UNIVERSITE KASDI MERBAH – OUARGLA

Faculty of Sciences and new communication technologies

Department of Electronics

FINAL PROJECT THESIS

Study and conception of an antenna in the UHF band

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COLLEGE YEAR : 2023/2024

ملخص

تعتبر هوائيات ضرورية لمختلف التطبيقات من اجل تحليل البينات والاتصالات. تهدف هده الدراسة الى microstrip كما قمنا بالعمل على هوائي . UHFتصميم ودراسة هياكل الهوائيات المتكيفة مع أنظمة الاتصالات ذات التردد فوق عالي للحصول على نتائج دقيقة ، مما نتج عنه نطاق ضيق دو ابعاد واسعة ، فالنتقلنا الى CSTتقليدي بواسطة جهاز محاكاة هوائيين متحدين في المستوى مما أدى الى زيادة في عرض النطاق الترددي، وانخفاض الكسب والاتجاه .تم إضافة هوائي مصغر الى العنصر وتقليل حجمه، مما نتج عنه نطاق ترددي واسع مع مكاسب وكفاءة عالية نسيسا.

summary

Microstrip antennas are essential for various applications for data analysis and communications. This study aims to design and study antenna structures adapted to UHF communications systems. We also worked on a traditional antenna using a CST simulator to obtain accurate results, which resulted in a narrow band with wide dimensions. We moved to two antennas in the same plane, which led to an increase in bandwidth, and a decrease in gain and directionality. A miniature antenna was added to the element and reduced Its size, resulting in a wide bandwidth with high gain and efficiency.

résumé

Les antennes microruban sont essentielles pour diverses applications d'analyse de données et de communications. Cette étude vise à concevoir et étudier des structures d'antennes adaptées aux systèmes de communications UHF. Nous avons également travaillé sur une antenne traditionnelle à l’aide d’un simulateur CST pour obtenir des résultats précis, ce qui a abouti à une bande étroite aux dimensions larges. Nous sommes passés à deux antennes dans le même plan, ce qui a entraîné une augmentation de la bande passante et une diminution du gain et de la directivité. Une antenne miniature a été ajoutée à l'élément et a réduit sa taille, ce qui a permis d'obtenir une large bande passante avec un gain et une efficacité élevés.

Acknowledgement

I would like to express our sincere gratitude to our promoter Mr. BELHEDRI ABDELHAKIM and co-promoter Mr. MEKIMAH BOUALEM for their contribution, patience and motivation through all the stages of our project thesis. Besides our advisor, I would like to thank Mr. CHBARA FOUAD and Mr. CHENINA LHACHEMI. Special thanks to all the people who contributed to the

success of our thesis

I would also like to thank the members of the jury for the honor they gave us by accepting to evaluate our work.

Finally, I acknowledge our warmest thanks to our parent and my family members who always supported and encouraged us.

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Abreviations list

- εr : relative permittivity.
- tg(δ): Loss tangent.
- σ : Conductivity.
- L : Patch Length
- λ: Wave length.
- µ: Magnetic permeability of vacuum
- ÉF : Finished elements
- $\vec{E}$: electric fields.
- $\vec{H}$: magnetic field
- $\vec{D}$: Electric induction field
- CST : computer simulation technology (simulation software)
- wsub: Simulated substrate width
- lsub : length of simulated substrate
- wp : Simulated Patch Width
- lp : simulated patch length
- Wf : Line width
- fi : line length
- t : thickness of metal layers
- K : carrying coefficient
- g : gap of the feed line
- h : Substrate thickness.
- VSWR: Voltage Standing Wave Ratio.
- S11: Reflection coefficient
- BW : bandwidth.

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General Introduction

General Introduction:

In a communication system, antennas are components in their own right requiring special study. While seeking to improve the performance of a antenna, it must be adapted to the most recent applications.

In high performance applications used in aircraft, spacecraft, satellites and missiles, where volume, weight, ease of installation and profile aerodynamics are constraints, low profile antennas are required. Currently, other government and commercial applications, such as mobile radio and wireless communications have the same specifications. the microstrip antenna can meet all these requirements. The rapid development of markets, especially in communication systems

(PCS), mobile satellite communications, direct broadcast (DBS), wireless local networks (WLAN) and intelligent vehicle-highway systems (IVHS), suggest that demand for microstrip antennas will grow even further. Between Growing demand calls for continued development . However, microstrip antennas have some disadvantages. A death disadvantages is the creation of surface waves which originate in the layer of substrate. These surface waves are undesirable because, when the antenna radiates, a portion or even all of the energy to be radiated is retained along the surface of the substrate. Surface waves weaken the efficiency of the antenna, its gain as well as its band passing. Several techniques have been developed to improve antenna parameters conventional microstrip using different processes such as FSS techniques (Frequency Selective Surfaces), AMC (Artificial Magnetic conductors), PBG (Photonic Band Gap), etc... The use of microwave equipment with DefectedGround Structure (DGS) has gained popularity among all for the simplicity of its design. Any shape engraved or presenting a defect on the ground plane is considered as DGS. [1]

In this dissertation, after presenting microstrip antennas, their technologies, as well as than the methods of analysis, we approached a theoretical study of the behavior of General Introduction 2 the electromagnetic wave at the limit of two media, notably dielectric and metallic, and inside a resonant cavity. Which partly explains the creation of charges electrical and current on surfaces and resonant frequencies. These elements largely determine the operation of the antenna and its performance. The “Defected Ground Structure” (DGS) technique addressed in this work counts by the popular techniques currently used to improve the performance of microstrip antennas. By applying this technique to an antenna, in fact, it amounts to acting directly on the distribution of charges along the surface of the ground plane which influences noticeably on the behavior of the wave inside the antenna and consequently on its performance .

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Mémoire : M. BERMATI Abdellatif et M. BADA Amor : Effet des irrégularités dans le plan de masse sur les performances d'une antenne microbande

Chapter I

General description of microstrip antenna

1.1 Introduction

Microstrip patch antenna is commonly used in wireless communication systems because of its small size, low profile, and easy integration. It is composed of a conductive patch mounted on a dielectric substrate with a ground plane underneath. The feeding mechanism connects the patch to the RF signal source and determines the antenna's polarization and radiation pattern. By adjusting the patch's dimensions and substrate properties, microstrip patch antennas can be customized to operate at specific frequencies within the microwave range [1].

In this section, we will provide a general description of microstrip patch antennas, along with their advantages and disadvantages.

I.2 Description of patch antenna

An antenna is a metallic device that is essential in all wireless communication systems. It enables a modulated signal, carrying information, to be transmitted from a transmitter to a receiver through a transmission channel such as a waveguide or free space. The antenna converts the electrical signal into an electromagnetic wave and vice versa, playing a reciprocal role.

The printed antenna is made up of a thin metallic conductive layer of any shape, known as the radiating element, which is placed on a dielectric substrate. The lower face of the substrate is entirely metalized to serve as a ground plane. At the top of the radiating element, there is another substrate (superstrate) [3]. These radiating elements can have various shapes such as square, rectangular, triangular, circular, elliptical, or even more complex shapes.

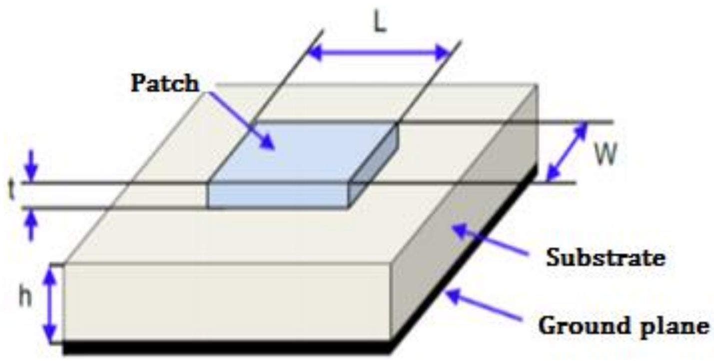

Figure I.1: Patch antenna structure

With:

$$\begin{cases} W : Widht \\ L: Lenght \\ h: Height \end{cases}$$

The antenna consists of a patch mounted on a dielectric substrate, which provides both mechanical +support and electrical insulation. The substrate is usually made of low-loss materials with a high dielectric constant, such as fiberglass-reinforced epoxy or ceramic. The choice of substrate material has a significant impact on the antenna's performance, bandwidth, and efficiency. Beneath the substrate, a conductive ground plane acts as a reflector and enhances the antenna's radiation efficiency by providing a return path for the electromagnetic waves. The ground plane is typically larger than the radiating patch to minimize radiation losses. The radiating patch is connected to the RF signal source through a transmission line, typically in the form of a microstrip or coaxial cable. This connection determines the antenna's polarization and radiation pattern.

I.3 Patch shapes of microstrip antenna

The various types of simplest radiating elements are shown in the following figure [4]

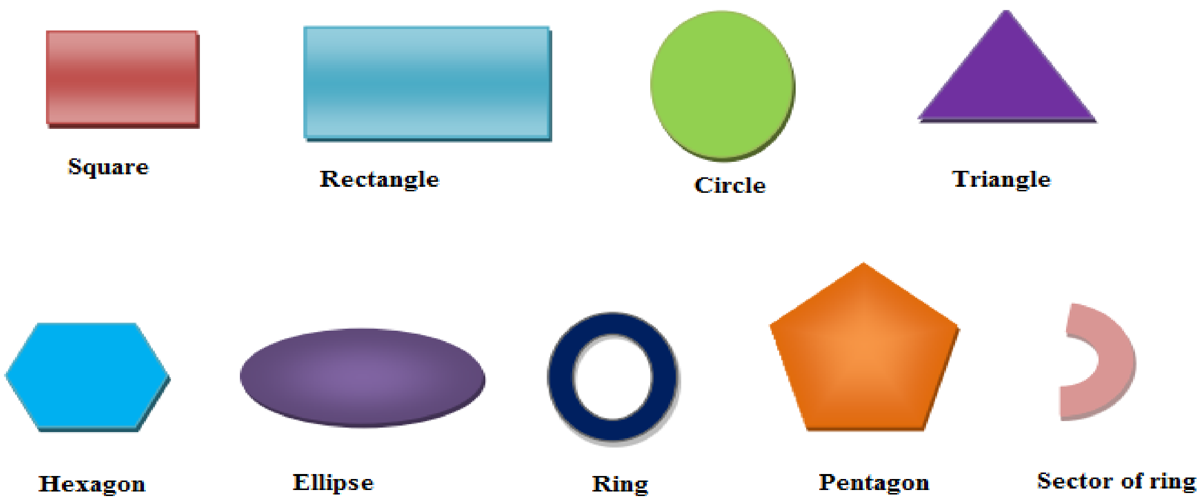

Figure I.2: Various shape of Patch

Other forms can be more intricate and difficult to analyze, as they are often the result of combining two simple shapes. They are typically used in specific applications. The selection of antenna shape depends on the desired type of application and the parameters we aim to optimize, such as bandwidth, gain, efficiency, input impedance, and secondary lob levels.

I.4 Characteristic of microstrip antenna

In wireless communications, each application highlights specific characteristics of the antennas. Generally, an antenna used in one application type cannot be used in others. Each antenna is designed to meet the unique requirements of a specific application. An antenna is characterized by:

Reflexion coefficient S11

This coefficient is the amplitude ratio between the incident wave (transmitted to the antenna) and the reflected wave due to the optimization of the antenna concerning frequency. It makes it possible to characterize the antenna's adaptation to the circuit that precedes it. For a reflection coefficient of −10 dB, 90% of the power is transmitted to the antenna. The network analyzer measures the reflection coefficient as a frequency function. It is linked to the input impedance presented by the Ze antenna [2].

$$Z_e = Z_c \frac{1+S_{11}}{1-S_{11}}$$

(I.1)

With Z_C is the characteristic impedance.

- **Gain**

Gain is considered one of the main parameters of a directional antenna; energy is less critical in some directions and more critical in others. An antenna's gain is evaluated by the ratio between the power emitted by the antenna and the power transmitted by the antenna. Omnidirectional, both antennas are powered [3].

$$G(\theta,\varphi) = \frac{P(\theta,\varphi)}{Pr} = \frac{P(\theta,\varphi)}{pt/_{4\pi R^2}} = 4\pi R^2 \frac{P(\theta,\varphi,)}{\iint P(\theta,\varphi)}$$

(I.2)

With:

P: Power density radiated by the directional antenna (W/m²).

Pt: The total power radiated by the two antennas (W).

