# Current Status of 4GSR Control System

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## Outline

1. Introduction about 4GSR
1. Overview of 4GSR Control System
2. Summary

# Introduction

## 4GSR Outline

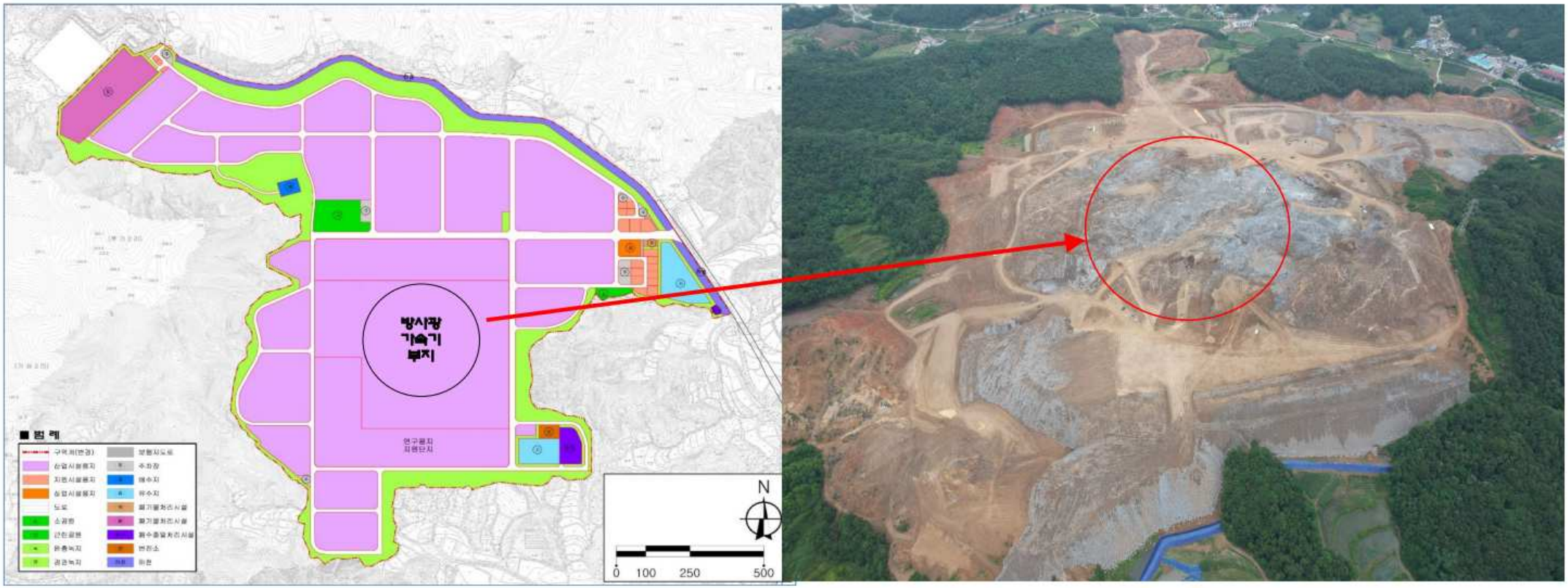
❖ **Multipurpose Synchrotron Radiation Construction Project**

- Period: 2021 July to 2027 June (6yrs)
- Budget: 1.0454 Trillion KRW (≈ USD 750M)
- Land: 540,000 ㎡ / Building: 69,400 ㎡
- Location: Ochang, Chungcheongbuk-do

## Specifications

- Beam Energy: 4 GeV
- Beam Emittance: less than 100 pm·rad (CDR: 58 pm·rad)
- Circumference: 800m
- Beamlines : more than 40
- Accelerator: Gun, Injector LINAC, 4 GeV Booster
- Lattice: MBA-7 Bend Achromat

## Construction Site




Korea-4GSR Project
계획의 전제
과학기술 기초역량 강화를 위한 세계 최고 수준의 차세대 다목적 방사광 가속기 구축.
선도적 원천기술 및 미래핵심기술 확보를 위한 R&D 과학기술 인프라의 요람.
차세대 첨단기술의 집약적 활용으로 국가 기술경쟁력 강화에 기여.
KEY MAP

# Overview of 4GSR Central Control System

## Control Group Manpower

❖ **Current status(2024.04)**

| Work Scope | Person |
|---|---|
| FOFB, Signal Archiving, EPICS Infrastructure, etc. | Seung-Hee Nam |
| Machine Protection System(FOI, MIS), etc. | Jinsung Yu |
| Slow Control System, Data Acquisition, etc. | Yunho Kim |
| Timing System, Network etc. | Sohee Park |

