

A CAN BASED STATUS CONTROL AND INTERLOCK PROTECTION SYSTEM FOR THE SRS

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Abstract

The status control and interlock protection system of the Synchrotron Radiation Source (SRS) control system has been redesigned. The new design uses Controller Area Network (CAN) to communicate between the plant and the controlling VME system. The plant interface module is an in-house design, utilising a microcontroller to process the CAN protocol, while the VME interface is a commercial module. The resulting design minimises the number of in-house built modules while maintaining the same interface to the plant as the existing system. The ability to distribute the modules has simplified the installation and reduced the subsequent build costs. The first application of this system, controlling the vacuum equipment on a photon beam line, has now been commissioned and future installations are planned.

1 INTRODUCTION

The SRS at Daresbury Laboratory consists of a linac, booster synchrotron, 2 GeV storage ring and some 35 photon beamlines and experimental stations. The SRS came on line in 1980, the storage ring was upgraded to a high brightness configuration in 1987. Two superconducting wavelength shifters were installed in 1981 and 1992 and in 1998 two permanent magnet multipole wigglers were installed.

During the life of the SRS, the control system has developed to support the increasing needs of operating the facility, and to remove obsolescence from the systems being used. The most recent development is in the use of CAN bus to interface between the equipment being controlled and the control system.

2 SRS CONTROL SYSTEM

The original SRS control system is based around three mini computers [1]. These are tiered with the upper computer providing databases and user interface and the lower two computers interfacing to the linac, booster synchrotron, storage ring and beamlines over CAMAC highways. The CAMAC crates then interface to the equipment being controlled through the status system.

The control system is currently being upgraded by replacing the minicomputers with PCs, driving the CAMAC highway, which act as servers via an ethernet network to PC based user consoles as the clients [2]. For new projects embedded VME computers [3] are used as the servers, communicating with the same protocol to the PC clients, and using the status system to connect to the plant.

3 THE STATUS SYSTEM

3.1 Status Plant Interface

A single channel of status interface, to the plant, consists of 22 signals, see Table 1. Output signals are clean contacts from relays and inputs are optically isolated 24V signals.

Table 1 Status Interface Signals to Plant

No	Signal	Dir	Description
1	Reset	Out	Reset to update interlock from the plant
1	On	Out	On request to switch on the plant
1	Auxiliary On	Out	On timing or interlock mask to the plant
1	On Reply	In	Reply when the plant is on
1	Continuity	In	Continuity to the plant to show it is plugged in
1	Auxiliary On Reply	In	Reply when the plant is in a timing or starting condition
16	Interlocks	In	Interlock to take the plant off

One channel of the status interface, with one or more channels of analogues, is recognised as a control parameter, i.e. one piece of equipment to be controlled. This gives a structure to the control system as a whole and particularly the interface from the control system to the equipment being controlled. This is particularly valuable when fault-finding as a fault can quickly be tracked to system, module and signal. The concept has proved to be very effective to interface a wide spectrum of plant over the life of the SRS.

3.2 Function of Status System

The status system provides an interface between the control system and the plant, allowing remote operation and monitoring of the plant. It further provides interlocking and protection of the plant where required. To do this it responds in real time, to switch off a piece of plant in the case of an interlock failing. The process of protection is independent of the higher levels of the control system and rules to determine the protection are defined in the status system.

These functions ensure that a piece of plant cannot be operated if all the interlocks guaranteeing safe operation are not present. It further reports which interlocks have failed allowing the operator to take appropriate action. If

a piece of equipment is on and one or more interlocks fail then the first failed interlock is recorded giving indication of why the equipment went off.

The operation of a status interface standardises the plant interface to the control parameter model. Considering a general-purpose module it has four states: UNPLUGGED, OFF FAULT, OFF READY and ON. Requests from the higher level of the control system, ON-REQUEST, OFF-REQUEST and RESET-REQUEST and the plant status inputs CONTINUITY, ONREPLY and INTERLOCKS define the states. These are shown in fig 1.

