BEAM OPERATION AND SAFETY SYSTEM FOR THE PROTON LINAC OF THE JAERI/KEK JOINT PROJECT

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Abstract

The low-energy front of the proton LINAC for the JAERI/KEK joint project is under commissioning. To cope rapidly and safely with various operating modes in the commissioning stage, a beam operating and safety system is very important. We adopt the PLC (Programmable Logic Controller) control system, which always watches the machine and environmental conditions, operates the machine in accordance with some sequential procedures and stops the beam in the case of an emergency [1].

1 OUTLINE

1.1 Composition

JHF-LINAC is an accelerator machine complex, which consists of Ion source (50keV), RFQ (3MeV), DTL (50MeV) and S-DTL (60MeV), which has four operating modes. Although the machine is situated at KEK presently; it will be moved to the Japan Energy Research Institute (JAERI) site in the future, and will be used as an injector for Japan Hadron Facilities.

1.2 Beam switch

In every operation mode, in order to make the beam ON, the operator should consider the conditions of every machine and safety concerning the mode (see Fig.1). When all conditions are ready, he can turn on the beam switch. But, if one of the machine conditions fails, the beam switch shall be automatically turned off immediately. Even if the failure time is very short and the condition recovers quickly, the beam cannot return ON automatically. After the operator checks the machine condition (Inter-Lock system), he can switch on the beam by pushing the reset button.

When the beam switch is turned on, a trigger signal is sent to the ion source, and a Gate Valve (GV1) and a beam shutter (BS) are opened.

1.3 Radiation Safety system

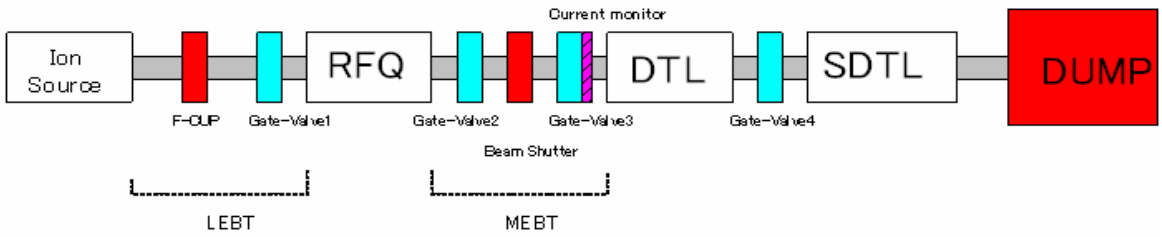
All doors to the accelerator room are closed by an electric lock. The inter-lock system includes the conditions of the door, personal-key and emergency beam stop switch. In the machine-operation mode, except for Ion-source mode, the beam can be ejected only in the case that all doors are locked. When a staff member enters the accelerator room, he must pull his personal key out from the key-box, and use it at the main gate. Other gates are used only for an emergency.

In the accelerator room, there are yellow revolving lights and emergency boxes at intervals of 30m, in which there are emergency beam-off buttons. By pushing the beam switch, the yellow lights start to revolve and a warning buzzer starts to ring. After 30 sec, the beam is ejected into the LINAC. Once the emergency beam-off button is pushed, the beam is stopped immediately.

The status of the Gate Valve and the Beam Shutter in every operation mode is as follows:

- Ion-source mode: In order that people can work in the accelerator room even in the condition of beam-on, the beam is stopped by a Faraday-Cup (F-CUP1) and Gate Valve 1.
- RFQ mode: From this and the upper mode, Gate Valve 1 is automatically opened upon turning on the beam switch, but is closed by pulling out the personal key.
- DTL mode: From this and the upper mode, the Beam Shutter is automatically opened upon turning on the beam switch, but is closed by taking out the personal key.

The answerbacks of the state of the Gate Valve and the Beam Shutter are input into the interlock condition of the beam switch.



