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# Research of Anti Electromagnetic Interference Technology for PMSM Driving System

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**Abstract.** The permanent magnet synchronous motor (PMSM) is a key part of hybrid power vehicle's driving system, and the reliability of its control is important for the normal use. With more and more electronic equipments settled in the vehicle, the type and quantity of electromagnetic interference are increasing, and will finally affect the motor driving system's reliability. This paper analyzed the sources of interferences in the driving system, and solved them with circuit preplan and design. With the experiment, these solutions were effective and improved the driving system's reliability.

**Keywords:** Permanent magnet synchronous motor (PMSM); electromagnetic interference; driving system

## 1. Introduction

The permanent magnet synchronous motor (PMSM) is a key part of the hybrid power vehicle's driving system, and the reliability of its driving is important for the normal use. With more and more electronic equipments settled in the vehicle, the type and quantity of electromagnetic interference are increasing, and will finally affect the motor driving system's reliability. It is necessary to analyze the possible interferences that may affect the PMSM driving system, and choose appropriate solutions to eliminate them. In this way, the PMSM driving system's reliability can be improved.

The system electromagnetic interference is defined as follows: any conductive and radiant electromagnetic energy that may disturb or block radio communications, and degrade or limit other electronic equipments performances [1]. This shows that the electromagnetic interferences of PMSM are from conduction and radiation paths, and each of them have its own characteristics. This paper will analyzed the PMSM driving system's electromagnetic interferences in these two paths and discuss the solutions to solve them.

## 2. Electromagnetic Interference and Effects

The electromagnetic interference in the PMSM driving system includes power supply voltage fluctuation, ground potential fluctuation, interference signal radiant coupling, and static discharge and so on. Their paths are multiple and have different effects to the driving system.

### 2.1 Power supply voltage fluctuation

Power supply voltage fluctuation is usually seen in the PMSM driving system. It is supply voltage's sudden change in the key circuits. The reasons are mainly bad power supply circuit design, bad IC choice, not enough power supply for the whole circuit and so on. The IC, modules and other active devices in the circuits

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need steady power supply to drive their inner circuits, clock and I/O. For the digital ones, if power supply voltage fluctuation exceeds the normal range, the inner circuits will damaged or even destroyed. For the analog ones, it will change the A/D and D/A conversion results and finally affect the PMSM driving.

### 2.2 Ground potential fluctuation

The reasons of ground potential fluctuation are no full isolation between low voltage circuits and high voltage circuits, multiple connections between digital and analog ground and so on. If there is ground potential fluctuation in high voltage circuits or digital ground, the relative low voltage circuits or analog ground potential will be affected.

The ground potential fluctuation will bring not only fluctuation to power supply voltage, but also interferences to other circuits in the conduction path. Finally, this will affect the PMSM driving system.

### 2.3 Interference signal radiant coupling

The resource of interference signal radiant coupling is from high speed signal and transient interference signal in the circuits. For need of transmission and application, high speed signal's edge is always sharp, and contains a lot of useless harmonics in it. Based on Maxwell equations, these harmonics will affect neighbor conduction lines by the space coupling path and change its inner signal's shape and affect relative circuits. The transient interference signal also produces this interference.

### 2.4 Static Discharge

The static discharge is a complex process, and in fact it is electric charges movement between two objects with different potential when they are getting close. It may break down some IC and modules or bring voltage fluctuation to the key circuits. On the other hand, when the static discharge happens, the interference signal will couple into other circuits by space path and bring them some signal radiant coupling problems.

## 3. Structure of PMSM Driving System

The structure of PMSM driving system is shown in figure 1. It contains three parts: motor control system with DSP (Digital Signal Processing) as its core, data acquisition system with MCU (Micro Controller Unit) and sensors as its core and power driving system with power MOSFET (MetalOxide Semicoductor Field Effect Transistor) and IGBT (Insulated Gate Bipolar Transistor) as its core. The control system and data acquisition system are low voltage circuits. They share a 5V power supply and exchange data by CAN (Control Area Network). The power driving system is high voltage circuits. It receives signals from control system by cables and uses them to switch power MOSFET and IGBT on and off.

