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Design of CAN Board Circuits Based on SJA1000 for Vehicle Motor Drives Systems

Shuxiao WANG K.W.E. CHENG K. DING

Department of EE, The Hong Kong Polytechnic University
Email: eewsx@polyu.edu.hk
eeecheng@polyu.edu.hk, eekding@polyu.edu.hk

Abstract- This paper presents a motor drive circui that is to provide motion control for DC motor which is designed to connect the computer's series port with the CAN fieldbus. The principles of design and the program flow chat are also introduced. The interfacing to the motor drive system is described. The system shows the control and configuration of the motor drive using H-bridge system and the CAN bus for the electric vehicle.

I. .INTRODUCTION

DC motor drive is now a simple and heavily used system for motion and actuation control in vehicle [1]. Today vehicle has more than 50 motors is not uncommon. The application of the motor includes the traction drive, alternator, and actuator such as window winder, wiper, seat controller, door actuator, air-conditioning compressor motor, and pump. The motor drive control is therefore a paramount important for study. Many of them are high power and power regeneration is needed. Some motor are acted as active generator. For higher power, a power electronic drive is commonly used because of the easy control and power handling.. The typical method of motor drive is to use H-bridge power converter which allows the bi-directional power flow and 4-quardant control of the motors. The power level of the H-bridge varies from a fraction of Watt to tens of kW and can be applied for different motor requirement.

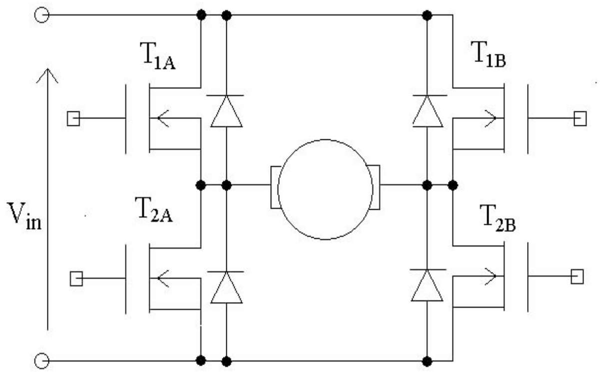

Fig 1: H-bridge controller for motor drive

Fig 1 shows a typical H-bridge drive for the motor drive. It allows positive and negative voltage to apply to the motor for the control of the bi-directional rational. The current flow can also controller to be directional in order to regulate the current and power conditioning.

For simple system, 2-transistor forward can be used as show in Fig 2. The transistor is removed and the circuit is reduced. The circuit allows good control of the terminal voltage of the motor and power regeneration to the source is possible. It is suitable for medium power of motor control. Fig 3 shows the simplest circuit which only simple transistor is used. The circuit provides only simple direction of rotation. Power regeneration is not very successful in this circuit and they are suitable for low power motor actuation system such as less than 10W.

