Modular Communication Power Design Based on CAN Bus

[1]Yu-Juan Du, [2]Jin-Yong Gao and [3, *]Xin-Fu Liu

Abstract

With the technological development of the modular distributed power, modular switching power supply applications in the communication systems are widely used. The power system should be proposed with higher requirements in its intelligence, operational efficiency, safety, reliability and economy. Therefore, the AC / DC power supply communication module with 220V AC input and 48V DC output is regarded as the research object. According to the current modular communication power supply design, this paper presents digital modules and a communication power system based on CAN bus.

This paper describes a CAN bus control system. The modular digital control system of the communication power has been designed in detail in the article. In order to achieve reliable and stable control effects, the digital control power supply's voltage, the current signal sampling, the processing and the control system are used in the DSP technology. The digital control system makes it easy that the modular of communicate power supply is feasible. The application of the digital control system also enables the flow between the power modules to get a good display interface of power status. In addition, the characteristics of the digital modules is suitable for the distributed module power systems. Attaching control unit in the module power system's application has achieved the goal of remote monitoring and distributed control.

Keywords：Control system, Modular, CAN bus, Communication power, Control unit

1. Introduction

CAN (Controller Area Network) is a LAN controller. It is a serial data communication protocol developed by Bosch, German company in the early 1980s to solve the data exchange between control and test equipment of modern cars. It can effectively support distributed control and real-time control systems[1]. It is a multi-master bus with its communication rates up to 1Mbps [2]. It is fully able to meet the application requirements of the communication rate. The CAN bus composed of a contention-based multi-master bus structure and any node on the CAN bus can be active at any time to send messages to other nodes on the network with misplaced priorities. It can achieve the freedom of communication between the nodes. With the data length up to 8 bytes, CAN bus meets the general requirements of the control command, the job status and the test data in the industrial field. The most important feature of the CAN protocol is that it can be embedded into the communication data block. It makes the number of nodes in the network unlimited theoretically and different nodes simultaneously receive the same data. This design is useful in the distributed control system [3].

The CAN is used to interconnect an industrial process monitoring equipment particularly because of its excellent features, the high reliability, the timeliness and its unique design. So it become valuable day by day in the industry. It has been recognized as one of the most promising field bus[4]. In summary, the CAN communication protocol is suitable for each module when the module is connected in parallel between powers.

The communication power supply system is the power basis of the communication network. It is a general term for varieties of communication equipments and building load to provide electricity equipments [5]. The system consists of the AC power supply systems, the DC power systems, the surveillance systems and the ground systems. The AC power supply system consists of the main AC supply, the dedicated substation, the electrical oil machine conversion screen, the low voltage distribution panel, the AC distribution panel, the backup generators and the AC uninterruptible power systems (UPS). The DC power supply system includes a rectifier equipment, batteries and DC power distribution equipment. Some office stations also use a DC - DC converter to provide a DC voltage of different criteria for compatibility of different communication devices. Monitoring systems can control the stand-alone systems or equipment for each remote supply system. It can record and feedback data, and information. Grounding system can divide work grounded, grounding and lightning protection grounding according to the functions[6]. A good grounding and the lightning protection devices can improve the quality of the communication effectively. It also ensures the communication equipment and the operating personnel's security.

*Corresponding Author: Xin-Fu Liu
(E-mail: Liuxf999@163.com)
School of Mechanical Engineering, Hebei University of Technology, No.1 Road , Hongqiao District 300130, Tianjin, China.

Communication power systems must ensure the stability of its work with reliability and security when it is powered to the communication device. The quality of the power supply indicators has relevant requirements and regulations, such as electromagnetic compatibility index system[7]. A communication power supply should also have the characteristics of high efficiency, energy saving, light weight, small size, easy expansion, easy installation and maintenance, high degree of intelligence, being centrally monitored, few people to realize, or being unattended, etc. A modular power supply achieves high-power, high-reliability power systems. Today, an efficient and highly reliable power module has broad application prospects including the aerospace, shipbuilding, telecommunications, computer and medical industries.

