Machine Physics Application Program for Control, Commissioning and Error Findings for Storage Rings

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Abstract

We have developed a Machine Physics Application Program (MPAP) package for control, commissioning and error finding to be used on the SRRC storage ring with user friendly graphic interface. The program gives on-line machine parameters as well as Twiss functions together with the machine elements in graphic form. It supported the following capabilities: machine modeling, orbit corrections and adjusting, tune adjustments, error findings for the misaliment and strength setting, etc. The code is written in ANSI C and can be imported to both VAX and UNIX operating systems which support the standard X-window/Motif. The arrangements of the code is in such a way that the interface with the on-line Control Data Base can be easily implemented for use on any machine. It can be used both for on-line control and/or for off-line analysis.

1. Introduction

To aid the commissioning and operation of the 1.3 Gev electron storage ring dedicated for synchrotron radiation we have developed a Machine Physics Application Program (MPAP) package using ANSI C combined with X-window/Motif which provides friendly user graphic interfaces in real operations.

Since only ANSI C are used in the coding, the program can be compiled and run in both VMS and UNIX machines. This flexibility will allow the program to be used in the VMS machines , which is being used in the control system at SRRC at this moment, and in the UNIX machines which becomes more and more popular among the accelerator communities around the world.

The package can be used both for on-line control and for off-line analysis. For the on-line version, an interfacing program linked the Machine Physics Application Programs directly with the Control Data Base . Because of the module structure of the programming, implementation of the program on other machines is straightforward.

2. Overview of MPAP

Fig. 1 shows the essential structure of the package. The package is composed of several individual modules. Intercommunications between different modules are facilitates

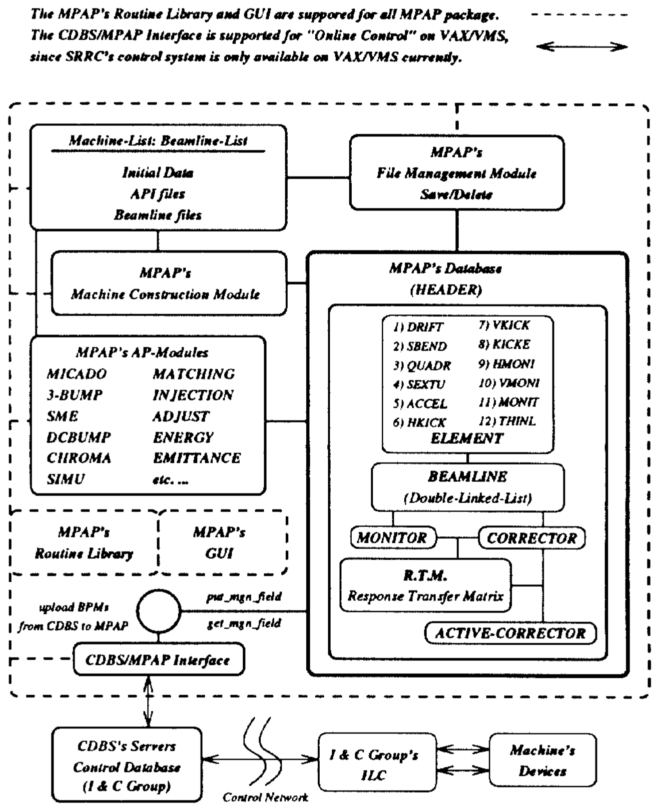

Figure 1: The structure of SRRC/Beam Dynamics Group's MPAP.

by various text files. The program is started by reading the appropriate Beamline files which contains the relevant machine element data for the beamline to be studied. A control panels provide the possibilities of switching among different selections of the relevant data. Convenient file management facilities are provided for saving and restoring of the data for future analysis. The necessary data such as the BPM readings and the current settings can also be obtained directly from the Control Data Base(CDBS) directly.

Currently supported facilities include: machine modeling, machine parameters and Twiss functions calculation, orbit corrections for both transport lines and storage rings, chromaticity calculation and adjustments, adjustment of

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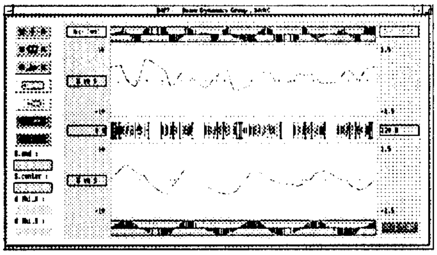

Figure 2: The COD of SRRC Storage Ring before vertical correction (RMS-Vertical = 2.405 mm).

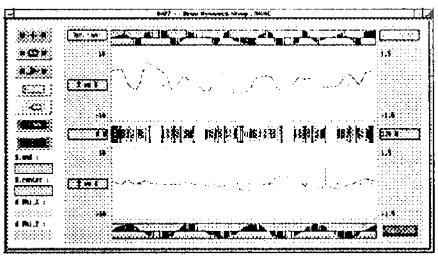

Figure 3: The COD of SRRC Storage Ring after vertical correction with SME method (RMS-Vertical = 1.028 mm).

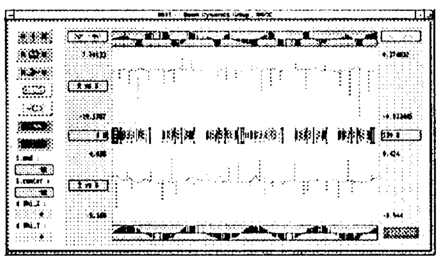

Figure 4: The best COD of SRRC Storage Ring currently with Energy = 1.3026 GeV (RMS-Horizontal = 0.4915 mm; RMS-Vertical = 0.2823 mm).

launching conditions, emittance measurements, etc. Control panel and the graphical display of the relevant quantities are provided for each of the application modules. Relevant machine parameters and Twiss functions are calculated and exhibition in graphic form for easy apprehension. We will demonstrate the MPAP in detail for an explicit usage on orbit correction in SRRC commissioning in the next section.

