Study on the Digital Control System for Low-speed MAGLEV Traction Converter

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ABSTRACT: This paper introduces a high precision, high performance converter control system. It is the combination of Multi-CPU and DSP based on VME bus. This digital control system has been successfully applied in the MAGLEV traction control system. Communication between CPUs basing on VxWorks embedded operating system and high performance DSP of TMS320F2812 uses Dual-Port RAM. The DSP receives control instruction from upper CPU to generate three-level SVPWM pulses that control the inverter. Fast data exchange is realized between the upper control system and the Multi-CPU system via high speed reflect memory. The information of auxiliary device, such as input and output switch cabinets and some information of the converter system, is collected by ET200 which communicates with Multi-CPU system via PROFIBUS. Some current and voltage measurement signals are sent to Multi-CPU control system through A/D board after being processed. In addition, perfect protection system is designed in the digital control system to ensure the reliability of the converter.Test shows this digital control system has characteristics of sensitive reaction and good regulation performance. Performance of the control system reaches the design standard, and meets the requirements for MAGLEV traction control.

1 INTRODUCTION

At present, the quickest way to go anywhere on the ground is taking MAGLEV train. It possesses the advantages of low noise, safety, being fast, smooth and comfortable. The world's first commercial application of a high-speed MAGLEV line is the demonstration line in Shanghai, and it has operated for several years. It can run through the 30 km line to the airport in just 7 minutes 20 seconds (top speed is 431 km/h). On the other hand, the mid-speed and low-speed MAGLEV systems also have many advantages such as low noise, being smooth and comfortable. With the fast development of MAGLEV technology, the mid-speed and low-speed MAGLEV systems are going to be used more and more in the city traffic in the near future.

We have developed a high precision, high performance converter control system which used in MAGLEV control system. This paper will describes the hardware architecture and protection of converter programming design in detail as follow.

2 HARDWARE ARCHITECTURE

The digital drive control system of MAGLEV is the combination of Multi-CPU and DSP based on VME bus. Figure 1 shows the hardware architecture of it.

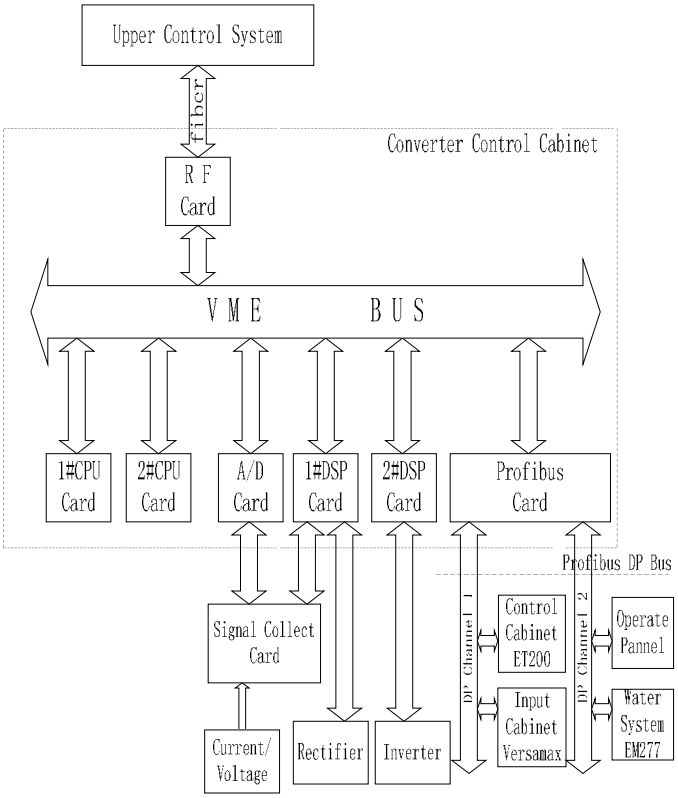


Fig1Hardware Architecture of Digital Control System

The digital drive control system is a complex system constitutes by three levels of networks. The first level network is called the reflection memory network, in this network, the upper control system is communicated with the reflection memory card in the control system of inverter by the two fibers which called the receive fiber and transmits fiber. The characteristic of the reflection memory card is quickly and reliable, which make the data exchange between the upper control system and the control system of inverter real-time and fast. The upper control system receive the information uploaded by 1#CPU in the control system of inverter such as the inverter output voltage, the inverter output current and used them in the many calculations such as the vector control, motor model, rotor position angle computation, and download the results to the reflection memory card in the control system of inverter by the transmits fiber. 1#CPU card reads the data from the reflection memory card and transmits the data to the 2#DSP card through the dual-port RAM. The 2#DSP card produces the PWM pulse of inverter in order to control the speed of MAGLEV.