P0: Power density radiated by the isotropic antenna (W/m²).

- **Directivity**

The directivity of an antenna is the ratio of the power radiated per unit of solid angle in the direction (θ, Φ) to the power that the isotropic reference source would radiate per unit of solid angle for the same total power radiated [4].

$$D(\theta,\varphi) = \frac{P(\theta,\varphi)}{Pr/4\pi}$$

(I.3)

- **Efficiency**

Efficiency is the ratio between the energy radiated by an antenna and that supplied by the power supply. It is given by [2]

$$D(\theta,\varphi) = \frac{P(\theta,\varphi)}{Pr/4\pi} \quad \text{(I.3)}$$

$$\eta = \frac{R_r}{(R_r+R_p)} \quad \text{(I.4)}$$

R_r : Radiation resistance

R_p : Loss resistance

It can also give by the following equation:

$$\eta = \frac{P_r}{P_a} \quad \text{(I.5)}$$

P_r: the power radiated by an antenna

P_a: La puissance fournie par l'alimentation

- **Bandwidth**

The bandwidth of an antenna refers to the frequency range over which the antenna can operate properly. It represents the number Hz for which the antenna represents a rate less than 2 (which is equivalent to almost -10dB of the curve of the coefficients of reflection). [1]

$$BW\% = \frac{f_2 - f_1}{f_0} \times 100 \quad \text{(I.5)}$$

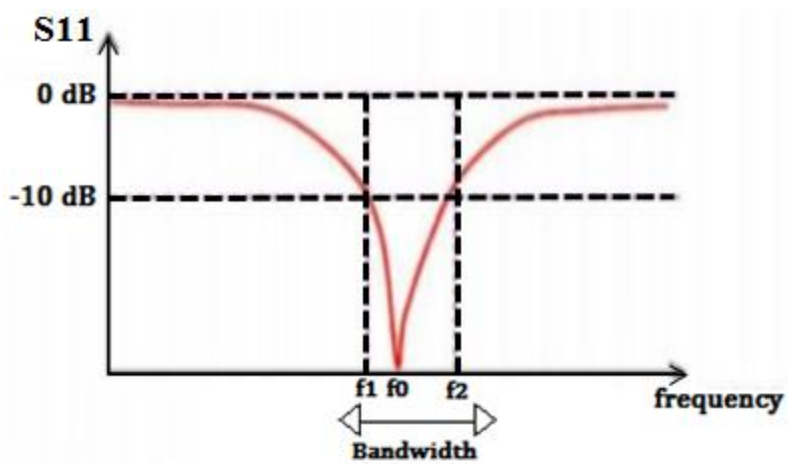

Figure I.3: Bandwidth

- **Radiation pattern**

The radiation pattern of an antenna shows the variations in the radiated power per unit of solid angle in different directions in space. Apart from the case of omnidirectional antennas in certain planes, antennas do not radiate their powers uniformly in all directions in space.

There is generally a maximum radiation direction around which a large part of the radiated power is concentrated and secondary directions around which the remaining power is distributed. The characteristic radiation function F (θ, Φ) of the antenna provides an overall view of the radiation. It is defined as being the ratio of the power transmitted in a given direction P (θ, Φ) to the power P_{max} of the direction where the radiation is maximum. [2]

$$P_0(\theta,\varphi) = \frac{P_\alpha}{4\pi} \tag{I.6}$$

- **Polarization**

The polarization of an antenna is given by the direction of the electric field $\vec{E}$. If $\vec{E}$ maintains a constant direction over time, we say that we have rectilinear polarization. There are, however, antennas, which radiate an electric field whose direction varies with, time such that if, at a given point, we diagram the successive positions of E, the end of the representative vector describes a circle or an ellipse. We then say that the radiated field has circular or elliptical polarization. This is particularly the case for antennas used in radar and space telecommunications.

This is the case for the majority of antennas with linear radiating elements. In particular radiating dipole antennas, which are used in VHF and UHF waves. [2]

- **Input impedance**

The antenna input impedance is the impedance seen from the feed line at the antenna. [2]

$$Z_{in} = Z_0 \frac{(1+S_{11})}{(1-S_{11})} \tag{I.7}$$

Z_0 Is the characteristic impedance of feed-line.

- **Voltage Standing Wave Ratio (VSWR)**

The ratio of maximum and minimum standing wave pattern values along a transmission line to which a load is connected. The VSWR value varies from one (matched load) to infinity for a shorted or open load. For most antennas, the maximum acceptable value of VSWR is two. VSWR is related to the reflection coefficient Γ by:

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|} \tag{I.8}$$

I.5 Alimentation of microstrip antenna patch

There are several feeding techniques commonly employed for microstrip patch antennas [5]. It depend on how the antenna is integrated into the device.

I.5.1 Alimentation of antenna microstrip patch by coaxial

The standard SMA connector is soldered to the ground plane, which is perforated to connect the central core to the patch by crossing the dielectric substrate (see Figure I.5). The coaxial guide supplies the energy. This type of antenna is easy to manufacture, generates low parasitic radiation, and has a low bandwidth. However, it is not easy to model.

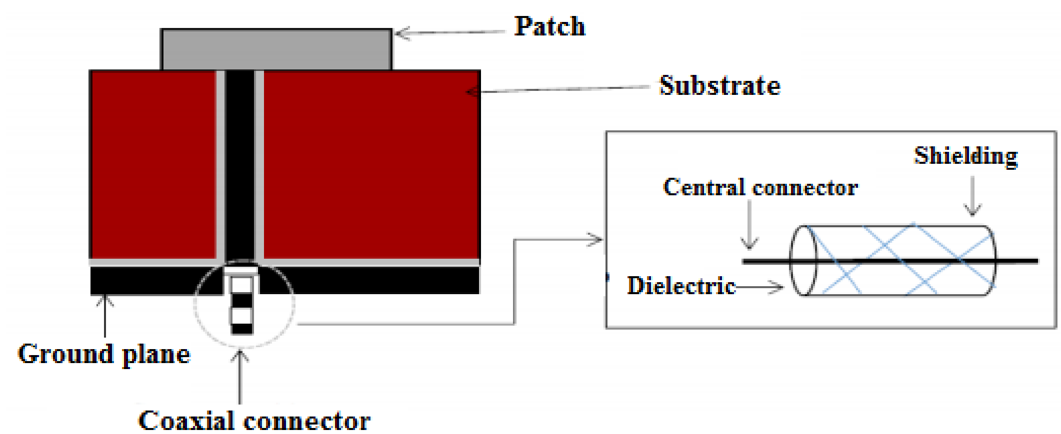

Figure I.4: Microstrip antenna powered by coaxial

I.5.2 Alimentation of antenna microstrip patch by proximity

Proximity coupling is a more intricate feeding method compared to others like coaxial feeding. It requires careful consideration of the capacitive interaction between the patch and the feed strip line during the design and analysis process.

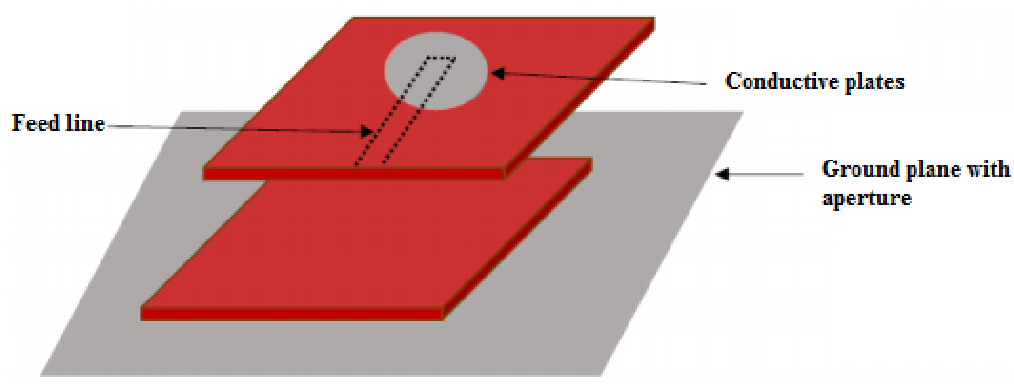

Figure I.5: Alimentation technic by proximity

I.5.3 Alimentation of antenna microstrip patch by line

Connecting an antenna patch to a power source using a transmission line, like a microstrip line, is commonly referred to as feeding the antenna patch. This method involves establishing a connection between the patch antenna and the feed line through the transmission line on a substrate. The use of a transmission line, such as a microstrip line, is essential in patch antenna designs as it enables efficient power transfer and impedance matching.

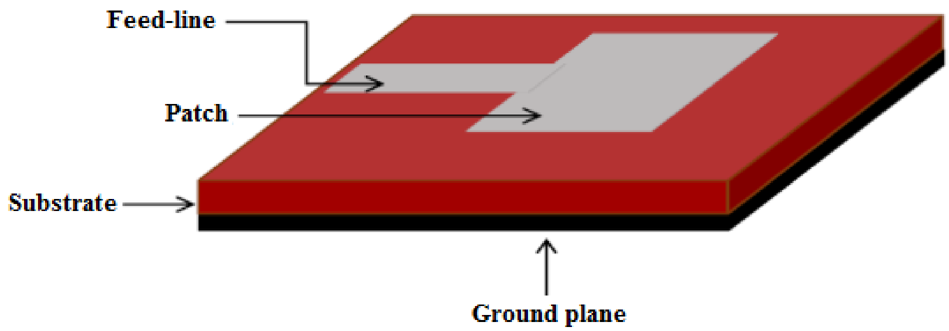

Figure I.6: Patch antenna powered by feed-line

I.6 Adaptation technique of patch antenna

Every energy transformation system on a transmission line requires adjustment. The line changes the load impedance to a different value at the source. Consequently, what the source perceives depends on the load impedance, the electrical length of the line, and its characteristic impedance [6].

- **Quarter-wave line adaptation** :

  In the construction of microwave circuits, we often seek adaptation, that is, to reduce the impedance obtained at the end of the circuit to different impedance (which is often the characteristic impedance).

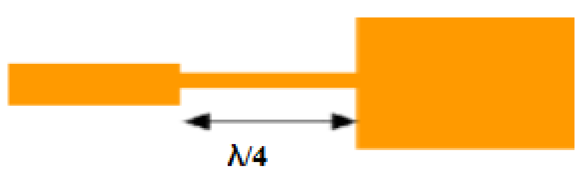

Figure I.8: Quarter line antenna adaptation

- **Adaptation by stub:**

Another method to adjust any load is by using a stub. This can be achieved by using an open circuit (open stub) or a short circuit (short stub). The preferred option is usually the one with the smallest footprint. While the calculation can be done in impedance, it is easier to start with admittance to combine the parallel impedances.

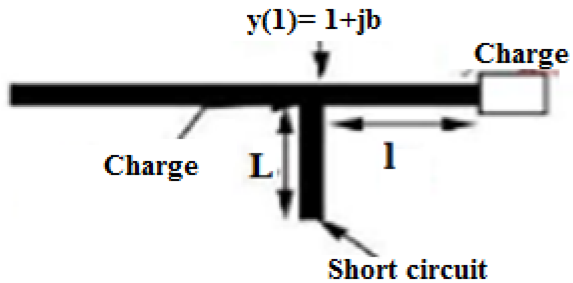

Figure I.9: Alimentation by a stub

- **Adaptation with slots**

To adapt the antenna, we use slots and modify the geometry of the patch [6].

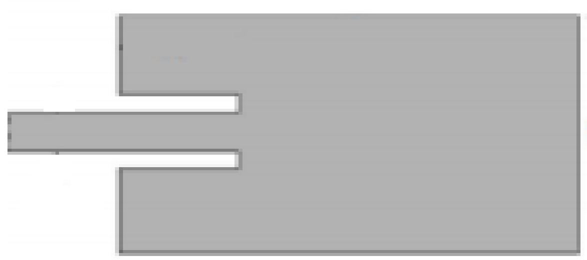

Figure I.10: Patch antenna with slots

I.7 Analysis method on antenna patch

The Method of Moments (MoM) is commonly used to analyze the behavior and performance of a microstrip patch antenna on a finite dielectric substrate. In this method, the patch antenna is excited by a feed-line passing below the dielectric substrate. The patch, feed-line, and dielectric substrate are modeled using triangular patches, and a set of coupled integral equations in terms of equivalent currents is derived based on the equivalence principle and associated boundary conditions. These equations are then solved using the Method of Moments to obtain numerical results that can be compared with experimental measurements, showing good agreement. The Method of Moments is a powerful tool for analyzing the characteristics of microstrip patch antennas, providing valuable insights into their performance and behavior under different conditions.

