KAGRA PLC System Overview

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About the name

We have been calling this system “Instrument Control System” or 「機器制御」

- This name is very generic, vague and confusing (does not tell what it does).

- I’d like to propose to call this particular system “The KAGRA PLC system”.

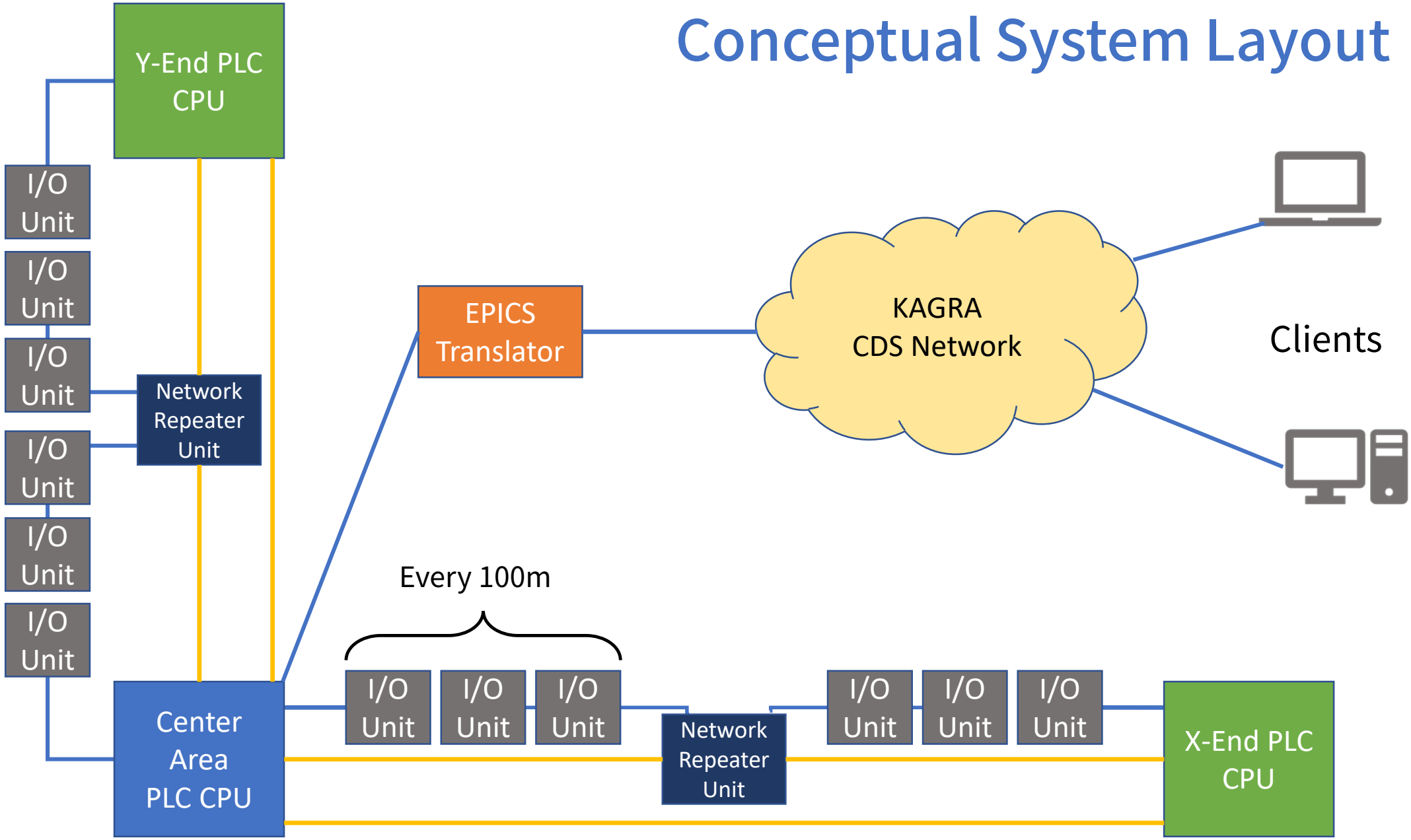
- This system is implemented with PLC (Programmable Logic Controller).
- This system implements several functions
  - Monitoring, Control, Interlock, etc

- It is better not to call it with its functions (~~instrument control~~)

- The common foundation of this system is PLC. Therefore, it is clearer to call it “The KAGRA PLC system”.

- KAGRA has no other PLC based system to my knowledge.

