Improvement of Data Transfer Speed of Large Memory Monitors

WEPD05

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Abstract

Beam monitors with long memories will be widely used in SuperKEKB accelerators. Since the slow data transfer time of such devices usually limits the operational performance, improvement of the transfer rate is required. Two kind of devices, VME-based module and Ethernet-based modules has been developed. On the VME-based devices such as turn-by-turn position monitors for damping ring or long bunch oscillation monitors, MBLT and BLT transfer method has been implemented. For the Ethernet based system, the gated turn-by-turn monitors, SiTCP has been implemented on the FPGA and the EPICS device support for SiTCP has been developed. The improvement of the data transfer speed with the long-term reliability will be presented.

Introduction

Large memory devices
- Turn-by-turn monitor with long memory
  - Phase advance measurement for optics information
  - Long term behavior of the orbit (ground motion)

Legacy, slow data transfer field bus
- VMEbus
- VXIbus
- GP-IB

FPGA based module with Ethernet IF
- Implementation of TCP/UDP

Fast data transfer and storage, fast data processing are essential to minimize lots of time of the operation.

Example

KEKB bunch oscillation recorder(BOR)

20MB(4k X 5120) VMEbus extend. EPICS R313 (supports only up to 2k waveform) 10Base speed on PPC6750

Data transfer (20MB) from BOR to remote disk
～5min to 10 min. (depends on network traffic)!

Improvement of data transfer time on
VME based system and Ethernet based system

Main parameter of SuperKEKB accelerators

	HER/LER	DR
Energy (GeV)	7/4	1.1
Circumference (m)	3016	135.5
Max. beam current (A)	2.6/3.6	0.07
Number of bunches	2500	4
Single bunch current (mA)	1.04/1.44	18
Bunch separation (ns)	4	>98
Bunch length (mm)	5/6	6
RF frequency (MHz)	508.887	
Harmonic number	5120	230
Revolution frequency (kHz)	99.39	2212
β* at IP H/V (mm)	25/0.30, 32/0.27	
Horizontal emittance (nm)	4.6/3.2	1700 – 42.9
X-Y coupling (%)	0.28/0.27	5
Vertical beam size at IP (nm)	59/48	
Rad. damping time T/L (ms)	58/29 43/22	11/5.4
Number of BPMs	446/444	83
Number of TbT monitors	135/135	83

VMEbus based systems

- Good size for beam instrumentation
- Simple bus I/F—easy to implement
- Enough accumulation of usable resources such as already developed boards and experiences.

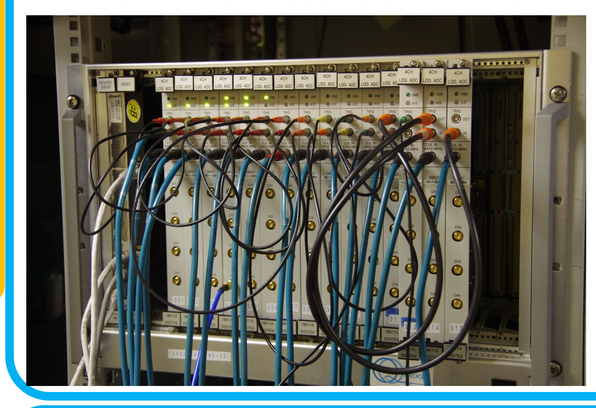
SuperKEKB control system

- VMEbus : still main field bus
- IOC: PPC6750->MVME5500
- VxWorks: Version 6.8.2
- EPICS R314.12.3
  Large waveform >20MB support

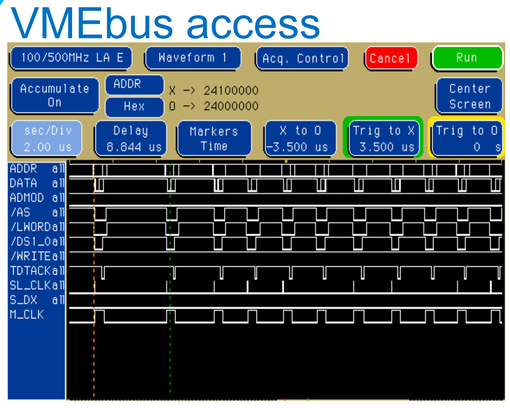
Beam position detector for DR

Positron damping ring (DR)
- Accumulation time : 40ms(typ.)
- Maximum 50Hz operation
  Min. injection interval 20ms.
  Min. bunch separation 98ns.

Turn-by-turn BPM using log-ratio method (18K11)
- Memory size : 32k turns to 256k turns per 4ch (14.5ms to 118ms)
- 83 BPMs in the ring, 4 BPM stations
  One BPM station handles 20 to 22 BPMs.
  Two VME64x sub rack with 10-11 18K11



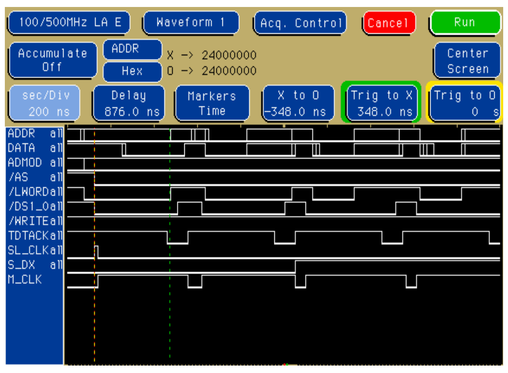
VMEbus access



Normal access (AM=0x0D)

