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Design of Electromagnetic Compatibility in automatically-controlled Door Control System used in EMU

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Abstract: In order to improve anti-interfere ability and increasing stability and reliability of automatically-controlled door Control System used in high speed Train. In this paper, we analysis the reason of electromagnetic interference and electromagnetic radiation on the system. the restrained technology of t he hardware interference was studied from the ranges of circuit board design , GND design , insulated technology and power interference rest rained aspects , and the software anti-interference mechanism was al so studied from redundancy. Based on this , the design of electromagnetic compatibility in automatically-controlled door Control System used in high speed Train was accomplished.Through actual vehicle experiments , the system design was verified , and the result showed that the system design is accuracy , reliable and creditable.

Keywords: Automatically-controlled door, Electromagnetic Compatibility, Interference suppression.

1. Introduction

EMU (Electric Multiple Units) has become one of the most important means of transportation in people's life is playing a more and more important role. China has become the country with the longest high-speed railway mileage in the world, has become the world's high-speed railway country. The electric end door of EMU is the passage for passengers to get in and out of the carriage. It is one of the most frequently used parts, and its reliability directly affects the safe operation of the vehicle.

EMU is a system which combines strong current and weak current closely, but the power, frequency and level of strong current part and weak current part differ greatly. The weak current part has low level, high frequency, high sensitivity and is very sensitive to electromagnetic interference signal, so the electromagnetic interference of the strong current part may cause the wrong action of the controller, or even damage the components. The control technology of EMU electric end door integrates modern advanced manufacturing, micro processing, electronics and signal processing technologies. Therefore, electromagnetic compatibility has become a problem that must be solved in the design and use of electric end door control system.

2. Electromagnetic Interference and Radiation Analysis

EMU electric end door control system must have the following three basic elements to form electromagnetic interference in the working process: lent an interference source exists, queues have reception units that are sensitive to interference, queues have coupling channels. In order to suppress electromagnetic interference, the above factors must be eliminated in the design and use of electric end door system.

2.1. Interference Source Analysis

The noise interference of the electric end door system of EMU mainly comes from the inside and outside of the electric system of the vehicle. Vehicle internal interference mainly comes from traction power supply, traction drive, safety signaling system, coupling between parallel AC and DC traction systems and other factors. External interference mainly comes from sky noise, discharge interference, radio frequency interference and power frequency interference of high-power transmission and distribution system. Fig. 1 Power waveform of electric end door control system measured on board during operation of Ha-Da Line EMUS. It can be seen from the figure that the transient fluctuation amplitude of power supply voltage is very large, indicating the existence of interference.

Through research and analysis, interference sources mainly include the following aspects:

(1) Load mutation of power grid. The sudden change of power grid load will generate transient voltage wave at the load, whose amplitude will be much higher than the power supply voltage, with steep front edge and wide frequency band, which is similar to the high-frequency oscillation voltage with a short period. It enters the control circuit through the DC regulated power supply, and then enters the earth through parasitic capacitor to form a closed circuit.

(2) Harmonic interference of power grid. The electrified railway began to use high-power electronic switching components to control vehicles, and the large current is segmented by chopper, which will produce a large number of harmonics when working, which seriously interferes with the gate control system.

(3) Strong electrical interference. The vehicle system internal strong electric components, in the on-off process will produce instantaneous over-voltage and impact current, the peak value can reach dozens of times of the rated working voltage value, at the same time to the line distribution capacitor charging. Transient voltage not only has the nature of surge, but also has rich harmonics, and a wide frequency band, through the DC power supply into the control circuit, the control system to form interference.

(4) Pulse width modulation (PWM) power conversion circuit interference. The control system uses PWM technology to control the speed of the motor. The fast turn-on and turn-off of the power switching device leads to a large

current change rate and voltage change rate of the power circuit, resulting in a large peak voltage on the wiring inductance, which is superimposed on both ends of the switching device, posing a serious threat to the safety of the switching device.

