DESIGN AND DEVELOPMENT OF MICRO-CONTROLLER BASED EMBEDDED SYSTEM FOR DIFFERENT TYPES OF POWER SUPPLIES

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ABSTRACT

A micro-controller based embedded system has been designed and developed to monitor and control the operation of various types of power supplies required for the super conducting cyclotron, from the front panel as well as from the remote terminal. The main objective of this development is to provide support for the supervisory control of the indigenous power supplies developed to energize different magnets like main magnet, trim coils etc. for the operation of the cyclotron.

The system is broadly divided into two parts - the interface part and the front panel. The interface part has been designed around Intel 80196KC micro-controller and has facilities to set the current of the power supply through 18-bit DAC. A 16-bit external ADC has been used to monitor the output current of the power supply, through a DCCT. The system has facility to load the status register to indicate the different interlock signals of the power supply. The interface card essentially establishes the communication between the personal computer (PC) and the power supplies through RS422 / RS485 and follows a standard command-response protocol. This facilitates the remote operation of a number of power supplies connected in a multi-drop fashion. This card is being used with some indigenously developed current-controlled power supplies.

The front panel which is also connected to the interface card through RS422 / RS485 provides local operation of the power supply. This card, also developed around Intel 80196KC micro-controller, is connected to the interface card through RS422 / RS485 serial interface. Thus the panel may be physically shifted from the power supply up to 1.2 Km away and one front panel may be used for many power supplies. The front panel allows the local or remote setting of the power supply through a toggle switch. Through the embedded front panel, a user can set the current (coarse, medium or fine) of the power supply, display the output current and the status of the power supply and other relevant parameters. This panel is presently under rigorous test at the laboratory.

INTRODUCTION

A reliable, faster and easy beam tuning is required for more productive operation of the accelerators.Here is a case of design and development of the low level device controller[1] e.g. interface and setting control of a power supply unit.

OVERVIEW

Fig.1 shows the block diagram of control and monitor sections of a typical DC constant current output power supply. The aim of this paper is to focus mainly on the main controller unit and the front panel unit. The main controller unit supervises different tasks inside the power supply. It generates 18 bit digital output to achieve the stability of the power supply by comparing the voltage drop across the burden resistor, connected across the high precision DC current transformer (DCCT)[2] with the output of the DAC (Digital to Analog Converter). A transistor bank in series [3] is used to control the current.25 numbers of hardware and software safety interlocks are used.

The front panel unit is basically a replacement of remote software. It also communicates with the main controller unit with RS422 serial link and generates the same commands as remote software. An optical encoder knob is used to control the current either by placing it locally or remotely.

MAIN CONTROLLER UNIT

The main controller unit in Fig.2 can be divided in the following subsections:
μ-Controller, Serial Communication, Interlock, Analog measurement, Control Parameters, watchdog.

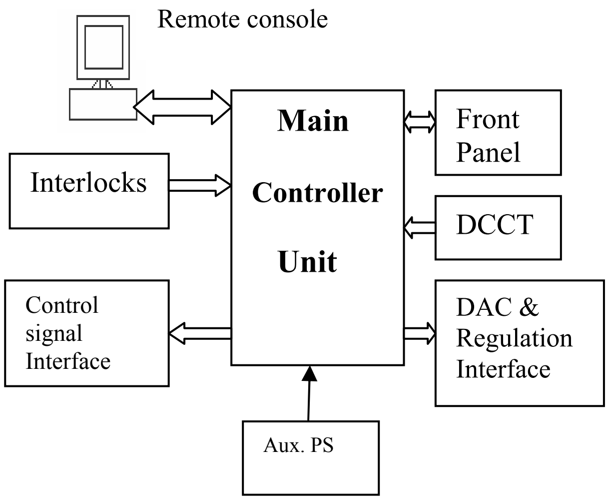

Fig.1: Block diagram of interconnections of the interface card inside the power supply

Fig.2: View of the interface card inside the power supply

μ-Controller

We have used 16 bit Intel 80196KC μ-Controller which belongs to MCS® 196 microcontroller families [4]. This CHMOS μ-Controller can handle high speed calculations and fast I/O operations. It uses a 12MHz crystal, which provides a T state of 0.16 μsec. The CPU of the controller contains register file and register arithmetic-logic unit (RALU) and it connects the memory controller and interrupt controller through a 16 bit internal bus. The register file is divided into upper and lower register file. The lowest 24 bytes of the lower register file are allocated as SFRs (Special Function register) and the stack pointer while the remainder is available as general purpose register RAM. The microcode engine instructs the ALU to perform operations either from lower register file or through window. CPU instructions move from the 4-byte queue in the memory controller into the ALU's instruction register. The microcode engine decodes the instructions and then generates the sequence of events that cause desired functions to occur. There are 256 numbers of accumulators in the μ-Controller for fast and efficient code execution. It also provides 29 numbers of interrupt in which 15 numbers of interrupts are vectored interrupt. The interrupt-handling system has two main components: the programmable interrupt controller and the peripheral transaction server (PTS). A micro coded hardware interrupt processor, provides high speed, low-overhead interrupt handling. An eight channel 10 bit successive approximation type ADC with 5mV resolution is one of the main features of the controller.