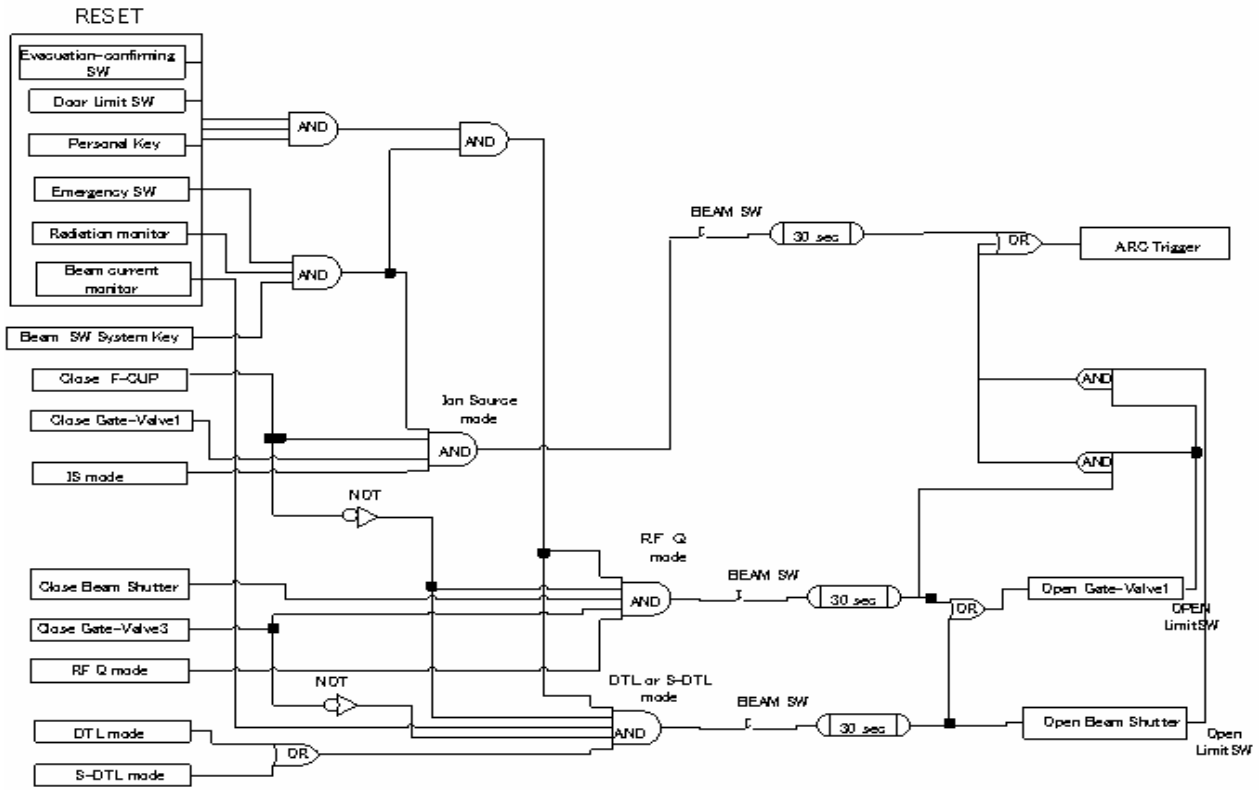


Fig.1 Upper figure: Beam Line
Lower figure: The sequence of beam switch control

2 FUNCTION OF CONTROL DEVICES

2.1 Programmable Logic Controller (PLC)

A block diagram of the beam-switch control and the safety system is shown in Fig.2. The PLCs are used for the beam control and the watching system of the personal keys. Inputs of the PLC for the beam control are connected to the ON/OFF status of all safety observation devices, interlock signals of the door and emergency switch. The status of the PLC is displayed on a beam-control panel. The input of the PLC for the personal key is connected to every personal key status, which is shown on a personal key display panel. The signal of the personal key PLC that all personal keys are set in the key-box is sent to the beam control PLC. Both PLCs have a program with about 2000 steps, and a scan time of less than 1ms. For extending the system in the future, the PLC has the capability of more than 8000 IN/OUT terminals.

Modules of the input and output signals are connected to the PLC with the ladder program method. Also, the PLC is connected to a Windows PC/AT by which we can change the program and observe the sequence.

2.2 Beam switch

Beam operation is done by using a beam-control panel, which is composed of a touch panel and a hardware switch panel. At first, the beam-control panel shows the accelerator machine complex through the beam line from the ion source to DTL, as well as touch panels of safety devices, which allows an operator to recognize the present situation of the machine operation at a glance. When one of the accelerator machines is touched, this can change the operation mode of the machine. The touch panels of safety devices are: (1) an evacuation-confirming switch, (2) an emergency beam stop switch, (3) a door limit switch and (4) a sensor limit switch. When the former two panels (1 and 2) are touched, the beam-control panel shows the location of the pushed switch; touching the other displays (3 and 4) shows the place where the limit is off.

The hardware switch panel is composed of a system key, a beam switch and a klystron stop switch.

The beam-control panel is inputted to a PLC and is also governed by the PLC. The color system used in these displays means that Green is normal and Red is abnormal. Their operation log is outputted by a printer as well as on a display.

