

HIGH-LEVEL APPLICATION PROGRAMS FOR THE TPS COMMISSIONING AND OPERATION AT NSRRC

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Abstract

For the Taiwan Photon Source (TPS) commissioning and operation we have developed more MATLAB-based application programs and tested them on the Taiwan Light Source (TLS). These additional applications built with the MATLAB Middle Layer (MML) include beta function measurement, dispersion function measurement, chromaticity measurement, chromaticity correction, and tune control. In this paper, we will illustrate what algorithms we use in these applications and show the test results. Especially, in order to get the first turn beam in the TPS commissioning, we adopt the RESOLVE algorithm for the beam steering and it has been built successfully in UNIX-like systems such as Mac OSX and different Linux versions. It can provide us some exercises of error finding and correction before the TPS commissioning.

INTRODUCTION

Continuing the development of the MATLAB-based accelerator physics application programs (APAP) for the TPS commissioning and operation [1], the preparation of high-level application software is on-going. We have discussed and thought about the requirements during the machine commissioning. In order to support the most important first turn beam steering, we survey and try to provide an application program (AP) for such a purpose. From the data folders, it was found that the old RESOLVE [2] program, worked on VAX/VMS computers, had provided some great contributions during the past PEP-II commissioning at SLAC although its revised version, which was tried porting to UNIX-like OS, did not work for a long time due to some memory bugs of programming. However, it is worth to reactivate the new RESOLVE and learn some algorithm from it.

Once the first turn beam steering is achieved and then beam can be stored and accumulated, some fundamental applications of beam parameters measurements will be applied to check and compare the real machine versus the machine design. In this report, we will present some such fundamental applications and their corresponding physics algorithms.

CURRENT STATUS OF APAP

Since part of the additional applications can't be merged into the MATLAB platform at this moment, we have to provide some directly data linking and external data linking through the MML for those APs. Figure 1

shows the revised structure of TPS APAP for the online control at NSRRC. It mainly includes following parts:

- The TPS control system will adopt the EPICS.
- MATLAB is chosen to be the main platform for APAP development. Some application programs may be applied in their original forms and not be ported to the MATLAB.
- MML [3], the main control interface for most APs, provides the data accessing between application programs and EPICS via the processing variables (PV). Through the MML, the external data linking for the application programs such as RESOLVE is provided. The directly data linking between EPICS and application programs is also allowed.
- The Accelerator Toolbox (AT) [4] used for machine modelling is also taken as a virtual machine for testing.

APAP for machine online control

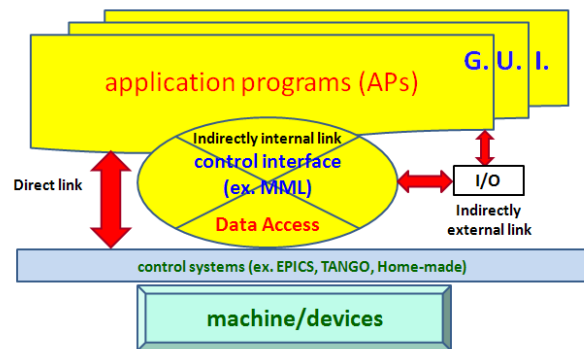


Figure 1: NSRRC/TPS APAP online control structure.

The first stage of MATLAB-based APAP developed in 2010, we had provides following application programs and they had also been tested online on the 1.5 GeV TLS machine in operation:

- Beam-based alignment (BBA) [5].
- Global orbit correction by SVD method.
- Lattice calibration by LOCO [6] algorithm including the measurements of response matrix and dispersion function.
- Beam parameters measurement of beta, alpha, and emittance at the linac exit.
- Provide the Graphic User Interface (GUI) for some applications.

In the following, we will present some fundamental APs and their physics algorithms including the beta function measurement, dispersion function measurement, chromaticity measurement and control, and tune control.

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A GUI for the indirectly external data linking between MML and the RESOLVE will also be described.

Beta Function Measurement GUI

The beta function measurement GUI is shown in Figure 2. In the β function measurement, we have to change the strength of the quadrupole magnets, the optics of the accelerator will be perturbed, and the betatron tune will be changed. Then we can use the following formula to obtain each beta function at each quadrupole position.

$$\beta = 4\pi \frac{\Delta\nu}{\Delta k \cdot l}$$

where $\Delta\nu$ is the measured tune change, β is the derived beta function at the chosen quadrupole location, Δk is the strength change of the driven quadrupole magnet and l is the effective length of the quadrupole.

