BEAM DYNAMIC INTERLOCK AND BEAM ABORT TRIGGERING SYSTEMS OF THE IHEP ACCELERATOR COMPLEX

V.V. Gotsev, V.V. Komarov, I.V. Lobov, A.A. Matyushin,
A.V. Popov, Yu.S. Tchernoousko, V.I. Terekhov*
OEA Department, IHEP, Protvino, Russia.
*Corresponding author, E-mail: terekhov@tx.oea.ihep.su

Abstract

The presented systems are aimed at increasing the accelerator radiation safety. They are built as standalone hardware distributed systems. The Beam Dynamic Interlock System prevents the beam transfer to the next stage of the accelerator complex if that stage is not ready for the operation (e.g., magnetic field is out of range, bad vacuum, etc.). The Beam Abort Triggering System reacts immediately to an emergency situation at the accelerator by triggering the kicker magnets to dump the beam. Conventional computer control means are only used for post-mortem diagnosis and self testing during beam pauses. This paper describes the conception and components of UNK Beam Abort Triggering System under development and Beam Dynamic Interlock System of U-70/UNK Transfer Line, which was successfully launched in 1994.

I. INTRODUCTION

The IHEP Fast Ejection System (FES) extracts beams to external targets of channels 8,21,22,23 [1] and UNK–I, via the Beam Transfer Line (BTL) [2]. Fig.1 gives a schematic layout of the beam ejection area. A finite probability of pulsed transfer line malfunctions can cause appreciable radiation losses, exceeding tolerable levels. To avoid such a situation permanent monitoring of the magnet excitation currents is used. If operating variables are out of preset range the fast ejection must be interlocked for the corresponding line. The problem at hand is solved by the Beam Dynamic Interlock System (BDIS).

A second aspect of accelerator radiation safety is concerned with the necessity of a single-turn ejection (emergency ejection) of the beam from the UNK–I to the beam absorber when the danger of radiation losses arises. The so-called beam abort is executed by kicker-magnet 10KM1 within the energy range of 70 GeV to 600 GeV [3,4]. The triggering pulse for 10KM1 is generated by the Beam Abort Triggering System (BATS) which acquires and processes the emergency signals from threshold devices distributed along the ring. The radiation monitors are mainly used due to their fast reaction to emergency and preemergency situations. In the framework of the given paper main components of both BDIS and BATS are outlined.

II. BDIS

The main components and structure of the BDIS are shown in Fig.2. This system is distributed, as dynamic permission signals are created at the Ejection Building (EB) and at 3 Surface Buildings along the BTL. These signals are input parameters of the BDIS. They are yielded by permanently monitoring in hardware the excitation currents of the pulsed magnets (window monitoring). The output of the BDIS is the dynamic permission signal for the KM14 and KM16 triggering.

In addition, a fraction of the BDIS inputs is used for monitoring the status of vacuum valves and the pressure at the beam pipes. At the EB some inputs are connected to the radiation monitoring system of the experimental area.

At the heart of the BDIS is a module called Concentrator and Analyzer of Dynamic Permissions (CADP). It has 8 inputs with Diode Optoelectronic Couplers (DOC) for galvanic decoupling that is important for such a distributed system. A built-in time-delay analyzer permits time monitoring of input signals with reference to ejection time with an accuracy of up to 2 ms. A mask register gives an opportunity to disable any input on operator command. That is very useful while modes are changing or during comissioning. A Multibus–I interface allows one to identify inhibition sources and to test the BDIS itself. An emergency switch for the operator is provided.

III. BATS

The system monitors and acquires all local alarm signals (LAS). Their sources are distributed over 16 Auxiliary Buildings located mainly along the UNK ring at typical distances of about 1.8 km from each other. The following original signals are used to generate the LAS:

- the RM signals;
- beam position monitor signals;
- signals from pick-ups of dampers of coherent beam transverse and longitudinal oscillations;
- signals from pressure monitors of the Vacuum System;
- signals “Failure” of the Timing System, etc.