2. Hardware Design

With the rapid development of the communications, communication power has made considerable progress as a communications network infrastructure equipment. Communication power is the system's concept. Implementation of system solutions requires hardware support to achieve. The digital control system is integrated in each power module. It is responsible for monitoring the working status of the module (output voltage, current, module temperature, protection status, etc.). It is connected via CAN bus and external modules equipment. Therefore, completing the design of the hardware part can optimize the security of the real-time system and reliability.

2.1 CAN Bus Circuit

The CAN controller in the C8051F04x series of devices is a full realization of the CAN full-featured modules of the Bosch. It is fully compliant with the CAN specification 2.0B.Figure 1 is a block diagram of the CAN controller. The CAN provides the tasks of shifting (CANTX and CANRX), the message serial /parallel conversion and other associated tasks with the protocol (such as sending and receiving data filtering). RAM can store 32 messages to receive nd send on the CAN network objects. CAN registers and message processors can provide an interface for data transmission and state notification between CAN controller and CIP-51.

CAN bus communication software design [8] mainly includes three parts: CAN node initialization, sending information and receiving information.

CIP-51 can access directly or indirectly CAN control register (CAN0CN) in the CAN controller, CAN Test Register (CAN0TST) and CAN status register (CAN0STA) through the special function registers.

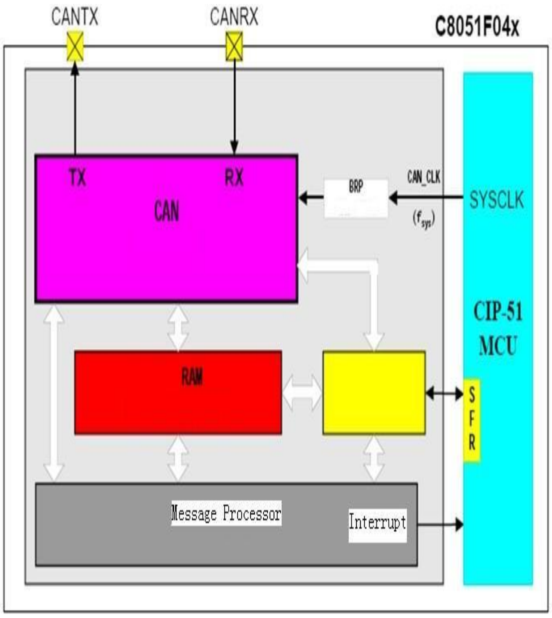

Figure 1: Block diagram of the CAN controller

The functional modules are connected to the bus via the CAN bus interface. PC connected to the bus has a control function. It can exchange data through the module transmitting data frame to the host machine [9]。

As shown in the Figure 2, the design uses the SN65HV230 produced by TI as a CAN bus transceiver [10]. It implements the transmission of the signal by providing bus differential transmission and receiving functions. It's the highest rate of up to 1Mb / s. It has many outstanding features including wide common-mode voltage range of the differential receiving capability, the cross-line protection, the thermal protection, the lost protection and the overvoltage protection, etc. To enhance the anti-jamming capability, you have to increase the speed of optical coupling between the C805lF040 and the SN65HV230. The bus systems meet the certain relationship between the bit rate transmitting data and the distance of two nodes [11]. The system clock of the CAN controller comes from the SYSCLK system clock of the microcontroller core. Both the CANH and the CANL ends of the CAN bus connect respectively the two 120Ω resistors. It consists of a closed network. It is a network topology of the CAN-bus [12]. Each network node is connected respectively at both ends of the bus. It constitutes a multi-node communication network.

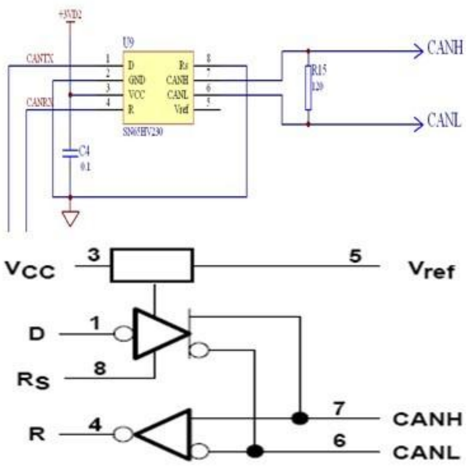

Figure 2: CAN interface circuit

2.2 Digital Control System

Currently in communications power systems, digital control is increasingly widely used. The digital simple applications of power supply include power system monitoring, protection and communication. Instead of a large number of analog circuits, it is able to complete the power start, the input and output over voltage protection, over current and short circuit protection output and overheat protection. Through a human-computer interaction interface, it can achieve the data communication and information display systems.