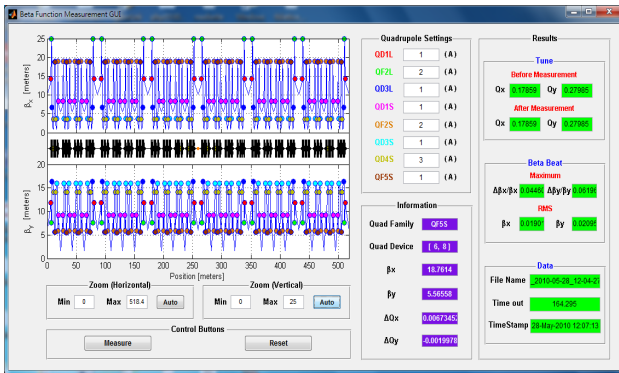


Figure 2: Beta function measurement GUI for the TPS storage ring.

In this GUI, users can choose how many currents of the quadrupole magnet to adjust the quadrupole strength. If the current change is too big, the optics and tune will be changed too much. The tune may hit the resonance line to let the beam loss. On the other hand, if the current change is too small, the tune change will be smaller to make the measured result not good.

Dispersion Function Measurement GUI

The dispersion function measurement GUI is shown in Figure 3. In the dispersion function measurement, we measure the orbit change at the BPMs positions with respect to the frequency variation of the RF cavity.

Adjusting the RF frequency, it makes the momentum deviation change according to the momentum compaction factor. And then one can measure the change of the electron orbit by BPMs. Finally we can calculate the dispersions at the positions of BPMs by using the following equations.

$$\eta_{x,y} = \frac{\Delta x, y}{\Delta \delta}$$

$$\Delta \delta = -\frac{1}{\alpha_c} \frac{\Delta f_{RF}}{f_{RF}}$$

where $\eta_{x,y}$ is the dispersion function, δ is momentum deviation, α_c is momentum compaction factor, $\Delta x, y$ is the variation of the closed orbit, f_{RF} is the frequency of the RF cavity and Δf_{RF} is the variation of the RF frequency.



Figure 3: Dispersion function measurement GUI for the TPS storage ring.

Users can choose what kind of the method (unipolar or bipolar) to adjust the RF frequency. This GUI also includes “delay time” function, because it need time to wait for the process complete during changing the RF frequency for current TLS SRF system.

Chromaticity Measurement and Correction GUI

The chromaticity measurement and correction GUI is shown in Figure 4. The chromaticity is the tune changes in an accelerator due to the momentum variation of the beams. During measuring the chromaticity, we can change the momentum deviation by driving the RF frequency and measure the change of the tune. Then we can obtain the chromaticity by the following formula.

$$C = \frac{d(\Delta\nu)}{d\delta}$$

If we want to do the chromaticity correction, we must set the target values of the chromaticities. And then we can use the following equations to calculate the selected sextupole strengths.

$$C_x = -\frac{1}{4\pi} \oint \beta_x [K_x(s) - S(s)D(s)] ds$$

$$C_y = -\frac{1}{4\pi} \oint \beta_y [K_y(s) + S(s)D(s)] ds$$

where C is the chromaticity, δ is momentum deviation, ν is betatron tune, β is the beta function, K is the quadrupole strength, S is the sextupole strength and D is the dispersion function.

In the correction part of this GUI, users can choose two sextupole families to control the chromaticity to the specified target chromaticities.

Tune Control GUI

Tune control is a very important issue for the accelerator operation (see Fig. 5), because we hope to minimize the tune variation and try to lock the tune

during the gap changes of insertion devices in the normal machine operation. If the tune is not locked at the fixed value, it may hit the resonance line and the beam will be loss.

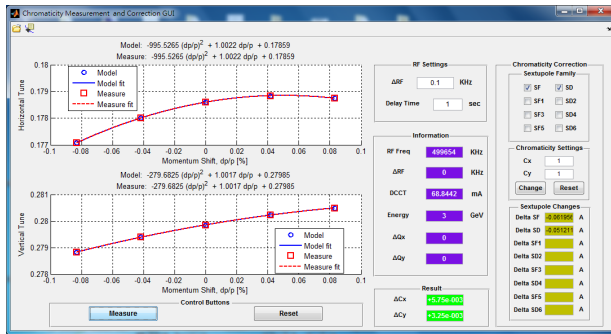


Figure 4: Chromaticity measurement and correction GUI for the TPS storage ring.

