# CAN-bus strategy and its application in multi-axis motion control of stepper motor

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*Abstract:* - CAN bus control system as the most active branch in the field of industrial measurement and control, has achieved rapid development in the field of industrial measurement and control. Regard to the rapid increase of the number of controllable nodes in the field of industrial measurement and control, there is higher request for the control of multi -node. Most of the traditional control mode used industrial computer control combining with control card. For multi-node control, industrial control needs more standard control interface, poor scalability, and it is expensive and high power consumption, this design uses the CAN bus distributed control node of control mode. Each control node uses STM32F103C8T6 as control core and small integration control driver circuit module and solve the problem of increased number of control node and low cost. Based on queue theory and UCOS II dynamic memory management principle, it optimizes data processing ability of CPU for the CAN communication. The system can achieve good robustness, high real-time performance under low hardware cost, reliable communication, and low power consumption of multi-axis control.

*Key-Words:* multi-axis; CAN bus; STM32; memory management;

## 1 Introduction

In the modern industrial control automation equipment, highly intelligent and integrated automation machines, such as in the medical automation, chemical production automation, workshop assembly automation and other fields are widely applied[1]. Multi-axis's motion control of step motor was widely used in high precision automation field. Traditional method of multi-axis motion control is basically rely on the Industrial Personal Computer with PCI slot control card combined with stepper motor drive mode, such as the document [3], this kind of control equipment several shortcomings such as bi, high energy consumption, strong electromagnetic interference and so on . If developing large automation equipment, it has to include control stepping motor's multiply increasing. And industrial control PCI card's slot resources is limited, the number of motor control is easy to reach saturation due to the limitations caused by the large motor control system. Multi-axis stepper motor control has the high requirement of real-time, such as the document [2] and [4], the multi-axis coordinated control and electronic machine monitoring mode. There is no optimization and processing on CAN bus data. but these methods has some shortcomings. The task in the system is relatively large. And when CPU load is high, the real-time performance becomes weakened. When data throughput becomes large, limited memory resources in the processor may cause the instability of the control of coordinate of accurate control in the system and real-time monitoring system due to some problem, such as the remains of memory fragments.

This thesis uses a controller based on local area network (CAN) to control signal transmission. Miniaturized drive control integrated circuit form a star topology's control node near the motor, each control node was connected through CAN bus connection and principle computer control the real-time communication. In data processing, combining with circular buffer and UCOS II the dynamic memory management principle deal with CAN bus data with high efficient and real-time data processing, so as to realize the reliable requirement of large automation equipment for multi-axis controls. The whole control system data processing with high efficiency, good robustness, low hardware cost, and reliable real-time communication, the control node can also be flexible to expand. The number of nodes can be greatly improved.

# 2 Framework Design of System

Structure design of CAN bus control system is distributed. which could enhance the reliability and extensibility of the control system [2]. Specific operation mode is the miniaturized integration control driver module circuit design and each of the driving control modules are integrated near the stepper motor. Reusing CAN bus controls every electronic machine and executes action command and be able to real-time monitoring of each motor motion state to get the sensor's information. The information of CAN bus transmission feedbacks to the upper machine and become a hub of PC and the underlying control.

PC real time controls and monitors each electronic machine's motor movement of the entire system. The operator only needs to control the whole system through friendly operation interface. As CAN bus system structure shown in figure 1, this kind of distributed control mode can increase a large amount of control nodes to meet the needs of large-scale automatic equipment control. On the one hand, it is very easy to extend control nodes number and not to affect other nodes' regular work. On the other hand, it reduces the volume of the hardware of the control part to a large and simplifies circuit structure and overall layout with corresponding decrease of power dissipation.

