Spectral Analysis of Electromagnetic Compatibility

Raghavendra Dakuri Venkata

Abstract — The report's main aim was to transmit the frequency signals without any disturbances and compute the time and frequencies of energies. Conduct the data burst system with the help of an anechoic chamber to study the electromagnetic interference and utilise the spectrum analyser to identify the required frequency during the conduction of signal transmission and minimise the noise disturbances.

Key words — Anechoic Chamber, Data Burst, Electromagnetic Compatibility, Spectral Analysis.

I. INTRODUCTION

A. Data Burst Using Virtual Instruments

Evaluation of Data Burst using Virtual Instruments (ISIS Simulator), a test PCB 'Data Burst' is to be evaluated. The PCB emulates a simple 'smart sensor' whereby an analogue input is measured and the value transmitted digitally. The digital signals will exhibit a frequency spectrum that may cause EMC problems. The simulation should investigate the output signals as both time and frequency using virtual instruments [1].

B. Data Burst PCB Using DSO

Measurement of Data Burst PCB using DSO, A prototype PCB is to be constructed and tested in the Laboratory. Here, the FFT function of the DSO and the usual time waveforms were to measure the spectrum of the output signals.

C. Radiated Emission Test

The RF Anechoic Chamber used to perform the Radiated Emission testing to measure radiated fields from equipment and study the Spectral Measurement for EMC for discussing how we can use time and frequency measurement techniques to determine any potential EMC threats [2].

II. PROBLEM ANALYSIS

A. Circuit Diagram

The Circuit diagram was a combination of various components used to connect all component connections internally and execute the graphical representation of all features to access and easily understand purposes. With the help of a circuit diagram, we can implement and manage the circuits easily.

III. PROBLEM SOLUTION

A. ISIS Proteus Software Package

Based on the available software package of Proteus 7.0, we can utilise and implement all components of the circuits. With the help of power tools of the proteus software, we can quickly draw and excuse the software. The calculation of the given five systems was completed with the helping of simulator designing tool options and obtaining the output parameters and theoretical comparison values of the system.

B. Anechoic Chamber

An anechoic chamber provides the best example of conducting Electromagnetic compatibility, and it's constructed of polynomial foam pyramid ship to prevent the transmission of the heat and reflections of the walls and ceilings. The construction provided infinite open space. It has a transmitter antenna and receiving antennas for...
conducting and transmitting the energy waves in straight directions; with the help of a computer, we can calculate the time and frequencies of energy. The main advantages can measure the high-speed differential mode transmission lines, and it mainly operates the electromagnetic phenomena and avoids any interference [3].

C. Electromagnetic Compatibility
To transmit the radio frequency signals without any disturbances to the environment.

D. Electromagnetic Interference
During the conduction of the transmission line, some unwanted signals will generate concerning the transmission lines at receiving end, known as electromagnetic interference. To reducing of switching circuits, we can eliminate electromagnetic interferences [4].

E. Spectrum Analyser
The electronics devices identify the required frequency during the conduction of the signal transmission. Mainly used and test in radio frequencies.

F. Fourier Theorem
It derives the physical variations between the time and frequencies of the system. It converts the time domain signal into the frequency domain signal, which helps analyse a signal and derive the mathematical function of signals for analysis. When the even part is symmetric concerning the y-axis stats, the graph was unchanged, and an odd function is symmetric concerning the origin means the chart remains intact.

IV. Problem Implementation
A. Data Burst Using Virtual Instrumentation
We were collecting all components and making them in a circuit with the help of the software itself. With the auto placer and auto-router option, save and compile the whole course into the schematic diagram. With the use of Proteus software, we can be getting the PCB layout. That diagram clearly shows all component connections. If it is needed means, we can also give references manually. With the support of Proteus software, we can compile and debug the file and finally, we got an output of the circuit diagram. Based on this output, we make it in an output file and component list and send it to order a PCB.

B. Data Burst PCB Using DSO

Gathered various information about the circuit, understood all circuit connections and collected all component datasheet information about each component's type, size, and frequency.

V. Results
A. Fourier Waveforms of Data Burst System

Fig. 2. The capture of the Data burst system.

Fig. 3. The capture of Data burst PCB.

Fig. 4. Fourier analysis of Data.

Fig. 5. Fourier analysis of Sync.
B. Data Burst PCB using DSO

Fig. 6. Fourier analysis of Clock.

Fig. 7. FFT of Data (Sync & Data).

Fig. 8. FFT of Clock.

