphone signals, and many more.

Our lives today have begun to depend on these technologies. If the internet is slow or unstable, it can be caused by the position of the WiFi router. A router is a device that transmits IP packets from one network to another using addressing and protocol methods. Routers function to create wireless internet networks (Wi-Fi) and coordinate data flow. (Agus Haryono, 2015). This allows users to easily access the internet wirelessly using a router.

To develop signaling, basic sciences are needed. One of the important sciences in signal development is the science of complex numbers. In applying the concept of complex numbers to router signals, it is stated that it is still not fully explored widely. The concept of complex numbers is a combination of real and imaginary numbers. This concept is the basis for implementing complex numbers in router signals. With a focus on mathematical modeling, data analysis, and network performance evaluation.

The application of complex numbers in router signaling has the potential to bring great benefits in improving network quality and efficiency. Internet connectivity is a vital need for every individual, including the students at An-Nur Dormitory. A stable and optimized router network is the key to smooth teaching and learning activities and communication in the dormitory. To make this happen, innovative efforts are needed to optimize router signal performance.

This research aims to apply the concept of complex numbers contextually in the analysis of raouter signals in a dormitory. This research utilizes a qualitative approach method that will be used to understand the context and practical experiences involved in the use of router signals by involving interviews, observations, or document analysis to gain comprehensive insights. In this article, we will look at the use of complex numbers in signal processing. The research and implementation of complex numbers in router signaling is expected to provide real benefits for the students and all residents of An-Nur Dormitory.

DISCUSSION

Complex numbers

Complex numbers are ordered pairs (x,y), so geometrically they can be presented as points (x,y) on the complex plane (argand plane), with x-axis (real axis) and y-axis (imaginary axis). In mathematics, a complex number consists of two parts, the real part and the imaginary part. Complex numbers are usually written in the following notation:

$$z = a + bi$$

Description:

z : complex number

a : real part

a : imaginary part

i : $\sqrt{-1}$

One of the uniqueness of complex numbers is the constant *i*. *i* is a unique constant because it is considered $i^2 = -1$. This is never found in the concept of complex numbers. In complex number operations, most of them follow the laws of real number operations. Here are explanations and examples of complex number operations:

a. Addition and subtraction

Addition and subtraction of complex numbers is done by adding and subtracting the real and imaginary parts separately:

$(a + bi) + (c + di) = (a + c) + (b + d)i$

example of addition operation:

$(6 + 2i) + (3 - 7i) = 9 - 5i$

b. Perkalian

Multiplication of complex numbers is defined in the following formula:

$(a + bi)(c + di) = (ac - bd) + (ad + bc)i$

An example of a complex number multiplication operation is as follows:

$(3 - 2i)(-4 + 3i) = -6 + 17i$

c. Division

Division of complex numbers is more complicated than division of real numbers because of the imaginary component. Here is the formula for complex number division:

$$\frac{a+bi}{c+di} = \frac{(a+bi).(c-di)}{(c+di).(c-di)} = \left(\frac{ac+bd}{c^2+d^2}\right) + \left(\frac{bc-ad}{c^2+d^2}\right) i$$

The formula is obtained by multiplying the nominator and denominator by the conjugate of the denominator so that the denominator part only produces real numbers. An example of complex number division:

$$\frac{(4+2i)}{(3+2i)} = \frac{(4+2i).(3-2i)}{(3+2i).(3-2i)} = \frac{16-2i}{9+4}$$

$$\frac{(4+2i)}{(3+2i)} = \left(\frac{16}{13}\right) - \left(\frac{2}{13}\right) i$$

Other laws in complex numbers follow the laws of real numbers, such as the laws of identity, inverse, associative, commutative, and distributive.

In the depiction of complex numbers using the argand diagram. Argand diagrams are used based on two axes. The horizontal axis represents real numbers, while the vertical axis represents imaginary numbers. With this diagram, we can describe a complex number as a point in a two-dimensional plane.

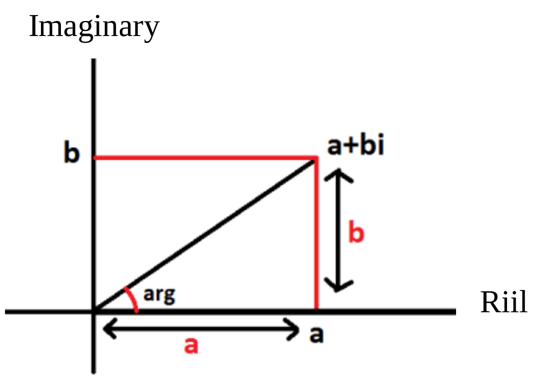

Figure 1. Example of an argand diagram

The addition of two vectors on an argand diagram is the same as the addition of two complex numbers, while the rotation and elongation of vectors is the same as the multiplication of complex numbers. Multiplication I is a 90 degree counterclockwise rotation $\left(\frac{\pi}{2} rad\right)$ and multiplying $i^2 = -1$ equal to 180 degree rotation $(\pi\ rad)$.

