STATISTICAL ANALYSIS AND FILTER DESIGN FOR CONDUCTED EMISSION NOISE

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JUDUL: **STATISTICAL ANALYSIS AND FILTER DESIGN FOR CONDUCTED EMISSION NOISE**

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

Electrical Engineering Department
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For my wife Rosni Binti Yusoff,

My daughter and my sons,

Nur Rahwani Safwah, Muhammad Rifqi Solihin dan Muhammad Rifqi Sufi,

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ABSTRACT

Electromagnetic compatibility (EMC) is the ability of equipment and system to function as intended without degradation or malfunction in their intended operational electromagnetic environment. Further, the equipment or system should not adversely affect the operation of, or be adversely affected by any other equipment. There are two categories of Electromagnetic Compatibility; (1) Electromagnetic Susceptibility (EMS) (2) Electromagnetic Interference (EMI). EMS and EMI can be further divided into two categories namely radiated and conducted. Conducted emission is the unwanted currents that are produced by electronic and electrical equipments emitted through the power lines. The main sources of conducted emission are common mode current and differential mode current. These currents will interfere with any equipments that are connected to the same power lines. EMC standards pertaining to the conducted emission (such as EN55014) define the limit lines that should not be exceeded or the product cannot be marketed. In order to avoid non-compliance to the standards, most electronic/electrical equipments have power line filter installed into them. However, these filters are not effective enough because they were designed without considering the emission currents characteristics. This project proposed a method to improve the design of a power line filter by analyzing the characteristic of the emission current noise. The results from the statistical measurements can be used to identify the range of frequencies where most of the noises are located. Eighty four blenders were used as a sample to identify the characteristic of the noise. It was found out that the conducted emission exceed the limit line from 150kHz to 1MHz by 5dB and by 10dB at frequencies from 1MHz to 30MHz. A butterworth filter with cut-off frequency of 70.56kHz and bandwidth from 0 to 120kHz was designed. The parameters of the filter were based on the statistical data of the conducted emission. The test result shows that the filter attenuate the noise about 42dB at frequency range of 150kHz to 10MHz and 10dB at frequency range from 10MHz to 30MHz. The low attenuation at frequencies from 10MHz to 30MHz is due to the existence of capacitive and skin effect. A better filter can be achieved if a higher quality component is used in the fabrication.

ABSTRAK

Keserasian Elektromagnet (EMC) adalah kebolehan suatu sistem elektronik untuk berfungsi secara serasi dengan sistem elektronik yang lain dan ia tidak menghasilkan atau menerima interferen. Terdapat dua jenis Keserasian Elektromagnet iaitu (1) Keserasian Menerima dan (2) Keserasian Memancar. Keserasian Menerima dan Keserasian Memancar dapat dibahagikan kepada dua iaitu pengalir dan radiasi. Sinaran pengalir adalah arus yang tidak dikehendaki yang dihasilkan oleh peralatan elektrik atau elektronik melalui talian kuasa. Sumber utama pengalir dan radiasi adalah arus mod sama dan arus mod beza. Arus ini akan mengganggu peralatan yang bersambungan dengan talian kuasa yang sama. Piawaian EMC yang berhubung dengan sinaran pengalir contohnya EN55014 menyatakan peralatan elektrik yang menghasilkan sinaran melebihi aras yang ditetapkan tidak boleh dijual. Untuk mengelak dari tidak memenuhi piawaian yang ditetapkan, peralatan elektrik dan elektronik dipasangkan penapis. Walaubagaimanapun penapis ini tidak berkesan kerana ia dibina tanpa mengambil kira tentang ciri-ciri arus yang tidak dikehendaki. Projek ini mencadangkan kaedah untuk meningkatkan keberkesanan penapis dengan merujuk kepada ciri-ciri arus hingar. Keputusan dari pengukuran statistik akan digunakan untuk mengenalpasti kedudukan arus hingar. Lapan puluh empat pengisar digunakan sebagai sampel untuk memgenalpasti ciri-ciri hingar. Hingar yang melebihi aras pada frekuensi 150kHz hingga 1MHz adalah 5 dB dan 10 dB bagi frekuensi dari 1 MHz hingga 30 MHz. Penapis yang terhasil adalah butterworth dengan frequensi potong pada 70.56kHz dan lebarjalurnya ialah 0 hingga 120 MHz. Parameter penapis diambil daripada data statistik pancaran pengalir. Pengujian penapis menunjukkan pengurangan hingar 42 dB pada frekuensi 150 kHz hingga 10MHz dan 10 dB pada frekuensi dari 10MHz hingga 30MHz. Sedikit pengurangan pada frekuensi 10MHz hingga 30MHz adalah disebabkan oleh kapasitan dan kesan kulit. Penapis yang baik boleh dicapai dengan penggunaan komponen yang berkualiti tinggi dalam pembinaan.