Serial Communication

The main controller unit consists of two physical serial interfaces, RS422 interface for communication with front panel controller and RS485 interface for multi drop network controlled from remote Computer. On chip RS232 interface is used for offline testing of the system. A USART chip is used with RS422 and RS485 signal encoder (Non Return to Zero) hardware driver chip to decode/encode signal level. Presently ASCII ACK/NACK data communication protocol has been adopted which will be upgraded to ASCII MODBUS in future for reliable and failsafe communication. All serial communication line is galvanically isolated from the controller by means of opto couplers and separate voltage supply is used for it. The baud rate, parity check and data format can be assigned either through the dip switches or through software. Switching between RS485 & RS422 is done by dip switch inside the controller.

Interlocks

The controller card has a facility to monitor system status on which interlocks are generated. All interlocks are hard wired and used to OFF the power supply if any interlocks are active. A RESET signal is required to ON the system again if the interlocks are clear. A delay line in the controller board ensures that an interlock signal only is accepted, if it stays high for longer than 50 msec to avoid spurious noise signal.

Analog Measurement

The system has a provision to monitor nine nos. of Analog channels in which a 16 bit ADC is used to fulfil the requirement of current monitoring resolution. Different system parameters like water level, load temperature etc. can be monitored from the system by proper ASCII command. All Analog channels are galvanically isolated from the main controller board by transformer-coupled isolation amplifier.

Control Parameters and Watchdog

To operate different relay switches for ON/OFF control of the power supply, the controller board provides some control parameters. These parameters can be set or reset by proper command.
A watchdog is used to live the system when it goes out of reset.

FRONT PANEL

Front panel is a user interface. As mentioned earlier, the user can control various parameters of the power supplies, apart from switching it ON/OFF, with the help of buttons provided on the panel. The user can also see the status of various interlocks and other information displayed on LCD and indicated by LEDs. The front panel is built around an 80C196KC microcontroller which is the heart of the hardware circuit. The microcontroller fetches the software instructions one by one from the memory and executes them. The software is an interrupt based program. Any button, for instance ON

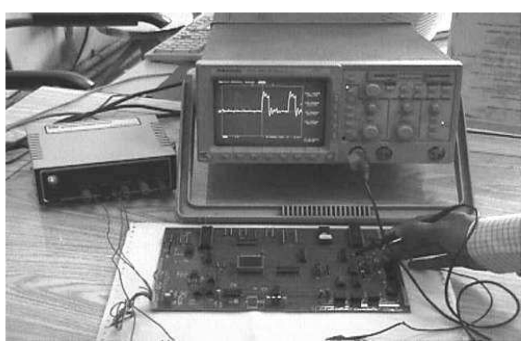

Fig3: Front Panel controller card under testing

if pressed generates an interrupt. The program counter then jumps to the respective service routine, executes it and returns back to the main loop. All interrupts used are vectored interrupts. The hardware circuitry incorporates various ICs. LCD and LEDs are connected to the microcontroller via 8255 programmable peripheral interface. Front panel communicates with the power supply on a two wire RS485/RS422 link. MAX 485/422 driver cum receiver IC is used for this purpose. An optical encoder is used to set the current value of the power supply. Push buttons are provided to set and see the status of various parameters. In this way both hardware and software portion of the panel work in tandem to meet the desired objective of the front panel.

FIRMWARE

The firmware of the whole system has been developed using 80196 cross assembler. It is loaded on a separate memory chip which is an 8KB UVEPROM. The firmware of the main controller is partially interrupt driven whereas the firmware for the front panel controller is designed to be fully interrupt driven. While the CPU is busy with its foreground task in the main controller, the data transfer occurs in the background. This assures best transfer rates and better software structure and also simplifies programming and debugging. The main routine of the main controller does not care whether the data source is from remote PC or Front panel. It only checks the buffer for new data to be processed. Using this concept the main routine can only target to data processing and the ISR (Interrupt Service Routine) handles the data transfer.

CONCLUSION

The system is designed to make a reliable and faster control system of the power supplies for the superconducting cyclotron. The hardware and firmware design for a reliable field bus protocol are in progress to make it operational in real control environment.

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