BPSS, THE BEAMLINE PERSONNEL SAFETY SYSTEM OF ANKA*

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Abstract

A modular Beamline Personnel Safety System for the synchrotron radiation source ANKA at Karlsruhe, Germany, was planed for up to 32 beamlines and erected simultaneously for 8 beamlines. We use a standardized, modular and by legal authority certified soft- and hardware to manage the safety needs of complex beamline configurations, like multiple beamline radiation hutches and/or shutters, further to manage the failure safe interaction with the beamline control system and the machine interlock, under the conditions of injection, beamline maintenance and erection, normal operation and alarm conditions.

Certification of all soft- and hardware components under the European Standard EN 954-1 risk category 4, [1] makes the safety commissioning of a beamline fast and easy.

1 THE ANKA FACILITY

ANKA is the synchrotron facility of the Forschungszentrum Karlsruhe, Germany, operated by the Institute for Synchrotron Radiation (ISS).

Based on a 2.5 GeV electron storage ring, photons are delivered essentially in the hard X-ray, XUV and infrared range, out of dipole sources. The inclusion of wiggler and undulator devices will provide a 2nd + generation facility of high brilliance for Research and Industry [2] to the middle of 2003.

2 THE ANKA BPSS

Low budgets for capital and operational costs, as well as stringent safety requirements by legal authority, include a thorough standardization of safety measures, regulating user access to the beamlines by a **B**eamline **P**ersonnel **S**afety **S**ystem (BPSS)

The task of the BPSS is simply to prevent persons and radiation to be at the same location at the same time. This has to be achieved under the following conditions:

- maximum Risk of irradiation must be less than 10^{-9} per user and worst case user action (opening accidently a radiation safety hutch, when beam is on and radiation shutter open).
- reliability of operation avoiding false alarms by the BPSS itself.
- easy maintenance of existing and integration of new beamlines to the BPSS.

* ANKA: Angstroemquelle Karlsruhe

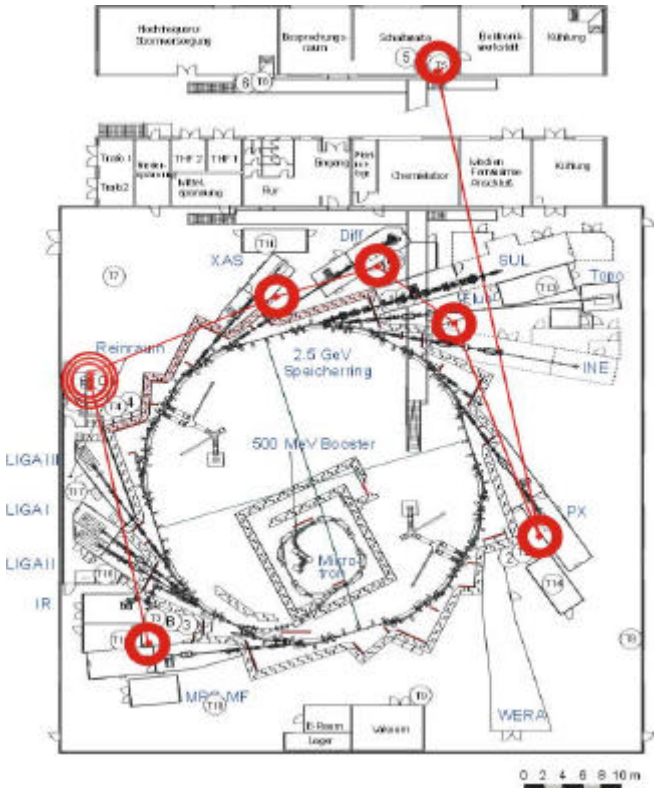

Figure 1 Location of the BPSS controller units at ANKA

3 THE HARDWARE CONCEPT

The BPSS consits as a network of failsafe PLC devices, one for each beamline, and a central PLC controller, interfacing the machine beam dump interlock with all local PLCs by a failsafe CAN-Bus [1]. The communication between the beamline BPSS and the machine control system is done via standard CAN-Bus (Status messages only) and redundant I/O channels. The BPSS is the only system with access to the beam shutters, verifying the requeststst from the other control systems to open a shutter.

