THE EFFECTS OF DIELECTRIC MATERIALS IN MICROWAVE SIGNAL TRANSMISSION TOWARDS ANTENNA RECEPTION

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Yours sincerely

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ABSTRACT

Research was done to learn the effects of dielectric materials in microwave signal transmission. The dielectric materials involved are Styrofoam, glass, wood, plastic and wet cloth foam, each material sized 10x10cm and width 5cm. Each material is put between transmitting antenna and receiving antenna in order to get the radiation pattern. The antennas used are Yagi-Uda antenna and dipole antenna, where Yagi-Uda antenna is functioning as transmitter while dipole antenna is the receiver. Frequency used in this research is 1 GHz. Wavelength for dipole antenna is set for ½ λ. Parameters investigated are radiation pattern, wave pattern and absorption loss. These parameters were used to make comparisons between antenna reception for different dielectrics materials and absorption loss toward antenna reception. Among the dielectric materials used in this research, absorption loss of wet foam (27.86% for E-plane and 8.125% for H-plane) mostly affected the radiation pattern followed by Styrofoam (19.29% for E-plane and 1.875% for H-plane), plastic (14.64% for E-plane and 1.875% for H-plane), glass (13.21% for E-plane and 11.25 for H-plane) and wood (11.79% for E-plane and 11.25% for H-plane).

ABSTRAK

Kajian dilakukan untuk mengkaji kesan oleh bahan-bahan dwielektrik dalam penghantaran isyarat gelombang mikro kepada antenna. Bahan-bahan dwielektrik tersebut ialah Styrofoam, kaca, plastik, kayu jenis plywood dan span kain yang dibasahkan, masing-masing bersaiz 10x10cm dan tebal 5mm. Setiap bahan dwielektrik diletakkan diantara antenna penghantar dengan antenna penerima untuk mendapatkan bentuk radiasi. Antenna penghantar yang digunakan ialah antenna Yagi-Uda manakala antenna dwikutub sebagai antenna penerima. Frekuensi yang digunakan ialah 1GHz. Panjang gelombang bagi antenna dwikutub ialah ½ λ. Parameter yang dikaji ialah bentuk radiasi, bentuk gelombang dan kehilangan penyerapan terhadap penerimaan antenna. Didapati span basah (27.86% bagi satah-E dan 8.125% untuk satah-H) paling mempengaruhi bentuk radiasi dengan kehilangan penyerapan, diikuti dengan Styrofoam (19.29% bagi satah-E dan 1.875% bagi satah-H), plastic (14.64% untuk satah-E dan 1.875% bagi satah-H), kaca (13.21% bagi satah-E dan 11.25% bagi satah-H) dan kayu (11.79% bagi satah-E dan 11.25% bagi satah-H).

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CHAPTER 1

INTRODUCTION

1.1 Preface

The period, T =1/f, of a microwave signal then ranges from 3 ns ($3x10^{-9}$) to 3 ps ($3x10^{-12}$ sec), respectively and the corresponding electrical wavelength ranges from λ=c/f.= 1 m to λ=1mm, respectively where c=$3x10^8$ m/sec, the speed of light in vacuum. Signal with wavelengths on the order of millimeters are called *millimeter waves*. It is really of the above quantities that make microwave engineering different from other areas of electrical engineering.

Microwave components usually are *distributed* elements, where the phase of the voltage or current changes significantly over the physical length of the device because the device dimensions are on the order of the microwave wavelength. At much lower frequencies, the wavelength is so large that there is little variation in phase across the dimensions of a component.

Electromagnetic waves offer the possibility of transmitting information over long distances. Among the first to realize this and put into practice was Guglielmo Marconi (1874-1937) who, in 1980s, invented and developed the wireless telegraph. With it, messages can be sent hundreds of kilometer at the speed of light without the use of wires. The first signal were merely long and short pulses that could be translated into words by a code, such as 'dots' and 'dashes' of the Morse code. The next decade saw the development of vacuum tubes. Out of this early work radio and television were born.

Today, more and more radio and television are being transmitted on microwave bands via satellites. The upper frequency limits of microwave are somewhere in the proximity of 10^{11} Hz up to 10^{12} Hz and therefore still about 3 decades below the range of those frequencies for visible lights (10^{15} Hz).

Nevertheless many of the characteristic of microwave radiation can be compared to those of visible light. Many of the laws applicable in optics also hold true for microwaves. The source of the microwaves used in this training system is a Gunn oscillator, which operates at a fixed frequency of 9.40 GHz and supplies a power level of approximately 20 mW.

