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SYSTEM INTERLOCKS FOR ACCELERATOR

I INTRODUCTION

Although many of the design problems of Injector, Accelerator, Switchyard and End-Stations can be solved independently of the other areas, there are a few system-wide interlock circuits which provide a strong interaction between these areas. These circuits have themselves been described as isolated subsystems. The purpose of this note is to describe a unified logic for all these systems.

In addition to the local protective interlocks, e.g., water, vacuum, for individual pieces of equipment, there are five system-wide interlock circuits which conspire to shut off the machine under irregular circumstances.

They consist of:

1. Access Control System
   which prevents entry to a radiation area when the machine is on.
2. Machine Shut-Off System
   which shuts off all RF power to the accelerator in circumstances where there is a possible radiation hazard to personnel.
3. Machine Protection System (1 millisecond network)
   which shuts off the injector in circumstances where there is a probable radiation hazard to equipment.
4. A 50 μsec Protection Network
   which shuts off the injector in circumstances where the switchyard is not ready to accept the programmed pulse.
5. Pattern Interlocks
   which shut off the program for a beam in circumstances where the beam is not desired by the experimenter or a beam channel is not ready to accept any beam.

The Machine Shut-Off system and the Access Control system have been reported as parts of the Personnel Protection System.(1) The Machine Protection System report is in preparation.(2)

The major portion of the 50 μsec network is being designed in the switchyard interlock system(3), and the Pattern Interlocks have been described as components of the trigger system.(4)

II ACCESS CONTROL SYSTEM

The access control system contains a tone loop with transmitter at Sector 2, interrupts at each variable-voltage substation and a receiver in Central Control. If all substations are off, the loop is closed and permissive signals are sent to relays in each area, interlocked with ventilation and access controls. Release of keys and opening of ventilation hatches also requires explicit signals from the Central Control operator. When any substation is turned on, the loop is broken; interlock relays are released and the Central Control operator has no power to release keys or initiate ventilation.

The major purpose of the access control system is to keep the number of people entering the housing, the number of people entering at once, and the duration of each entry, to a minimum. The housing should not be cleared because the beam is coming on but because the need for occupancy is finished.

Entry to any radiation area requires consent of the Chief Operator. Entry to the Switchyard or End-Stations may also require consent of a switchyard operator.

Subject to the actual operating state of the machine, the Chief Operator may grant individual permission for each entry at "yellow" doors or general permission for unrestricted entry at "green" doors. He issues individual keys for access to miscellaneous areas.

(1) ED-104-057 Engineering Design Report, Personnel Radiation Protection System, K. B. Mallory

(2) Technical Note in preparation: K. Breymayer, K. B. Mallory

(3) H. Dijkhuizen, TN-64-59 "Interlock and Status Circuits in the Beam Switchyard"

(4) ED-106-146 Design Criteria, Pattern Generator, K. B. Mallory

For emergencies, local relay buttons are provided behind protective glass panels.

Normal Personnel Accessways

Normal Personnel Accessways ("yellow" doors) are characterized by having keys in a local keybank and two interlocked doors. One of the doors is locked and serves primarily as access control, the other serves primarily for machine shut-off protection.

In general, the locked door will be self-closing so that a person requires a key each time he enters. Each person who enters is expected to take his key along with him. The absence of the key from the keybank is his primary assurance that the accelerator cannot be turned on.

The second door is latched open any time a person is working inside, and provides assurance that the machine cannot be turned on. Warning signals such as flashing lights or bells will be interlocked with the closing of this door.

The main accessway to the beam switchyard must be left open for ventilation while people are working in the BSY housing. A lock on the filter screen will therefore be used for access control.

Additional End-Station Doors

Certain doors in the end-stations ("green" doors) cannot be opened unless uncontrolled access is permissible. Their use automatically requires a full search of the accessible area before operation may be resumed. Examples are the sliding concrete doors and gates in the utility trenches.

Miscellaneous Areas

Many accessways are closed by large shielding blocks which are semi-permanent in nature. These will not be interlocked with the accelerator. Other accessways such as those closed with lighter shielding blocks, manholes adjacent to the accelerator housing, etc. will be provided with a token chain or bar which is padlocked and whose key is available from CCR.

III MACHINE SHUT-OFF SYSTEM

The purpose of the machine shut-off system is to limit the hazard of radiation exposure when personnel are in the housing by turning off all variable-voltage substations (VVS) which supply high voltage to the klystron modulators.