(5) Radiation interference. Dc motor under PWM control, the current in the armature winding changes direction quickly, forming a sharp change in the magnetic field, brush reversing spark will produce high-frequency radiation, interference through the wire into the control line.

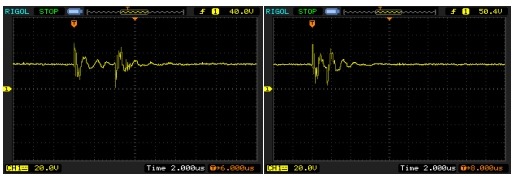

Figure 1. The waveform of power

2.2. Interference and Radiation Conduction Pathways and Mechanisms

The main ways of electromagnetic interference and coupling are conduction coupling, common impedance coupling, induction coupling and radiation coupling. The electric end door control system is subjected to all kinds of interference through electrostatic field, electromagnetic field, transmission line and circuit coupling into the system.

The form of interference mainly appears in the form of common mode and differential mode. The differential mode interference is connected in series in the signal loop and is related to the mutual inductance and frequency of the transmission line. Common-mode interference is added to both signal lines simultaneously. In gating system, the difference mode interference mainly comes from the sharp change of dc motor armature magnetic field and the alternating electromagnetic field of vehicle traction motor. The channels of common mode interference are very complex. Common mode interference may occur in all the loops related to ground and ground.

The CPU clock frequency of electric end door control system is very high, and its waveform contains higher harmonic frequency. Such high-frequency harmonics produce strong radiation that interferes with other circuits, especially the printed wires of printed circuit boards, power lines and I/O interface power supplies. When it generates standing waves, these conductors become highly efficient transmitting antennas in the vicinity of the frequency band. In addition, when the motor rotates, switch and relay contact on and off, the peak impact voltage can be as high as 1000 volts, and the attenuation oscillation frequency can be up to 500 Hz. The initial pulse front is only a few nanoseconds. Such spark discharge and high frequency oscillation can also produce very strong radiation interference.

3. Control System Hardware EMC Design

3.1. Hardware Interference Suppression Technology

3.1.1. Power Supplier Design

Because there are a lot of inductive loads and switching power devices, such as motors, relays, electric horns, chopper, etc., in the vehicle electrical system, these devices have great interference to the power supply during normal operation. If the control system only uses a group of power supply will affect the normal work of CPU and other chips, so in the design of dual power supply. A set of 5V supplies power to the CPU and control circuit; Another set of 24V supplies power to the motor. Power modules are isolated by DC/DC to avoid affecting the quality of some power supplies. In order to eliminate the common impedance coupling interference caused by the ground loop, realize the isolation of different voltage signals and suppress the transmission of interference, it is also necessary to isolate the control signal and feedback signal from the CPU, so that the motor drive circuit is completely isolated from the motor control circuit. Therefore, the ultra-high speed optocoupler HCPL2630 is used in the system design. HCPL2630 is a double-channel ultra-fast optocoupler with a response time of only 45ns and a switching frequency of up to 10MHz, which can fully meet the requirements in terms of transmission speed. Fig. 2 is the schematic diagram of motor drive circuit design.

