MITIGATION OF AM INTERFERENCE IN DIGITAL TRANSMISSION

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JUDUL: **MITIGATION OF AM INTERFERENCE IN DIGITAL TRANSMISSION**

SESI PENGAJIAN: 2003/2004

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"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Master Degree of Electrical Engineering"

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A project report submitted as partial fulfillment of the requirements for the award of the Master Degree of Electrical Engineering

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MARCH, 2004

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Date : 23 MARCH 2004

For My Mother Asiah Binti Jumali,

My Father Sulaiman Bin Naim,

And My Fiancé Noor Azradiana Binti Zahari with Love,

ACKNOWLEDGEMENT

I would like to express my gratitude to my supervisor, Professor Dr Mohd Zarar Bin Mohd Jenu for his guidance and help rendered throughout this project. His willingness to teach attitude and unfailing patience has been a great motivation for me to excel in my work. Without his guidance and invaluable time spent, this thesis would not have been completed successfully.

To Mrs. Rosila, Mr. Nazri, Mr. Aizan and others whose name could not be mentioned here one by one. Your encouragement and concern is greatly appreciated.

Finally, I would like to thank God for giving me this wonderful privilege to work on my project and entire lesson I've learned along the way. Surely it is an experience which will prove invaluable later in life.

ABSTRACT

The plain-old-telephone-system (POTS) is now increasingly used to carry high-speed data such as for Internet purpose. However, problem can occur if the telephone network is in close proximity to an AM radio transmitter, transmitting high power signal at a frequency which overlaps the bandwidth of the Internet transmission. The interfering electromagnetic field can induced enough current and voltage in the telephone network and causing significant data errors. This report presents a study on the effects of high-powered AM transmission at 576 kHz on a digital transmission system. A GTEM Cell was used to generate the 576kHz electric field intensity varying from 1V/m to 15 V/m with 80% amplitude modulation. The electric field is imposed on a section of the cable and the Bit Error Rate (BER) is noted using Data Tools 5000. Shielding technique was employed using four conducted materials (soft steel, hard steel, aluminum and copper) in order to test the attenuation of the electric field reaching the cable. Measured results showed that copper ($\sigma = 5.87 \times 10^7$ S/m, $\mu_r = 1$) can reduce up to 70% of the BER. The relationship between electric field $|\vec{E}|$ and BER for copper is expressed as

$BER = 2\times10^{-5} e^{0.399|\vec{E}|} + 2.48\times10^{-5}$, indicating that the BER increases exponentially with the magnitude of the applied electric field. It is obvious from the work done in this project that any network situated near a high-powered electromagnetic field transmitter should employ a good shielded cabling system. It is recommended that further study need to be carried out to find ways of mitigating the effects of the interfering field such filtering and grounding.

ABSTRAK

Penggunaan plain-old-telephone-system (POTS) pada masa kini semakin meningkat terutama untuk membawa data kelajuan tinggi seperti Internet. Walau bagaimanapun, masalah akan timbul sekiranya sistem ini terletak berhampiran pemancar radio AM yang memancarkan isyarat dengan kuasa tinggi terutama pada frekuensi yang bertaut dengan lebarjalur penghantaran Internet. Gangguan medan elektromagnet boleh menghasilkan arus dan voltan ke dalam rangkaian telefon dan menyebabkan kesilapan data. Tesis ini menerangkan kesan kuasa tinggi penghantaran AM pada 576 kHz keatas sistem penghantaran digital. GTEM Cell digunakan untuk menghasilkan 576 kHz keamatan medan elektrik diantara 1V/m hingga 15 V/m dengan 80% perubahan amplitud. Medan elektrik dikenakan keatas sebahagian kabel penghantaran dan Kadar Kesilapan Bit (BER) dicatat menggunakan Data Tools 5000. Kaedah pelindung digunakan dengan empat bahan pengalir (besi lembut, besi keras, aluminium dan kuprum) untuk menguji keamatan medan elektrik yang menghampiri kabel. Keputusan ujikaji menunjukkan kuprum ($\sigma = 5.87 \times 10^7$ S/m, $\mu_r = 1$) dapat mengurangkan sehingga 70% BER. Hubungan antara medan elektrik $|\vec{E}|$ dan BER untuk kuprum ialah