# Central Control System

## Goals

- To read, change and record all raw signals from all equipment of the accelerator and all logic signals
- To provide an effective standards : graphical user interface(GUI), operating system(OS), database, network, standard hardware, version control
- To oversee all equipment, alert operators, end-users, or both to fault conditions, and could provide tools in order to analyze any fault quickly

### Software

- 4GSR customized standard (OS, Middleware, Module)
- Various H/W interface driver (PLC, FPGA, DAQ)
- Optimized operation interface (GUI, Script)
- Naming convention (Process variable, Cabling)
- Data store & retrieval (Signal archiving system)

### Network

- Optimized control network design & Construction
- Control data transfer (EPICS record, Waveform)
- S/W and H/W security (Network separation, Authorization, IP management)
- Optimization of DB/Storage network performance

### Timing

- Time & Clock sync overall accelerator control devices
- Provide GPS synchronized timestamp
- Generate synchronized event sequence and trigger signals
- Propagate Post Mortem System

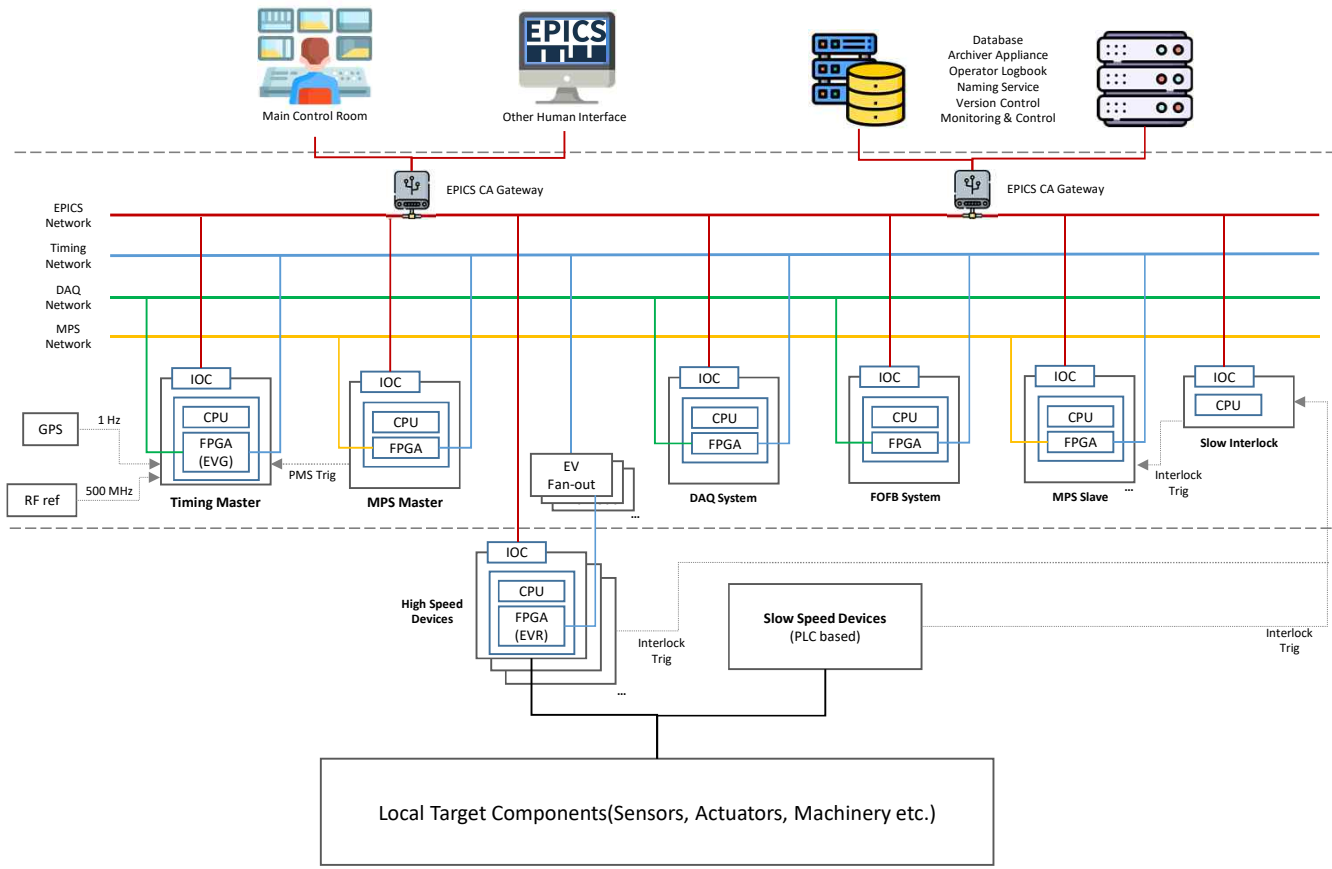
### MPS

- Machine Protection System for Slow and Fast Shut-off the accelerator
- Various sub-systems MPS interface (Water leackage, Vacuum, Magnet power supply, Radiation, Ion source, Target, beam dump etc)
- Generate Post Mortem Signal