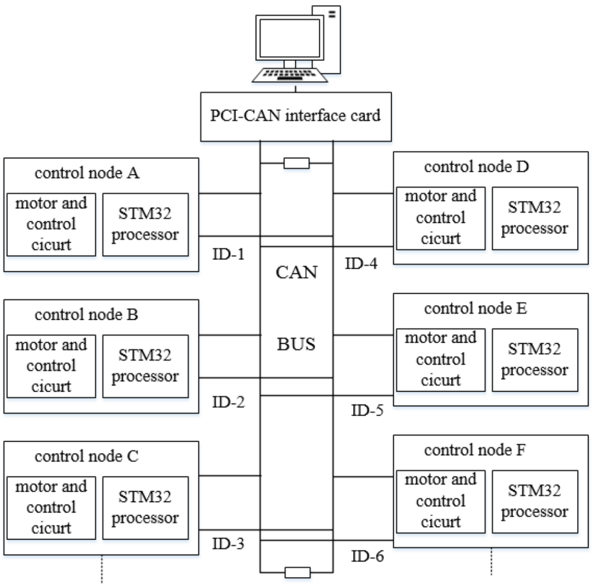


Fig 1 Framework of CAN Control System

# 3 Description of System Hardware

## 3.1 The control node's CAN c ommunication module

The microprocessor used in this system is STM32F103C8T6 produced in the ST company with a 72 MHz frequency, multi-channel in one road DMA transfer and built-in 64 KB of Flash multi-channel ADC. With its own CAN bus[5] control port, we need to connect high-speed CAN bus transceiver that real-time control every driver module. The core chip of CAN adopt high-speed transceiver TJA1050 which is up to 1 m bit/S transmission rate to completely achieves the real-time control.

## 3.2 Control node ID of the Settings

CAN bus's hardware filter can improve the processing speed of the system without CPU interference. And each control node control program is consistent, which it is easy to expand and assemble. Each control node ID must be set differently so that the system can identify every control node. As shown in figure 2, it can use code switches connecting to the STM32 IO port with one end to the 3.3 v port, the other to the ground and set every control node's ID according to the binary systems. First of all, it needs to set 16 mask filter register of CAN and concerned bit of filtration according to the number of the control node filtering out needless information. Secondly, we keep the state of port as the ID of the node in system initialization and make the CAN port only receives applicable data packets.

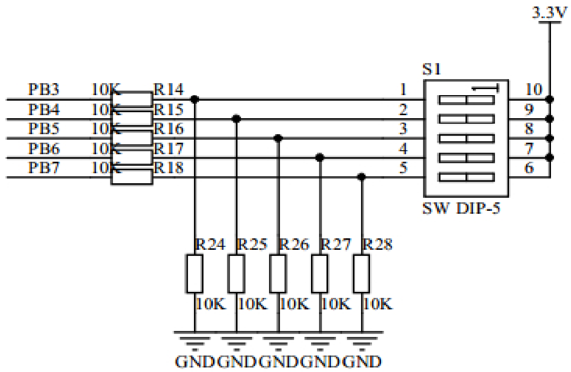


Fig 2 circuit diagram of ID dial

## 3.3 The control node's drive control module

In each of the CAN bus's control node drive the integrated stepper motor by driver circuit. A control chip with multiplexed output can match multiple drive chips, which it effectively simplify, the peripheral and control the cost and volume. Stepper motor control chip provides all functions related to the digital motor control, including position control, speed control, micro-step control and so on. Each stepper motor control chip connect three motor driver chip through DIR and STEP pulse signal connection, so each control node can control three axis. Hence, the use of control chip can release the microprocessor. The connection of every position sensor in each axis can implement the closed- loop control to feedback the position of motor. Control node's integrated driver module shows in figure 3.

