A Network-based Intelligent Controller for J-PARC

Kazuro Furukawa, Junsei Chiba,

Norihiko Kamikubota, Hidetoshi Nakagawa

JAERI/KEK Joint Project J-PARC

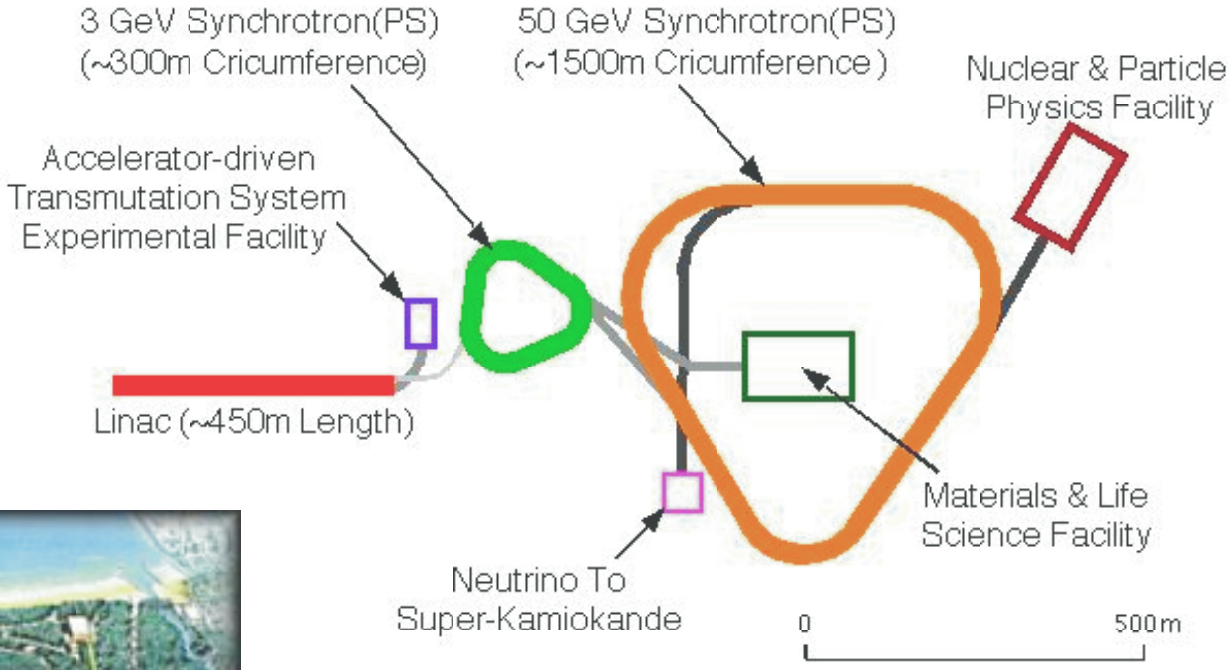
<URL:http://www-jparc.jp/>

Network-based controllers such as PLCs and measurement stations are planned to be utilized in the J-Parc project using Ethernet instead of specific field networks mainly for maintenance reasons. Since no good candidate controllers were found for medium-scale accelerator devices, a simple Ethernet board was designed. A 32-bit processor, Ethernet controller and a flash-ROM are put on a single-height (3U) Eurocard with an UTP Ethernet socket, LED indicators and a DIN connector for the corresponding hardware. Address, data and control lines are defined as an interface between hardware and the controller. Hardware input/output information is seen as a group of registers and can be read or written from the network. It also provides an autonomous reporting capability on important events. The IP address is assigned via BOOTP with a failsafe facility. The firmware can be upgraded over the network as well. While it was originally designed for power supplies of Q magnets for DTL (drift tube linac), it is being adopted for other power supplies. And it will be first used in 60-MeV proton linac for the project. The software and database for EPICS are being prepared for the commissioning.