I.7.1 Approximate method of antenna patch

These methods are based on the modeling of the microstrip antenna. Two models allow us to describe the operation of the antenna [7]:

I.7.1.1 Transmission line model

The structure is modeled by a section of line whose characteristics are well known. This is the first and simplest model used for the analysis and synthesis of microstrip antennas in terms of impedance, but it is less precise. This model is used for rectangular microstrip antennas.

The resonant frequency for the Tm0 mode can be evaluated at:

$$F_0 = \frac{mc_2}{(L+\Delta L)\sqrt{\varepsilon_{eff}}} \quad \text{(I.9)}$$

$$W = \frac{C}{2F_0\sqrt{\frac{\varepsilon_R+1}{2}}} \quad \text{(I.10)}$$

$$L = \frac{C}{2F_0\sqrt{\varepsilon_{eff}}} - 0.824h\left(\frac{(\varepsilon_{eff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{eff}+0.258)(\frac{w}{h}+0.8)}\right) \quad \text{(I.11)}$$

With

$$\Delta L = 0.412t(\varepsilon_{reff} \times 0.3)(W_t + 0.264)(\varepsilon_{reff} - 0.258)(W_t + 0.8)$$

(I.12)

$$\begin{cases} C: Speed\ of\ light \\ m: Mode\ index \\ L: Lenght\ of\ patch \end{cases}$$

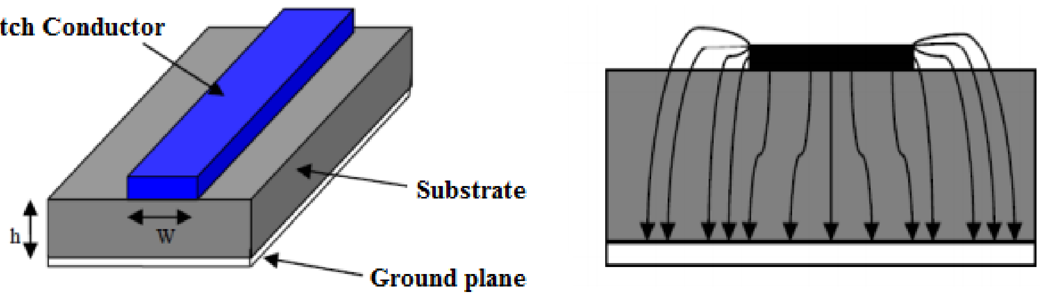

Figure I.11: Transmission line model

I.7.1.2 Resonant cavity model

In this model, the printed antenna can be likened to a cavity enclosed by two horizontal electrical walls (the ground plane and the radiating element) and four vertical magnetic walls. The electric field in the cavity has a component along the axis (Oz), and the magnetic field has two components: (oy) and (ox) [8].

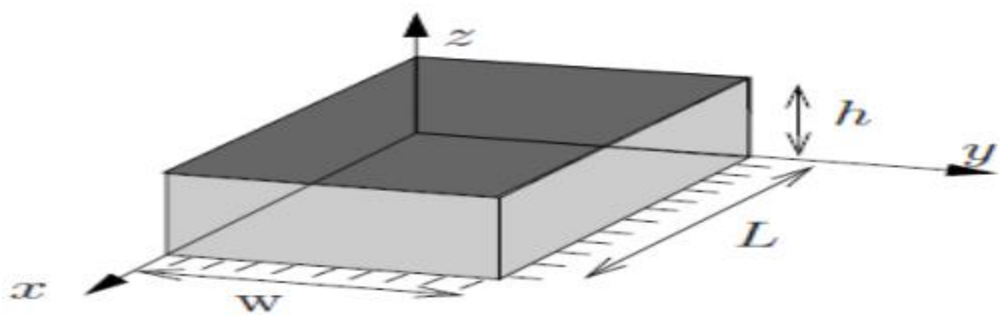

Figure I.12: Resonant cavity model

I.7.2 Numerical method of antenna patch

These methods are used for all patch antennas geometry [9].

I.7.2.1 Method of Moments (MoM)

It consists of discretizing the surface of the patch using small triangles, rectangles, and polygons with dimensions of λ/10 to λ/20, where the elementary current can be determined. Once the current is obtained, the electrical and radiation characteristics can be easily calculated.

I.7.2.2 finite element method (FEM)

In this method, we must discretize the space where the electric field exists in tetrahedral and then form a system of linear equations in which the fields are the unknowns.

I.7.2.3 finite difference method (FDM)

The structure to be analyzed is meshed with cubic cells, where Maxwell's equations are approximated by the central difference formulas. This method allows one to analyze printed antennas when they are positioned in an inhomogeneous medium.

I.7.2.4 transmission line matrix method (TLM)

This method has many similarities with the FDTD method. The TLM transmission line matrix method allows for discretizing the fields and currents of the structure studied into small elements. Each element is considered a set of transmission lines, and the calculations are carried out directly in the time domain. One of the strong points of this method is the simple formulation, which only depends a little on the geometry of the structure studied (which is not the case for the spectral method). It is easy to deal with complex structures composed of several materials and is particularly suitable for analyzing multilayer planar structures.

I.7.2.5 Spectral analysis method

This model considers the spectral domain's electric field integral equation (EFIE). This method makes it possible to solve systems of integral equations in the spatial domain efficiently. It is based on knowledge of electromagnetic fields in each region. The system of integral equations to be solved can be written in matrix form, and the choice of the surface continuity condition and the current vector on the patches makes it possible to reduce the relationship between the tangential components of the

electromagnetic fields and the surface currents. The integral equation approach in the spectral domain is widely used in the analysis and design of microstrip structures.

I.8 Application of patch antenna

The application of patch antennas is diverse and extensive, making them a popular choice in various fields due to their performance and robust design. Some common applications of patch antennas include [10]:

- Mobile Communication

- Satellite Communication
- Wireless Networks
- Phased Array Antennas
- Amateur Radio

These applications highlight the versatility and effectiveness of patch antennas across different industries and technologies, highlighting their importance in modern communication systems and devices.

I.9 Advantages and Disadvantages of patch antenna

Patch antennas have various advantages [11] and disadvantages [12] that are crucial in antenna design and implementation. Here are the key points extracted from the provided sources:

Advantages:

- Patch antennas are **smaller**, **lightweight**, and have a **low profile**, making them suitable for compact devices and applications.
- **Ease of Fabrication**: They can be easily etched on PCBs, allowing for simple manufacturing and troubleshooting during design and development. The visible micro strip pattern facilitates fabrication and integration with other components.
- **Cost-Effective**: Patch antennas have lower fabrication costs, enabling mass production and cost-efficient deployment.
- **Frequency Bands and Polarization**: They can support multiple frequency bands, dual and triple frequency operations, and both linear and circular polarization types.
- Patch antennas can be **easily integrated** with microwave integrated circuits (MICs) and are **mechanically robust** when mounted on rigid surfaces.

Disadvantages:

- **Bandwidth**: Patch antennas may have narrow bandwidth, limiting their frequency range and applications
- **Efficiency and Gain**: They offer lower efficiency and gain due to dielectric and conductor losses, impacting their overall performance

- **Radiation Characteristics**: They exhibit extraneous radiation from feeds and junctions, leading to potential interference and reduced performance
- **Cross Polarization**: Patch antennas can have a higher level of cross-polarization radiation, affecting signal quality and coverage
- **Power Handling**: They have a lower power handling capability compared to other antenna types, limiting their use in high-power applications.

In short, patch antennas have advantages such as compact size, ease of fabrication, and cost-effectiveness. However, they also have limitations including narrow bandwidth, lower efficiency, and potential radiation issues that must be considered in their design and deployment.

Conclusion:

In this chapter, we covered the concepts of technological development, the importance of microstrip antennas, and specific parameters on the operation and performance of this type of antenna, namely the constituent parameters and the type of power supply. We also focused on the microstrip antenna and its analysis methods and their advantages and disadvantages. We will cite their field of application.

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Chapter II

UHF Band And DEGETAL TELEVISION

II.1. Introduction

Digital broadcasting has been an area of active research, development, innovation and business models development in recent years. The Ultra High Frequency (UHF) band is used for terrestrial television broadcasting. The UHF band, which spans from 470 to 862 MHz, has traditionally been used for digital terrestrial television (DTT) broadcasting. This method of broadcasting is simple, inclusive, and cheap, offering instant access to a variety of public and private programs via a TV set with an antenna. In this chapter we will introduce the DTT technology and UHF and his characteristic and we finish by giving her advantages.

II.2. Definition of DTT

DVB-T or DTT is a digital television standard used in many countries. It is called "terrestrial" because its transmitters are installed on the ground [1].

(DTT) is a technical development in television broadcasting, based on the broadcasting of digital television signals by a network of terrestrial retransmitters. Compared to analogue terrestrial television which it replaces, DTT makes it possible to reduce the occupation of the Digital terrestrial television electromagnetic spectrum thanks to the use of more efficient modulations, to obtain better image quality, as well as to reduce costs. Operating costs for broadcast and transmission once upgrade costs are amortized. Digital terrestrial television is to be compared to digital television received by cable or satellite. In the latter case, broadcasting is not done through the network of terrestrial transmitters but via a satellite (hence the use of parabolic antennas instead of a conventional television antenna called a "rake" antenna).

(a) (b)

Figure II.1: (a) Parabolic Antenna; (b) Rake Antenna

DTT broadcasts are mainly in the UHF band which goes from 470 to 860 MHz. This band was divided into 8 MHz wide channels for analog TV, numbered from 21 to 69. DTT used the same channels.

With DTT, as with analog television, the radio waves used to transport the image are analog. The same frequency bands are used in both cases. They are therefore the same waves, but encoded differently. For analog television, the signal modulating the carrier wave is analog that is to say that the electrical modulation signal varies proportionally to the desired brightness. The 625 lines of an image are scanned one after the other; a mark in the electrical modulation signal allows the TV receiver to synchronize. What is digital in DTT is the information itself. Typically a video file (MPEG5 for example) is transported by the modulation of electromagnetic waves. The demodulator extracts digital data from the electrical (analog) signal received on the antenna [2]. Since the data at both ends of the chain is digital, we can benefit from digital data processing:

- Compression of files to reduce their size (which allows several programs to be put into a single frequency channel).
- Error correcting code (some data is added to the source, the receiver uses it to detect and correct errors introduced by the transport of information).

II.2.1. Numeric modulation

Modulation is the use of a high frequency (HF) to transport an electrical signal. The HF frequency is said to “carry” the signal to be transmitted. For example, for AM radio, the amplitude of the carrier is varied proportionally to the audio signal. An audible signal at a low frequency (< 20 kHz), is carried by a frequency of 150 to 1,500 kHz. In the case of FM, it is the frequency of the carrier which varies proportionally to the audio signal. In the case of DTT, the modulation is different: a large number of carriers are used side by side.

This type of modulation is called OFDM or Orthogonal Frequency-Division Multiplexing. The principle is to distribute (multiplex) the data over several carriers, by dividing the allocated frequency band. For example, a band of approximately 8 MHz is divided into 8,000 carriers spaced 1 kHz apart. The carriers are called “orthogonal” to each other because the spacing is regular, and it is calculated very precisely so that the information modulated on each carrier does not encroach on the next carrier.

