Journal of Renewable Energy, Electrical, and Computer Engineering
Volume 4, Number 2, September 2024. 159-165
eISSN 2776-0049
DOI: https://doi.org/10.29103/jreece.v4i2.14812
Research Original Article

Design of Microstrip Antennes for Use in Digital Television Network Systems

Wildan Nurgalih Pangestu✉[1], Didik Aribowo[2], Mohammad Fatkhurrokhman[3]
[1] Universitas Sultan Ageng Tirtayasa, Serang, 42117, Indonesia, 2283190023@untirta.ac.id
[2] Universitas Sultan Ageng Tirtayasa, Serang, 42117, Indonesia, d_aribowo@untirta.ac.id
[3] Universitas Sultan Ageng Tirtayasa, Serang, 42117, Indonesia, fatkhur0404@untirta.ac.id
✉Corresponding Author: 2283190023@untirta.ac.id

Received: January 11, 2024 **Revision: August 22, 2024** **Accepted: September 20, 2024**

Abstract
The quality of television networks in Indonesia is still undergoing continuous development in order to provide the best quality of the television network, but what remains the problem is the decline in the quality of such television network that is still not covering the entire territory of Indonesia. This requires additional supporting devices to be able to overcome the problem. In this study, a microstrip antenna was created using the array method, to work at a frequency of 400-900 MHz for digital television networks. The microstrip antenna will be observed and analyzed on the return loss (S-11), VSWR (Voltage Standing Wave Ratio), bandwidth, and gain antenna parameters. The simulation results for some parameters such as returnloss which has a value of -13.33639 dB and the VSWR value is obtained as 1.5489645 at a working frequency of 650 MHz. It already meets the criteria of a good microstrip antenna and is ready for manufacture and implementation.
Keywords: Antenna; Microstrip; Television; VSWR; Return Loss; Bandwidth; Gain

Introduction
The rapid development of technology is directly proportional to the emergence of new media tools to facilitate consumers. The result and effect of all this is that conventional media has begun to lag behind in attracting the interest of the general public. Inevitably, conventional devices such as television must quickly adapt to keep up with the changing times. The emergence of new media devices with almost the same character as television media makes it necessary to make updates so as not to be left behind by changing times, therefore television, which was originally analog broadcasting, has been transformed into digital broadcasting (Haqqu & Ersyad, 2020). Digitalization of television broadcasting will have an impact on the availability of many channels due to technological efficiency. If currently one analog frequency can only be used for one broadcast program channel, then through digital broadcasting it can be filled by 12 broadcast program channels (Frendy Christianto Imanuel Siahaan, Guntur F. Prisanto, Niken F. Ernungtyas, Irwansyah, 2020).

With the existence of digital broadcast television, the quality of sound and images obtained by consumers is much better than analog broadcasts, where there are no more images that look shaded or all forms that interfere with television monitors. In today's modern era, television viewers not only watch television but can get various facilities and conveniences such as internet access. So that it can be done using one procedure. Digital Television is a type of television that uses digital modulation and compression systems to transmit image, sound, and data signals to television sets. Digital television is a device used to capture digital TV broadcasts, a change from the analog to digital channel process that changes information into digital signals in the form of data bits like a computer. To be able to capture digital broadcasts, the user device (television) must have an additional device to read the broadcast. The digital broadcast receiving device is called a Set Top Box (STB) and no less important is the STB auxiliary tool, namely the Antenna (Nuryanto, 2014).

The antenna itself is a device designed to receive and transfer radio waves by utilizing the principle of electromagnetic waves. In this way, antennas can convert electrical signals into electromagnetic waves that are emitted into the air, or conversely, receive electromagnetic waves from the air and convert them into electrical signals that can be processed or transmitted. Thus, antennas play an important role in wireless communications and systems that use electromagnetic waves, such as radio communications, television, and cellular technology (Kurniasari et al., n.d.).

