

# PERSONNEL SAFETY SYSTEM IN SESAME

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## *Abstract*

SESAME (Synchrotron-light for Experimental Science and Applications in the Middle East) is a “third-generation” synchrotron light source under construction in Allan, Jordan. Personnel Safety System (PSS) in SESAME restricts and controls the access to forbidden areas of radiation. The PSS is an independent system which is built on Safety PLCs. In order to achieve the desired Safety Integrity Level which is SIL-3, as defined in IEC 61508, several interlocks and access procedures have been implemented in the system fulfilling characteristics such as fail-safe, redundancy and diversity. Also a system meant for monitoring and diagnostics of PSS is built based on EPICS and HMI. PSS PLCs which implement interlock logic send all the input and output bits and PLC status information to EPICS IOC which is not an integral function of PSS operation. This IOC will be connected to other control system’s IOCs to send informative signals describing the status of PSS to the main control system in SESAME. In addition, 5 combined Gamma-Neutron radiation monitors which are distributed around and over the booster area send interlock signals to personnel safety system.

## INTRODUCTION

Personnel Safety System is an independent access control and interlock system which interlocks accelerator operation and controls access to shielded enclosure to prevent personnel from exposure to high level of radiation forbidden by the law. PSS is designed based on the implementation of IEC61508 standard for programmable safety systems. In SESAME the safety Integrity Level of PSS interlocks is SIL-3. In addition, redundancy and diversity techniques have been applied to increase the reliability of these safety interlocks. For example to inhibit the operation of Microtron, the safety permissions will be removed from two different parts of the system; Microtron Trigger and Microtron High Voltage Power Supply. The first phase of SESAME PSS controls the Booster tunnel which contains Microtron and Booster ring. Following the adoption of IEC 61508 Standard, SESAME decided to use Allen Bradley GuardLogix® controller which is a dual processor solution that uses a primary controller and a safety partner to achieve SIL-3 [1,2].

## PSS DESIGN PRINCIPLES

Based on the experience from other synchrotrons the following design principles have been taken into account:

- PSS must be failsafe and PSS safety interlocks must dump the beam in case of any emergency status so that the safety integrity level equals SIL-3.

- Emergency stop and search buttons must be installed in the area covered by PSS, they need to be easily accessible, clearly labelled and distinguishable.
- Audible and visual warnings should be provided prior to accelerator operation and status indicators should be present to reflect the actual conditions of the machine.
- PSS needs to be a totally independent system and all PSS cables run in dedicated conduits and cable trays which are not shared with any other system [1,3].

## PSS SAFETY FUNCTIONS

The PSS has four main states, OPEN; which means there is free access to Booster tunnel, INTERLOCKED; after the search patrol has been completed, RESTRICTED and SECURED.

Booster tunnel is considered cleared of personnel when the search patrol is completed. The search process starts upon generation of Start Search command in PSS cabinet in control room. Search buttons distributed all around the Booster tunnel should be pressed in sequence within certain time limit based on the search path designed by the safety officer. During the search patrol audio warning is broadcasted by the sound system, asking the personnel to leave the tunnel [1,3].

The restricted access function is foreseen to provide short visits of personnel to the tunnel without the need for a new search. Like the Search patrol, the restricted access needs to be permitted by control room. After taking one of the personal keys the person is authorized to enter the Booster tunnel during RESTRICTED access mode (up to two people). In order to return back to INTERLOCKED state all personal keys must be in place on PSS cabinet door, tunnel door locked and the finish RESTRICTED access permitted by control room. The SECURED state exists when PSS is in INTERLOCKED state and the keys on the PSS cabinet in control room are in the position that allows the trigger of Microtron [1,3].

The tunnel door is locked by an electromagnetic lock and its status is monitored by a magnetic switch (SIL-3) and the feedback from electromagnetic lock [1,3].

In emergency cases (e.g. an individual is trapped in the Booster tunnel) they should press one of the red Emergency Stop buttons, distributed around the tunnel and on Booster PSS cabinets. This will immediately trip the interlock system, unlocks the Booster tunnel and stops the injection process [1,3].

To monitor the radiation level in service area, Booster roof and the inner ring of the Booster (pool), five combined neutron-gamma radiation trolleys ( by Thermo Fisher) are distributed in the mentioned zones. Three digital signals are continuously provided by each trolley to PSS, monitoring the status of radiation level and error signals. PSS will react accordingly to each of these signals [1,3,4].

