IEEE Transactions on Nuclear Science, Vol. NS-30, No. 4, August 1983

AN INTERACTIVE ALARM SYSTEM FOR THE CERN PS ACCELERATOR COMPLEX

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The new CPS controls system started operation in 1980 and is gradually being extended to control several accelerators and beam lines of the CPS complex. Part of the system and growing with it is a data-base driven alarm system. In each front-end computer, a program monitors the equipment, another the CAMAC interface and a third the beam currents. These programs send data to a central computer. In general-purpose consoles, a screen and touch-panel are dedicated to the alarm system. The alarms are displayed in various formats and levels of detail according to the wishes of the operator, who can also attempt automatic reset of individual faults or groups of related faults. Except for beam current monitoring, no details about the equipment are coded in the programs. The list of the equipment to be checked and information about it are stored in an off-line data base from which the necessary real-time files can be derived automatically. The result is a powerful and unified alarm system which can be easily maintained and updated.

Introduction

This alarm system is part of the new control system for the CPS accelerator complex. [1,2] At present, this covers the Booster, the Proton-Synchrotron, the Antiproton Accumulator and the beam transfer lines. The alarm system has been working satisfactorily for 2 years and about 1000 pieces of equipment (magnet power supplies, vacuum pumps,etc.) are now surveyed. New equipment is added to the survey regularly and, when the conversion to the new system is complete and the LEP pre-injectors are constructed, this may grow to more than 3000 pieces surveyed. Such a large system is difficult to cover by a collection of ad-hoc alarm programs. With the exception of some beam monitoring programs, all the alarm routines are general-purpose and they get their information about the equipment from a real-time data base. This necessitates a large effort before anything can be surveyed but after this it is easy to add new equipment or to change the specifications. It is also possible to do more than just display a list of alarm messages and every new facility works automatically for all the equipment. The data-base is especially attractive in our case where it became a general purpose facility for the control system because then the cost of updating is shared by the users and the danger of inconsistencies is minimised.

General Layout

The system configuration is shown on Fig. 1. The computers are shared with others systems; only the parts related to the alarms will be described.

The central computer contains the data base, the alarm colleting routines and a monitor program.

Any number of front-end computers can send data to the central computer. In many FECs, there is a program for reading beam currents. The operator, via a console program, can send intensity or efficiency limits to the program which will then monitor the beam for these limits.

In each FEC, there is a CAMAC survey program (designed and written by Dag Hallberg) which reads the CAMAC configuration from a table, specific for each FEC, and surveys, every few minutes, all the crates.

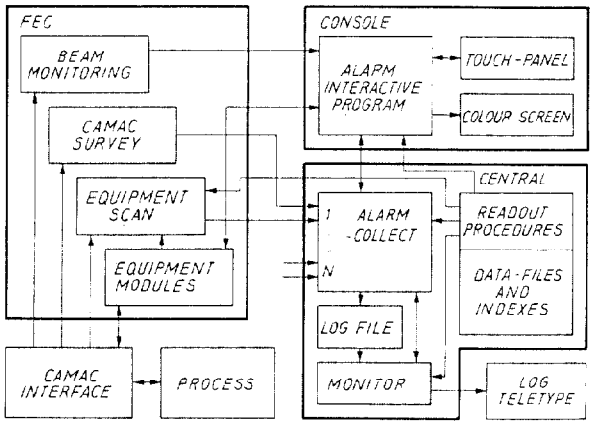

Fig. 1 Alarm system configuration

In each FEC which has accelerator equipment connected to it, program SCAN surveys this equipment. When SCAN starts, it reads its SCANLIST from the data-base. This list tells the program what to survey and how. SCAN will be described in more detail further on.

The survey programs send regular messages to the central computer indicating the equipment surveyed and a list of the faults found. This is safer than just reporting changes which goes wrong if one of the messages is lost due to a temporary malfunction in the computer system.

Any number of consoles can display the alarms. Each console has a large colour screen and an interactive touch-panel screen dedicated to the alarm system.

Access to the Equipment

All the accelerator equipment is connected to serial CAMAC. Normal access to the equipment is through software routines, the equipment modules (EM) which make the interface more or less standard. These EMs are addressed with an EM-number indicating the kind of equipment, an EQ-number giving the serial number of the equipment in this particular EM and a PROPERTY--CODE indicating the desired action.

SCAN can also address the CAMAC directly. The full CAMAC address gives LOOP/CRATE/STATION/SUBADDRESS/FIRST-BIT/NR-OF-BITS (up to 64 bits) or shorter: L/C/N/A/FB/NB.