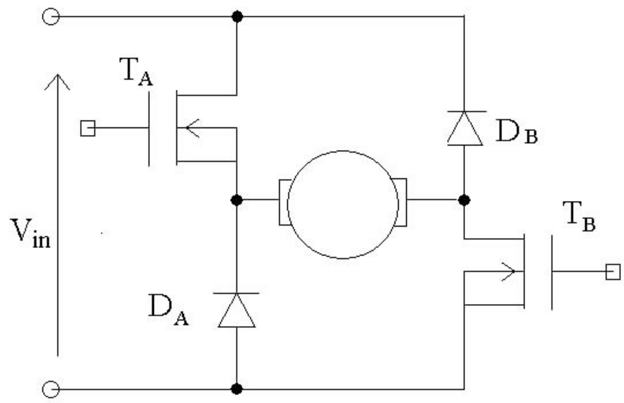

Fig 2: 2-transisor forward for motor drive

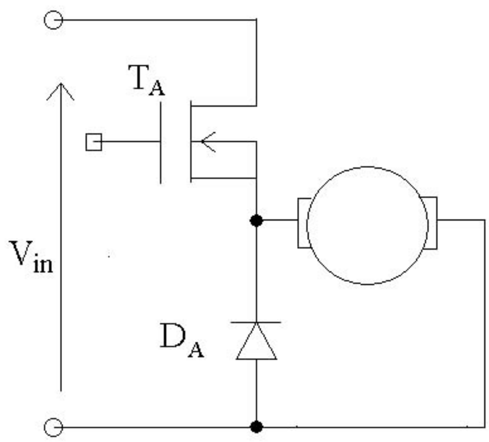

Fig 3: Simple Buck chopper

CAN bus is now being used for many vehicle systems. The use of CAN bus for motor drive in vehicle has been adopted by many manufacturers [2-4]. It varies from small motor to large motor and also find in electric vehicle and hybrid electric vehicle [2]. Fieldbus technology was developed in the late of 1980s. This technology included digital communication, intelligent instrument, computer technology, network technology [8]. The limitation of traditional point to point connection by analog or digital signal was disappeared and distribution control and center management were realized due to the development of Fieldbus. Control Area Network (CAN) is one of Fieldbus, and developed by Bosch company to provide data path for devices of car in 1983. CAN bus is gradually becoming an international standard (ISO 11898–1). Due to the incompatible between CAN bus signal and computer serial signal, the computer serial signal is needed to transfer to CAN bus signal. In this study, the design and principle of convert circuit are introduced.

II. FIELDBUS, STANDARD INTERFACE

A. CAN BUS

The interface of CAN bus is similar to that of RS-485. A pair of balanced differential lines are adopted to transmit signals in half duplex transmission. Balance driver and differential receiver are needed in each communication site. The electrical specification of CAN bus interface is defined as the following. When there is no load in the line the output voltage is ±5 V, otherwise, the output is ±1.5 V. The interface of CAN bus can driver more than 110 nodes. The specification of CAN bus is as the following:

a) Peer-to-peer network structure: CAN bus is a broadcast type of bus. Nodes can send massage to each other in all the time, no matter whether host node or slave node. CAN hardware provides local filtering so that each node may react only on the interesting message.

b) Nondestructive arbitration bus technology: nodes of the bus have different priorities. When several nodes send message in the same time, the lower priority node actively stops sending. However, the higher priority node continues to send message. When the higher priority node finishes sending, other nodes send message according to their priorities. Bus contention can be avoided.

c) The maxim number of effective bytes in one frame is 8. CRC is applied in each frame to avoid probability of error.

d) Where there is serious wrong with the node, interface of this node can be automatically turned off so that other nodes can be operated.

e) The maxim communication distance is about 10 kilometers. The maxim communication rate is 1 Mbps/s. Transmission medium is unshielded twisted pair or optical fiber.

B RS-232C standard interface

RS-232C is a standard interface approved by the Electronic Industries Alliance for connecting serial devices. Technically the RS232C is -3V to -12V for logic '1' and +3V to +12V for logic '0'.

The communication rate of RS-232C is 0~20000 bps. Normally, the maxim rate in application is 19200 bps. The communication distance is no longer than 15 m due to distributed capacitances of cable. If the total effective capacitances are controlled to less than 2500 pF, the length of cable can be extended.

C. TTL/COMS

TTL/COMS level is 0~5V. Technically the TTL/COMS is 0~0.8V for logic ‘0’ and 3.5~5v for logic ‘1’. The level of AT89C51 is TTL/COMS [6].

III. THE STRUCTURE OF SYSTEM

In order to connect the serial port of computer with CAN bus, level of RS-232C is needed to be transferred to level of CAN bus. RS-232C transfers data by bytes, and CAN bus transfers data by frames. The format conversation is also needed between RS-232C and CAN. AT89C51 is selected to use as processor. AT89C51 is 8-bits MCU of ATMEL company. It is compatible with MCS51. There are 4 K bytes of in-system reprogrammable flash memory. The maxim frequency is 20 MHz. There are two signal transformations in the system, one is transformation between RS-232C and TTL/COMS, the other one is transformation between TTL/COMS and CAN bus. The aim of the system is that computer controls AT89C51 and AT89C51 controls SJC1000 CAN controller.

A. The circuit of CAN interface

This circuit consists of CAN controller and driver. SJA1000 produced by Philips company is selected. SJA1000 is a stand-alone controller which can be compatible with PCA82C200 controller (Basic CAN) [8]. SJA1000 is applied to moving object and the net of factory environment. PeliCAN mode is added in SJA1000. This mode supports CAN 2.0B protocol. PCA82C250 is selected to use as driver. It is fully compatible with the “ISO 11898” standard, high speed (up to 1Mbps), slope control to reduce Radio Frequency Interference, and differential receiver with wide common-mode range for high immunity against Electro Magnetic Interference, an unpowered node does not disturb the bus lines, and at least 110 nodes can be connected. In this system, the baud rate is low. Slope control mode is selected. The block figure of connection between SJA1000 and PCA82C250 is shown in Figure 4.

