SEQUENCING AND RAMPING IN HERA

Jürgen Maass, DESY, Hamburg, Germany

Abstract

For all accelerators at DESY we use so called file-operating or ramp programs to save and set the magnet currents. Hera, the biggest accelerator at DESY, consists of two coupled machines with both seperate and common magnets. The HERA proton machine has normal and superconducting magnets with very different changes in their magnetic fields. The ramp software must take all of thesefactors into consideration during magnet operation. The sequencer is responsible for processing the task list nessessary to store colliding proton and electron beams.

During the winter shut down 1997/98 the PC dominated control system for HERA was largely in place. The ramp program like all HERA console programs is written in Visual Basic 5 with ActiveX controls and runs in the control room on Windows NT workstations. The graphic display for the control of the magnet ramp and the data exchange with the magnet server (a SUN-workstation running under solar 2.6)are implemented with the ACOP-control.The new ramp program has been in operation and running reliably since May 1998.We report here on our experiences and note that the combination of Visual Basic plus ActiveX controls has been invaluable in debugging and fine-tuning the application to meet the needs of the operators.

1 PREVIOUS DEVELOPMENTS

The first development of a file operating program began in 1977 / 78 during construction of the accelerator PETRA. At that time we used 16 bit minicomputers from Norsk Data for the machine control. The program development was done in POCAL [1] an interpretative language. At that time the demands on a file operating program were relatively low. The program only needed to store the present currents of all PETRA magnets on a disc file and to reproduce the magnet settings from that file. The operator had a catalogue to manage all the stored machine settings.

During subsequent years all existing DESY accelerators received a computer aided control system and consequently a file operating program. After achieving reliable magnet operation with this program, requests for improvements to store and reproduce values of other devices came up. So we expanded the programs to handle a few other devices. This was limited by the 16 bit POCAL interpreter.

The complexety and the fast changing operating modes of the accelerators and beam lines place high demands to the file operating programs now. For suppling the accelerators with different particles we need a fast switching of the Linac's and the beamlines.

With the new PC based control system we had to develop a new file operating program. J. Wilgen presented his project as a poster on the PCaPAC 1996 at DESY [2]. This program is now in use on all DESY accelerators and beamlines with the exception HERA. HERA is a much longer and complex accelerator and uses a different control system than the other DESY accelerators [3]. It was not possible to adapt the program for all specific and expanded needs at HERA also this program was written in Visual Basic 3 and lives in a 16 bit world with IPX data exchange.

2 HERA

2.1 Storage ring

HERA is a 6.3 km long proton-electron storage ring. Both machines are build up in one common tunnel. In two of the four experimental areas the vacuum chambers of both machines are connected together. This means both particle beams use the same vacuum chamber and are influenced by the same common magnets.

The energy of the proton machine has to be ramped from 40 GeV (the energy for proton injection) up to 920 GeV (the energy for the experiments). The energy in the electron machine has to be ramped between 12 GeV and 27.5 GeV.

2.2 Special Features

The proton machine has superconducting dipole circuits and normal conducting circuits for all other magnets. The magnetic field changes of normal and superconducting magnets are very different. If we have a stored beam in the machine, the fields of the magnets have to fit together at all time. Therefore we need a special procedure to steer the magnets during acceleration of the particle beam. We measure the field in a superconducting reference dipole and produce field dependent pulses to steer the normal conducting magnets.

Additional correction for sextupole fields have to be done in the energy range between 40 and 150 GeV.

