CLOSED ORBIT CONTROL IN ENERGY RAMPS ON THE SRS AT DARESBURY

S.F. Hill and S.L. Smith, CLRC Daresbury Laboratory, Warrington WA4 4AD, UK

Abstract

The SRS is a second generation synchrotron radiation source which ramps from its injection energy of 600 MeV to 2 GeV in about 1 minute. Some orbit control during energy ramping has taken place on the SRS for the last two years, to overcome problems encountered with large uncorrected orbit drifts and allow high currents (>300 mA) to be ramped reliably for operations. This has now been extended to give tighter control to the orbit at all points during the ramp, in preparation for the installation of two new insertion devices in the ring. The reduced vertical aperture specifications for these will demand a higher degree of position control through all phases from injection to user beam. Typical orbit deviations previously seen in energy ramps are described, and compared with new results gained by the application of steering corrector files at suitable points on the ramp.

1 INTRODUCTION

The Daresbury SRS is a second generation light source and the world's first high energy dedicated synchrotron radiation source. The machine has been operational since 1980. The current high brightness lattice [1] was implemented in 1986 and over the subsequent years the operationalperformance has been enhanced. In the past improvements have concentrated on the control of orbit position and stability at full energy [2]. The requirement to ramp high current beam in a more reproducible and controlled manner has prompted efforts to control the orbit during the energy ramp. With the installation of improved magnet power converters [3] the ramp rates have increased by more than a factor of ten making orbit control a much more challenging task. The proposed introduction of small gap insertion devices [4] imposes a future requirement for even more stringent orbit control [5]. This paper outlines the implementation of orbit control during the energy ramp in the SRS and addresses the problem of control in the future.

2 ORBIT MEASUREMENT AND CORRECTION

2.1 Correction Elements

The SRS has a 16 cell FODO lattice structure, with a circumference of 96 m. Figure 1 is a schematic diagram of one of these cells showing the position of the main corrector elements and the beam position monitors (BPMs). Table 1 lists the magnet elements used for orbit correction during the energy ramp.

Table 1: Corrector Elements in the SRS

Name	Type	Use
VSTM	Dedicated Steering Magnet	Vertical
DIPT	Trim Coil on Dipole	Horizontal
HSTR	Programmed on Multipole	Horizontal

The multipole magnet (MP) has 12 windings which can be individually programmed for horizontal or vertical deflection, octupole field, or a combination of all three [6].

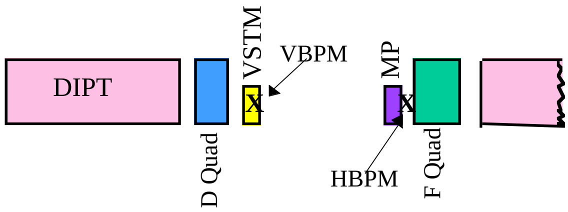

Figure 1: Schematic showing position of correctors and monitors in an SRS lattice cell.

2.2 Requirement for Correction

As in all storage rings the uncorrected (bare) orbit in the SRS changes over many months [7]. In the SRS these change are large due to the continual thermal cycling of the magnets and even with annual quadrupole relocation the typical bare orbit in the SRS has deviations of many millimetres at the position monitors (shown in Figure 2).

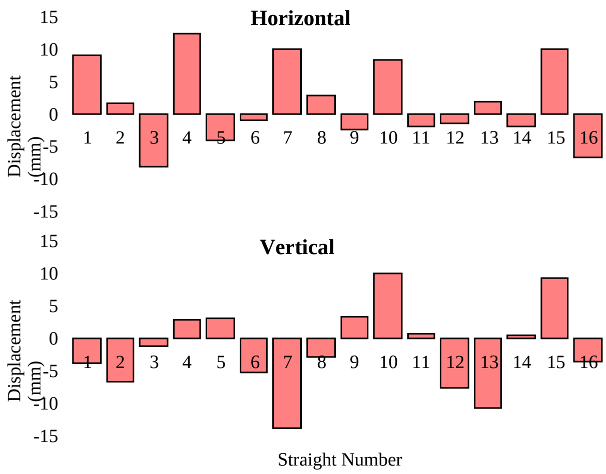

Figure 2: Example of the bare orbit displacements typically observed in the SRS.

The response of the position monitors saturates beyond about 8 mm and the orbits shown in the figure have been scaled from the changes observed on reducing the corrector strengths by 25 % from a fully corrected orbit.