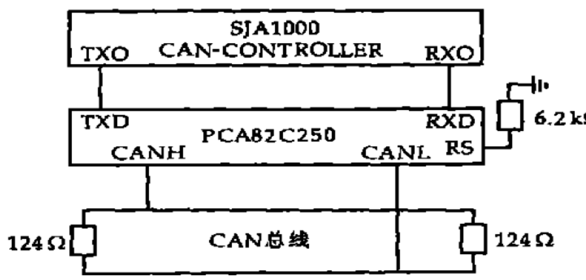

Fig. 4: Connection between PCA82C250 and SJA1000

B The connection between the computer serial port and transformation system

RS-232C is used in the computer serial port. AT89C51 is TTL/COMS. Signal level is needed to be transferred. MAX202 transceivers are designed for RS-232 and V.28 communication interfaces where ±12V supplies are not available. On-board charge pumps convert the +5V input to the ±10V needed for RS-232 output levels. The MAX201 operates from +5V and +12V, and contain a +12V to -12V charge-pump voltage converter [5, 7]. The MAX202 drivers and receivers meet all EIA/TIA-232E and CCITT V.28 specifications at a data rate of 20kbps. The drivers maintain the ±5V EIA/TIA-232E output signal levels at data rates in excess of 120kbps when loaded in accordance with the EIA/TIA-232E specification. The power for MAX202 is +5V, the output signal level is TTL/COMS. A few devices are needed by MAX202, the application is shown in Figure 5.

All the DC sources are provided by a regulator provided from the vehicle battery. A power converter is used to step down 12V to fixed positive and negative 5V for the required power conditioning to all electronics circuit.

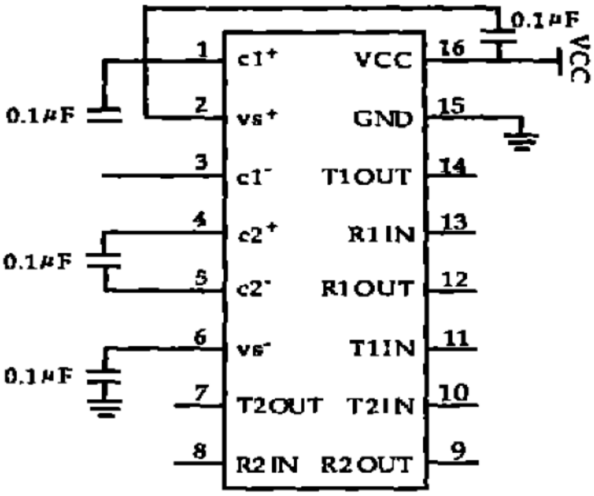

Fig. 5: Application circuit of MAX202

C The isolation circuit between computer and transformation system

In order to protect computer from the effect of transformation system, DC-DC module is used to provide power for MAX202. The connection between MAX202 and AT89C51 is through optical coupler. The schematic diagram of transformation system is shown in Figure 6.

D. The software of transformation system

When the transformation system is turned on, SJA1000 and ports of AT89C51 are initialized. Data is treated in the in interrupt program. The initialization of SJA1000 is shown in Figure 7. The initialization of the SJA1000 is clearly shown. The main program is shown in Figure 8.