If we want to change the tune of the accelerator, we can adjust the driving currents of the quadrupoles to obtain the target. The equation is shown in the following.

$$\Delta\nu = \frac{1}{4\pi} \int \beta \Delta k ds = \frac{1}{4\pi} \sum_i \beta_i \frac{\Delta I_i}{I_i} k_i l_i$$

where I_i is the main current of the i^{th} quadrupole magnet power supply, ΔI_i is the current change of the i^{th} quadrupole, l_i is the effective length of the i^{th} quadrupole, k_i is the strength of the quadrupole magnet, β is the beta function and $\Delta\nu$ is the change of the tune.

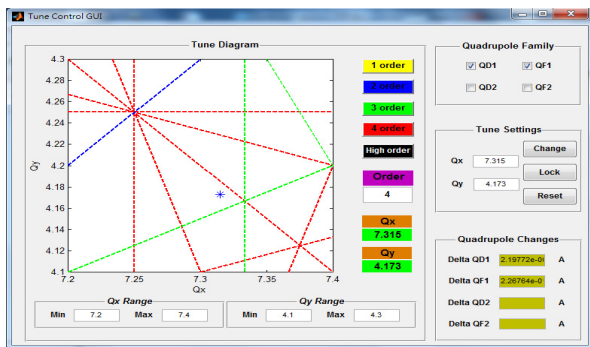


Figure 5: Tune control GUI for the TLS storage ring.

This is an actual example of the TLS. Users can choose the quadrupole families to adjust the tune and set the target value of the tune that they want. For the machine operation, we also add the tune lock function and it has been tested on the TLS.

RESOLVE and File Transfer GUI

In order to get the first turn beam during the commissioning, we also use the beam steering program “RESOLVE” (shown in Figure 6) developed by Martin Lee. H.P. Change had reactivated the revised version on MAC/OSX and PC/Linux systems. For the online control, we are building the interface, called the “File Transfer GUI”, between MML and RESOLVE for the data access. The main function is to transfer the data files between MML and RESOLVE.

06 Beam Instrumentation and Feedback

T04 Accelerator/Storage Ring Control Systems

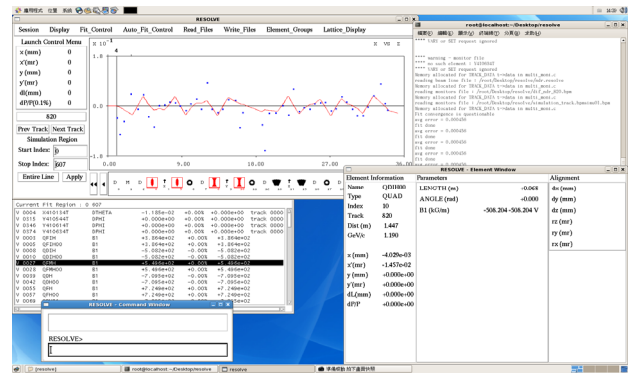


Figure 6: RESOLVE

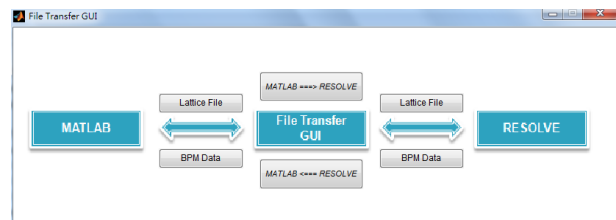


Figure 7: File transfer GUI

SUMMARY AND ACKNOWLEDGEMENT

The preparation of high-level accelerator physics software for the TPS commissioning and operation is presented. We have tested these programs on the existing TLS storage ring to get the experience for further improvement except the RESOLVE program. With the interface built between RESOLVE and MML for the online machine control, we will test the beam steering program RESOLVE on the TLS in the near future. The development and improvement of the high-level APAP and related GUIs will be continued for user friendly operation.

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REFERENCES

- [1] F. H. Tseng, et al., MATLAB-based Accelerator Physics Applications for the TPS Commissioning and Operation at NSRRC, Proceedings of IPAC 2010, THPE031, Kyoto, Japan.
- [2] M. Lee, “RESOLVE User’s Guide”.
- [3] J. Corbett, et al., PAC 2003, p. 2369; G. Portmann, et al., PAC 2005, p. 4009.
- [4] A. Terebilo, PAC 2001, p. 3203.
- [5] G. Portmann and D. Robin, EPAC 1998, p. 620.
- [6] J. Safranek, Nucl. Inst. And Meth. A338, 27, (1997); EPAC 2002, p. 1184.