Development of a VME-Based Control System for the SRS Orbit Feedback Project

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Abstract

A new control system for the SRS steering magnets has recently been installed and commissioned. This system, using VME with 16 bit DACs and ADCs, allows feedback control for local and global closed orbit correction with extremely high accuracy. As a result, photon beam position stabilities of a few microns have now been achieved at the beam line experimental stations. This paper will describe the control system and the algorithms in use for beam steering.

1. INTRODUCTION

The Daresbury SRS is a 2 Gev electron storage ring dedicated to providing synchrotron radiation to approximately 36 stations on 11 beamlines. It came into operation in mid 1981 and was upgraded with a high brightness lattice in 1987. This upgrade reduced the source size by a factor of 10 subsequently leading to difficulties at the experimental stations with beam alignment and position drift over the period of a stored beam. A project was started in 1990 to upgrade the steering system by:-

1. Provision of a VME-based system to provide local intelligence and the capability for feedback control of the steering magnets.
2. Replacement of the 12 bit CAMAC DACs and ADCs with 16 bit VME devices.
3. Provision of beam line Tungsten Vane Monitors for photon beam position monitoring.
4. Provision of improved electron beam monitors having a resolution of 10μm.

The project is now completed and work is continuing to fully exploit the system. Work on the Tungsten Vane monitors and the improved electron beam monitors has been described elsewhere [1,2]. This paper will describe the changes required to the control system to interface to the new VME system and the software used for local and global closed orbit correction.

2. CONTROL SYSTEM

2.1 Control system prior to upgrade

The SRS control system was originally configured as shown in Figure 1. The operator interface is a Concurrent Computer Corporation 3230. The plant interface computers are Concurrent Computer Corporation 3205s. These machines operate under OS/32 and communicate via CAMAC fast serial data links.

Interface to the plant is via CAMAC serial highways. Access to the plant from the operator level is provided by a process i/o software package 'PROCESIO' running in the 3230 which determines the location of database defined parameters and sends requests to and receives responses from the appropriate plant interface computer. A process 'REMPIO' at the plant interface computer deals with the request and accesses the plant through special analogue input,output and status drivers in the plant interface computers.

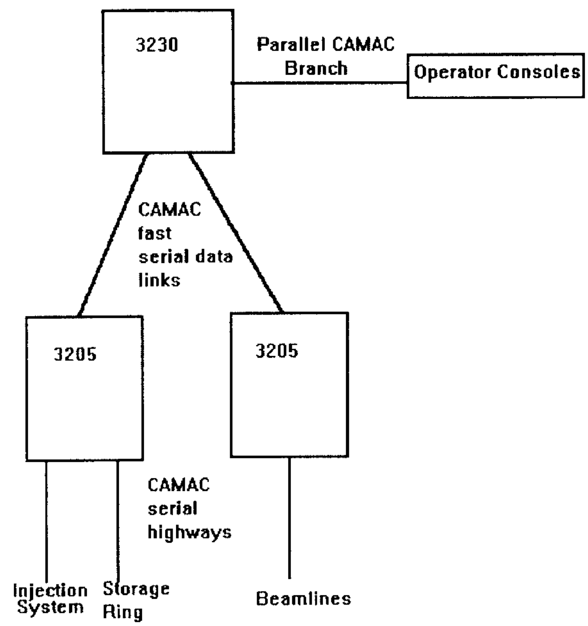

Figure 1. The SRS Control System

The steering system consists of 16 vertical steering magnets (VSTMs), 16 dipole trim magnets (DIPTs) and 16 multipole magnets (MPs). Each of the multipole magnets consists of 12 windings and at present these can be configured simultaneously by the software as 16 horizontal steering magnets (HSTRs) 16 vertical steering magnets (VSTRs) and 16 octupole magnets (OCTPs). There are a total of 224 windings to be controlled. In the original control system the steering magnets were driven on the CAMAC serial highway allocated to the storage ring shown in Figure 1. The CAMAC DACs and ADCs were 12 bit bipolar devices. Control of the multipole magnet types was provided by a 'virtual parameter' mechanism consisting of software modules in the 3230 driving the 12 windings of a multipole in a way which was transparent to the operator. These software modules placed an extra load on the 3230 when parameters based on the multipole magnets were being manipulated and there were limitations on how many could be accessed at a time.