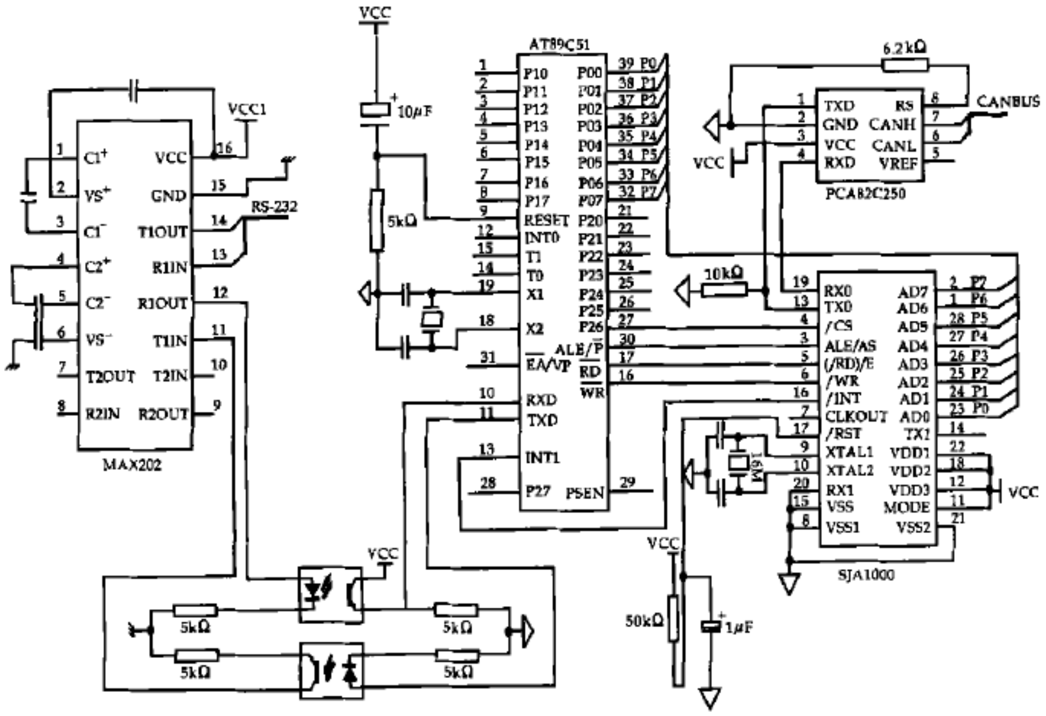

Fig. 6: The schematic diagram of transformation system

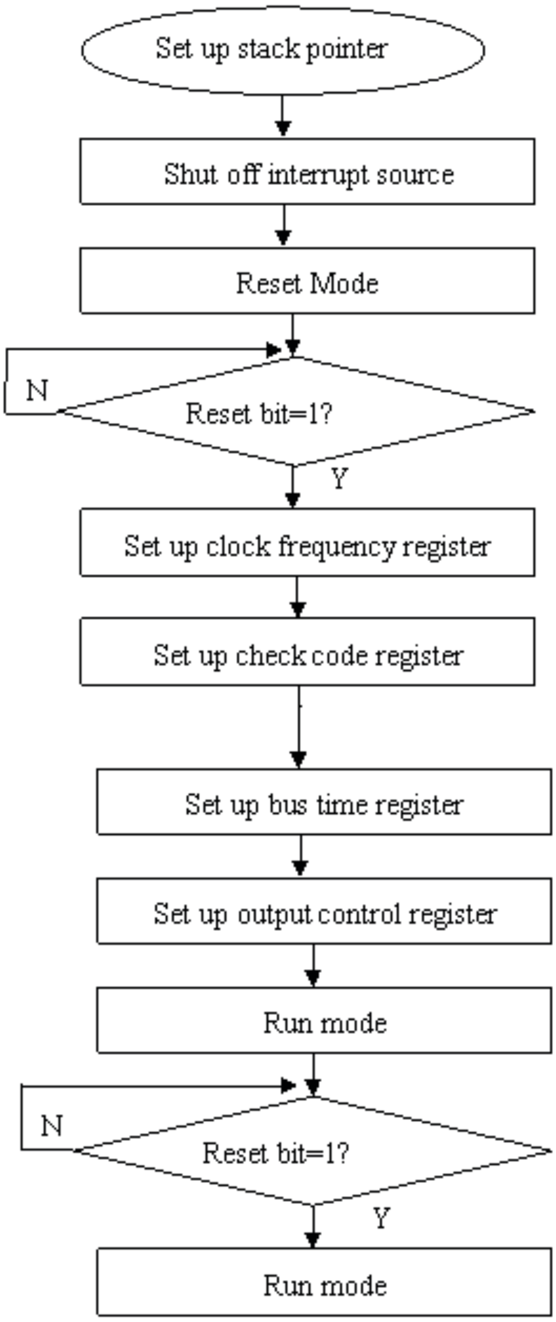

Fig. 7: The initialization of SJA1000

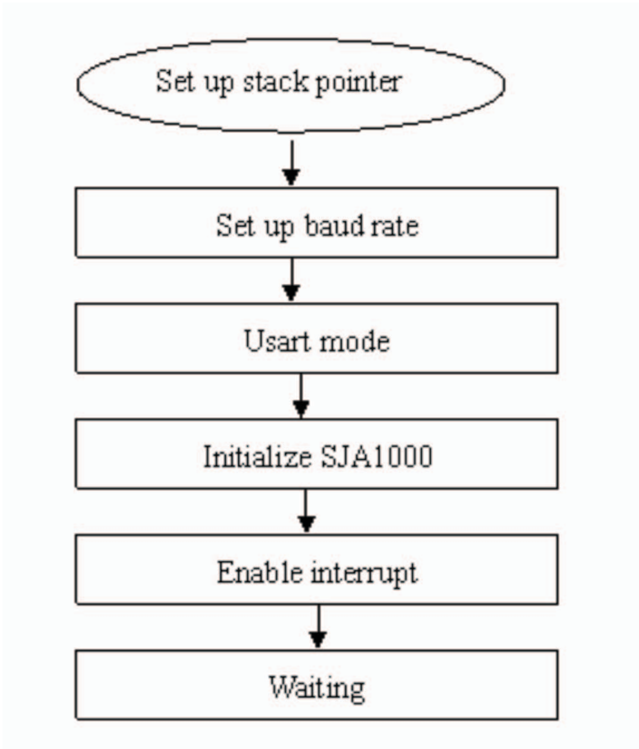

Fig. 8: The main program

IV. THE APPLICATION OF SJA1000 ON DC MOTOR CONTROL

A. The structure of DC motor control system

In this system, there are two systems, one is main controller, the other one is performer. The block diagram of this system is shown in Figure 6.

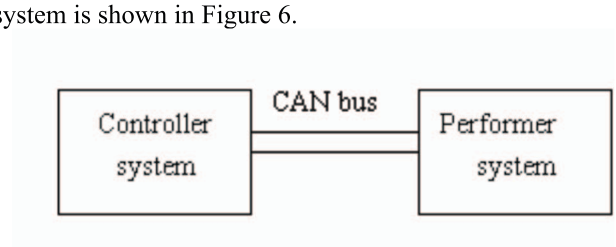

Fig. 9: The block diagram of DC motor control system

Figure 9 shows that controller system is connected with performer system through CAN bus. The message sent by the controller system and the received by the performer system. ATMEG 8 is used to MCU of controller system and performer system. It is high performance and low power AVR 8-bit microcontroller, RISC architecture, 16 MIPS, 8 K bytes of in-system self-programmable flash, 512 bytes EEPROM. In controller and performer systems, SJA1000 is used to CAN controller.

B. The circuit of controller and performer system

The controller system consists of ATMEG 8 and SJC1000. The circuit of controller system is shown in Figure 10. R4-R6 are the pull-up resistors. X1, C1 and C2 are the oscillator for timing. R3 is the voltage supply resistor.

Figure 10 shows that the port B of ATMEG 8 is used data port and connected with SJA1000. PD0, PD1 and PD2 are used to button input.