With the development of chip technology, more and more functional modules are integrated into a single chip. A conventional electronic circuit design is replaced increasingly by a high integrated simple chip [13]. The design of a digital circuit controller used the high-performance C8051F040 by the U.S. company launched in recent years as the master chip, which has the main features in the following[14] :

1). High speed. It has a pipeline command structure. 70% of the instruction execution time is one or two system clock cycles. Its speed is up to 25MIPS, which is 20 times faster compared with the standard 8051.

2). Powerful analog signal processing functions. It has 13 external input 12-bit AD converters and its programmable slew rates up to 100ksps. It has a programmable gain amplification function, and a built-in temperature sensor. It also has two 12-bit DA converters, voltage reference, and three analog comparators.

3). Advanced JTAG debugging features. It supports the system, full-speed, non-intrusive debugging and programming. It does not take up any resources within the film. It has breakpoints, single-step, observation points, and Stack Monitor. It has better performance than the chip emulation system simulation, target emulation or simulation socket head.

4). Powerful control capabilities and rich serial interfaces. It has eight 8-bit wide I / O ports, and Bosch Controller Area Network （CAN2.0B）. It can be used in hardware SMBus simultaneously (I2CTM compatible), SPITM and two UART serial ports.

5). Memory. It has 4352 bytes of internal data RAM and 64KBFLASH. It can be programmed in the system. It is a sector size of 512 bytes and the external interface data memory is 64KB.

A digital control system is integrated in each power module. It is responsible for monitoring the working status of the module (output voltage, current, module temperature, protection status, etc.) and is connected via CAN bus and modules external devices. The C8051F040 regarded as the core constitutes a module power digital control system. A digital signal by the A / D conversion output of the module controlled by the control unit is transferred to the controller's internal CAN special register [15]. Load voltage detecting signal + S,-S, and the output current signal S1m, S1- are fed to the AD converter after isolation. The processor also detects temperature and protection signal modules. It gives the power supply to the module output voltage by converting the given signal Vrv isolation and output current limiting signal Vri. This circuit controls the four-panel lights PWR, output S1, S2 and ERR. It uses CANBUS to communicate. Its specific digital control circuit diagram is shown in Figure 3.

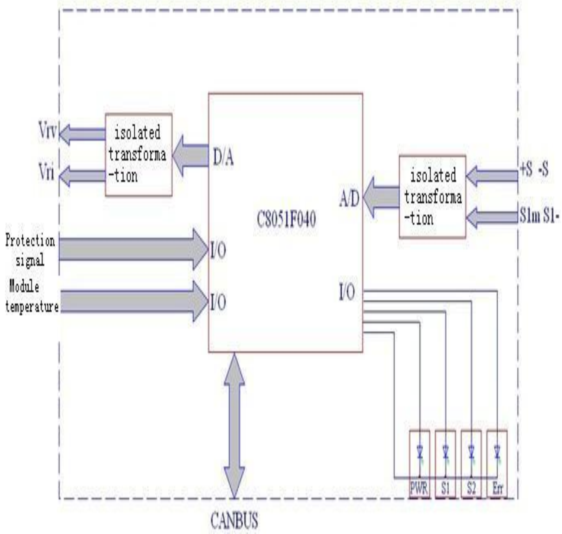

Figure 3: Digital control circuit diagram

A peripheral circuit of C8051F040[16] is shown in Figure 4. When added with an active low signal to the / RST pin, it will cause MCU entering the reset state. Power-on reset signal generated by R9 and C11 controller provides power-on reset signal. AD converter chip reference voltage is generated by the voltage reference chip KA431 with 2.5V external reference voltage. In order to meet the precision requirements of the CAN communication, C8051F040 generally requires the use of an external oscillator. This selection of the crystal oscillator frequency is 22.1184MHz.

