THE QSBPM SYSTEM PERFORMANCE, AND A COMPARISON TO CONVENTIONAL BPM SYSTEMS

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Abstract

The novel QSBPM system which has been developed at MAX-lab and that uses quadrupole shunts has been implemented in the Third Generation Storage Ring MAX II. The performance of the QSBPM system in this machine has been investigated. The use of some of the design features in MAX II which the QSBPM system benefits from is discussed. A comparison with conventional BPM systems is done. Especially the one that exists in MAX II. The comparison includes resolution, stability of pickups, electronics and other BPM system components. The features of the QSBPM system makes it easy to calibrate the conventional BPM system in situ. This has been done on MAX II. A short description of the systems and results from the measurements on MAX II is included.

1. THE QSBPM

The QSBPM system measures the beam position with respect to the quadrupole magnets magnetic centra in the machine by shunting off some current from the quadrupole where the beam position is to be measured. The QSBPM system requires some kind of BPM system to read beam position changes. QSBPM systems have been implemented in the two storage rings at MAX-lab and and the technique is also used at some other labs.

1.1 The use of QSBPM at MAX-lab

At the smaller machine MAX-I, where the QSBPM system was developed, the system is used as a BPM system since the machine does not have another BPM system. At MAX-II which is a third generation synchrotron light source is the QSBPM used to calibrate the ordinary BPM system that has button pickups.

1.2 At MAX-I

In MAX-I the vacuum chamber moves quite a lot due to the thermal load from the stored beam. There are no absorbers for synchrotron radiation so the radiation hits the vacuum chamber wall directly. Because of this the ring lacks a functioning RF-based BPM system. The position data needed by the QSBPM system is taken from two position sensitive Wallmark plate detectors that look at the synchrotron radiation at two dipole ports.

The use of the QSBPM system as the ordinary BPM system has the advantage of always measuring against the quadrupoles. The disadvantage is that the beam position is slightly moved when shunting a quadrupole magnet, and should thus not be used when users are running on the machine.

The QSBPM resolution in MAX-I is 65μm horizontally and 26μm vertically [3].

1.3 At MAX-II

In MAX-II there is an RF based BPM system [5] using button electrodes as pickup elements. The button electrodes is very rigidly mounted to the magnet girders fig.1. Also is the vacuum chamber equipped with bellows [1] in such a way that the BPM heads can not be subjected to any thermal forces from an expanding or bending vacuum chamber which can be seen in fig.2. We use the QSBPM system to calibrate the BPM system.

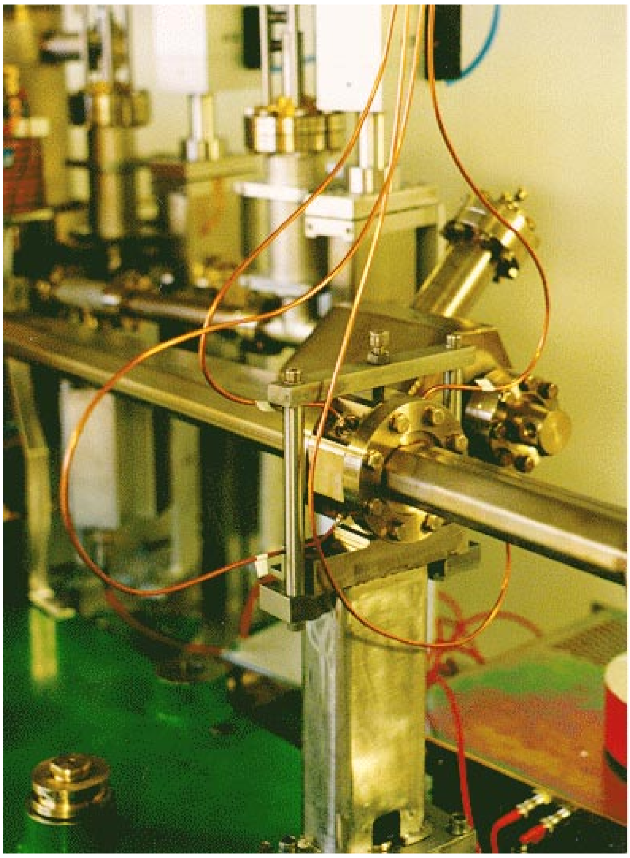

Fig. 1. A BPM head in MAX-II mounted on its rigid support pillar on a girder before mounting of the magnets.

