DEVELOPMENT OF AUTOMATIC TURN-ON SYSTEM FOR TPS MACHINE

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Abstract

The Taiwan Photon Source (TPS) has been successfully commissioned and has reached now stable operation. Now, the machine must be turned off routinely for weekly maintenance. While following standard machine turn-on procedures for now, we have developed an automatic turn-on program to accelerate operation, for automatic system status checks and to prevent human errors. The turn-on program process flow includes: turn-on of the LTB (linac to booster transport line), the BTS (booster to storage ring transport line), the SR (storage ring), the BR (booster ring) power supplies and BR&SR pulsers as well as degaussing magnets, turning on the BR&SR RF systems, activating the linac electron source, opening all insertion device (ID) gaps to their parking positions, setting all ID phases to zero, controlling all front ends (FEs) and loading the desired machine lattice. Individual procedures can be executed alone depending on the desired practical situation. Experience so far shows, that it takes about 30 minutes to proceed from tunnel safety search to the injection ready state of the light source, including a 20 minute period for magnet degaussing.

INTRODUCTION

The Taiwan Photon Source (TPS) is one of the highest brightness synchrotron light sources in the world operating at 3-Gev and a stored beam current of 500 mA. During the commissioning phase I the maximum stored beam current was limited to 100 mA. After reaching a 35 A•hour accumulated beam dose, a check of the vacuum cleaning progress provided a satisfactory vacuum environment for the installation of two SRF cavities. In commissioning phase II, the stored beam current could thus be raised to 520 mA on December 12 and soon after seven insertion devices (ID) were commissioned serving now seven beamlines for users [1]. During commissioning and user operation mode, the machine has to be turned off for weekly maintenance or for other unscheduled reasons. In order to accelerate operation and prevent human errors, an automatic turn-on system was designed.

The EPICS (Experimental Physics and Industrial Control System) is a set of open source software tools, libraries and applications developed collaboratively and used to create distributed soft real-time control systems for scientific instruments such as particle accelerators. To control and monitor power supplies or sub-systems based on the EPICS environment, connected by Ethernet, the clients should have installed the specific EPICS base and the graphical OPI (Operation Interface) toolkits, such as EDM (Extensible Display Manager) and MATLAB

(channel access via the labCA module) [2]. Channel Access(CA) is used as an interface for machine process variable (PVs) access [3]. In this system, a MATLAB-based GUI (Graphical User Interface) and script were developed to run through all machine turn-on procedures (Fig. 1).

GRAPHICAL USER INTERFACE

The main idea is to simplify the control interface by reducing all pop-up control windows into one. Each step can be selected to be executed individually. All current status conditions and errors are displayed.

GUI Layout

The key features of the GUI are:
- Intuitive operation
- Optional execution of individual steps
- Current status and errors are displayed in lists
- Inquiry between steps or in case of error to determine further process
- Status of each executed step will be compared with expected status
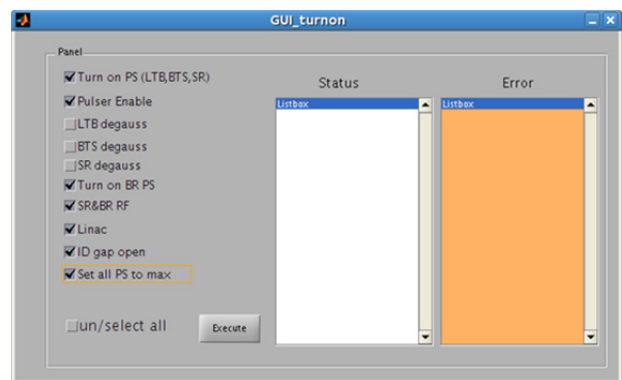- Start, end and elapsed times are displayed

Figure 1: Layout of TPS turn-on GUI.

Process Flow Chart

A typical machine turn-on procedures proceeds as follows [4]:
- turn on the LTB(linac to booster transport line), the BTS(booster to storage ring transport line) and the SR(storage ring) power supplies
- Enable injection & extraction pulser high voltage and timing control
- Turn on BR(booster) power supplies
- Degauss LTB, BTS, SR magnets
- Set BR&SR RF systems to operation mode
- Enable electron source high voltage and linac' RF modulators

06 Beam Instrumentation, Controls, Feedback and Operational Aspects

T04 Accelerator/Storage Ring Control Systems

- Put all ID (insertion device) gaps into parking position
- Set all power supplies to max and load desired lattice