Conceptual System Layout



Explanation of the system layout

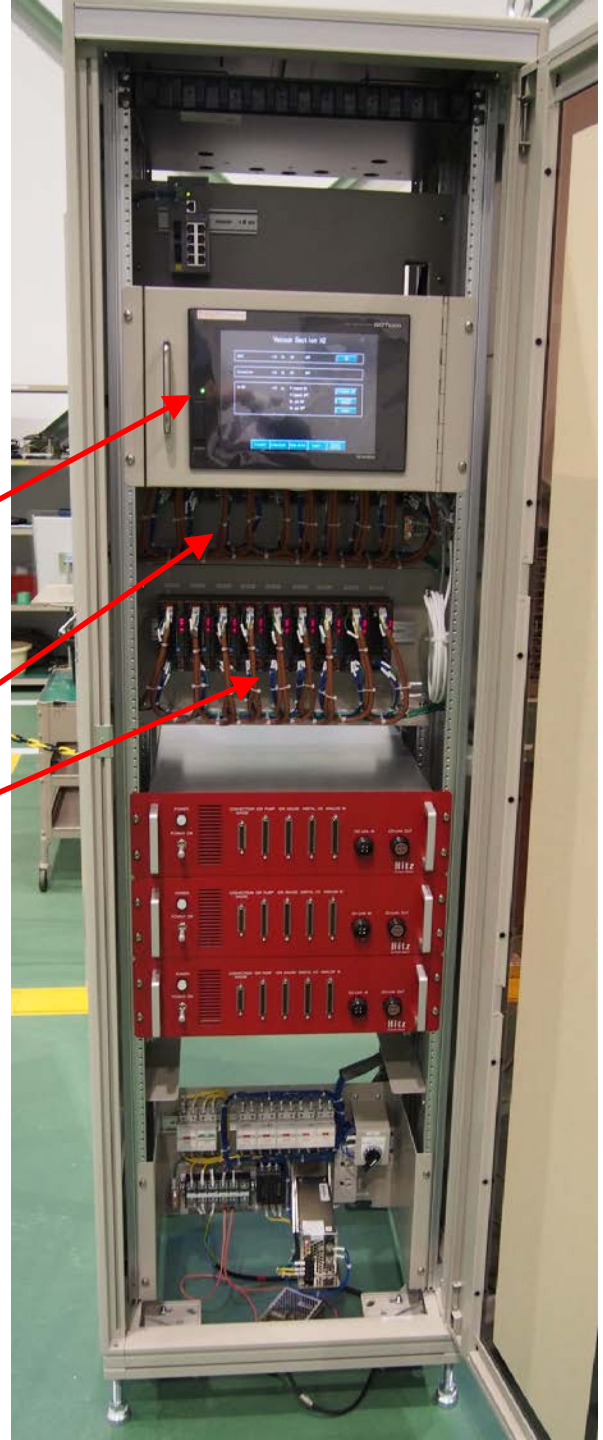
- There are 3 CPUs, center, X-end and Y-end
- Each CPU has its own I/O boards
- Remote I/O units are connected to the CPUs through a dedicated TCP/IP network
- The network repeater units are installed at the middle of each arm
  - The CPUs communicate with some of the I/O units through the repeater
- All the information collected by the I/O units are sent to one of the CPUs.
- Each CPU can implement interlock logics to automatically shutdown connected instruments in case of emergency
- End CPUs send all the collected information to the center CPU
- The EPICS translator talks to the center CPU with PLC's HTTP interface
- The EPICS translator converts all the information collected by the center CPU to EPICS PV
  - The converted EPICS PVs are broadcasted to the KAGRA CDS network
  - Client computers can access to these PVs through the CA protocol
  - KAGRA frame builder should be able to collect these PVs and store the trend data