The Data Base

The source files are maintained by a home-made file editing and manipulation system on an off-line computer. On request, a program reads these files and converts them to a format suitable for fast real-time access which is transported to the central computer. The readout procedures give access to this data base. There are 4 source files:

1. The EQUIPMENT-DATA file has a record for each accelerator equipment attached to the computer system. The fields which interest us here are:
- the equipment name
- FEC/EM/EQ numbers
- accelerator and equipment-group numbers
- group numbers of possible error causes

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- control-response description number (pointer to file 2)
- up to 4 status-word description numbers (pointers to file 3)
- absolute and relative analog tolerances
- CAMAC address for status bits
- CAMAC address for reset bit
- equipment and interface location codes

2. The CONTROL-RESPONSE file describes the control bit patterns. Each record contains:
- control and status word property codes
- patterns to mask irrelevant bits in control and status words
- 4 control patterns and corresponding labels
- 4 response patterns and corresponding labels
- treatment codes

16 possible labels indicate states such as on, off, standby, in, out, etc..

3. The STATUS-WORD file describes 16-bit status words. Each record contains:
- status word property code
- pattern to mask irrelevant bits
- reference pattern
- 16 error numbers,one per bit (pointers to file 4)

4. The MESSAGE file contains 28-character messages devided into 16 categories (general messages, place names, group names, equipment module errors, CAMAC errors, internal errors, external interlocks, etc.)

The SCAN Program

Among the data, generated by the off-line program, is one SCANLIST per FEC. This list is acquired by SCAN when it starts (or when a new version is loaded on the central computer). The SCANLIST is a kind of program which is interpreted by SCAN and contains all the information for doing the survey. The format of each word in SCANLIST is a 4-bit operation code and a 12-bit information field. The operation codes are: new EM-NR, EQ-NR out of sequence, new CAMAC-L/C, new CAMAC-N, new analog value tolerance, new control-response or status word description (followed by the description or pointer to it if already in list) and finally, one word per equipment with CAMAC-A/FIRSTBIT and space to memorise the latest control label. The list is very compact if the equipment comes in groups with similar descriptions and sequential addresses. In our system, it is typically 1200 words long for 500 pieces of equipment surveyed.

SCAN loops continuously, at the lowest priority, over all the equipment (with some delays built in to prevent it to loop faster than once a minute). For each piece of equipment, it checks the status words for faults. If several faults are found, the highest error number is retained (this can be influenced by priority bits). If no fault is found, the control pattern is compared with the status pattern and, if not ok, a message code is made with the labels which, decoded, reads like: "CONTROL=ON/STATUS=OFF".

Analog values are checked against a threshold tolerance in the case of current measurements in ion pumps. If a flag is set by the operator then analog values for other equipment may be checked against the control value.

Alarm Collecting

In the central computer, EQLIST (Fig. 2) has one word for each piece of equipment in the data-base. This word indicates the status : OK, MASKED (not surveyed) or FAULT. In this last case, the word points to an ALARM record in the ALARMLIST.

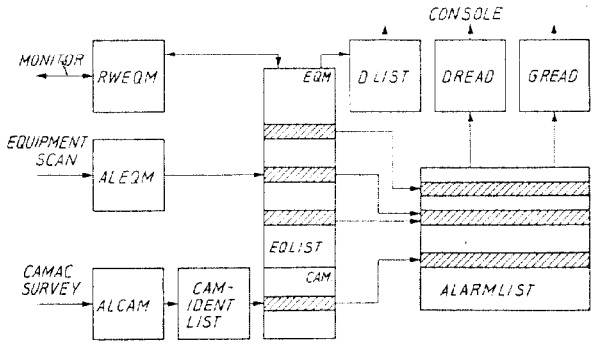


Fig. 2 Alarm status lists and readout procedures

Several words can point to the same ALARM, provided that: (1) they belong to the same equipment group; (2) they went faulty together (within a tolerance of a few minutes) and (3) with the same error number. There is place for 300 ALARM records in the list. An ALARM contains the information to display a line, describing the fault, on the console screen.

When a new fault comes in, details about the equipment are read from the data-base. The fault is attached to an existing ALARM or a new ALARM is created. If the equipment is again OK, the pointer to the ALARM is removed and the ALARM itself deleted if no other equipment is pointing to it.

The procedure for CAMAC crate faults is slightly different: they are never grouped together and have no entry in the data-base but I will not go into details here.

The ALARMS form a linked list, ordered according to the creation time of each ALARM. Routines are provided which enable the consoles to interact with the EQLIST and the ALARMLIST.

A monitor program checks whether all programs and computers in the alarm system are running well and also helps in logging the alarms.

