BIT ERROR RATE FOR PRIVATE MOBILE RADIO (PMR) DUE TO LIGHTNING ELECTROMAGNETIC FIELD RADIATION (LEMR)

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Dedicated to the dearest persons in my heart and the idol of my life

Puan Hajah Rosminah Mahmud

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ABSTRACT

The conceptual implementation to access the extend influence of lightning electromagnetic radiation (LEMR) on mobile radio communication. Binary data has been transmitted through a pair of Motorola Talkabout T5420 walkie-talkie with 14 channels and 38 eliminator codes and operates on 14 UHF Family Radio Service (FRS) Frequencies. Two types of induced interferences which are high voltage and high current experiment has been conducted in High Voltage Laboratory, Institute of High Voltage and High Current, UTM. In order to achieve the implementation mention above, a research has been conducted with the title of the project is "*Bit Error Rate for Private Mobile Radio (PMR) Due to Lightning Electromagnetic Field Radiation (LEMP)*". The objective of the first part of the research is to determine whether the lightning could produce the error of the bit in term of bit error rate in digital communication. If there any errors, the research will continue to ascertain how much it damage or influence the data. In optical communication, in practice, a low bit error rate in the region 10^{-7} to 10^{-10} may be tolerated with pulse code modulation (PCM) transmission. Although, in wireless communication, the receiver will face much higher bit error rate due to the environment and nature phenomena such as rain drops, fogs, thunderstorm and lightning.

ABSTRAK

Konsep yang diimplementasi bagi mendalami kejadian yang dipengaruhi oleh radiasi elektromagnet kilat (LEMR) ke atas perhubungan radio bergerak. Penghantaran data binari melalui sepasang radio (Walkie-talkie) Motorola Talkablout T5420 dengan 14 saluran dan 38 penyahkodan serta 14 UHF FRS. Dua jenis gangguan tambahan iaitu eksperimen menggunakan voltan tinggi and arus tinggi ke atas talian penghataran telah dijalankan di makmal voltan dan arus tinggi, Institut Voltan dan Arus Tinggi, FKE, UTM ke atas talian penghantaran. Bagi merealisasikan implementasi yang tersebut, kajian yang bertajuk "*Bit Error Rate for Private Mobile Radio (PMR) Due to Lightning Electromagnetic Field Radiation (LEMP)*" telah dijalankan. Tujuan utama kajian ini adalah untuk melihat samada kilat akan menpengaruhi atau memberi kesan ke atas komunikasi digital dalam bentuk kadar ralat bit (bit error rate). Jika terdapat ralat, kajian diteruskan bagi memantau sejauhmana kerosakan pada data, secara praktikalnya, kadar ralat bit amat rendah iaitu antara 10^{-7} hingga 10^{-10} yang mungkin boleh diterima dengan penghantaran menggunakan pemodulatan kod denyut (PCM). Walaubagaimanapun, dalam perhubungan tanpa wayar, bahagian penerima isyarat terpaksa berhadapan dengan kadar ralat bit yang lebih tinggi disebabkan persekitaran dan fenomena alam semulajadi seperti hujan, kabus, ribut dan kilat.

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LIST OF SYMBOLS

x (t)	-	Frequency shift keying (FSK) signal
x_0 (t)	-	FSK signal when bit is 0
x_1 (t)	-	FSK signal when bit is 1
t	-	Time domain representation
A	-	Amplitude of cosine signal
f_1	-	Upper frequency
f_0	-	Lower frequency
T_b	-	Time interval
S, s	-	Sequence of binary bit
y (t)	-	Original signal including noise
n (t)	-	Noise signal
r_b	-	Bit rate
n_0	-	Noise at time n (t_0)
N_0	-	Noise power at t_0
$x(n)$	-	Discrete-time signal
n	-	Number of discrete signal
$x_\delta(t)$	-	Set of impulse of the continuous-time signal
Ts	-	Discrete time interval
f_s	-	Sampling frequency
f_{max}	-	Maximum frequency
$X(f)$	-	Aperiodic continuous-frequency
L_s	-	Free space loss
d	-	Distance in km

Q	-	Q function
P_e	-	Probability of error
Erf	-	Error function
E_b	-	Energy in one bit
C	-	Coulomb
kA	-	kiloampere
V	-	Volts
kJ	-	Kilojoules
μs	-	Microsecond
Ms	-	Milisecond
$\overline{E}$	-	Electric field intensity
$\overline{B}$	-	Magnetic field intensity
$\overline{J}$	-	Current density
υ_c	-	Velocity of light
ρ	-	Electric charge density
μ_0	-	Permeability of free space
ε_0	-	Permittivity of free space
$\overline{A}$	-	Vector magnetic potential
ϕ	-	Scalar electric potential
H	-	Lightning channel height
z’	-	Observation point height of EM field
f_c	-	Carrier frequency
m	-	Meter
cm	-	Centimeter
Hz	-	Hertz
kHz	-	kilo Hertz
MHz	-	Mega Hertz
GHz	-	Giga Hertz
Cos	-	Cosine

