Use of VME CPU Modules for Performance Upgrade of G64 Equipment Controllers for the LEP RF System

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Abstract

Each major piece of equipment in the RF system of LEP is controlled by a G64 based Equipment Controller. There is a total of 500 controllers consisting of several types. The performance of the more heavily loaded types can be considerably improved by the replacement of the existing eight bit CPU with a more powerful 16 bit CPU running a real-time operating system. A wide choice of CPU modules is available in the 3U height VME standard. However conversion of the complete controller to VME standard is expensive and unnecessary. A G64 to VME interface has been developed to permit insertion of a small number of VME modules into an existing G64 chassis. A description of the new hardware and software configurations is presented, together with an outline of new facilities introduced and performance improvements obtained.

1. INTRODUCTION

Control of the equipment making up the room temperature and super-conducting (SC) cavity RF units for the RF system of LEP is based on G64 bus standard 'Equipment Controller' (EC) crates [1]. Each major element of the unit, e.g. cavity, klystron, HV equipment, low level RF, etc. has its own EC, these containing the dedicated interface hardware and equipment software. The ECs are connected by GPIB busses to a VME based 'Data Manager' (DM) which co-ordinates the control of the RF unit. The final upgraded RF system for LEP2 will be made up of 20 RF units, each containing up to 26 ECs, making over 500 in total.

Present CPU hardware is based on a G64 Z80 processor module with a 64 kB memory area split between EPROM, RAM and some memory mapped I/O. Software is developed on CP/M development systems using a Pascal compiler. No real time operating system runs in the target systems, critical tasks such as remote GPIB communication and control being based on interrupts. This relatively simple system has been satisfactory for the original room temperature copper cavity RF system where rapid data taking and real time requirements at this lowest equipment level were not critical. The implementation of global RF voltage control and the introduction of SC cavities, however, bring requirements for faster communications, more local data taking and for closed loop control. The limited memory and lack of multitasking capability with the existing CPU present severe limitations.

Upgrade of the entire G64 EC with a higher performance bus and consequent replacement of all existing I/O modules is unnecessary, eight bit access being adequate for practically all equipment I/O operations. Partial upgrading, i.e. the replacement of only existing CPU, memory and communications interfaces using VME based counterparts is an attractive solution in view of the large range of moderately priced VME 3U height 68000 family CPU modules now commercially available.

A small plug-in module holding a small number of VME can be designed to fit into an existing Eurocrate, connecting to the G64 by an adapter which provides power and the VME to G64 interface logic. A version containing up to 3 VME modules has been successfully used for the upgrade of 50 G64 crates in the slow controls system of the ALEPH experiment at LEP [2]. A version specifically adapted for the dimensions of the RF system EC crates allows insertion of up to four VME modules.

2. VME TO G64 ADAPTATION

The specially constructed 3U cassette is shown in Fig. 1. Interconnection to the G64 bus is by two short PC cards which provide 5V power to the cassette and mechanical rigidity. The G64 to VME logic adapter is in the form of a small module mounted at right angles to the left hand connecting PC. This solution has been adopted to keep the overall depth to 220 mm, such that the cassette can be installed with its front flush with that of the EC crate.

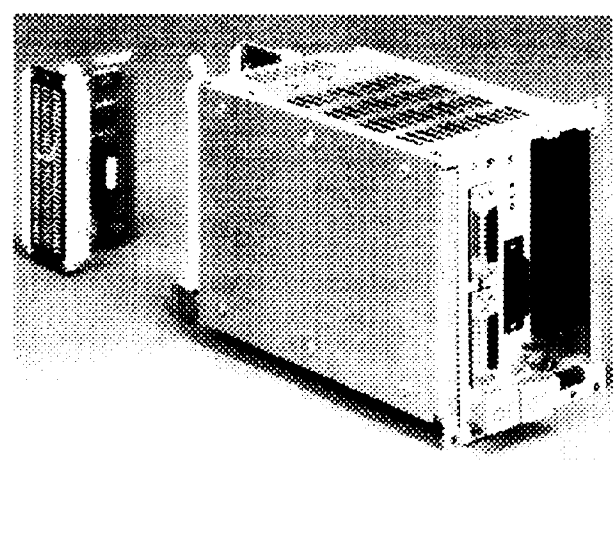

Fig. 1 VME adapter and cassette for insertion in G64 crate

A block diagram of the VME to G64 interface logic is shown in Fig. 2.