The interaction of the machine shut-off system and the access control system is somewhat like putting two cars in a one car garage. If any VVS is on, there may not be people in the housing. If there are people in the housing, we may not turn on any VVS.

The machine shut-off system contains two parallel tone loops which determine that each radiation area is secure. The system recognizes the following separate radiation areas: Injector, Sector 1, Sector 2, ..., Sector 30, Beam Switchyard, End-Station A and End-Station B. If all of the areas have been secured, the tone loop is completed and a permissive interlock allows the operator to turn on the Variable Voltage substations. If the security of any of the areas is broken, the tone loop is interrupted and all Variable Voltage substations are automatically turned off.

The Machine Shut-Off system has the following inputs: all doors to radiation areas, access keybanks, emergency shut off pushbuttons, beam stoppers, slit positions and pulse magnet interlocks.

The emergency shut-off circuit contains a lock-out relay which must be reset each time the shut-off circuit is tripped. A separate lock-out circuit and a separate reset are provided in each area. Each time the emergency shut-off circuit is tripped the area accessible from the vicinity of that button must be searched. Upon completion of this search a reset button within the area must be operated. Simultaneous acknowledgement by the Central Control operator is also required to complete the reset process.

In order to allow experiments to be carried out in one end-station while equipment is being set up in the other, an alternative definition

of security is required for the End-Stations. If the pulse magnet modulator for that area is interlocked off, a beam stopper is in position and the slits are closed, the end-station may be defined secure and access may be permitted without shutting off the Variable Voltage Substations.

IV MACHINE PROTECTION SYSTEM

The Machine Protection System has a normal response time of one millisecond. Its major component is the one millisecond network, which consists of a Tone Transmitter in the DAB, Tone Interrupt Units at the Experimental Areas, Switchyard and each Sector and a Tone Receiver at Sector 0. The network shuts off the gun trigger if the circuit is interrupted at any of the tone interrupt units. The inputs to the machine protection system at each sector are those signals indicating those conditions which will cause total loss of the beam or loss of the energy contribution in one or more sectors. The inputs at the switchyard are signals indicating that no beam may safely pass through that portion of the switchyard common to all beams and a radiation monitor in the cooling tower loop for the radioactive-water heat exchangers. Additional inputs of the switchyard and target areas indicate that equipment is actually being overheated by the beam.

Breach of security of any of the radiation areas shuts off the gun through the machine protection system in addition to shutting off the Variable Voltage Substations through the Machine Shut-Off System. The Machine Protection System shuts off the injector for a minimum of one second and may be reset by the Central Control Operator only after the trouble has been cleared.

V 50 μSEC NETWORK

Provides a pulse-by-pulse shutoff of the gun in case of failure of any switchyard interlocks or of the pulse magnet to approach the proper field strength for the programmed beam. A pulse generator located at the DAB will generate a 200 μsec pulse approximately 150 μsec in advance of each beam pulse. If the interlock determines that the switchyard is prepared for the beam, the pulse is transmitted to

the injector trigger generator and drives a gate which transmits trigger pulses to the gun. A beam thus cannot be accelerated unless the permissive pulse is received from the switchyard.

A similar network arises at the Positron target. This transmits a permissive signal when the wand or wheel targets are clear of the beam and also when they are in all respects prepared to produce positrons. A third circuit will arise at the take-off magnet for the storage ring.

VI PATTERN INTERLOCKS

Interlock signals which must operate on the next beam pulse will be handled through the 50 μsec network. This network has no lockout feature. Interlock signals which are to be effective for a longer duration and shall affect only one beam will shut off the pattern for that beam at the pattern generator in Central Control. Examples of such signals are the experimenter's on/off switch for his experiment, interlock signals for the experimenter's equipment and interlock signals for the beam transport system into a target area. These signals will turn off the patterns for beams to that area without interfering with beams programmed to other experimental areas. Since the other systems necessarily turn off all beams, this is the only system which can handle signals which pertain to a single beam or experiment. It is also the one system through which the experimenter has explicit control over his own beam. The inputs to the system will be dry contact switches which, if opened, shut off a particular beam.

Provision has been made in the trigger pattern generator for programming alternate beams for a given experiment. An experimenter may have a high intensity and a low intensity beam programmed and may switch from one to the other as he desires. He might indeed provide for automatically switching from high intensity to low intensity when his target overheats, or his detectors overload.