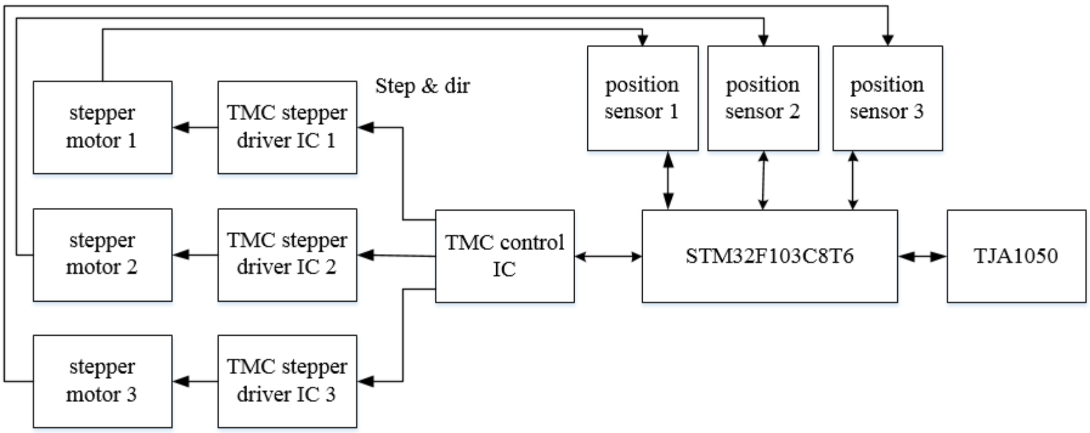


Fig 3 integrated control driving model framework

## 4 Can Control Node's Data Processing Strategy

Comparing to the a single control system of control, multi-axis control needs to implement more extended control function, or it can not meet the requirements without data processing and optimization. Therefore, in this paper, Based on queue theory and UCOS II dynamic memory management principle, it needs to deal with the memory of real-time data and microprocessor of CAN bus, improving the processing speed and efficiency of the processor to meet the requirements of real time and high efficiency in practical use.

### 4.1 receiving and sending data of queue

The cycle buffer structure shown in figure 4, i ts essence is to establish an array to story data which CPU failed to timely process and to locate the blank area and data area through CANRXIndex and CANTXIndex. In order to prevent the CAN bus's data loss caused by over large amount of throughout, buffer area has to be set with great capacity to deal with the size of the amount of data at first. Otherwise, it would cause the data loss caused by external interrupt and data buffer putting during the processing, which lead to mechanical error or malfunction during the system running.

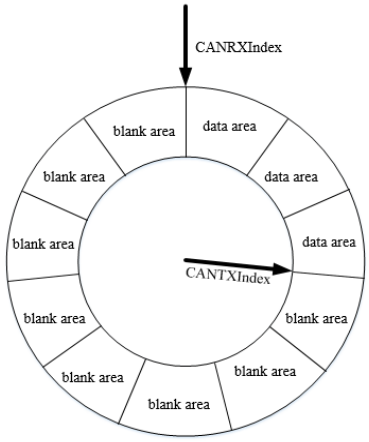


Fig 4 buffer cache's round-robin queue

### 4.2 dynamic memory management

Control mode requires lots of memory space in some tasks, while the STM32 chip memory resources are limited. In the use of daily life, machinery equipment continuously operates for a long time, which will produce a large amount of memory fragments and system instability factors. Can communication must meet the demand of real-time, high efficiency and reliability, and dynamic memory management can be efficient and flexible allocation of memory size. Accordingly, a dynamic management principle is proposed, which is a real-time dynamic memory management mechanism on the base of uCOS-II[6].

uCOS-II implements a two-level management for memory, that is, a contiguous memory space is divided into a number of regions, and each partition is divided into a number of equal size of the memory block. The operating system partitions the unit to manage the dynamic memory, while the task takes the memory block as the unit to obtain and release dynamic memory. Memory control block to record the use of memory blocks and memory partitions. Figure 5 shows the partition with control block.

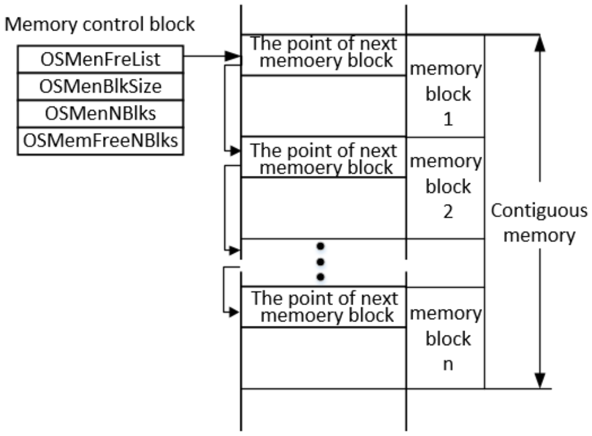


Fig 5 memory partition with control block

Firstly, according to the structure design of figure 5, memory management based on UCOS-II memory management is established. The management region is the basis of other memory management. Then we need to process the data of CAN bus, namely, the CAN data distribution, acquisition, release and other operations. The use of dynamic memory management mechanism achieves the efficient and flexible memory.

