MACHINE PROTECTION SYSTEM FOR PETRA III

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Abstract

The basic design for the machine protection system (MPS) for the light-source PETRA III is discussed. High synchrotron radiation can damage absorbers and vacuum chambers. Therefore the MPS identifies alarm conditions from different systems, including the beam position monitors (BPM), temperature and vacuum systems and creates a dump command within 100us. For diagnostic purposes a post-mortem trigger is implemented and a first alarm detection is planned. The initial commissioning of the MPS with its alarm-delivering systems is described.

INTRODUCTION

The former electron and proton preaccelarator PETRA II was reconstructed into a high brilliant X-ray source. PETRA III will operate at 6 GeV. The circumference of the accelerator is 2.3 km. In the first step a beam current of 100mA is planned, the goal is 200mA [1]. The experiments are placed behind 14 undulator beamlines. Absorbers and beam chambers in the damping wiggler section and the undulator section have to be protected against synchrotron radiation. Closed vacuum shutters in the whole storage ring have to be protected as well against the electron beam. A dump trigger from the MPS is connected to the RF system which stops delivering power to the beam. The beam will be lost within 1ms at a dedicated scraper. In addition the beam shutters will be driven into the beam.

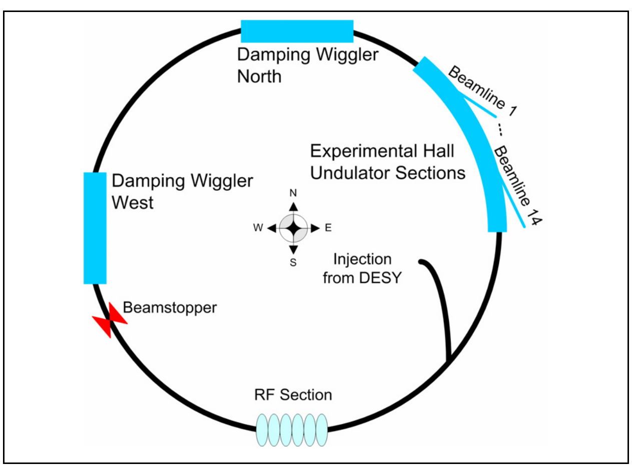

Figure 1: Overview PETRA.

MPS SPECIFICATION

The MPS should provide a dump trigger within 100µs after alarms are received. After a beam loss the MPS should provide a post mortem trigger which is delivered to other systems. In order to locate the initial alarm which triggered the dump, a first alarm detection should also be implemented.

About 170 alarms are connected to the MPS to protect the machine against damage from synchrotron radiation or the electron beam. Further 50 alarms are connected to the MPS for optimizing the first alarm detection. The alarms are distributed over nine PETRA halls but with main contributions from the damping wiggler sections and the experimental hall. Partially alarms are merged to one alarm for the MPS. The Tables 1 - 3 give an overview of all alarms connected to the MPS.

Table 1: Dump Triggering Alarms

System	Total Count of Alarms	Inputs at MPS
Beam Position Monitors	95	95
Temperature	260	17
Vacuum Shutters	35	8
Fast Vacuum Shutters	14	14
Personnel Interlock	1	1
Getter pumps	26	13
Vacuum Hand Shutters	14	4
Water Flow	33	5
Screen Monitor	1	1
Total	**479**	**158**

Table 2: Alarms for Masking Other Inputs

System	Inputs at MPS
Undulator Gaps	14
Damping Wiggler Gaps	2
Total	**16**

Table 3: Alarms First Alarm Detection

System	Total Count of Alarms	Inputs at MPS
Magnet Power Supplies	700	42
RF System	8	8
Total	**708**	**50**

A dump button is implemented into the software console program in addition to a hardware dump button. Both dump buttons are connected to standard alarm inputs.

Every alarm input is masked with an individual beam current threshold. In the damping wiggler sections and the undulator sections several alarm inputs have to be combined. Figures 1 - 3 show the different assemblies.

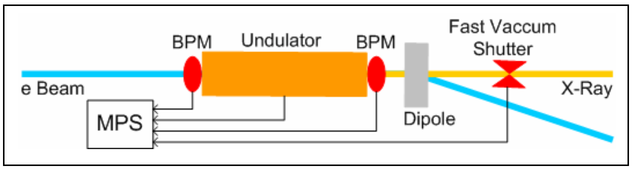

Figure 2: Single Undulator Section.

For a single undulator module section a dump is triggered if one of the BPMs or the fast vacuum shutter gives an alarm and the undulator gap is closed.

