A.3: Development of enhanced version of betatron tune feedback system for Indus-2

Betatron tune feedback system has been deployed in Indus-2 to maintain the betatron tune constant within the specified band during machine operation, which is important to ensure electron beam stability. Presently, the tune feedback system has a correction rate of once in ~20 s. In the present system, measurement of tune is based on the swept frequency excitation employing a spectrum analyzer, which requires ~15 seconds for measuring betatron tune in both the transverse planes, which constitutes major portion of the overall correction time. To improve the correction rate, an enhanced version of betatron tune feedback system has been developed by the Beam Diagnostics Section of Indus Operations, Alignment & Beam Diagnostics Division.

In the new scheme, Fast Fourier Transform (FFT) of bunch-by-bunch beam position data, obtained from the Indus-2 bunch-by-bunch feedback system, has been used. Betatron tune in horizontal and vertical planes are measured simultaneously in the new scheme whereas these are measured sequentially in the existing method. Schematic diagram of feedback system is shown in the Fig. A.3.1.

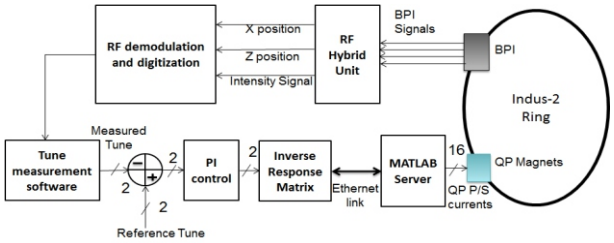


Fig. A.3.1: Block diagram of enhanced betatron tune feedback system

The feedback scheme is based on online correction of currents of quadrupole magnet families. Proportional and Integral (PI) control is applied to the tune error in horizontal and vertical planes, which is difference between set tune value and measured tune value. The PI coefficients were optimized to provide stable operation in beam injection and stored beam mode. The inverse of response matrix between change in betatron tune with respect to change in quadrupole magnet currents is multiplied with the output of PI controller to get the required correction in quadrupole magnet currents. The quadrupole power supplies settings are modified accordingly through the MATLAB server as in the existing tune feedback system.

With this development, tune measurement time has been reduced significantly from ~15 s to ~1 s thereby enhancing the correction rate of tune feedback system to once in ~ 2 s. This system is useful in correcting fast changes in the betatron tune which may occur due to changes in the machine optics. The betatron tune feedback system is capable of correcting the tune within ±0.0005 in the user mode of machine operation. A screenshot of the developed graphical user interface is shown in Fig. A.3.2.

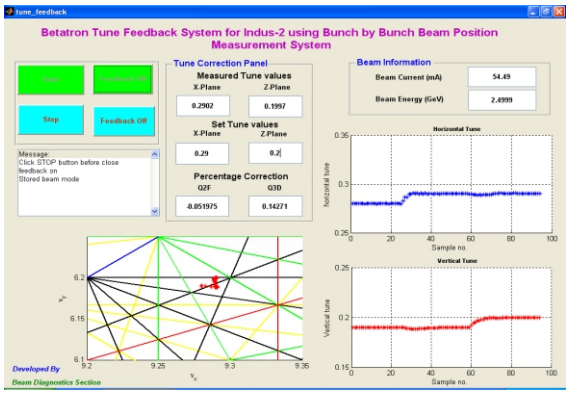
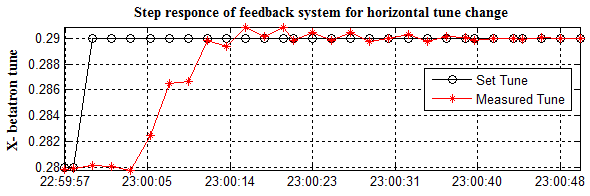
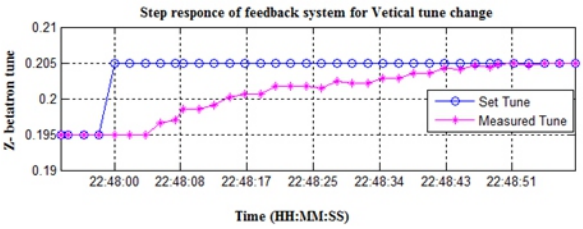


Fig. A.3.2: Screenshot of graphical user interface of enhanced betatron tune feedback system

To test this system, step changes were applied in the set value of betatron tune in horizontal and vertical plane sequentially at beam current of 55 mA @ 2.5 GeV. The typical graphs of the response of tune feedback system are shown in Fig A.3.3.



(a)



(b)

Fig. A.3.3: Typical results of tune feedback system response for step change in set value of tune in (a) Horizontal plane (b) Vertical plane

The system also has provision of data logging of betatron tune with time, beam current and beam energy, which is very helpful for investigating the problems in beam operation of the Indus-2.

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