CPU rack

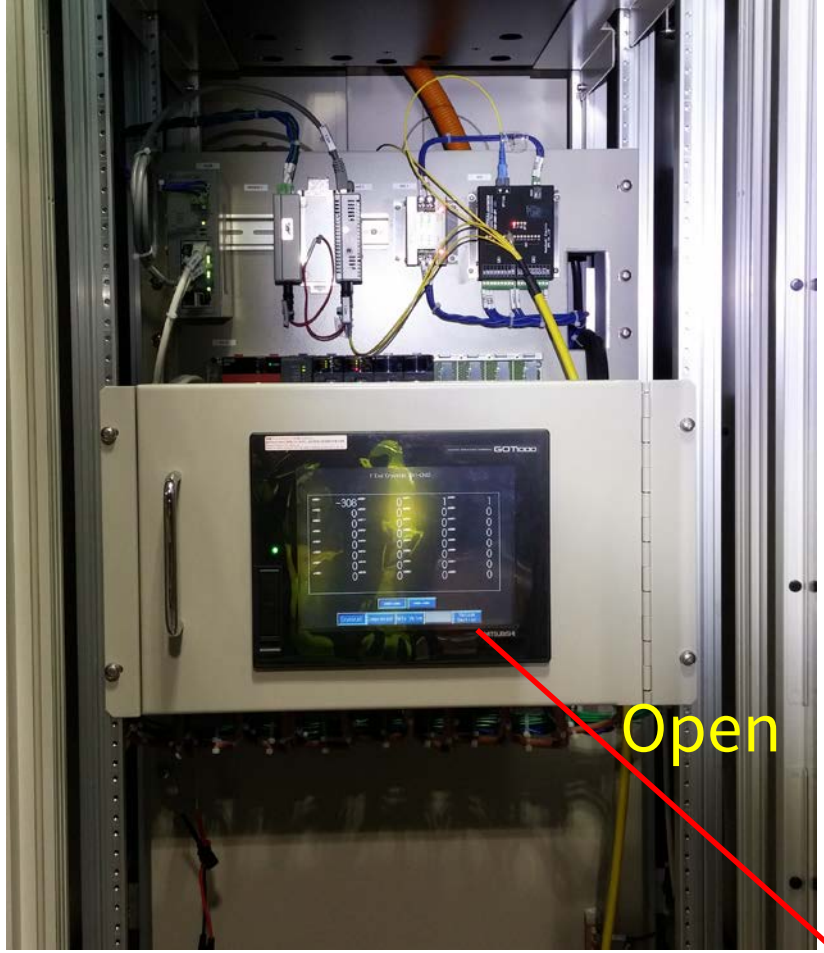
Center

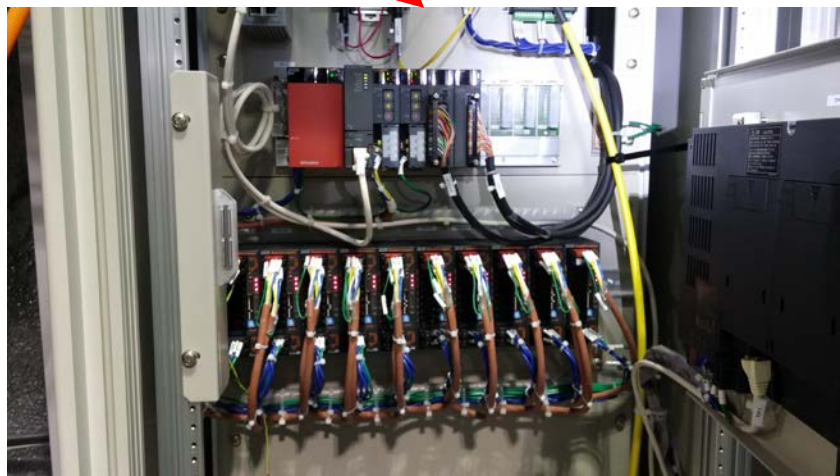
Monitor Screen

PLC I/O Units



Y-End





I/O unit

3 units shown

D-Sub interface ports

- Assuming specific models of vacuum gauges, pumps
- May need to change the wirings

Center Area CPU Rack

ADC: 152ch
Digital Input: 64ch
Digital Out: 32ch

End Area CPU Rack

ADC: 80ch
Digital Input: 32ch
Digital Out: 32ch

Remote I/O Unit

ADC: 16ch
Digital Input: 16ch
Digital Output: 16ch

ADC: 10V-10V Differential 16bit

Digital Input: 24V DC, plus common
isolation with photo-couplers

Digital Output: Relay Outputs
(Internally, relay terminals are connected to PLC digital output modules with open-drain outputs, isolated with photo-couplers)

Interlock logic

- Sample logics are implemented in the PLC CPU
  - Concrete specifications of the vacuum and cryogenic instruments were not available at the time of the development of the PLC system
  - The sample logics assume certain models of vacuum and cryogenic instruments, which may not be the same as actual KAGRA hardware

Interlock outputs

There are several relay outputs to perform emergency shutdown of critical KAGRA components

- Laser shutdown
- Close the large gate valves

Triggering the interlock

When certain conditions are met, the interlock is triggered to perform the emergency shutdown

- Vacuum gauge readings get higher than a threshold value

Possible extensions

The KAGRA PLC system can be modified or extended in several ways.

Interlock logic

Implemented with the software on the PLC CPU. It is relatively easy to change. Asking Hitachi Zousen is one way. Another way is to update the software by ourselves.

Adding more I/O channels

There is still some space to add more PLC I/O modules, though the center Area rack is congested.

Implement the laser safety interlock
with the extension of the PLC system ?

References

As built documents by Hitz (JGW-T1503712)

http://gwdoc.icrr.u-tokyo.ac.jp/cgi-bin/private/DocDB/ShowDocument?docid=3712

KAGRA network diagram (JGW-D1503778)
http://gwdoc.icrr.u-tokyo.ac.jp/cgi-bin/private/DocDB/ShowDocument?docid=3778

MELSEC PLC (sequencer) web page
http://www.mitsubishielectric.co.jp/fa/products/cnt/plc/

完成図書 詳細

ソフトウェア/ : PLC ロジックのソースコード

図書/ 以下

- 01 センターエリア機器保護装置_改造図.pdf
  - Center CPU Rackの図面。一度改造が行われたため，改造図と呼ばれている。PDF後半の「現状図」というのは，改造前の古いバージョン。
- 02 エンドエリア機器保護装置_改造図.pdf
  - End CPU Rackの図面。一度改造が行われたため，改造図と呼ばれている。PDF後半の「現状図」というのは，改造前の古いバージョン。
- 04_製作図_真空ｾｸｼｮﾝ制御装置.pdf
  - Remote I/O Unitの図面
- 04 センターエリアソフトウェアブロック仕様書.pdf
  05 エンドエリアソフトウェアブロック仕様書.pdf
  - PLCロジックのブロック図