Injection takes place into a corrected orbit. In the horizontal plane a static bump is applied to move the beam across closer to the septum using current shunts on the three dipoles closest to the septum. The orbit correction is applied using VSTM and DIPT magnets. The DIPTs are less effective than the HSTR multipole coils, however at low energy they have adequate strength to correct the orbit so that the multipoles can be dedicated to producing the necessary octupole field to damp instabilities. A typical injection orbit as measured on the BPMs is shown in Figure 3. It should be noted that the actual offset at the septum is larger than the 9 mm indicated on BPM 1 due to monitor saturation.

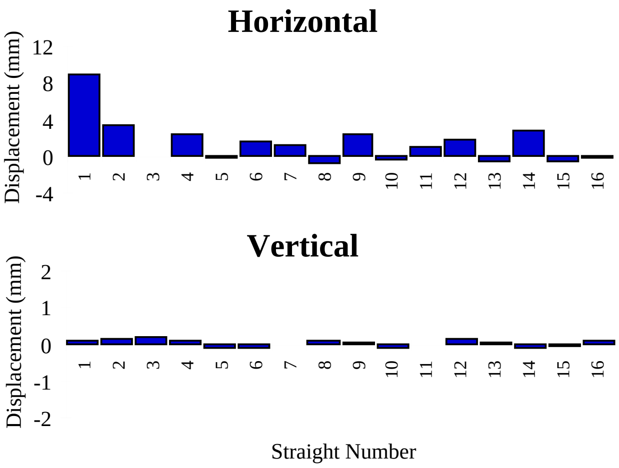

Figure 3: Typical Injection Orbit

3 RAMPING AND EARLY ORBIT CONTROL TECHNIQUES

3.1 Ramping from the Injection Orbit

The power converters originally in use on the SRS were elderly roller regulator types and could not maintain tracking at high *dI/dt* so energy ramps took typically 14 minutes. Without any orbit control during the energy ramp the closed orbit progressively tended to the bare orbit since the effect of the DC correctors was reducing with increased energy.

For many years these large orbit excursion were tolerated. A combination of deteriorating bare orbits and a desire to maximise the machine current led to problems ramping reliably.

3.2 Initial Orbit Control Methods

Modifications were made to the ramp control software to allow steering correctors to be applied at intermediate energies, particularly in the early part of the ramp where the beam was unstable and required greater aperture. At higher energies (> 1 GeV) the DIPTs were supplemented with HSTRs by reducing the octupole field as necessary to avoid multipole winding saturation. This technique of correction led to a significant improvement in the reliability of the energy ramp at high currents.

4 EFFECT OF MACHINE SYSTEM UPGRADES

For most of the operating life of the SRS, ramp control was maintained by a integrated system of minicomputers, which controlled all main magnet supplies, RF and steering supplies. 1995 saw a move to upgrade several areas of the ring, starting with the installation of OCEM thyristor phase-controlled power converter units [3] which would be controlled by a spreadsheet-based distributed control system using PCs (developed originally for the ISOLDE Beamline at CERN) [8].

4.1 A Hybrid Control System

The degree of local intelligence in the power converters means that that once a table of ramp timings and required magnet currents is downloaded and a trigger signal sent, the magnets ramp autonomously. This dual-system configuration did not present a great problem to the minicomputer-controlled RF system, since the beam was not very sensitive to exact RF setting, but gave problems when trying to apply steering at the appropriate energy. This was further complicated by the move to a much shorter ramp time of 70 seconds, to exploit the fast tracking control available from the new power converters.

4.2 Improved Orbit Control

Initially the orbit monitoring and correction were still run on the old mini-computer system and interim measures were taken to improve the ramp orbit control by using a pragmatic adjustment of the timing of orbit corrections to minimise the orbit excursion during the fast energy ramp. Figures 4 and 5 show the evolution of the orbit displacement at the BPMs during a 70 second ramp.