The second level of network is called the VME bus network, which is a system based on VME bus and contains multi cards such as the two CPU cards, a reflection memory card, a AD card, two DSP cards and a PROFIBUS DP card. These cards are the standard 6U card and insert in slots of the rack. The two CPU card have the binuclear processor in which the high speed real-time VxWorks embedded operating system. The IoWorks is software which supports the C language programming, the modular programming, and the online debugging. All programs in system is programming in the IoWorks software environment.

The main function of the 1#CPU card is realization of real-time data exchange between the inverter inner cards and data exchange between the inverter control system and the upper control system. The data conclude all control information and the protection information of inverter.

The logical control of inverter, management of all auxiliary equipments, system protection and information displaying are implemented by 2#CPU card.

The 1#CPU card collects the information of the voltages and currents of the inverter from 16 bits A/D card and transmits it to the DSP cards, the communication between the 2#DSP card and the upper control system through the dual-port RAM.

The 1#DSP card can get the information of the input current and DC voltage , carry out vector control, produce the PWM pulse of rectifier, regulate DC voltage, realize four quadrant operation, convert the brake energy to power grid and regulate power factor.

The 2#DSP card can receive the control command from the upper control system to produce the PWM pulse in order to control the speed of the MAGLEV.

The third level of network is Profibus-DP. the highest speed of Profibus DP is 12Mb/s. The converter control system is used as a master station , Input Switch Cabinet, water cooling system and operate panel are used as slave stations. Profibus card has two independent channels, the first channel control input switch cabinet and converter control cabinet, realize the protection of converter. the second channel control water cooling system and operate panel .remote IO is series of Versamax and ET200, Versamax and ET200 are provided with complete function, flexible configuration, many I/O interface modules, so the converter control system can monitor and control all of auxiliary equipments.

3 PROTECTION PROGRAMMING DESIGN

A effective protection system is the key of the reliable operation. we have designed a perfect programming. System faults are divided three levels. The first level is the most seriously, mainly refer to IGCT fault and IGCT power fault. when these faults occurred, protection system can immediately block the pulse of IGCT, and discharge the DC-link voltage, cut off input voltage at the same time. The degree of damage of the second

level is lighter than the first level. The second level faults include voltage and current over set value, communication error, transformer error, soft starter err, and so on. when these faults occurred, protection system will immediately block the pulse of IGCT, after confirm the separating status of the input brake, discharging the DC-link voltage. The third level is the lightest. which is called warn. Warn can't hurt the converter in a short time, so after a while, the system warn still exist, we will stop the converter, examining and repairing.

Except for the software programming, we design hardware emergency-stop. mergency-stop switch is installed on the control cabinet, which connected to input switch cabinet through the cable. It is used under the quite imminent situations of failure of control system.

Table 1 shows the Type and protection mechanism of Three levels faults

Figure 2 shows faults processing flow

4 EXPERIMENTS

When the MAGLEV running, output voltage and output current are measured by oscilloscope, as shown in figure 3. The output line voltage is PWM pulse, and the output current is about sine wave, which has a little harmonic. Moreover, the control system operates reliably and stably.

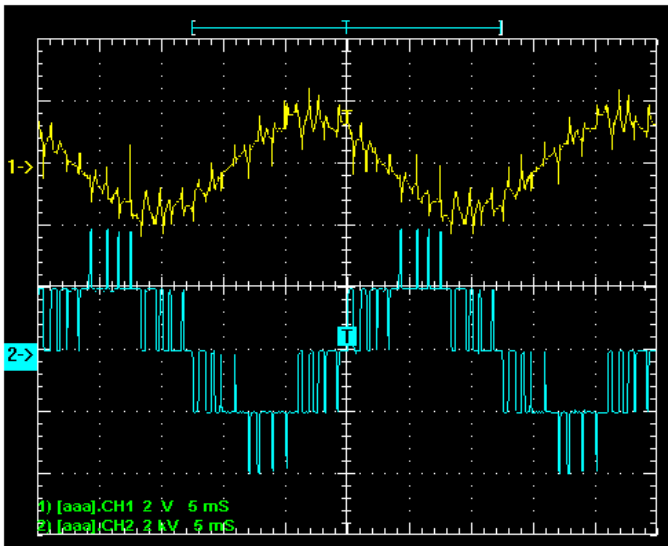


Fig3 Output Voltage and Current waveforms

5 CONCLUSIONS

We have successfully developed a converter control system，and it is used in the test line of shanghai MAGLEV. This control system, which is the combination of Multi-CPU and DSP basing on VME bus, will be applied more and more to the city traffic system