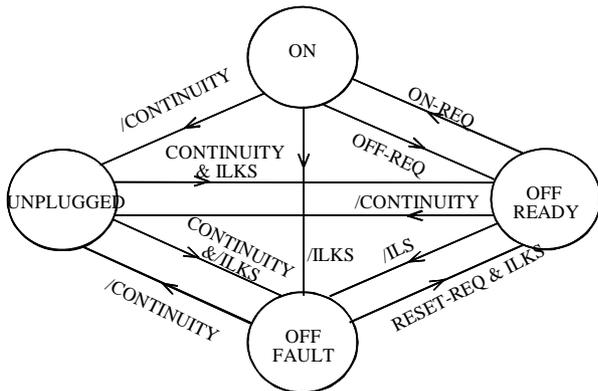


Figure 1 Status diagram for a general-purpose status interface.

4 DEVELOPMENT OF A NEW STATUS INTERFACE

4.1 Requirements of the New Status Interface

The new status system would have to interface between the VME front end computers and the plant, while maintaining the same plant interface. The solution was to make best use of commercial hardware, involving the minimum amount of hardware design and use a standard field bus. A number of bus options were considered, with CAN bus [4] proving to have the best match of the requirements: real time response, low packet overhead, good electromagnetic immunity, wide acceptance and support in silicon. This meant the system would consist of an in-house designed module to interface from the plant to the CAN bus, the CAN bus and a CAN bus to VME interface.

4.2 CAN Status Module

The design for the new CAN status module uses a Motorola 8bit microcontroller [5], with built-in CAN controller, to interface between the plant and the CAN bus see Fig 2. This receives all CAN messages, decodes the messages destined for that module, writes the outputs and reads the inputs to reply to message requests.

The address of the module is encoded on pins of the incoming CAN highway connector. This ensures that when a module is changed it automatically picks up the correct address and is not dependant on a person setting the address on switches. The module address is mapped to a block of 32 CAN identifiers, corresponding to write status, read status with 8 interlocks, read status with 16 interlocks and reserved functions. The write status message is used to refresh a watchdog timer in the microcontroller by toggling a bit in alternate messages. The watchdog has a time out period of 160 msec and enables the signals to drive the output relays. The inputs and outputs to the plant are galvanically isolated from the microcontroller, the CAN bus and hence the higher levels of the control system.

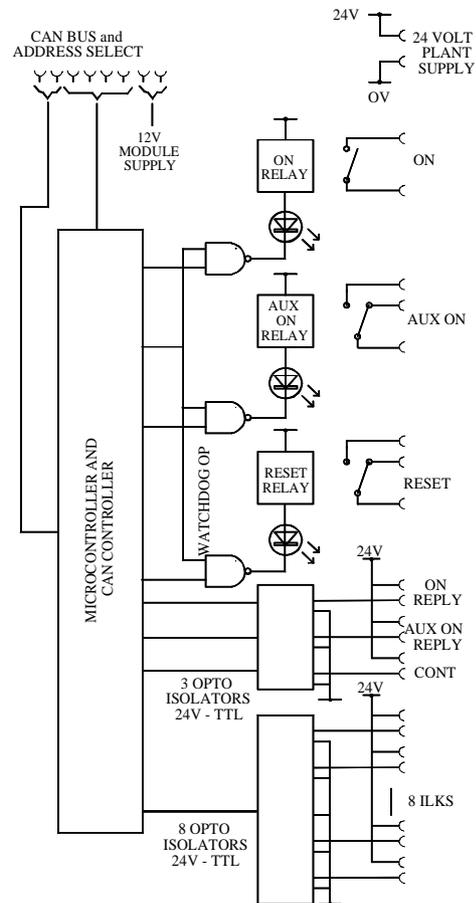


Figure 2 One Half of the CAN Status Module

The program for the microcontroller was developed in assembly language with the aid of an in-circuit emulator. The small overall code size, around 600 bytes, is related to the high level of functionality provided by the microcontroller to handle the CAN protocol. The microcontrollers used are one time programmable devices with 32Kbytes of EPROM. By setting a pointer in the EEPROM memory it was possible to have multiple version of the program code in EPROM with the most recent executed.

