Electromagnetic Compatibility Design of the Computer Circuits

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Abstract. Computers and the Internet have gradually penetrated into every aspect of people's daily work. But with the improvement of electronic equipment as well as electrical system, the electromagnetic environment becomes much more complex. Electromagnetic interference has become an important factor to hinder the normal operation of electronic equipment. In order to analyse the computer circuit compatible with the electromagnetic compatibility, this paper starts from the computer electromagnetic and the conception of electromagnetic compatibility. And then, through the analysis of the main circuit and system of computer electromagnetic compatibility problems, we can design the computer circuits in term of electromagnetic compatibility. Finally, the basic contents and methods of EMC test are expounded in order to ensure the electromagnetic compatibility of equipment.

1. Introduction
Computer is a digital device which processes data and information. Generously, information is transmitted and processed in the form of an electromagnetic signal. With the development of information technology and the popularization of microcomputers, computer has become an electronic device which is widely used in information processing and information transmission. Due to the special structure of the computer and the way to work, it transmits electromagnetic wave inevitably. The electromagnetic radiation will jeopardize the surrounding in three ways. The first one is that it is detrimental to the health of those people who are around the computer; the second one is that it will cause the formation of electromagnetic interference; the third is the information leakage. Therefore, the research on the compatibility of computer and electromagnetic environment has become a global concern.

This article mainly includes the significance of researching the computer electromagnetic compatibility, the concept of the computer electromagnetic compatibility, EMC design of the computer and the electromagnetic compatibility test. The structure of this paper is shown in Figure 1. This paper analyzes and put forward some measures about electromagnetic compatibility design of the computer circuits from these aspects.
2. Conception of computer electromagnetic compatibility
Electromagnetic compatibility (EMC) is the branch of science and engineering concerned with the design and operation of equipment in a manner that makes them immune to certain amounts of electromagnetic interference, while at the same time keeping equipment generated interference within certain specified limits. EMC must be regarded as an issue that affects all aspects of design: electrical, electronic, and mechanical. It cannot be adequately addressed in isolation. Typically, a complete design may consist of a number of subsystems that interact with each other through signal and power cables and through reactive (capacitive and/or inductive) or radiative mechanisms [1].

The hardware of the computer usually contains digital circuits, which is predominant, and analog circuit. The crosstalk among outside electromagnetic radiation, internal devices and the various transmission channel generates interference or threaten the stability and reliability of computer.

3. EMC design of the computer
This section focuses on the analysis of the electromagnetic radiation and electromagnetic compatibility in the main part of computer system as well as the computer board level, and put forward the pertinence measures in computer design to further increase the EMC of the overall system.

3.1. EMC design of computer board level
The mainboard is a large circuit board with sockets and memory slots, and a large scale integrated circuit chip called a chipset. The mainboard is one of the main components of computer generating electromagnetic leakage. Then, the computer mainboard is a complex PCB board. PCB board refers to the printed circuit board, which is the electronic components of the electrical connections provider. The analysis of the factors affecting the PCB board and EMC design of the PCB board will be discussed below.

3.1.1. Factors affecting high speed PCB signal transmission
1) Interconnect delay is the time at which the signal passes from the output end of the drive device to the receiving end. The interconnect delay depends on the size of the signal transmission rate, interconnect length, and the capacitive load that causes the rise time to elongate.

2) When the signal energy passes through the conductor and is not absorbed at the terminal of the conductor, some of the energy will be reflected back to the conductor, resulting in reflected noise. In
high speed systems, reflected noise causes a change in the state of the logic, which often results in triggering of errors.

3) Crosstalk between signal lines is a major concern in high speed PCB designs since it can cause electromagnetic interference issues apart from conventional signal integrity (SI) problems. Since crosstalk between signal lines increases with frequency, it becomes increasingly important to consider the impact of crosstalk on EMC for very high speed PCBs. As a rule of thumb, when 100µV appears on an unshielded wire leaving a shielded enclosure, the fields at 10m will violate the EMC standards for computer hardware. Thus, for meeting EMC standards and avoiding re-design, it is imperative to factor in the impact of crosstalk on EMC even at the early stages of PCB design [2].

3.1.2. EMC design of PCB board for high speed digital system

1) Select and use multilayer PCB reasonably
   a. Do not route clock and high speed signal on the surface, in case if the requirement is not meet, restrict routing length to minimum 2mm - 5 mm.
   b. For all long (length > 2mm-5mm) surface signals ensure that these signals do not run parallel to any clock/high speed traces in the inner layers of board.
   c. Avoid routing of power plane associated with clock circuitry.
   d. Avoid routing of long floating (un-terminated)/high impedance terminated traces.
   e. Do not cut/punch GND plane below the outer layer routing [3].
   f. Separating digital circuits from analog circuits, because high-speed digital signals have a wide spectrum, which are the primary source of interference. Thus it must be arranged separately from the sensitive circuitry.
   g. The wiring layer should be arranged adjacent to the whole metal plane. This arrangement is designed to produce energy offsets.