2μs access cycle (slower than PPC6750)

Implement A32 64-bit block transfer (MBLT)



MBLT(AM=0x0C)

Bus cycle <0.5μs DTACK and DS0/1 to control bus (up to 256)

IRQ to data transfer start : 24μs
Data transfer (32kw x 4ch) to IOC : 17ms
Raw data to X-Y positon (IOC) : 7μs

12-18K11 with 32kw data transfer : 0.3s
1 Hz beam position read-out : OK

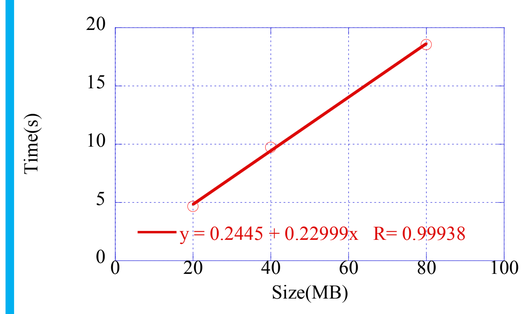
Bunch current/bunch oscillation recorder

Digitex 18K10
8-bit ADC(MAX108)
Spartan6 FPGA on SO-DIMM size daughter card (Mars MX1)
128MB DDR2 SDRAM

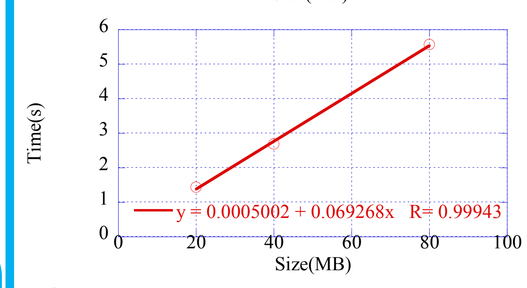
BCM : Block RAM
BOR : DDR2 memory

Data transfer using BLT(AM=0x0F)
- IRQ response : 8.9μs
- Data transfer starts after 36.5μs of IRQ
- BCM transfer (5k) : 1.1 ms

Large data transfer



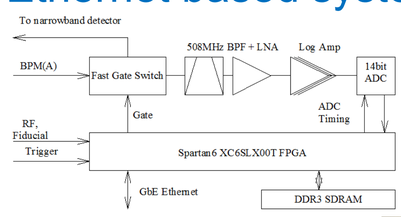
BOR to IOC
~4MB/s



IOC to NAS
(GbE and 10GbE)
~14MB/s

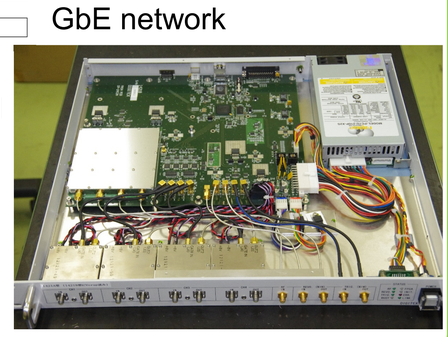
Still VMEbus is the strongest limiting factor

Ethernet based system



1421B Gated turn-by-turn position monitor
Spartan6SLX100T FPGA
DDR3 SDRAM
GbE network

12-15 1421Bs in one local control room (x20)
EPICS R314 on CentOS 6.5-64bit



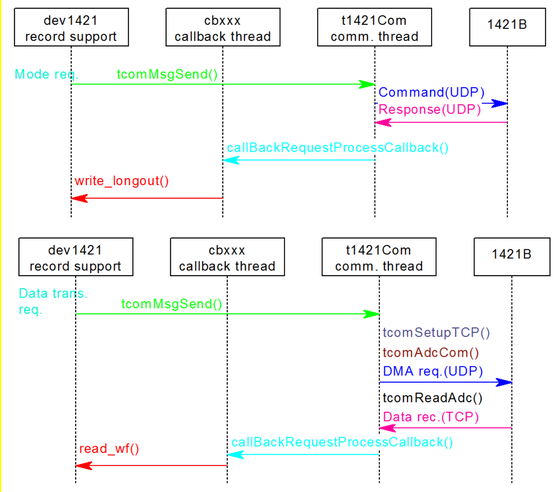
MicroBlaze controlled data transfer

0.5M turns of data transfer (1421->Host) : 44 s!
  5 sec of turn-by-turn data
  Transfer rate : 2Mbit/s (terribly slow)

Implement SiTCP

SiTCP
- High speed communication stable at the upper limit of TCP
- Slow control function using UDP
- Small circuit scale
- Provided as FPGA library(Xilinx only)

EPICS device support



Command access (UDP)

Data transfer (UDP + TCP)

Data transfer rate
1421B -> Host : 400MBPS
Host-> 1421B : 280MBPS

Long-term, higher load communication test
- Unexpected comm. error during TCP data trans.
- Implement error handling/recovery function in comm. thread.
- Still remains (rare) comm. hung-ups. Planning to implement remote-reboot function.

Summary

Implemented and tested fast data transfer on VMEbus device
- Turn-by-turn BPM for DR (MBLT)
- Bunch Oscillation Recorder (BLT)
  Also examined fast data storage to remote disk

Implemented SiTCP on direct Ethernet connection device (Gated turn-by-turn monitor)
- Developed EPICS device support for SiTCP
- Good data transfer speed have been shown

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