Libera Fast Orbit Feedback Solutions

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Introduction

- The Purpose of Global FOFB
- FOFB Principles
- Fast Acquisition Data Stream on Libera Electron/Brilliance/Brilliance+
- Levels of FOFB integration
 - GDX Module & FPGA based FOFB
 - Libera Grouping & GbE
 - Diamond Communication Controller
 - Hybrid: GbE + RM @ Elettra
- Timing Synchronization
- FOFB in mixed environment



The Purpose of Global FOFB



- Global FOFB: Global Fast Orbit Feedback
- To decrease the beam emittance
- To stabilize the beam in Storage Ring
- Disturbances:

- Mechanical vibrations
- Vacuum pumps
- Ground motion
- Electrical power lines
- Etc.
- Courtesy of Guenther Rehm, Diamond, Libera Workshop 2007

FOFB Principles

$$\begin{array}{c} m_1 \\ m_2 \\ m_3 \\ \vdots \\ m_k \end{array} = VS^{-1}U^T \begin{array}{c} x_1 \\ x_2 \\ x_3 \\ \vdots \\ x_n \end{array}$$

Multiple BPM devices (x) Multiple magnet correctors (m)

- Interdependency One magnet correction influences the position of the beam at virtually all BPM positions.
- Response matrix R

Global FOFB



Fast Acquisition (FA) Data Stream – Logical View

- Real-Time Stream
 - Continuous flow
 - ~ 10/20 kHz

• FA Atom Content

- Va, Vb, Vc, Vd
- X, Y, Q, Sum
- Packet counter & Status



Fast Acquisition (FA) Data Stream – Physical View



- Hardware
 - SFP ports
- Hard-Real-Time packet transmission
- Levels of integration:
- Orbit/FA data concentration
- FOFB application (magnet corrections)





FOFB: Levels of integration

• Semi integrated (data concentration only):

- Libera Grouping
- GbE
- DCC
- Hybrid (e.g. GbE + RM)
- Fully integrated (FOFB application):
 - External
 - Internal
 - Centralized
 - Distributed







GDX Module FPGA Development Kit







GDX Module & FPGA Development Kit







Data Concentration: Libera Grouping & GbE







Instrumentation

Technologies

Data Concentration: Diamond Communication Controller



Courtesy of Guenther Rehm, Diamond, Libera Workshop 2007

Diamond Communication Controller - Topology



Courtesy of Guenther Rehm, Diamond, Libera Workshop 2007





Technologies

Data Concentration: GbE + RM @ Elettra



Courtesy of Marco Lonza, Elettra, Libera Workshop 2007

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FOFB & Syncronization

- Timing synchronization is a must for proper FOFB/Grouping/DCC operation!
- Time-out role





FOFB & Hard-Real-Time

- FOFB is a feedback control
- All digital feedback controls rely on constant processing interval T



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FOFB in Mixed Environment



Conclusion

• Multiple options available for FOFB:

- Semi integrated
- Fully integrated
- Open development framework (FDK)
 - Allows for the implementation of custom FOFB solutions
 - Data concentration
 - FOFB algorithm calculation
 - Streaming to magnet correctors
- Synchronism is built in all Libera instruments by design
- GDX Module enables fully integrated FPGA based FOFB
- FOFB now possible in mixed environments (Libera Electron/Brilliance/Brilliance+)

