A.11: VME controller development for accelerator control applications

A new VME32 controller board has been developed for use in present and future accelerator control projects. This card will replace the existing Motorola 68K and 68040 based VME controller boards in Indus-1 and Indus-2 control systems. On this controller board, two processing systems have been provided, i.e., (a) NXP i.MXRT1062 microcontroller (ARM M7 core) running at 600 MHz for onboard resource management applications and (b) The MicroBlaze system-on-chip (SoC) in the Spartan 6 FPGA for handling VME bus tasks (main accelerator control tasks). Figure A.11.1 shows the developed board.

The board has been designed with features specifically required in control systems of large accelerator machines like network booting, boot image synchronization, remote board management & diagnostics, ethernet communication, RS485 and RS232 communications, NTP/ PTP/ GPS based time synchronization, timing event distribution and management, etc. Table A.11.1 lists main features of the board and its processing systems. The software development tool-chain is developed using open source tools. The software development kit (SDK) along with the board support package (BSP) for use in standalone mode, i.e., without RTOS has been developed, ported on the board and tested for use with important VME I/O boards available with us. For field testing of the developed card and the software tool chain, the embedded control software for one of the VME controller in Indus-1 low conductivity water (LCW) plant control system has been written using the developed SDK. The programmed new controller card has been successfully deployed in Indus-1 LCW control system (see Figure A.11. 2).

Table A.11.1: Main features of the VME controller.

Features	At CPU 1 level	At CPU2 level
CPU /MCU	NXP i.MXRT1062	MicroBlaze SoC v.8.50
FPGA	---	Xilinx Spartan -6 LX75
RAM	1MB (extendable to 8MB)	256KB
Flash Storage	8MB flash, SD Card	32Mb, remote boot
VME IRQ	IRQ3, IRQ4, IRQ5, IRQ6, IRQ7	
C1-C2 Comm.	SPI Buffered 32Mbps, 1 Serial port @921600 baud,	
Front fascia LED	Board Manager st, C1 BL st, C1 User Prog. St, Time Synq. St, C1 activity st., C2 Activity st. LAN activity status	
Interface	Ethernet 100Base T, RS485	RS-232, Serial Console (TTL)
Time Synq.	NTP, PTP, GPS	Synchronized Precision RTC
Timing Clock	RTC, GPS clock	Precision RTC
RTOS	FreeRTOS	FreeRTOS, Xilkernel
Board Diag.	Voltage Measurements (+5V, +3.3V, +12V, -12V) , CPU1 temp, CPU2 Temp.	

Fig. A.11. 1: mVME2c controller board.

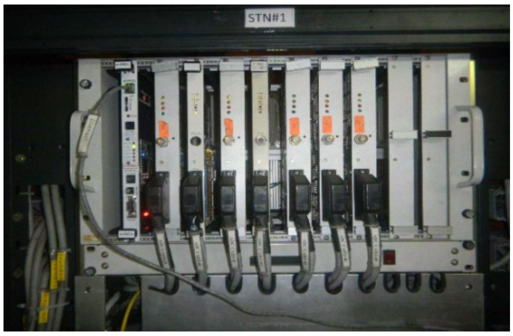

Fig. A.11.2: mVME2c controller board installed in Indus-1 LCW plant control system for field testing.

The software tool chain for RTOS, Free RTOS version 10.4 along with TCP, FAT, CLI and IO has been developed and ported on the board. The complete software development kit is now being ported to open source Arduino development environment. This will prepare us for utilizing the strength of students with minimum training for embedded code development for future accelerator projects.

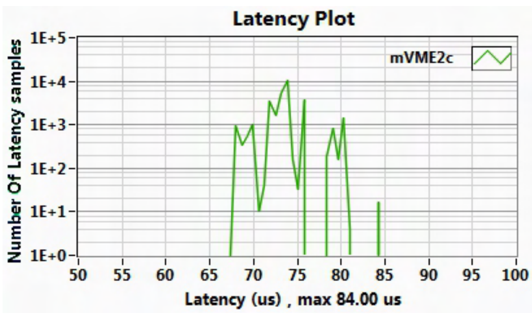

Fig. A.11.3. mVME2c VME bus interrupt latency graph.

Interrupt latency for normal VME interrupts is shown in Figure A.11.3. For fast interrupts (latency up to ~10 µs) the dedicated logic in FPGA can be added in the form of an IP to the board and the slow interrupts (latency up to 150 µs) can be forwarded to CPU2. This board is also of general nature and can be used in almost all the industrial VME SCADA systems.

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