LIST OF ABBREVIATIONS

A/D	-	Analog to Digital
ASK	-	Amplitude Shift Keying
BER	-	Bit error rate
BW	-	Bandwidth
CPFSK	-	Continuous Phase FSK
DPSK	-	Differential PSK
EM	-	Electromagnetic
EMP	-	Electromagnetic Pulse
FM	-	Frequency Modulation
FRS	-	Family Radio Service
FSK	-	Frequency Shift Keying
FS	-	Fourier Series
FT	-	Fourier Transform
HC	-	High Current
HEF	-	Horizontal Electric Field
HV	-	High Voltage
IF	-	Intermediate Frequency
IVG	-	Impulse Voltage Generator
LEMP	-	Lightning Electromagnetic Pulse
LEMR	-	Lightning Electromagnetic Radiation
LOS	-	Line of Sight
pdf	-	Probability Density Function
PMR	-	Private Mobile Radio

POE	-	Probability of Error
PRBS	-	Pseudo random Binary Sequence
PSK	-	Phase Shift-Keying
PSTN	-	Public Switch Telephone Network
PTT	-	Push to Talk
QPSK	-	Quadrature PSK
QAM	-	Quadrature Amplitude
RTS	-	Recloser Test Set
UHF	-	Ultra High Frequency

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CHAPTER 1

INTRODUCTION

1.1 General

Wireless communication technology has developed and more reliable in order to communicate with other people around the world. In transferring the data from one end to the other end, especially in wireless and mobile data transmission, the expected data at the receiver should be the same as from the transmitter. Otherwise, the data will not be classified as a reliable data.

However, the development of this technology is still unable to preserve their reliability from several natural phenomena such as rain drops, storm and lightning effects. In telecommunication, the sequence of rain on the microwave system at a particular frequency is more critical especially for the countries located in tropical and equatorial region (Din J. et. al, 2003) and so as lightning.

Lightning is a natural prodigy that is of great attention to human being because it annihilating deformities to the equipment and installations. It integrated the formation of high flashing of light and thunder sounds. In the early year, some primitive people

lightning were assigned to myths and superstitious. The first person endeavoured that lightning is an electrical phenomenon was Sir Benjamin Franklin (Golam Sorwar, 1997).

Lightning plays a role as a major natural force of electromagnetic radiation and the ability of transmitting data to the receiver become unreliable. A lot of amendments, improvements, adjustments and alterations are to be made over the affected data in order to make it become reliable and as the same as has been transmitted. A lot of research and experiment has been done to conserve the data during the transmission after it being influenced by this kind of natural prodigy. Therefore, a reliable and dependable data can be accumulated at the receiver.

1.2 Objectives of Research

The objectives of this research are as follows;

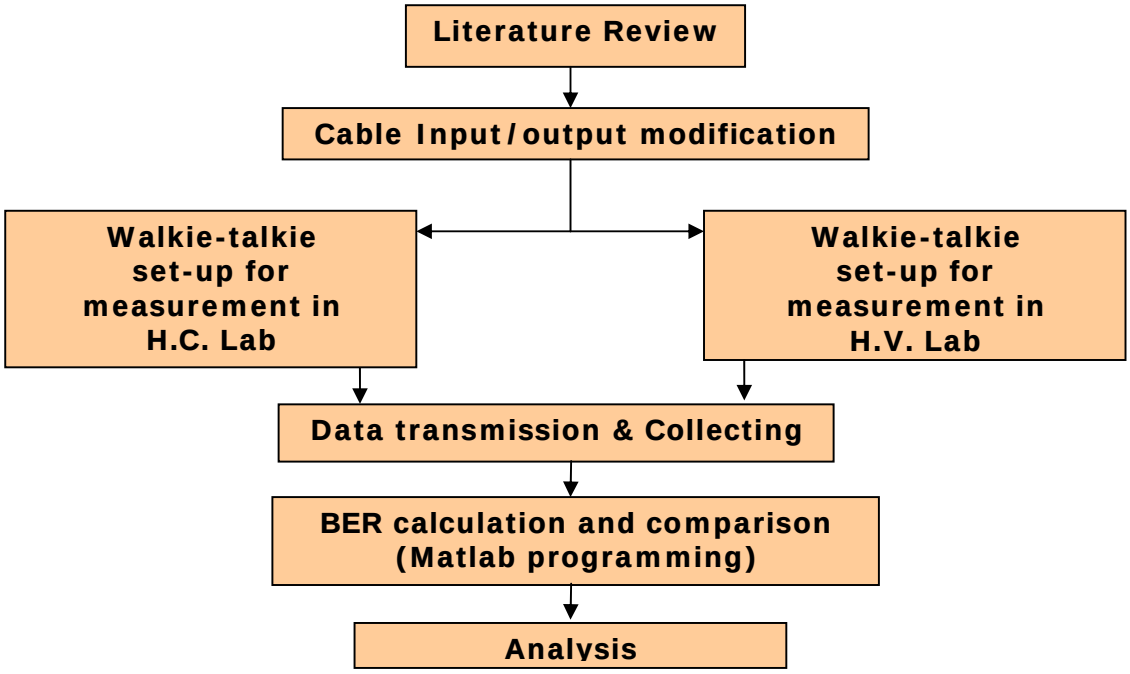
1. To ascertain and prove whether lightning can contribute to BER in digital communication.
2. To determine which of the lightning electromagnetic field components cause maximum data corruption and deterioration.
3. To model the lightning interaction model with the data transmission using electromagnetic theory.