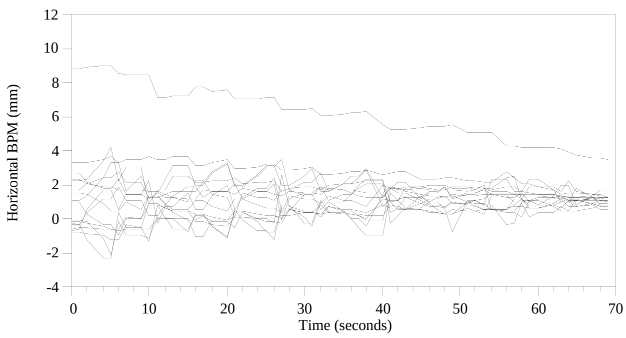

Figure 4: Horizontal orbit displacement at the 16 monitors

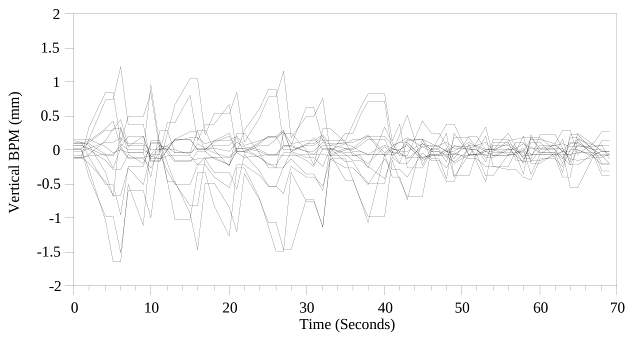

Figure 5: Vertical orbit displacement at the 16 monitors

Maximum horizontal orbit deviation (outside the dipole shunt bump) from the 1.5 mm average offset orbit [9] was 3.5 mm (r.m.s. of 2.0 mm), whilst the maximum vertical deviation was 1.6 mm (r.m.s. of 0.8 mm). The method has since been adopted for operations use and has proved reliable.

4.3 ISOLDE Ramp Orbit Correction

Earlier this year the VME-based steering system, incorporating both corrector control and BPM readout, was integrated into the ISOLDE control system. This conversion included new software to apply sets of correctors at discrete points during the energy ramp in the same manner as the previous mini-computer based control. Initial trials of the new ISOLDE software have given similar results to those shown above but attempts to further improve this method of correction by using the ISOLDE monitor of the dipole current to control the setting of the corrector magnets failed because of the slow communication rate with the power converters and. timing uncertainties at the ISOLDE system level (of the order of a few seconds).

4.4 Problems With Discrete Orbit Correction

As mentioned above, the ISOLDE system does not give any further improvement on the original hybrid. The timing uncertainty will be improved by changing the method that the ramp software applies the previously created flat orbit correctors, but cannot be removed. The other main problem with a discrete corrector based method is that periodically all the corrector files will have to be modified, as the bare orbit of the machine degenerates over time. This is a manual process at present, involving the pausing of the ramp at each energy point, correcting the orbit and re-saving the correctors to file. This then occupies valuable beam studies periods on a regular basis.

5 FURTHER DEVELOPMENT

To meet the more stringent demand for orbit control in the future and to reduce the effort on maintaining up to date orbit corrector settings, it is envisaged that the orbit during the ramp will be controlled using an automatic servo system based at the VME level. Such a system has already been used successfully to very precisely control the horizontal and vertical orbit at 2 GeV [2,9]. The ramp orbit control does not require the same order of precision but will have to operate around 30 times faster and will be required to balance the application of DIPT, HSTRs and distributed octupole as well as correcting the orbits.

A very preliminary trial of a ISOLDE-based ramp servo has recently been performed which indicated an improvement of approximately 10 % in the orbit r.m.s. seen on the best discrete corrector-controlled orbits in the ramp.

REFERENCES

[1] V.P. Suller et al, "Performance of the Daresbury SRS with an Increased Brilliance Optic", Proc. European Particle Accelerator Conference, Rome, June 1988, p418.

[2] B.G. Martlew, R.J. Smith, S.L. Smith, "Development of Global Feedback for Beam Position Control in the Daresbury SRS Storage Ring", Proc. European Particle Accelerator Conference, London, June 1994, pp1574-1576.

[3] D.E. Poole, S.A. Griffiths, M.T. Heron, "New Magnet Power Converters for the SRS at Daresbury", Proc. European Particle Accelerator Conference, London, June 1994, pp2333-2334

[4] M.W. Poole, J.A. Clarke, "Upgrading the Daresbury SRS with Additional Insertion Devices and its Implications for the Storage Ring Layout", these Proceedings.

[5] H.L. Owen, J.A. Clarke, "Operation of the Daresbury Synchrotron Radiation Source with Reduced Vertical Aperture", these Proceedings.

[6] N. Marks, "The SRS Prototype Multipole Magnet", Proc. Sixth Int. Mag. Tech. Conf., Bratislava 1977, p528.

[7] L.A. Welbourne, "Long Term Drifts and Correction of the SRS Closed Orbit", Proc. European Particle Accelerator Conference, London, June 1994, pp1577-1579.

[8] B.G. Martlew, M.J. Pugh, W.R. Rawlinson, "Present Status of the SRS Control System Upgrade Project", these proceedings.

[9] J.B. Fitzgerald et al., "The Daresbury Global Horizontal Servo Feedback System: Status and Outlook", these Proceedings.