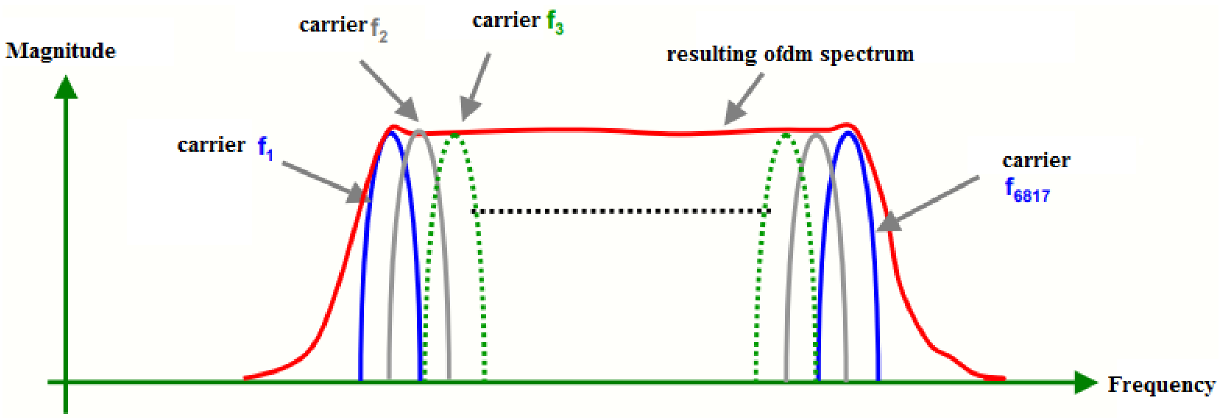

Figure II.2: OFDM spectrum

With digital data, it is possible to largely correct transmission errors. DTT is much less sensitive to parasitic noise than analog TV. The main advantage of distributing the data over 8,000 carriers is to optimally use the frequency band, all carriers having on average the same power. TNT transmitters can transmit almost ten times less power than old transmitters for the same coverage. Correction of transmission errors allows you to have a perfect image, up to a certain error rate. Above this threshold, initially a few blocks are no longer correctable with a loss of image blocks (there is never “snow” as with analog receptions) but if the number of faults increases (appearance of square blocks on the screen first intermittently then more and more frequently) and there comes a time when no error can be corrected: the image freezes.

In the case of analog TV, weather disturbances caused noise to appear on the image and the quality was greatly reduced, but the image remained visible for a long time. With DTT, the image remains almost perfect if the quality of the received signal is in the zone where all errors can be corrected. If the quality of the received signal degrades pixels begin to be missing from the image, then more and more pixels will be missing until the image freezes intermittently, revealing blocks of pixels intermittently [3].

II.2.2 Transmission

Digital television is transmitted on radio waves across terrestrial space in the same way as analogue television, the main difference being the use of multiplex transmitters allowing the transmission of several programs on the same channel. Terrestrial digital television uses frequency bands previously allocated to analog television (band III in VHF, bands IV and V in UHF). Depending on the country, transmission is done according to standards such as DVB-T6 (particularly in Europe) or ATSC7 (in North America). The video codecs used are H.262/MPEG-

2 Part 2 and H.264/MPEG-4 AVC, more recent and more efficient. H.264 notably allows three high-definition television services to be carried on a DVB-T channel at 24 Mbit/s.

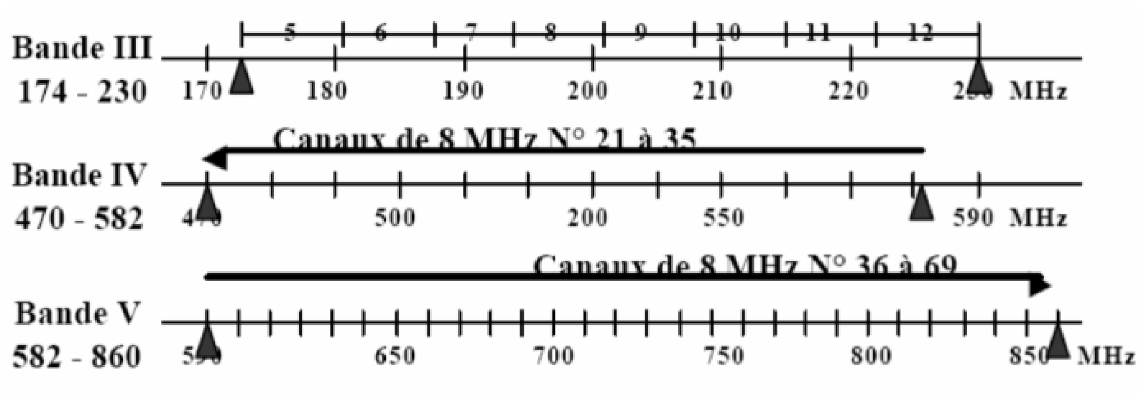

Figure II.3: TNT allowed frequency bands.

II.3. DVB (Digital Video Broadcast)

- Standard based on the audio and video part of MPEG-2.
- DVB offers how to transmit MPEG-2 signals via satellite (DVB-S standard), cable (DVB-C standard) and terrestrial broadcasting (DVB-T standard) as well as program guide information and a system of encryption.

II.3.1 Digital video broadcasting terrestrial

Development of terrestrial digital broadcasting has revolutionaries the broadcasting industry changing its perception that has existed for decades, increasing extensively the carrying capacity of a frequency channel for broadcasting stations, introducing mobility and facilitating convergence of data transmission, broadcasting and telephony. Hence, the business models and broadcasting value chain have changed. Digital broadcasting offers a number of new business opportunities and challenges. The broadcasting industry that was fragmented in the analog broadcasting era with PAL standard used in Europe, Asia and Africa; NTSC standard used in Japan, America and South Korea; while SECAM standard used in France and Africa has been repeated again in the digital era with DVB-T standard used in Europe, Asia and Africa; ATSC standard in Northern America; ISDB-T standard used in Japan and Latin America while DTMB being used in

China. The fight for digital broadcasting standard adoption worldwide has already closed down. It is apparent that political and economic alliance, geographical proximity and historical ties played a significant role in the choice of standard adopted.

The Digital Video Broadcast Terrestrial (DVB-T) is a European developed technical standard that specifies the framing structure, channel coding and modulation for digital terrestrial television (DTT) broadcasting that was first published in 1997 although its development started in 1993. It allows delivery of a wide range of services, from HDTV to multichannel SDTV, fixed, portable, and even handheld mobile reception. The second generation of DVB-T is DVB-T2. Some believe however

that the necessity to upgrade to second generation over such short period is a result of principle weakness in the first generation. This standard's transmission system uses orthogonal frequency division multiplex (OFDM) modulation which uses a large number of sub-carriers and capable of handling very harsh conditions. DVB-T has 3 possible modulation options (QPSK, 16QAM, 64QAM), 5 different forward error correction (FEC) rates, 4 Guard Interval options, Choice of 2k or 8k carriers and can operate in 6, 7 or 8MHz channel bandwidths (with video at 50Hz or 60Hz). These characteristics have been strongly enhanced in the second generation, the DVB-T2. Table I shows the standard's characteristics extract. This standard allows, with use of appropriate guard band in OFDM modulation, deployment of Single Frequency Networks countrywide and whole enhances indoor reception with simple gap fillers. The standard has also Hierarchical Modulation capacibility allowing two completely separate data streams to be modulated onto a single DVB-T signal by embedding a "High Priority" (HP) stream within a "Low Priority" (LP) stream. DVB-T belongs to the DVB standard family that includes DVB-T2, DVB-S, DVB-S2, DVB-C and DVB-H/SH that are designed to meet specific broadcasting environment/delivery platform. DVB-T2 has adopted different FEC schemes and increased significantly the number of subcarriers, broadened the modulation schemes, transmission modulation and bandwidth options hence enhancing the capabilities of the standard in digital terrestrial broadcasting [4].

II.3.2 Terrestrial Digital Video Broadcasting – Transmitter

There are wide fields of applications of DVB-T technologies in order to exploit the capability of all possible underlying technologies; such as a data transmission technique. DVB will enable (Reimers 2006): a multiplication of the number of television programs which can be broadcast in one transmission channel, data transmission for entertainment and business purposes, a flexible choice of image and audio quality, full interactive services by interaction channels between the viewer and the network operator or content provider, an open and interoperable software platform for enhanced services, and the possible integration into the world of personal computers, among others. At the systems level, guidelines document (ETSITS-101-154 2009) includes restrictions to the syntax and parameter values described by MPEG- 2 and preferred values used in DVB-T applications. The baseband signal that is transmitted is an MPEG-2 transport stream (MPEG-2 TS) (ISO/ IEC-13818 2007). Also; MPEG-4 content can be transported over an MPEG-2 TS. The DVB-T standard provides transmission technical specifications (ETSI-TR-101-190 2008), while MPEG specifications are used for video and audio coding (ETSI-TS-101-154 2009). The DVB-T standard can be implemented using existing analogue networks by an individual set of radio frequencies for each transmission site. It intends to cope with different noise and bandwidth environment, and with multi-path. The DVB-T provides flexibility by serving a wide variety of applications and implementation scenarios, and specifying a wide range of options using different modulation formats, guard intervals, and code rates

(ETSI-TR-101-190 2011). DVB-T transmitter consists of several signal-processing components, as it is illustrated in the functional block diagram of the system in (ETSI-EN-300-744 2009).

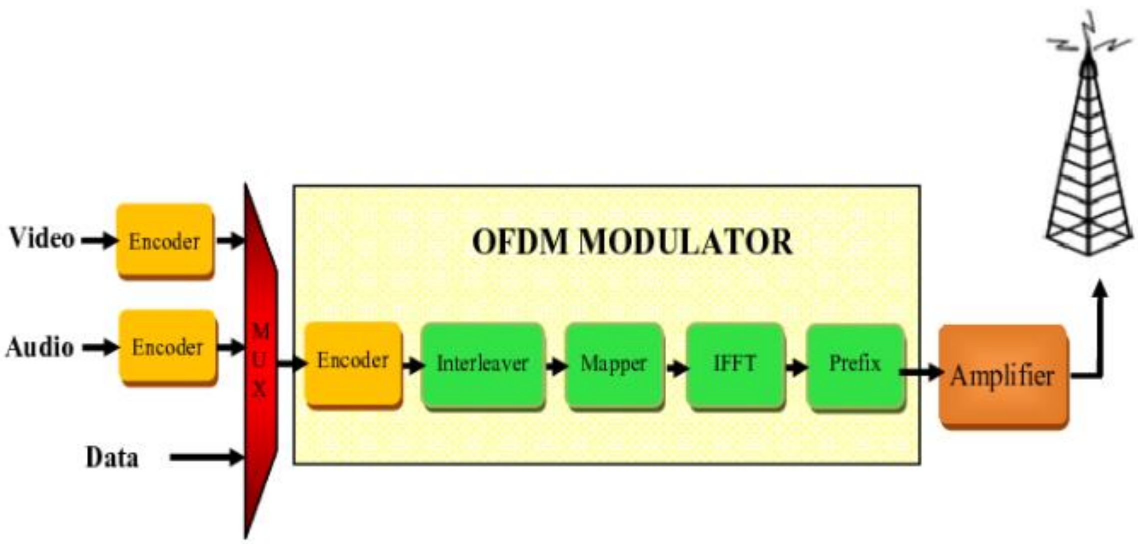

Figure II.4: DVB-T Transmitter [5].

II.3.3 Terrestrial Digital Video Broadcasting – Receiver

The basic DVB-T modes and parameters important to the inner receiver are specified in ETSEN-300-744 (2009) [5] and EN-50083-9 (2002) [6]. The standard also defines interleaving across subcarriers; the data frame structure, a mechanism for robust signaling of transmission parameters (TPS), and dedicated synchronization symbols embedded into the OFDM data stream. In addition, the following aspect must be determined (ETSITS-102-201 2005): [7].

1) The range of SNR needed for the required outer receiver performance;

2) The upper bound on the additional noise caused by any transmission imperfection;

3) Bounds on the accuracy of parameter estimation, allowed receiver mobility, and the quality of analog components.

a) *General RF part*: Reception and demodulation of the DVB-T signal transmitted in accordance with ETSI-EN-300-744 (2009); [8].

b) *Reception mode*: Reception of the DVB-T signal in SFN and MFN;

c) *Frequency bands*: Reception of all channels in UHF and VHF;

d) *Reception combinations and parameters*: Transmission mode, COFDM Modulation, Code rate, Guard interval and optional hierarchical mode;

e) *Echoes*: reception of the DVB-T signal in environment with echoes according to ETSIEN-300-744 (2009); [8].

f) *Signal level and signal quality*: Within the user interface the receiver has to provide the information of signal level and signal quality. The implementation of user interface is responsibility of the producer;

g) *Input connector*: A receiver is required to be at least one tuner input connector in accordance with ETSI-TS-102-201 (2005) [9]. The input impedance is required to be 75 Ohm;

h) *Tuning/Scanning procedures*: A receiver is required to – in case of same Transport stream Id and Service Id on two or more different frequencies – save all frequencies, or selects the frequency with better signal. Also, a receiver is required to be able to receive and react on tuning parameters in PSI/ SI tables;

i) *Interfaces for Conditional Access*: CIslot is required to comply with EN-50221 (1997); [10].

j) *MPEG Demultiplexer*: A Demultiplexer is required to be compliant to the MPEG-2 transport layer defined in ISO/IEC-13818-1 (2007) [11] and ETSI-TS-101-154 (2009); [12]

k) *MPEG Video Decoder*: The decoder of a receiver is required to fully comply with ISOIEC-14496-10 (2012) [13] for decoding MPEG-4 AVC, a decoder is required to also comply with ETSITS-101-154 (2009) [14] and decoding of MPEG-2 coded signal according to ISO/IEC-13818-2 (2000); [15]

l) *Service information*: A receiver is required to have system software for interpretation and handling of the active service information and control of the local hardware/ software according to ETSI-EN-300-468 (2010) [16] and ETSI-TR-101-211 (2009); [17]

m) *Teletext*: insertion of the Teletext data conform to ISO IEC 62216-1 (2010) [18] and to requirements defined in ETSI-EN-300-706 (2003); [19]

n) *Subtitling*: decoding and displaying DVB subtitle services, which are transmitted in conformance with ETSIEN-300-743 (2006), [20] and

o) *Software update through the incoming DVB-T or DVB-T2 signal (DVB-SSU) is specified in ETSI-TS-102-006 (2008).* [21]

II.4. Advantages of Digital terrestrial television:

Digital television offers multiple advantages [22]:

- Rights acquisition,content aggregation
- Service scheduling
- High definition (HD) channels.
- Broadcast transmission
- Better image and sound quality: DVD image, stereo digital sound or home cinema.