Antennas have several types, one of which is the microstrip antenna. Microstrip antenna is an antenna that has a thin board dimension and can function at very high frequencies (Ahmed et al., 2022). In shape, this antenna does look simple because it generally consists of a slab like a PCB (Printed Circuit Board) which is already known in the scope of electronics. In its most basic form, a microstrip antenna consists of a radiating plane (patch) located on one side of the dielectric layer, while on the other side there is a ground plane. This configuration creates a structure that allows the antenna to efficiently transmit and capture electromagnetic waves, depending on the dimensions and shape of the patch and the type of dielectric used. Microstrip antennas are often used in various communication and wireless applications due to their efficiency in transmitting and receiving radio frequency signals (Charisma et al., n.d.).

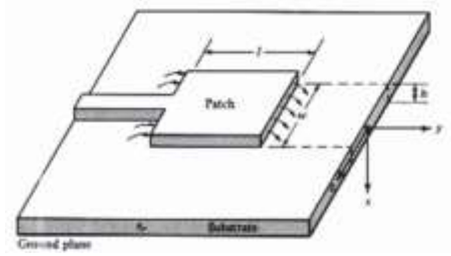

Figure 1.Microstrip Antenna Structure

Microstrip antennas are a popular form of antenna today because they are affordable, small, and not difficult to manufacture. In addition, microstrip antennas are easy to manufacture for resonant frequency, input impedance, polarization, and radiation pattern (Alfaresi et al., 2020). Microstrip antennas have a ground plane component made of copper at the bottom layer which works as a perfect reflector. The substrate above it has a dielectric constant (εr) and substrate thickness (*h*). There is also a patch located at the top which functions as a radiator which can have shapes such as rectangular, square, circular, and others (Chhabra & Dayal sharma, 2020). The rectangular patch shape is easy to analyze and is most accurate for thin substrates. The dimensions of the microstrip antenna can be found through calculations from simplified formulas (Christyono et al., 2016).

The radiation pattern of an antenna is defined as a mathematical function or graphical representation of the radiation properties of the antenna as a function of space coordinates (Fadilah & Budayawan, 2022). Radiation has characteristics that include aspects such as power flux level, radiation intensity, field strength, as well as phase direction or polarization. The radiation pattern consists of a number of components known as lobes, which can be divided into major and minor parts (side and back lobes) (Akbarrizky et al., 2017). The radiation pattern is a representation of how the antenna radiates its energy in three-dimensional space. The radiation pattern is formed by the distribution of the electromagnetic field at a considerable distance from the antenna. This radiated energy refers to the intensity of the electric field generated by the antenna in various directions (Haekal et al., n.d.).

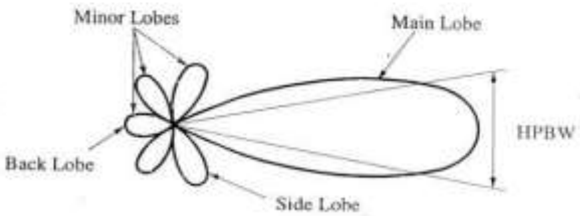

Figure 2. Shape of *Lobe* Division of Radiation Pattern

Return loss is a parameter used to measure the extent of an antenna's impedance match. It measures how little energy is reflected back to the source, most of which should be absorbed by the antenna. Return loss is measured in decibels (dB) and is the inverse of the reflection coefficient. A highly efficient antenna will have a return loss value that is close to zero or even negative, as you mentioned, i.e. less than -10 dB, which indicates that most of the signal is absorbed by the antenna and only a little is reflected back. (Kirana, 2021).

Return loss can occur due to a mismatch between the impedance of the transmission line and the input impedance of the load. (Rahmanda & Rahayu, 2016). VSWR (Voltage Standing Wave Ratio) is the ratio between the maximum voltage amplitude and the minimum voltage amplitude in a standing voltage pattern on a transmission line. It is used to measure the extent of power level fluctuations due to mismatch between the transmission line and the load connected to it (Anou, 2019). The magnitude of the VSWR value can vary in the range between 1 (ideal) to infinity. The higher the VSWR value, the greater the mismatch between the transmission line and the load. In other words, the higher the VSWR, the more energy is reflected back to the source rather than absorbed by the load, which can result in power losses and reduced transmission efficiency (Madiawati & Simanjuntak, 2021).