$BER = 2\times10^{-5}e^{0.399|\vec{E}|} + 2.48\times10^{-5}$, menunjukkan bahawa BER meningkat secara eksponen dengan peningkatan magnitud medan elektrik. Ujikaji yang dijalankan menunjukkan dengan jelas bahawa setiap sistem yang berdekatan dengan pemancar medan elektromagnet kuasa tinggi mesti menggunakan kaedah pelindung kabel yang baik. Adalah dicadangkan bahawa kajian lebih mendalam harus dibuat untuk mancari cara mangatasi gangguan medan elektrik seperti kaedah penapis dan pembumian.

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GLOSSARY OF ABBREVIATIONS

E	-	Electric Field (V/m)
B	-	Magnetic Flux (T)
f	-	Frequency (f)
H	-	Magnetic Field (H/m)
J	-	Current Density
μ_r	-	Relative Permeability
σ_r	-	Relative Conductivity
S	-	Shielding Effectiveness
Z	-	Impedance (Ω)
AC	-	Alternating Current
ADSL	-	Asymmetric Digital Subscriber Line
AM	-	Amplitude Modulation
ATM	-	Asynchronous Transfer Mode
ATU	-	ADSL Terminal Unit
BER	-	Bit Error Rate
BERT	-	Bit Error Rate Tests
CB	-	Citizens Band
CE	-	Conducted Emission
CM	-	Common Mode
CO	-	Central Office
DC	-	Direct Current
DM	-	Differential Mode
DMT	-	Discrete Multi Tone
EMC	-	Electromagnetic Compatibility
EMI	-	Electromagnetic Interference

EMS	-	Electromagnetic Susceptibility
ESD	-	Electrostatic Discharges
EUT	-	Equipment under Test
FCC	-	Federal Communications Commission
FDD	-	Frequency Division Duplex
FEC	-	Forward Error Correction
FEXT	-	Far End Crosstalk
FFT	-	Fast Fourier Transform
FM	-	Frequency Modulation
GTEM	-	Gigahertz Transverse Electromagnetic
HF	-	High Frequency
JMLSE	-	Joint Maximum Likelihood Sequence Estimation
MMSE	-	Minimum Mean-Square Error
NEXT	-	Near End crosstalk
NID	-	Network Interface Device
POTS	-	Plain Analog Telephone Service
RF	-	Radio Frequency
RFI	-	Radio Frequency Interference
RT	-	Remote Terminal
SNR	-	Signal to Noise Ratio

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The widespread use of electronic circuits for communication, computation, automation and other purposes makes it necessary for diverse circuits to operate in close proximity. All too often, these circuits affect each other adversely. Electromagnetic interference (EMI) has become a major problem for circuit designers, and it is likely to become more severe in the future. The large number of electronic devices in common use is partly responsible for this trend. In addition, the use of integrated circuits and large-scale integration has reduced the size of electronic equipment. As circuitry has become smaller and more sophisticated, more circuits are being crowded into less space, thus increasing the probability of interference.

Today's equipment designers need to do more than just make their systems operate under ideal conditions in the laboratory. Besides that obvious task, they must also make sure the equipment will actually work in the "real world" with other equipment nearby. This means that the equipment should not be affect by external noise sources, and should not it be a source of noise to the environment. Electromagnetic compatibility (EMC) should be a major design objective. Figure 1.1 shows four aspects of EMC issues.