In case of an accidental beam trip, the system can only be executed without stored beam (Fig. 2). To maintain a controlled process, break points are located between steps for inquiries before executing the next procedure (Fig. 3).
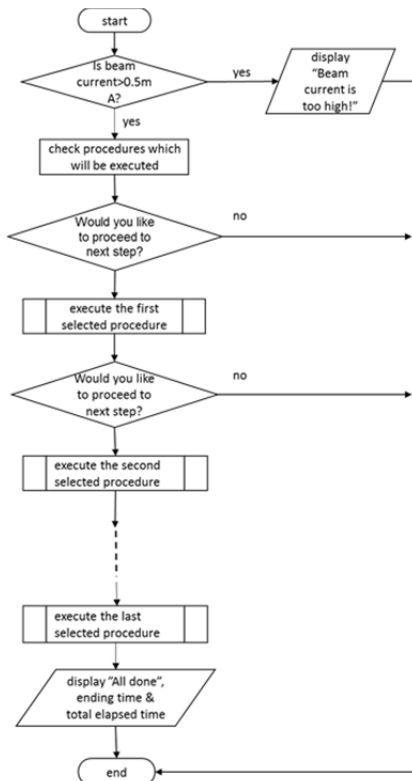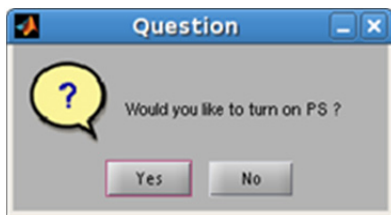

Figure 2: Flow chart for automatic TPS turn-on.

Figure 3: Inquiry before executing next procedure.

Turn on PS (LTB,BTS,SR)

In this step, the LTB, BTS, SR power supplies will be turned on (Fig. 4). If the power supplies are not ready for 'on', an error message will be displayed in the 'Error' list, followed by an inquiry on what to do next. (Fig. 5)
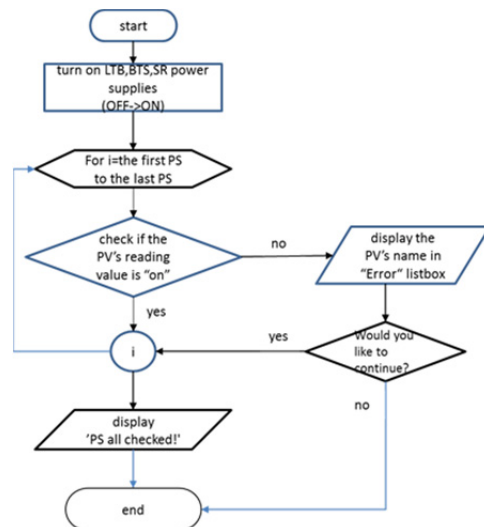

Figure 4: Flow chart of "Turn on PS(LTB,BTS,SR)".

Figure 5: Inquiry about proceeding.

Enable Pulsers

In this step, SR pulsers including injection septa, kicker high voltages and timing control will be enabled (Fig.6).
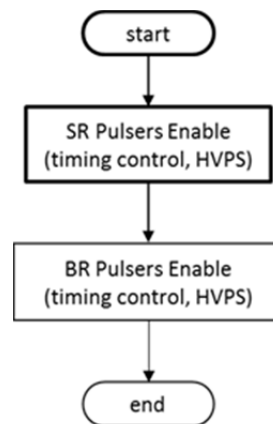

Figure 6: Flow chart of "Pulser Enable".

