THE FEED-FORWARD CONTROL DESIGN OF CORRECTION COIL POWER SUPPLY FOR SSRF DEPU

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Abstract

An initial design for the feed-forward control (FFC) has been proposed for the dual elliptically polarized undulator (DEPU) which operating in SSRF. In order to reduce the orbit distortion during movement of the DEPU gap and shift, the feed-forward correcting magnetic field must be put at the entrance and exit of the DEPU must be taken [1]. The FFC is implemented in an individual controller which is independent of the DEPU motion controller, so that the regulation of correction currents would follow the gap and shift alteration real-timely and accurately in case gap or shift changes fast. According to one 2D look-up table (LUT) CCPS controller calculates the excitation currents for entrance and exit coils of the DEPU. The 2D LUT is composed of different gaps, shifts and corresponding currents acquired during the DEPU commissioning procedure.

INTRODUCTION

The super high resolution and wide energy range photoelectron experiment system for SSRF will adopt diversified synchrotron radiation produced by the DEPU. The DEPU consists of two 5m-long APPLE-II type EPUs(showed in the Figure 1), magnetic field periods of

Figure 1: The DEPU in SSRF storage ring.

Which are respectively 58mm(EPU58) and 148mm (EPU148). The two EPUs are installed parallel on one mechanical facility. Alternant operation between the two EPUs are through their transverse movement. The two correction magnets with horizontal and vertical coils are respectively installed on the entrance and exit of the DEPUs. In order to correct the beam orbit variation owing to magnetic field change during gap and shift movement of the DEPU, There are two 2D LUTs for each EPU, and the LUTs will be altered following the EPU alteration. The correction magnetic field must alter in accordance with the DEPU magnet field. The exciting currents of correction coil power supply (CCPS) must follow the changes of gap and shift real-timely and accurately with corresponding LUTs.

ARCHITECTURE

The original FFC algorithm of correction coil power supply (CCPS) is implemented in the input and output controller (IOC) based on VME [2]. The correction current value is not consistent with the gap and shift change because the communication between IOC and insertion device (ID) controller takes up longer time. Furthermore, the slow correction current update rate resulting in mismatch between current and gap when gap move quickly relatively. Therefore, we propose one FFC architecture that the FFC is fulfilled in a sole CCPS controller, which gets the gap, shift and EPU position information from the DEPU controller and does the correction by CCPS.

DEPU Layout

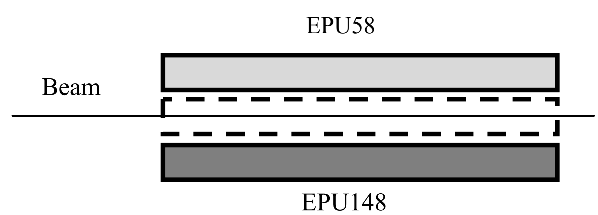

Figure 2: DEPU schematic layout.

The DEPU consists of two EPUs (schematic layout is as Figure 2), one is EPU58, another is EPU148. Each EPU has two positions, one is at operation position, another is at waiting position In the Figure 2, the dot frame means that the EPU is at operation position, and another two solid frames are situated at waiting position.

CCPS Controller

The CCPS controller with Profibus-DP interface is used to implement direct control through analog interface. The CCPS controller is equipped with 16bit analog output (AO) and analog input (AI) modules. Besides, Ethernet module is also necessary for communication between CCPS controller and remote EPICS system [4].

CCPS

The DEPU is equipped with two correction coils per end, for vertical and horizontal corrections. Each pair of coils is driven with a 3 Amp bipolar analog power supply.

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The CCPS can respond rapidly to analog control voltage variation in 1ms on resistance load, and has a RMS current stability of 0.08%.

Network Structure

The DEPU motion controller is dedicated to the motion control, limit protection and other interlock task (the overall network structure is as Figure 3). At the same time, the DEPU motion controller provides the position information including gap and shift to CCPS controller via Profibus-DP. The remote EPICS system with access to CCPS Controller via Ethernet must handle communication tasks such as sending the operating commands, 2D-LUT information and receiving the CCPS working status.

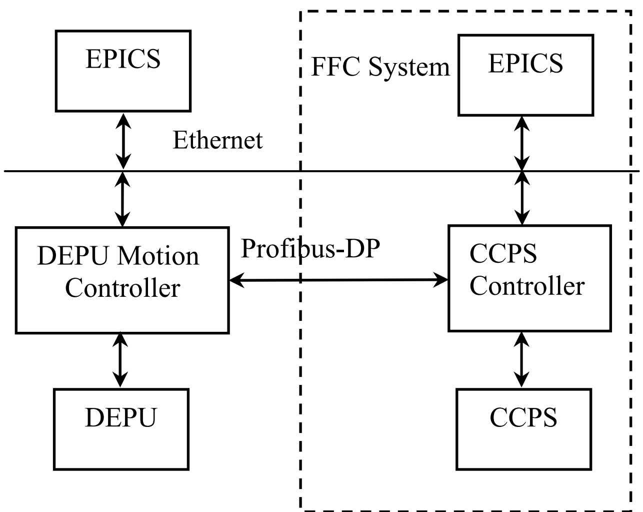

Figure 3: the FFC system network structure.