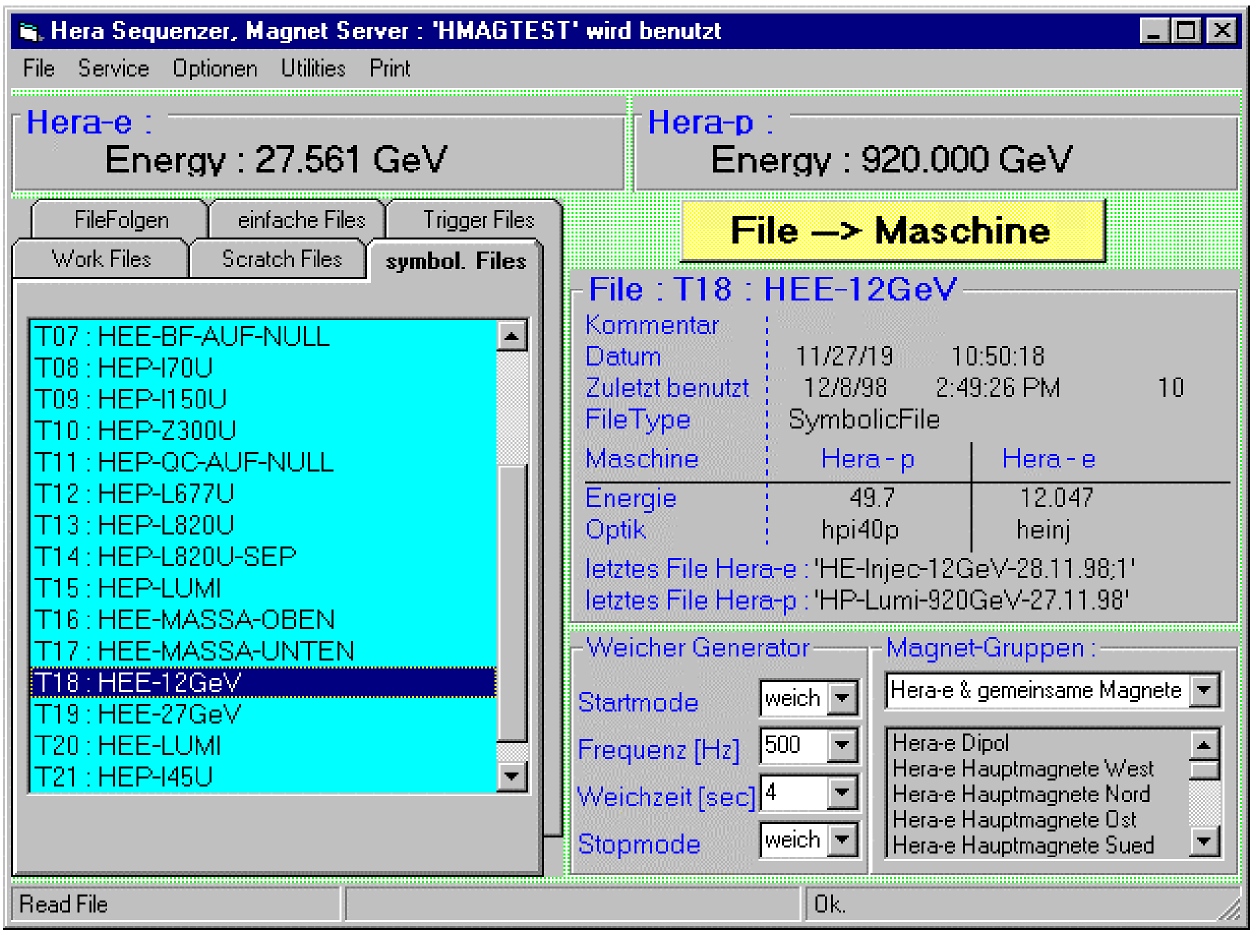
3 RAMP PROGRAM AND SEQUENCER

This program is like all other HERA consol programs written in Visual Basic 5 with ActiveX controls and runs on Windows NT workstations in the control room. The data exchange with the magnet server, a SUN workstation, all other servers and the graphic display to control the magnet ramp is done by the TINE protocol [4] with the ACOP control [5].

3.1 Ramping the magnets

To raise the energy of the accelerator (ramping) the currents of all magnets have to be increased from its present values to the values given from the file in a synchronous way. The program calculates an individual current increment for each power supply and writes this value to its controler. Then a generator sends the maximal count of pulses needed to all power supply controlers. By receiving a pulse each controler changes its current by its individual increment.

To adjust reproduceable magnet fields we have to avoid hysteresis effects. To achieve this we cycle all magnets between their minimal and maximal currents. We call this a magnet massage.