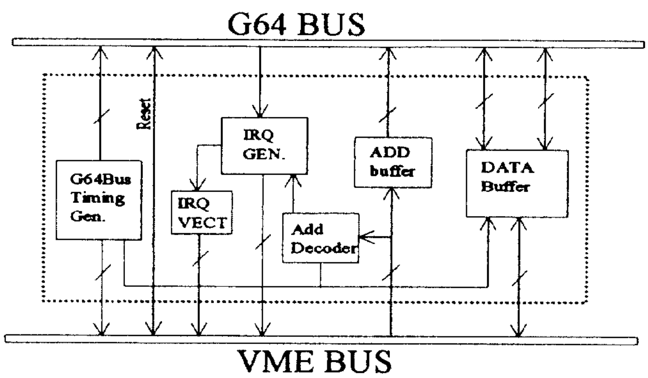

Fig. 2 VME to G64 interface logic

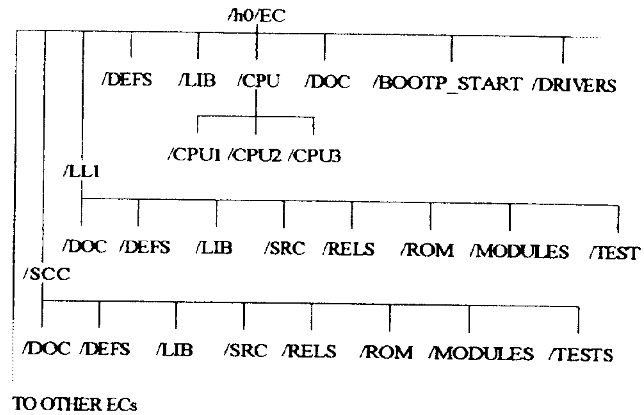

Fig. 3 Development system configuration

The G64 bus is used in synchronous mode, the bus timing being derived by logic driven by standard VME timing signals (AS,DS0/1,R/W) A VME3000 chip takes care of the VME interrupt generation procedure in accordance with the VME specifications. Solder pads on the printed circuit board allow the selection of any one of the three G64 interrupt lines for the activation of one of the seven VME interrupt levels. A window of 1024 bytes is mapped into the VME standard address range (A24/D16), the base address being PAL programmed on the interface. The interface is intended for G64 I/O only and the G64 VPA line is validated during access.

3. SOFTWARE AND SOFTWARE DEVELOPMENT

The OS-9 68K real-time operating system was chosen since it provides all the multitasking facilities required, it is already used in the DMs of the RF units and it produces compact code which can be burned into EPROM. The 'C' language is used rather than the original Pascal. Remote booting of a target from a development system over Ethernet is implemented using BOOTP. This allows rapid loading of new software and has been invaluable for debugging.

In general the different EC versions use similar utilities for GPIB control, command processing, low level graphics, etc. but have their own specific set of equipment routines and overall control functions. With the eventual aim of upgrading all EC versions, the directory structure of the 68040 based software development system has been arranged such that common software and data definitions are shared between the different versions, e.g. low level RF (LL1), SC cavities (SCC), etc. The make files have been created such that a given application can be run on a variety of CPU make and model types, each with its own specific memory map and interrupt configuration.

4. LOW LEVEL RF EQUIPMENT CONTROLLER APPLICATION

The low level RF EC was upgraded primarily to provide fast and reliable serial communications handling for RF global voltage control as well as more flexible control of RF voltage and other parameters.

Existing Z80 CPU and memory were replaced by a VME cassette containing an industrial 16 MHz 68030 CPU board with 4 MByte RAM and 2 MByte ROM. An Ethernet interface was included for the development stage. The software configuration is shown in Fig. 4.