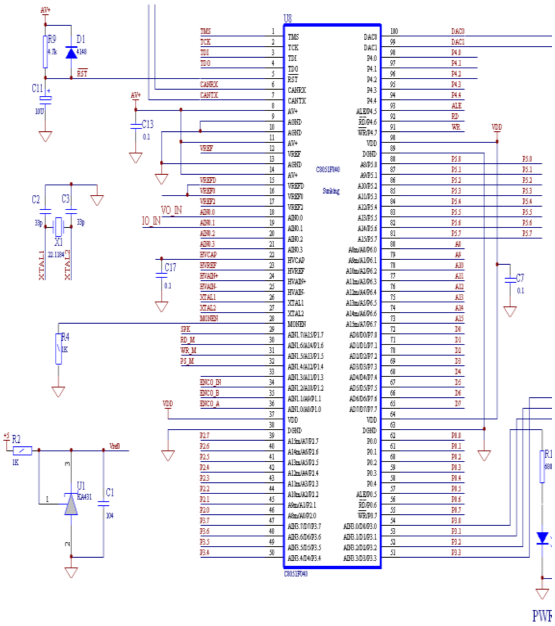

Figure 4: C8051F040 peripheral circuit

C8051F040 ADC0 subsystem consists of a 9-channel programmable analog multiplexer, a programmable gain amplifier and a 100ksps, 12-bit successive-approximation-register ADC. ADC includes track and hold circuits and programmable window detectors. As shown in Figure 5, the system needs load voltage signal acquisition + S,-S and the output current signal S1m, S1-through linear optocoupler isolation. Finally, it is entered on the C8051F040's AD input pins.

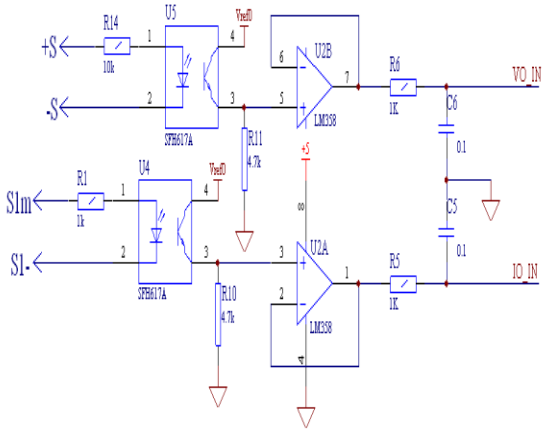

Figure 5: Input circuit of ADC

C8051F040 processor has two on-chip 12-bit voltage mode digital / analog converters (DAC). Each DAC's output swings are 0V, which corresponds to the input code range is from 0x000 to 0xFFF. DAC's voltage reference is provided by the pin. Figure 6 is a DAC output circuit. Analog output signal generated by the processor is driven by the operational amplifier U3. This provides the power unit with a control circuit after the linear optocouplers U6, U7 are isolated from output. When the module power supply output voltage is fixed at the terminal, a constant voltage value of the control module is outputted. When the output limit value of the module power is fixed, the limit value of the control module power is outputted.

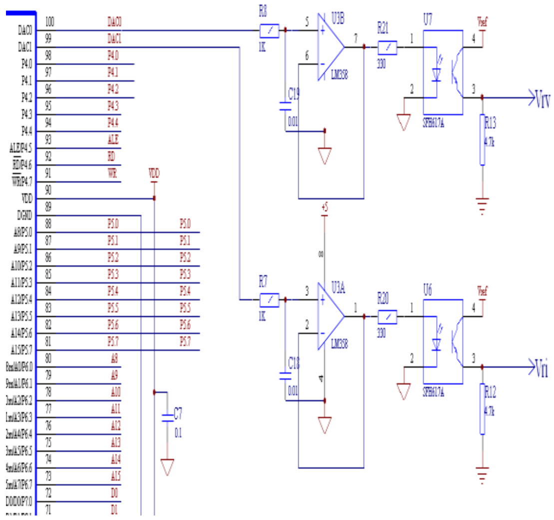

Figure 6: Output circuit of ADC

2.3 Central Control Unit System

In order to improve the module itself EMC targets and reduce the volume weight, this paper proposes a central control unit. It can set up and adjust the parameters.

