MICROPROCESSOR BASED POWER SUPPLY CONTROL SYSTEM

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ABSTRACT

A microprocessor based control system is being developed which would not only service many of the power supplies own internal functions, but also incorporates an intelligent computer communication port. This will often eliminate the need to use a separate interface. Certain configuration variables are stored on an EEPROM (Electrically Erasable Programmable Read Only Memory)[1], which can be programmed using simple ASCII commands via the computer port.

BACKGROUND

For many years we have been building power supplies to meet customer specifications. These specs almost always include some sort of "remote control" options, such as, analog reference inputs and relay contacts for status monitoring and so on. The burden is the on the user to interface the power supply to the accelerators main computer. CAMAC or Gould MODICON interfaces are widely used, and laboratory personnel have spent countless hours connecting, programming, and testing such systems.

More recently several customers have specified that the power supply should contain the interface and we have developed both IEEE-488 and RS-232 control boards. We custom program each board specifically for those supplies and depending upon what exactly the user wanted, may be configured in any number of different ways.

Microprocessor technology has advanced to the point that we felt that it was time to develop a new second-generation "smart" control system based on the idea that in direct proportion to the intelligence added to the power supply, that much less programming is required by the user. The power supply of the future will perform many of the functions that previously had to be done by the accelerators main computer.[2]

INTRODUCTION

Many types of laboratory equipment today include an integral computer port. Manufacturers have designed these to be easy to use. "PD" to a plotter might mean "pen down", "R1" to a voltmeter might mean "range 1". To our knowledge, no power supply manufacturer has developed an easy to use control language for power supplies. We envision that all the major functions of the supply can be initiated by simple commands, such as "ON", meaning ON. The same microprocessor that handles the communication protocol can also take care of the floating point math required for the scaling of units and also the power supplies interlock functions, thereby replacing numerous relays.

The design phase of this new control system is virtually complete. A prototype is now being built and the software is being written.

Some key features of the new design are :

1. Standardization of PC board pinouts to allow interchangeability and future upgrades.
2. Separate PC boards will be made for each major function. A complete system would then be built by plugging the necessary boards into the chassis.
3. Easy to understand ASCII command words will be used for computer communication.
4. The software will scale the DAC and ADC binary to an ASCII string representing actual units, for example, "300 AMPS" not "1111 1111 1111 1111".
5. Interlocks will be handled as ASCII strings, for example, "FAULT-WATER FLOW" not "bit 7 is low".
6. The entire system will fit within a standard 19 inch EIA chassis, 3.5 inches high.
7. Optical couplers are used to isolate between the digital and the analog sides of the the circuit.

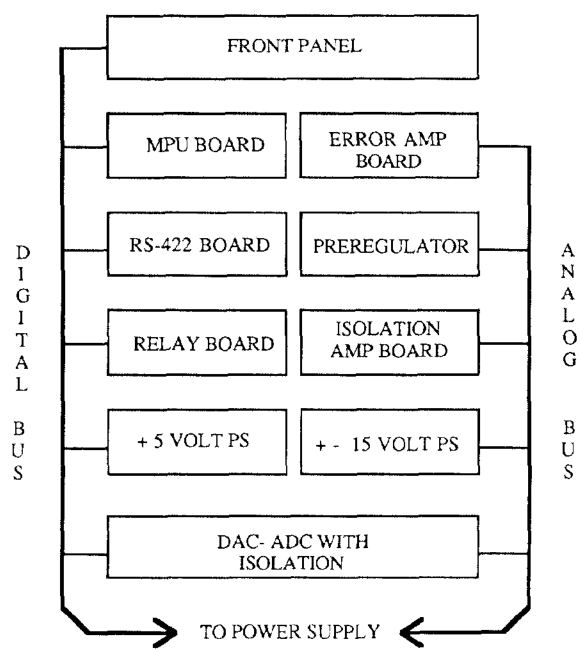

FIGURE 1 BLOCK DIAGRAM

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MICROPROCESSOR

A Motorola 6809 microprocessor[3] was chosen to use in the system. It is one of most advanced 8 bit processors available. Although considered a "mature" MPU by todays standards, it is widely used and will continue to be available for many years to come. The 6800 family of peripherals include the 68488 General purpose interface adapter (GPIA), 6850 Asynchronous communication interface adapter (ACIA), and the 6821 Peripheral interface adapter (PIA).

The MPU PC board contains the 6809, the program EPROM, 2k bytes of RAM, 2k bytes of EEPROM to hold the configuration variables, 2 PIA'S to read the interlocks and the necessary address decoding to properly map the memory.

COMPUTER PORT

One of two optional PC boards may be used in the system to provide either an IEEE-488 port or a serial port. These boards handle the necessary level shifting and handshaking required to interface the computer bus to the systems microprocessor.

The serial board can be loaded with drivers for either the popular RS-232[4] bus or the RS-422[5] or RS-485[6] bus. The later permits networking at distances up to 4000 feet. The board will use a unique software addressing scheme, whereby, the bus address is sent over the bus as the first byte of data, if the system recognizes this address as its own the remainder of the transmission will be executed. The software will also recognize a user defined name as being a valid address. Dip switches are installed to select the bus addresses as well as the baud rate, stop bits, etc. It was decided not to use any hardware handshaking on the serial board, this allows simple "party line" connections using one shielded twisted pair of wires. The unit can be setup to either respond automatically with a acknowledgement after each command word or to store the acknowledgement for a latter query.

