A Dedicated Multi-process Controller for a LEP RF Unit

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Abstract The operation of each RF unit for LEP requires that several control processes can be run at the same time. Local and remote access is required to around 2,500 individual parameters and status indications inside the unit. Normal operation of the unit involves complex procedures involving a considerable amount of sequential access of equipment within the unit. Optimum performance and overall maintainability is achieved by calling up locally resident procedures. In addition the surveillance and alarm monitoring needed can run locally, making a summary status available for the control centre. The local process controller ("data manager") hardware is realised as a hybrid VME/G64 crate with a 68020 VME module as the main processor. Two 68000 VME slave processors having G64 ports handle communication with equipment buses. VME high resolution graphics interfaces provide interactive local control via a touch screen and seperate data display. A VME MIL-1553 interface provides the connection to the control system. Local control, remote control and surveillance run concurrently on the main processor under the OS-9/68K multitasking operating system. Apart from specific device drivers all software is written in "C".

1 Introduction

The RF system for the initial phase of LEP consists of eight identical accelerating units. Each unit consists of 16 accelerating/storage cavity assemblies, two 352 MHz 1 MW klystrons, 100 kV power converter with high voltage interface, cavity vacuum equipment and associated low level and controls electronics. All of this equipment (excluding the power converter) is situated underground, the controls electronics for each unit being in a group of racks housed in the separate klystron gallery parallel to the main tunnel [1][2]. The RF units are driven by a central frequency source and synchronized by common timing but are otherwise autonomous and may be operated independently.

Each unit requires its own dedicated controller (data manager) to coordinate overall control of the unit. It must execute complex procedures involving access to groups of equipment, carry out background surveillance and logging and also provide remote access to all equipment data and functions from the LEP control system network. In addition facilities for interactive local control of the RF unit are required.

The interface to the equipment inside the RF unit is via a set of 23 G64 based "equipment controllers" [3], one being assigned to each of the major components making up the unit. The equipment controller contains the interface hardware and provides low level control functions related to the equipment concerned. Dialogue with the data manager is over GPIB and RS422 buses, the latter being primarily for the distribution of cavity vacuum data. Two separate GPIB buses are required due to the number of devices. Since a considerable amount of communication is required, it is desirable that the two GPIB buses may be operated in independently and in parallel.

The present form of the data manager has evolved from experience gained mainly in the running of the "test string", a prototype RF unit assembled in an experimental hall at CERN and first operated in 1986. In this case the data manager was a CAMAC based "intelligent touch screen" as used in SPS operations with the addition of two GPIB interfaces. This provided a menu driven touch screen together with high resolution colour display which proved an ideal way of implementing interactive local control. The NODAL interpreter allowed basic debugging of equipment routines and build up of procedures resulting in an "automatic switch on" program and a first version of a local surveillance program for the RF unit. However the inability to execute these tasks in parallel was a serious limitation particularly since further parallel tasks (e.g. remote control) would also be required. A multitasking or multiprocessing system was therefore needed as well as a structured language for increasingly complex programs.

In order to meet these requirements it was decided to implement a multitasking operating system on a main CPU to allow concurrent execution of all processes and to have two slave processors to handle the GPIB and RS422 buses independently.

The design is based on the VMEbus and 68000 family of processors both widely used in CERN. The main CPU is 68020 and the two slave 68000 CPU modules have G64 bus ports on the P2 connectors. This allows the use of G64 GPIB and RS422 modules identical to those in the equipment controllers. A schematic diagram of the data manager is shown in Fig. 1.

The main processor module has an on-board SCSI interface which connects via a controller card to a 52 Mb hard disc and two floppy drives. There are two high resolution colour graphics interfaces one of which provides the display for the touch screen. The touch screen consists of a capacitive faceplate fitted to a standard free scan colour monitor and interfaced via an RS232 port on the touch screen graphics interface. The other high resolution graphics interface provides the local data display. A MIL-1553 VMEbus interface module provides the link to the LEP control system PCA (process control assembly) in the surface building. There is also a VME module to interface the LEP slow timing required for equipment inside the RF unit. Communication between the main processor and the slave processor is via shared memory in a static RAM module which also contains EPROM for fixed data. The two 68000 based slave processor modules have flat cable connections from their P2 connectors to short G64 buses accessed from the rear of the crate, as shown in Fig. 2. Each G64 bus contains a GPIB module thereby allowing parallel independent accessing of two groups of Equipment Controllers. One G64 bus contains an RS422 module while the other has a G64 based graphics interface for a local display of bus activity on a small monochrome monitor.