LTB BTS SR Degauss

In order to establish reproducible magnetic fields, each magnet should be degaussed by applying five cycles of ramping up to maximum current and then return to zero. If test values does not agree with target values, the error will be displayed in the 'Error' list (Fig. 7).
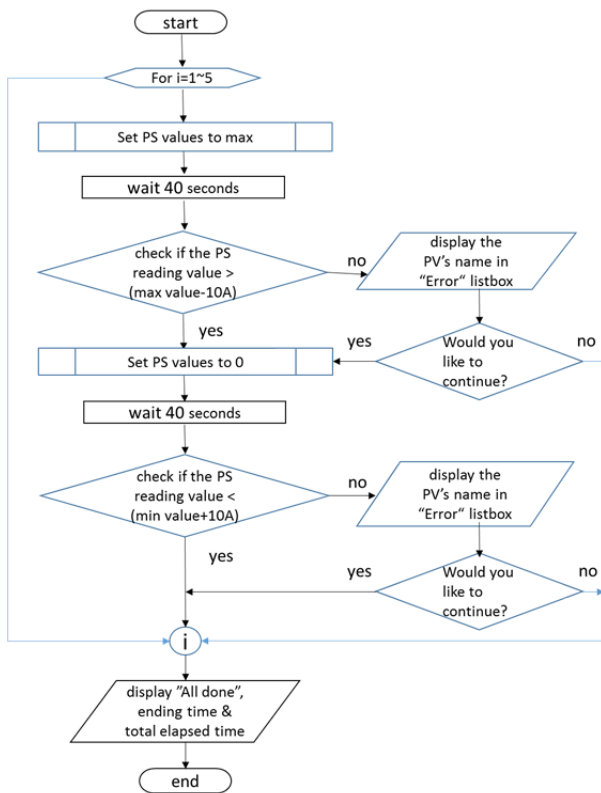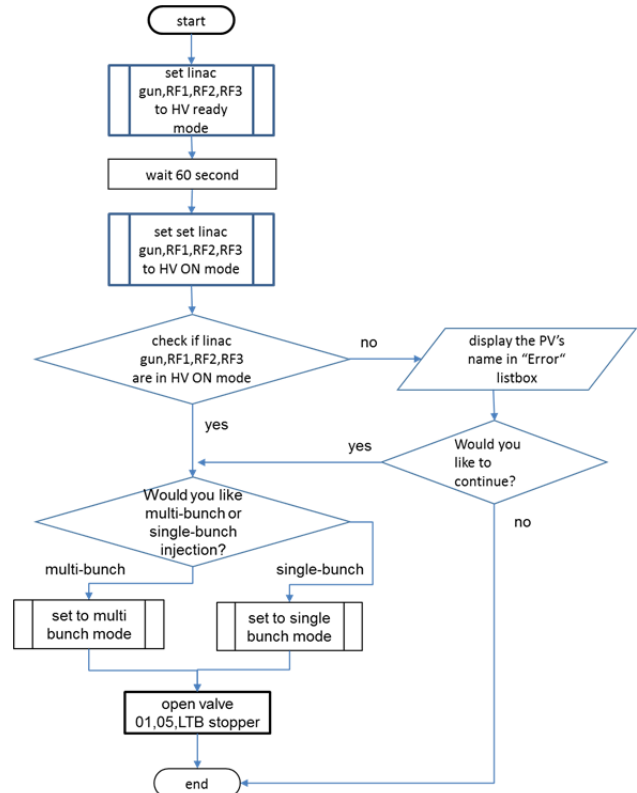
Figure 7: Flow chart for magnet degaussing.

SR&BR RF

Both booster and storage RF system controls will be set to "tune mode" and after waiting for 90 seconds they become ready to operate (Fig. 8).
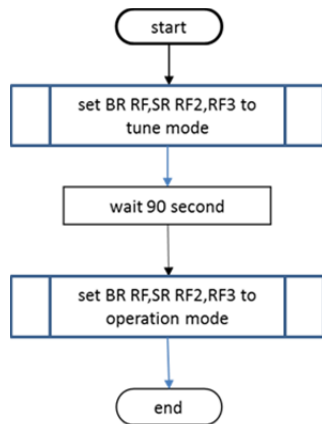

Figure 8: Flow chart for "SR&BR RF".

Linac

The high voltage for electron gun and linac RF modulators will be enabled. An inquiry about multi-bunch or single-bunch injection mode will pop up, because both require different operation conditions, e.g., grid voltage, pulse width, etc. After all linac systems are ready, the vacuum valve to the LTB and electron beam stopper will be opened for injection (Fig. 9).

Figure 9: "Linac" flow chart.

ID Gap Open

On injection, all insertion devices (IDs) including three elliptically polarized undulators (EPU), seven planar in-vacuum undulators (IU) and one in-vacuum tapered undulator (IUT) should be set to their parking positions. In this step, all ID gaps will be open and all beamline frontends & hutches will be disabled (Fig. 10).
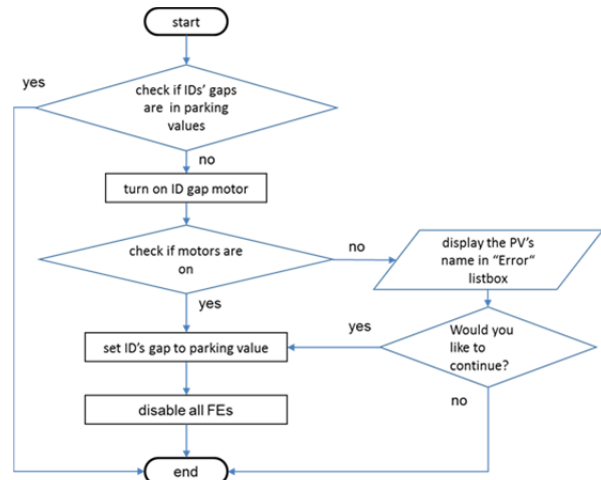

Figure 10: Flow chart of "ID gap open".

CONCLUSION

According to experience, it takes some 30 minutes, including about 20 minutes to degauss magnets, from tunnel safety search to ready status for injection. In addition, operators can focus on troubleshooting without delaying

or overlooking other procedures, which may save more time for users.

Step by step, more functions, especially operating procedures such as current accumulation, orbit correction, orbit interlock, orbit feedback, top-up injection mode, etc., will be integrated in this GUI.

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