

Research of Choice and Design for PMSM Driving System Data Transmission and Control Communication Bus

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Abstract. The permanent magnet synchronous motor (PMSM) has some advantages such as big power density and reliability, and been widely used in vehicle driving and other industrial area. The space vector pulse width modulation (SVPWM) is the main technology in PMSM driving control. The motor information contains rotor magnet field position, motor speed, and stator current and so on. Speed and reliability of its transmission is not only the base of SVPWM calculation in the control system, but also the guarantee for users to adjust the motor control command in time. The research on choice and design for PMSM driving system data transmission and communication bus is important.

Keywords: Permanent magnet synchronous motor (PMSM); driving system; bus

1. Introduction

The PMSM has some advantages such as big power density and reliability, and been widely used in vehicle driving and other industrial area. The SVPWM is the main technology in PMSM driving control. Compared with sine pulse width modulation (SPWM), SVPWM has some advantages such as better using for direct current voltage, lower torque vibration, small current aberration and so on [1]. A typical PMSM driving system based on SVPWM technology is shown in figure 1.

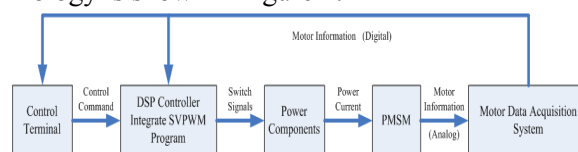


Figure 1. PMSM driving system based on SVPWM technology

The key step for PMSM driving system SVPWM control is high speed and reliable transmission for motor information such as rotor magnet field position, motor speed, stator current and so on. On the one hand, by this information, system power component's switch order can be calculated with SVPWM program embedded in the control IC (Integration Circuit). In this way, magnet field produced by stator current can be controlled, and the speed and reliability of PMSM control can be guaranteed. On the other hand, users need this information to adjust the motor control command to meet the final goal. The research of choice and design for PMSM driving system data transmission and communication bus is important.

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2. Choice for Data Transmission and Control Communication Bus

2.1 Choice for data transmission bus

In the PMSM driving system, the data transmission bus is mainly used for data exchange between motor data acquisition and motor control system. The speed and reliability are two important requirements in its choice. The CAN (Control Area Network) and FlexRay are both high speed and reliability buses, and suit for motor control use.

CAN is widely used in industrial area such as vehicle design and so on. It is a real-time, high reliability serial communication protocol with multiple nodes. The advantages of it are:

- Based on multiple host competition and nondestructive arbitration, the data can be transmitted at 1Mbps by its precedence. Compared with traditional host-customer mode, this obviously enhanced its speed.
- The differential transmission, CRC (Cycle Redundancy Check), bus error state watching, frame check and bit filling technology guaranteed the reliability of data transmission.
- The CAN has been integrated in a lot of microcontrollers and needs no additional work in hardware design.

FlexRay is the next generation vehicle high speed network. In its protocol, there are not only the advantages such as high speed and reliability in the CAN, but also improvement for new application needs. The advantages of it are:

- The dual channels redundancy and separate CRC design strengthen its reliability of data transmission.
- It has a 10Mbps transmission speed for each channel and even can be 20Mbps if the dual channels redundancy design is not used.

The FlexRay is better than CAN in speed and reliability area, but price and IC types are its disadvantages. Because there are not enough manufactures, the IC which supports FlexRay is little and price is high. On the other hand, the CAN has been integrated in lots of microcontrollers and its price is lower. Finally, the CAN is chosen as the data transmission bus.

2.2 Choice for control communication bus

In the PMSM driving system, the control communication bus is mainly used for command and data exchange among motor data acquisition system, motor control system and control terminal (such as computer, touch screen). The speed, reliability and common connector are important requirements in its choice. RS-232 and USB (Universal Serial Bus) are common connectors in control terminals, and suit for control communication use.

RS-232 is a common communication bus in the circuit design. Almost all the microcontrollers integrate it. In the 5V system, cooperated with a MAX232 driver IC, the controllers can easily exchange data with it.

As an old bus, there are some disadvantages in its protocol. First, its transmission speed is lower and can not support multiple nodes communication. Second, the data is transmitted by common mode signal and easily affected by electromagnetic interferences. Third, there is no CRC in its protocol and can not guarantee the reliability of data.

