INTELLIGENT AGENT BASED CONTROL OF TL-1

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Abstract

The Agent based control of complex systems is becoming popular due to its ability to identify the critical situation and its ability to dynamically search for the best available solution to the problem with constrained optimization of the inputs. In this paper we are presenting the architecture of intelligent agent for automatic control of power supplies of TL-1 (Transfer Line 1) to maximise the injection process against the changes in the input beam obtained from Microtron. The paper discusses the results obtained by applying this agent architecture to the accelerator model comprises of Microtron output, TL-1 and booster.

INTRODUCTION

The INDUS-1 and INDUS-2 storage ring facilities are the synchrotron radiation sources located at Indore, India. It consists of seven major accelerator components- Microtron, TL-1, Booster, TL-2, INDUS-1, TL-3 and INDUS-2. Microtron serves the purpose of pre-accelerating the electrons to 20MeV before these are injected to computer-ramped booster synchrotron for acceleration up to the maximum final energy of 450MeV for storing into INDUS-1 storage ring and to 550 MeV for injection into INDUS-2. This paper discusses the intelligent agent architecture for controlling the power supplies of TL-1 to maximise the injection process against the changes in the input beam position at Microtron output along with the results obtained by applying this agent architecture to the accelerator model.

OUTPUT BEAM FROM MICROTRON

The 20MeV electron beam coming out of Microtron shows beam position drift which can be broadly classified into two categories- Category-I and category-II. Here Category-I is the drift which is observed at the time of starting of the Microtron for about an hour of operation before the Microtron stabilizes for its normal operation state. (This is shown in Fig. 1) This position drift mainly arises because of the shift in the RF cavity resonant frequency with the cavity temperature and slowly dies out as the cavity stabilizes with time. The Category-II is the slow drift in the stabilised beam position seen on day to day basis shown in Fig. 2. This is mainly due to cathode aging and day to day environmental variations. In normal course of operation the operator waits for the stabilization time of about 30-40 minutes and then optimises the Microtron to obtain the desired beam position on beam slit monitor. If required, the operator then adjusts the TL-1 power supplies to obtain the desired value of injection current in the booster synchrotron.

In case of degradation of the injection current in the booster synchrotron the operator has to manually readjust the settings of power supplies to obtain the desired value of injection.

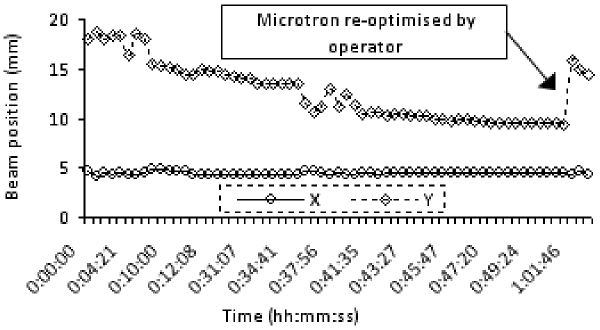

Figure 1: Category-I beam position drift observed in beam at Microtron output.

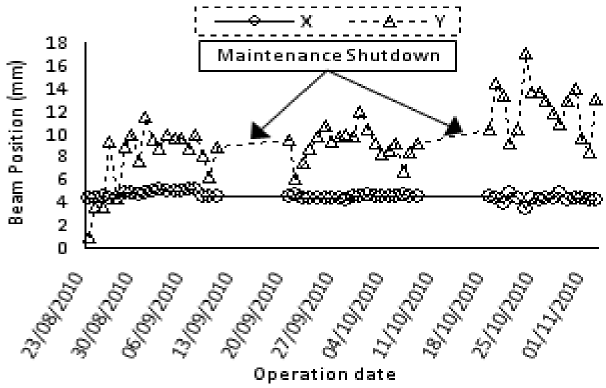

Figure 2: Category-II beam position variations observed in beam at Microtron output.

TL1 LAYOUT

Transfer Line 1 comprises of Microtron extraction tube, three pairs of dc-quadrupoles (QF1-QF3 and QD1-QD3), four horizontal steerers (HSC1-HSC4), five vertical steerers (VSC1-VSC5), one 15º dc-dipole (DP1) and one 15º injection septum (pulse width 200µs). For measurement of beam position there are three fluorescent screen type beam position monitors (BPM1-BPM3). The detail description of transfer line 1 is provided elsewhere [1]. Only a portion of the 500µs pulse obtained from Microtron actually gets injected in the booster synchrotron for actual acceleration process.