Figure 7 is a system block diagram of the central control unit. In order to improve the reliability of the circuit, which is designed with 220V AC power after EMC is filtered into two parallel AC-DC power modules. When any one of AC-DC modules is failed, the other module can also work. With this design the entire power system is not paralyzed. A computer control panel is the heart of a central control unit. Peripherals connected to it has a keyboard and monitor, as well as CANBUS interface circuit.

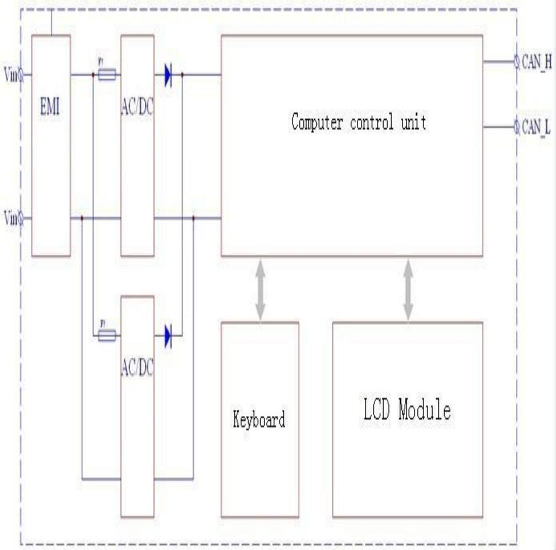

Figure 7: Block diagram of central control unit

As shown in Figure 8，a high-performance microcontroller C8051F040 produced by Cygnal company is the core of the central control unit ,the same as the microcomputer control circuit module power. The difference is that the processor is also responsible for keyboard scanning and dot matrix display, but it does not require analog processing. Because of the need for key signal scanning and displaying the signal process, the design uses digital IO port resources of the processor. P7 port is displayed as a data interface. P4 port pins are used to implement part of the display control signal interface.

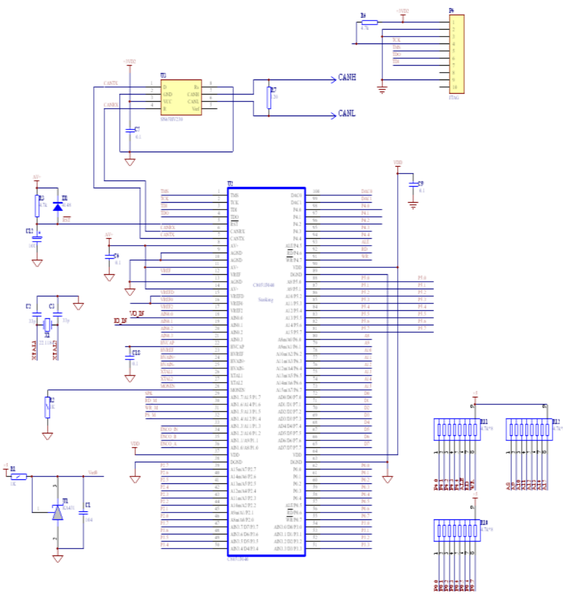

Figure 8: Block diagram of central control unit

3. Module Application with Control Unit

Modular communication power has flexible application methods. As a high-performance power module, it should be able to meet the requirements of various usage environments. By a simple combination of transformation, the communication power realizes the output function of different powers, different voltages and different characteristics. This article provides a redundant structure based on a combination of reliability of power supply equipments. Digital characteristics of the communication power is suitable for distributed power systems. This can achieve the function of remote monitoring.

3.1 Single Module Application

Because the proposed control has given proper road design, power modules are used either individually or in combination. Simple application of a single module refers to the fact that after connecting the power line with a module the circuit system can output 48V DC. This design does not require the size and characteristics of the power supply to be adjusted。As shown in Figure 9，the entire power system consists of a single module. It outputs 48V DC. The power outputs the electric current directly after it is powered. When the load of the DC power supply has a larger swing, the output leads to change a larger voltage drop. To be able to detect the voltage across the load directly and ensure a constant rated voltage of the load, this circuit requires the voltage detection terminals + S and-S to be connected to the output across the load.