II.5. Definition of UHF

Ultra high frequency (UHF) refers to the band of electromagnetic radiation with a radio frequency range between 300 MHz and 3 GHz (3000 MHz). This band is also known as the decimeter band, with a wavelength ranging from 1 m to 1 dm. The UHF radiations are least affected by environmental factors, that is why they are most commonly used for TV and radio transmission and channel broadcasting. They have strong directivity, but, at the same time, the receiving error increases [23].

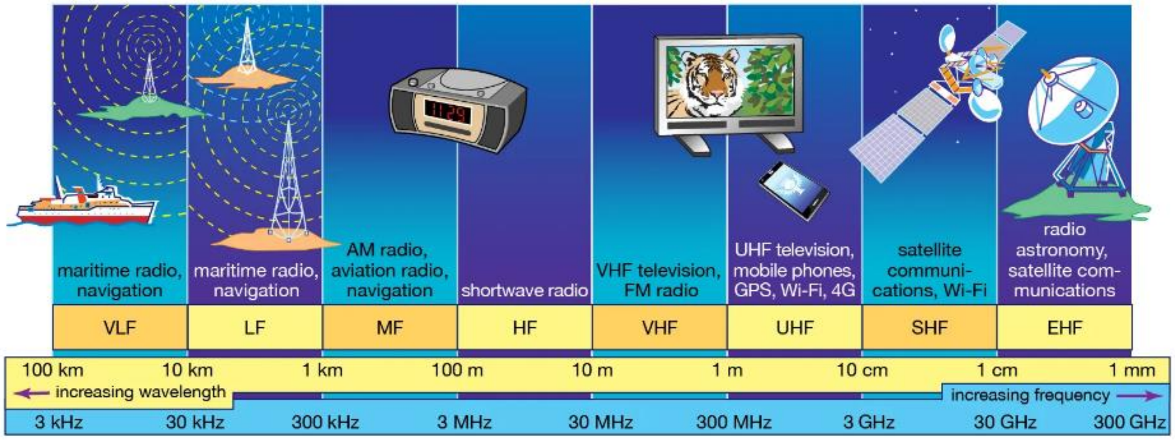

Figure II.5: Radiofrequency Spectrum

II.6. Uses and fields of UHF band :

UHF technology has revolutionized the way we interact with our world, ultra high frequency has found its place in many sectors and we use it every day [24]. Some key applications of UHF:

- **Television broadcast:** UHF waves are commonly used for terrestrial television broadcasting. They offer better signal quality and allow a greater number of channels than VHF waves.
- **Wireless communication:** UHF plays a crucial role in wireless communications systems, allowing devices such as cell phones, radios and walkie-talkies to transmit and receive signals over long distances.
- **RFID Technology:** Radio frequency identification (RFID) technology relies on UHF waves to track and identify objects. It is commonly used in inventory management, supply chain logistics, access control systems, inventories and retail.
- **Remote sensing:** UHF waves are used in remote sensing techniques, such as radar systems and satellite communication, to collect and analyze data about our planet's weather, land use, and more.

II.7. Conclusion

The digital terrestrial television broadcasting (DTTB) technologies are as fragmented as the analogue versions being phased out with the regions of influence remaining similar and linked to economic, political and historical ties and geographical proximity. DVB-T has been the mostly widely adopted technology. Implementation of DTTB has been much slower than anticipated in developing countries/economies because of the high costs involved and the logistics involved prior to launching DTTB and a number of challenges provided in this paper. It is significant to note that the functionalities and capabilities of the different DTTB technologies have increasing converged although compatibility still remains an issue to be addressed.

The world of ultra-high frequency (UHF) offers a multitude of possibilities in various fields. From entertainment to communication to data analysis, UHF waves have the power to transform the way we live and interact with technology.

UHF has proven to be a critical component, and its applications will continue to expand as technology advances. Ultra high frequency has many advantages; time saving, productivity, economic gain, traceability... Significant advantages for our society where speed occupies a central place.

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Chapter III

Results and discussion

III.1 Introduction:

It is essential to simulate the antennas accurately before they are built. We used suitable software such as Microwave Studio from CST (Computer et al.). CST is a key step in antenna design, helping us study complex structures in three dimensions with the desired parameters and take account of their electrical and dielectric parameters. This is why we use CST to simulate and calculate the Sij parameters—resonance frequencies, radiation patterns, and electromagnetic fields.

This chapter aims to design a patch antenna that will operate at 486-494 MHz at least with acceptable gain. To do this, we will calculate the antenna before proceeding to the simulation to find its characteristic parameters, such as the reflection coefficient S11, the bandwidth, the gain, the directivity, the polarization, and the radiation pattern.

III.2 Design methodology:

Step 1:

Calculation of the dimensions of the antenna with the choice of substrate to have the resonant frequency. The dimensions obtained are used by the CST simulator to obtain accurate results.

Step 2:

Increased bandwidth by using a coplanar line power supply (CPW) to solve the narrow bandwidth problem in step 1.

Step 3 : Reduction in antenna size while maintaining bandwidth in the UHF range, using slot technology.

III.3 Calculation of conventional antenna dimensions:

In the following calculations we will use the substrate with εr=4.3 and thickness h=1.6 mm. The following formulas is used to calculate the width and the Length of a patch operating at the resonant frequency F_0=490 MHz:

$$W = \frac{C}{2F_0\sqrt{\frac{\varepsilon_r+1}{2}}} \quad \text{(III.1)}$$

$$L = \frac{c}{2F_0\sqrt{\varepsilon_{eff}}} - 0.824h\,\frac{(\varepsilon_{eff}+0{,}3)\left(\frac{w}{h}+0{,}264\right)}{\left(\varepsilon_{eff}+0{,}25811\frac{w}{h}+0{,}8\right)} \quad \text{(III.2)}$$

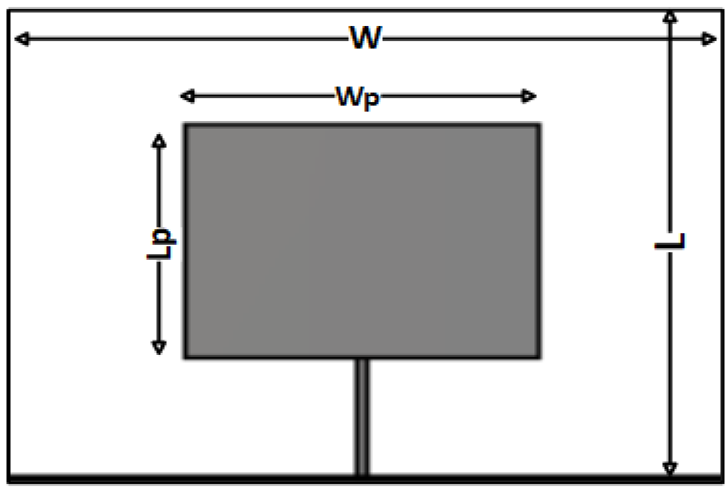
After calculation:

W = 188.04 mm.

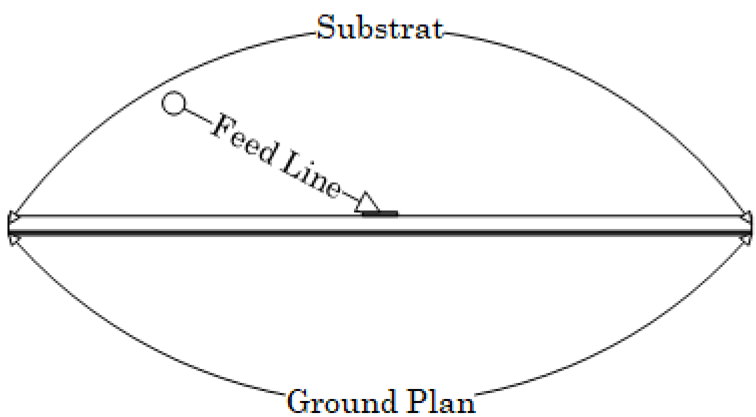
L = 147.49 mm.

III.3.1 Conventional antenna design:

The initial antenna in our study is a rectangular antenna fed by a microstrip line. The geometry of this antenna is given in Figure III.1. The antenna consists of a rectangular patch printed on the top face of an FR4-type substrate of relative permittivity εr = 4.3 and thickness h=4.8 mm. The ground plan is printed on the surface below the substrate, and the line's characteristic impedance is calculated to be 75 Ohm.



(a) Front view.



(b) Side view.

Figure III.1 : schematic Rectangular microstrip antenna.

The geometric parameters of the conventional antenna are listed in the table below:

Table III.1: geometric parameters of the conventional antenna

Parameters	W	L	W_p	L_p	h	t	W_f
Value (mm)	310	240	190	139	4.8	0.035	4.18

III.3.2 Simulation results:

III.3.2.1 Reflection coefficient:

Figure III.2 shows the variation of the reflection coefficient in function of frequency. It can be seen that the pass band is narrow and the S1.1 equal to - 38.4 dB with a resonance peak obtained at 490 Mhz.

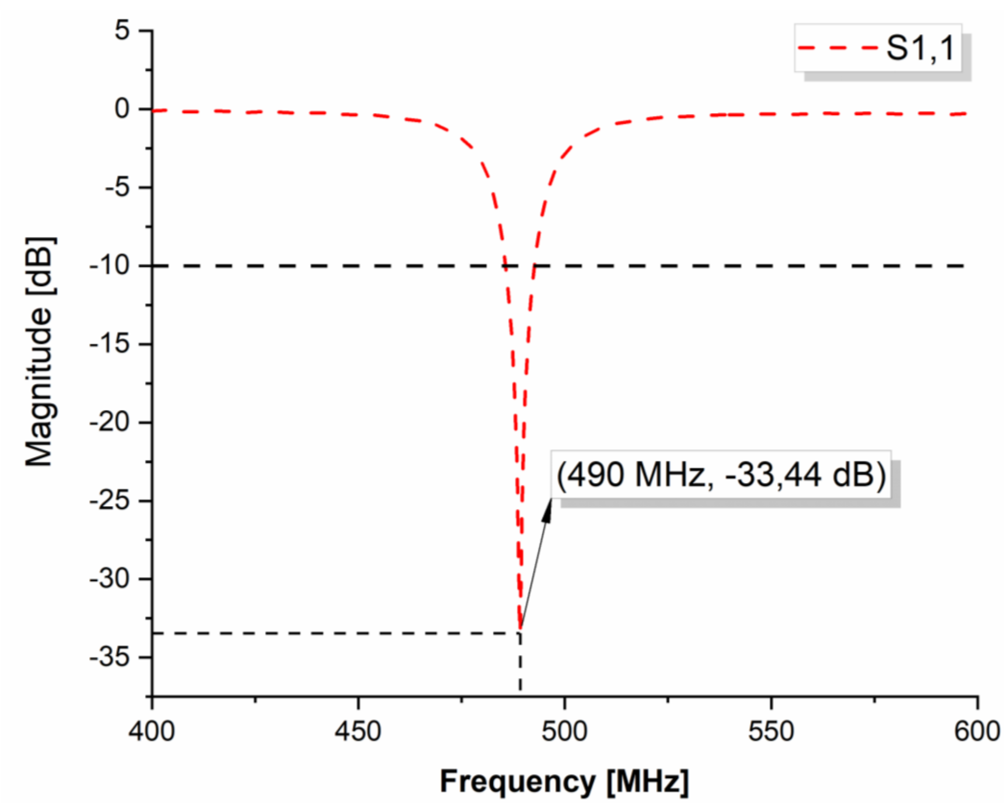


Figure III.2: Reflection coefficient in [dB].