1.2 Characteristics of microwaves

Just as the high frequencies and small wavelengths of microwave energy make for difficult analysis and design of microwave components, these same factors provide unique applications for microwave systems. This is because of the following considerations:

- Antenna gain is proportional to the electrical size of antenna. At higher frequencies, more antenna gain is possible for a given physical antenna size.
- More bandwidth (and hence information-carrying capacity) can be realized at higher frequencies. A 1% bandwidth at 600 MHz is 6 MHz (the bandwidth of one television channel) while at 60 GHz a 1% bandwidth is 600 MHz (about 100 television channel).
- Microwave signal travel by line-of-sight, and are not bent by the ionosphere as are lower frequency signals. Communications link (both terrestrial and with orbiting satellites) with high capacities are thus possible. (Millimeter wave frequencies can however be highly attenuated by atmosphere or rain).
- The effective reflection area (radar cross-section) of a radar target is usually proportional to the target's electrical size. This fact, coupled with the characteristics of antenna gain, often make microwave frequencies the preferred band for radar applications.

Today, the majority of applications of microwaves are related to radar and communication systems. Microwave communications system handle a large fraction of international and other long-haul telephone traffic, in addition to television programs and military communications (Pozar, 1993).

1.3 Objectives

- To made a research how microwave signal was transmitted via dipole antenna and received by Yagi-Uda antenna.
- To analyze the radiation pattern when λ /2 is used in dipole antenna.
- To analyze the differences in antenna reception when various dielectric materials are used in experiment.
- To prove the absorption loss will effect the antenna reception.

CHAPTER 2

LITERATURE REVIEW

2.1 Microwave

2.1.1 History of microwave engineering

The foundation of modern electromagnetic theory was laid down in Maxwell's treatise in the late nineteenth century. In this theory Maxwell hypothesized, electromagnetic wave propagation and the notion that light was a form of electromagnetic energy. In the period 1887-1891, Hertz carried out a series of experiment that completely validated Maxwell's theory of electromagnetic waves. In addition to Hertz's work, Oliver Heaviside contributed significantly with a series of papers between 1885 and 1887 that made the theory of Maxwell more accessible to practicing scientists, introduced vector notation, and provided a foundation for practical applications in guided waves and transmission lines theory (Pozar, 1993).

2.1.2 Microwave definition

Deferred to Pozar, microwave is state as *"Designating of that part of the electromagnetic spectrum lying between the far infrared and some lower frequency limit; commonly regarded as extending from 300GHz to 300MHz."*.

While Sadiku gave the microwave definition as *"A term applied to radio waves in the frequency range of 1000MHz (1.0 GHz) and upward. Generally defines operations in the region where distributed constant circuits enclosed by conducting boundaries are used instead of conventional lumped-constant circuit elements."*

Harsany states microwave as *"An electromagnetic wave of length between 50 cm (600 MHz) and 1.0 mm (300 GHz)"*

Laverghetta gave the definition as *"A term to signify radio waves in the frequency range from about 1000MHz (1.0 GHz) upwards."*

Microwaves are electromagnetic radiation of frequencies from several hundred MHz to several hundred GHz, by virtue of their high frequency, have extremely short wavelengths, therefore, the word 'micro' in the name. Figure 1.2 shows the available frequency spectrum ;

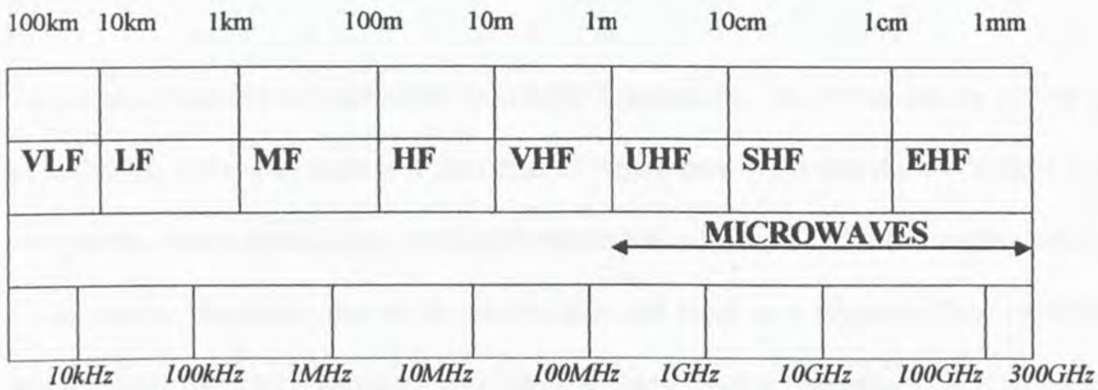

Figure 2.1 Wavelength (in air).

