

PC-BASED APPLICATIONS PROGRAMMING ON THE SRS CONTROL SYSTEM

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Abstract

The CERN PC-based ISOLDE control system has been installed at the SRS electron storage ring at Daresbury Laboratory. The use of Windows NT for the control consoles together with PC and VME front-end computers running under several operating systems has resulted in a flexible and reliable system for accelerator control. The implementation and philosophy of control application programs, based around a suite of Microsoft Visual Basic and Excel programs, is described. In particular, the use of Excel to provide adaptable programs online allows rapid generation of new control functions; orbit correction and servoing at the application level are described as examples of this.

1 ISOLDE CONTROLS ON THE SRS

1.1 Overview

Over the last few years there has been a policy of gradual upgrade of the SRS control system from a 32-bit mini-computer based system using 1970's technology to a modern PC based system. The ISOLDE ion-separator beamline at CERN was chosen as the model for this upgrade because of its use of a simple client/server paradigm and its philosophy of making maximum use of standard, commercial PC hardware and software [1,2]. Presently, the control system is a hybrid of the old mini-computers and the new ISOLDE PC system.

1.2 SRS Enhancements

Since its introduction on the SRS the ISOLDE system has been enhanced in several ways.

1.2.1 Conversion of operator console to Windows NT

The original system used Windows 3.11 as the client system. This suffered from severe resource limitations

and considerable difficulty in multi-tasking. For these reasons it was decided to switch to Windows NT. This has proved to be a very much more stable system which can successfully multi-task many control system applications as well as simplifying system installation and maintenance.

1.2.2 OS-9 VME systems as Front End Computers (FEC)

The original DOS FEC has been supplemented by porting the server code to OS-9. This was originally necessary in order to interface to an existing VME/OS-9 based sub-system used for control of the storage ring beam steering and orbit diagnostics systems [3]. It has since proved to be a very versatile and inexpensive (especially in 3U format) alternative to DOS-based PCs.

1.2.3 Support for LabVIEW based FECs

Recently the RF group developed a monitoring system based around a PC running Windows 95 and LabVIEW. It is now possible to access this as though it was an ISOLDE style FEC by the development of suitable interface software. This technique is described fully in [4].

1.3 Access to Plant Data

The control system provides two basic methods for accessing plant information: an Application Programming Interface (API) implemented as a Win32 Dynamic Link Library (DLL), and a Dynamic Data Exchange (DDE) server that can provide periodic updating of requested plant information. Alternatively, any standard networking or inter-process communication mechanism available may be utilised in specialised applications. These three alternatives will be discussed in more detail.

The present layout of the PC-based part of the SRS Control System is shown in figure 1.

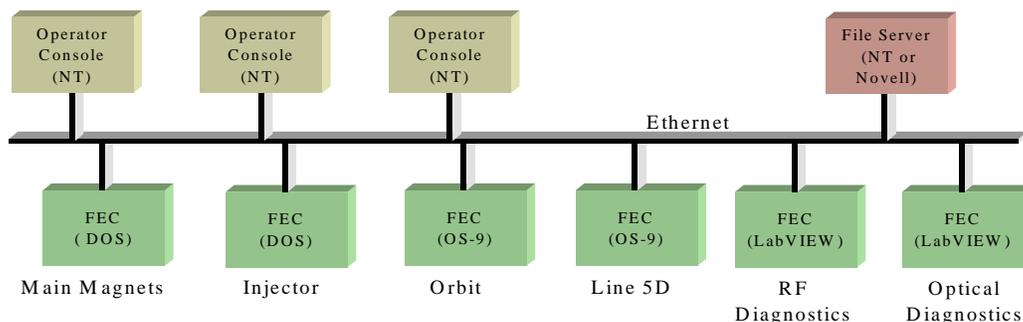


Figure 1: Layout of the upgraded SRS Control System

1.3.1 Win32 API

API calls are the most versatile way of providing access to plant data from the operator consoles. However, their use does demand some programming knowledge as well as a detailed understanding of the under-lying operation of the system. API calls can be used from any programming tool or system that supports access to DLLs.

1.3.2 DDE Server

DDE is a mechanism to simplify the transfer of small quantities of data between different applications. In addition it supports the concept of hot-links, which automatically update client programs whenever new data becomes available. For example, the contents of a cell in an Excel worksheet can be set to update at a user-specified rate. However, it is relatively slow, it is not easy (though possible) to set new values via DDE and it can only be used by those applications that have been specifically written to support DDE.

1.3.3 Network/Inter-Process Communications

The two techniques described above cope with the great majority of requirements but some specialised applications need to be able to transfer large data files (eg. images or waveform data) or to use complex data structures not easily supported by the standard ISOLDE mechanisms. In these cases use may be made of standard TCP/IP sockets or file sharing to access data.