III.3.2.2 Voltage Standing Wave Ratio (VSWR) :

Figure III.3 shows the respective standing wave rate curves:

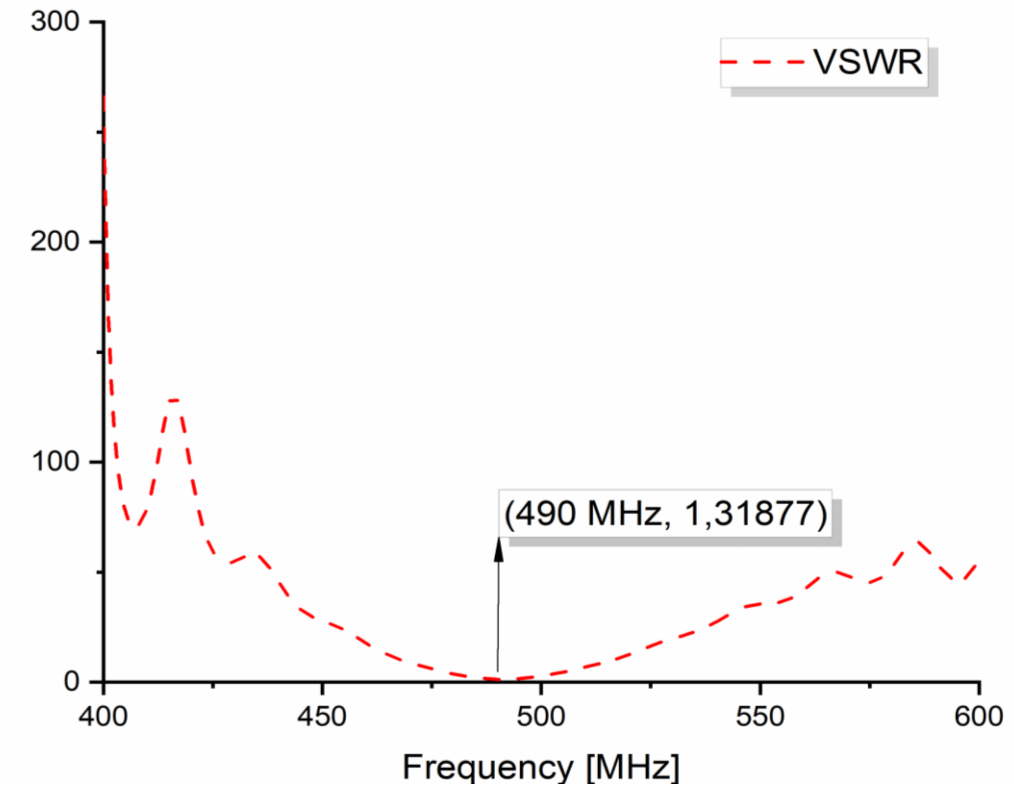


Figure III.3: Voltage Standing Wave Ratio (VSWR).

Like the parameter S11, the standing wave rate also gives us an assessment of the adaptation. For the 490 MHz frequency, we found a VSWR<2 in the passband. This confirms that our antenna is very closely matched to the resonant frequency.

III.3.2.3 Radiation diagram: The 3D radiation diagrams are shown in Figure III.4. The simulated maximum values of gain and directivity are 2.44 dB and 6.6 dBi respectively.

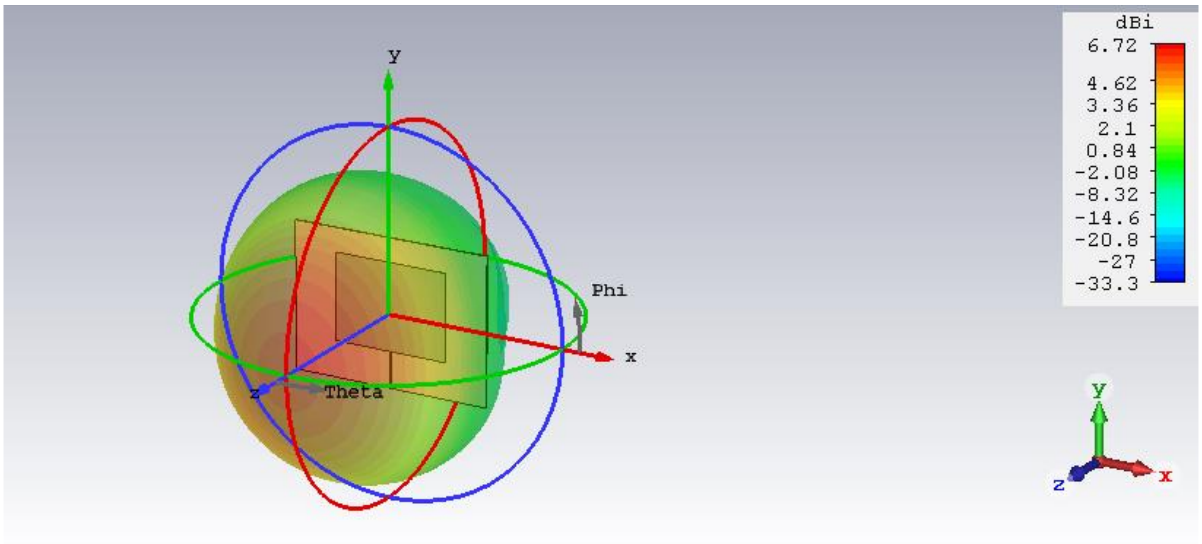
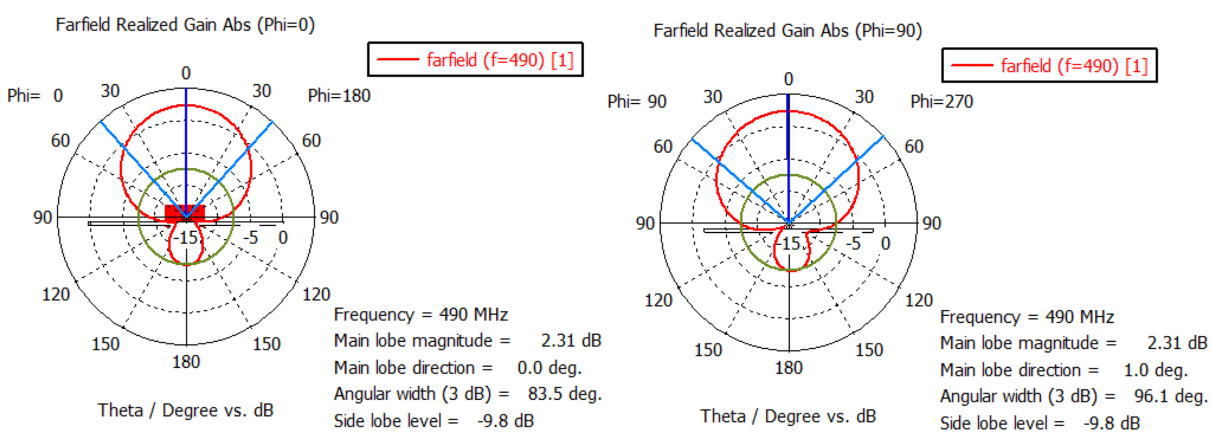


Figure III.4: The 3D radiation diagrams.

Figure III.5 shows the polar radiation pattern curve, where phi=0 the radiation pattern is almost 0.0 deg , and for phi =90 the radiation pattern is 1 deg .



(a) (b)

Figure III.5: polar radiation diagrammes, (a) Phi = 0 deg, (b) Phi = 90 deg.

III.3.2.4 Gain and directivity:

The next figures represent the antenna gain and directivity:

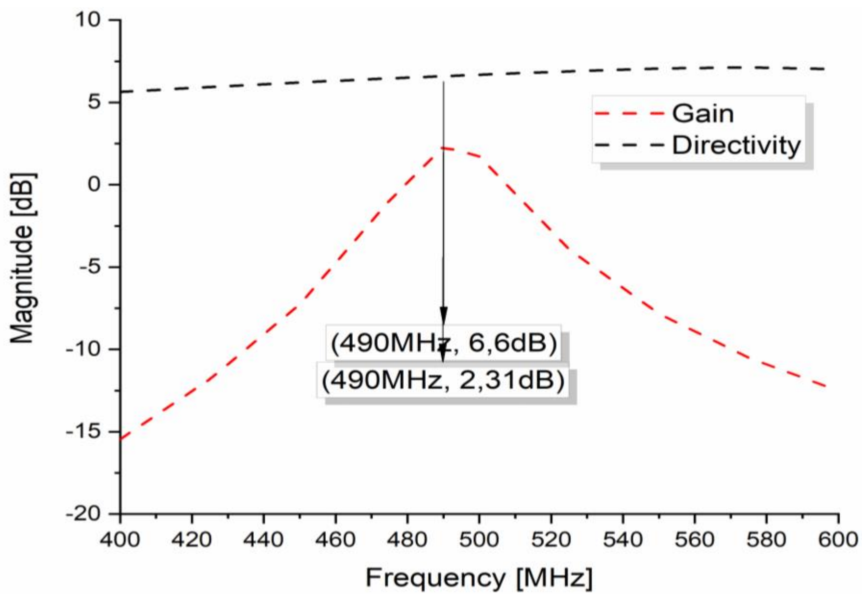


Figure III.6: Gain and directivity Vs Frequency.

The results of the conventional antenna are summarized in the table below:

Table III.2 : Summarized antenna results.

Specifications	Conventional antenna
Dimension (mm)	310 x 240
S1.1 (dB)	- 33.44
Bandwidth (MHz)	7.9
VSWR	1.31

Gain (dB)	2.31
Directivity (dB)	6.6
Efficiency (%)	37.23

III.3.3 Coplanar rectangular antenna (CPW):

Coplanar Wave Guide, is a line in which all conductors are located in the same plane, consisting of a central conductor of width W_f located between two ground planes via slots of dimension g, all printed on a substrate of permittivity $\varepsilon r=4.3$ and thickness h=4.8mm Table III.3 shows the new characteristic.

Table III.3: geometric parameters of CPW antenna

W	L	Wp	Lp	h	t	W_f	G
310	**190**	**165**	**135**	**4.8**	**0.035**	**4.18**	**2**

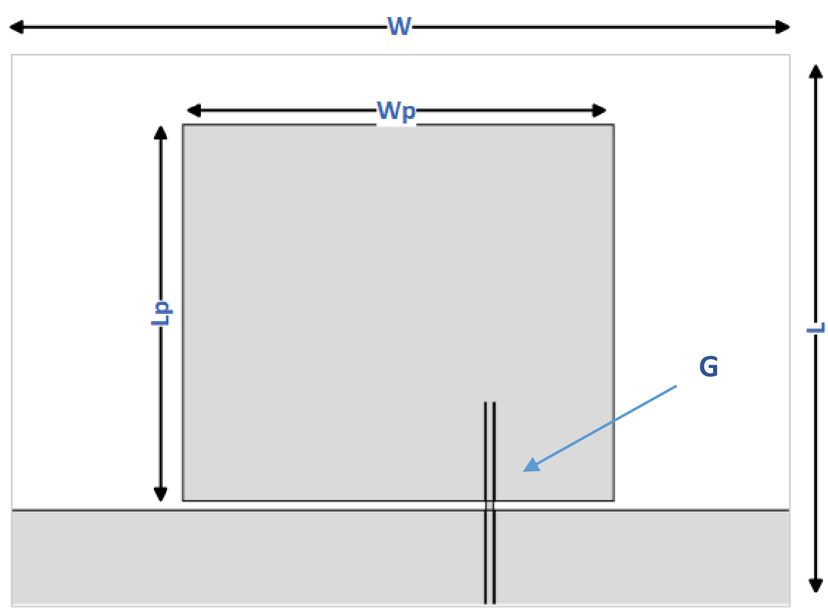


Figure III.7: Coplanar rectangular antenna front view

III.3.3.1 Reflexion coefficient

The simulation results of the reflection coefficient are shown in Figures III.8. The resonant frequency obtained are 490 MHz with a reflection coefficient value of S1.1= -19.71 Db.