2.2 *Control system after upgrade*

Figure 2 shows the overall layout of the control system on completion of the project.

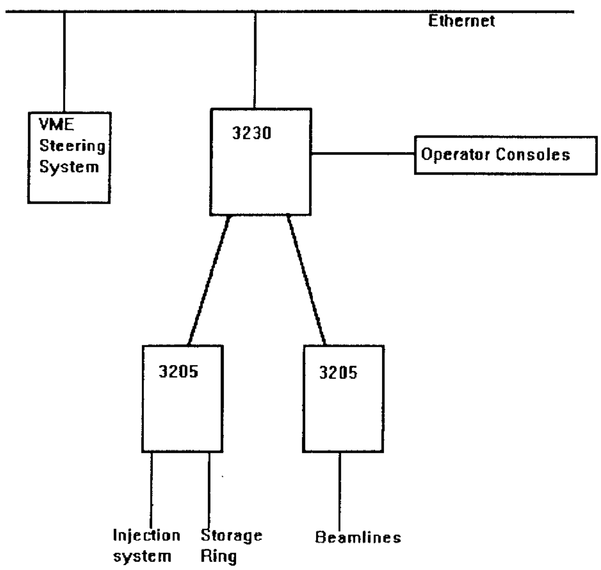

Figure 2. Control system after upgrade

The 3230 was enhanced with an ethernet board and the relevant software. The 'PROCESIO' package in the 3230 was expanded substantially to access steering magnet windings on the VME system. A version of the 'REMPIO' process was produced for the VME system to make it appear to the 3230 as another 3205 as far as process i/o requests were concerned.

The VME system is shown in more detail in Figure 3. The interface to the main control system is via the Gateway processor('G') which runs the 'REMPIO' process. The main VME crate also contains the Database server processor('D') which communicates with the four Plant interface crates (PICs) over a separate dedicated ethernet network and keeps a database continually updated with analogue values and requests analogue settings from the database to the PICs. The database is held in shared memory with access from both the Gateway and the Database server.

The Gateway processor is a disc-based system whilst the Database server and the Plant interface processors are ROM-based. All processors are Motorola 68030 and run version 2.4 of OS-9. In addition to providing the interface to the main control system, the Gateway processor runs the feedback algorithms for both local and global orbit control.

Each of the four PICs contains the 16-bit DACs and ADCs to control and monitor one quarter of the storage ring steering magnets. In addition, the Tungsten Vane photon monitors provide inputs to ADCs in the PICs. The HSTR,VSTR and OCTP magnet types are now implemented in software in the plant interface processors('P'). This relieves the load on the 3230 and removes previous restrictions on numbers of 'virtual parameters' which can be manipulated at a time.

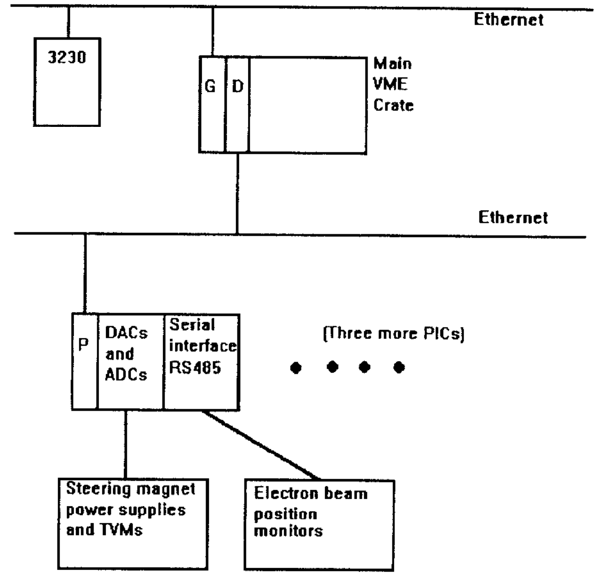

Figure 3. VME Steering system

A new digitally multiplexed electron beam monitoring system was also recently interfaced to two of the PICs allowing easy access to the 16 horizontal and 16 vertical electron beam monitors both from the main control system and from the Gateway processor. These monitors are read into the system via an RS485 serial link using OS-9's NFM protocol. Prior to this upgrade the electron beam position monitors (BPMs) were read into the control system via an analogue multiplexor. Multiplexor switching time led to slow and awkward applications. With the new digital multiplexor the BPMs are normal control system database parameters which can be updated at the same rate as any other parameter on the machine.