### FOFB

- Fast Orbit Feedback system for storage ring
- Use turn by turn steam data
- Low latency and high stability for beam orbit error

# Central Control System Architecture




## Applications

GUIs for data Analysis
Processing and archiving system
System configuration
Configuration databases
Runtime & historical data

## Facility Integration

Complex control function
Process and device control
High dependability
Executes local control
functions

## Local Control System

Process and device control
High dependability
Executes local control
Functions
Analogue and digital signal

# 4GSR Standard

❖ **Software Standard**

- Standardization guide for EPICS operation ha been prepared to prevent various indiscriminate operating environments
- Separate exceptions are made when dependencies necessary for operating the operating system and system occur
- Minimize system maintenance and operating costs.
  - EPICS Middleware : EPICS7 7.0.7 or later
  - Operating System :

    - Debian 11 or later

    - Rocky7 or later

    - Xilinx SoC : PetaLinux
  - Display (GUI) Manager : Phoebus
  - Centralized Storage System : EPICS Archiver Appliance
  - Industrial Protocol : ModbusTCP
  - Database : MariaDB
  - Version Control : Git Lab

# 4GSR Standard

❖ **Software Standard**

- **Install Scripts**

```
Auto Installation script
Enter the number of you want to install
1 : EPICS V7 version 7.0.7
2 : EPICS synApps
3 : EPICS extension
0 : Exit script
Enter the number :
```

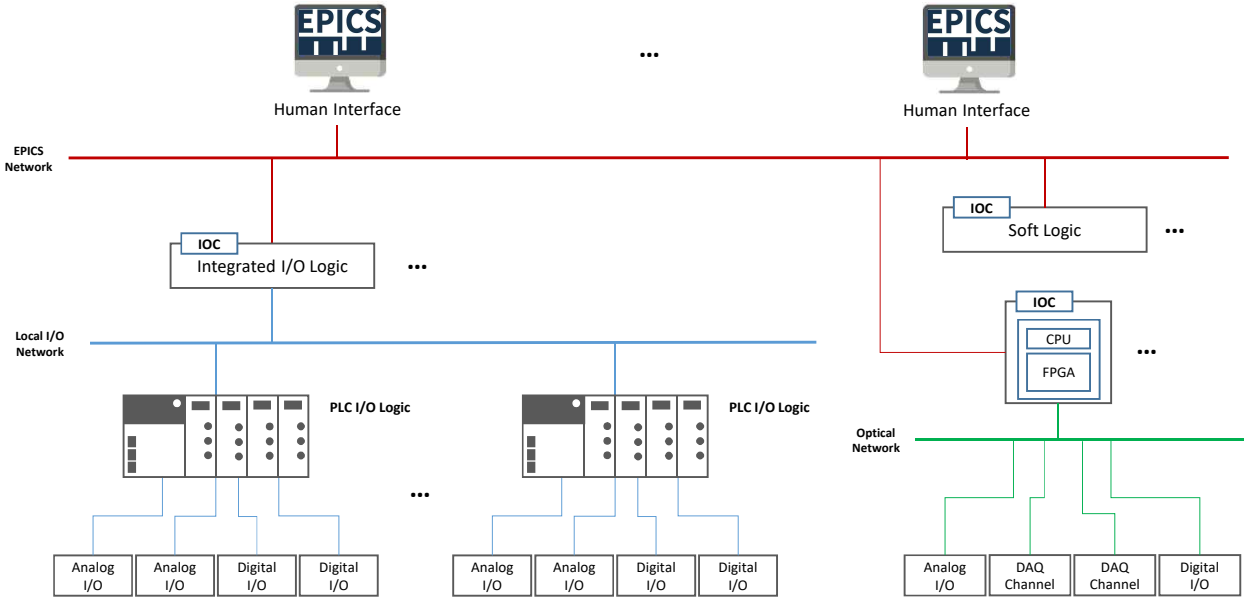
  - Establish standardization of development environment
  - Prevent problems with configuration inconsistencies in software development and operation in control systems
  - install script is an EPICS development environment automatic installation script that supports installation of EPICS Base, EPICS synApps, and EPICS extension in Debian, Ubuntu, and Rokcy environments.
  - Dependency packages for installation items are automatically set by the script.

```
ctrluser@debian:/usr/local/epics/EPICS7$ tree -L 1
.
├── archappl-1-1
├── archiver_appliance
├── base
├── downloads
├── extensions
├── modules
├── setEpicsEnv.sh
├── siteApp
└── siteLibs

9 directories, 1 file
```

  - EPICS module is a synApps module and includes basic libraries such as Asyn, StreamDevice, and autosave.
  - EPICS extension configures EDM and MEDM in the src folder for display management.
  - The siteApp and siteLibs folders contain self-developed IOC and library code.