Picture 1 : Mainform of the Rampprogram and Sequencer

On the left side of picture 1, one can see the file catalogue divided into 6 tables according to the 6 different file types. On the right side some important general data from the selected file :

- **Kommentar :** a comment line
- **Datum :** date and time of file creation
- **Zuletzt benutzt :** date, time of last use and a usecount
- **FileType :** type of file
- **Energy :** only important in magnet files, shows the end energy of the machine if one has tranfered the file to the machine
- **Optik :** name of the machine optic which belongs to this file.

3.2 Catalogue

The catalogue holds a list af all stored machine states, the reference to the disk file and some other important data which are needed in the program.

3.3 Magnet files

A magnet file holds the device names, the currents, the status and a flag of all ~1200 HERA magnets. The device name decides in which power supply the current has to be loaded. The flag means whether the device has to be accessed or not. The status is not used at the moment.

3.4 Scratch files

The catalogue holds a fixed list of scratch files. These files are rewritable files. The operator can simply select one of this files to store a machine state in it. But he has to be very carefully because someone else could overwrite this file at any time.

3.5 Simple magnet files

At the store operation of such file the operator will be ask to define a catalogue name for that machine state. The data will be stored under an automaticly generated file name. The catalogue administrates the connection between file name and catalogue name.

It is not possible to overwrite such a named file.

Because the data in this file are read directly from the machine it holds only valid values and can always be transferred back to the machine. If a device is not accessable or produces an error during readout this will be marked in the device flag. A device with a marked flag will not be accessed during a transfer of the file data to the machine.

3.6 Symbolic files

For the standard operation of HERA we need about 20 important magnet states. Each of these states has an assigned symbolic file. The operator has to know and to use only these few files. He doesn't have to remember or to search for the best or last used file in the list of about 400 simple files.

A symbolic file holds no data. It has only a reference to a simple file. If someone generates a new file with a better machine state of HERA he should also update the reference in the symbolic file which will be used to identify this machine state.

3.7 File sequence

The next step for a more easier operation of HERA is the file sequence. A file sequence should bring the machine from one main operating state to another. This means for example from injection up to 920 GeV. To do this one has to start 5 symbolic files by hand. The file sequence holds the commands to start the symbolic files and a list of the needed symbolic files. For the standard operation of HERA we need only 5 file sequences :

File sequence	**Description**
Hera-p Massage	Massage of all HERA-p magnets, end conditon : Injection
Hera-p Rampe	HERA-p ramp from 40 GeV to 920 GeV
Hera-e Rampe	HERA-e ramp from 12 GeV to 27.5 GeV
Hera-e Refill	Separation of particles, massage of HERA-e magnets, end conditon : Injection
Hera Lumi	Preparing luminosity

3.8 Work files

A workfile is something like an experimental file. The simple magnet files and scratch files always hold the data of a complete HERA state. These states come from the machine and can consequently be written back to the machine. A workfile can hold the imported values of a calculated machine state. Such a calculated state knows only currents for the main magnets, and has no values for the correction power supplies. In this case the file does not hold a complete machine state. The program than cares only about the devices which are specified in this file. All other devices will not be influenced.

During import of a file it is possible to mix the imported data with the data of an existing file. It is for example possible to import new calculated values for the main magnets and mix it with a well known corrector state of an existing file.

In addition it is allowed to edit a workfile. Therefore it is possible that a workfile contains illegal values.

3.9 Generator adjustments

One can also adjust the ramp speed, ramp modes and so called soft times of the puls generator. The soft time means a time in which the pulse generator increases his frequency from zero to the selected speed and at the end of the transfer it decreses the frequency down to zero again.

Each stored magnet file and symbolic file has his own set of generator parameters. The dataset contains also the name of the desired magnet groups.