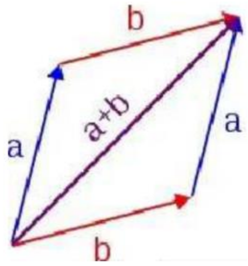

Figure 2. Addition of two complex numbers geometrically by forming a parallelogram.

The number *i* in rotation has an important role in complex numbers, one of which is in rotation. Multiplication of a complex number by the number *i* will rotate the number in the argand diagram by 90° counterclockwise. Conversely, multiplication by -*i* will rotate the number by 90° clockwise.

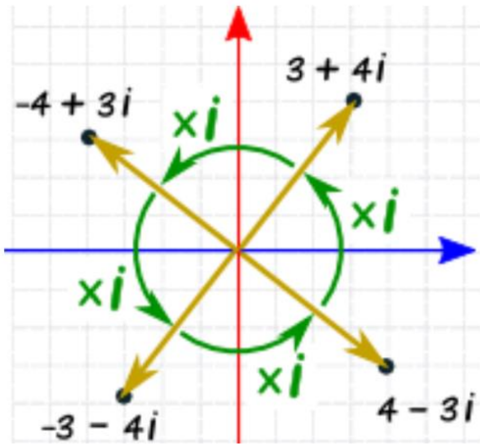

Figure 3. example of multiplication by *i*

Router

Definisi Router

A router is a device that sends data packets through a network or the Internet to their destination, through a process known as routing. The routing process occurs at layer 3 (the Internet Protocol-like network layer) of the seven-layer OSI protocol stack.

Routers can be used to connect many small networks into a larger network, called an internetwork, or to divide a large network into several subnetworks to improve performance and also simplify management.

Router Functions

Routers have several functions, including:

1. The main function of a router is to connect several networks to convey data from one network to another. Routers are used to connect one LAN to another LAN.
2. Routers also function to transmit information from one network to another.
3. Routers also function to connect local nets to a DSL connection, also called a DSL router. The general function of this router is to block broad cast data traffic so that it can prevent broad cast storms that can cause network performance to slow down.

How a Router Works

The main function of a router is to route packets (information). A router has routing capabilities, meaning that the router can intelligently determine where the information (packet) travel route will be passed, whether it is intended for other hosts on the same network or on a different network. If the packets are destined for a host on another network, the router will forward them to that network. Conversely, if the packets are destined for hosts on the same network, the router will block the packets from leaving.

Router Signals

A signal is a measurable electrical quantity that changes in time and or in space, and carries information. Router signal refers to the strength or quality of the WiFi signal emitted by a wireless router. It is an indication of how well a device can receive the WiFi signal from the router and how far it can be from the router without losing a good connection or speed.

Router signal is affected by several factors, including:

1. Distance

   Distance is a quantity that lies in the horizontal plane, and is the shortest length that connects two points. The farther the device is from the router, the weaker the signal. Doors, walls, or other physical obstacles can also reduce signal strength.

2. Disruption

   A disturbance is an event that creates a disruption in the normal functioning of a process. The router signal may be interrupted by electronic devices, electrical appliances, or even interference from the household WiFi network.

3. Antenna

   The router signal may be interrupted by electronic devices, electrical appliances, or even interference from the household WiFi network (Christyono et al., 2016). The quality of the router's antennas affects how well the signal is transmitted and received. Routers with adjustable antennas or more powerful antennas tend to have better coverage.

4. Frequency

   Frequency is the number of waves in one second (Nugroho et al., 2019). Routers can work at 2.4 GHz or 5 GHz frequencies. The 2.4 GHz frequency has a wider range but is more prone to interference, while the 5 GHz frequency has a shorter range but less interference.

5. Router quality

   The quality of the router itself can affect the signal quality. Routers with better quality tend to have better signal performance than routers with lower quality. Routers with powerful antennas, advanced technology, and good traffic management capabilities tend to provide better signals.

   A weak router signal can be caused by some of the factors above. To solve the problem of a weak signal, some of the ways that can be done are to keep the router away from the floor, walls, and metal objects that can interfere with the signal, and fix the position of the router to maximize signal coverage. In addition, apps like Cloudcheck or Amped can be used to monitor and improve WiFi signal quality.

Application of Complex Numbers in Router Signal Processing

Figure 5. First point Router Signal

Figure 4. Second point Router Signal

1. Analog Signal Processing

   Analog signal processing is signal processing performed on continuous analog signals with analog methods. An analog signal is a signal that has a value for each time and is continuous with respect to time. Digital signals are derived from analog signals that are sampled, which means taking the value of an analog signal from the start $t = 0$, $t = \Delta t$, $t = 2\Delta t$, $t = 3\Delta t$ and so on.

   In analog signal processing, the formula used is as follows:

a. Convolution

Convolution is a basic concept in signal processing that expresses an input signal that can be combined with system functions to find an output signal. The convolution function basically inverts and shifts the function g along the axis, and calculates the integral of its products (the inverted and shifted f and g) for each possible number of shifts.