Bandwidth in antennas can be defined as the frequency range where the antenna performance, which includes characteristics such as input impedance, radiation pattern, radiation width, polarization, gain, efficiency, VSWR, return loss, and axial ratio, meets the requirements or specifications of a predefined standard. In this frequency range, antennas are usually designed to provide optimal performance according to the needs of a particular application (Rufaidah et al., 2020).

The gain of an antenna is a parameter that describes the ratio between the power focused by an antenna in a particular direction and the power radiated by a reference antenna. Gain measures the antenna's ability to direct or focus electromagnetic energy in a particular direction. The higher the gain value, the more efficient the antenna is in directing the signal in the desired direction (Permana & Fath, 2021). In practice, gain measurement is carried out using the *Gaincomparison Method* or *gain transfer mode*. The principle of this measurement is to use a reference antenna (usually a standard *dipole* antenna) whose gain value is already known (Anggraeni & Khusna, 2023).

Methods

The implementation of the research is carried out using such stages to be able to obtain results that are in accordance with the objectives of this research. The microstrip antenna to be designed is a microstrip antenna with a *circular patch* type with antenna specifications made to work at frequencies of 400-900 MHz for use in digital television network systems. This microstrip antenna is designed using the *array* method, this method is one of the techniques for miniaturizing the size of a microstrip antenna that works by forming a parallel on the sides of the antenna *patch* (Charisma et al., n.d.).

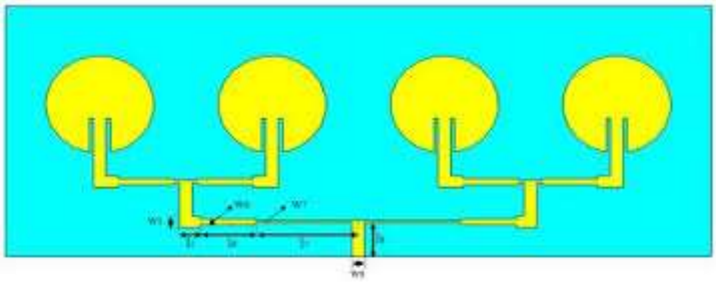

Figure 3. Microstrip Antenna Structure with Array

The use of arrays in antennas can affect current flow at the top surface, resulting in current deflection which in turn increases the electrical length of the patch. The effect of this is a decrease in the operational frequency as the physical dimensions of the patch become longer. Exclusively, the frequency value can be further reduced by adding more slits. The use of multiple slits can direct the current flow around them, resulting in a change in the radiation pattern of the antenna. This is one of the techniques used in designing antennas to change their operational characteristics, especially in terms of working frequency and radiation pattern (Dan et al., 2021).

The microstrip antenna is designed using the help of the CST Studio Suite Application, the following is the flow of research implementation as outlined in the flow chart. CST Studio Suite (also known as Microwave Studio) is a comprehensive software used to analyze and design electromagnetic systems, especially in the high frequency range. Once the model is built, a fully automated meshing procedure is implemented before starting the simulation process. With an advanced visualization engine and flexible post processing capabilities, CST Studio Suite enables users to analyze and improve designs in a relevant and efficient manner. The software is mainly used in product development and research in various fields involving electromagnetics, such as microstrip, antenna, and other high-frequency circuits (CST, 2018).