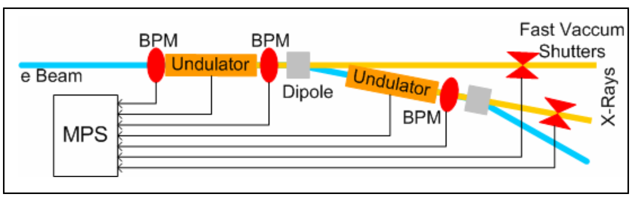

Figure 3: Double Undulator Section.

For a double undulator section a dump is triggered if one of the three BPMs gives an alarm in combination with one or both undulator gaps or if a fast vacuum shutter gives an alarm in combination with the corresponding undulator gap.

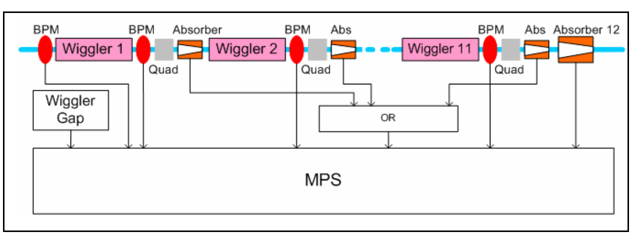

Figure 4: Damping Wiggler Section.

In a damping wiggler section a dump trigger is created if a minimum of two BPMs or the summary alarm of water flow sensors gives an alarm in combination with the closed wiggler gap. The water flow sensor in the last absorber in the section creates an alarm itself.

MPS DESCRIPTION

The MPS is a distributed system without a central unit. In every PETRA hall a crate is located which collects up to 112 alarms and provides a dump trigger as well as a post mortem trigger. The MPS crates are linked together with a redundant optical fibre loop. The connection to the control system is done through the SEDAC fieldbus, which is an inhouse development. All modules needed for the MPS were developed and built at DESY.

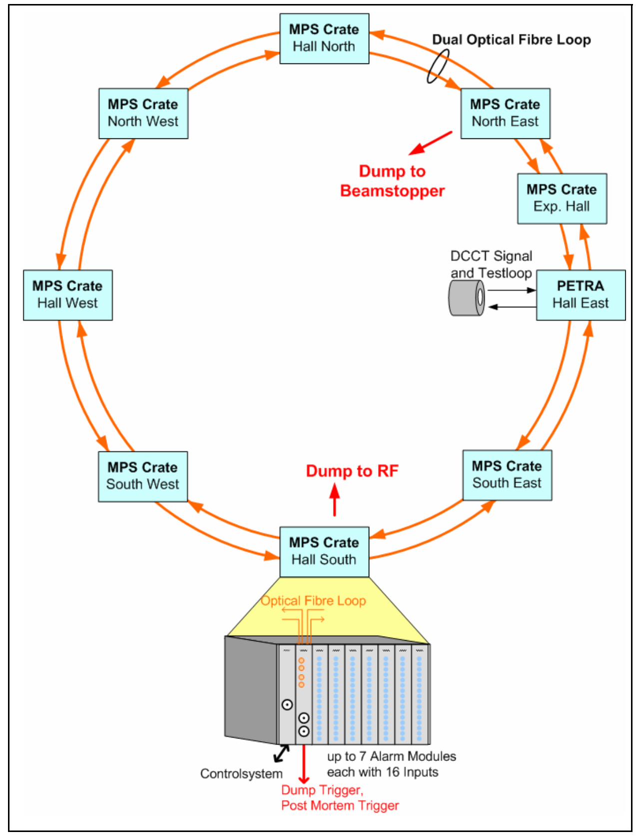

Figure 5: Overview of MPS Components.

Alarm Inputs

Alarm delivering systems provide a potential free contact to the MPS. An alarm corresponds to an open contact. An MPS input provides a 5V / 10mA source combined with a differential input to read the contact as shown in Fig. 6. The advantage in comparison to a 24V technique is very fast alarm detection (~1µs). By the use of shielded differential cables EMI problems are reduced to a minimum.

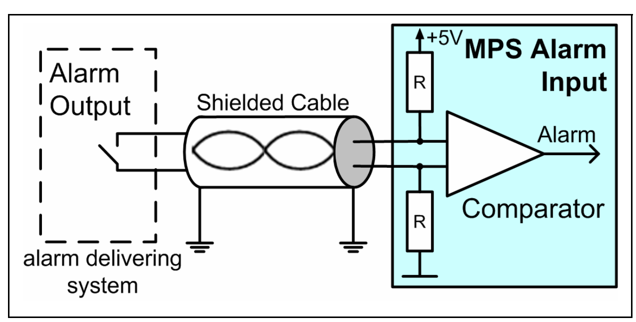

Figure 6: Differential Alarm Input.

Signal Flow Inside an Input Module

All alarm inputs can be configured by software with individual beam current thresholds. The active beam current is received from a dedicated DCCT beam current monitor through the optical fibre link. It is possible to combine the 16 inputs within a module into an and/or matrix. Figure 7 shows the alarm flow.