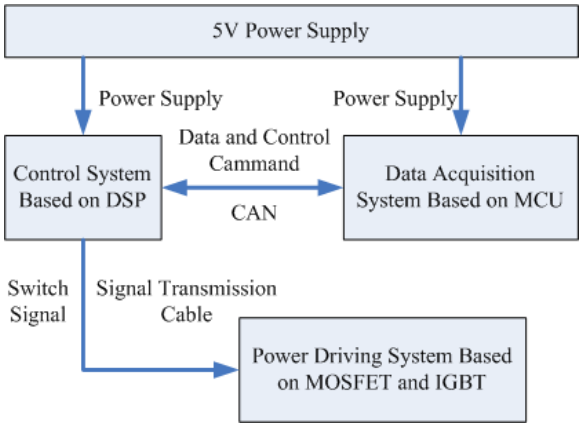


Figure 1. Structure of PMSM driving system

In the PMSM driving system, the power supply circuit, CAN driving circuit and signal transmission cable are typical key components. If there is no anti electromagnetic interferences solutions, the performance and reliability of PMSM driving system will be affected in use.

# 4. Anti Electromagnetic Interference Solutions

## 4.1 Power supply circuit design

The electromagnetic interferences in the power supply circuit are mainly supply voltage fluctuation, ground potential fluctuation, static discharge and so on. The corresponding solutions are choosing suitable power supply IC with wide range of input voltage ones, classify the types of ground points and replacing them in the preplan of circuits, and applying filter circuits and TVS (Transient Voltage Suppressor) components in the circuits.

In the motor control system, the TPS767D318 produced by TI is the power supply IC. It supplies the power for DSP, MCU and other components in the low power circuits. The range of its input voltage is 2.8V-10V, output current is 1A, and dual output voltages are 1.764V-1.836V and 3.234V-3.366V. In its design, capacitances are connected to TP767D318 input and output pins to filter high frequency interference signals in the power supply. If the design budget is enough, special filter module is better choice for some interference signals in appointed frequency bands, and its effect is better than the capacitances.

Power supply circuit with TPS767D318 is shown in figure 2 [2].

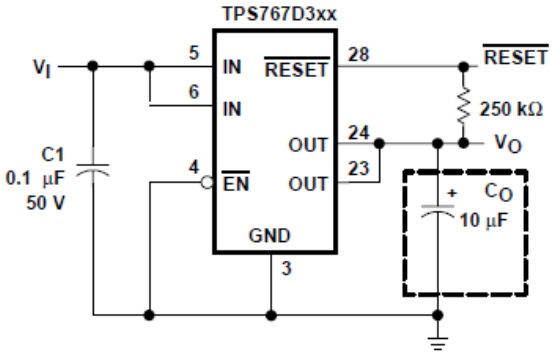


Figure 2. Power supply circuit with TPS767D318

On the other hand, digital ground and analog ground are preplanned before the circuit design. In the design, they are separated into two different parts and connected by one magnetic bead. The bead will reduce the high frequency interference transmitting between them. The design with magnetic bead is shown in figure 3.

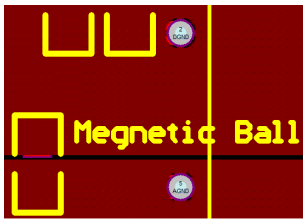


Figure 3. Design with magnetic bead

For the static discharge problem, a TVS named P6KE6.8 is used between 5V power supply and ground. When the static discharge happens, the TVS can be conductive immediately to free the current and avoid damage to the PMSM driving system. The design with TVS P6KE6.8 is shown in figure 4.

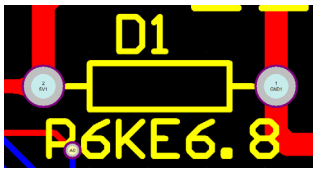


Figure 4. Design with TVS P6KE6.8

## 4.2 CAN driving circuit design

The CAN is an important part in the PMSM driving system, and all the control commands and motor information data are transmitted by it. The transmission quality and efficiency are decided by its driving circuit's reliability when the electromagnetic interference happens. The interference includes ground potential fluctuation and useless harmonic in the data signals.

The CAN drive IC used in the PMSM driving system is PCA82C250 produced by NXP, figure 5 shows its design circuit with photo coupler and isolation power supply [3]. The photo coupler 6N137 is used to filter high frequency interference in the data signals and a DCP010505 produced by TI is used to design an isolation power supply. It is shown in figure 6. By this design, the interferences are transmitted into the ground layer and absorbed.