Feed-Forward CONTROL

2D LUT

The required correction magnetic field applied to the stored electron beam is a function of gap and shift. Since there are no definite relation derivation, a 2D-LUT with 20*20 matrix will be used to define the correction values for defined gap and shift values. Each correction current value should be determined by test with minimum beam orbit perturbation. The procedure used to create the 2D-LUT is to move the ID gap to approximately 20 positions keeping a fixed shift position which will gradually add to 20 positions, and cycle the current in each coil while recording the RMS orbit perturbation at all BPMs. A second order polynomial is fit to the RMS and the minimum defines the current needed at that gap [3].

Control Algorithm

The correction value (coil current) for present gap and shift will be derived by linear interpolation referring to the 2D-LUT. In the Figure 4, I(gx, sx) is defined as the correction current for the present gap (gx) and shift (sx). I(g1,s1) is known current corresponding to gap s1 and shift s1 in the 2D-LUT, and so on for I(g1,s2), I(g2,s1), I(g2,s2).

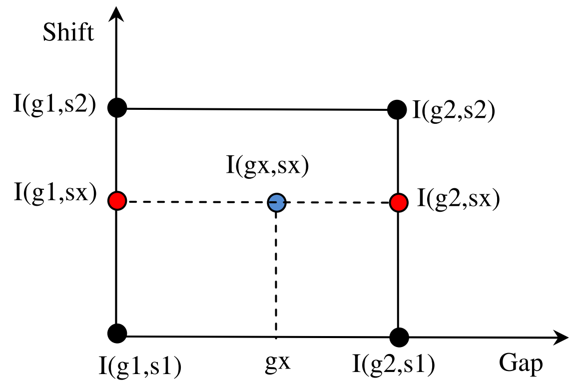

Figure 4: 2D Linear interpolation schematic diagram.

For deriving I(gx,sx), the first step is to find the location of the present gap and shift in the 2D-LUT. Consequently, four currents adjacent to I(gx,sx) would be located. The second step is to calculate I(g1,sx) and I(g2,sx) by linear interpolation. The last step is to calculate I(gx,sx) relevant to gap gx and shift sx according to the I(g1,sx) and I(g2,sx) by linear interpolation too.

Operator Interface

The remote control interface for CCPS is an OPI (Figure 5) based on EPICS via Ethernet. The CCPS has two

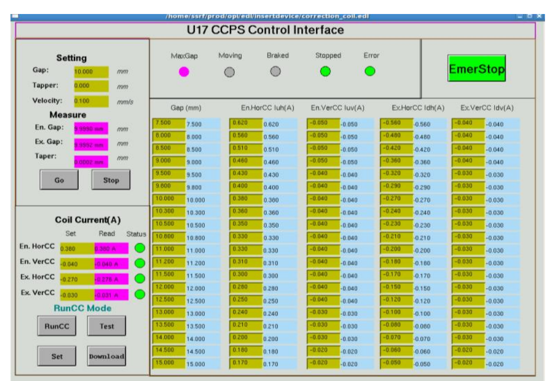

Figure 5: OPI for CCPS.

working modes, one is the Test Mode for operation to test and get the 2D-LUT during the DEPU commissioning stage, another is RunCC Mode under which the CCPS controller updates current automatically according to the 2D-LUT.The 2D-LUT is made under Test Mode and downloaded to the CCPS controller. Because a large number of experiment data need to be downloaded to CCPS controller under Test Mode, it is necessary for remote EPICS IOC to use autosave function recording the changed parameters every certain intervals so as to recover these values in case IOC restart. At the same time, because big number of data communication would take up more scanning time of CCPS controller, which should skip receiving the 2D-LUT data if these data are unchanged.

CONCLUSIONS

At present, the FFC for the DEPU is under progress. One similar 1D-LUT FFC architecture has been applied in in-vacuum undulator (IVU) orbit stability compensation with current updating rate of about 10Hz. And from the result of accelerator physics experiment, the FFC is effective. By contrast with the IVU controller implementing both IVU motion control and the CCPS control, the CCPS controller for the DEPU has less processing time for control algorithm because of its single task. Thus it could be predicted that the FFC for the DEPU is also feasible and effective.

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