Research on Suppression Technology of Electromagnetic Interference in CAN Communication

Weibo Li, Cong Xu, Wei Li, Qi Li and Yue Lu
Wuhan University of Technology, College of Automated institute, 430070, Wuhan
liweibo@whut.edu.cn, 13986156805

Abstract. CAN communication is a relatively common communication method used in the industrial and automotive fields. It analyses the main cause of communication interference in the electromagnetic interference phenomenon of CAN communication in industry. Due to factors such as circuit imbalance and space electromagnetic field, the CAN bus will cause common mode interference due to radiation. The strong interference generated in the field may cause the relay to malfunction and cause the wrong signal. Therefore, this paper proposes protection measures against the malfunction of the relay from the perspective of signal input and relay triggering, and has strong anti-interference ability after testing in actual projects.

1. Introduction
CAN bus is mainly used in data communication in the field of industrial control. It is a communication bus technology based on controller LAN bus control [1]. It has the advantages of fast communication speed, long transmission distance and high reliability. At present, CAN bus technology is mainly applied in industrial environments and on-board equipment [2]. The production environment is relatively noisy, and there are many interference factors, which have a great influence on the reliability and accuracy of signal transmission in CAN communication. With the continuous improvement of the automation and intelligent level of the power system, the concentration of the device controller is getting higher and higher, and it is highly susceptible to electromagnetic interference. Especially in the widespread use of relays in these devices, there are large electromagnetic interferences, often This causes the relays in some devices to malfunction or malfunction. In severe cases, the switching switches frequently jump. In particular, the widespread use of large-capacity power electronic devices, such as switching devices in large-capacity inverter devices, generates high di/dt, du/dt during high-speed switching, and is generated by charge and discharge of parasitic capacitance and inductance. Common mode voltage and current form severe common mode electromagnetic interference to the inverter itself and other electronic devices. They are easily coupled to other weak signal control devices in a confined space (such as a ship mobile platform), resulting in the above phenomenon. Occurs, especially for CAN-like communication devices, which can affect their normal operation. To this end, this paper conducts experimental research on this aspect of the problem and provides solutions to solve their interference problems on the spot.

2. Basic principle of CAN communication
Different from the previous communication methods that use clock signals to synchronize, CAN communication consists of two signal lines, CAN_H and CAN_L [3], which together form a set of differential signals for data transmission. The multi-node of the device is connected to the CAN bus.
When the device has a signal, the levels of the CAN_H and CAN_L signal lines are respectively set to 3.5V and 1.5V, and there is a voltage drop. The signal line is formed by a 120Ω termination resistor at both ends. Data communication; when the device has no signal, the voltage of both signal lines is 2.5V, there is no voltage drop between the lines, the bus is idle, the CAN bus block diagram and working level are shown in Figure 1.

![CAN bus block diagram](image)

**Figure 1.** CAN bus block diagram

In the industrial environment, the CAN bus is used to realize data transmission and information communication between controllers. In addition to considering the technical principle under ideal conditions, it is easy to ignore the interference caused by the complex industrial field environment to the data transmission on the bus, thus destroying the accuracy of the data.

3. **Cause analysis of interference**

The common mode voltage is the potential difference between the two differential signal lines and the earth, and exists for the transmission line. The effective signal voltage transmitted on the signal line and the effective current in the loop do not change due to the existence of the common mode voltage [4]. In theory, the normal operation of the system will not be affected; while the differential mode interference voltage will affect the differential current in the loop during signal transmission, resulting in interference of signal transmission, making it the root cause of signal transmission failure. Because of this, in the anti-interference design process, we usually idealize the communication circuit engineering environment, focusing on how to filter out differential mode interference and ignore common mode interference. However, in practical applications, common mode interference cannot be ignored, but should be given enough attention, the main reasons are as follows.

The circuit has asymmetry and there will be an imbalance. Even if the same common-mode voltage is present on the two signal lines, the common-mode current generated by the same common-mode voltage is not the same, and thus converted into a differential mode that interferes with communication. Voltage and current.

The presence of common mode current will cause peripheral equipment to be exposed to radiation interference. In the industry, radiation interference is one of the key factors affecting the performance of the equipment, so the impact on the equipment should not be underestimated.

The generation of radiated interference can be based on Maxwell's equation, changing the electric field to produce a changing magnetic field, changing the magnetic field to produce a changing electric field. The inverter acts as a device that converts direct current into alternating current, which generates strong radiation interference during operation, of which single phase the working principle of the inverter is shown in Figure 2.