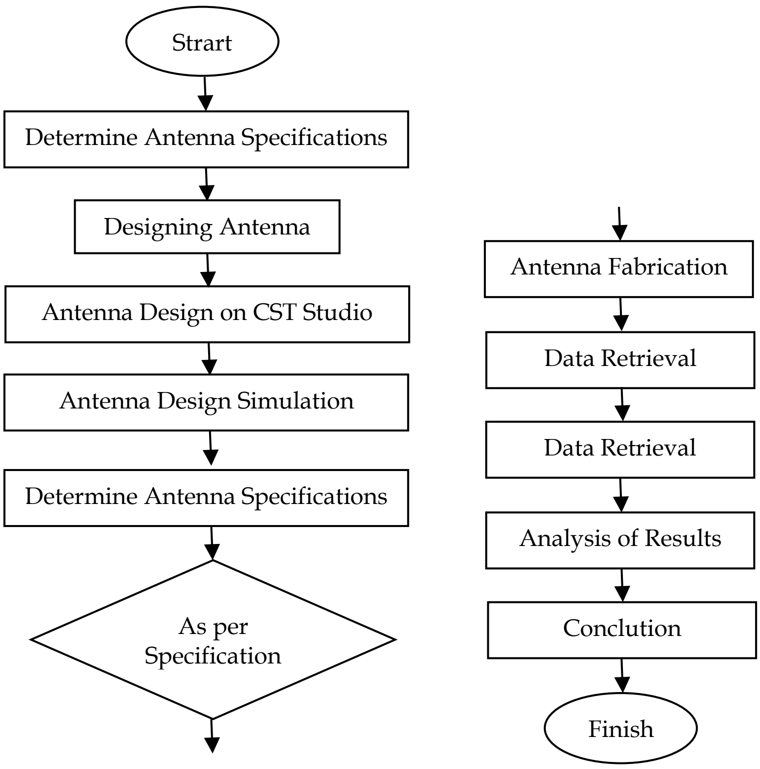

Figure 4. Research Flow

Results and Discussion

In the design of microstrip antennas, the initial stage is to perform calculations to determine the specifications and dimensions of the microstrip antenna to be made. In this calculation there are several formulas used to determine the dimensions of the microstrip antenna to be made, including:

a. Patch Diameter (a)

$$a = \frac{F}{\{1+\frac{2h}{\pi\varepsilon_r F}[\ln(\frac{\pi F}{2h})+1,7726]\}^{\frac{1}{2}}} \quad (1)$$

b. Groundplane

$$Wg = 6h + 2a \quad (2)$$

$$Lg = 6h + \frac{\pi}{2} a \quad (3)$$

c. Transmission Line Feed

$$y_0 = 0.3 \times d \quad (4)$$

$$W_0 = z_0 \times \frac{h}{\varepsilon r} \quad (5)$$

$$L_0 = \frac{1}{4}\lambda d \quad (6)$$

Description:

C = $3x10^8$ *m/s* (Speed of Light)
εr = Dielectric Constant
h = Substrate Thickness (mm)
a = Patch radius
εr_{eff} = Effective dielectric constant
L_{eff} = Effective length
Lg = Groundplane length
Wg = Groundplane width
Ls = Slit length

The calculation is done with reference to the working frequency of the antenna to be made, which is 400-900 MHz. Based on the calculations carried out using the formulas above, the results of the dimensions of the microstrip antenna to be made are outlined in the following table.

Table 1. Microstrip Antenna Specifications

Parameters	Specifications
Dielectric material	FR-4
Dielectric constant	4.3
Dielectric thickness	1.6 mm
Patch material	Copper
Patch thickness	0.035 mm
Patch radius	43.67 mm
Substrate length	145.41 mm
Substrate width	156.38 mm
Ground length	96.94 mm
Ground width	78.19 mm
Wavelength (λ)	334 mm
Dielectric lambda (λd)	161 mm

The microstrip antenna specification data is then entered into the antenna design stage using the CST *Studio Suite* application. In the application, simulation experiments will also be carried out on the results of the microstrip antenna design made by paying attention to parameters such as *returnloss* (S1.1), VSWR (*Voltage Standing Wave Ratio*), *Bandwidth*, and *Gain*. Based on the results of these calculations which are poured into the antenna design made with the CST *Studio Suite* application, the results of the *rectangular patch* microstrip antenna design with the *peripheral slit* method are obtained as shown below.