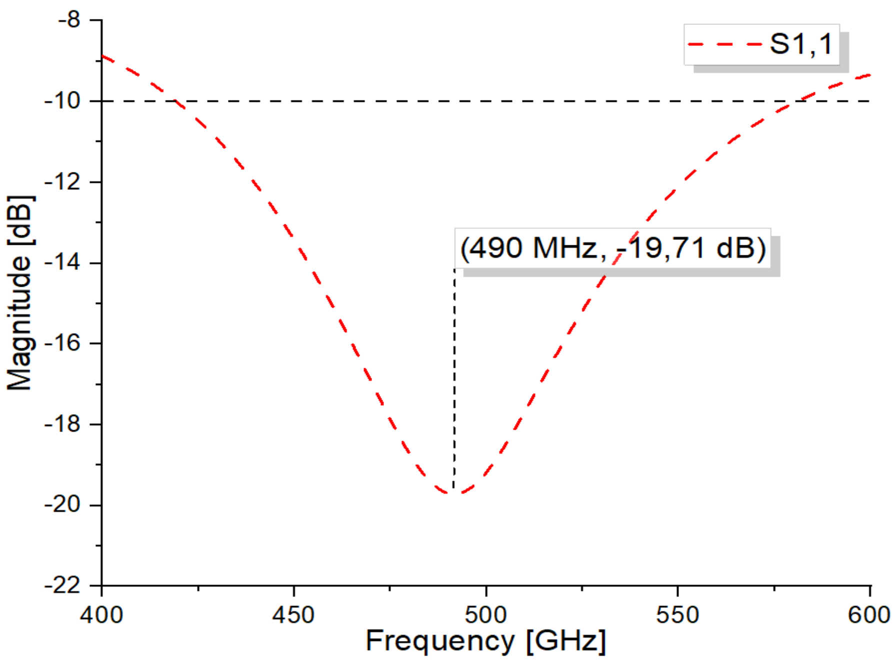


Figure III.8: $S_{1.1}$ of the simulated antenna

III.3.3.2 Voltage Standing Wave Ratio (VSWR):

Figure III.9 shows the respective standing wave rate curves as the VSWR value varies between 1 VSWR<2.

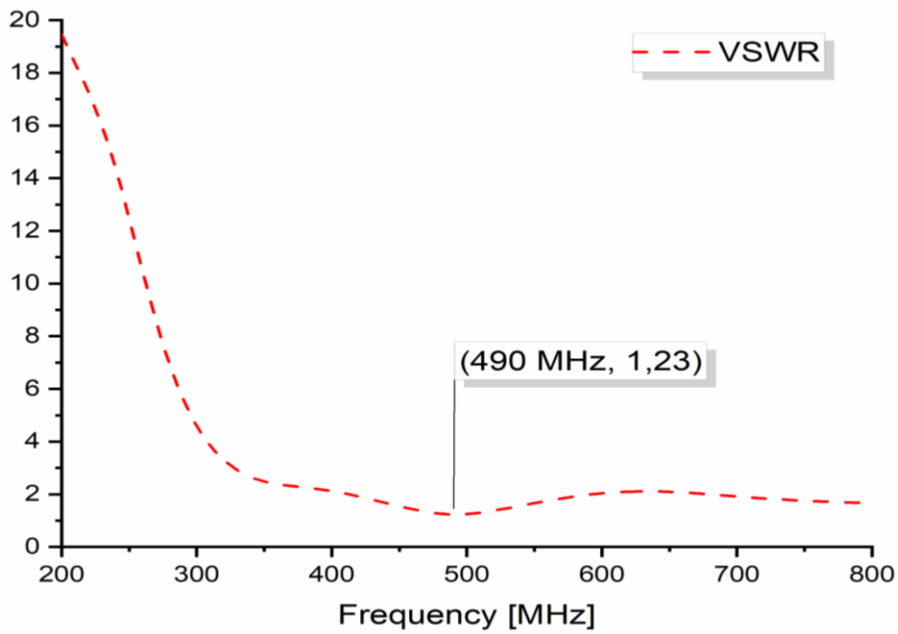


Figure III.9: VSWR of the CPW antenna

III.3.3.3 Radiation Diagram

The 3D radiation patterns are shown in Figure III.10. The simulated gain and directivity are 0.36 dB and 2.11 dB respectively.

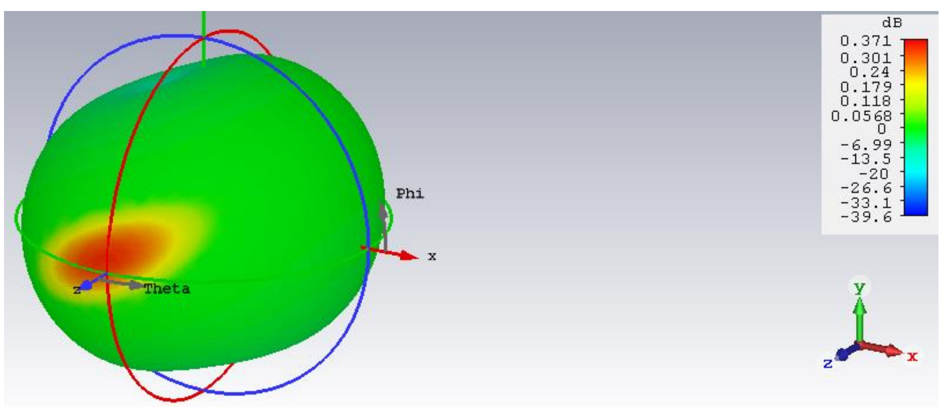
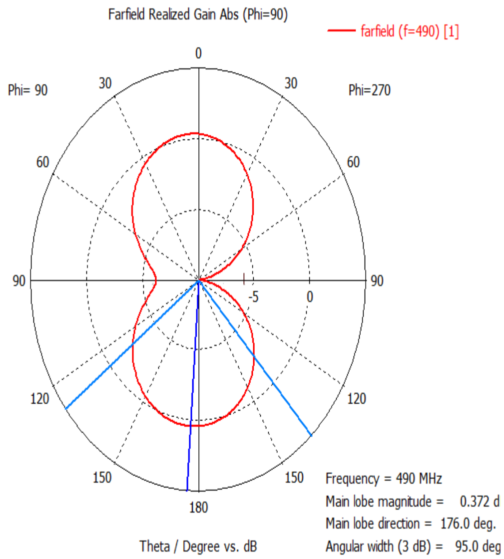


Figure III.10: 3D radiation diagram of coplanar antenna

Figure a and b show the radiation pattern curve of the coplanar antenna (CPW), where phi=0 the main lobe radiation pattern direction almost 175.0 deg , and for phi =90 the radiation pattern direction 176 deg .



(a) (b)

Figure III.11: polar radiation diagram; (a) Phi =90˚, (b) Phi=0˚

III.3.3.4 Gain and Directivity

The next figures represent the antenna gain and directivity:

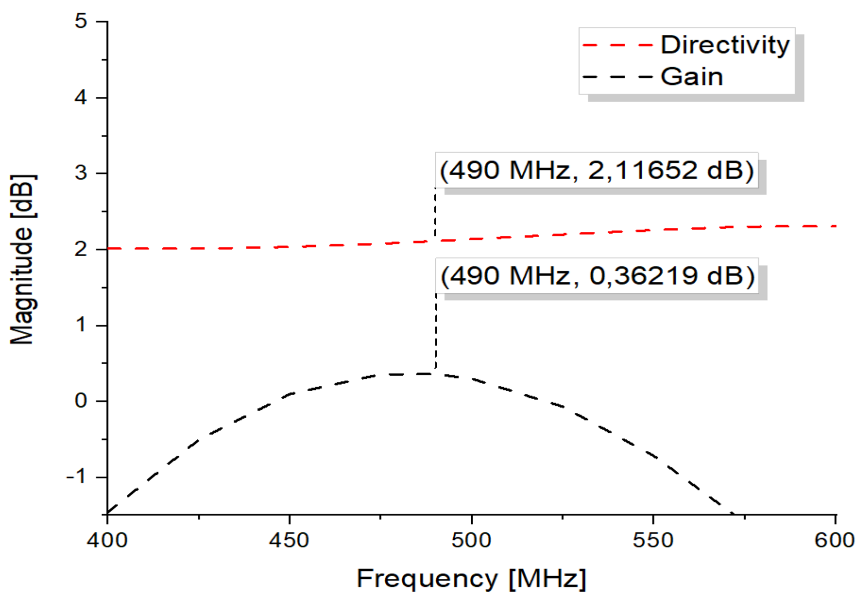


Figure III.12: Directivity VS gain of CPW antenna

The results of the conventional antenna are summarized in the table below:

Table III.4 : Summarized antenna results.

Specifications	CPW Antenna
Dimension (mm)	310 x 190
S1.1 (dB)	-19.71
Bandwidth (MHz)	160.8
VSWR	1.23
Gain (dB)	0.36
Directivity (dB)	2.11
Efficiency (%)	66%

III.3.4 Coplanar rectangular antenna (CPW) miniaturized

The miniaturization of antenna patches means they can be better integrated into communication objects. And for that we used one of the methods of miniaturization which the insertion of slots.

Table III.5: geometric parameters of miniaturized antenna

Parameters	W	L	W_p	L_p	h	t	d
Value (mm)	280	180	195	130	4.8	0.035	21.8

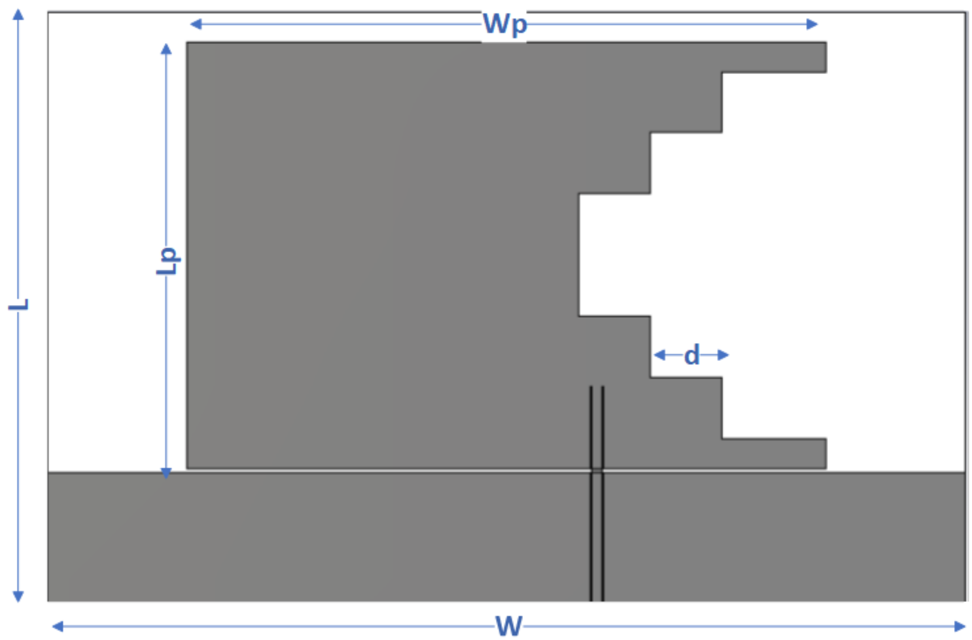


Figure III.13 : Miniaturized Coplanar rectangular antenna (CPW)

III.3.4.1 Reflexion coefficient

The simulation results of the reflection coefficient variation curve are shown in Figure III.14. We have optimized the miniaturized antenna to reduce its dimensions. The resonant frequencies obtained are 490 MHz with a great reflection coefficient value = -40.39 dB.