6 REFERENCES

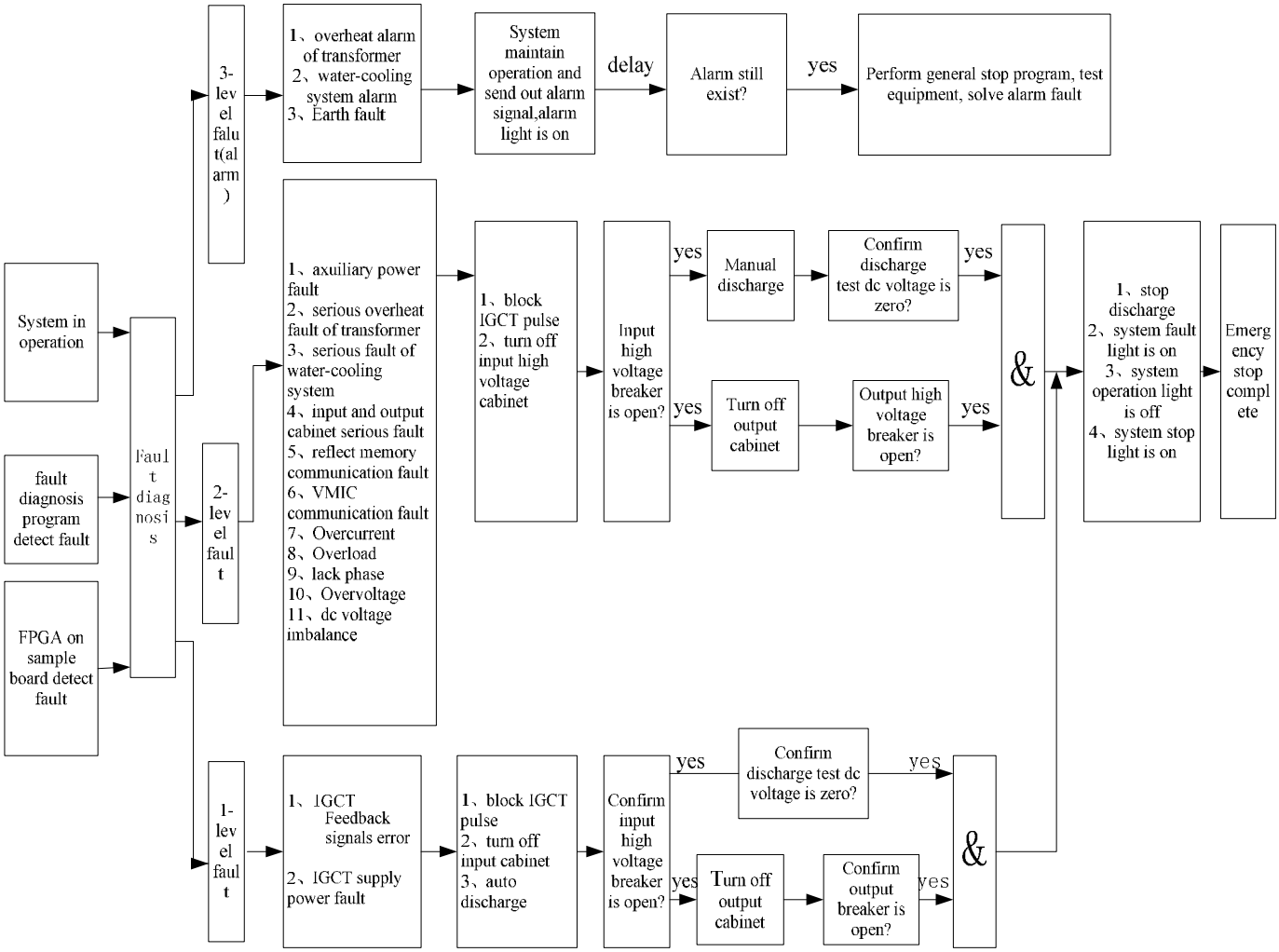
[1] Bin Wu. High-Power Converters and AC Drives. IEEE Press, Wiley-Interscience, 2006.

[2] Chokhawala R., Catt J., Pelly B., "Gate Drive Considerations for IGBT Modules", IEEE Transactions on Industry Applications. 1995, 31(3):603~611.

Table 1 Protection Type and Protection Mechanism

Type		Type detail	Protection mechanism
First-class fault	IGCT fault IGCT power fault	The IGCT – feedback signals are monitored and cross checked with the command signals； IGCT power feedback signals error；	Immediate pulse blocking and Immidiate discharge of DC – link and input switch off
Second-class fault	Low voltage AUX power fault Communication Over voltage and over current Transformer overtemperature Input switch fault Soft starter fault Water cooling system fault Overload	24V operate power，24V control power，LEM power; etc RF memory Profibus DP and double-port RAM fault Voltage and current over set value Temperature over Set value Input switch cabinet Not act or braker fault Soft starter not act Over the press of water and pump fault, etc The junction temperatures are calculated with the actual current	Input switch off and Immediate pulse blocking，after ensure the off -status of input switch，discharge of DC – link
Third- class fault （warn）	Transformer warn	over temperature；	After a while ,if the warning still , stop the converter and check it

Fig.2 Faults Processing Flow



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