1.3 Research Scopes

In order to ensure an accurate and reliable transmitted data, persistency and consistency of data detector or receiver need to be clearly studied. The measurement of bit error rate (BER) is a step towards the development of a reliable and error-free data receiver. This research is to study the interaction between the electromagnetic field produced by the lightning and the electromagnet field existed when transmitting signal to the other end. Therefore, it is important to know which type of lightning is extremely hazardous to the signal or data during the transmission. For that reason, it is required to develop an electromagnetic modelling regarding the lightning interaction with the data transmission. Besides, bit error rate (BER) during lightning strike activities for private mobile radio will be measured. Two experiments has been conducted which involved the use of a high voltage low current equipment and a high current low voltage equipment. The first experiment, using impulse voltage generator (IVG) and the second experiment using recloser test set. A pair of walkie-talkie at frequency from 925.130MHz to 935.430MHz Motorola T5420 was used in this experiment.

1.4 Research Methodology

1.4.1 Flow chart



1.4.2 Methodology

From the chart above, it can be described in detail as below:

1. Literature study related to this topic. The topic is divided into two diverse topics which are bit error rate and lightning electromagnetic field fundamentals.

2. A sequence of binary data is generated using Matlab software and been transform into frequency shift keying (fsk) signal before it can be transmitted into the air interface.
3. A pair of walkie-talkie will be used in order to transmit and receive data; therefore a pair of cable is going to be utilized in the experiment. The cable is modified from the walkie-talkie handsfree that it possible to be connected into the input and output port of the computer.
4. Experimental Setup - Two types of experiment will be conducted that are using two main different equipments:
    a. High voltage equipment – Impulse Voltage Generator (IVG) in High Voltage Laboratory
    b. High current equipment – Recloser Test Set (RTS) RCL19 in High Current Laboratory
5. Signal is ready to be transmitted. Layout of both experiments can be referred in chapter 5. The position of radios must be in line of sight (LOS) in order to ensure there is no obstacle along the transmission path. Data is collected at the end of the transmission path, receiver.
6. Several data starting with no lightning condition, high voltage values and high current values. Received data or signal than be stored in the base station (computer) and analysis will be done at the end of measurement.
7. All signals in the base station will actuate several simulation processes in order to identify bit error rate. Bit error of the received signal will be calculated using Matlab software. Other analysis will also be executed to determine the effect of lightning strike to the transmitted signal through air interface.

unavailability of insulator to insulate the IVG. The results have found that no error or loss of bit has been identified and not much of delay been exposed. Maximum delay of received signal compared to no lightning data transmission is 2.0ms.

For the second experiment, it can be concluded that 8 has been analyzed started with 200A, 440A, 650A, 720A, 850A, 1100A, 1500A and 2000A. From the results, loss of bit has been identified at the current value of 440A, 850A and 2000A. Total bit loss for those three current values is 25 bits or 0.025% loss out of 1000 bits of binary data. Furthermore, delay of received signal in high current experiment has also been exposed compared to no lightning condition. Minimum delay of received signal (for no lightning condition) is 18.0ms. Maximum delay of received signal compared to original 10seconds data is 29.2ms. Maximum delay of received signal compared to no lightning condition is 11.2ms

As the final conclusion, in telecommunication nowadays, an accurate data transmission is the most expected in developing countries. In this proposal, literature reviews of the effect of lightning electromagnetic field radiation to the mobile data transmission have been presented. The results of the research can be used as the basis for improving the performance of mobile transmission system especially in environment where there are high lightning activities. This is can be executed by proper placing of microwave repeater towers on hilly area which are less prone to lightning strikes.

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