Improvement of Data Transfer Speed of Large Memory Monitors

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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
• VXIbus

FPGA based module with Ethernet IF
• Turn-by-turn monitor with long memory
  Large memory devices

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

Example
KEKB bunch oscillation recorder (BOR)

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

<table>
<thead>
<tr>
<th>HER/ER</th>
<th>DR</th>
</tr>
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<tbody>
<tr>
<td>Energy (GeV)</td>
<td>7/4</td>
</tr>
<tr>
<td>Circumference (m)</td>
<td>3016</td>
</tr>
<tr>
<td>Max. beam current (A)</td>
<td>2.6/3.6</td>
</tr>
<tr>
<td>Number of bunches</td>
<td>2500</td>
</tr>
<tr>
<td>Single bunch current (mA)</td>
<td>1.04/1.44</td>
</tr>
<tr>
<td>Bunch separation (ns)</td>
<td>4</td>
</tr>
<tr>
<td>Bunch length (mm)</td>
<td>5/6</td>
</tr>
<tr>
<td>RF frequency (MHz)</td>
<td>508.887</td>
</tr>
<tr>
<td>Harmonic number</td>
<td>5120</td>
</tr>
<tr>
<td>Revolution frequency (kHz)</td>
<td>99.39</td>
</tr>
<tr>
<td>β* at IP H/V (mm)</td>
<td>25/0.30, 32/0.27</td>
</tr>
<tr>
<td>Horizontal emittance (mm)</td>
<td>4.6/3.2</td>
</tr>
<tr>
<td>X-Y coupling (%)</td>
<td>0.28/0.27</td>
</tr>
<tr>
<td>Vertical beam size at IP (mm)</td>
<td>50/48</td>
</tr>
<tr>
<td>Rad. damping time T/L (ms)</td>
<td>56/29</td>
</tr>
<tr>
<td>Number of BPMs</td>
<td>446/444</td>
</tr>
<tr>
<td>Number of Tb1 monitors</td>
<td>135/135</td>
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</tbody>
</table>

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->VME5500
  • VxWorks : Version 6.8.2
  • EPICS R314.12.3

SiTCP
• Implement error handling/recovery function in comm. thread.
• Still remains (rare) comm. hung-ups. Planning to implement remote-reboot function.

Data transfer rate
1421B -> Host : 400MBPS
Host -> 1421B : 290MBPS

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

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VMEbus access

Normal access (AM=0x0D)
2µs access cycle (slower than PPC6750)

IRQ to data transfer start : 24µs
Data transfer (32kw x 4ch) to IOC : 17ms
Raw data to X-Y position (IOC) : 7µs
12-18K11 with 32kw data transfer : 0.3s
1 Hz beam position read-out : OK

VMEbus based system

Implement A32 64-bit block transfer (MBLT)
MBLT(AM=0x0C)
Bus cycle <0.5µs
DTACK and DSO1 to control bus (up to 256)

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)

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Ethernet based system

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

Still VMEbus is the strongest limiting factor