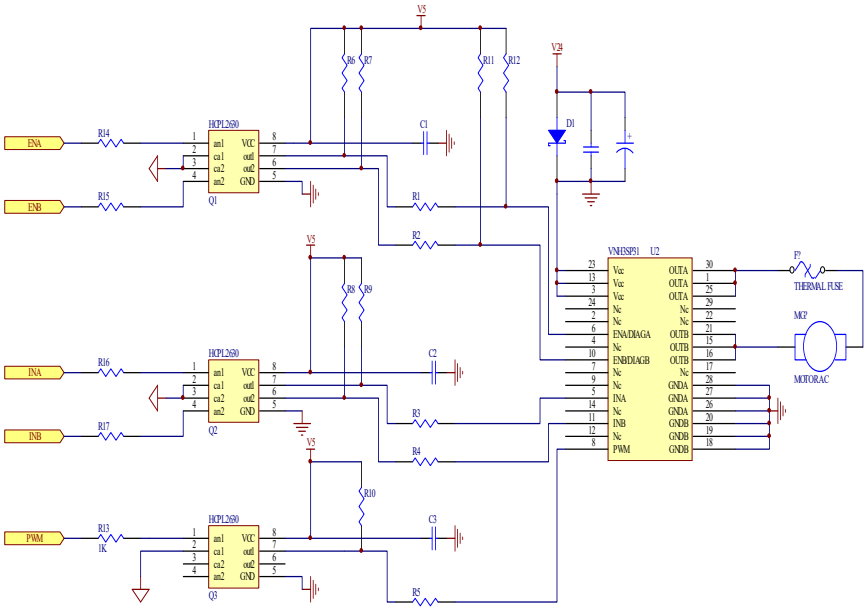

Figure 2. Electronic motor drive

3.1.2. Selection of Components

In the system design, the CPU chooses the MICRO-core PIC microcontroller, which has powerful control function and adopts RISC structure and pipeline operation, so this kind of microcontroller can run at a higher speed at a lower clock frequency, thus reducing the electromagnetic radiation of the system and improving the electromagnetic compatibility of the system.

When selecting other digital logic devices, consider their edge rate. The amount of rf energy produced by a component is not only related to its actual operating frequency, but also to its edge speed. As component speeds increase, interference from the RF loop increases, and the edge rate of any digital device is the source of rf energy generated in almost all PCBS. So choose the components that are as slow as possible with sufficient time margin.

3.2. Pcb Board Design

In the design of PCB board to optimize the layout and wiring design, there are two problems need to be elaborated here, one is the grounding problem, the other is the trace line segmentation problem.

3.2.1. Ground Wire Design

Due to the existence of ground impedance, the current flowing in the ground will generate voltage on the ground, through the coupling of the ground wire into the circuit, causing interference of the ground wire, so that the function of the system is affected, so a good grounding system is an important measure to suppress electromagnetic interference. The following principles are adopted for grounding in the system: when the signal working frequency is less than 1MHz, single point grounding is adopted; When the signal frequency is larger than 10 MHz, multi-point grounding is adopted.

3.2.2. Trace Division And 3-W Principle

In the system design, the clock signal should be as straight and short as possible, and the use of the hole as little as possible, because the hole will increase the trace self-induction, trace self-induction can make the quality of the useful signal worse or generate potential RF radiation. In addition, there will be crosstalk influence between PCB board and line, which can make data line, address line, control line and I/O circuit by cross influence and coupling influence, and this kind of interference problem mainly comes from clock and periodic signal. To suppress the above effects, the 3-W wiring principle is used in the design (the distance between two traces should be greater than twice the width of a single trace). If the width of the clock line in the system is 0.25mm, no other trace can appear within a distance less than 0.5mm), minimize the coupling between trace and signal, so that the signal flow and return flow can be correctly connected and cancelled. See Fig. 3.