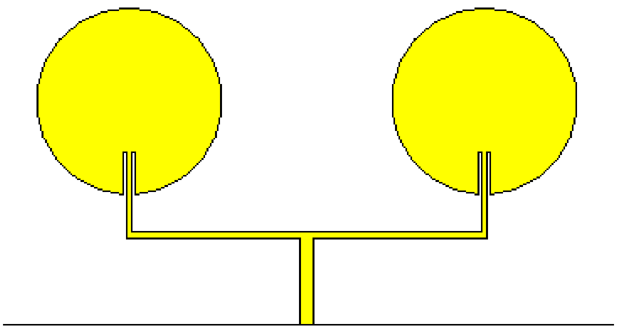

Figure 5. Microstrip Antenna Design Results

The microstrip antenna design above is used in antenna simulation experiments in the CST Studio Suite application, the following are the results of the parameters considered in the microstrip antenna simulation.

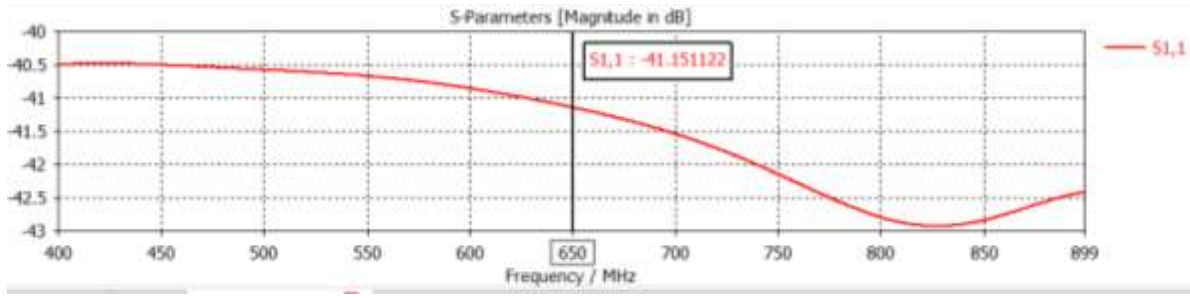

Figure 6. Returnloss Results

Based on the simulation results carried out on the microstrip antenna design made, a return loss value of -41.151122 dB was obtained, at a working frequency of 650 MHz. This value is included in the good antenna criteria because the provisions of a good return loss are <-10 dB.

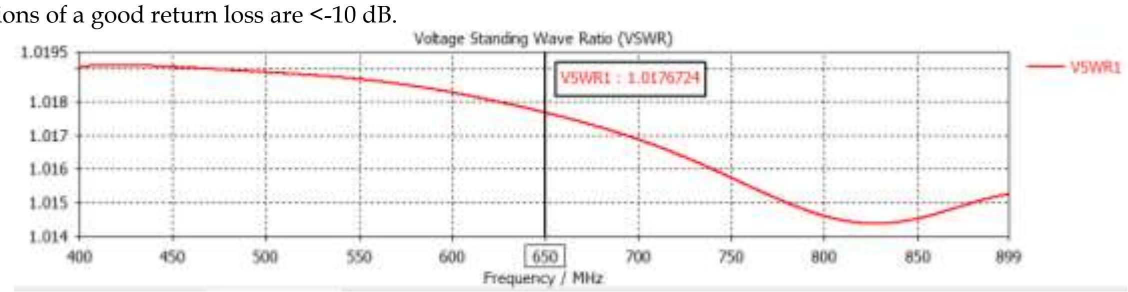

Figure 7. VSWR Results

Based on the results obtained in the simulation process, the VSWR parameter is obtained with a value of 1.0176724 at a working frequency of 650 MHz. This value is still between the values of 1 and 2, where a good antenna will have a VSWR value close to the value of 1. Therefore, based on these results it can be said that the designed microstrip antenna has met the criteria of a good antenna to use.