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GLOSSARY OF ABBREVIATIONS

AC	Alternating Current
AMN	Artificial Mains Network
CE	Conducted Emission
CISPR	The International Special Committee on Radio Interference
CM	Common Mode
DC	Direct Current
DM	Differential Mode
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMS	Electromagnetic Susceptibility
EUT	Equipment under Test
FCC	Federal Communications Commission
HF	High Frequency
IL	Insertion Loss
ITE	Information Technology Equipment
LISN	Line Impedance Stabilization Network
N	Neutral
P	Phase
PCB	Printed Circuit Board
PDF	Probability Density Function
PFC	Power Factor Correction
RF	Radio Frequency

LIST OF APPENDIX

CHAPTER I

INTRODUCTION

1.1 Introduction to Project

The problem of achieving electromagnetic compatibility (EMC), which is the ability of electrical equipment to coexist without mutual interference, is as old as electromagnetism itself. However the awareness of it did not arise until electromagnetic incompatibilities really become problem. As time went by, the EMC problem broadened. Not only did interference between set have to be avoided (as a result of the steadily growing density of circuit and increasingly high frequencies), it was also necessary to control electromagnetic influence of circuit within a single set, a single printed wiring board and even within a single chip. As such, it is important to create awareness and understanding on the source of emission from various circuit and their mitigation techniques.

This project will investigate the mechanism by which emission are generated and are conducted out of the product along the product's AC power cord. The conducted emission noises (electrical transient, surges and their disturbance) carried by electrical power supply line are classified into two categories, common mode current/voltage and differential mode current/voltage. EN55014 is a standard for household appliances of electrical tools and similar. This standard includes the

measurement for conducted emission from frequency 150 KHz to 30 MHz [1]. Due to the proliferation of electrical and electronic product at ever increasing complexity and speed, it is desirable in the near future to look beyond 30 MHz to ensure proper mitigation device are employed such as filter. Consequently, it is of important to perform statistical study on the conducted emission noise from electrical and electronics equipments. Normally, electrical and electronic equipment that is having motor will produce high conducted noise. Most modern motor drive use varies high switching frequencies for currents and voltages, which is make unintentional current path [2]. In this project, helping certain device such as LISN, EMC Analyzer, EMTEST Software, can do measurement on class B ITE. Class B ITE is a category of apparatus which is satisfies the class B ITE disturbance limits [3]. By using a few electrical equipment as a sample for conducted emission test, can get the characteristic of noise from Gauss distribution plot. The characteristic is referring to equipment. Such as table fan, hair dyer and Blander. So that a dynamic filter can be developed which is used the characteristics of noise from measurement result. A dynamic filter can call as smart filter. This filter is applicable to filter the noise at a few equipments.

