Application Design of Armored Vehicle Power Carrier Bus System

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Abstract: The data communication technology of armored vehicle bus has been widely used. At present, these buses need to adopt special data harness, which will increase the manufacturing cost and maintenance difficulty of armored vehicles, and bring unstable factors to data transmission in armored vehicles. The data communication technology of armored vehicle power carrier bus realizes data transmission and sharing among ECU modules in armored vehicle without increasing the wiring harness in armored vehicle. In this paper, the key technologies of how to design and implement the bus are studied.

At present, there are many current bus standards for armored vehicles, among which CAN bus and J1850 are widely used. These buses all adopt special data harness, and the ECU units of armored vehicles have different requirements for data transmission. It is necessary to arrange several different data networks in armored vehicles at the same time. In addition, the realization of these data buses requires special data communication wiring harness, which increases the wiring harness, manufacturing cost and maintenance difficulty in armored vehicles, and brings unstable factors to data transmission in armored vehicles. This paper introduces a new data transmission method of armored vehicle bus, the data communication technology of armored vehicle power carrier bus. This method can realize data transmission and sharing among ECU modules in armored vehicle without increasing the inner wiring harness of armored vehicle.

1. Analysis of System Bus Communication Channel Model

Like low-voltage power line carrier system, the load of armored vehicle power line carrier system is complex and time-varying. Various types of electrical appliances are sometimes connected or disconnected, which makes the impedance characteristics of the conductor have great fluctuation. The transfer function of the system changes with the change of load at any time. It is a time-varying system. The time-varying communication channel model can be used to describe the armored vehicle power line carrier bus system. In the figure, except that noise interference is represented as additive random interference process, the other parts of the system are represented by corresponding frequency response functions. Transfer function and noise model in communication system can be obtained by measurement or theoretical analysis. This system model comprehensively summarizes the important characteristics that must be considered in the design of communication system.

To further study the characteristics of armored vehicle power line carrier system, it is necessary to determine the parameters of transmission characteristics in the channel model. In this paper, the vector network analyzer 8712ES produced by Aglient Company in the United States is used. For an armored vehicle system, it is practically impossible to accurately describe the parameters of the vehicle network. The channel model is studied experimentally. The experimental method is to treat the system as a black box, without knowing the structure of the box accurately, as long as the transfer function describing the transmission characteristics of the black box signal can be obtained through experiments to express the system.

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For the armored vehicle power line carrier communication channel, its frequency response is a slowly changing stochastic process. The stochastic process can be seen as a white noise with a variance of Q2 passing through the output of a causal stable filter. If the system of the filter is selected correctly, the stochastic process can be expressed with limited parameters.

Based on a large number of experimental measurements, the transmission characteristics of the power line carrier communication channel of armored vehicles are studied in the frequency band of 500 kHz to 10 MHz. The third-order autoregressive model of the channel's amplitude-frequency characteristics is established by using the random signal processing method. The following conclusions are drawn:

1) There is no problem of multi-aperture transmission in armored vehicle power line carrier communication channel, which is usually encountered in low-voltage power line carrier communication channel.

2) The power line carrier communication channel of armored vehicle is time-varying. In frequency domain, the time-varying only occurs in the frequency range below 5MHz, while in the frequency range above 5MHz, the time-varying is not obvious.

2. System Design

According to the analysis of system bus communication channel model, armored vehicle power carrier bus adopts armored vehicle carrier communication standards and protocols; at the same time, combined with the actual situation of data transmission rate requirements of various electrical appliances in armored vehicle, armored vehicle line harness carrier communication network with different data rates is established. The high-speed carrier communication network connects the modules which need high data transmission rate in armored vehicles, while the electrical modules which do not require high data transmission rate use the speed communication network. In this way, all the electrical appliances in the armored vehicle can be connected separately through a few power harnesses to form several subsystems. The information sharing among these subsystems is realized through the inter-network connector (gateway), which achieves the coordinated action of each electrical module of the armored vehicle and realizes the intelligent control of the armored vehicle. In the armored vehicle carrier communication system with this topological structure, a new standard of armored vehicle carrier communication bus is adopted to connect the electrical modules with the carrier communication modules.