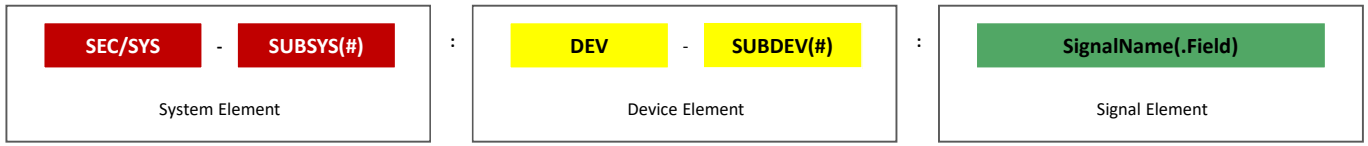
# Local Control System Integration




| Device Controller | Detail | | EPICS Module | System |
|---|---|---|---|---|
| PLC | - Industrial Protocol (ModbusTCP) | | ModbusTCP | Vacuum<br>Slow Interlock |
| Programmable SoC | Xilinx Zynq | - Vivado (FPGA Code)<br>- Peta Linux (Xilinx Linux Kernel)<br>- Linux Device Driver | asyn<br>Stream<br>user-driver | Timing<br>FOI<br>FOFB<br>LLRF |
| Serial Controller | - MOXA serial server<br>- Ethernet to RS232 / 485<br>- SCPI standard serial command<br>- Embedded EPICS IOC Controller | | asyn<br>Steram | Magnet<br>Power Supply<br>Vacuum |

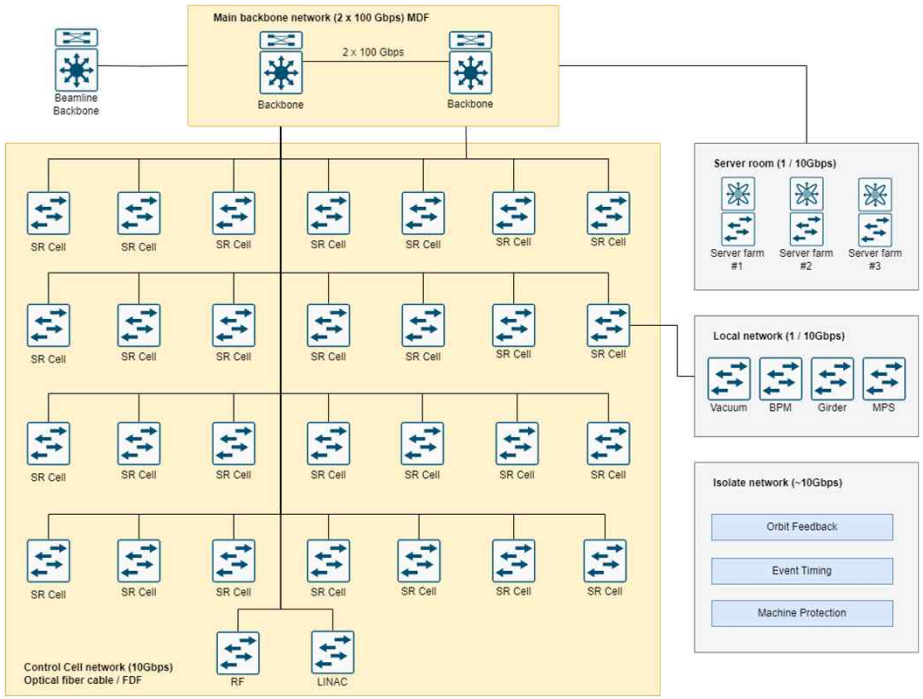
# Naming Convention

- Rule for matching signals, which are from devices and equipment of an accelerator, to signals
- Naming must not conflict in the overall systems (Unique naming)
- Well defined naming rule lets us to know
  - What the signal is (Current, Voltage, Temperature, Valve, Power, Speed, etc.)
  - Where the signal comes from (SR, LINAC, BR etc.)
  - Which device or equipment is related (Magnet, RF, Faraday Cup etc.)