C. Radiated Emission Testing

1) First harmonic Calculations

| S. No | Frequencies | Dbm  | Plane Direct |
|-------|-------------|------|--------------|
| 1     | 432         | -70  | X            |
| 2     | 432         | -74  | Y            |
| 3     | 432         | -73  | Z            |
| 4     | 432         | -75  | X1           |
| 5     | 432         | -72  | Y1           |
| 6     | 432         | -76  | Z1           |

The maximum value of the first harmonic was = -70 dbm. The cable losses was = -2dbm.
The minimum value (dbm) = -70 – (-2) = -68 dbm.

Power in watts $P_{dbm} = 10 \log \left( \frac{P_{watts}}{10^3} \right)$.

1000P_d=10^{-6.8} \rightarrow P_d = 1.58 \times 10^{-10}$

Power density $S = G \times P/4 \pi r^2$ \rightarrow $S = 7.56 \times 10^{-13}$

$S = E^2/120\pi$ by inserting into the above equation.

$E = \text{Sqrt} \left( s \times 120\pi \right) E = 1.68 \times 10^{-5}$ v/m.

EMI (dbµv/m) = 20 log (E/10^{-6}) = 154.53 dbmv/m.

2) Second Harmonics Calculations

| S. No | Frequencies | Dbm  | Plane Dir |
|-------|-------------|------|-----------|
| 1     | 865         | -57  | X         |
| 2     | 865         | -65  | Y         |
| 3     | 865         | -62  | Z         |
| 4     | 865         | -66  | X1        |
| 5     | 865         | -55  | Y1        |
| 6     | 865         | -64  | Z1        |

The second harmonic was = -55 dbm.
The cable losses was = -2dbm.
The maximum value (dbm) = -55 – (-2) = -53 dbm.

$P_{dbm} = 10 \log \left( \frac{P_{watts}}{10^3} \right)$ Substituting the equation.

-53 = 10 log (P_o/10^3).

$P_{watts} = 50/nw$Power density $S = G \times P/4 \pi r^2$

$S = 3.19 \times 10^{-11}$ w/m

$S= E^2/120\pi$ by inserting into the above equation.

$E = 1.09 \times 10^{-4}$ \rightarrow EMI (dbµv/m) = 20 log (E/10^{-6}) = 40.74

3) Noise Floor Calculation at = -85

Maximum value power = -85 dbm.
Cable losses = - 2dbm.
Maximum value = -85 – (-2) = -83.

$P_{dbm} = 10 \log \left( \frac{P_{watts}}{10^3} \right)$ \rightarrow -83 = 10 log (P_o/10^3).

$P_{watts} = 5.011 \times 10^{-12}$\rightarrow$S = 2.39 \times 10^{-4}$

$S = 6 \times 4 \pi \times 10 \times 10$

$E = \text{Sqrt} \left( s \times 120\pi \right)$

EMI (dbµv/m) = 20 log (E/10^{-6}) = 109.54.

VI. DISCUSSION

It states information about how signals were generated, conducted, and transmitted in an anechoic chamber; with the help of a black box, singles are generated and sent through transmitter and receiver antennas without any disturbances of signals stored in a spectrum analyser. With the help of a spectrum analyser, we can calculate the signal frequencies and time domains and keep them into a data formation. This experiment was beneficial to knowing the concept of radiated electromagnetic compatibility and interference and studying the anechoic chamber.
VII. CONCLUSION

Conclusion and Correlation between the lab results and simulation results are slightly varying. The simulation results are more accurate when compared to the lab results because the lab results have some disturbances like noises and soldering problems during the lab experiment. Conducting the data burst PCB test was very reliable because the design and simulation process is simple understanding procedures. With the help of this experiment, we can easily understand the Spectral analysis of Electromagnetic compatibility.

REFERENCES

[1] J. Alexander, Da-Yong Cai. On the dynamic of a bursting system. *Journal of Mathematical Biology*, Feb 1991; 29:405-23, ISBN: 0303-6812.

[2] Tae-Weon Kang, Hyo-Tae Kim. A proficiency testing of electromagnetic radiated emission measurements. *Measurement Science and Technology*, 2002; 13(9): 1475., ISBN:0957-0233.

[3] Christopher L. Holloway, Paul McKenna, Roger Dalke, Rod A. Perala, Charles Devor. Time-domain Modeling, Characterisation and Measurements of Anechoic and semi-Anechoic Electromagnetic Test Chambers, *IEEE Transactions on Electromagnetic Compatibility*, Feb 2002; 44(1): 102-118, ISSN: 1158-187X.

[4] Thanh Tran. Electromagnetic Interference. *High-Speed DSP and Analog System Design*, April 2010; 44(1): 195-210, ISBN: 978-1-4419-6308-6.