STATUS FOR BEAM DIAGNOSTICS OF SESAME

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Abstract

SESAME[*] synchrotron radiation source which is under construction in Amman (Jordan) consists of a 22.5 MeV microtron, 800 MeV booster and a 2.5 GeV storage ring [1]. The electron beam diagnostics will play a major role during the commissioning, machine studies and user operation. Furthermore the beam parameters during injection, acceleration, ramping and storing of the beam will be measured, monitored and integrated into other subsystems. The major diagnostics components and the general design for booster and storage ring are reported in this paper.

INTRODUCTION

Different diagnostics instruments have been foreseen for microtron, booster, transfer lines and storage ring. While the beam will pass or stay in microtron, booster and transfer lines for short time duration, it will remain in the storage ring for a relatively long time which dictates the choice of different instrument and design based on the beam-instrument effects and also different resolution demands on measurements. For the microtron and booster, many diagnostics instruments of the early BESSYI [2] are utilized; however the electronics and some hardware's are replaced or modified. For the storage ring the complete instrumentation, hardware and software for beam diagnostics system will be newly developed.

MICROTRON DIAGNOSTICS

Four diagnostics devices have been foreseen for the diagnostics purposes of the microtron commissioning and normal operation. One deflection tube monitor (DTM) consisting of a magnetic shielded tube is located inside the microtron magnet gap which provides a free magnetic field passage through the electron trajectory. DTM is controlled via a motor to be placed on successive electron orbits inside the microtron. The tube signal is transferred outside the microtron via a matched impedance coaxial cable for monitoring on an oscilloscope. From the signal provided by DTM the electron acceleration inside the microtron and the approximate energy of the extracted electrons are identified. At the exit of microtron there is one cavity monitor which was not used during the microtron commissioning due to its vacuum leakage. This device is used to monitor the current pulse magnitude and time structure of the macro pulse extracted from the microtron. One beam viewer is installed in the transfer line between microtron and booster. This is a destructive device where is moved through the beam passage to provide the shape and dimension of the accelerated beam. It consists of a fluorescent screen (material doped on a copper plate) which operates in the vacuum. A CCD camera is installed outside the beam viewer chamber and can observe the screen through the glass window and an appropriate lens. The camera is related to a TV monitor in control room. At the end of the beam trajectory, one faraday cup is installed, which is used as a beam stopper and beam current measurement device. The faraday cup is coaxial based design for a 50 Ω impedance matching and the output signal can be viewed directly on an oscilloscope. Since both faraday cup and beam viewer can interrupt the beam passage, therefore at the same time just one of these devices has active diagnostics signal. Figure 1 shows the beam shape during the microtron commissioning [1] at an energy of 6 MeV provided by beam viewer at the exit of microtron.

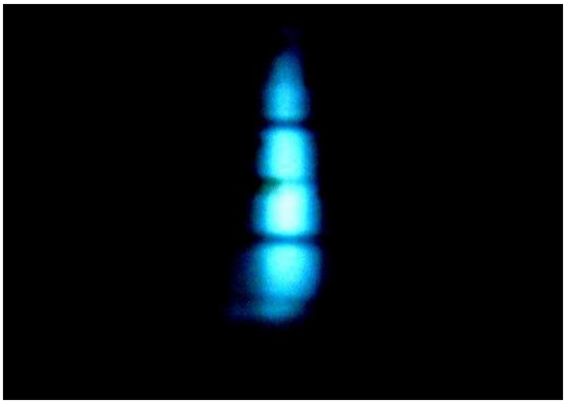

Figure 1: Treated image of the microtron beam shape from the installed beam viewer during commissioning.

BOOSTER DIAGNOSTICS

The main beam properties which are measured in the booster consist of beam current, beam transverse shape, beam position and horizontal and vertical betatron tunes of the beam. Overall three out of vacuum fluorescent screen monitors are installed in the booster. The first screen is located in the injection section to observe the incoming beam from microtron, the second screen is installed in the second straight section and the third screen is located on the extraction septum. Table 1 shows the diagnostics related parameter of the booster.

Table 1: Various Diagnostics Related Parameters of the Booster

Injection/Extraction Energy (MeV)	22.5/800
Beam Current (mA)	7
Circumference (m)	38.4
RF frequency (MHz)	499.654
Revolution freq. (MHz)	7.807
Ramping time (ms)	430
H/V Tunes υ_x/υ_y	2.22/1.31
H/V Emittances $\varepsilon_x/\varepsilon_y$ (nm.rad)	155/16
Straight sections β-func.(H/V) (m)	5.2/2.9

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There are five beam position monitor (BPM) blocks for the purpose of beam position measurement. Three of them are designed as stripline electrodes and the other two are the button type electrostatic pick ups. Since the booster BPM block diameter is relatively large (150mm) compared to the beam displacement, and on the other hand the electrode locations in horizontal and vertical planes are symmetric, we expect a linear response from the BPM difference over sum values and in the same time a small sensitivity to the beam displacement. The 2D analysis confirms the expectation of the linearity and sensitivity of the BPM sets of the booster (see figs 2, 3). The coupling between horizontal and vertical reading for a maximum beam off-centre of 10mm is 2.2%. The BPM sets sensitivity in both horizontal and vertical planes is as small as 2.7%.