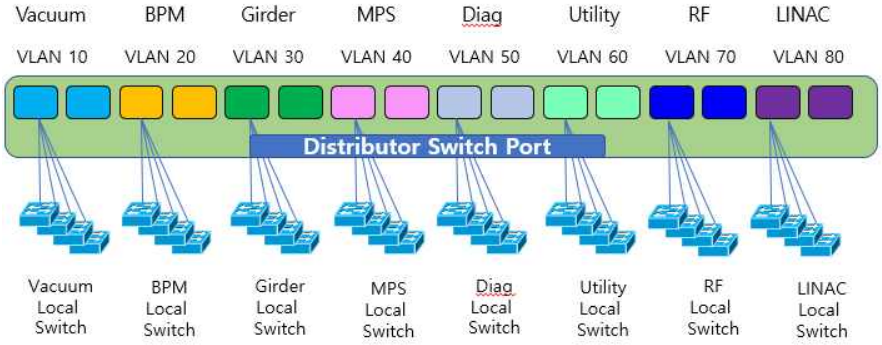



- Syntax Rules
  - Allowed characters are alphanumeric characters (A-Z, a-z and –9) and two separator characters(-, :)
  - Avoid using the uppercase letter O, be confused with the number 0
  - Avoid using the uppercase letter I, be confused with the number 1
  - First letter of a word is uppercase
  - Vendor specific naming should be avoided
- Example : SR-Cell1:Mag-DM01:CurrentSet

# Control Network




- Configure network infrastructure to monitor and control information on all devices required for accelerator beam operation in real time
- Network scalability selects a centralized topology considering ease of adding/removing equipment.

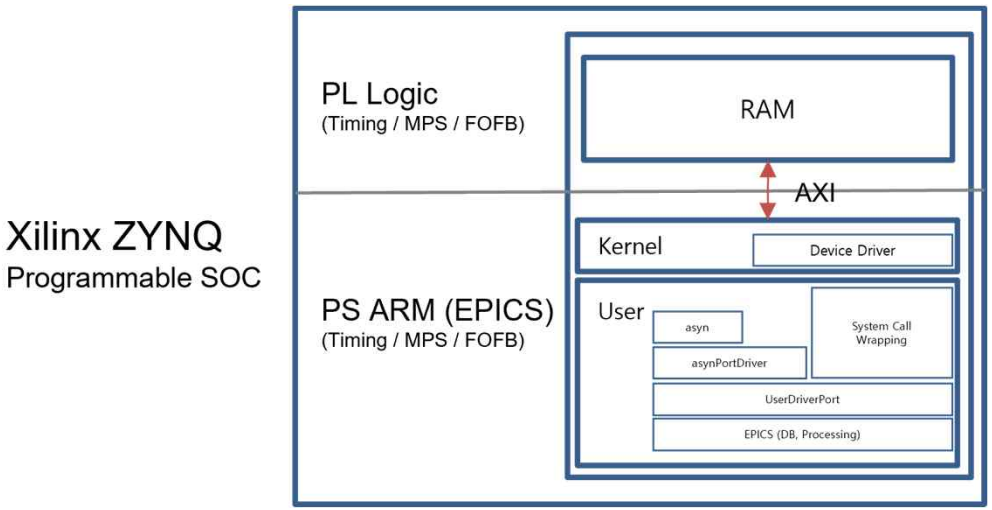



- **VLAN**
  - Each device configures the system using VLAN (Virtual Local Area Network)
  - Minimize broadcasting traffic sent to all nodes for each event
  - Realize centralization by logically integrating physically distributed networks
  - The VLAN for each device is independent from each other, so the network can be configured while maintaining security.

- **IP address**
  - The system utilizes Class A private IP (10.0.0.0) to intuitively and effectively assign IP addresses.
  - 10.100.0.0=Vacuum, 10.101.0.0=Diag etc.

# Fast Control System

❖ **EPICS IOC Development for Fast Control System**




- **PL (Programmable Logic)**
  - FPGA (Field Programmable Gate Array) executes critical logic operations, offering flexibility and efficiency in processing.
- **PS (Processing System)**
  - The Processing System hosts the operating system, ported for compatibility with the EPICS middleware.
  - EPICS asynchronous library is standardized, facilitating seamless integration with FPGA firmware through system calls.
  - **AsynPortDriver Class**
    - AsynPortDriver simplifies the usage of EPICS asyn module by wrapping C API into a C++ class.
    - The userDriverPort inherits AsynPortDriver, enabling easy implementation of EPICS IOC-related logic.
    - Internally, it encapsulates a series of system calls accessing Linux Device Drivers for efficient communication.

# Thank you!