CONDUCTED EMISSIONS TESTING FOR ELECTROMAGNETIC COMPATIBILITY

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ABSTRACT

Operating frequencies in the gigahertz range is creating an increased need for electromagnetic compatibility (EMC) testing. In the United States, FCC regulations require conformance to radiated and conducted emissions specifications. An EMC laboratory was established at Cal Poly San Luis Obispo (screen room, test instrumentation, and software) and an experiment was developed to explore conducted emissions effects. This paper will describe the test configuration, explain the calibration procedure needed to acquire accurate measurements, and illustrate measurement techniques applied to two example systems. In addition, the data collection process is software donated by illustrated through CKC Laboratories (EMC specialists). To verify the functionality of the laboratory and to assess measurement accuracy, two 12V/15W switching power supplies are characterized for conducted emissions performance; one as supplied by the vendor (KGCOMP) and a second unit with the EMC filters removed. The noise spectrum for both units are plotted against frequency and compared to FCC specifications. The unaltered unit is shown to be in compliance, thus verifying the accuracy of the test procedure and instrumentation.

Keywords: Facility Descriptions, Data Acquisition, Commercial Products, Measurement Systems, Standards

1.0 Introduction

This paper describes a system level design for performing university-level EMC testing for conducted emissions in compliance with FCC part 15 standards [1].

ANSI C63.4-2001 [2] was the primary guide used for the design of the system. Electromagnetic compatibility references [3, 4] also aided in the completion of this project.

An EMC laboratory was established at California Polytechnic State University, hereafter referred to as "Cal Poly." The eventual goal is to provide EMC instruction to students and prepare them for real-world problems faced in industry today.

2.0 Conducted Emissions and Measurement

Conducted emissions are the radio frequency noise present in the physical wiring or traces of an electrical system. This noise is generated by switching transistors or harmonic resonances within a circuit. This results in unwanted common mode and differential mode currents within a system. Detailed analysis indicating their existence can be found in [3, 4].

A Line Impedance Stabilization Network (LISN) performs conducted emissions measurements. A LISN provide two functions [3], to isolate the test system within its boundaries and to provide a measurement point. The operator selects the frequency range, which is usually governed by the standard being used. For this system, FCC part 15 [1] was used.

3. 0 System Setup

The equipment was selected based on the information provided in [3, 4] and recommendations at CKC Laboratories and Montrose Compliance. All equipment was purchased through the C³RP Cal Poly initiative.

Due to the existence of an anechoic chamber and a high power FM antenna, the EMC system was enclosed in a copper mesh screen room.

For observation of RF signals present in the system, an HP 8568B Spectrum Analyzer (SA) with the HP 85650A quasi peak adaptor was used.

For automated control of the SA, a desktop computer was used with a GPIB interface. CKC Laboratories donated the interface software. For SA burnout protection, an ARA Transient Limiter was used. An ARA High-Pass Filter was included in the system to suppress frequencies outside the operating range.

The LISN used in the system is a Fischer Custom Communications 16A, twin line LISN. The operating frequency is 150kHz to 100MHz, well within the FCC part 15 standards.



Figure 1 System Block Diagram

The equipment configuration internal to the screen room, such as bench placement, LISN placement and spacing, was based on ANSI C63.4 standards [2].





Figure 3 Wiring Diagram

The data sheets supplied with the equipment indicate that the devices are operating within specification needed in this system. At the Cal Poly laboratory, the devices were subjected to a frequency sweep from 150kHz to 30MHz at 107dB μ V (0dBm) to ensure proper operation upon the delivery of items. In addition, all cables and connectors were measured for loss. For safety precautions, the earth grounding of the screen room and the earth ground connections to the LISN were tested and verified to be electrically conductive.

4.0 System Verification

For verification of system operation, the noise floor of the system was measured. The pink line (in Figures 4, 5, 6 and 7) represents the FCC Class B voltage limit.



Figure 4 System Noise Floor Plot

The trace represents the noise floor of the system, which was approximately $32dB\mu V$.

As outlined in the ANSI standards [2] a complete computer system was setup and measured. One measurement was made of the monitor and another with the computer itself. Both measurements conformed to FCC class B standards [1].



Figure 5 Desktop Computer Emissions



Figure 6 Desktop Monitor Emissions

5.0 EMC Experiment/Study with Switching Power Supplies

To further test the performance and functionality of the system and to provide a basic laboratory experiment for students, a commercial power supply was measured with its electromagnetic interference (EMI) filters removed. The power supply contained a common mode choke and a differential mode current bypass capacitor. The power supplies are manufactured by KGCOMP and are rated at 12V/15W.

Measurements were made with both filters removed, only the chokes installed, only the bypass capacitor installed, and with both filters installed. In addition, the system noise floor was measured.

The power supply was placed in the screen room in accordance with ANSI standards [2] which require a minimum height from the floor and distance from the walls, and routing of the power cables.

Using the CKC Laboratories software, the parameters were configured for a FCC class B device. Following procedures outlined in the ANSI standards [2], both the black "Hot" and white "Neutral" lines were measured. The voltage measurements were compared against each other and against the FCC standards for a Class B device.



Figure 7 Output Plots

The plot only represents data taken from the black line power line. The blue trace is the measurement with no filter elements installed. The device does not meet FCC Class B specifications: amplitude peaks exceed the 40dB over the limit. The green trace represents the emissions performance with only the bypass capacitor of the EMI filter installed. Only a slight improvement of less than 5dB can be seen. Upon insertion of the EMI chokes (red trace), the voltage amplitude greatly improved and meets FCC specifications. Finally, the purple trace indicates system performance with the entire EMI filter in place. These filters reduce the power supply EMI emission levels near the noise floor of the system.

6.0 Summary

The goal of providing a conducted emissions laboratory at Cal Poly was achieved with these tests. At a systems level, all elements of the system operated as predicted. The system showed compliance to FCC class B consumer goods. Further investigation of the EMI measured in these experiments is beyond the scope of this paper and is left to future students taking the EMC courses to study. The author hopes this EMC laboratory will be the stepping-stone into bringing EMC studies to Cal Poly.

7. REFERENCES

[1] Federal Communications Commission. <u>FCC Rules</u> and Regulations Part 15. Washington DC, FCC, 2003

[2] American National Standards Institute. <u>ANSI C63.4</u> 2001 American National Standard for Methods of <u>Measurement of Radio-Noise Emissions from Low-</u> Voltage Electrical and Electronic Equipment in the Range of 9kHz to 40GHz. New York, IEEE, 2001

[3] Montrose, Mark and Nakauchi, Edward. <u>Testing for</u> <u>EMC Compliance Approaches and Techniques</u>. New York, IEEE Press/John Wiley and Sons, Inc., 2004. [4] Paul, Clayton. <u>Introduction to Electromagnetic</u> <u>Compatibility</u>. New York, John Wiley and Sons, Inc., 1992

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