USB is also a common communication bus in the control terminals. Depending on different editions, the USB has three types of speed which are 1.5Mbps, 12Mbps and 480Mbps [2]. As a widely used bus, many manufactures integrate it in ICs or produce special ICs for extended circuit design. The advantages of it are:

- Three types of speed (1.5Mbps, 12Mbps and 480Mbps) and four types of transmission (block, synchronous, interrupt and control mode) can be combined in design depending on the system requirements.
- The reliability is guaranteed by hardware design and data transmission protocol. The standard driver, receiver and cable design avoid the interference effect, and data error detection in protocol can find the integrality problem.

Compared with RS-232, the USB is better choice not only in the speed, but also in the reliability in the data transmission, and it is chosen as the control communication bus.

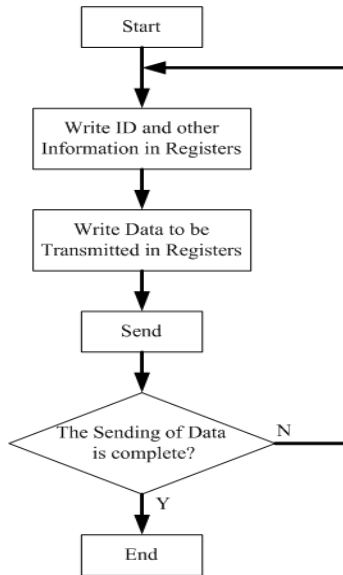


Figure 5. Process of Data Transmission

3.2 Design for control communication bus

For the safety reason, the control terminal is usually far away from control system in the PMSM driving system. If they are directly connected by USB cable, the resistor in cable will attenuate the signals. Considered the advantages of CAN in anti electromagnetic interference, the interface board is used in control communication bus design. The schematic diagram of it is shown in figure 6.

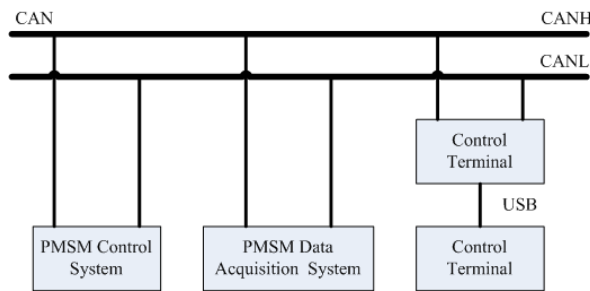


Figure 6. Schematic diagram of interface board

In the CAN interface design, the C8051F500+PCA82C250 mode is used and in the USB interface design the C8051F500+CH372 mode is used.

The CH372 is a USB interface chip produced by WCH. On the chip there are 8 bits data bus, read/write/chip-selection control lines and interrupt output. It can be easily connected to C8051F500. In the software design, CH372 have simple API for communication with control terminals [3].

In the PMSM driving system, the internal firmware mode of CH372 is used. In this mode, the CH372 internal firmware processes all the USB communication requirements and C8051F500 only needs to respond the interruption from the CH372. In the hardware design, the CH372 is connected to C8015F500 special pins and uses the C8051F500 external memory interface (EMI) to exchange data. This simplified the hardware design for control communication bus.

The circuit schematic diagram of USB interface is shown in figure 7.

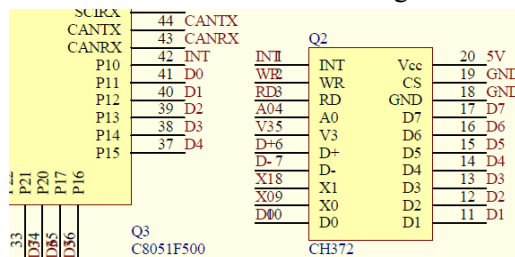


Figure 7. Circuit schematic diagram of USB interface

On the interface board, the C80151F500 and CH372 exchange data by interruptions. When the CH372 completed a data transmission or received some data, an interruption will be sent to C8051F500 and C8051F500 will respond it and process the requirements. The CH372 uses communication API to exchange data with control terminal and shows the motor information on it. The schematic diagram of data receiving and transmission between CH372 and control terminal is shown in figure 8 and figure 9.