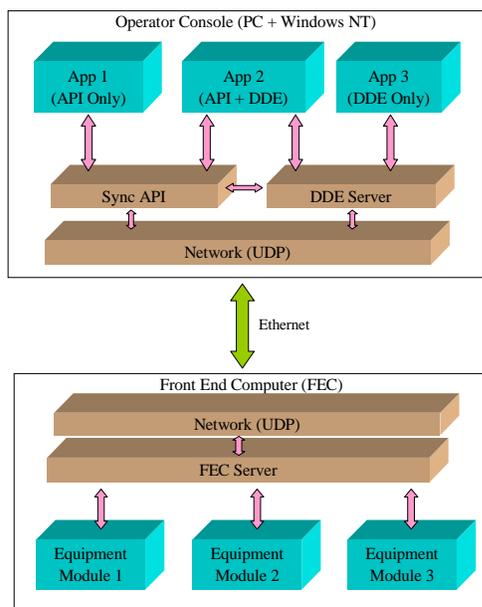


Figure 2: Data Flow from Console to FEC

These three mechanisms, either separately or together, can be used to construct control system application using any of a wide range of application development tools (MS VC++, Visual Basic, MS Excel, Tcl/Tk and LabVIEW have been used on the SRS). Figure 2 illustrates the data

flow between application and FEC when using the standard ISOLDE interface

2 CASE STUDIES

2.1 DDE and OOP in Excel

One of the principal advantages of the ISOLDE system is the ease and flexibility of program development. The features of Microsoft Excel, which is already widely used for the analysis and presentation of scientific data, have been taken advantage of by using the two principal ISOLDE data interfaces - DDE hotlinks and API function calls.

2.1.1 DDE Hotlinking

DDE hotlinks are a straightforward method of providing data for instant analysis within an Excel worksheet. For example, a simple status monitor has been written which automatically updates beam current, beam lifetime and other information. Similarly, other monitoring is possible, for instance dynamic orbit displays; by adding formulae to the worksheet cells, dynamically updating calculations can be provided to aid data analysis for control system users. The use of Excel allows users to write custom applications online during experiments, which dramatically reduces the development time required for new applications.

2.1.2 Object Modules

Although the ISOLDE API function calls can be used directly within Visual Basic and Excel, code is not simple to read and consequently debugging is harder. To overcome this, wrapper functions have been written in Excel using Visual Basic for Applications to give an object interface to equipment. Parameters which have single numeric read and write values, for instance individual steering magnets, use the PROPERTY LET and PROPERTY GET functions to give transparent reading and writing. Simultaneous reading or writing of multiple values, such as reading the orbit, is accomplished using Methods provided by SUB procedures. Sets of related parameters are grouped, using the SRS naming convention, into Excel modules. The whole set of modules is grouped into a single workbook (the APM - Application Programming Modules) which may be referenced by a user application. Example command syntaxes are:

ZM.VSTR(4) = 2.83 sets 2.83A on storage ring magnet (ZM) vertical steer (VSTR) number 4.

A = ZB.HBPM(8) reads value from storage ring monitor (ZB) horizontal BPM (HBPM) number 8 into variable A.

ZM.HSTR_Apply B applies current values in amps in array B to all horizontal storage ring steering magnets.

2.1.3 Scaleability

New parameters can be prototyped at the application level. For instance, in the SRS some horizontal and vertical steering magnets are provided on common multipole elements in the lattice: Individual coil settings are calculated at the VME level, giving 'virtual' parameters at the ISOLDE level. Skew quadrupoles have been implemented at the application level, with the APM keeping track of values which have been applied; once these are tested at the application level, they can be implemented at the VME level to improve speed. The advantage of this system is that to the user the command syntax remains the same.

Additional functionality can be provided with extra properties and methods which are not appropriate to direct parameters. For instance, closed-orbit bumps are provided at the VME level as virtual parameters. However, when setting large amplitude bumps the sequential application of the individual steering currents making the bump can cause unacceptable orbit deviations and risks instabilities in the beam. To overcome this, bumps can be ramped in 1mm steps using a simple APM Method. Overall, the modules offer a simple, scaleable system to interface between Excel and the ISOLDE front-end system.

2.2 Prototyping SVD and other servo correction systems

Similarly to individual parameters, more complex machine control algorithms are easily prototyped at the application level. For example, the use of singular-value decomposition (SVD) techniques is presently being developed to replace the present system of locally servoing the source beamlines. The new system will perform simultaneous correction of the electron beam orbit and the beamline vertical tungsten vane monitors (TVM), and prototyping within Excel has proved invaluable in studying and optimising the usage and weighting of correctors and monitors.

2.3 Quadrupole Realignment

2.3.1 The Need for Realignment

The daily operational cycle of beam injection and subsequent decay of stored beam causes thermal cycling of the storage ring magnet elements. This in turn gives rise to a repeated expansion and contraction of the elements which causes the storage ring quadrupoles to 'walk' over extended periods of time. The consequent steering effect of the misaligned quadrupoles eventually becomes beyond the practical limit of correction for the steering magnets. Magnet realignments are performed at periodic intervals; in the SRS correction is performed approximately every 6-12 months using a combination of survey and beam-based correction.

2.3.2 Automation Using Excel

Since only a few magnets can be moved at a time, due to operational restrictions, choosing the optimum set to

move is of great importance to best compensate errors affecting both the working points used in the machine. Previously, only manual prediction and simulation of solutions was possible, limiting the number that could be explored. However, the use of the Excel Solver allows the rapid calculation of all possible solutions; the quadrupole moves can then be simulated on the storage ring with scaled corrector magnets in each of the machine modes. The combination of rapid data collection and analysis afforded by ISOLDE and Excel has greatly improved the efficiency and reliability of magnet realignment.

3 FUTURE DEVELOPMENTS

The APM discussed in 2.1.2 above is presently only useable from within Excel. However, since it is written using standard Visual Basic for Applications code it will be a simple exercise to port it to Visual Basic 4.0 and compile it as an OLE server. This will allow the encapsulated objects to be used from any OLE-enabled application and will also remove the need to reference the APM in every Excel application that requires it.

Also, several applications written using the APM are now in regular use and could be converted into full Visual Basic 4.0 applications to improve performance and maintainability.

4 ACKNOWLEDGEMENTS

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