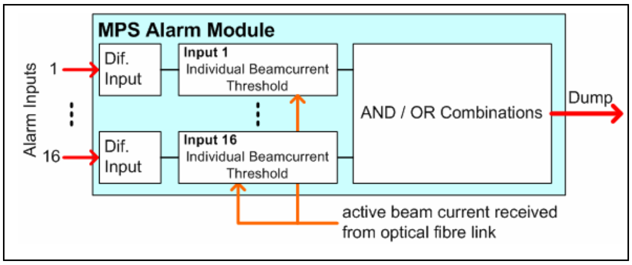

Figure 7: Alarm flow.

BEAM CURRENT MEASUREMENT

The beam current is measured with a dedicated DCCT and transferred via the optical fibre loop to the whole system. An integrated test loop through the toroid is used for an ongoing test of the complete DCCT installation as shown in Fig. 8. Such a permanent test is important since a zero-reading of a non-working monitor disables alarms.

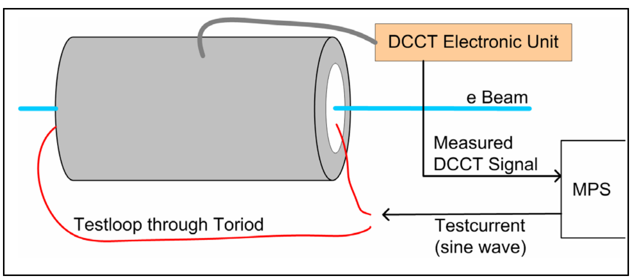

Figure 8: DCCT Layout.

REDUNDANT OPTICAL FIBRE LOOP

The MPS crates in the 9 PETRA halls are linked together with a redundant optical fibre loop. The following information is transmitted:

- beam current from the DCCT
- timing synchronisation of all MPS crates (planned)
- post mortem trigger
- dump trigger

The redundancy serves two purposes: The machine availability is increased by allowing machine operation when one fibre is damaged. For a timing synchronisation the second fibre is also needed.

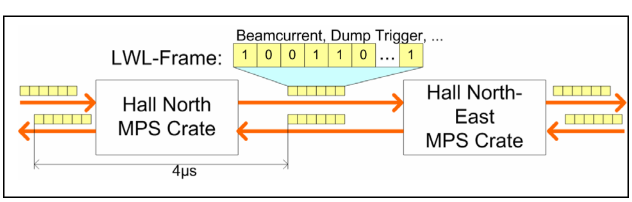

Figure 9: Redundant Optical Fibre Loop.

CONTROL SYSTEM

The server and console programs are implemented in JAVA. In the console program each alarm input is represented by an icon. The different icon styles and colours show the input status. Choosing a column gives more detailed information about a module and its alarm inputs. Figure 10 shows the console program.

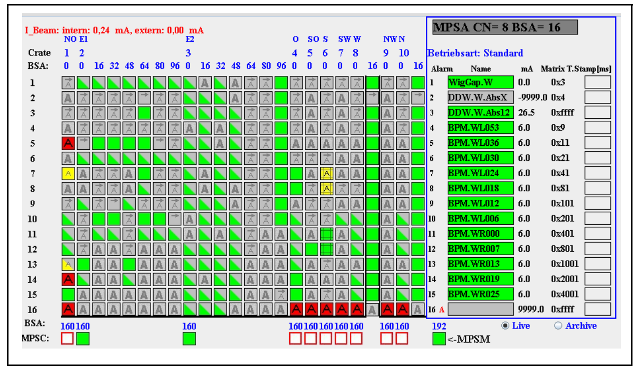

Figure 10: MPS Console Program.

MPS Data Archive

When states of the alarm inputs change this information is saved with a timestamp in an event archive. In a special mode of the console program the archive data can be viewed in the same way as live data.

COMMISSIONING

In the end of January the MPS started its first test operation and since April with the first turns in PETRA the system is active. With increasing machine current more alarm inputs are activated and viewed in the control room. The first experiences are positive. Up to now no malfunction such as unwanted dumps were noticed.

CONCLUSIONS AND OUTLOOK

The MPS is a tool which keeps the machine safe. Presently 10 crates are installed with a possible total number of 1120 alarms over 9 PETRA halls. Additional crates can easily be integrated in the system. With a firmware upgrade it is possible to combine any alarm inputs throughout the whole MPS by transferring the input status over the optical fibre loop.

The effect of the planned timing synchronisation will be a post mortem trigger and a first alarm detection with an accuracy of ~1µs.

REFERENCES

[1] The Technical Design Report (TDR) "PETRA III: A low Emittance Synchrotron Radiation Source" Ed. K. Balewski et al., DESY 2004-035