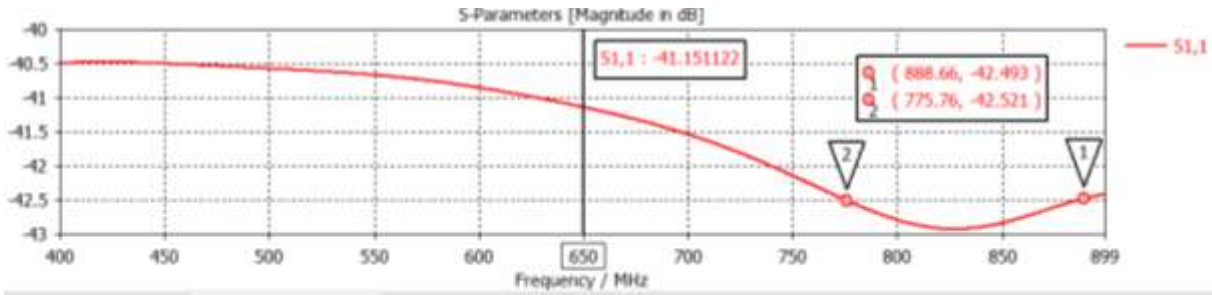

Figure 8. Bandwidth Results

Based on the results obtained from the simulation process carried out, the microstrip antenna bandwidth value obtained can be seen from the returnloss parameter graph. As in the picture above there is marker 1 at a frequency of 888.66 MHz and marker 2 at a frequency of 775.76 MHz, the bandwidth is obtained by calculation using the following formula.

$$BW = f_h - f_I \tag{9}$$

Description:

BW = Bandwidth

f_h = Top Frequency

f_I = Lower Frequency

Then:

f_h = 888.66 MHz

f_I = 775.76 MHz

BW = 888.66 - 775.76

= 112.9 MHz

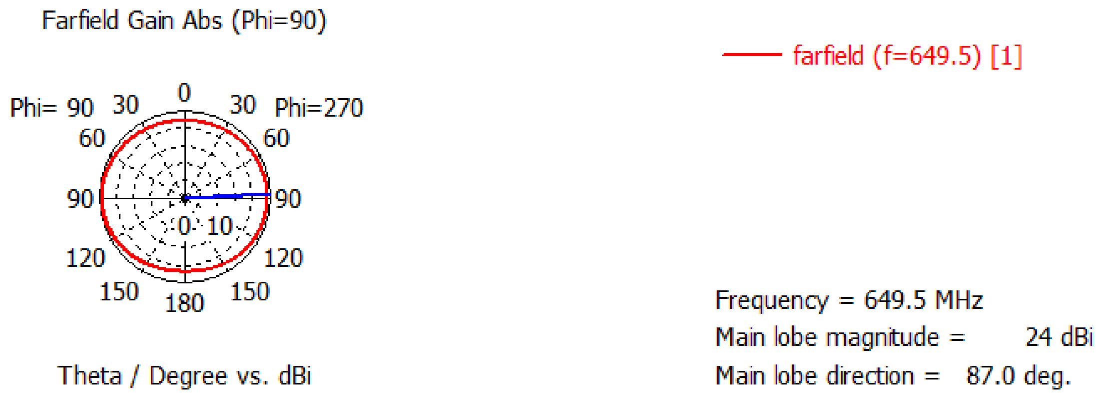

Figure 9. Antenna Gain Results

Based on the results of the simulation, the microstrip antenna gain is obtained at 24 dBi. This value is quite large and is above the initial design of the antenna which aims to have a gain value above 2 dBi. From these parameters, it has met several criteria for each parameter or the value planned at the beginning, but it can also still be further developed or optimized to be able to produce better parameter values in order to create a microstrip antenna that is more capable of being used.