TL1 INTELLIGENT AGENT ARCHITECTURE

Fig. 3 shows the model based, goal based intelligent agent with modular architecture with different functional blocks adopted for exercising the TL-1 agent. The

"Perception" and "Execution" blocks directly interact with the accelerator environment. In TL-1 case it will interact with the TL-1 power supplies and beam diagnostic devices (Fast Current Transformer (FCT) through Oscilloscope, Fluorescent Beam Position Monitor

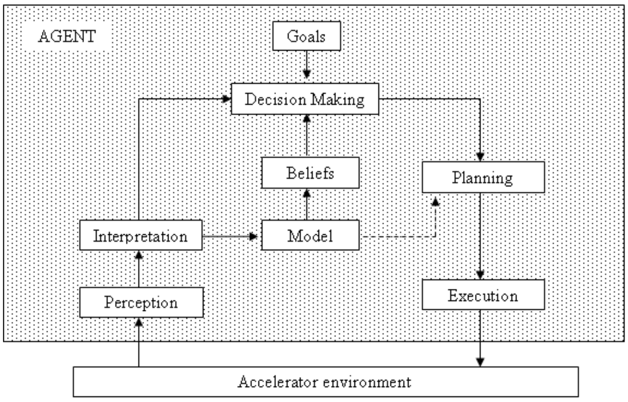

Figure 3: Architecture of Transport Line 1 Intelligent agent

(BPM) screens). Function of the "Perception" block is to read different P/S settings and read-back values, FCT & Oscilloscope traces and BPM images. Depending upon the read data it then generates the appropriate event. Events are passed directly to the respective blocks in the form of messages along with the required data. The "Interpretation" block serves the purpose of processing the raw data acquired by the "perception" block to convert it to the required form in TL-1 this block extracts the beam position (X , Y) and beam sizes (σx, σy) from the BPM images and the injection current value from FCT and CRO traces. "Beliefs" block is basically the agent's data storage. This stores the system state and other Meta data required in the processing / decision making steps. "Goal" block contains the definition for all the goals and provision for enabling / disabling of goals. Definition of goal comprises of plan list. Plans in the list are the alternate plans by which the goal could be achieved in different system conditions. The position of the plan in the plan list decides its priority. The plan at higher level in the list has higher priority. The "Decision Making" block depending upon the current events and the agent beliefs decide the plans to be executed to achieve all the active goals. It does this by evaluating the plan applicability function and selecting the highest priority applicable plan from the list for each active goal. The "Planning" block serves the purpose of executing the selected plan in synchronised/coordinated way and updating the active goal list. Each plan body comprises of sequence of actions i.e. steps to be followed to attain the desired goal. The "Execution" block sends the commands obtained from different blocks in the form of messages to machine components after checking them for the validity. The "Model" block in itself is an intelligent agent comprising of the TL-1 model and serves the purpose of providing the information about the probable outcome of the stated actions on the machine.

SIMMULATION RESULTS

In order to test the TL-1 control using the intelligent agent the overall system model is simulated in LabVIEW® [2] environment using the MAD [3] based component models. The agent continuously monitors current injected into the ring and if it falls below low limits, it calculates the beam parameters from the BPM images and decides the new setting values to be applied to the P/S for increasing the injection current value. This process goes on iteratively till the required injection is achieved. Fig. 4 shows the normalised injection current with respect to the beam position variation with and without applying the intelligent agent based control.

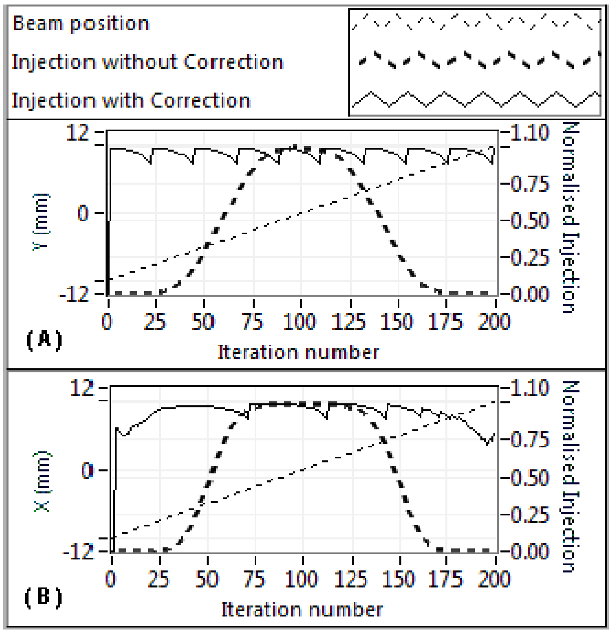

Figure 4: Simulation results for injection current with and without applying correction for beam position variation in vertical (A) and horizontal (B) plane.

CONCLUSIONS AND FUTURE WORK

The simulation results obtained by applying the Intelligent agent based control on MAD component based system model comprising of Microtron-TL1-Booster shows that the concept can be applied successfully for stabilizing the injection current in booster against the beam position variations at Microtron output.

Presently we are trying to optimise the injection for the measured beam position. Further work will be focused on injection optimisation by position tracking rather than position measurement.

REFERENCES

[1] Singh, G. et al., Synchrotron radiation source Indus-1, InPAC-03, CAT, Indore, Feb., 3-6, 2003
[2] http://www.ni.com/labview
[3] http://wwwslap.cern.ch/mad