In this design, the carrier communication system of armored vehicle adopts master-slave structure, and the overall network structure is tree-like distribution. The system includes a main control module and several slave control modules. From the perspective of network topology, the whole communication system is composed of the main control module, the armored vehicle power harness and the control module. The armored vehicle power harness also plays the role of communication channel in the system. The connection between the main control module connected to the carrier communication system of the armored vehicle and the loads such as electric doors, windows and chairs. The control information is transmitted among the control modules through the armored vehicle power harness.

3. Implementation of System Control Unit

The intelligent illumination control system of armored vehicle based on carrier communication technology includes the main control module and the slave control module. It can be seen from the figure that there is not much difference between the master control module and the slave control module except for the external interface. They include CPU module, modem module and coupling module. These are all necessary units for carrier communication. Next, the specific implementation of these modules will be discussed in detail.

Each control unit system uses PIC series MCU, the main control unit uses PIC16F877, and the slave control unit uses PIC16F873. PIC (Peripheral Interface Controller) is a series of microcontrollers launched by Microchip Company in the United States.

4. Realization of Main Control Unit

The following is the implementation of CPU in the main control unit. The main control module has no specific load control requirements. According to the different functions, it can be divided into internal system and external system. In the aspect of external system, it mainly plays the role of information exchange with external system, including man-machine interface and CAN bus module. Through this part, the system can receive commands sent from outside, and also can send the status information of each module of the system to the outside system. In the internal system, the task of the main control unit is to convert the external commands into specific control contents, send them to the slave control units in the system, and receive the status information sent from the control units, and play a management and control role in the operation of the whole system.

The external system task of the main control module is realized through its interface with the external system. The extended CAN bus interface of the system is used to communicate information with other subsystems in armored vehicles, so as to realize information sharing among the subsystems in armored vehicles, so that they can cooperate and realize intelligent control of armored vehicles. The extended keyboard module of the main control module is used to receive the control commands of operators.

The communication of internal information in bus system is realized by carrier coupling module. According to the above analysis, the signal coupling module of the system includes two parts: sending and receiving. Separating the coupling output of sending and receiving can avoid the confusion of information transmission within the system.

In addition, the main control unit also expands a system status information display module, which displays the operation status of each slave control unit in the system through a series of LED. Because the main control unit has many interfaces, the CPU is controlled by the main control unit with 33 input/output pins.

For each slave control unit, because they do not need to communicate with the external modules of the system, and do not need too many external interfaces, PIC 16F 873 MCU with less 21 input/output pins is selected as the slave control unit to control the CPU in order to save cost. The slave control unit includes CPU module, carrier communication module and power electronic module to control load.

5. Implementation of FKS Modulation and Demodulation

In carrier communication system, the signal from CPU module is a binary data sequence which has been coded and processed. The signal modulation and demodulation process used in this system is divided into two layers, namely FSK modulation and demodulation and spread spectrum modulation and demodulation.

In the system, FSK modulation strategy is implemented by using two integrated chips: one as a modulation chip and the other as a demodulation chip. The FSK modulation of the system is realized by using voltage controlled crystal oscillator (VCO) chip. The chip generates a sinusoidal wave whose output frequency is proportional to the DC voltage applied to the chip. By changing the given voltage of the VCO chip, the frequency of the output AC signal waveform can be changed, and then the AC sine wave can be used for FSK modulation. The specific circuit is shown in Figure 8. As can be seen from the figure, the signal generator chip XR2206 is used in the system. The chip is a multi-purpose voltage controlled oscillator, especially suitable for FSK signal modulation. The chip needs only a few peripherals to work properly. The resistance at pin 7 and pin 8 of the chip together with the capacitance at pin 6 determines the signal frequency at logical "1" and logical "0" of the device. The voltage dividing circuit at pin 3 is used to shape the output sinusoidal signal of the chip. (The external circuit diagram at pin 3 and pin 6 is not drawn.)