2 Software

The data manager software is required to perform three main tasks: surveillance of the present state of the unit and associated alarm generation, full local operator control via an interactive, menu-driven touch screen, and a remote command interpreter allowing access to all aspects of the RF unit. A schematic of the data manager software is shown in Fig. 3. Processes per-

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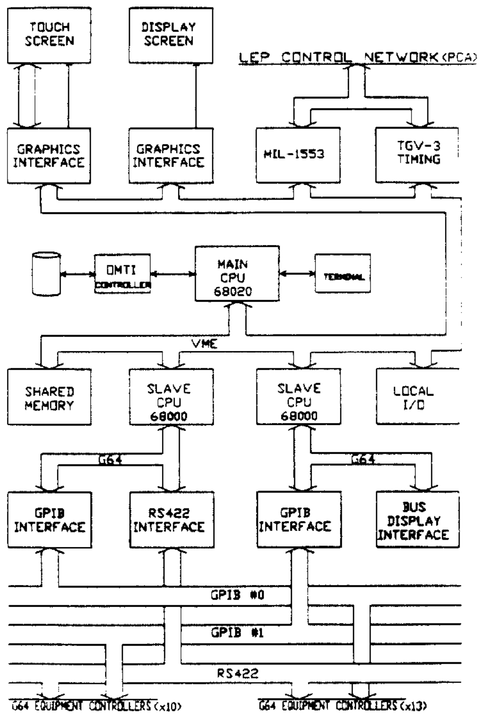

Figure 1: Schematic Diagram of the Data Manager

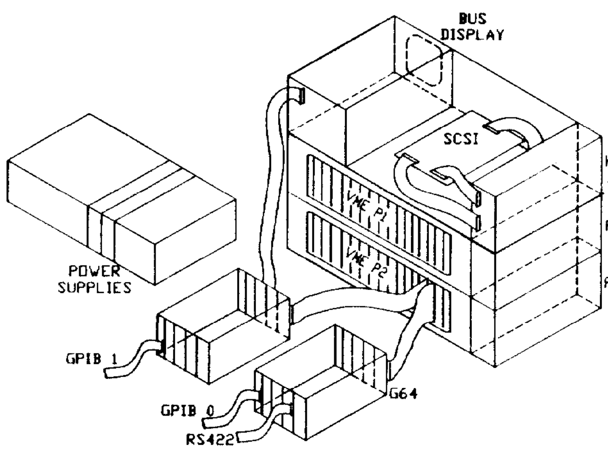

Figure 2: Data Manager Crate Interconnections

form i/o to the appropriate devices (touch screen,local bus, local display, MIL-1553 interface) via a series of libraries of routines. Additional libraries are provided for system management and to perform complex actions, such as touch screen pad layout and multiple sequential access of equipment controllers.

Communication between the main processor tasks and the slave processors is via multiple communications buffers defined in shared memory. At present buffers are defined to allow up to eight OS/9 processes independent access to the equipment buses. Bus states, handshake flags and active device lists are maintained for each buffer to control data flow. The slave processors service pending requests in the buffers on a round-robin priority basis. The program which runs on the slave processors was developed under OS/9 but executes in a non OS/9 environment. Additional software allows automatic retry on timeout and error recovery.

All transfers across the equipment buses are made in the form of ASCII strings. The sending of commands and the conversion of replies to the appropriate type in the main processor tasks is performed using a library of routines. Response time has been reduced by providing a single command/multiple response facility in the slave processor. This allows the sending of the same command sequentially to several equipment controllers and then reading the replies back in turn. This feature facilitates forming of average and total values for groups of equipment. It is also faster than pure sequential access. This is particularly important for relatively slow equipment actions.

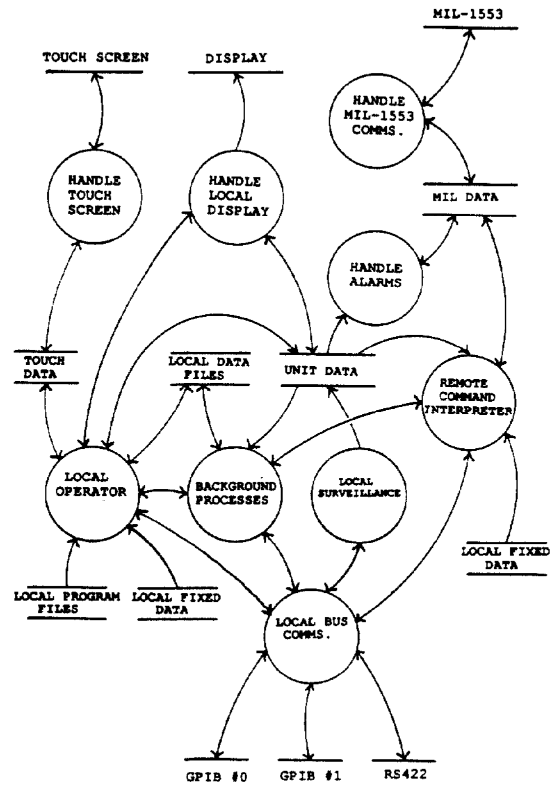

Figure 3: Data Flow Diagram for Data Manager Software

The process "local operator" shown in Figure 3 allows full control of the RF unit by an operator in the LEP tunnel. The desired operation is selected via a tree structured series of touch screen menus. These menus, which exist as seperate program modules, make requests on the local buses, start and stop background processes and provide output either via a message area on the touch screen, or the local display. A stack records the position in the menu tree. Touch screen communication is performed by a special interrupt-driven OS/9 device driver to an RS232 port on the graphics controller. A touch produces an ASCII coded coordinate stream which is decoded by the driver. Simple error checking is provided in the driver. Libraries of graphics routines have been written to provide a GKS-like interface for both touch screen and local display. These libraries are similar, except that for the touch screen extra routines are provided to allow the drawing and activation of touch screen pads.