Control System for JAERI-KEK Joint Project J-PARC (Japan Proton Accelerator Research Complex)

- Chose EPICS After Studied Control Systems at KEK
  - Success of KEKB
  - Possibility to Share Software Resources with Others
- Chose Ethernet/IP Network Controller
  - instead of Using Special Field Networks
  - Success at KEK e^+/e^- Linac with Network Controller
    - ~ 250 Controllers
  - Only TCP/IP Software and Infrastructure
- Scripting Languages like SAD/Tk, Python/Tk with EPICS

◆ Requires Very High Reliability because of the Beam Power of 1MW



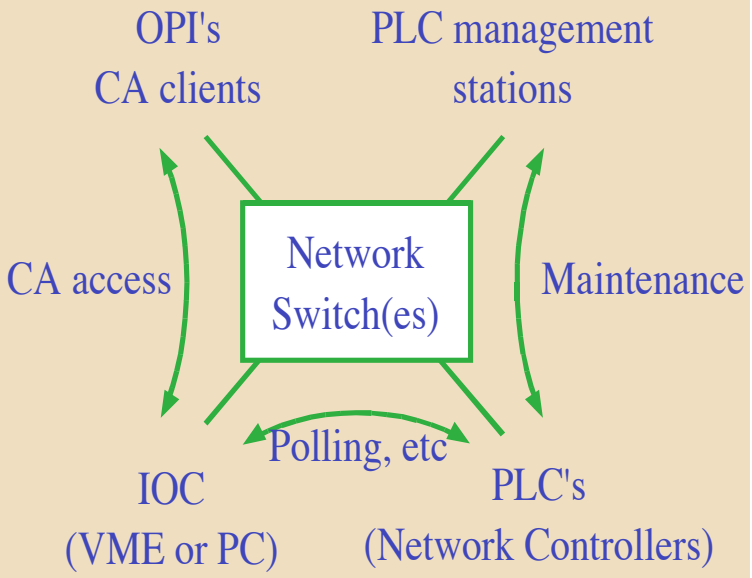
High Intensity Proton Accelerator Project

Network Connected Controllers

- Simplified Software, Management, Troubleshooting
  - Efficient in Speed, Cost, Manageability
  - Do not Consume Human Resource much
- Selection of Standard Network Device Technology
  - Standard Software
  - Flexible in Designing the Network
  - Easily Understood (the Same Technology at Offices)
- Normally UDP/IP for Simplicity and Error Handling
  - TCP/IP as well (cf. out-of-band TCP packets)

Network Controller (NC) under EPICS (1)

- 5 Components
- NC (such as PLC) : Mostly Designed by Experts, Carries Local Logics
- EPICS IOC : Carries Logics between Several Devices
- EPICS OPI : Normal OPI Nothing Special
- Management Station : Software Downloading and Monitoring
- Network : Switch Technology Physical and Logical Views are Different



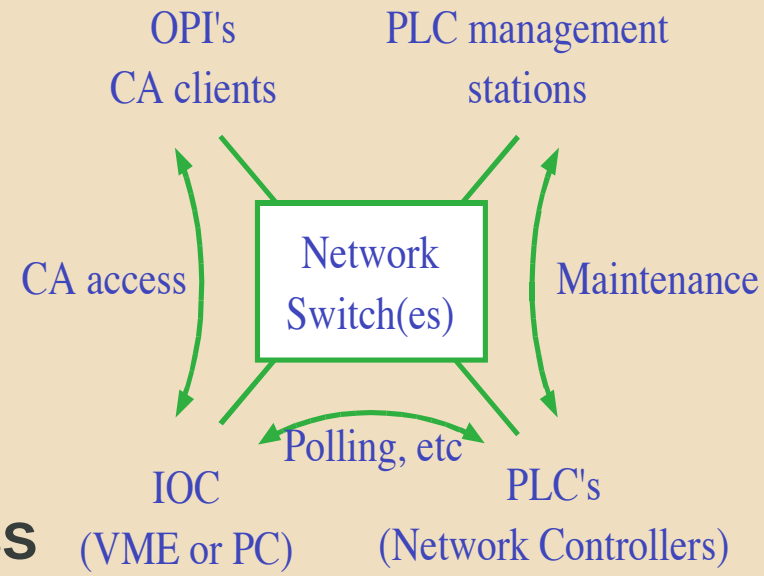
Network Controller (NC) under EPICS (2)

- 3 Ways of Communication
- NC - IOC : In its Own Protocol

  Polling (+ Urgent)
- IOC - OPI : Through Channel Access

  Normal EPICS
- NC - Management Station :

  During Maintenance Time



Programmable Logic Controller; PLC

- Modern PLC's are Powerful and Flexible

  Good Candidate for Remote I/O Controllers
- Not too Fast on the Network (~5 millisecond Response)

  but Fast Enough for General Purposes
- Pre-processing of Control Variables

  Scientific Functions, Floating Point Calculations
- Chose Yokogawa's FA-M3 (Factory ACE)

  Maintenance Capability over Ethernet/TCPIP

  (Not from other Venders in Japan)