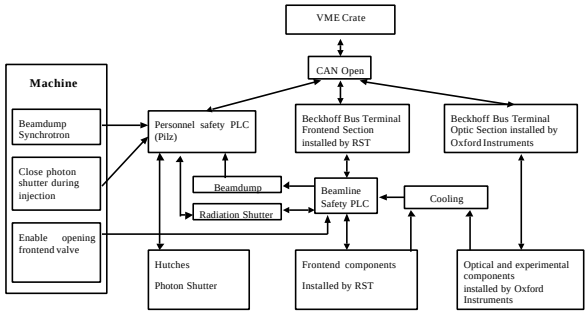

Figure 2 Interaction of the BPSS with the ANKA machine and beamlines control systems

The safety hardware e.g. shutter limit switches, door switches and locks, search and alarm buttons and cabling are avctively monitored with dual channel feed back loops, the electromechanical components are failsafe by construction [3]. A 1kHz Pulse signal traces the opto-couplers and filters, monitoring the on-line response of the safety actuators and I/O devices. In case of I/O failure the watchdog timer of the managing device (the PLC) stops all programme activity and brings the safety actuators in a predifined safe state. At ANKA this means that radiation safety hutches are locked and not accessible by users and/or a beam dump is initiated

Figure3 right: three BPSS Cabinets for LIGA Beamlines

3.1 PLC controler architectur

The diverse redundant three controler architecture is error tolerant in the case of one error (standard application only), if more than one errors accumulate, the System is stopped, there are three possible error classes :

- minor error in application programme or hardware, ST (standard) application running, FS (failsafe) stopped
- severe error, stop of the ST and FS application programmes
- fatal errors: system fails, but actuators are in a safe state

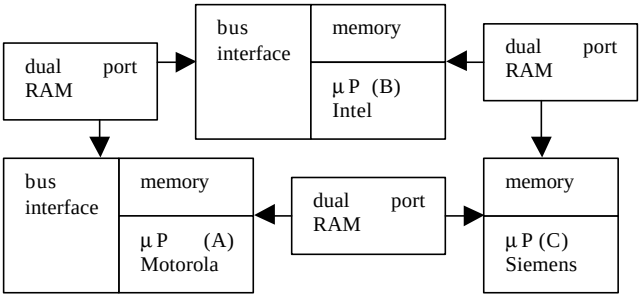

Figure 4 Three 16 Bit controller structure

3.2 process communication

The handling of input data from I/O devices can be done in two ways

- direct access during the cycle time of the application programme (alarm handling).
- polling the I/O process pattern before each application programme cycle binary inputs read by the 3 microcontrollers must be equal.
- data word inputs are compared by users need: out of seven possible criteria (equality, min, max, mean, amount, sign)

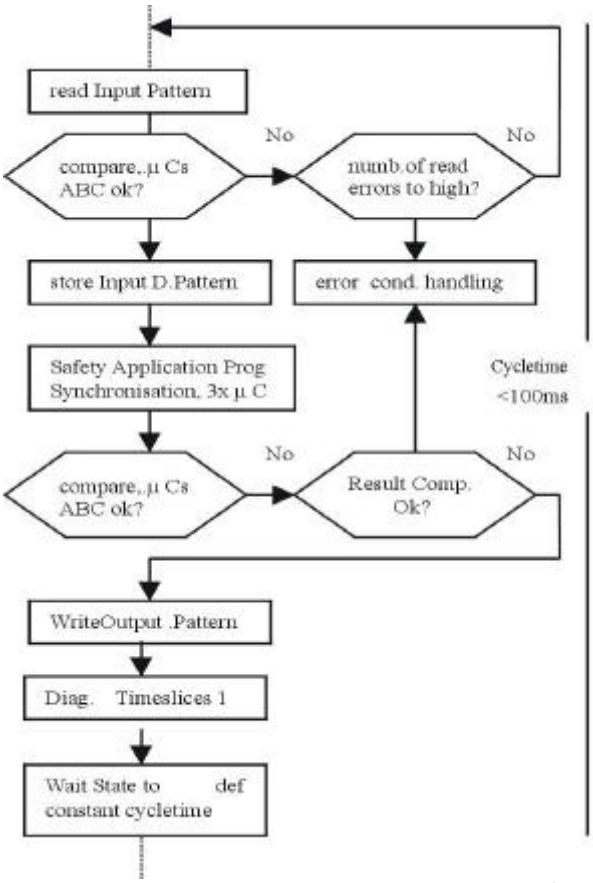

Figure 4 three processor channels (A,B,C) control flow

The process alarm handling is done by interrupting immedeately the running application programme and marking the module by flag. The application programme is finished and an alarm object is started. For alarm inputs there is need for special hardware. Up to 32 alarms can be handled by the system, the priority is set by choice of the alarm input pins. The time scale of alarm handling is of great importance and discussed in the next chapter.

