

## **Motor protector's EMC design based on DSPIC single chip microcomputer control**

Jinye Yang<sup>1</sup>, Jianmin Wu<sup>1</sup>, Meijuan Yang<sup>2</sup>, Fei Liu<sup>1</sup>, Chuanlong Xi<sup>1</sup>  
(1. School of Mechanical Engineering, Shanghai University Of Engineering Science, China)  
(2. School of numerical control technology, Jining technician college Science, China)

---

**ABSTRACT:** For weakening motor protector electromagnetic interference of the control system, improve the motor protector the veracity and reliability of control system, using DSPIC single-chip computer as the microprocessor, and from two aspects of hardware and software to analysis and design, proposed to the DSPIC of electromagnetic compatibility design of the control of motor protector. To eliminate the interference between the control module of the system, the decrease in signal transmission system between line and the effect of electromagnetic interference in the control system in order to generate source and route of transmission, designed the four levels of control circuit board structure. Shielding, isolation and kalman filtering and other hardware anti-interference techniques and software anti-interference technology such as software watchdog, making the DSPIC single chip microcomputer control motor protector to EMC standards.

**Keywords :** EMC, DSPIC, motor protector.

---

### **I. INTRODUCTION**

According to the American association of electrical and electronic engineers for the definition of electromagnetic compatibility, EMC is refers to the equipment or system meets the requirements in the electromagnetic environment is not in the environment to its running any equipment to produce intolerable electromagnetic disturbance ability. Therefore, the requirements of the EMC include two aspects: on the one hand, refers to the equipment in normal operation of the process towards the environment in which the electromagnetic disturbance cannot exceed a certain limit; On the other hand refers to the equipment for the environment of electromagnetic disturbance has a certain degree of immunity, namely electromagnetic sensitivity. Electromagnetic compatibility design of the purpose is to make electronic devices can inhibit a variety of external interference, make the electronic equipment can work normally in the specific electromagnetic environment, and also can reduce the electronic device itself electromagnetic interference to other electronic equipment.

In today's digital era background, the DSP with its obvious speed advantages and powerful data processing ability quickly preempted market, while the DSPIC is a single-chip microcomputer control characteristics of the combined with the advantages of DSP high speed computing devices, it removes the current demand in the similar design of additional component, thus reduced the PCB space, also reduces the system cost. But as a result of motor protector work environment is relatively poor, the electromagnetic interference sources are more, plus the DSPIC itself is a complex structure of high frequency mode, several circuit hybrid system, seriously affected the stability and safety of the control system of motor protector. To reduce electromagnetic interference, makes the motor protector according to the set of expected value, operation must be conducted when the motor protector control system in the development of EMC design.

### **II. Motor protector way electromagnetic interference sources and control system**

Due to the complexity of the scene environment, control system around there are a lot of electromagnetic interference, can be introduced into internal control system through the following ways: one is the input system, the sensor collected data and the actual value is large; Second, internal control system, internal pointer to unknown cause the program! Not carried out in accordance with the people expected

Execute! Control state disorder; Three is the output system! Output signal is consistent with the expected control signal process, lead to a series of serious consequences [1]. Electromagnetic interference sources in the surrounding environment control system mainly include the following:

: (1) the perceptual load motor in the inevitable existence of inductive components, a series of pulses in the perceptual load disconnect instant, and the system input accumulated, eventually make the range of the interference level than the system components of noise threshold.

Dynamic RAM (2) : to the capacitor discharge as the basic principle, the normal working state down peak electric current is 100 ma, at the same time frequency can be as high as 100 MHZ, thus it can be produced by crosstalk noise and public impedance causing interference to the world.

(3) power supply: as the control modules in the system to work with dc power supply, and public power grid can provide the ac power signal, the system will therefore need to design a certain module in the alternating current (ac) in the power grid rectifier [2]. This module will work itself when the electromagnetic noise, together with the power grid in the high frequency noise transmitted to the control system circuit boards, affect the normal work of the other modules.

(4) generator and transformer: its radiation while working out the high frequency electromagnetic wave, on the surrounding causing interference of other components.

(5) PCB wiring: the system circuit board stratification is not reasonable, the signal line layout is not standard, on the ground, the decoupling and shielding design is not perfect cause mutual interference between each module.