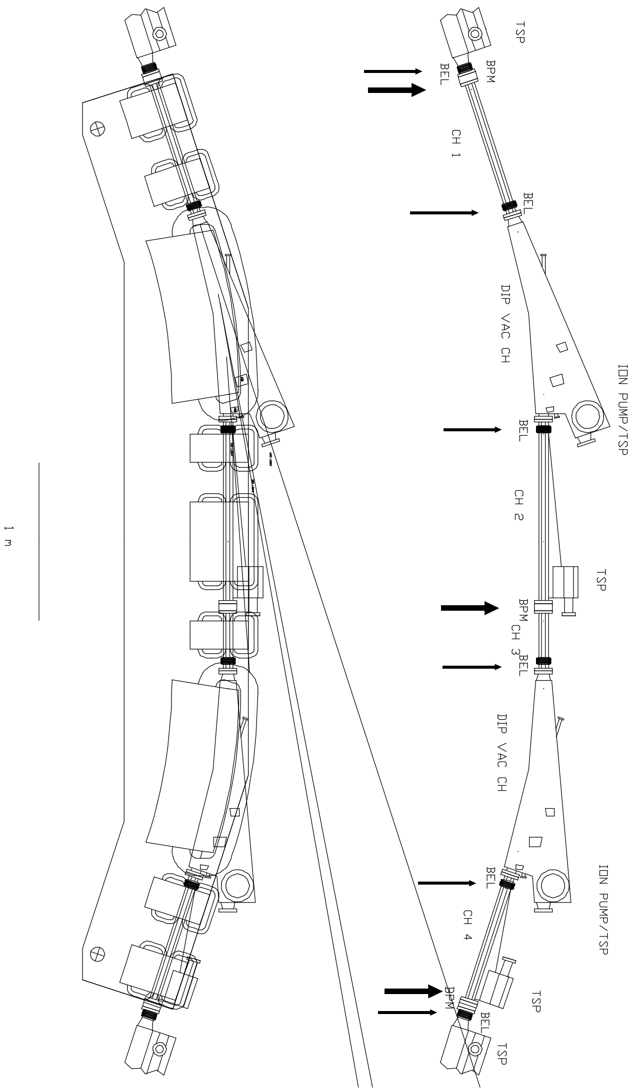

Fig. 2. The vacuum system of one ring cell. The thin arrows show the locations of bellows and the thick arrows the location of BPM heads.

2. CALIBRATION OF THE MAX-II BPM SYSTEM

Table 1 shows a typical set of offsets to be subtracted from the BPM readings to get a correct beam position reading. If certain parts of the BPM system has been dismantled a new table of offsets has to be created.

We have seen that it is enough to disconnect the SMA connector to a button electrode and then reconnect it to change the offset by as much as 20µm. We even used a torque wrench for SMA connectors when reconnecting it. In MAX-II where the BPM heads is not subjected to vacuum chamber forces, the main source of offset changes in the position reading is the BPM electronics. The electronics consist of filters and multiplexers in the RF-path. Each button has its own filter and input to a multiplexer. These electronic components are subject to the temperature variations of their surroundings and will vary their characteristics including the transmission damping with temperature. There is of course also ageing of the electronics that introduces changes in the position reading offsets. The noise level in the BPM readings at MAX-II was such that the resolution was about 8µm. By increasing the BPM systems integration time a factor of 100 to 1.5s a resolution of 2µm was reached.

1µm change in BPM reading corresponds to a change in signal strength on one button of 0.0003dB. This accuracy is of course impossible to achieve with the tolerances available on connectors and other electronic components.

Table. 1. Example of offsets in BPM readings found with the QSBPM system in the MAX-II button BPM system. 500 units is 1mm.

	h:	v:
1	600.0	-687.0
2	250.0	400.0
3	54.0	149.0
4	417.0	54.0
5	-30.0	39.0
6	355.0	310.0
7	537.0	250.0
8	-90.0	62.5
9	322.0	-541.0
10	493.0	-14.0
11	470.0	-24.0
12	425.0	1.0
13	590.0	-246.0
14	30.0	-35.0
15	663.0	-107.0
16	355.0	-17.0
17	-140.0	243.0
18	450.0	-200.0
19	540.0	390.0
20	90.0	30.0
21	416.0	218.0
22	128.0	-3.0
23	120.0	-241.0
24	-30.0	-35.0
25	82.0	45.0
26	680.0	176.0
27	284.0	140.0
28	320.0	210.0
29	380.0	-96.0
30	510.0	178.0

2.1 How we measure the BPM offsets

There are several methods to measure the BPM offsets with the QSBPM system. One method that is lattice and almost machine independent was chosen by us [2]. One condition for the method to work is that there is a quadrupole magnet close to the BPM head to be calibrated. The quadrupole magnets shunt is then closed and opened as the beam position change on the BPM head is observed. A correction magnet somewhere in the storage ring is then changed until there is no orbit change observed on the BPM as the shunt is operated. Now the beam is centred in the quadrupole and we read what position the BPM says. The read position value is then the offset for that BPM head and its electronics. The accuracy of the offset is the same as the resolution of the BPM system which in MAX-II is about 2μm.

2.2 Stability of the BPM system

The beam stability in MAX-II is discussed elsewhere in this conference [4]. It can however be said that the stability of the BPM system is such that a re calibration is not necessary more than when work has been done on the machine.

3. β-FUNCTION MEASUREMENT

A second use for the quadrupole shunts is the measurement of machine the β-functions. This can easily be done from the control room. Just close one shunt in the system and watch the tune shift on a network analyser connected to its pickup and excitation electrodes in the machine.

4. REFERENCES

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