The demodulation of FSK signal is realized by a PLL integrated chip. The PLL is worth keeping the input signal waveform frequency locked. When the frequency of the input signal waveform changes, the PLL will produce an error signal, which causes the PLL to change the locking frequency to match the frequency of the input signal again. By carefully adjusting the chip circuit, the locking frequency is consistent with the intermediate frequency of logic "1" and logic "0". As can be seen from the figure, the system performs FSK demodulation operation through the chip RC2211N. According to the above analysis, the chip works on the basis of a PLL topology. The important external components in the circuit include pin 8 and pin 13. The parameters of these elements set the intermediate frequency, attenuation parameters and gain of PLL. According to the design of the system, the signal after FSK modulation will be sent to the frequency hopping spread spectrum modulation module for frequency hopping spread spectrum modulation.

6. Realization of Modulation and Demodulation of Frequency Hopping Spread Spectrum Signal

Considering the electromagnetic environment in the armored vehicle and the carrier channel characteristics of the armored vehicle power line harness, the frequency hopping spread spectrum modulation mode is adopted in the system. Frequency hopping spread spectrum systems, whether slow or fast hopping, generally input modulated signal is modulated digital signal s (t). Its carrier usually uses intermediate frequency band, then enters the frequency converter (multiplier) of the frequency hopping system, and another radio frequency provided by the frequency synthesizer controlled by PN code, which randomly changes its frequency value. After mixing the carrier wave with the carrier wave, the transmitted signal is output by the band-pass filter, which constitutes the transmitting module of the spread spectrum modulation system. At the receiving end, the process is the opposite. Signal modulation is used to improve the performance of basic communication systems under strong interference conditions, so that the system can identify and avoid the existence of strong interference bands.

FM spread spectrum signal modulation is achieved by using integrated chip, as shown in Figure 8. Specific flow: The high frequency spread spectrum carrier signal provided by voltage control chip MAX8038 is sent to integrated chip MC1496, which completes the amplitude modulation operation of carrier signal and FSK modulation signal. The chip MC1496 is a multiplier, which works in suppressing carrier amplitude modulation mode. In the mode of suppressing carrier amplitude modulation, the carrier frequency is not transmitted, so the transmission efficiency can be improved. The high frequency carrier signal generator MAX8038 is a suppressing signal generator, whose frequency ranges from 10 kHz to 20 MHz. The demodulation principle of frequency hopping spread spectrum signal is similar to that of the modulation process. The modulated high frequency spread spectrum signal is sent to MC14% multiplier chip. The demodulation signal of frequency hopping spread spectrum signal can be obtained by multiplying the carrier signal of the same frequency with the previous process and performing amplitude demodulation operation.

7. Communication Performance Test of Bus System

In order to evaluate the performance of the system, the bit error rate of data transmission received and transmitted by each control port of the system at different data transmission rates is tested experimentally.

The experiment is carried out at a fixed data transmission rate. First, the main control unit is tested, and then the order of each slave control unit is tested. Experiments can achieve the test requirements by programming the functions of the corresponding buttons. For example, if it is necessary to test the bit error rate of the signals sent by the master control unit, the slave control units can directly press the pre-set buttons so that the master control unit in the system can send the data status until this time. When the control button is pressed again. The experimental data is set as a loop from 00H to FFH, so that the correct data transmission can be known by comparing the received data value with the pre-set value at the receiving end. If the received data is not equal to the pre-set data, the error count will be increased by 1. In the experiment, the number of bytes sent per time is set to 5000 times, which can evaluate the performance of the system more accurately and eliminate some accidental factors.

Experiments show that it is feasible to use armored vehicle harness for power line carrier communication in armored vehicles. This technology can reduce the basic hunger of wire harness used in armored vehicles and improve the intelligence level of armored vehicles. Power line carrier technology has great application prospects in data transmission in armored vehicles.

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