The LASs are generated by the threshold devices associated with the corresponding systems and are sent to a Concentrator - Repeater (CR). The inputs of the CRs are optically isolated from all external devices. All CRs are interconnected by means of an independent loop (coaxial cable). Activity of the BATS takes place during the period between beam injection and beam transfer to the 2nd UNK stage. A Driver Generator (DG), located in the Main Control Room, feeds a 1 MHz pulse train into the loop and receives it. The presence of any LAS at the input of any CR interrupts the train propagation. Having detected train disappearance, the CR of the Abort System building promptly outputs a kicker trigger pulse.

Such an algorithm ensures a time lag between firing of an LAS and the trigger pulse of less than 100 ms including the time propagation delays. Thus the kicker trigger pulse is generated only by hardware. All the CRs are linked to a Multibus–I backplane for post-mortem diagnosis, selftesting in no-beam states and masking any CR input on operator command. It is important to notice that the BATS provides for injection inhibition after an ejection trigger pulse has been generated.

As it was mentioned above, the fastest response is ensured by the RM signals. That is why the associated threshold device was given special attention. The simplified block diagram of the Alarm Level Discriminator (ALD) of radiation losses is given in Fig.3. The signals from the RMs, located near septum magnets, scrapers and other so- called “narrow places”, are individually input to Current - to - Voltage Converters (CVC). Their rise time is about 05 ms over an input current range of 15 nA - 15 mA. The output voltage of the CVC is compared with a predetermined reference. When that reference is exceeded, that comparator creates the LAS. A counter registers the event time for post-mortem processing. The reference levels are changed during the period of beam circulation, taking into account the rising risk of radiation as the beam energy increases. That energy is provided by using timing pulses at the major points of the UNK–I magnet cycle.

IV. CONCLUSION

The created BDIS was successfully used during the launching of the BTL in March 1994. The main principles of the BDIS have been confirmed by long-term operation of dynamic interlocking at the FES of U–70. Prototypes of the modules for the BATS have been tested. The electronics modules of the both systems are packed in Euromechanics. The systems are expected to be extended to UNK–II as well.

References

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[4] V.N. Alferov et al. *The UNK Control System*, *Proceedings of the 1991 IEEEE Particle Accelerator Conference.* San Francisco, May 1991, pp.1356–1358.