3. FEEDBACK SOFTWARE

Feedback software consists of a local vertical servo programme and a global feedback programme. Both of these programmes run on the Gateway processor. Multiple copies of the local vertical servo programme are invoked to allow simultaneous and independent correction on multiple beam lines.

3.1 *Local vertical feedback*

The local vertical feedback programme is invoked from the main console and takes as its input the name of a configuration file for the beam line concerned. This configuration file is an ascii text file, see Table 1, containing, among other parameters, the time between samplings of the tungsten vane monitor, the time to apply the correction, the photon beam reference position, information on the bump type to be applied and bump calibration data.

Description	"Line 5 Local Vertical Servo Trial"	
Testmode	False	
Datafile	/h0/STEERING/DATA/Line5	
#		
# SetTime and ServoTime are specified in seconds		
#		
SetTime	2	#Seconds
ServoTime	30	#Seconds
#		
# TVM beam monitor specification		
#		
MonitorName	"ZB.TVM5.01"	
AverageCount	10	
ReferencePosition	0.00	#millimetres
PositionTolerance	0.10	#millimetres
#		
# Bump Specifications		
#		
Magnet1Name	"ZM.VSTM.05"	
Magnet1Ratio	1.3630	# Amps/mm at 2 Gev
Magnet2Name	"ZM.VSTR.05"	
Magnet2Ratio	-1.7930	# Amps/mm at 2 Gev
Magnet3Name	"ZM.VSTM.06"	
Magnet3Ratio	0.3700	# Amps/mm at 2 Gev
BumpCalibration	-0.316	#(mm of bump)/(mm of beam movement)
BumpTolerance	0.030	#millimetres
MinimumBump	0.0005	#Smallest allowed bump (mm)
MaxBumpIntegral	0.100	#Maximum bump integral (mm)

Table 1. Configuration file for Local Vertical feedback

The programme reads in the tungsten vane monitor position. A simple proportional control algorithm is applied to calculate the size of the required bump. The contribution from integral and differential terms was found to be insignificant and they were therefore not included in the final algorithm. The calculated bump size is then compared with minimum and maximum bump tolerances and applied if satisfactory conditions apply. It then waits for the specified time to elapse before repeating the cycle. The programme keeps a record of the bump integral and deactivates the application of bumps if limits are exceeded. In this way there is protection against a beam port closing, for example.

3.2 Global feedback

The global feedback programme can be used to correct the electron beam orbit in the storage ring in the horizontal and/or vertical plane. An ascii text configuration file, see Table 2, is set up for the plane of correction containing the time between samplings of the electron BPMs, the time to set the correction, the name of a file containing the response matrix, the type of correctors to be used in the algorithm and calibration data.

The programme reads in the electron BPMs, uses the response matrix to compute the corrections required on the specified correctors and applies these over the period specified in the configuration file. The programme then waits the specified interval before repeating the process.

Description	"Trial of Horizontal Global servo operation"	
ServoTime	10	# Seconds
SetTime	1	# Seconds
BPMAverage	1	
TestMode	True	
ResponseMatrix	./horiz.response	
Correctors	HSTR	
BPMS	HBPM	
OrbitAverage	TRUE	
ReferenceOrbit	./h.orbit	# Required orbit values
MaxMagnetInc	6.0	# Max. inc. correction(amps)
MagnetCal	2.38	# Magnet kick calibration factor
DataFile	/h0/STEERING/DATA/Global_Horizontal	
MaxRMSDev	100.0	# Maximum allowed rms orbit # deviation

Table 2. Configuration file for Global Horizontal feedback

4. PRESENT STATUS

The feedback control system has been in regular routine operation for local vertical feedback on two beam lines since October 1993. Two further beamlines are soon expected to be routinely operated in this mode and work is in progress on the remaining lines. Global feedback trials have been completed and it is hoped that global feedback control will become routinely operational in the autumn of 1994.

There are plans to decouple the beam steering system from the existing control system and interface it to a new control system based on IBM compatible PCs. These plans are described in another paper to this conference[3].

5. CONCLUSIONS

The performance of the feedback system has already exceeded its specification. The introduction of global orbit correction on a routine basis and the extension of local vertical feedback to more beam lines is expected to substantially improve the quality of the beam provided to users of the SRS.

6.REFERENCES

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