### III. Motor protector hardware anti-interference design of the control system

#### 3.1 the PCB design

Control circuit board as shown in figure (1) the four layers of circuit boards, reduces the power line and the impedance of the ground, reduce the circuit loop area. Ground plane design in the second layer, the power supply design in the third layer, high speed signal to choose walking on top of the line, low speed signal on the bottom line, as a result of the CPU clock input, the clock generator and crystals are easy to produce radiation noise, impact on other parts, so when the design to make it close to the ground plane, at the same time, the clock circuit and the distance between the I/O signal lines to appropriately increase, or block them, in order to weaken the influence between each other. In addition, PCB printing line direction to avoid the mutation, the extending along a direction as far as possible, otherwise it will produce radio frequency interference.

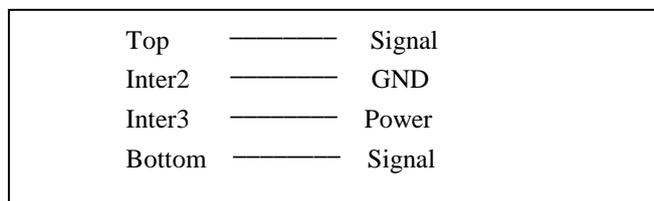


Fig.1 Diagram of the four-layer PCB design

#### 2.2 the filter design

To weaken the influence of the external signal interference on the system circuit board, to enter the internal signal filtering, so in the power part adopts source filter and spatial isolation measures. Possible because of the high frequency component, power supply board will produce larger radio frequency electromagnetic energy, flows through the system circuit board can be reduced by the decoupling capacitor surge current peak, the power supply layer and ground layer closely adjacent to form a decoupling capacitor, must connect 0.1 u F centralized capacitor, consideration should be given at the same time between the two layers of inductance and the resonance frequency, bypass capacitors can be used to eliminate the power supply module, such as the high frequency noise, thus inhibiting common-mode interference, capacitors used to reduced voltage fluctuation due to switch is closed, the development of a system can be designed with the decoupling capacitor and consideration, used to suppress the components caused by current flowing through the change of noise.

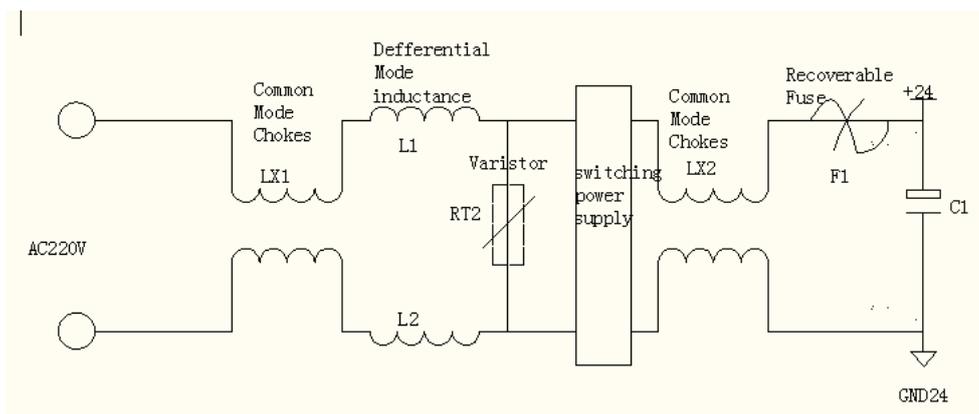


Fig 2 Filter circuit schematics

In front of the circuit is divided into two stage filter, switching power supply for the first level filter, switching power supply back for the second filter. After ac 220 v input common-mode choke LX1 filter, and then into the differential mode inductance L1 and L2 filtering, after switching power supply 24 v dc output voltage. As long as space allows common mode choke LX1 volume can be as far as possible big, which can effectively prevent the pulse train interference. Varistor RT2 can effectively prevent the bad switch power surge voltage. Common mode choke LX2 with electrolytic capacitor C1 is filtering effect, recoverable fuse F1 is to prevent the level after a short circuit for 24 v switching power supply. As a result of the switching power supply before level 220 v high voltage, so should pay attention to in the design of print circuit board wiring strength separation.

### 2.3 shielding design

Shielding technology by using shield to weaken the influence of electromagnetic interference, the main there are two purposes: first is to avoid regional internal to the external electromagnetic energy loss which affects the other components, the second is weakened regional external electromagnetic energy impact on the internal components of the region, in system of PCB production, interference signal lines shall be separate block or twisted together as far as possible in order to eliminate the coupling [3]. Because in the electromagnetic shielding conductive shield to make sure the continuity. So you can use filter connector for shield connection, filtering on interfaces to ensure the completeness of the shield.