4 THE SAFETYBUS P

The beamline PLCs and the central PLC unit are interconnected by a modified CAN-Bus (open source SafetyBus-p). Regarding the ISO/OSI (Open System Interconnection) reference model, the physical- and data link

layers are identical CAN, with an additional application layer to improve data transmission safety.
Bus devices standard profiles are specified by the application group of the SafetyBUS p club international e.V.
The club members are the manufacturers of SafetyBUS p compatible devices [4].The additional features of SafetyBus are specified in the SafetyBus p protokoll including

- checksum monitoring (CRC algorithm),
- echoing
- connection monitoring
- adress monitoring
- time monitoring

The SafetyBus p protocoll is available as firmware on a chipset for OEMs who must be members of SafetyBus p club.
The reaction time to a system alarm in the worst case is smaler than 100 msec for the ANKA-BPSS.

5 STATUS VISUALISATION AND DIAGNOSTICS

The BPSS communicates via standard CANBus with the VME-Beamline control system The transmitted format is a 16Bit data object with the following 4 process data objects

- status of safety modules (shutters hutches)
- alarms (beamline safety, beam dump)
- safety components diagnostics. (switch contacts, cabling)
- PLC diagnostics (error stack, parameter, location)

For the three first items, data type is ‘data word’ for the last it is ‘number’.
For each beamline there are resulting 62 status and diagnostic bit, available on a beamline VME system
By combining the information status and alarm, error messages are generated and visualized.
The visualisation of the BPSS status is done with a graphical user interface at each beamline
An overview of all ANKA beamlines beside the single beamline status is available on the machine operator PC.

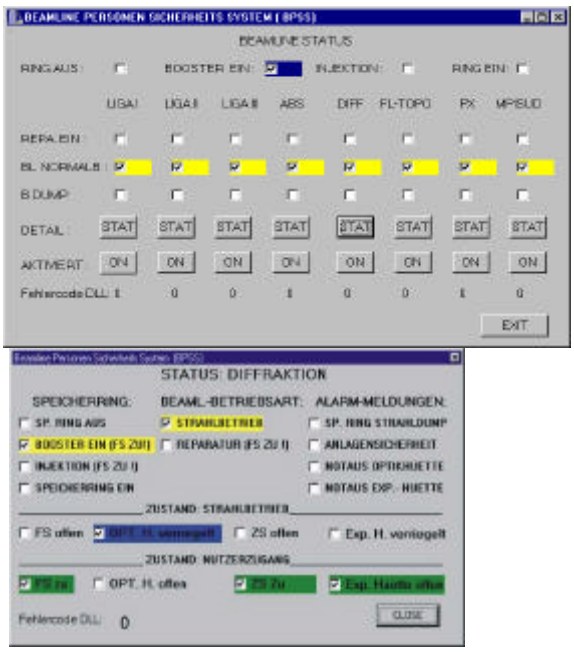

Figure 5 Status panels: machine, lower: Diffraction beamline status panel

6 CONCLUSION

After one and a half years experience with the ANKA BPSS we can report the following BPSS related event statistics:

- twice radiation hutches were blocked for beamline users by the BPSS due to mechanical failure of a vent delivering the pressurized air to move a shutter.
- A mechanical Problem due to a non centered shaft of a shutter
- A SafetyBus transmission error, requesting a local BPSS reset.

In all cases the BPSS worked according to specification, blocked access to dangerous areas and/or initiated a beam dump and sent a diagnostic message to operator.

7 REFERENCES

[1] EN 954-1, European standard for machine safety
[2] ANKA Beamline Book, Synchrotron Radiation Facility for Microfabrication and Analytical Services, FZK 2002
http:/www.fzk.de/anka/
[3] BIA-Report 6/97e, Categories for Safety related Control Systems in Accordance with EN 954-1
[4] http:/www.safetybus.com