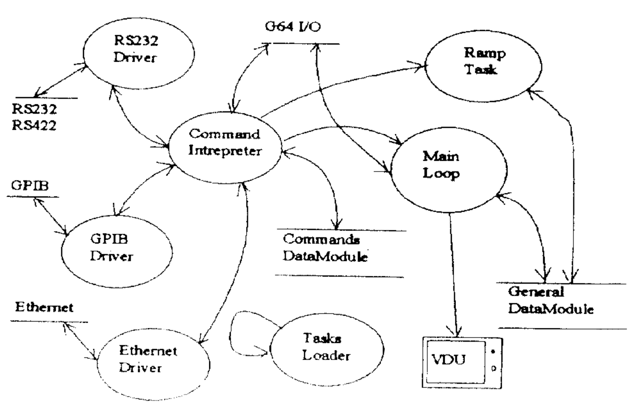

Fig. 4 Low level RF controller software

All global equipment data is stored in a main data module accessible to all processes. A main loop process carries out equipment surveillance, accumulates data for remote interrogation and displays selected information on a local monitor. Concurrent interrupt driven processes handle serial and GPIB communications, making use of common command interpreter and equipment access routines to gather data and set equipment states as required. A simple reservation scheme based on use of process identification numbers prevents interference where this could arise from concurrent access to the same interface. The possibility of using Ethernet for communications is allowed for, with the same command/response system of GPIB and serial lines.

Slow ramping of RF voltage, phase or other parameters is carried out by the waking of dedicated background processes, the status of these being indicated by flags in the main data module.

All low level RF controllers were upgraded last shutdown and at the same time several new functions were added to improve overall operation. Significant performance improvements have been obtained and global RF voltage control using the serial interface has proven reliable.

Fig. 5 shows performance comparison between original 8 bit Z80 and upgraded VME 68030 CPU low level RF ECs for remote access via GPIB bus and serial line. For each case a three character command is sent, interpreted and a 36 character reply returned. For GPIB the overall time taken is reduced by a factor 5.7. This results from a reduction of the command interpretation time to less than one tenth and an increase in data transmission speed by a factor 1.5. For the RS232 serial line the improvement in command interpretation time is the same, but the use of an OS-9 driver brings a considerable improvement in data transmission speeds. The data rates obtained approach those which correspond to the baud rates used. Using a baud rate of 38,400, not possible with the old system, an improvement factor of 17 is obtained for the overall transaction.

GPIB	Total Time mSec	Interpreter Time mSec	Comm. Time mSec	Comm. Rate char/Sec
Z80	16.000	13.700	2.300	15652
VME	2.800	1.270	1.530	23529

RS232	Baud Rate	Total Time mSec	Interpreter Time mSec	Comm. Time mSec	Comm. Rate char/Sec
Z80	9600	260.000	13.700	246.3	146
VME	9600	44.900	1.270	43.630	825
VME	19200	25.000	1.270	23.730	1517
VME	38400	15.000	1.270	13.730	2622

Fig. 5 Performance for command/response transactions (39 characters total per transaction)

Restructuring of the data and software organisation and final translation of software routines into 'C' took approximately six man months.

5. OPTICAL TRANSMISSION AND SC CAVITIES

Optical transmission equipment (OTE) ECs in the surface buildings of LEP have been upgraded with VME CPUs and are now connected directly to the LEP machine Ethernet, using 3U VME Ethernet modules. Identical hardware to that of the low level RF is used and the software structure is similar, except that Ethernet rather than GPIB or serial lines provides the communication channel.

Software development for the SC cavity controllers is nearing completion. The structure is similar to that used in the low level RF EC but with the addition of several concurrent processes handling closed loop functions such as the control of helium gas valves and tuning system reference values as well as the continuous monitoring of data such as levels, pressures, temperatures, vacuums, RF fields and powers. All 200 SC cavity ECs originally equipped with 8 bit G64 CPU to allow hardware testing and basic facilities for initial operation will be upgraded before SC cavities become operational in large numbers.

6. CONCLUSIONS

Insertion of a complete VME cassette with VME/G64 bus adapter provides a straightforward means of upgrading the G64 ECs of the LEP RF system. *In-situ* upgrading of large numbers of controllers is now possible, with minimal disturbance to existing installations. The use of fast CPUs and real-time operating system has significantly improved performance and reliability. Greater numbers of tasks can now be handled and their scope considerably increased. Careful structuring of the software development environment and extensive use of make files facilitate the development of new applications. The availability of BOOTP for downloading these over Ethernet for test in the target before committing to EPROM is invaluable.

Acknowledgements:

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References:

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2. L. Arnaudon, J. Niewold, C. Parkman and M. Saich, "A VMEbus Adapter for G64," Proceedings of the Open Bus Systems Conference 1992, ETH, Zurich , October 1992.