The advantage of this control circuit is simple wiring. The entire power system has only one group of lines and a set of output lines. It is suitable for such an occasion for less electrical power demanding. The disadvantage of this control circuit is that the operating status of the power supply can not be effectively monitored. The power supply system has only a simple maximum protection.

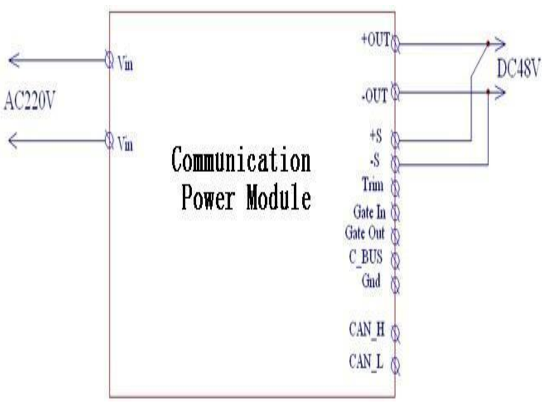

Figure 9: Diagram of single module usage

In some special applications, people do not ask for the power supply, but ask for the power requirements of the operating conditions for effective monitoring and adjustment. In this case the additional control units are added to the module power supply system. ◦

Figure 10 is an additional control unit of a single-module communication power system. Between the control unit module and the power module are connected via the CANBUS. The signal of the working state power module (output voltage, current, supply voltage, a variety of fault protection) is passed to the control unit via the CANBUS module. The control unit receives information needed to display on the liquid crystal display module. This system is sent to the remote monitoring computer based on the actual request. Meanwhile, the control unit can also send control commands to the power unit. It forces the output of the power unit to shut down or startup. And it can adjust the output voltage and the output characteristics and change the output current limiting, etc. Therefore, this communication power system realizes the remote monitoring and power control.

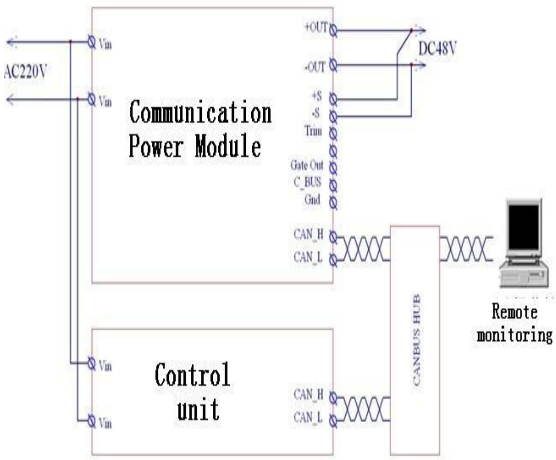

Figure 10: Diagram of single module with control unit

Figure 11 is a single-module communication power system structure attached to a control unit. Because there is no the rack in the single power， it has not the work environment of relying on a centralized forced air heat dissipation rack. The overall structure of communication power is the no-frame structure. Part of the power unit requires the burdened axial fan. The control module can be installed side by side with the power module and can be also install separately. Simple connection between two modules is only one CANBUS bus.