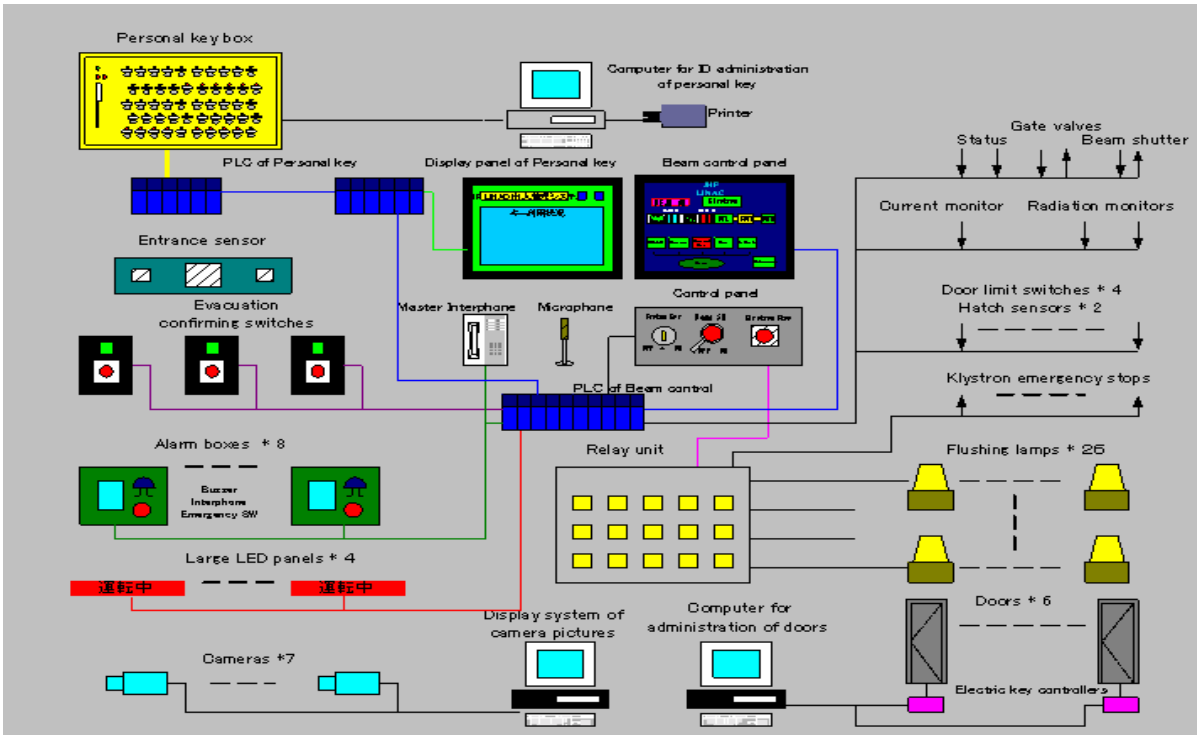


Fig.2 Control of the beam switch and construction of the safety system

2.3 Personal key system

There is a personal key box at the entrance of the accelerator room, in which 50 personal keys are set. Only a registered person can take off his personal key by using his ID card and enter the accelerator room by the key. When a staff member removes his personal key or returns it, the computer commanding the personal key box outputs the date, time, his ID number and the name not only on the touch panel, but also by the printer. It also keeps the data in the memory file. The computer is connected to a non-failure power supply. If the primary line power is cut off, the computer shuts down automatically.

2.4 Safety device

There are alarm boxes in the accelerator room and the control room. Each box has an emergency beam stop switch, an intercommunication phone and an alarm buzzer for beam ON. The beam can be stopped by pushing the emergency-stop switch. There are evacuation-confirming switches. At the start of machine operation, the last person who leaves the accelerator room checks the safety in the room and pushes the switch. Then, the status to accelerate the beam can be satisfied.

The door limit switches are set at the doors and the sensor limit switches at the hatches. Their outputs are used as interlock signal. At the entrance of the accelerator room, there is a sensor to check persons entering or exiting from the room. Once it detects a person passing, it starts a warning to carry and return the personal key. In order to display the present accelerator status, there are large LED panels with 12 characters at the entrances of the accelerator room. There are also warning lamps that are flashing while the accelerator is operating.

2.5 Watching camera system

There are cameras that watch for any device trouble as well as people going in and out. The camera pictures are shown simultaneously on a computer display. At the time of any severe problem, like fire smoke, the picture is saved in the computer automatically.

2.6 Administration system into or out from the accelerator room

There are magnetic card readers at all entrance of the facility. Only registered persons can enter the facility. All card readers are connected to a computer, in which the data of persons who enters the facility are kept in a file. The computer is connected to a non-failure power supply.

REFERENCES

[1] E.Kadokura et al., “The improvement of the KEK PS control system”, International Workshop on Controls for Small-and Medium-Scale Accelerators KEK, Tsukuba, Japan November 11-15,1996,pp103-105