## PSS SAFETY INTERLOCKS

The interlock devices linked to PSS are as follows:

**Microtron PSS Interlocks:** Microtron Trigger Interlock and Microtron High Voltage Power Supply Interlock

**Booster PSS Interlocks:** Booster RF Interlock and Booster Vacuum Gate Valve Interlock

Any of the Microtron PSS interlock devices can cease the operation of Microtron and terminate the injection process while the Booster RF Interlock will stop energizing of the beam and the Vacuum Gate Valve Interlock eliminates the stored beam in Booster. Each of the PSS safety interlocks is applied through phoenix contact PSR-SCP Safety relay which is approved for SIL-3 high and low-demand applications. The configuration shown in the picture below can fulfil the failsafe requirement up to SIL-3 as per IEC 61508 [1,2].

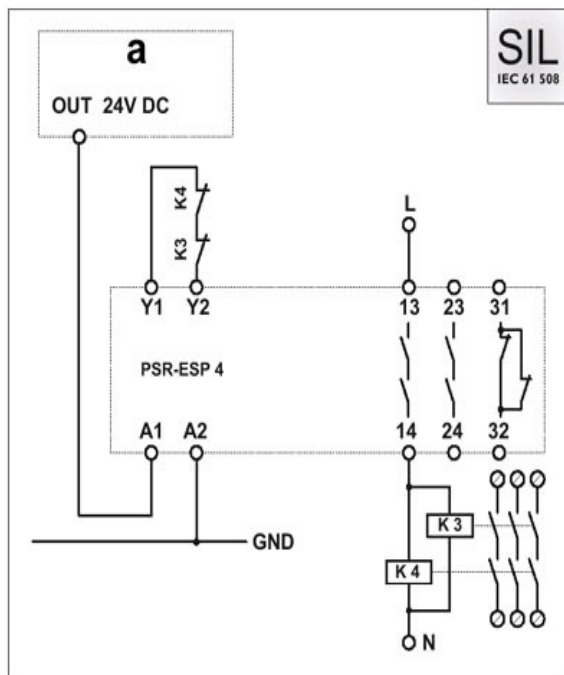


Figure 1: One-channel evaluation of a safety controller with automatic activation, suitable up to SIL-3.

## OPERATOR INTERFACE

The operator interface and operation keys are installed on the PSS cabinet in the control room. FactoryTalk® View is the HMI software product used to build a variety of screens on HMI. This system is only designed for monitoring and diagnostics. It does not have write access to the safety data block of PLC. The most critical operation permits are given with physical keys. The status of PSS, radiation monitors interlock signals, beam-on, etc. can be monitored via HMI. To unify the PSS GUI (Graphical User Interface) with other GUIs in control system of SESAME, work is underway to produce PSS operator interface in CSS.

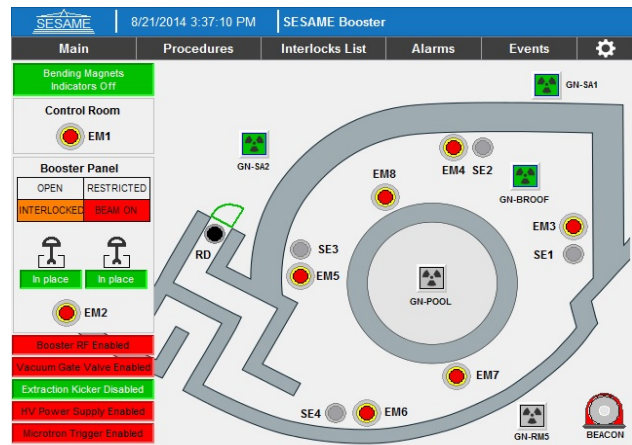


Figure 2: Main GUI OF Booster PSS.

## ARCHITECTURE AND TECHNOLOGY

The architecture decided for PSS project is to use safety PLCs as the processing element. Safety PLCs are designed and certified for use as part of a safety function. They have specific design features intended to meet the failure rate, redundancy, and diagnostic requirements of an IEC61508 compliant system. The PSS in Booster phase is built on an Allen Bradley 1756-L72S CPU, a GuardLogix® controller that also provides safety control. The GuardLogix system is a dual processor solution that uses a primary controller and a safety partner to achieve SIL-3. A major benefit of this system is that it is a single project, with safety and standard control together.

Another basic design feature is to use a distributed remote I/O architecture. The Guard I/O modules implement the CIP-safety protocol extensions over EtherNet/IP networks and provide various features for the safety system. CIP Safety, the extension to the Common Industrial Protocol (CIP) for functional safety applications on the EtherNet/IP networks, provides fail-safe communication between nodes, such as safety I/O blocks, safety interlock switches and safety PLCs in safety applications up to Safety Integrity Level SIL-3. Safety application coverage in CIP provides the ability to mix safety devices and standard devices on the same network or wire for seamless integration and increased flexibility. Because the safety application layer extensions do not rely on the integrity of the underlying standard CIP services and data link layers, single channel (non-redundant) hardware can be used for the data link communication interface. This same partitioning of functionality allows standard routers to be used to route safety data. The routing of safety messages is possible, because the end device is responsible for ensuring the integrity of the data. If an error occurs in the transmission of data or in the intermediate router, the end device will detect the failure and take an appropriate action [5].