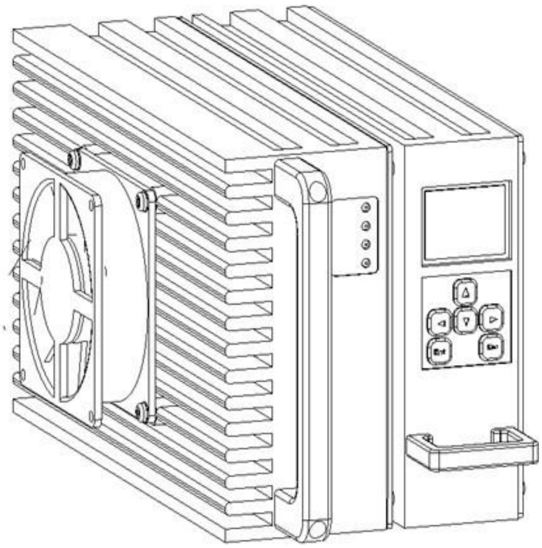

Figure 11: Structure diagram of single module with control unit

3.2 Integrated Multi-module Application

With the rapid development of communications, science and technology, automatic performance has greatly improved communications equipment. With the development of the basic technology and systems technology, a power system gradually gets to a higher level. Accordingly, the power supply system and the environment need increasingly high requirements. Because of a lot of the construction of communication stations, the arrangement of communication power supply equipments is scattered. A lot of power equipment is scattered in various stations. Power equipment often fails to be alert to the outside world when a failure occurs. At this time, the centralized monitoring and management communication systems need to be improved. Communication is an important part of the communication system power. If you want to adapt to the overall development of communication technology, inevitably you should centralize the positive monitoring system[17]. Development direction of a power equipment is centralized monitoring. We gradually realize the communication station and the power supply less unattended. This requires a reliable power supply system at the same time and intelligent management features.

A communication power module can be used in parallel. When there are some of the following requirements, the power of communication needs to be expanded to the power supply module:

1). Power Shortage. When the load requires more power than a single power module providing output power, communications power supply needs to be extended. Theoretically, the n parallel power modules can provide the n times of the maximum current output. However, after taking into account the modules connected in parallel flow accuracy, communication power can reach 90% of the total power after parallel connection.

2). Redundancy Applications. When a high level of module power applications, in order to ensure security of supply, a redundant backup needs to be done. When a module fails, its parallel module can automatically increase the output power. Faulty module quits working. This will achieve a continuous supply under fault conditions without the human intervention in the short term.

When the supply voltage does not need to be monitored, multiple modules are stacked in parallel as shown in Figure 12 where each unit and Gate_out Gate_in end to end ensure that each power switching and pulse phase are synchronized. This achieves the effect of both streams. In order to achieve the desired average flow effect, all of the power units sharing bus C_BUS are connected together.

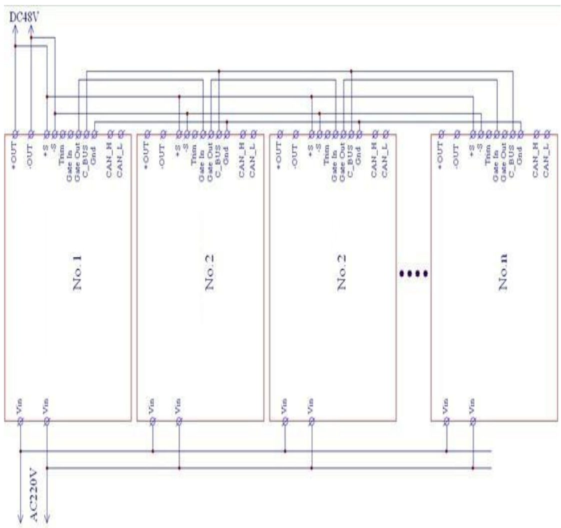

Figure 12: Diagram of multi- power module

Figure 13 is a system block diagram of an integrated multi-power supply unit provided with a control module. In order to achieve the expansion and redundant power supply control, the circuit uses the n units of integrated power modules in parallel programs. Where all the power modules and control units are connected using the CANBUS, and it is connected with the remote monitoring computer. A control unit monitors all operating conditions of the power unit including the output current of each unit, the temperature fault condition and the output voltage. It calculates the total output current display. When a module fails, the system automatically disconnects the output power of this module. After displayed on the operation panel, the system will alarm to the remote monitoring computer. In addition, this circuit can output it via CANBUS programmed with characteristics of each power module, setting the constant current point and the overcurrent threshold.