Secondly, after the establishment of memory management region, we need to retrieve a memory block from it so as to send and receive data content in can bus, and unit allocation depends on the actual size of the dynamic memory. Its core code is：

tcb=(*ptr).OSMemFreeList;

if((*ptr).OSMemFreeNBlks==0){return (void *)0;}// (if the number of blank blocks of memory is 0)

(*ptr).OSMemFreeNBlks--; //(blank memory minus one, which points to the next memory)

index=(u8 *)tcb; //tcb (Point to memory block node pointer)

index+=4;

return index; //(Return to memory block node pointer)

Finally, creating the process that putting memory with deleting functions into buffer zone for sending and receiving can. After the data sending or receiving successfully, we need to remove and release the occupied memory block, which is also a memory recovery process. The core code deleting are as follows:

(void **)tcb=(*ptr).OSMemFreeList; //(Reput OSMemFreeList into the blank pointer)

(*ptr).OSMemFreeList=tcb; //( Point the next pointer to the blank area pointer)

(*ptr).OSMemFreeNBlks++; //( Add 1 blank memory block)

The employment of these methods in the control system realizes the real-time and stability characteristics of the system on the condition of high data load of can bus. The use of dynamic memory management can manage the memory of micro controller except for the memory in global variables and static structure variables, which effectively prevents the unpredictable situations like memory overflow and system disorders when the system is running, and guarantees the robustness of the system.

# 5 Software Architecture Design and Implementation

PC is the control center of the whole system and it is responsible for co-ordination between multi axis[7] motor which is generates through the movement of a specific device. With the assignment of synchronous motion control task to different control nodes via CAN bus and the detection of the motion state in each motion control axis, monitoring and managing the operation the entire control network are implemented, as well as multi axis motion control.

In the control system, host computer software is designed to achieve the core functions, such as man-machine interaction, monitoring and adjusting the motion parameters of each control node and feedback real-time state, and we use VC++ to set the control parameters of each axis and monitor motor state. In addition, the bottom STM32 chip integrates a stepper motor into the motion functions, and the motion control function library is a motion control API. With the using application software -function library and its relevant motion control function, we can control our own multi axis automation equipment in accuracy, high speed and coordination, as shown in figure fig.6 Library function can handle all the complex problems about motion control. Therefore, we can develop our own software system according to the specific application demands, like build blocks, without knowing the details of the underlying hardware, thus greatly shorten the software development cycle.

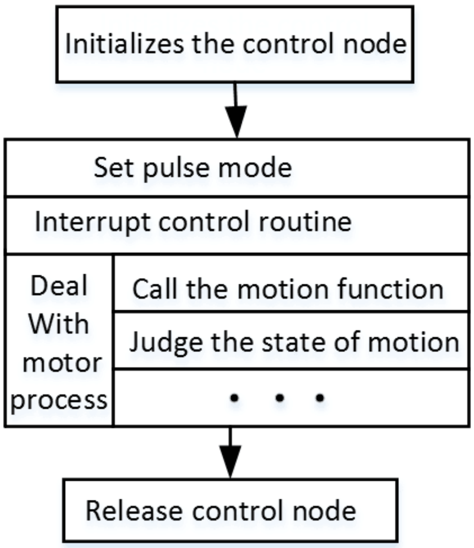

Fig 6 flow chart of application

## 6 The Experimental Results and Analysis

Compared with the multi-axes stepper motors control system, which is on the basis of EVOC IPC810B with thunder game DMC1410 four axis motion control card, we can conclude that the system at most carry six control cards and control 24 stepper motor coordinated movement. If the CAN bus in this paper controls 24 a stepper motors, the hardware cost is one third of industrial computer control system and power consumption is about 65% of industrial control system. What's more, the expansion of the control node can reach more than 110, and the control node has a great improvement. Comparison with the can bus control method, which does not use the principle of queue and UCOS-II dynamic memory management principles for data processing, we get the use of CPU by testing the percentage of the time and the amount of the task to use, which is the study of the work of CPU. The specific approach are as follow: defines an IO port, pull low the IO when waiting for entering into a task in while(1), wait for the end, begin to work, pull up the IO, thus IO port output duty cycle is the CPU occupancy rate.