![Single-phase inverter](image)

**Figure 2** Single-phase inverter works
From the working principle of the inverter, we can analyse that when the inverter is working, the switch tube generates a large voltage change rate, and then charges and discharges through the parasitic capacitance $C_{com1}$, $C_{com2}$ and $C_{com3}$ to generate a potential difference $V_{com}$, which forms common mode interference, thereby causing electromagnetic the generation of interference. It can be seen that di/dt and du/dt are respectively coupled with the parasitic capacitance parameters of the stray inductance, resulting in severe interference current $i_{com}$ and interference voltage $u_{com}$ as equation (1), (2). The formula is as follows. In the case of severe electromagnetic interference, interference suppression is required. The generation of electromagnetic interference is inseparable from the three elements of electromagnetic interference. The three elements of electromagnetic interference are interference sources, coupling paths and sensitive equipment. The interference source is the inverter; the coupling path has both an external signal transmission path and a signal coupling path inside the device. Any signal transmission process will become a coupling path of electromagnetic interference; sensitive devices generally have various internal relays. Equipment such as sensitive devices.

$$i_{com} = C \frac{du}{dt}$$  

$$u_{com} = L \frac{di}{dt}$$

4. Field test phenomenon

The malfunction of the relay is generally caused by poor contact and unstable voltage. The multiple harmonics generated by the inverter during operation will propagate in the air, but more of it will propagate through the hard wire, and the electromagnetic interference in the hard wire will be stronger than the electromagnetic interference propagated in the air. The oscilloscope's test leads are suspended to measure the electromagnetic interference waveform in the air when the inverter is working, as shown in Figure 3.

![Figure 3 Measured electromagnetic interference waveform of the inverter in the air](image1)

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![Figure 4 The measured waveform of the input signal affected by electromagnetic interference](image2)

At the same time, the waveform of the digital input signal (i.e., DI signal) is monitored by an oscilloscope as shown in the blue waveform of FIG.

Analysis of the test results shown in Figure 4 shows that if such an input signal is supplied to the powered device, it will inevitably cause malfunction of various relays in the device, followed by a series of switch false jumps and signal lights. Flashing has a great impact on the normal operation of system equipment.

5. Electromagnetic interference suppression measures

Therefore, the suppression of electromagnetic interference is also based on the three elements of interference source, coupling path and sensitive equipment [5]. For the interference source inverter, rewiring is required, and the line and inverter are isolated [6]. The inverter needs to be grounded as required to minimize electromagnetic interference caused by inverter harmonics.

For the coupling path, when the economic conditions permit, the signal transmission line should be replaced with the shielded twisted pair as much as possible [7]. Where the strong electric field is used, the galvanized pipe shield should be considered. When wiring, keep away from the high voltage line, and not the high voltage. The power and signal lines are bundled together to reduce common mode
interference generated by the inverter. These measures can only reduce the electromagnetic interference of the external environment to the signal transmission process, but if there is a large amount of harmonic interference in the signal output from the inverter, it is meaningless to shield only the external interference. The most practical method is to add a relay to the signal input of the device to isolate the input signal of the device. The circuit is shown in Figure 5.

![Figure 5 signal input isolation relay and coupling](image)

Observing the circuit, we can find that diode D1 is used to prevent current from flowing backwards [8], and resistor R1 is to prevent the relay from being accidentally touched by the pulse voltage generated by electromagnetic interference in the input signal [9]. The relay completely isolates the external electromagnetic interference from the device, allowing the relay inside the device to work normally.

For sensitive devices, there are a large number of relays in the device for triggering various semaphores. However, once the relay is triggered, the relay coil will induce a magnetic field due to electromagnetic induction, and the generated magnetic field will affect it. Relays, if other relays also induce current, the contacts of the relay will always be in a state of being pulled in and out of contact, thus affecting the normal operation of the device. The coupling between the above relays is shown in Fig. 6.

In order to solve the above problems, we need to design the circuit to prevent the induced current between the relays from being accidentally touched by the relay. The circuit design is shown in Figure 5.

Observing the circuit, we can find that the diode D2 prevents the current from flowing backward, and the resistance-capacitance absorption circuit formed by the resistor R2 and the capacitor C1 is used to absorb the induced current generated in the relay, preventing the relay from malfunctioning due to the induced current.

6. Improved measured results

After taking the above three measures, the oscilloscope is used again to measure the waveform of the input signal of the device, and the measured waveform is as shown in the blue waveform of Fig. 7.

![Figure 7 Device input signal after taking protective measures](image)

From the waveform we can find that after the above series of treatments, the influence of electromagnetic interference cannot be said to have been completely eliminated, but it has been
reduced to the extent that it will not affect the equipment. At the same time, the device will not have any relay malfunction phenomenon.

7. Conclusion
In the field of industrial engineering, the sources of interference are complex, and electromagnetic interference has always been a major factor affecting equipment performance, production efficiency and production quality. In order to effectively suppress differential mode and common mode interference in engineering projects, the best strategy is to fully consider the interference problems that may be encountered before and during the project, and timely design in the system, circuit design and software design. Corresponding anti-interference measures are taken to filter out and suppress these disturbances, rather than leaving the actual environment, and to carry out after-the-fact remediation after the design is completed or run. In the project of using CAN bus to realize data communication, only by improving the electromagnetic compatibility of the CAN system to meet the requirements of electromagnetic interference resistance, the production efficiency can be improved and the service life of the equipment can be prolonged. This paper expounds the risks of CAN communication from the three aspects of interference source, coupling path and sensitive equipment, and proposes isolation at the interference source, using relay to isolate at the signal input and adding RC absorption to the coil relay. Measures such as preventing the influence of induced current effectively solve the risk of CAN communication in a strong electromagnetic interference environment and can be verified in actual projects.

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