Development of EPICS Controlled Remote Car

T. Obina, H. Sagehashi, S. Nagahashi, T. Nogami
KEK, High Energy Accelerator Research Organization
T. Michikawa
East Japan Institute of Technology Co., Ltd.

(Presented by N. Yamamoto on behalf of the authors at the EPICS collaboration meeting in Korea)

[ Contact : takashi.obina@kek.jp ]
T. Obina, H. Sagehashi, S. Nagahashi, T. Nogami
KEK, High Energy Accelerator Research Organization
T. Michikawa
East Japan Institute of Technology Co., Ltd.

(Presented by N. Yamamoto on behalf of the authors at the EPICS collaboration meeting in Korea)

[ Contact : takashi.obina@kek.jp ]
Outline

1. Motivation
2. Our Solution
3. Block Diagram / Fabrication
4. GUI/Control
5. Test
6. Components
7. Performance
8. Summary and Future Plan
1. Motivation

- What we want to measure is:
  - Temperature of accelerator components
  - Temperature of cable rack or other equipments
  - Beam Loss
1. Motivation

- What we want to measure is:
  - Temperature of accelerator components
  - Temperature of cable rack or other equipments
  - Beam Loss

During Machine Operation!!
Inside Accelerator Tunnel!!
Temperature Measurement
Temperature Measurement

- If we found a high temperature region, we can attach temperature sensors on the place. Then we can monitor and archive very easily.
Temperature Measurement

• If we found a high temperature region, we can attach temperature sensors on the place. Then we can monitor and archive very easily.

  Good tool to avoid catastrophic event
Temperature Measurement

- If we found a high temperature region, we can attach temperature sensors on the place. Then we can monitor and archive very easily.

  Good tool to avoid catastrophic event
Temperature Measurement

• If we found a high temperature region, we can attach temperature sensors on the place. Then we can monitor and archive very easily.

  ➤ Good tool to avoid catastrophic event

• ...... of course, we know the temperature change is not so fast.
Temperature Measurement

- If we found a high temperature region, we can attach temperature sensors on the place. Then we can monitor and archive very easily.

  Good tool to avoid catastrophic event

- ...... of course, we know the temperature change is not so fast.

- In electron machine, it may possible to get into the accelerator tunnel immediately after beam shut off.
Temperature Measurement

- If we found a high temperature region, we can attach temperature sensors on the place. Then we can monitor and archive very easily.

  Good tool to avoid catastrophic event

- ...... of course, we know the temperature change is not so fast.

- In electron machine, it may possible to get into the accelerator tunnel immediately after beam shut off.

- How about for proton or heavy ion machine?
Candidates

- Put many number of cameras inside the accelerator tunnel ...... ?
  - Visible light camera is very popular and cheap
  - Calibrated IR Camera is expensive

- Surveillance camera with "Rail"
  - Expensive
  - Obstacle for other installation work
  - Hard to access near the vacuum chamber
2. Our Solution

- Make it simple: Starting from a "Cart"
Our Solution

- 4-Wheel Direct Drive Motor
  - Independent control for 4 wheels
  - No needs for steering
Our Solution

- Camera
  - Visible and Infrared
Our Solution

- Battery
Our Solution

- Controller (PLC) : EPICS Ready
Our Solution

• Wireless LAN Access Point
Our Solution (Concept)

• Use Wireless LAN infrastructure
  – Already available all over the accelerator

• Utilize "Standard" components only.
  – No Special equipment
  – Combination of standard technique & hardware
  – PLC based I/O modules
    • EPICS Ready
    • Rapid development has been achieved

• Quite good extensibility
  – We have a lot of I/O channels

• Cost effective
Controller

- Yokogawa PLC-based I/O
  - On of the popular hardware in KEK recently
- PowerPC CPU + Standard Linux OS
  - Low power consumption
  - No Ladder program; Simple C/C++
  - EPICS Ready
- Many I/O Channel
  - Analog and Digital
  - Extensible
Ready?
Here you are!
Inside the box
Movie
Movie

- Forward/Backward Movement
Movie

- Forward/Backward Movement
• Forward/Backward Movement
• Rotational Movement
  – pivot turn by counter-rotation of tire
Movie

- Forward/Backward Movement
- Rotational Movement
  - pivot turn by counter-rotation of tire
3. Block Diagram
4. GUI (CSS)
5. Test at PF-Ring / KEK
Test at PF-Ring / KEK
6. Components
IR Camera

- Visible and IR camera (NEC/Avio S30)
  - 430k JPY ( ~ 5.4k$)
Visible Image and IR image must be shown together, otherwise it is hard to determine the target object.
Controller

- "Griffin Power Mate" is used as a controller.
  - Acceleration/Deceleration and rotation control
- Linux driver is available

Griffin Power Mate (Encoder): Push to stop, Rotation for Acceleration/Deceleration
Frame / Cover

- Aluminum joint-frame
  - Easy to design and fabrication
  - Light weight

- Cover
  - Formed polystyrene + FRP (Fiber-reinforced plastic)
  - Look-and-feel is important, however, not essential.
  - At the "KEK Open House", the cover played an important roll to get much attention. Especially good for children!
We can buy a spare tire.
(smaller than this photo)
Battery Pack

• Li-ion Battery

use this part
Performance
Battery Lifetime / Speed

- 1 Battery pack can operate for 1 hour (without slope or other barrier)
- Can equip up to 6 battery packs

- About 22min to circulate PF-Ring (187m)
  - Maximum speed and torque can be adjusted by selecting a gear-box between a motor and a tire.
Summary

- We have made the EPICS-Controlled Remote Car for the surveillance purpose.
- It can be a versatile tool because of its extensibility.
- Successfully operated in the KEK-PF wireless LAN environment
  - Not tested during the machine operation yet.
  - We have a chance to test in next month.
- Demonstrated at
  - Annual meeting of Particle Accelerator Society Japan
  - KEK Open-house
Future Plan

- Future Plan .... for example
  - Measurement of beam loss
    - Build an "Arm" to put loss monitor sensor
  - Evaluation of long-term stability
  - Automatic Battery Charge
    - Like iRobot/Roomba
  - Power saving for long lifetime of battery
  - Automatic surveillance
    - Add a line tracer or Image analysis
  - Distance sensor to protect accelerator equipments or human injury.
  - Down-sizing

We have just started the development, and have a lot of things to do.
We are really excited to have such kind of interesting tool!
Thank you for your attention

원 경청 감사
Encoder

• Griffin Power Mate: USB connected knob
  – [http://store.griffintechnology.com/desktop/powermate](http://store.griffintechnology.com/desktop/powermate)

• About $45

• Linux control possible.
  – Official driver is only for Win/Mac

• Action: Push, rotate left/right, Push+Rotate