When sending a fixed length motion command in the 3 motor of A node, B node sends back to the origin movement, C node moves continously. Due to distinction among byte length of the various orders, we get the following data in table 1:

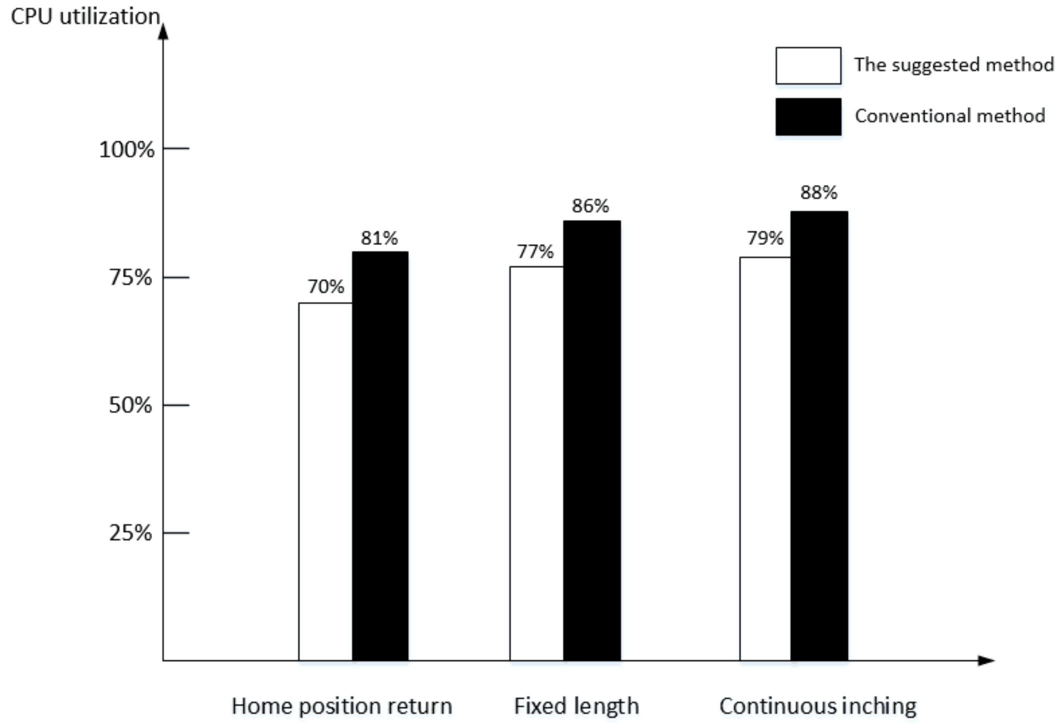

Fig 7 CPU utilization

The whole system runs continuously for a long time. We can conclude that CPU applied with the method in the paper, whose occupancy rate is lower. And the control system is in higher efficiency. Through the running in each motor shaft position and returning of the real-time information, we conclude that the whole system is in reliable stability and good coordination. And communication data is not lost and conflict, motor doesn't lose step, nor out of the step.

## 7 Conclusion

In this paper, we use the CAN bus for data transmission which is on account of its employment in field of automation control. Taking the advantages of easy expansion, strong anti-interference ability and easy to develop of Can bus node, and the real-time control ability and good communication of STM32, we carry out the data processing, monitor and control the real-time status of each control node and the running status of the motor according to the principle of queue theory and UCOS-II's dynamic memory management in a star topology. At the same time, with the applying of the host computer software, we achieve the setting and condition monitoring of each node's parameter in Can. Using VC++ to develop the PC software interface of host computer, which realizes a good real-time control and management functions. The control communication mode b based on CAN bus, is well built in the multi axis stepper motor control system, which is a low cost, high efficiency and good real-time system architecture. Multi-axes stepper motors has been applied in the preparation of a large medical full automatic chemiluminescence instrument, and the coordinated motion of the 36 axis stepper motor is controlled.

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