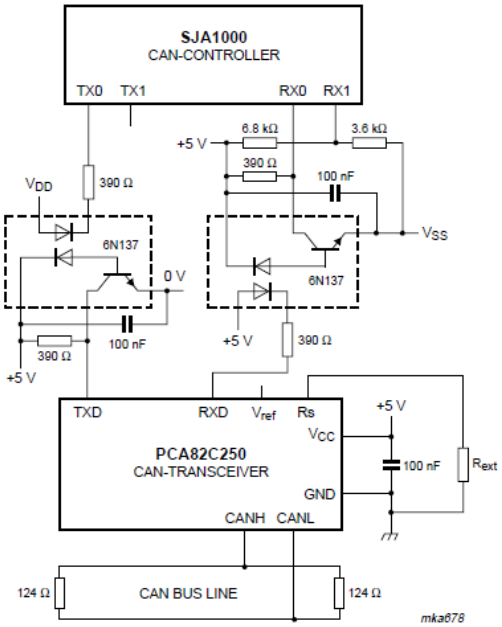


Figure 5. CAN drive circuit design

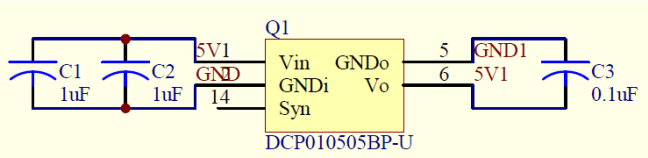


Figure 6. Isolation power supply design

## 4.3 Signal transmission cable design

The signal transmission cable is used to transmit switch signals to the power driving system. If the switch signals are changed by the electromagnetic interferences, the order of power components' switch will be wrong and the safety of PMSM will be affected, even the power components may be destroyed. The interference is mainly useless harmonics in the switching signals by the space radiant coupling.

For this problem, shielding of signal transmission cable is an effective solution. The cable for important signal transmission must be 360 degrees shielded and grounded at one or two ends. In this way, the interference that coupled on the cable can be transmitted into the ground immediately and has no harm to the PMSM driving system. The cable for normal signal transmission can be simply shielded and grounded at one end to reduce the hardware design cost.

In the design, the optical isolation device and optical fiber is another choice to replace the metal cable to transmit signals. It needs no shielding and grounding in application. Because the optical fiber is easily broken or damaged, it is only fit for the system that not needs to remove it frequently.

## 5. Experiment Verification

In this paper, a 24V/12W PMSM driving system is improved to verify the anti electromagnetic interference design's effect. It is shown in figure 7.

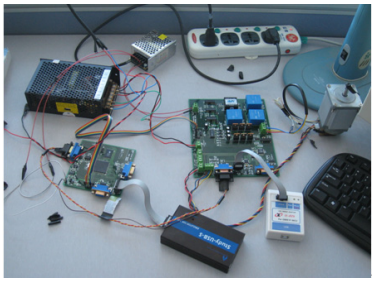

Figure 7. 24V/12W PMSM driving system

Before the improvement, the electromagnetic interference had not been considered, some problems such as power supply voltage fluctuation and bad motor speed stability appeared in the use.

In the anti electromagnetic interference improvement, the power supply design, grounding design, and static discharge design were reviewed and some problems were found. For example, there was no filter circuit for power supply, the digital ground and analog ground are not separated, no TVS component is used to free the static discharge current and so on. These bugs resulted the PMSM driving system problems.

After the improvement design, these bugs are solved. For example, special filter circuit is used in power supply circuits, the digital ground and analog ground are separated and connected by one magnetic bead, the TVS components are used in power supply and CAN drive circuit design and so on. In the experiment, the power supply voltage and motor speed stability are much better than before. The anti electromagnetic interference design is effective.

## 6. Conclusion

With the development of PMSM application in the vehicle driving and other industrial area, the electromagnetic interferences the affect PMSM driving system are more and more. The relative solutions must be considered before the PMSM driving system design.

In the system hardware choosing, with the development of electronic technology, most manufactures have known the electromagnetic interference harm and paid attentions to their new product's reliability. These products should be firstly considered and properly used in the design. In this way, the cost of designing additional anti electromagnetic interference circuits can be saved.

On the other hand, application of new industrial control bus can obviously reduce the interference effect to data transmission. For example, FlexRay is a new vehicle control area network with two channels data transmission at 10Mbps and own different CRC check for each of them. With help of this, the data transmission can get not only faster speed, but also more reliability. If there is something wrong in the transmission, the bus still has enough time to resend the data.

The types and reasons of electromagnetic interference in the PMSM driving system are complex, and the solutions of it are multiple. The PMSM driving system's reliability can be guaranteed if these solutions properly applied in the system design.

## 7. References


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[2] Electronic Publication: TPS767D3XX Datasheet (TI), pp.21–22.

[3] Electronic Publication: PCA82C250 Datasheet (NXP), pp.7–8.