The ELBE Center for High Power Radiation Sources

The ELBE facility has recently received an upgrade in terms of new secondary radiation sources and beam lines, while advancing the accelerator infrastructure towards 1.6 mA operation (1.0 mA before). Therefore, the machine interlock system (MIS) was redesigned in parts to meet the new timing requirements resulting from the increased overall beam power.

The superconducting electron accelerator (40 MeV, TESLA cavities) works in 24/7 operation and is worldwide unique to accelerate beams from a thermionic electron source or superconducting RF source (SRF Gun) in c.w. mode. The beam line upgrade from 2011-2013 included a revision of the positron an neutron production targets and the implementation of a new THz facility (TELBE), ref. [1].

The ELBE Machine Interlock System

The MIS of ELBE is composed of:

- beam loss interlock system (BLIS)
- equipment protection system (EPS)
- RF interlock system (RFIS)
- Vacuum monitoring system (VMS)

Its fundamental task is to prevent from:

- cathode damage or degrading
- damage to RF vacuum windows and amplifiers
- damage and/or contamination of the beam line
- contamination of the superconducting RF cavities
- damage to any beam instrumentation or beam guide components (coolant failure, radiation, direct electron deposition)

All components are integrated in the ELBE control system [2] for configuration and monitoring.

Beam Loss Detection and Fast Logic Interlock System

We use ionization chamber beam loss monitors (BLMs) and a system of strip line sensor based difference current monitors (DCMs) to detect beam loss [3]. To trip the electron sources (thermionic injector or SRF Gun) within a response time of 1 ms, we developed a new CPLD based fast logic interlock system [4]. Each module has 16 inputs to read isolated contacts (sub module) or optical fiber signals (main module) and a threefold optical output (POF). A Profinet interface on each unit enables configuration by the main MIS PLC and control system integration.

Vacuum Monitoring System

We replace an older in-house built trigger system with a commercial fast shutter system delivered by VAT [6]. It comprises:
- 2 VS-2 controller stations
- 6 fast shutter valves
- 15 UHV gauges

The system is configured by PLCs according to the actual beam path to enlarge the lifetime of the shutter valves. The overall response time of the system to a massive inrush is around 10 ms. This can protect the cavities if the event occurs at a distance of at least 20 m.

PLC-driven Equipment Protection System & RF Interlocks

EPS: Several PLCs evaluate the status of coolant, vacuum or beam instrumentation depending on the chosen electron source and secondary beam target, as well as on the actual beam mode:

- We use M2M communication based on S7 connections on Profinet and Proibus technology and send/receive mechanisms to share information needed by the MIS code on every PLC.
- The diagnostics mode limits the beam to 10 µA c.w. current or a charge deposition of 400 nC per macro bunch period (borderline for invasive beam diagnostics to be directly exposed to).

The RF interlock system involves also the main MIS PLC:

- PLC interrupts quickly shut down the low level RF in case of cavity mismatch, controller limitation or discharges at the RF windows (detected by photomultipliers)
- Overheating of the RF windows or bad waveguide vacuum trip the solid state amplifiers [5].

References