Conclusions

Research conducted on microstrip antennas with rectangular patches to work at frequencies of 400-900 MHz as antennas for digital television broadcasting systems obtained simulation results for several parameters such as returnloss which got a value of -41.151122 dB and VSWR value obtained by 1.0176724 at a working frequency of 650 MHz. The Gain magnitude obtained is 24 dBi and the antenna bandwidth value obtained is 112.9 MHz. These values have met the criteria of a good microstrip antenna and are ready to be fabricated and implemented.

References

Ahmed, O. F. … Ahmed, S. R. (2022). Design And Fabrication Of Uwb Microstrip Antenna On Different Substrates For Wireless Communication System. *Hora 2022 - 4th International Congress On Human-Computer Interaction, Optimization And Robotic Applications, Proceedings*, *3*(7), 13–16. Https://Doi.Org/10.1109/Hora55278.2022.9799852

Akbarrizky, F. … Walidainy, H. (2017). Perancangan Dan Pengujian Antena Microstrip Circular Patch Array Dua Elemen Untuk Aplikasi Wimax 2,3 Ghz. *Jurnal Komputer, Informasi Teknologi, Dan Elektro*, *2*(4), 21–28.

Alfaresi, B. … Ardianto, F. (2020). Analisa Model Propagasi Okumura-Hata Dan Cost-Hata Pada Komunikasi Jaringan Wireless 4g Lte. *Jurnal Ampere*, *5*(1), 32. Https://Doi.Org/10.31851/Ampere.V5i1.4158

Anggraeni, D., & Khusna, E. M. (2023). *Dielektrik Kevlar-Tepung Kaca Komposit Jurusan Teknik Elektro Politeknik Negeri Semarang , Semarang Latar Belakang Peranan Yang Dirasakan Dengan Kemajuan Teknologi Telekomunikasi Saat Ini Adalah Kemampuan Untuk Mendistribusikan Informasi-Informasi Yang Te*. *5*, 354–362.

Anou, K. N. (2019). Perancangan Dan Karakterisasi Antena Monopole Sebagai Pemancar Dan Penerima Gelombang Wifi Frekuensi 2,4 Ghz Design And Characterization Of Monopole Antenna As Transmitter And Receiver Wifi Wave At 2.4 Ghz Frequency. *Jurnal Natural*, *15*(1), 40.

Charisma, A. … Yani, A. (N.D.). *Metode Proximity Coupled Pada Perancangan Antena Mirostrip Persegi Persegi Panjang Peripheral Slits Untuk*. 94–102.

Chhabra, V., & Dayal Sharma, S. (2020). A Paper On Performance Analysis Of Microstrip Rectangular Patch Antenna. *International Journal Of Technical Research & Science*, *Special*(Issue1), 35–38. Https://Doi.Org/10.30780/Specialissue-Icrdet-2019/006

Christyono, Y. … Cahyo, R. D. (2016). Perancangan Antena Mikrostrip Array Pada Frekuensi 850 Mhz. *Transmisi*, *18*(2), 87–95.

Dan, P. … Yunita, T. (2021). *Sirkular Monopole Pada Frekuensi 2 , 1 Ghz Untuk Lte (Design And Realization Of 4 × 4 Mimo Antenna Monopole Circular Patch On Frequency 2 , 1 Ghz For Lte)*. *8*(6), 11738–11752.

Fadilah, I., & Budayawan, K. (2022). Desain Dan Karakteristik Antena Microstrip Sebagai Sensor Non – Destructive Mikrostrip Dengan Menggunakan Cst Suite Studio . *Jurnal Vocational Teknik Elektronika Dan Informatika*, *10*(2).

Frendy Christianto Imanuel Siahaan, Guntur F. Prisanto, Niken F. Ernungtyas, Irwansyah, S. H. (2020). Migrasi Siaran Televisi Analog Ke Digital Arah Formulasi Kebijakan. *Jurnal Risalah Komunikasi*, *4*, 155–164.