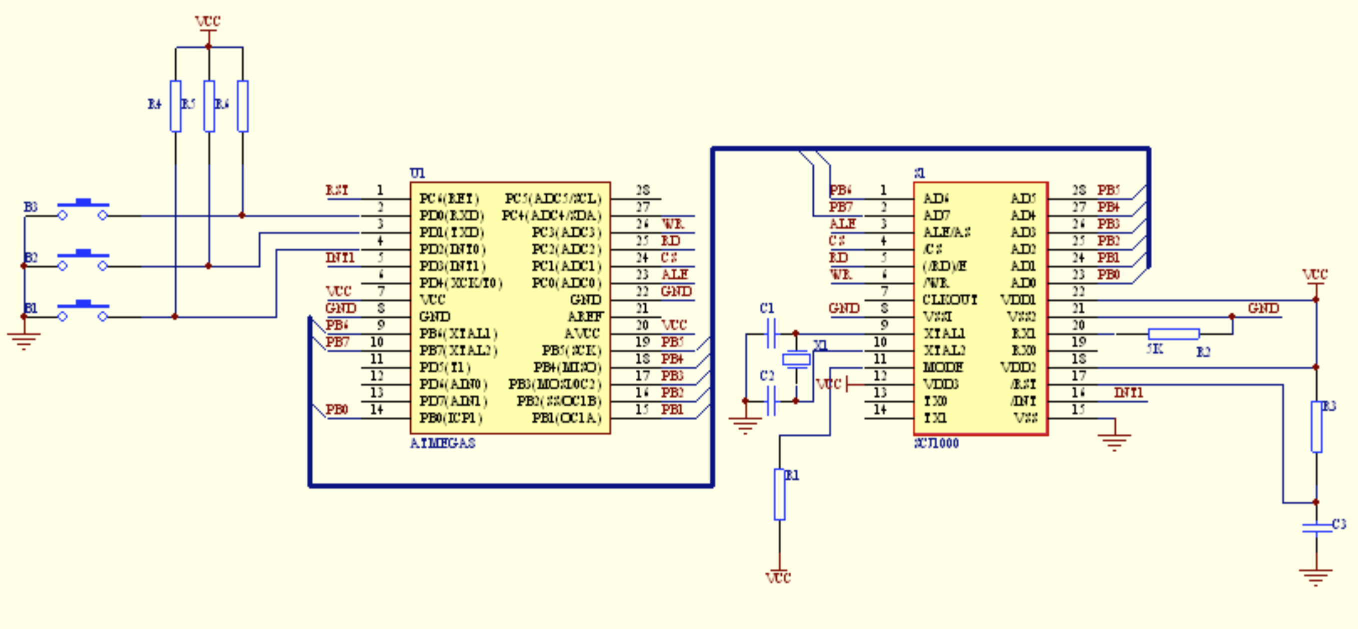

Fig. 10: The circuit of controller system

The performer system is similar to the controller system. One additional DC motor control part is added in the performer system. The circuit of DC motor control is shown in Figure 11.

The transistor for the motor drive presented here is an opto-driver with integrated power transistor. Alternatively, it can be replaced by power module of half-bridge transistor with a level-shifted or boot-strap gate-driver. The DC rail PVCC is a control voltage derived from the battery DC rail. A decoupling capacitor is connected to the rail for noise decoupling and stable operation.

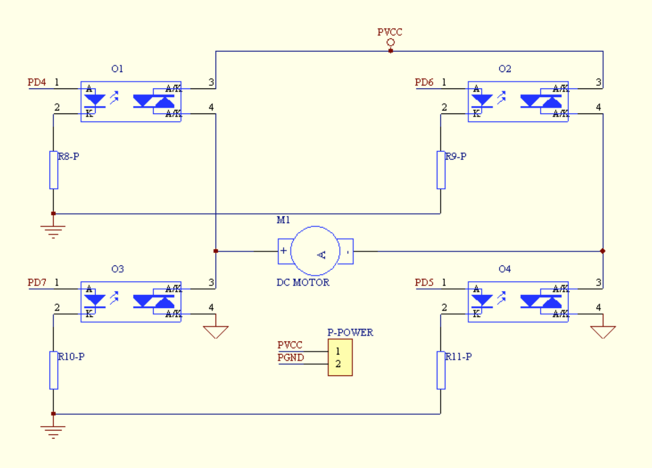

Fig. 11: The circuit of DC motor control in the performer system

Figure 11 shows that PD4, PD5, PD6 and PD7 are used to control DC motor. When PD4, PD5 are ‘1’ and PD6, PD7 are ‘0’, O1, O4 are breakover, O2, O3 are cutoff. DC motor is turned on. When PD4, PD5 are ‘0’ and PD6, PD7 are ‘1’, O1, O4 are cutoff, O2,O3 are breakdown. The rotation direction of DC motor is changed. When PD4, PD5, PD6, PD7 are ‘0’, DC motor is turned off. In the circuit of DC control, TLP127 is selected to drive the DC motor. TLP127 consists of a gallium arsenide infrared emitting diode, optically coupled to a darlington photo transistor with an integral base−emitter resistor, and provides 300V VCEO.

When O1 and O4 are turned on, the voltage of the motor is shown in Figure 12. It can be seen that a PWM waveform is generated for the regulation of the motor speed. The forward voltage is regulated by using PWM and the reverse voltage is clamped by the series diode.

When O2 and O3 are turned on, the voltage of the motor is shown in Figure 13. The inverted voltage is developed that allows the change of the motor direction. It can be seen that now the reverse voltage is regulated to be large and the motor direction is then reversed.

Experimental results have shown that very good driving performance has been achieved. The driving current is satisfactory and can give modern control and communication through the CAN bus.

