Shanghai Deep UV–FEL Control System

Control Group

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SDUV-FEL Control System

- Introduction
- System Design
- Device control
  - Power supply control
  - Vacuum control
  - Microwave control (Phase shifter, modulator…)
- Timing and Interlock
- Others
Introduction

- SDUV-FEL is pre-search of Chinese hard X-ray FEL
- There are several FEL facilities under construction:
  - LCLS (Linac Coherent Light Source)
  - EURO-XFEL
  - SCSS (SPring-8 Compact SASE Source)
- SDUV-FEL control system is an extended system based on 100MeV linac control system:
  - Keep no change to those old devices which existed in 100MeV
  - New devices will be added in through extended cards/buses
  - Almost all of new devices can use the control method in SSRF
- Total system can be separated to following sub systems:
  - Injector sub-system
  - Linac sub-system
  - Undulator sub-system
  - Timing and interlock sub-system
Normal Operation of SDUV FEL

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed laser wavelength</td>
<td>1048 nm</td>
</tr>
<tr>
<td>Seed laser duration</td>
<td>10 ps</td>
</tr>
<tr>
<td>Electron beam duration</td>
<td>2 ps</td>
</tr>
<tr>
<td>Electron beam energy</td>
<td>160 MeV</td>
</tr>
<tr>
<td>Peak current</td>
<td>300 A</td>
</tr>
<tr>
<td>Normalized emittance</td>
<td>6 mm-mrad</td>
</tr>
<tr>
<td>Local energy spread</td>
<td>$5 \times 10^{-5}$</td>
</tr>
<tr>
<td>Modulator period length</td>
<td>50 mm</td>
</tr>
<tr>
<td>Modulator length</td>
<td>0.80 m</td>
</tr>
<tr>
<td>Modulator gap</td>
<td>Alterable</td>
</tr>
<tr>
<td>Radiator period length</td>
<td>25 mm</td>
</tr>
<tr>
<td>Radiator length</td>
<td>9.00 m</td>
</tr>
<tr>
<td>Radiator gap</td>
<td>10 mm</td>
</tr>
<tr>
<td>Radiator resonant wavelength</td>
<td>262 nm</td>
</tr>
</tbody>
</table>
Future Plan

SSRF-XFEL
System Design

- SDUV-FEL control system is a distributed system based on “Standard Model”
- OPI Layer
- Front-end Layer
- Device control Layer
  - Ps controller
  - Vacuum controller
  - Pump ps controller
  - PLC, etc.
- Network/filed buses
  - LAN, DeviceNet, serial, etc.
- As we upgrade from the old control system, we obey the rules “use old devices as much as possible”
System Design (Architecture)

Network

Internet

Operator Interface

Firewall

Front-end

Device Control

I/O Controllers

Field bus (Ethernet)

PLCs

Measurement Instruments

Intelligent Controller

D/I D/O A/I A/O

Severs

Archiver Loggers Consoles...
System Design (Hardware)

- 1 EPICS file/data server
  - FTP Server
  - NTP Server
  - NFS Server
  - Data Archiver
  - Running soft IOCs
- 4 OPI computers
  - Including original 2 Desktops
- 7 IOCs
  - Including original 3 servers, add 4 new VME7050
- Device controller
  - Already 1 PLC (For vacuum interlock)
  - Add 2 new I/O modules
  - Other device controllers are maintained by other groups
System Design (Software)

- **OS**
  - OPI: Scientific linux
  - IOC: vxWorks 5.5.1
  - EPICS Server: Scientific linux

- **EPICS base**

- **OPI Interface**
  - edm

- **Other tools**
  - StripTool, AlarmHandler, Channel Archiver, etc.
Power supply of Injector and linac
- Old power supplies are kept to be used
- Some new homemade digital power supplies are added

Magnet’s power supply in undulator
- Takes new homemade digital power supplies

Two types of PS, two types of interfaces in our system
- DeviceNet
- Ethernet
Main part of injector and linac
- Keep the same control method of 100Mev in injector and Linac
- Add two vacuum gauges (1 Varian, 1 Pfeiffer), control in the same way as above

Udulator
- 6 vacuum gauges (one leybold, others undefined)
- Controlled through Ethernet
**Device Control - Vacuum Monitor (Injector and Linac)**