## IV. Motor protector software anti-interference design of the control system

### 3.1 digital filtering technology

By writing a certain computer, a frequency signal filtering, to reduce the proportion of the target signal interference. For periodic interference, can use PSDIC within two A/D conversion elements to eliminate interference signals: for random disturbance, can use digital filtering technology of interference of the target signal to weaken and eliminate # digital filtering technology to deal with small frequency signal! Overcomes the defect of the hardware filter, at the same time, the program running state is influenced by the outside world smaller than a hardware, can keep stable in the process of work, low error rate, in the program design the arithmetic average filtering module, improved the control quality of the motor.

### 3.2 instruction redundancy technology

Refer to the appropriate placement of the program memory write some word stanza instruction NOP and some important data tables and procedures as a backup, to ensure stable and reliable control of motor control system. When the CPU DSPIC interference, mistaking may be some operand as instruction code to execute, cause IP pointer confusion, lead to motor does not operate as intended. When the CPU of the CS register IP pointer to a single byte instruction, will return to normal operation of the program. Because the DSPIC data storage based on data pages, to prevent the program runs is disorder, to perform operations on data across pages deal with the data under the data pages to fill, should indicate the data in the page at the same time, guarantee the regular operation of the motor.

### 3.3 software trap technique

Refers to the related code "by a unconditional jump instruction guide in the abnormal state running program to jump to a program for the area of error handling, using the instruction redundancy technology to reset the run fly program to meet the following two conditions: first, in the CS register pointer must point to the program area, shall be carried out by the second

Redundant instruction, thus has certain limitation. . Adopted in the design of the following 3 instruction constitutes the software trap:

```
NOP
NOP
JMP  ERR
```

### 3.4 software watchdog technology

Watchdog timer (WDT) will enter an infinite loop is the main purpose of the program back to normal to run the program "make equipment to recover from failure, its main model is to use A and B two timer, A monitor to B, B to monitor system program, the main program is on A monitor, the annular interrupted surveillance system. When the normal execution of the main program, each B through A cycle counter plus 1, detect the working state of A to B, if the result is normal, regularly make counter reset. The WDT is the ring in the monitoring system timer B, if the main program into dead circulation, WDT not promptly reset making counter overflow, causing reduction of the whole control system, control system out of the infinite loop.

## V. Conclusion

This design strictly abide by the basic principles of electromagnetic compatibility design, from two aspects of hardware and software, puts forward some specific measures to improve motor electromagnetic compatibility, according to the modular design principle adopted four layers circuit board structure of the three areas, weakening the entangled within the system module, reduces the sensitivity of the control system to EMI, so as to make the motor in strict accordance with the expected value, the motor control system design of EMI test has been used for a certain type of brushless dc motor, the practical application shows that the control system program is running in good condition, the motor running condition has reached the expected design purpose.

## References

- [1] WANG Ya-ping. EMC design of brushless DC motor experimental platform based on DSP[J]. *Small & Special Electrical Machines*,2005(6):14-16.
- [2] ZHOU Chao, LV Jian, DENG Hao. Embedded systems electromanagetic compatibility design research[J].
- [3] *Softwar Guide* , 2011,10(1):21-23.
- [4] ZHU Shi-qiang, YIN Ya-long. Design on EMC of motor system based on DSP[J]. *Micromotors*, 2010,43(3):70-72.
- [5] CAI Hong, ZOU Xue-feng, LUO Yang. Brief analysis shunt capacitor's characterislic and application in PCB[J]. *Electronics & Packaging*, 2010(7):35-39
- [6] LI Cheng-bin, HU Sheng-qing. Electromagnetic compatibility design of the MCU system[J]. *Automation & Instrumentation*, 2000(2):28-30.
- [7] GUO Jin, WANG, Ba-song. The research of brushless de motor control system based on DSP[J].
- [8] *Silicon Valley*, 2011(12):94,118.
- [9] Maanchur C, Erven C C. Development of a model for predicling Ticker from electric are furnaces[J]: *IEEE Transactions on Power Delivery*,1992,7(1):416-420.
- [10] Benchaita L, Saagate S, Salemnia A. A comparison of voltage source and current source shunt active filter by simulation and experimentation [J]. *IEEE Transactions Power System* , 1999,14(2):642-647.
- [11] ZENG Yu, MA Xia. CAD of chebyshev filters[J]. *Semiconductor Magazine*, 1996(4):21-23.
- [12] GAO Da-wei , SUN Xiao-ru. A detecting method of current distortion of Electric Power
- [13] *Systems*, 2000,24(13):45-47.