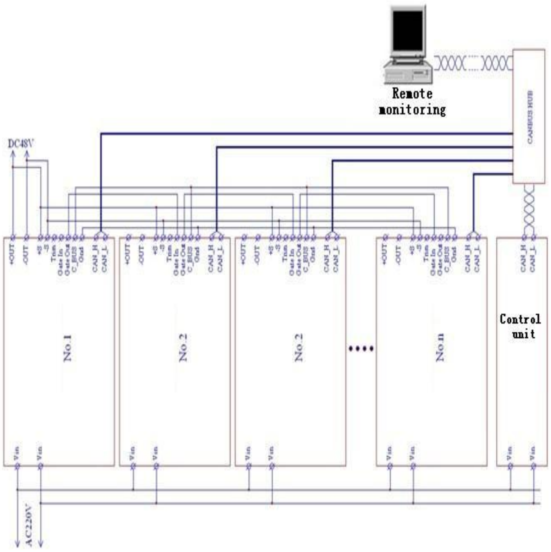

Figure 13: Diagram of multi- power module with control unit

Figure 14 is a block diagram of communications power systems with 7 units of multi-modules. The overall structure is a frame structure. The axial fan in the back of rack is installed for heat dissipation to the power module group. The power modules are connected by the metal rails and racks. In order to improve the power supply EMI index of the system, it must guarantee that the enclosure grounding of the power supply is good, and it can also realize hot-plugging at the same time. In order to ensure smooth and efficiency of the heat dissipation channels and airway, a damper is mounted to the control unit.

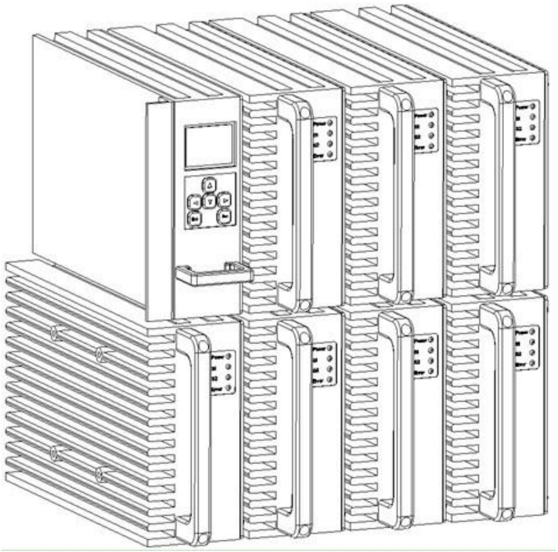

Figure 14: Structure diagram of multi- power modules with control units

4. Conclusions

This paper presents some new ideas and methods in the field of power supply design, such as the distributed, the modular and so on. Based on the growing demand for communication-powered device performance, the communication power supply system based on CAN bus control system is proposed. The paper described the design of digital power control system in detail including the communication power module circuit structure of a digital control unit and the additional circuit structure of a control unit. CANBUS hardware structure of the control unit is simply analyzed. The use of CAN field bus technology enables CAN bus communications to make the operating status and control power system become easy. By building a modular power system, the circuit has many features such as short design cycle, high reliability, compact overall structure, small size, easy system upgrades, etc. It has broad application prospects.

This design has a high-power system-on-module. It can not only be run with a single module, but also be combined with multi-modules into a more powerful power supply system. It provides greater power or the parallel combination of the redundant power systems. Having two ways with the center control unit, the CAN bus module power management enables monitoring and remote monitoring. The modular intelligence is an important direction for future development of communication power supply systems. This technique has the important significance for the power and security guarantee safe operation of the communication devices, and the system with the energy conservation.

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Yu-Juan Du was born in Hebei, China in 1988.She received the bachelor degree in software engineering from Hebei University of Science and Technology, Hebei, China, in 2011.She is currently a graduate student in the Instrumentation Engineering of Hebei University of Technology. Her research interests include computer control technology and system development.

Jin-Yong Gao was born in Hebei, China in 1970. She received the bachelor degree in microelectronics and solid state electronics from Hebei University of Technology, Hebei,China. She is now a senior engineer in Graduate School , Hebei University of Technology. Her research interests include intelligent information processing and communication technologies.

Xin-Fu Liu was born in Shunping county, Hebei province, China, in 1963. He received the B. S. and the M. S. degree in mechanical engineering and management information engineering from Hebei institute of Technology and Tianjin University in Jun. 1984 and Jun. 1998, respectively, and earned the Ph. D. in School of Information Engineering, Hebei University of Technology from Sep. 2000 to Dec. 2003. He is currently a professor in the school of Mechanical Engineering, Hebei University of Technology, and at same time he is now a Visiting Professor in the Department of Mechanical Engineering of National Chin-Yi University of Technology. His research interests include measurement of semiconductor, mechatronics, machine tool design and equipment design.