- **Epics: base-3.13.10**
- **O.S: vxWorks 5.3**
- **Device support/Driver:**
  - Support: devAscii
  - Carrier driver: drvIpac, drvVipc616
  - IP driver: drvOctal
  - Serial driver: drvSerial, drvAscii

```
Consoles

<table>
<thead>
<tr>
<th>IOC</th>
<th>IP-Octal232 on VIPC616</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVME2302</td>
<td>IP-Octal232 on VIPC616</td>
</tr>
</tbody>
</table>

RS-232

Signal converter box

VARIAN

VARIAN

VARIAN

PFEIFFER

PFEIFFER

PFEIFFER

Vacuum guage
```
Device Control - Vacuum Monitor (Undulator)

- **Epics**: base-3.14.8.2
- **OS**: vxWorks 5.5.1
- **Device support/Driver**
  - asynDriver
  - streamDriver

Diagram:
- VME/IOC
- Serial/Ethernet converter
- Vacuum gauge
- STP link
- STP link
- LAN
Device control – Vacuum Pump

Injectors and linac
- Keep old RS485 control method of 100MeV control in injector and linac
- 3 new pump supplies were added and controlled through Ethernet

Undulator
- 17 new pump power supplies
- Controlled through Ethernet
Device Control - Valve Control

- Use AB PLC-5 to control valves and implement interlock
- There are 3 vacuum parts
  - Injector (valve V1,V2)
  - Linac (valve V2,V3)
  - Udulator (V4,V5)
- When the guage value reaches alarm, relay breaks, PLC output to close valves at both ends
- Comparing with old 100Mev control, 2 modules of 16 channels are added and new control logic was designed
- PLC communicate with VME/IOC based on AB’s DCM protocol
Device Control - Valve Control

- IOC MVME2302
- VME Remote I/O scanner
- AB PLC-5
- Signal converter box
- Valve controller
- Varians
- Leybolds
- Pfeiffers
- Others
- Valves
- Trigger interlock
Device Control - Microwave

- One 2856MHz solid state amplifier’s control
  (Has been implemented in 100MeV)
- 4 high power phase shifter, 1 power switch
- 2 modulators (110MW/70MW)
Device Control – Phase Shifter

Phase shifter (including power switch control) takes DC motors, each motor include:
- Motor direction choice
- Position control
- Position current read back (0-10v)

Use 100MeV Linac microwave control’s free ports:
- IOC controls motors’ digital/analog I/O
- I/O modules’ type is VMIC 2536 (32 channel DI/DO)
- Vmic4514A (16 channels AI/AO)
Device Control – Phase Shifter

- OPI/Linux
- VME IOC
- VMIC 2536 32CH DI/DO
- VMIC 4514A 16Ch AI/AO
- Convert/controller (homemade)
- OPQ'1
- OPQ'2
- OPQ'3
- OPQ'4
- RS' TU
- VWXYQ 2998MHz
- LAN
Device Control – Modulator

- **110MW modulator** (old control system in 100Mev)
  - Local PLC (SLC-500) control with ladder
  - PLC communicates to IOC through Ethernet by 1746-DCM module

- **70MW modular** (newly added device)
  - Local Omoron PLC control
  - Communicate to IOC through ethernet

- All control logic/interlock/execute/data acquisition are all finished by local PLC
Timing and Interlock

Keep 100MeV design, use BNC company’s MODEL 555-8 8 channels digital pulse delay generator

- Timing pulse generator BNC555-1
- BNC555-2
- Trigger interlock unit
- Output circuit

RF GUN联锁
调制器1组合联锁
调制器2组合联锁
反射功率保护
真空系统联锁信号
辐射防护联锁信号
热供水温联锁
备用
驱动激光器
调制器1预触发
调制器1触发
调制器2触发
微波放大器1触发
微波放大器2触发
束测系统触发
45MW功率源低电平
30MW功率源低电平
光学测量触发
Timing and Interlock - Parameters

- Channels: 8
- Trigger types: Ext Trig, Ext Gate, Int, Single Shot, Burst, Duty Cycle
- Repeat freq: 0.01Hz-1.0 MHz
- Duty factor can be adjusted in each channel
- Output pulse range: CMOS/TTL
- Output pulse polarity can be chosen
- Output pulse width: 10ns-100s, resolution 1ns
- Output pulse delay: 0-100s, resolution 1ns
- Rising edge < 5ns
Network
- 3 switch hubs locate on central control room, power supply room and device room, consist of local network

Video/broadcasting system
- keep old system
Thanks for your attention!
谢谢大家！