The new CAN status module includes the option to be configured as a dual channel module consisting of two groups of status signals and 8 interlocks each, or as per the original standard of one channel of status, and 16 interlocks.

4.3 CAN VME interface

There are a number of commercial CAN to VME modules available from different manufacturers, including: CAN interfaces for mezzanine modules Industry Pack and M-Modules [6], intelligent CAN interfaces with a dedicated processor to handle the low level CAN message, and general VME CAN interfaces. The interface selected, the CAN01 from HM Computers Ltd [7], provides two CAN buses, with 1500V isolation, using Intel 82527 CAN controllers in a 3U form. The VME interface is in short IO data space with programmable vectors for each channel and interrupts available on receipt of packets.

4.4 CAN protocol

While a number of CAN application level protocols are well established, the relative simplicity of this application, and the requirement for a low packet overhead, lead to direct use of the CAN message objects. The system operates with the VME crate as a master and the CAN status modules as slaves. The VME crate writes to the slaves to set outputs and refresh the watchdog timer, and initiates remote frame request CAN cycles to read from the modules. This ensures that the maximum of 31 modules can be accessed in a total time of 50 mSecs when operating the CAN bus at 500Kbit/sec. The maximum bus length is 40m, which comfortably serves one experimental beamline.

4.5 VME System

The VME system runs a number of processes, three of which are specific to the control system applications: a 'Server' process to the higher levels of the control system, a process 'Status' to communicate with the CAN bus and implement the status and interlock functionality and 'Comm' a process to communicate with intelligent instruments over serial communications, see Fig. 3.

The CAN01 interface module was supplied with device drivers and libraries for the OS-9 operating system. A wrapper was put over these to read and write to the data in the CAN messages.

The Server process and the Status process communicate through a database in memory. The database, created in RAM when the system boots, contains the initialisation and configuration for the particular installation. This includes the devices, driver, plant type, module number, interlocks used, interlock mask and timing values for various states, for each item of plant. The Status process reads the plant information over the CAN bus, and processes the status and interlock

according to rules defined for the plant type. The new state for the plant is then written to the outputs over the CAN bus. The Server process can return the state of the plant from values read from the database or control the plant by writing into the database.

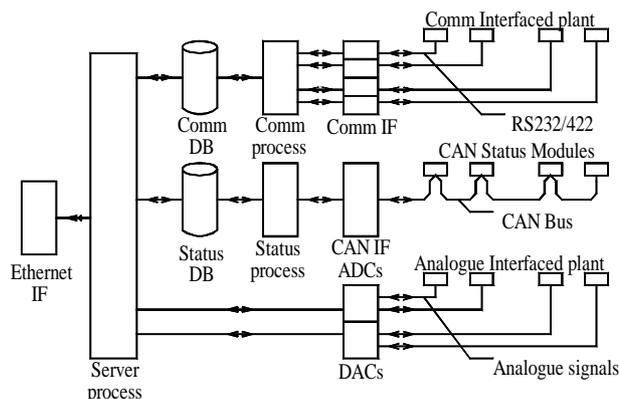


Figure 3 VME System Block Diagram

5 CONCLUSION

The CAN status modules have been used successfully in the design of the vacuum control system for three photon beamlines, one of which is now fully commissioned and in routine use. The use of the module has minimised inter-connection to the plant, simplified installation and reduced commissioning time. There have been no problems experienced with the CAN bus.

A development of the module is now planned to include two channels of analogue output and two channels of analogue input to a high precision. This would then be particularly suitable for control and interfacing of power converters.

6 REFERENCES

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