Generally, microwaves are electromagnetic waves in the frequency range of approximately 300 MHz to 300 GHz. These high frequencies correspond to a free space wavelength λ_o from 1m down to 1 mm in the air. The lower microwave range borders on the frequency spectrum containing frequencies used in radio and television broadcasting (Harsany, 1997)

2.2 Microwave Transmission

Terrestrial microwave transmission uses radio frequencies. The dishes can be put on top of buildings, as long as there is a clear line of sight between the two dishes. If there is an obstruction, like a mountain or building between the receiver and the destination, another tower can be placed on top of the obstruction and used as a repeater. This additional tower simply receives a signal on one side and transmits it to the other side. The signals used for microwave transmission can be sent only 20-30 miles. Longer distances require using multiple hops, with additional towers in between. These intermediary towers act as repeaters, receiving the signal and passing it on. There can be no obstructions between the two antennas. Microwave transmission bandwidth can exceed 250 Mbps (Beyda, 1996).

2.3 Microwave communication systems

Microwave communication links are an important practical application of microwave technology, and are used to carry voice, data, or television signals over distances ranging from intercity links to deep-space spacecraft. Microwave communication systems can be grouped into two types; guided-wave systems, where the signal is transmitted over a low-loss cable or waveguide, and radio links, where the signal propagates through space. In both cases the information-carrying signal will have a much lower bandwidth than the microwave carrier frequency (Pennock, 1998).

Using modulation and multiplexing techniques, a microwave link can carry a large number of individual channels. Microwave radio propagation is essentially *line-of-sight*, meaning that microwave signals travel in straight lines, and do not follow the contour of the earth or reflect off the ionosphere, as do lower frequency signals. So for long distances links on the ground, repeater stations are required at frequent intervals, to receive and retransmit the signals (Harsany, 1997).

2.4 Microwave signal transmission application in radio and television.

Microwaves demonstrate quasi-optical behavior. Just like light waves, they are easily focused and applied in radio or microwave links for point to point connections in signal transmission. Here it is necessary to pack the voice or data signal onto the microwaves. The microwaves will serves as the carrier, which is modulated by the message signal from the function generator. In amplitude modulation, the oscillation amplitude of the transmission signal is altered by the voice.

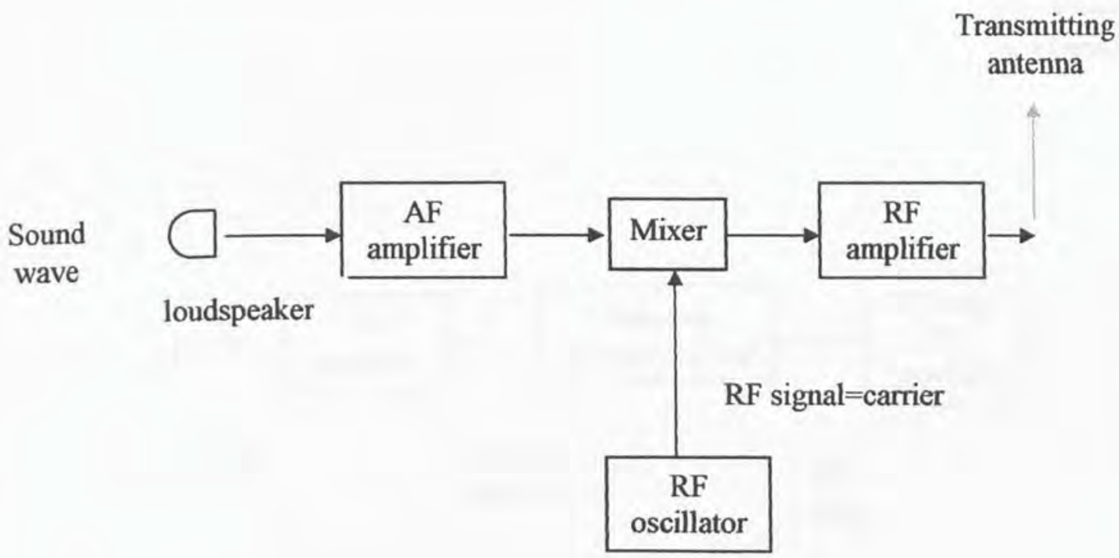

Figure 2.2 Block diagram of signal transmitter.

Transmission of microwaves is a process which signal is transmitted (see Figure 2.2). The information is changed into an electrical signal of the same frequency by a loudspeaker. This electrical signal is called the audiofrequency (AF) signal, since the

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