"The ability of device, equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment is called EMC". [1]

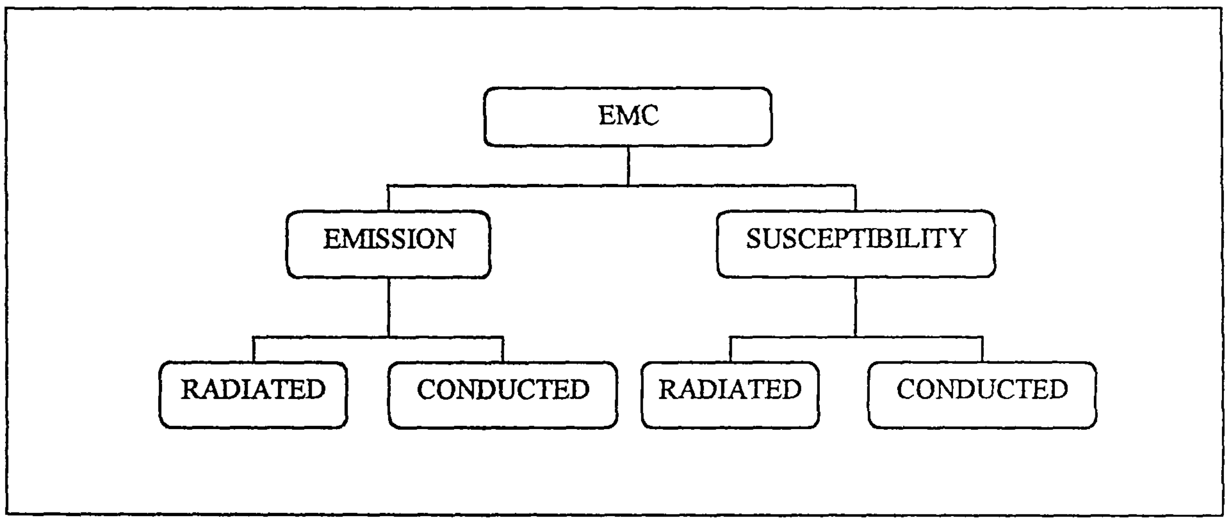

Figure 1.1: Aspects of EMC [1]

Interference can be eliminated or at least reduced by using many techniques such as shielding, grounding, filtering, separation, orientation, and cable design etc [2]. With all these method available, it should be remembered that noise usually could not be eliminated; but it could be minimized to the point where it no longer causes interference. A single unique solution to the noise reduction may not exist. Compromises are generally required, and which of the many alternative solutions is the best can be the subject considerable agreement.

1.2 Problem Statement

New digital technologies operate at high frequencies is an economical alternative to deliver broadband services over the existing copper access network. In order to be successful, digital transmission will have to deal with a number of impairments that exist in the local loop. The focus is on interference from and into radio users. Because digital signals contain frequencies up to several megahertz, these broadband signals are susceptible to more hostile noise conditions such as radio system. In this study we will discuss the interference and noise reduction techniques due to AM radio system that used 576 kHz frequencies; with 73dBm (20kW) power which happen into digital transmission.

1.3 Objectives

The project objectives are as follows: -

(i) To determine effect of high power AM signal in digital transmission

(ii) To identify the potential techniques in reducing the electromagnetic interference.

(iii) To do experimental meası rements and testing on the performance of the mitigation techniques.

1.4 Scope of Work

The scope of the project is as follows:

(i) Use base band modem mod. BM/EV and data tools 5000 to test interconnection cables, terminals and transmission lines for twisted pair cables

(ii) To do immunity measurement on the twisted pair cables using Gigahertz Transverse Electromagnetic Cell (GTEM Cell) with 576 kHz frequency of AM signal.

(iii) Only shielding technique is used.

(iv) Analysis the shielding concept with various materials and polarization.

1.5 Importance of Project

(i) To understand the behavior of the electromagnetic interference due to AM transmission.

(ii) Propose to manufacturer to upgrade the twisted pair cable using shielded material in high electromagnetic interference area.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction to Broadcast Signal

Radio communication is typically in the form of AM radio or FM Radio transmissions. The broadcast of a single signal, such as a monophonic audio signal, could be done by straightforward amplitude modulation or frequency modulation. A radio wave is an electromagnetic wave propagated by an antenna. Radio waves have different frequencies, and by tuning a radio receiver to a specific frequency (Figure 2.1) we can pick up a specific signal.