The IEEE-488[7] board will implement the following subsets SH1, AH1, T4, TE4, L2, LE2, SR0, RL0, PP0, DC0, DT0, C0.

All of the digital PC boards operate from a +5 volt supply that is at earth potential. The + - 12 volts for the RS-232 board is generated on the bus driver IC[8] and complies fully with the standard.

POWER SUPPLY INTERFACE

The MPU PC board contains 2 PIA's each with a sixteen bit port configured as TTL inputs. These inputs are connected to the various interlock switches and contacts throughout the supply. The EEPROM is programed at the initial setup as to the number of interlock switches and the name of each switch. Thereafter, should a interlock fault occur, the supply will turn off, then, that name will be shown on the front panel and transmitted to the computer port.

DAC'S AND ADC'S

The 18 bit digital to analog converter (DAC)[9] provides the reference voltage to the power supply. Optical couplers are used to connect the earth potential microprocessor bus to the DAC's digital inputs which are at the power supplies output potential. This permits full 18 bit resolution through the isolation barrier. The digital isolation scheme always performs better than any analog isolation method which is both expensive and impractical beyond about the 14 bit level. The DAC is monotonic to the full 18 bits, which is necessary if it is to be used in a digital "closed loop" circuit.

The analog to digital converter (ADC)[10] is a state of the art 20-bit delta-sigma converter. The delta-sigma technique has several distinct advantages of other types of ADC's in this application, namely :

1. The serial output simplifies the required optical isolation.
2. The digital 6-pole Gaussian low-pass filter has a typical corner frequency of 10 hertz, this provides excellent rejection of 50 and 60 hz ripple.
3. On chip calibration circuitry can be initiated at any time and insures offset and gain errors of less than 1/2 LSB.
4. No missing codes to 20 bits

In contrast, a successive approximation ADC, if used to measure a power supply output must have start pulses synchronized with the power line to avoid reading the output ripple. An integrating type converter, while it can be triggered at random, must integrate over integer multiples of the line frequency to reject ripple. 100 milliseconds is commonly used because it rejects both 50 and 60 HZ. A delta-sigma converter, on the other hand, updates the output at a 4 KHZ rate, while still having a low pass corner at about 10 HZ.

The analog input to the ADC will be multiplexed and will read not only the output current but the output voltage, the DAC voltage and other important signals in the power supply.

FRONT PANEL

The optional front panel, when used, has all digital circuitry, current and voltage set points are entered using pushbuttons to count up and down. By holding down the up button, for instance, the DAC will count up, slowly at first then continually faster and faster. This will allow the user to set to one bit resolution, yet still go through the entire 262144 bits without taking all day.

The multipurpose alpha-numeric display can show everything needed, from current output to interlock faults to a message sent via the computer port. By showing the interlock faults on the display, the front panels can be constructed identically even if one supply has three interlocks and another has thirty.

SOFTWARE

The software program for the 6809 is stored on a standard 27128 EPROM. The program is written in a high level language then compiled into machine language. Our software development system can emulate the 6809 MPU for debugging purposes and produce ROMable code directly from the compiler. We have been very satisfied with the system when it was used on several other projects.

COMMAND WORDS

When the following words are received via the computer port the 6809 will interpret the words, check for proper syntax then execute the appropriate routine. Alternately, the first three letters of the command are also valid, and can be used as "shorthand". Most commands have a parameter word or value following it.

COMMAND	PARAMETER	COMMENTS
MODE	LOCAL	
MODE	REMOTE	
MODE	SETUP	inputs configuration
LLO	ON	local lock out on
LLO	OFF	local lock out off
POLARITY	+	
POLARITY	-	
STATUS	ON	
STATUS	OFF	
STATUS	RESET	
ISET	(value)	the current set point
ESET	(value)	the voltage set point
ISTEP	+	steps the current DAC one count positive
ISTEP	-	steps the current DAC one step negative
ITRIP	(value)	overcurrent trip point
ETRIP	(value)	overvoltage trip point
PADLOCK	ON	supply ignores every-thing
PADLOCK	OFF	
NAME	(name)	name recognized as a valid address
DISPLAY	(message)	displays this string on the front panel
DISPLAY	CLEAR	erases the display
CALIBRATE		initiates an ADC calibration cycle
IDENTIFY		unit will respond with ID information, model number, etc.
HELP		responds with some useful information

Many of the above commands can be used as a query by preceding it with a question mark (?), for example, ?MODE would respond with either LOCAL REMOTE or SETUP, likewise, ?STATUS might respond with FAULT-WATER FLOW.

This list is by no means exhaustive, new command words can be added as the need arises.

OTHER APPLICATIONS

The system can also connect to other equipment that uses contact closures for interlock and status controls, and analog voltages for current and voltage control. By configuring the unit for the names of the contacts and the scaling for the analog signals, it can be used on a wide variety of equipment. Because it is housed in a standard 19 inch chassis it should be easy to adapt to most laboratory environments.

CONCLUSION

A "smart" microprocessor based power supply control system, together with software that can easily be configured to meet a wide range of requirements is a very practical alternative to using a separate interface system. Total plant design is simplified, compatibility problems are minimized, and by spreading around the intelligence, mainframe overhead is reduced.

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