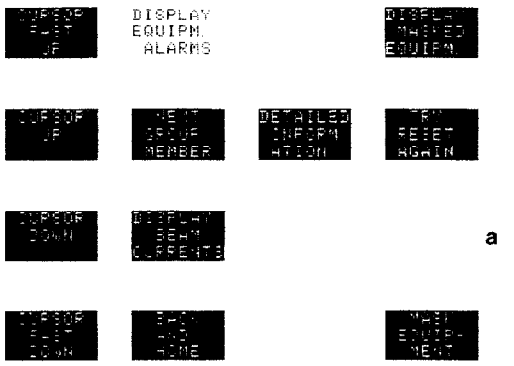
Console Interation and Display

A panel with 16 touch-sensitive areas, backlighted by a CRT with a page of "button" legends, serves to interact with the alarm system.

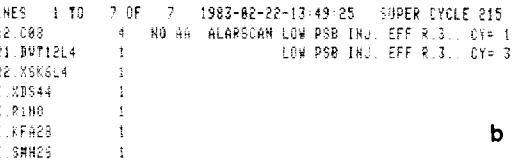
The upper half of the colour screen has a fixed format (Fig. 3b):
- at left, there is a place for 10 summary alarms (name of first equipment and number of equipments in alarm group). With the touch panel in the "home page", there are buttons for moving through the list else the 10 latest alarms are shown.
- In the middle, the system faults are shown: computer links down, hardware or software faults in computers, alarm programs not running.
- At right, the beam currents which do not meet the tolerances, are listed.

Interaction in each console is independent from all other consoles. In the "home-page", an accelerator can be selected. The information for this accelerator is then displayed on the lower part of the screen in any of several formats determined by a tree of touch panel pages.

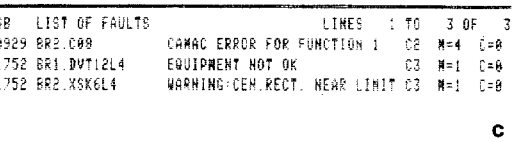
Most used is the equipment alarm display (Fig. 3c) with the associated touch panel page (Fig. 3a). The alarms are shown with the time of appearance, the name of the first piece of equipment, the alarm message, the number of pieces of equipment in the alarm group,



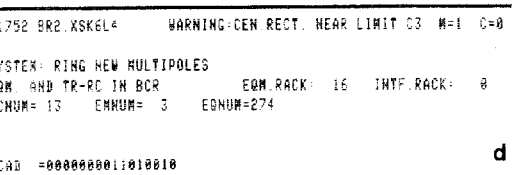
a



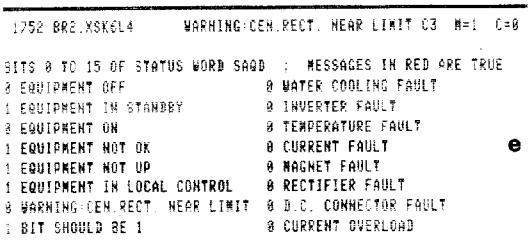
b



c



d



e

Fig. 3 Console Displays. After selection of the PS Booster, touch-page (a) appears and the colour screen shows the general alarms on the upper half (b) and the PSB alarms on the lower half (c). Two additional levels of detail about the alarm can be called on the lower half of the screen (d and e).

the number of the console which did a reset attempt and the number of consequential faults. Other displays are the list of masked equipment and the display of the beam currents of the accelerator.

Four buttons move a cursor through the lists. A few buttons interact with the line in front of the cursor: (1) send a reset sequence for the equipment in the alarm group; (2) list all the equipments in the group; (3) display one by one all the pieces of equipment in the group and mask them if so desired or get details about them.

The first level of detail is shown on Fig. 3d which is the result of an independent check of the console program. Amongst other things, the bit pattern of the control word and up to 4 status words is shown. The detailed significance of each bit in the words can also be obtained (Fig. 3e).

Consequential Analysis

Quite often, many pieces of equipment go down together because there is e.g. no cooling water or bad vacuum. It is important not to swamp the screen with too many messages so that the operator can see what is going on. A first step in this direction is to group the alarms as described above. This very effectively reduces the amount of alarms and makes the next step less urgent. This next step is to link the messages according to the causal relationship. The operator can then display the relationship or display alarms in different colours according to whether they are primary or consequential alarms and he can even suppress consequential alarms. The mechanisms for doing all this are ready but not yet implemented.

Alarm Logging

All available details of the alarms are written to a disc file and kept at least a few days before they are overwritten by newer alarms. These details can be read and printed on request. Every day, a summary is printed with one line per alarm.

Acknowledgments

The alarm system was made possible by the computer and software environment and its interface with the equipment. The specifications for the alarm system were made in collaboration with the accelerator operations group. The detailed alarm messages depend ultimately on the data supplied by the equipment made by many hardware specialists.

References

1. The improvement project for the CPS controls, Baribaud et al, IEEE Trans. Nucl. Sci., Vol. NS-26, No. 2, June 1979, p 3272.

2. Starting of the new CPS controls, Baribaud et al, IEEE Trans., Nucl. Sci, Vol. NS-28, No. 3, June 1981, p 2267.