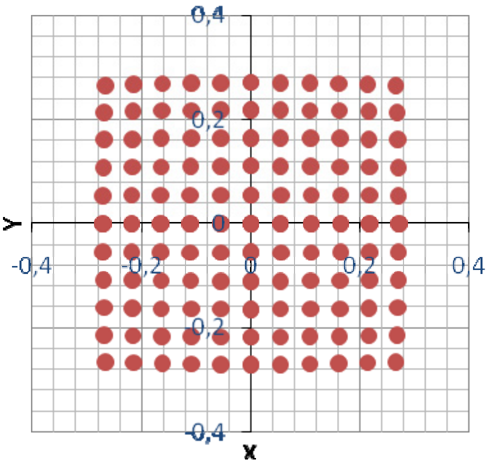

Figure 2: Map position for booster BPM blocks.

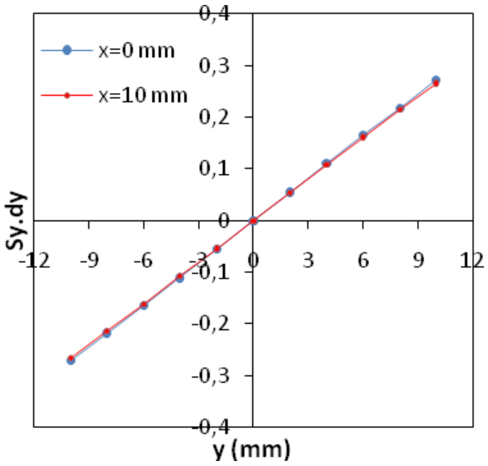

Figure 3: Booster BPM sensitivity curve for vertical plane.

One stripline block with four electrodes also located in the fifth straight section is dedicated for the tune measurement purpose. This stripline block can shake the beam in horizontal and vertical directions to give the information on betatron tunes on both planes. The booster is operating at 1 Hz repetition rate with a ramping time of 430ms. The designed BESSYI beam current of the booster is 7mA, but lower beam current is to be considered in case of different injection and acceleration efficiency of the booster. Analysis of the BPM signal level for different beam current and displacement from centre is carried out. Fig. 4 shows for 1 mA beam displacement of 10mm, the minimum signal level from the electrode goes to -47 dBm which is considered together with the cable losses for electronics detector input signal level issues.

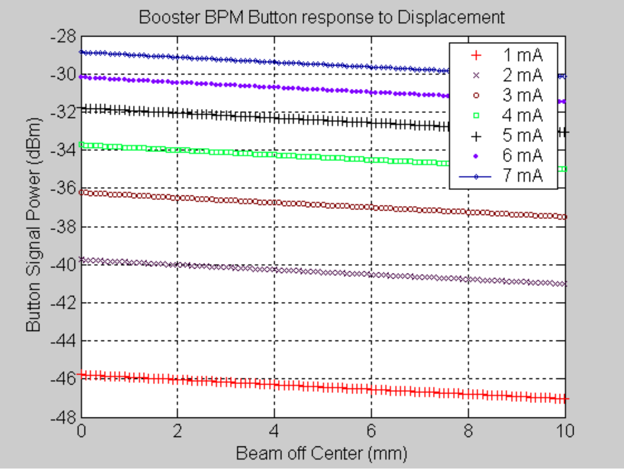

Figure 4: BPM signal level for various currents.

The booster stripline electrode length for both tune measurement and beam position monitoring is 14.5cm, while due to different functionalities of the two types, the characteristics impedance of them are 15Ω and 50Ω respectively. Fig.5 shows the transfer impedance changes with frequency for the booster stripline sets of beam position monitoring. The bode diagram of magnitude and phase response for the button type BPM sets is shown in Fig. 6.

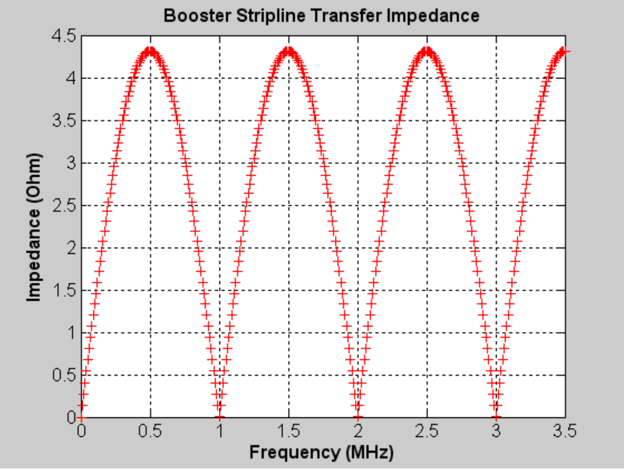

Figure 5: Stripline Transfer impedance versus frequency.