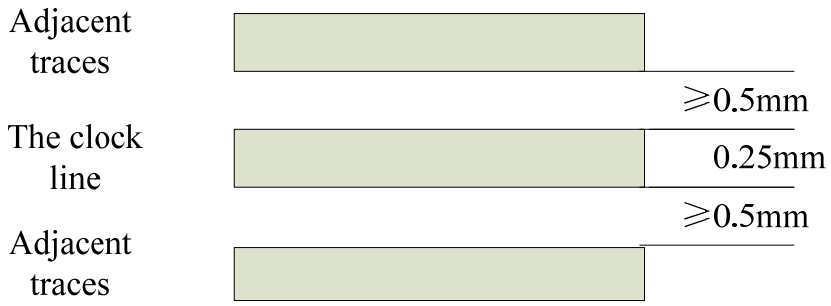

Figure 3. Design of 3-W principle

3.3. Software Anti-Interference Technology

Serious electromagnetic interference exists in the complex operation environment of EMC, which will destroy the timing of digital signals, change the contents of CPU registers, and cause the program to 'run-away' or 'enter into an infinite loop' phenomenon. Therefore, the reliability of software plays an important role in improving the performance of the whole system. Due to the large number of switching inputs in the electric end door control system, the interference of the input switching signal is usually a series of discrete sharp pulses superimposed on the effective level. Sometimes, it can't be effectively suppressed by the hardware circuit. Therefore, special anti-jamming design of switching software is needed in the control system. Its basic idea is to use the method of repeated detection to detect the input signal: repeatedly detect the input data in the interface, if the detection results are completely consistent, it is the true input signal; If inconsistent, it is a false input signal. If the time of interference is T and the number of repeated detection is K, the time interval between two adjacent detections is T =T/K. Fig. 4 shows the program flow of the repeated detection method. If the two adjacent detection results are equal, 'J' counts. If not, 'I' counts. After K repetitions, the results of 'I 'and 'J' are judged to determine the authenticity of the input signal.

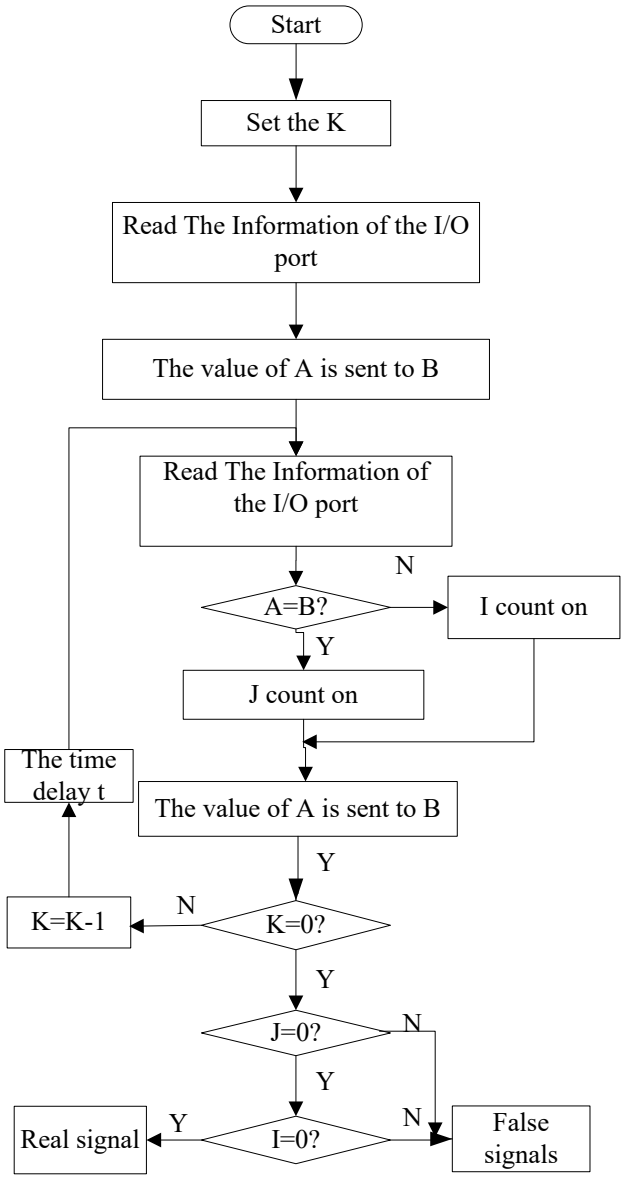

Figure 4. Flowchart of repetition detection

4. Conclusions

With the rapid development of electronic technology and computer technology, the number of electric and electronic equipment used in EMU is increasing greatly. In addition, the electromagnetic environment of the road condition is also very complex, which makes the electromagnetic interference problem in the car very prominent. In order to improve the reliability of the control system of the electric end door of EMU, EMC design becomes a very important factor. In this paper, the main electromagnetic interference source of electric end door control system is studied and analyzed, and the electromagnetic compatibility design of software and hardware of the system is discussed.

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