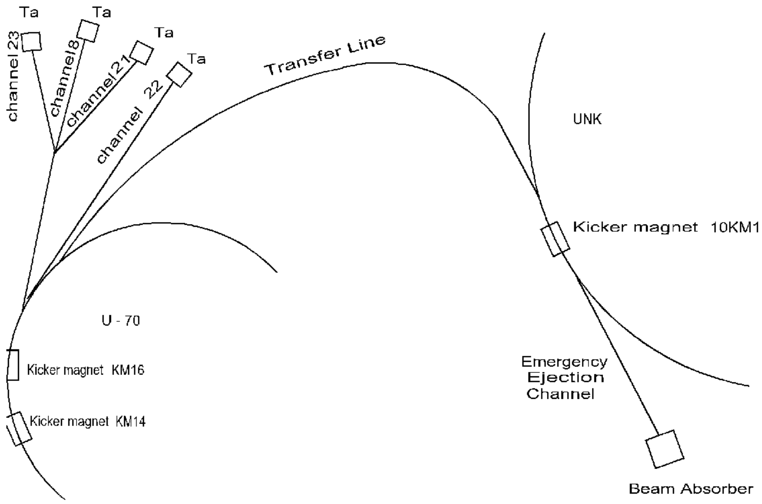

Figure. 1. Schematic Layout Of The Beam Area Of The IHEP Accelerator Complex

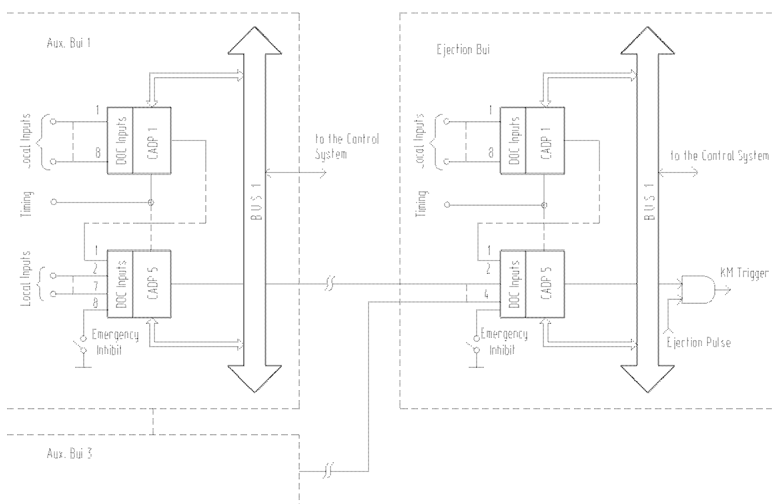

Fig.2. Block Diagram of the Beam Dynamic Interlock System

Figure. 2. Block Diagram Of The Beam Dynamic Interlock System

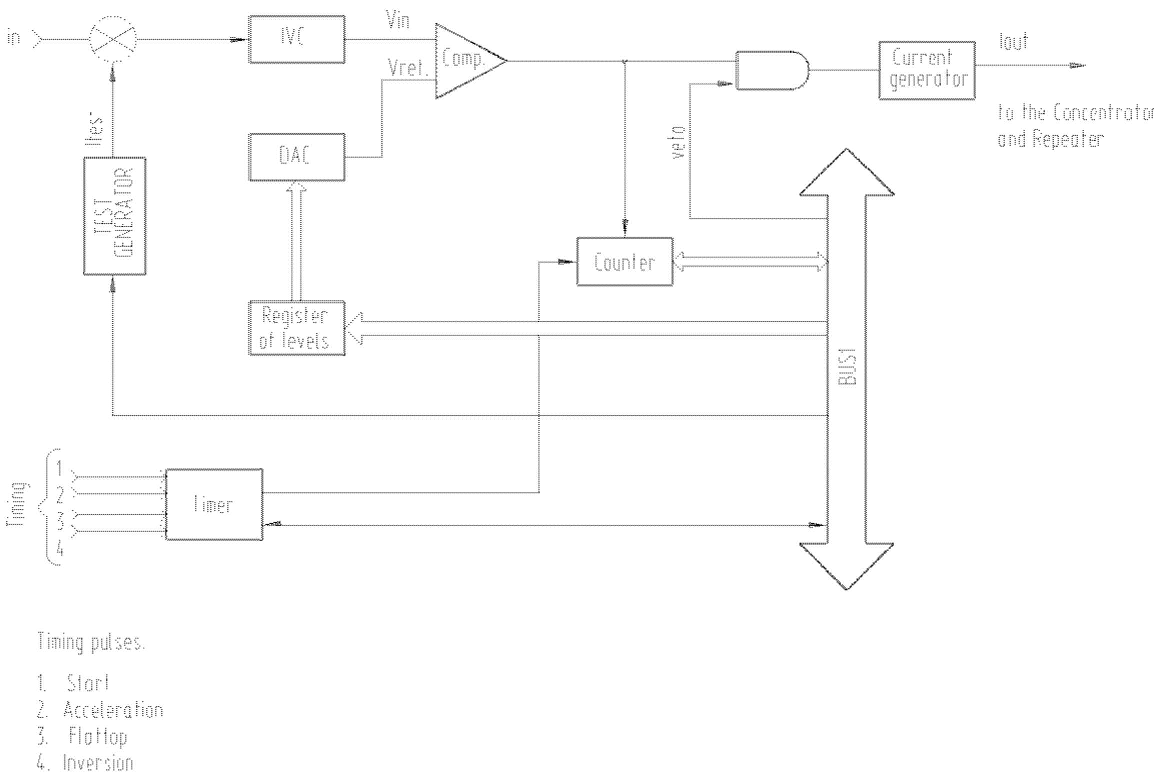

Fig.3 Block Diagram of the ALD of Radiation Losses

Figure. 3. Block diagram of the Alarm Level Discriminator (ALD)