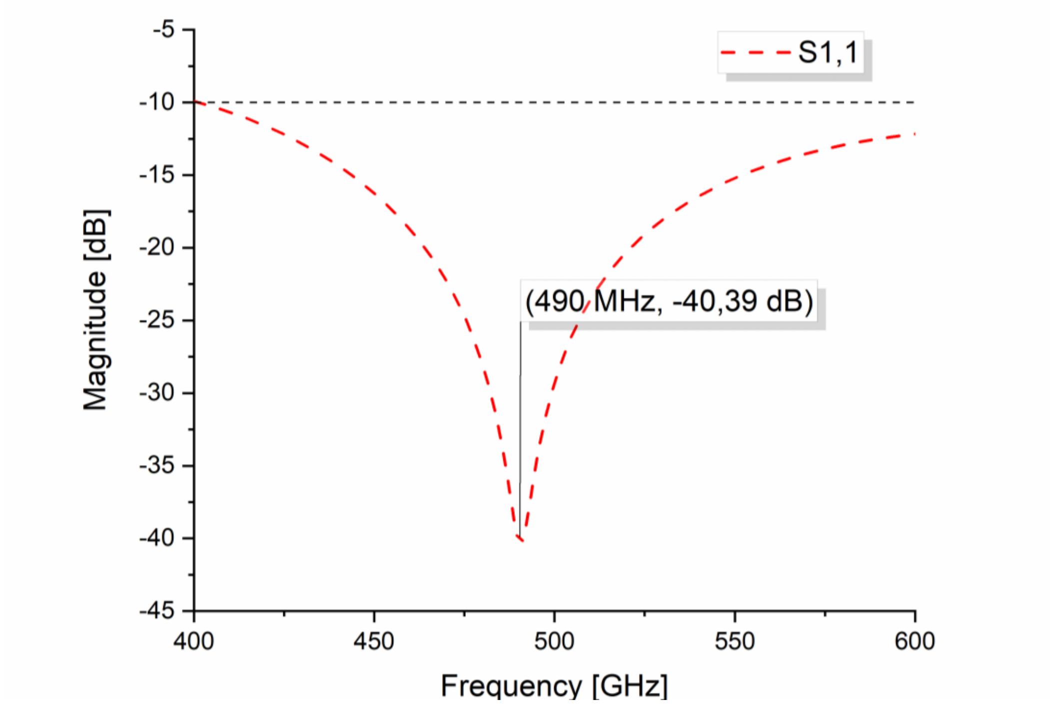


Figure III.14: Reflexion coefficient.

III.3.4.2 Voltage Standing Wave Ratio (VSWR):

Figure III.15 shows the respective standing wave rate curves as the VSWR value is 1.15.

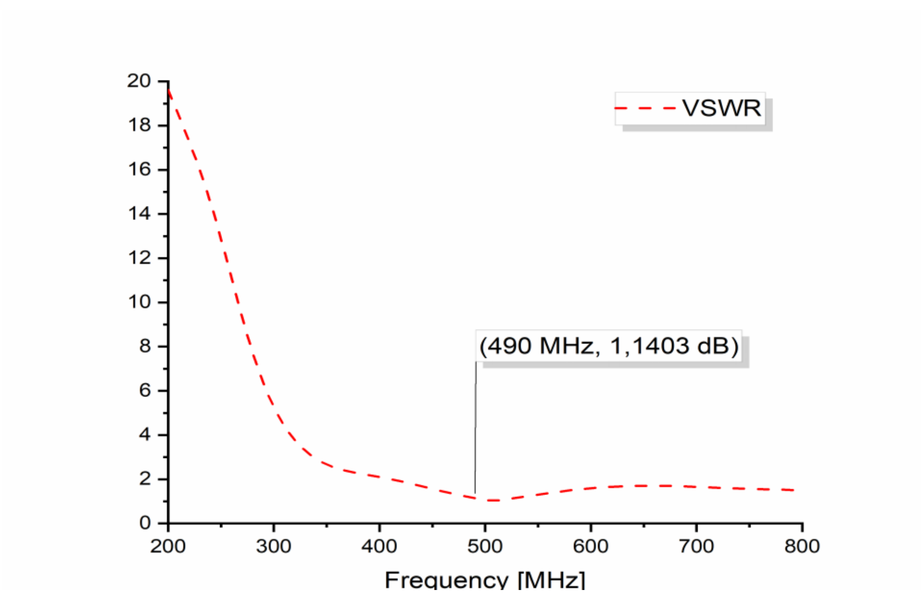


Figure III.15 : Voltage Standing Wave Ratio vs frequency

III.3.4.3 Radiation Diagram:

The 3D radiation patterns are shown in Figure III.16. The simulated value of the 3D gain and directivity are 1.74 dB and 2.25 dB respectively.

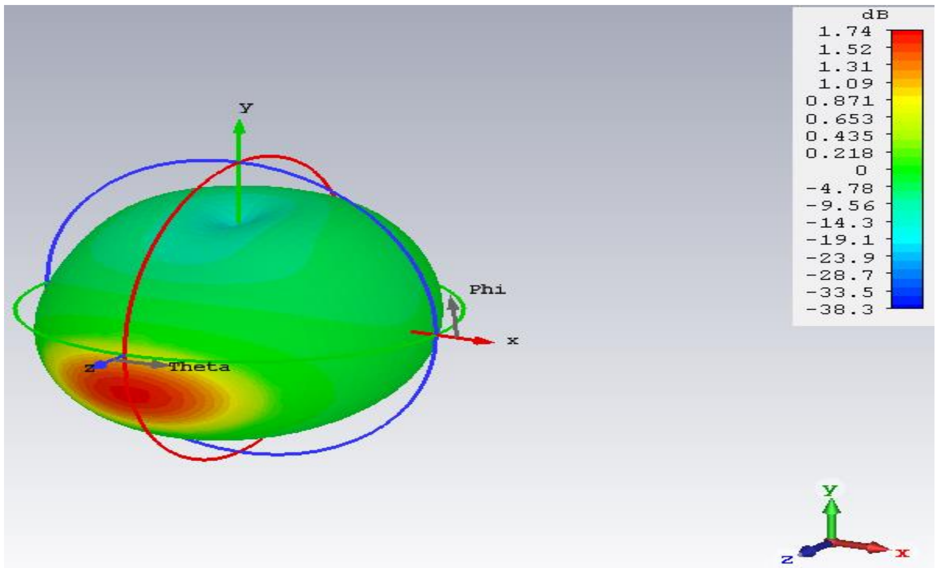


Figure III.16 : 3D Radiation Diagram.

Figure III.17 show the radiation pattern curve of the miniature antenna, where for phi=0 deg the main lobe radiation pattern direction is almost 0 deg, and for phi=90 deg the radiation pattern direction is 16 deg.

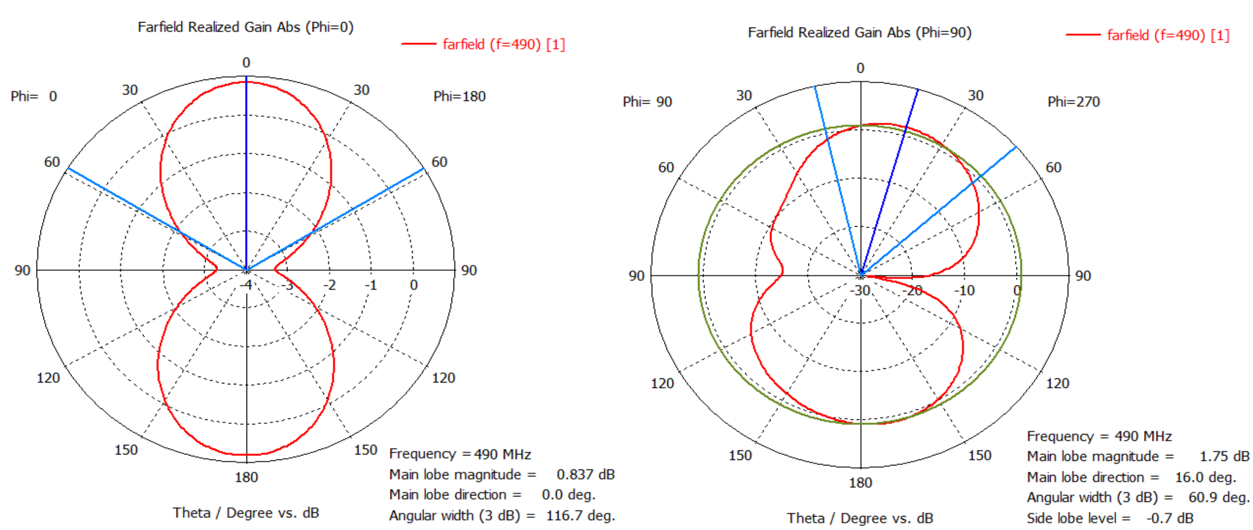


Figure III.17 : polar radiation diagram

III.3.4.4 Gain and directivity of CPW miniaturized antenna:

The following figure represents the gain and the directivity of the antenna.

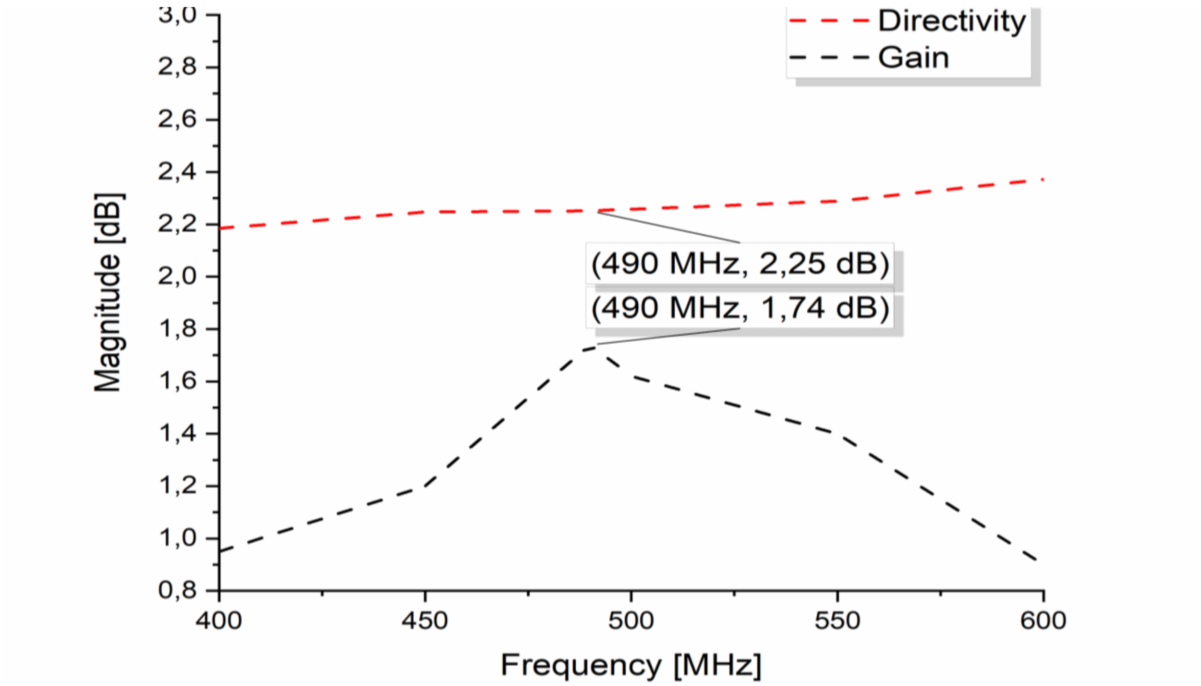


Figure III.18 : Gain VS directivity

The table below summarizes the results of the conventional antenna

Table III.6 : Summarized antenna results.

Specifications	CPW miniaturized Antenna
Dimension (mm)	280x180
S1.1 (dB)	-40.39
Bandwidth (MHz)	>200
VSWR	1.14
Gain (dB)	1.74
Directivity (dB)	2.25
Efficiency (%)	88.92%

III.4 conclusion

In this last chapter, we designed and studied antenna structures adapted to UHF communication systems. The first step was to work on a conventional antenna, which resulted in a narrow band with wide dimensions, so we moved on to two coplanar antennas to increase the bandwidth. The results can satisfy the bandwidth requirements, but the gain and directivity are low compared with the conventional antenna. Finally, a miniature antenna was added to the element, simulating the results obtained and reducing the antenna size. This antenna has a wide bandwidth with relatively high gain and efficiency. It can operate in the digital television band. Its dimensions allow it to be integrated into television applications.

General conclusion

This Worke discusses technological development, microstrip antennas, digital terrestrial television broadcasting (DTTB) technologies, and ultra-high frequency (UHF) communication systems. Microstrip antennas are crucial for various applications, such as entertainment, communication, and data analysis. DTTB implementation has been slower in developing countries due to high costs and logistics. UHF has numerous advantages, including time savings, productivity, economic gain, and traceability. An antenna structure was designed for UHF communication systems, ranging from conventional antennas to coplanar antennas. A miniature antenna was added to simulate results, resulting in a wide bandwidth with high gain and efficiency, suitable for digital television applications.