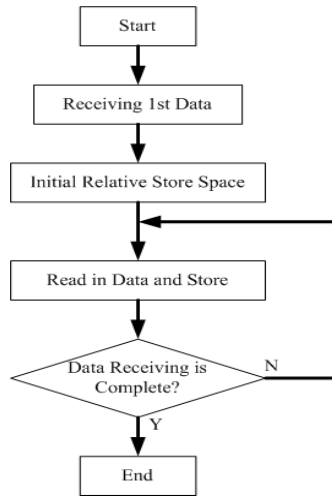


Figure 8. Schematic diagram of data receiving

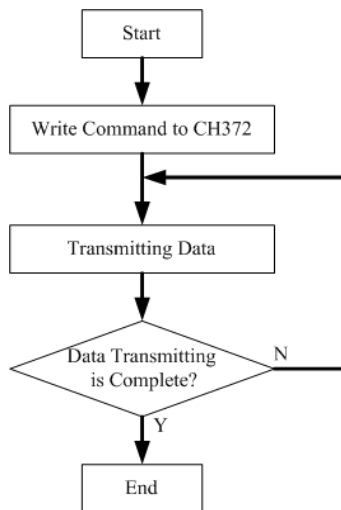


Figure 9. Schematic diagram of data transmission

4. Experiment Verification

For a 24V/12W PMSM, a driving control system based on CAN and USB is designed, and a computer is used as the control terminal. The real system is shown in figure 10. For convenient use, the interface board is designed with motor data acquisition system together, so there are only two PCBs in the figure 10.

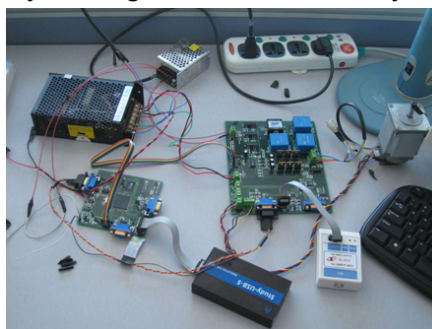


Figure 10. 24V/12W PMSM driving control system

The relative software on control terminal is shown in figure 11.

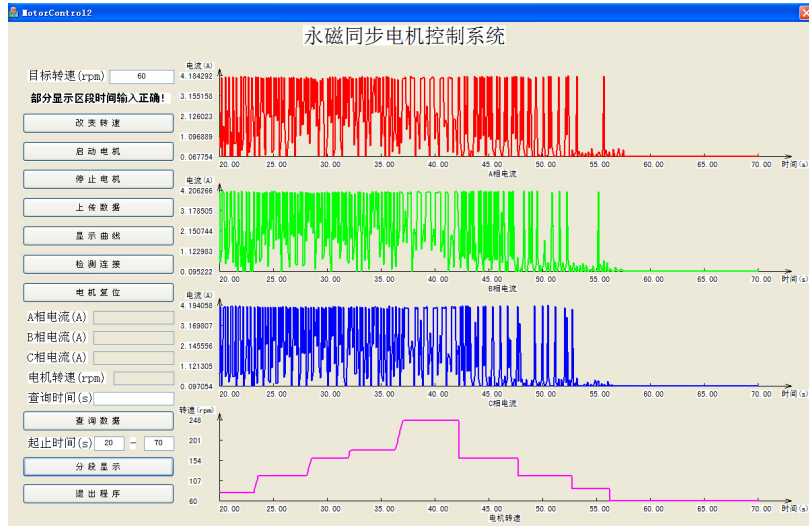


Figure 11. Relative software on control terminal

In the experiment, the data transmission and control communication buses were effective, the PMSM driving control system completed all the commands and the motor information was shown in the control terminal completely. The choice and design for data transmission and control communication bus are successful.

5. Conclusion

The data transmission and control communication bus are key parts in the PMSM driving control system design. The former guarantees the motor information transmission in the system and the later guarantees the user's adjustment for PMSM control. The choice and design of them is important.

The CAN is a typical control area network and has good performance in anti electromagnetic interferences and so on. The USB is integrated in almost all the control terminals, using it in the design can save not only the hardware cost, but also the software design time.

With the careful design and final experiment, the design of PMSM driving control system with CAN and USB is successful, and the control command and motor information transmission is reliable and meeting the design requirements. The high speed and reliable control for the PMSM is achieved.

6. References

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