2) The arrangement of components
   Components should be grouped on the board. The purpose is to partition the space on the printed board, so as to ensure that the components of each group do not interfere with each other in space.

3) The layout of the ground wire
   The first consideration of the ground line is to set ground wire in digital circuits and analog circuits relatively according to the different power supply voltage.

4) The arrangement of the power line and filtering.
   There will be a large number of transient supply electricity in the PCB circuit of the high-speed digital system, which will cause EMI. Using decoupling capacitor and reducing the characteristic impedance of the supply line can restrain the interference in the power line.

3.2. EMC design of computer system

3.2.1. EMC design of I/O in computer. The I/O unit is responsible for driving, level conversion, and ESD protection. We should avoid lacking the enough power of driving and ensure the electrostatic protection. The following focus on the ESD protection.

ESD protection can be obtained through components such as Transient Voltage Suppression (TVS) diodes, Polymer diodes and Varistors. Polymer diodes and Varistors offer huge residual pulse and hence are not preferred.

TVS diodes for a particular interface are selected based on many characteristics. Few of the key characteristics are stated below.

1. ESD protection level: IEC 61000-4-2 standard specifies level 2 for tablet products. TVS diodes are chosen to withstand these ESD voltages.
2. Bidirectional or Unidirectional ESD protection: TVS diodes are to be chosen based on protection required for bidirectional or unidirectional signals.
3. Clamping voltage: Clamping voltage of TVS diodes must be lower enough to avoid soft failures.
4. Residual pulse: It is a short duration high voltage peak seen after the TVS diode clamps the ESD pulse. Care should be taken while choosing TVS diodes to avoid residual pulse leading to crosstalk and soft failure issues.

5. TVS Diode Capacitance: For high speed interfaces, TVS diodes which offer lower capacitance are preferred to allow for good signal integrity[4].

3.2.2. EMC design of switching power supply. With the increase of the switching frequency, the EMI problems become severer. They interfere not only to the environment and the equipment around them, but also to themselves. In order to improve the stability and reliability of the devices, the electro-magnetic compatibility (EMC) of the switch power supply is got more attention than ever before [5].

The peak voltage interference generated by voltage conversion circuit and current harmonics generated by the rectifier circuit to produce are the main factors that switching power supply produces electromagnetic harassment. Additionally, formation of switch pulse and control circuit in high frequency rectangular pulse will produce electromagnetic disturbance.

There are two measures of suppressing electromagnetic interference produced by switching power supply:

Firstly, reduce the harassment intensity of the disturbance source

(1) Select the appropriate switching power supply mode and frequency

In practical design, when selecting the work mode, we should consider the circuit complexity, the conversion efficiency, the production cost and the difficulty of debugging and its electromagnetic compatibility, which can often get an idea effect. As for the frequency of work, it should be smaller if not increases the cost and affects the efficiency of the work.

(2) Select the appropriate circuit components

The switching loop is the direct and major source of electromagnetic interference generated by switching power supplies. In the switching loop, the switch tube is the core. The design of the switch tube takes the high frequency suppression and the momentary shock of the switch into account. Another key component in the switching circuit is a pulse transformer. The influence of pulse transformer on electromagnetic compatibility is shown in two aspects: one is the distributed capacitance of primary coil and secondary coil, and the other is the leakage of pulse transformer. By adding the electrostatic shielding layer in the primary and secondary coils and leading it to ground, we can greatly reduce the switch capacitance between the primary and the secondary transformer, thereby reducing the coupling of the primary and secondary electric field disturbance.

Secondly, cut off harassment routes of transmission

(1) Using filtering technique

We can insert the common-mode and differential-mode filter in the switching power supply AC power line input end, which prevent the power line from common-mode and differential-mode noise.

3.2.3. Chassis design. The reasonable design of the chassis can restrain the electromagnetic interference and shield the electromagnetic wave outside the computer. Enabling the chassis to possess good continuity of conduction is the key of design.

The concrete method is to use the electromagnetic gasket with good conductivity fasten the joint of the shell board. Prevent the line from passing through the shield directly and use the cable socket with the proper filter.

4. EMC test

4.1 The basic content of EMC test

EMC testing is mainly composed of electromagnetic interference testing and electromagnetic sensitivity testing. When the tested intelligent controller in normal operation, it will produce
electromagnetic wave signal, and electromagnetic interference testing is detecting electromagnetic signals emitted by intelligent controller [6].

4.2 EMC test method
Use the EMC radiation intensity tester to judge whether the computer system meets the regulatory requirements, namely the design in accordance with the "International Electro technical Commission" standards, including FCCRART15, EN55022, and GB9254 etc. In general, according to different types of products and where the products to sell the region, we can determine which standard to use. Then according to the standard, we can determine the corresponding test items.

5. Conclusion
With the spread of the computers, electromagnetic interference has become a problem that has to be solved. Through the analysis of electromagnetic compatibility of computer board and system, we can effectively take effective measures to avoid electromagnetic interference in the design stage, which means that we can improve the validity of EMC design and reduce the cost during design stage.

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