Haekal, A. F. … Utama, H. S. (N.D.). *Ahmad Fachri Haekal, Joni Fat, Hadian Satria Utama Analisis Antena Mikrostrip Patch Rectangular Substrat Fr-4 Pada Frekuensi 2,3 Ghz Untuk Aplikasi Lte*. 171–180.

Haqqu, R., & Ersyad, F. A. (2020). Eksistensi Media Televisi Di Kalangan Remaja. *Dinamika Sosial Budaya*, *22*(1), 38–44. Http://Journals.Usm.Ac.Id/Index.Php/Jdsb

Kirana, N. W. (2021). Desain Dan Analisis Antena Mikrostrip Rectangular Dengan Slot " M " Untuk Aplikasi Wlan 2,4 Ghz. *Je-Unisla*, *6*(1), 453. Https://Doi.Org/10.30736/Je.V6i1.581

Kurniasari, P. … Sriwijaya, U. (N.D.). *Desain Antena Mikrostrip Menggunakan Konfigurasi Slit Pada Bidang Patch Peradiasi Untuk Kinerja Wireless Fidelity 2 , 4 Ghz*. 852–858.

Madiawati, H., & Simanjuntak, A. B. (2021). Antena Mikrostrip Rectangular Array 4x2 Elemen Dengan Metode Inset Feed Pada Frekuensi 3,5 Ghz Untuk Aplikasi 5g. *Jtera (Jurnal Teknologi Rekayasa)*, *6*(2), 175. Https://Doi.Org/10.31544/Jtera.V6.I2.2021.175-182

Nuryanto, L. E. (2014). Mengenal Teknologi Televisi Digital. *Orbith: Majalah Ilmiah Pengembangan Rekayasa Dan Sosial*, *10*(1), 29–36.

Permana, A., & Fath, N. (2021). Rancang Bangun Antena Microstrip Sebagai Penguat Sinyal Wifi Dan Jaringan 4g Lte Pada Frekuensi 1800 Mhz. *Maestro*, *4*(2), 240–248.

Rahmanda, D., & Rahayu, Y. (2016). *Pencatuan Microstrip Line Untuk Aplikasi Wireless Body Area Network (Wban) Pada Frekuensi 2 . 4 Ghz*. *3*(2), 1–9.

Rufaidah, R. … Anwar, R. (2020). Perancangan Antena Mikrostrip Array Pada Frekuensi X-Band Untuk Aplikasi Radar Cuaca. *E-Proceeding Of Engineering*, *7*(2), 3830–3838. Https://Openlibrarypublications.Telkomuniversity.Ac.Id/Index.Php/Engineering/Article/View/12935

Widodo. (2009). Nilai-Nilai Luhur Dalam Lelagon Dolanan. *Harmonia: Journal Of Arts Research And Education*, 9(2), 167-172.

Raffles, T. S. (2008). *Sejarah Jawa.* Translated By Eko Prasetyaningrum. Yogyakarta: Narra-Tion.

Galley. K. E. (Ed.). (2004). *Global Climate Change And Wildlife In North America.* Bethesda, Md: Wildlife Society.

New York State Department Of Health. (2002). After A Sexual Assault. [Brochure]. Albany, Ny: Author.

Greenhouse Effect. (2005). *American Heritage Science Dictionary.* Boston, Ma: Houghton Mifflin.

Schneider, S. H. (2000). Greenhouse Effect. *World Book Encyclopedia* (Millennium Ed. Vol. 8, Pp. 382-383). Chicago, Il: World Book.

Sudarsono. (2010). Garap Lakon Kresna Dhuta Dalan Pertunjukan Wayang Kulit Kajian Tekstual Simbolis. *Journal Of Arts Research And Education*, 12(1), 75-86.

Bogdonoff, S., & Rubin, J. (2007). The Regional Greenhouse Gas Initiative: Taking Action In Maine. *Environment,* 49(2), 9-16.