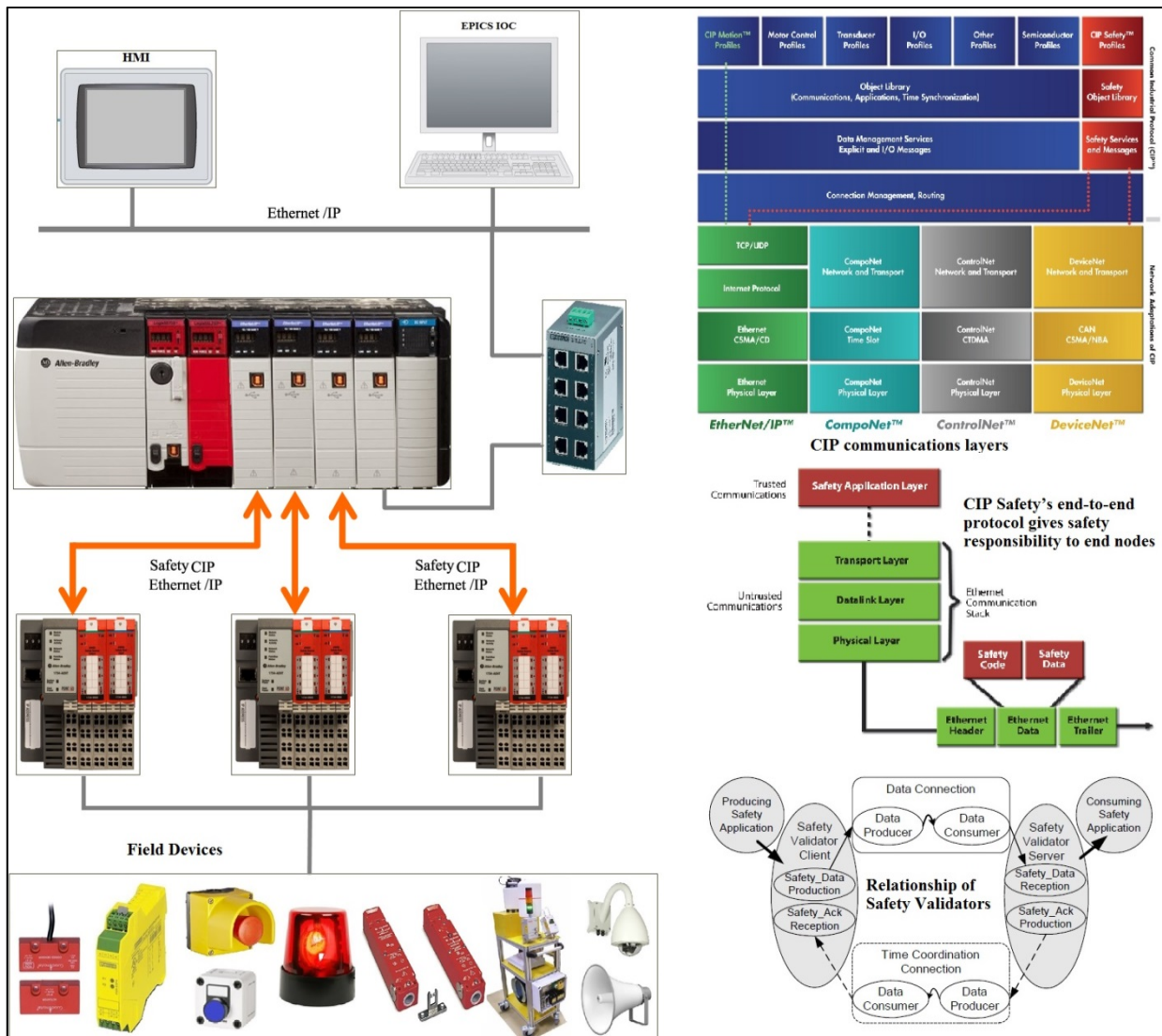


Figure 3: Network Layout of Booster PSS.

## SUMMARY AND FUTURE WORK

The Personnel Safety System in SESAME is established on safety PLC based system to meet the requirements of IEC 61508 standard and the design logic of this system is fulfilled with the safety interlock principles. The design uses a distributed safety architecture that increases reliability and lowers costs. The successful implementation of this system has increased the operation safety of SESAME facility. Lots of work is still underway to develop other phases to cover Storage ring and 3 day-one beam lines in SESAME.

## ACKNOWLEDGMENT

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