Convolution in integrals is symbolized by (*) and is formulated in the following integral form:

$$y(t) = (x * h)(t) = \int_a^b x(\tau)\, h(t-\tau) d\tau$$

The formula is used to find convolutions and systems with $a = -\infty$ and $b = +\infty$.

b. The Fourier Transform (FT)

The Fourier Transform (FT) is a signal transformation using complex numbers to transform a signal from the time domain to the frequency domain and vice versa. It is very important in WiFi signal processing for spectral analysis and digital filters. The Fourier transform converts a function in the time domain into a function in the frequency domain. The shape of the Fourier transform is called the frequency- domain representation. A function in the time domain must have an equivalent function in the frequency domain. Not all functions can be Fourier transformed. The conditions for a function to be Fourier transformed are:

$$\int_{-\infty}^{\infty} |x(t)|\, dt < \infty$$

The Fourier transform itself is formulated in integral form:

$$f(\omega) = \int_{-\infty}^{\infty} f(t)\, e^{-i\omega t}\, dt$$

Sometimes, we also want to use the inverse of the Fourier transform. The inverse transform is used to transform the function from the frequency domain to the time domain, which is formulated as:

$$f(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} f(\omega)\, e^{i\omega t}\, d\omega$$

It can be seen that in this transformation there are components that are complex numbers. The Fourier transform is used in signal processing such as radio signals, light waves, seismic waves, and images.

c. The Laplace transform

The Laplace transform is derived from the Fourier transform in 1822. Laplace transformation is one type of integral transformation that can solve various linear ordinary differential equations. In accepting a function in the Laplace transform that is with a positive real number variable t (time) into a function with a complex variable s (frequency). The requirement for Laplace transformation is $t > 0$, which is used on continuous time signals, both stable and unstable signals with the following formula:

$$X(s) = \int_{0^-}^{\infty} x(t)e^{-st}dt$$

In the inverse Laplace Transform, if all singularities of X(s) are in the left segment of the complex plane with the following formula:

$$x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(s)e^{st}ds$$

2. Digital Signal Processing

Digital signal processing is signal processing performed on digital signals that are discrete, either discrete time, discrete frequency, or other discrete domains. Digital signals are data signals in the form of pulses that can undergo sudden changes and have a magnitude of 0 and 1. Digital signals are generated on technology that can convert signals into a combination of sequences of numbers 0 and 1 (also with binary), so they are not easily affected by noise, information processing becomes easy, fast and accurate. However, transmission with digital signals only reaches a relatively short distance of data transmission. Applications of digital signal processing include audio signal processing, radar signals, digital images, and many more.

In digital signal processing, researchers generally study signal processing in specific domains. These domains are as follows:

a. Space and Time Domain

Processing in the space and time domain is the analysis of signals as a function of time. One of the most commonly used methods in this domain is digital filters. A digital filter is a system that performs operations on a discrete-time signal to degrade or enhance certain aspects of the signal.

b. Frequency domain

Signals in the space and time domain can be transformed to the frequency domain using the Fourier transform described in the previous section. The difference is that for discrete signals, the transformation used is the discrete Fourier transform.

The discrete Fourier transform is an equivalent form of the Fourier transform, but it is used for signals that are discrete, i.e. have values only in certain places and are discrete (e.g. finite and discrete data). In this transformation, since each data is discrete and has a finite amount, the discrete Fourier transform is formulated in the form of a sum as follows:

$$X_k \stackrel{\text{def}}{=} \sum_{n=0}^{N-1} x_n . e^{-j2\pi kn/N}$$

In addition, the formula for the inverse of the discrete Fourier transform is as follows:

$$x_n = \frac{1}{N} \sum_{k=0}^{N-1} X_k . e^{j2\pi kn/N}$$

Signal processing in the frequency domain generally aims to check the characteristics of the signal.

c. The Z transformation

In analog signals, we usually convert the signal to the s domain using the Laplace transform. In digital signals, the signal is transformed and analyzed in the z domain resulting from the Z transform. The Z transform converts a discrete time signal into a signal in the frequency domain. The Z transform is formulated as:

$$X(z) = \mathcal{Z}\{x[n]\} = \sum_{n=-\infty}^{\infty} x\,[n]\, z^{-n}$$

In this transformation, n is an integer while z is a complex number of the form:

$$z = Ae^{j\emptyset} = A(\cos \emptyset + j\, sin\, \emptyset$$

Transformation to the z- domain provides a way to describe digital frequencies into real and imaginary components.

CONCLUSION

The results show that complex numbers have an important role in router signal processing, both analog and digital signals. In analog signal processing, complex numbers are used in convolution, Fourier transform, and Laplace transform for signal analysis. While in digital signal processing, discrete Fourier transform and Z transform are used to analyze signals in the frequency domain. The implementation of complex numbers in router signals enables more accurate and efficient analysis. This proves that complex numbers are not only relevant in mathematical theory, but also have significant practical applications in improving the quality and efficiency of router networks. Factors such as distance, interference, antenna quality, and frequency affect the strength of router signals. By understanding and addressing these factors, as well as applying complex number analysis, signal quality can be significantly improved, which has a positive impact on overall network performance.

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