Some facilities involve complex actions on groups of equipment. These may require many accesses on the local busses and take several seconds to complete. These "slow functions" exist as separate program modules which may be called either locally from the touch screen, or by a remote operator. They run concurrently with the normal operating tasks and any messages they produce can be redirected to an appropriate destination. Several slow functions have been written, mainly concerned with switching the unit on or off. Additional background tasks are required for conditioning of the units after periods of shut down. A typical example is a program which checks the vacuum in the cavities and increases the RF power progressively to a predefined limit. The difference between these conditioning tasks and the slow functions is that, once started, a conditioning task will continue to operate until an operator decides to terminate it, or for some reason the RF is switched off.

A permanent background process surveys the state of the RF unit on a regular basis and makes the information available to any interested process. This information, consisting of about 100 reals, integers and strings is stored in the "unit data" buffer. It is used for the default surveillance display on the local display. The update time for the information is set at about 15 s. As the update period is relatively short, local and remote programs can use this unit data information instead of making direct access to the equipment.

The remote command interpreter must allow full access to the RF unit from the LEP controls network. This involves granting access to the local buses, starting slow functions, starting and stopping conditioning tasks, transmission of the unit surveillance data and the provision of diagnostic and system wide facilities. The local buses use ASCII string transfers for all communications and this has been extended to the remote control system. It has the advantage that there are no problems of data type format differences and allows response strings formed in the equipment controllers to be transmitted transparently by the data manager to the control network. The calling workstation transmits three main parameters : a unit address, a destination address and the command to be executed. The unit address determines which RF unit is to be accessed. The destination address is used to route the command to the device on which it will be executed. This may be the data manager itself, a single equipment controller or a group of equipment controllers. The response from the RF unit is also in the form of an ASCII string up to 10kBytes in length. Averages and totals are calculated in the data manager and transmitted in ASCII coded form to the network. Conversion of the response to the required data type is carried out by the calling workstation.

The interface to the control network is provided by an interrupt driven OS/9 device driver for the MIL-1553 interface. A library of routines handles message transfer to and from the network, together with error-recovery and diagnostic facilities.

3 Status and Performance

All eight data managers required for the accelerating units of the LEP RF system are installed in the klystron galleries. Figure 4 shows a data manager crate in the controls racks, together with its touch screen, colour graphics display and local terminal.

The present 68020 based data manager was preceded by a 68000 prototype. While this was able to carry out all the required functions touch screen and remote control responses were relatively slow and the initiation of additional tasks resulted in further degradation in performance. With the processor and FPU now installed in all units the concurrent main CPU tasks run at an acceptable speed with fast touch screen response.

A typical single local access via the GPIB takes around 30–50 ms and in multiple acquisition mode a block of 12 temperature measurements from all 16 cavities (12 single command/multiple reply accesses) takes approximately 2 s, i.e. 10 ms per reading.

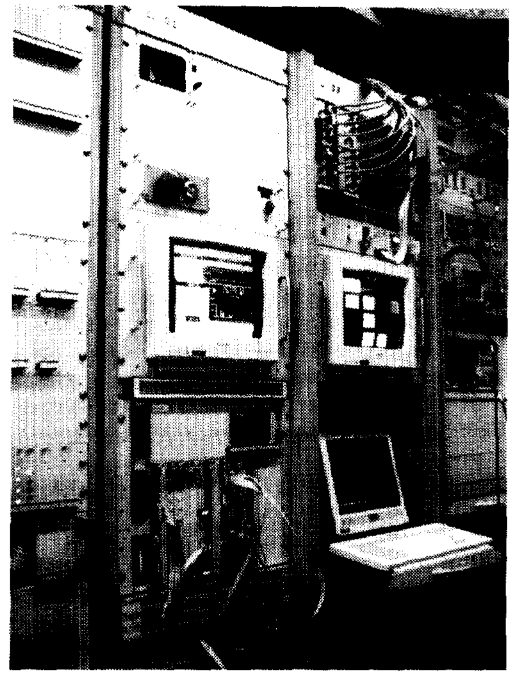

Figure 4: Data Manager in Klystron Gallery

4 Conclusions

The data manager permits the running of all the required processes for the control and operation of the RF unit. A data manager for RF equipment in the LEP control room is also being installed, this being based on the same principles but with its own application software. The same implementation will also be used for the control of the RF units equipped with superconducting cavities for the upgrading of LEP. Preliminary software for equipment testing is in preparation.

5 Acknowledgements

We are grateful to G. Shering for the provision of the CAMAC based intelligent touch screen originally used in the test string. Thanks are also due to M. Paccani for the construction of the data manager hardware.

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