3. Orbit Correction

Currently there are three methods of orbit corrections are available: MICADO[1], beam bump method, and also SME (which automatically includes bounds on the current settings). Fig. 2 shows an output panel for orbit correction. The upper half and the lower half of the panel exhibits in graphical form the BPM readings of the Closed Orbit Distortions(COD) in the horizontal and the vertical plane respectively. The middle region shows the corresponding machine elements. The appropriate machine parameters (such as the Corrector-to-BPM response functions may be obtained directly from the control panel.) Zooming for the machine elements and for the COD values as well as the setting values of the correctors are achieved by suitable clicking of the mouse on the panel. Shown on the top part and the bottom part of the panel are the graphical exhibition of the corresponding tunes in each plane. In this example, the behavior of the vertical BPM errors are very similar to the phase advance of the machine, indicating that a single corrector could be very effective in reducing the errors. This is in Fig 3. which shows the results of the vertical BPM errors after applying a single corrector. In agreement with theoretical calculation, the RMS of the COD errors in the vertical plane is reduced from 2.41 mm down to 1.03 mm by application of a single corrector indicated in the panel by the single bar. The values of the corrector strength is given by the length of the bar.

To further reduce the rms of the COD values, we may use the package to find the desired settings for the correcors. After the setting values of the correctors which produce satisfactory trajectories have been found we may use the package to set the combined settings of correctors in the machine. If necessary, we can divide the settings in a desired number of steps (with fixed ratios between) and watch directly the response of the BPM values step by step. Fig 4. shows the results after such an application. The RMS values of the COD errors in the horizontal plane and the vertical plane is 0.49 mm and 0.28 mm respectively. The bars shown represents the strengths of the correctors.

4. Error Findings

Error finding facilities of the package are still in the process of developing and improvement. However since we may use the package to obtain the relevant parameters and Twiss functions, and these values can be checked with the observed behavior of the machine to detect possible errors of the machine settings. For example, in the process of correcting the COD values, if the BPM readings did not improve at each substeps of corrector settings, it will indicate that there is probable some setting errors.

In a more quantitative example, we may subtract the BPM readings of the COD errors after each correction from the those values before correction and compare the differece of these BPM values with the calculated response function from the package. It is worthwhile to remember that the linear contributions of alignment errors has been eliminated by the subtraction process. Fig. 5 and Fig 6 shows such a comparison for vertical orbit correcting and horizontal orbit correcting respectively. The agreement in the vertical plane is almost perfect. This means that the modeling for the vertical beta functions and the BPM readings are essentially correct. However, in the horizontal plane, the real response functions of the machine has an overall factor of about 1.7 comparing with the calculated ones. From the expression of the COD increments

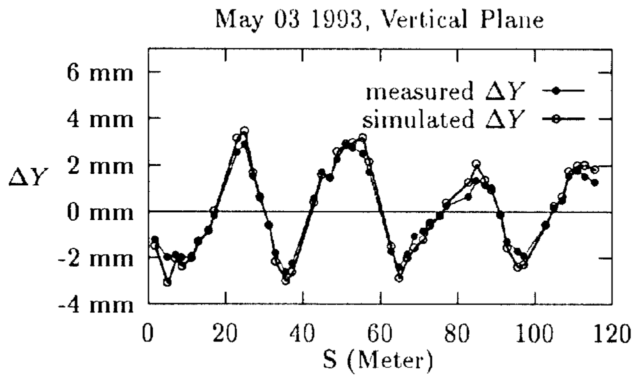

Figure 5: Comparison of the measured ΔY and simulated COD change by the correctors with specified strengths.

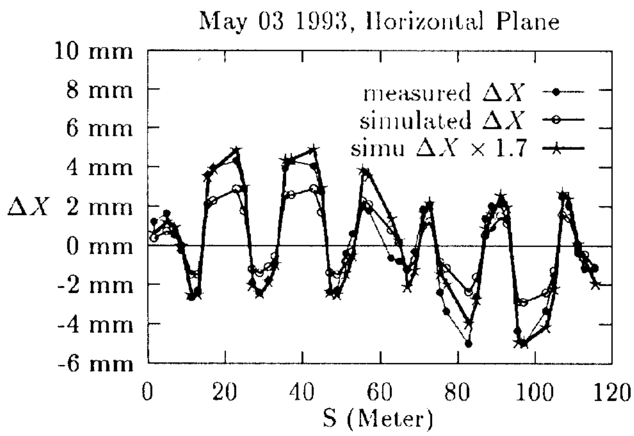

Figure 6: Comparison of the measured ΔX and simulated COD change as well as ($1.7\times$) simulated COD change by the correctors with specified strengths.

at the monitors

$$\Delta x_m = \sum_k \frac{\sqrt{\beta_k \beta_m}\ \delta_k}{2 \sin \pi\nu} \cos(\pi\nu - |\phi_k - \phi_m|) \qquad (1)$$

where β_k and β_m are the values of the beta functions at the correctors and monitors respectively, we find that the most probable source of the errors are due to errors of tune values. The major reason of this error comes from an energy error. A subsequent readjustment of the machine settings using this information brought the model in close agreement with most of the experimental results such as tune measurements and beta function measurements in the commissioning of SRRC storage ring and is very close to the original design[2].

5. Summary

The MPAP package developed by SRRC has been successfully applied in the commissioning of the SRRC 1.3 Gev electron storage ring dedicated for synchrotron radiation in Taiwan which has just finished construction and installation. The module of the package should allow the package to be easily used in any accelerators.

6. Acknowledgements

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