One Beam current monitor (BCM) is located in the RF straight section of the booster. This current monitor will provide the average beam current data during the beam acceleration. Together with the beam current values available in the two transfer lines, one from microtron to the booster, and the other from booster to the storage ring, we can measure the injection and extraction efficiency of the booster. On the same approach the injection efficiency to the storage ring will be identified.

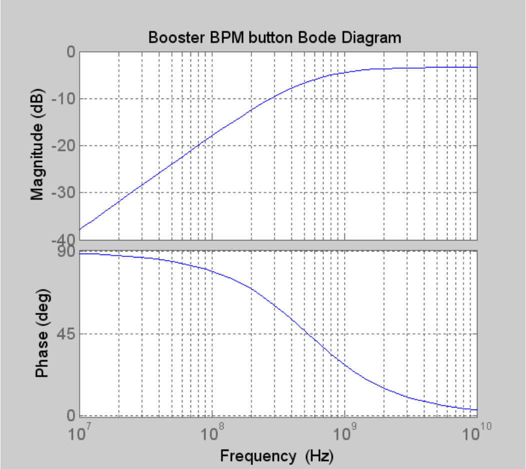

Figure 6: BPM button frequency response.

STORAGE RING DIAGNOSTICS

All the beam diagnostics devices for the storage ring will be of non destructive manner. Overall there will be 64 BPMs distributed all around the storage ring. They are located in both sides of the dipole magnets chamber and in both sides of the straight sections for an efficient closed orbit correction. They are of button type and have identical blocks which will be welded in the vacuum chambers. The optimised horizontal distance of the buttons is 24 mm, while the vertical distance is fixed by the vacuum chamber dimension as 28 mm. The analysis of the map position and sensitivity for a previous dimension of the vacuum chamber already is discussed in [3]. For the Closed Orbit, Turn-by-Turn and Fast Feedback, various data acquisition rates of 10 Hz, 2.25 MHz and 10 kHz (max.) will be required.

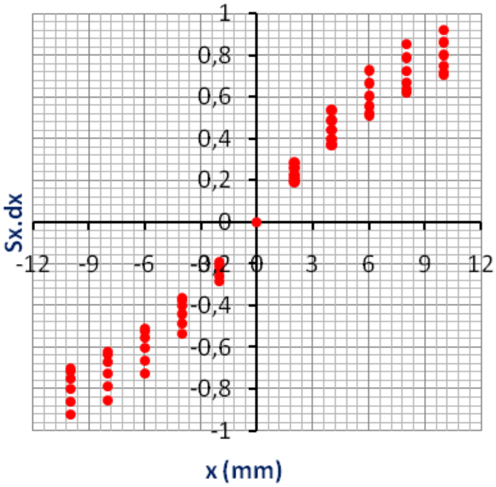

Figure 7: Storage ring BPM sensitivity at x-direction.

There is one extra double BPM block which is foreseen for the future needed signals for transverse feedback or spectrum measurement or any purpose other than closed orbit control. Fig. 7 shows the sensitivity curve of the BPM blocks for a difference over sum interpretation. In the figure the physical distances between points are 2 mm. The sensitivity in horizontal plane is 8.5 [%/mm] and the maximum coupling between horizontal and vertical planes at 10 mm vertical off-centre is 25%. The cable length between BPM blocks and the electronic detector racks are considered to be maximum 50m due to small signal level at single bunch and low current beams.

One stripline as a shaker for the purpose of tune measurement will share a straight section with one of the injection kicker. The horizontal and vertical tunes of the beam are 7.23 and 6.19 respectively with the revolution frequency of 2.25 MHz. To shake the beam, one sweep signal generator and a standard 10 MHz amplifier with maximum 50W in both horizontal and vertical planes will be used. One horizontal scraper located in non-zero horizontal dispersion straight section is foreseen to control the losses after a stop of the RF. A vertical scraper is located in the second straight section to protect the insertion devices and damp the beam when it is necessary. The two scrapers will be equipped with cooling water pipes to absorb the heat appropriately.

One visible beam line is extracted from 6.5^0 dipole port and transported via a Φ5 cm pipe through the shielding wall to the optical hutch. Since the beam dimensions at the source point, σ_x and σ_y are as large as 230µm and 80µm, it would be possible to do the imaging with visible light. This visible line source is located on the dipole just after injection line. From this location is also possible to observe the injection process. However one dedicated screen monitor is located on the injection septum for injection process. The visible line data will be used for profile measurement and beam instability observation. One X-ray line based on pinhole camera will be located on one dipole port (D14, see the layout in [1]) to do the emittance measurement and profile cross check. All the slits and the pinhole camera assembly inside a shielded cage will be located in the storage ring tunnel. One DCCT for average beam current measurement and one FCT for current and filling pattern measurement will be located in one straight section. There are four Beam Loss Monitor (BLM) distributed around the ring to give the information on beam losses.

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[3] S. Varnasseri, "The Beam Diagnostics for SESAME" DIPAC05 proceedings, pp 90-92, Lyon, France.