1.2 Objectives

i) To understand the mechanisms that produce conducted emission noise.

ii) To perform statistical study on conducted emission noise spectrum from electrical and electronics equipment.

iii) To design the topology for conducted emission filter based on the measurement result (ii)

1.3 Scope of Work

i) Measurement the conducted emission noise between 150 kHz to 30 MHz.

ii) To study the measurement equipments (LISN, Transient Limiter, Spectrum Analyzer and EMTEST software) function.

iii) To study the conducted emission noise (common mode and differential mode).

iv) To perform statistical analysis on conducted emission noise measurement.

v) Single phase equipment for EUT

vi) Blender was chosen for EUT

1.4 Importance of Project

i) To develop the efficiency filter which is applicable for all electrical / electronic equipment.

ii) To propose the manufacturer to use this filter.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction to Electromagnetic Compatibility

Electromagnetic compatibility (EMC) is the ability of equipment and system of function as intended without degradation or malfunction in their intended operational electromagnetic environment. Further, the equipment or system should not adversely affect the operation of, or be adversely affected by any other equipment. For a system to be electromagnetically compatible, it has to generally satisfy 3 criteria which are [4]:

i. It does not cause interference with other system
ii. It is not susceptible to emission from other system.
iii. It does not cause interference with itself.

EMC is dividing into two main groups, which is the electromagnetic Interference (EMI) and electromagnetic Susceptibility (EMS). EMI is defined as a degradation of the device, equipment or system by an electromagnetic disturbance. EMS is the in ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance [5]. EMI and EMS can

be dividing further into two parts, which is radiated and conducted. Figure 2.1 shows the EMC network.

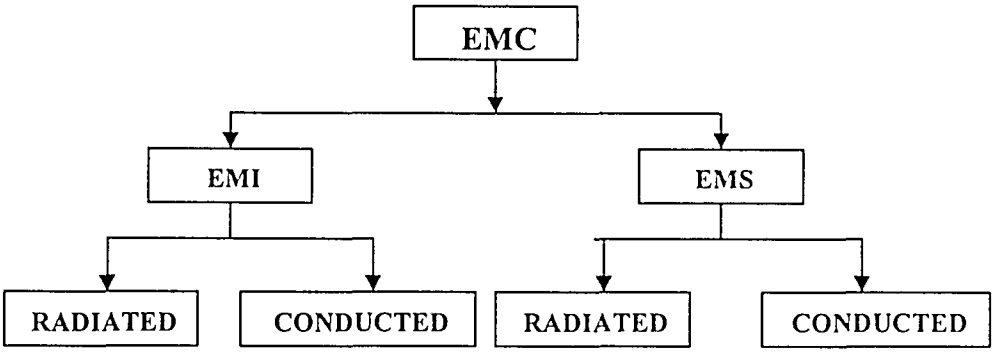

Figure 2.1: Introduction to Electromagnetic Compatibility

2.2 Introduction to Electromagnetic Interference

The undesired or unintentional coupling of electromagnetic energy from equipment (called emitter) to another equipment (called receptor) is the electromagnetic Interference [5]. The various methods of electromagnetic interferences coupling between an emitter and receptor are illustrated in figure C will briefly describe these in the following.

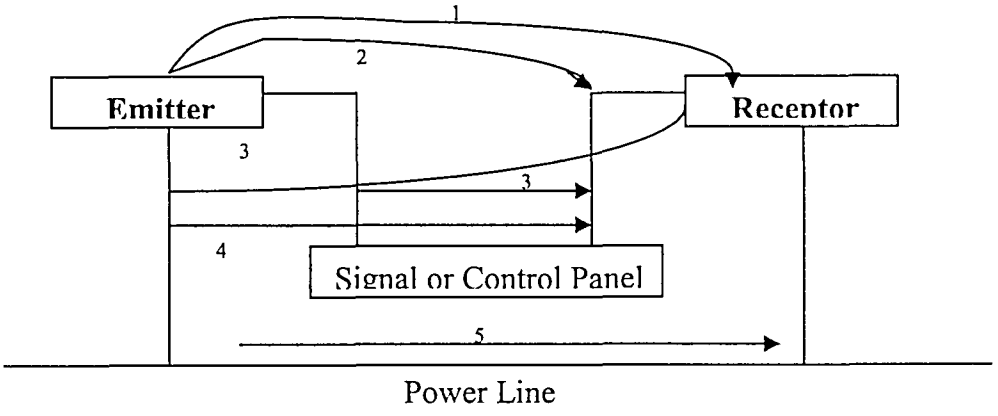

Figure 2.2: Electromagnetic Energy Coupling between Emitter and Receptor