3.10 Magnet groups

Appropriate to the two coupled accelerators with common magnets in the experimental areas and some other special requirements of HERA it has to be possible to operate different magnet groups of the machine. For the main operation we have defined the following groups:

Group name	**Description**
Hera-e	Tuning luminosity in HERA-e
Hera-e & gemeinsame Magnete	Ramp HERA-e and common magnets
Hera-p nur Dipol	Massage of the HERA-p Dipol
Hera-p ohne Dipol	Changing the optic, massage of all normal conducting magnets in HERA-p
Hera-p rampen	HERA-p ramp

The definition of these magnet groups is contained in the programs initialisation file. For the definition of a new group or for changing an exiting group it is not necessary to change the program code.

4 SEQUENCER

The operators in the control room have to process a long list of tasks to bring HERA from one state to another. The processing of this list should be automated by the sequencer part of this program. The trigger files, an additional file type, the symbolic files and the file sequences represent the interface to this program part.

4.1 Trigger files

In addition to magnet ramping we have to steer and control nearly 50 other devices or device groups. Some examples :

- Steering and controlling of scrapers
- Preparing RF-transmitters for a magnet ramp
- Adjust kicker and septa magnets for a particle injection
- Load and activate correction tables into the power supply controler
- Perpare and start special sextupol corrections

A trigger file contains the task (commented) and necessary parameters to access a device server. The server processes the task and returns his acknowledgement. If the task could not be finished direcly the program starts a polling link to wait until the task is finished.

4.2 Symbolic files and file sequences

In addition to the reference of a simple file this files can have references to trigger files and can processes commands for program steering. With this file not only the magnets should be ramped, it should process everything to bring the machine from one to another state.

The files are divided into two parts. The first part is a so call action list with task descriptions. The second list is a file list with the file names which are necessary to process the tasks.

Example with symbolic file : ‚**T08 : HEP-I70U**‘

Action list :

Description	Parameter	Flag
Dipolkorrektur : Stop	File 8	True
Sextupolkorr : Motor ein	File 2	True
Warten bis Motor laeuft		True
Sextupolkorr bis 70 GeV	File 4	True
Hera-p auf 70 GeV	File 1	True
Sextupolkorr : Stop	File 3	True

File list :

File	Catalogue Name	File Type
File 1	HP-Ramp-70GeV	SimpleFile
File 2	Sextupolkorr_Motor_ein	TriggerFile
File 3	Stop_SextupolKorr	TriggerFile
File 4	Start_70GeV_Korr	TriggerFile
File 8	Stop Dipol Korr	TriggerFile

Meaning of the columns in the action list :

- **Description** of the tasks as simple text
- **Parameter** necessary for processing the task. This for example can be the name of a file in the file list
- **Flag** says whether the task has to be processed or not.

Meaning of the columns in the action list :

- **File** is a reference to one of the tasks in the action list
- **Catalogue name** of the file which has to be transferred to the machine
- **File type** of the catalogue file.

5 CONCLUSION

During the winter shut down 1997/98 the principal control system for almost all elements of HERA has been upgraded. In particular the complete magnet control has been rearanged from Norsk Data minicomputers to a SUN workstation.

All PC based workstations in the control room are running under Windows NT now. The programs are developed under Visual Basic 5. The servers are based on different plattforms like SUN, HP, VX-Works and different PCs which are running under DOS, Windows 3.11, Windows NT and Linux. On the PCs we run programs written in ‚C‘, and Visual Basic 3 / 4 / 5.

For a nearly perfect dataexchange between all this systems cares the ACOP control [5] and the TINE protocol [4]

Since the restart of HERA in May/June 1998 the programs are under continuing development and had to be fitted to the needs in the contol room. This is also due to the control system software. As well the ActiveX controls have to be further developed. In neither case has the operation in the control room been hampered.

The windows NT workstation and the sequencer are running very reliably and we have seen no problems with the client server communication.

After one year of work invested in writing this program, I note further that Visual Basic 5 is a really powerful and developer friendly tool.

REFERENCES

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[4] P. Duval, “TINE: An Integrated Control System for HERA”, these proceedings.

[5] I. Deloose, P. Duval and H.G. Wu, “The Use of ACOP Tools in Writing Control System Software”, proceedings Icalepc’97 and these proceedings.