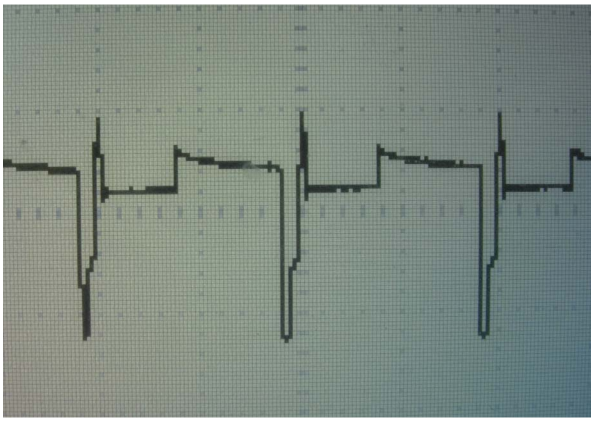

Fig. 12: The voltage of motor when O1 and O4 turning on (5V/div, 1ms/div)

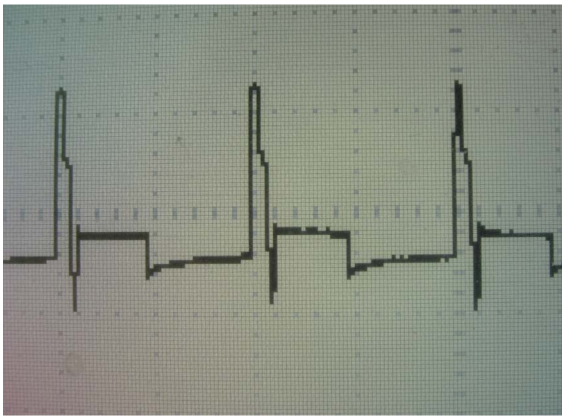

Fig 13: The voltage of motor when O2 and O3 turning on (5V/div, 1ms/div)

V. CONCLUSION

The CAN bus is a higher performance method of control of the vehicular system. Its circuit and the controller card is simple. The communication distance is long. Due to the application of optical coupler, the computer is isolated from the CAN bus. The CAN card is applied in monitor system and DC motor control system. The system is proved to be stable and can decoupled form the noise derived from the motor drive and other actuation system. The motor drive examined in the project is an H-bridge power converter which allows good control of motor in terms of motoring, regeneration and bi-directional power control. A DC-bus is used that decoupled all the power signals to the other control units. There is no limitation of the motor used in the CN bus control system.

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REFERENCES

[1] Jinrui, N.; Fengchun, S.; Qinglian, R.; :A Study of Energy Management System of Electric Vehicles", Vehicle Power and Propulsion Conference, 2006. VPPC '06. IEEE6-8 Sept. 2006, pp. 1 - 6

[2] Tao Zhao; Qunjing Wang; Weidong Jiang; Youyuan Ni;, "System design and development of parallel-hybrid electric vehicle based on CAN bus", Proceedings of the Eighth International Conference on Electrical Machines and Systems, 2005. ICEMS 2005. Vol. 1, 27-29 Sept. 2005, pp. 828 - 832.

[3] Liu Jun; Hu Guangyan; Wen Xuhui; "DSP and CAN bus based induction motor control in electrical vehicle application", Sixth International Conference on Electrical Machines and Systems, 2003. ICEMS 2003. Vol. 2, 9-11 Nov. 2003, pp. 585 - 587.

[4] Zhang Dongliang; Tian Xincheng; Xuqing;, "Application of CAN bus technique in digital AC servo drives", The 4th International Conference on Power Electronics and Motion Control Conference, IPEMC 2004.Vol. 2, 14-16 Aug. 2004, pp. 746 - 749.

[5] Fu, H. and Y. Xu, The application of CAN in temperature control system. Industrial Control Computer. **15**(3): p. 26-27.

[6] He, L., The technology of MCU. 1997: Beihang University Press.

[7] He, X., D. liu, and B. Guan, Design and Realization of a Kind of Set about RS-232 Bus Transformation CAN Bus. Industrial Control Computer, 2002. **15**(1): p. 11-12,19.

[7] Philips, Semiconductor Application note, SJA1000 stand-alone CAN controller. 1997.

[8] Yang, X., The technology and application of Fieldbus. 1999, Beijing: Tsinghua University Press.