Programmable Logic Controller; PLC

- At the Joint Project,

  Vacuum, Magnet, Ion Source and Microwave Equipment

- Out-sourcing of Accelerator Equipment Easier

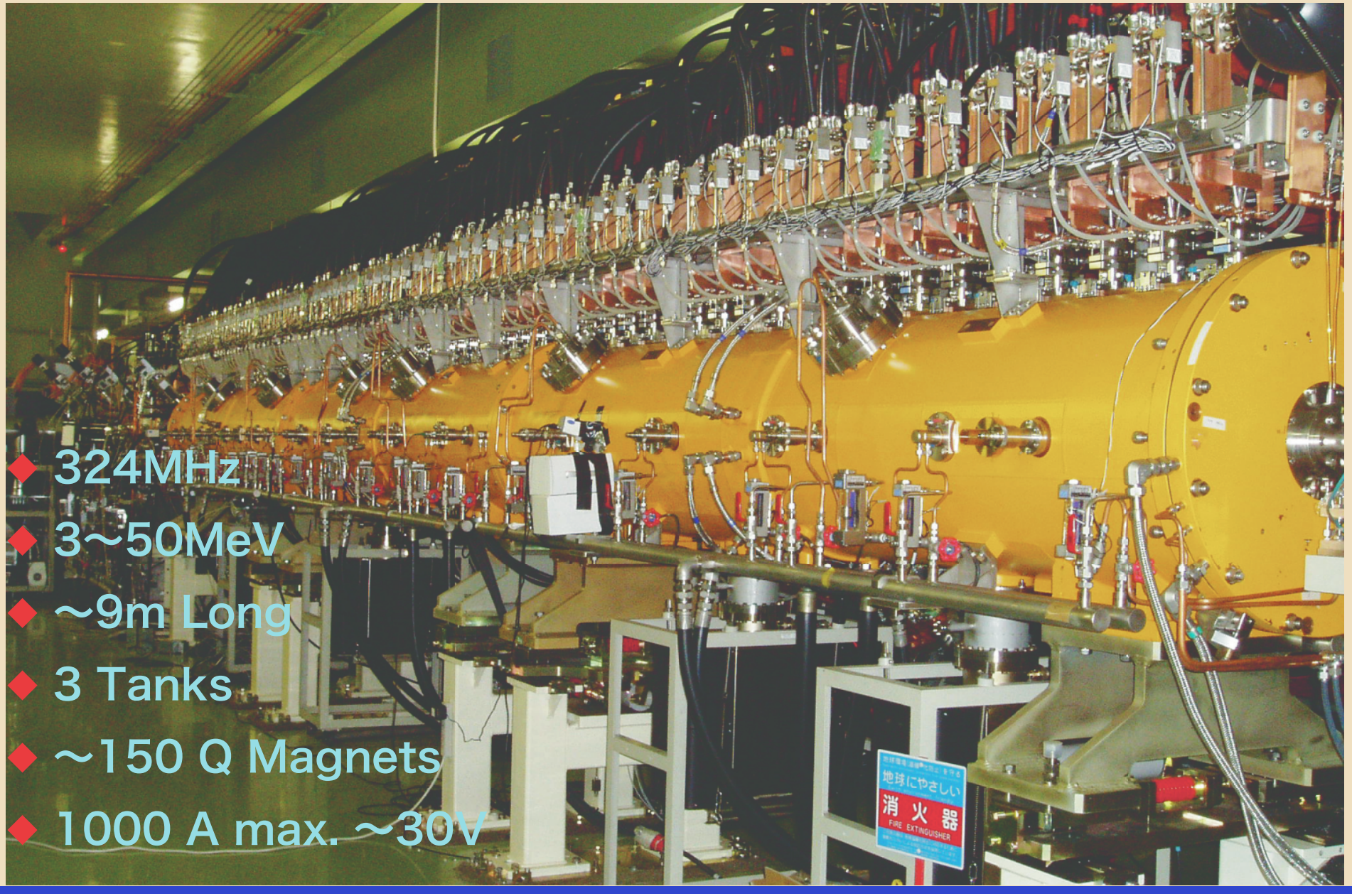
  Network Isolated

  Ladder Program Development on Windows

Plug-in Network Controller

- On Designing Relatively Large Power Supply
  for Drift-tube Linac (DTL) and Separated DTL
- Added to Intelligent Internal Controller
  Ethernet Board with about 50 (User Visible) Registers
  Including Diagnostic Information
- Being Built with Power Supplies
- Although Extended,
  Software is Almost Compatible with PLCs

Drift Tube Linac (DTL) for J-PARC Linac

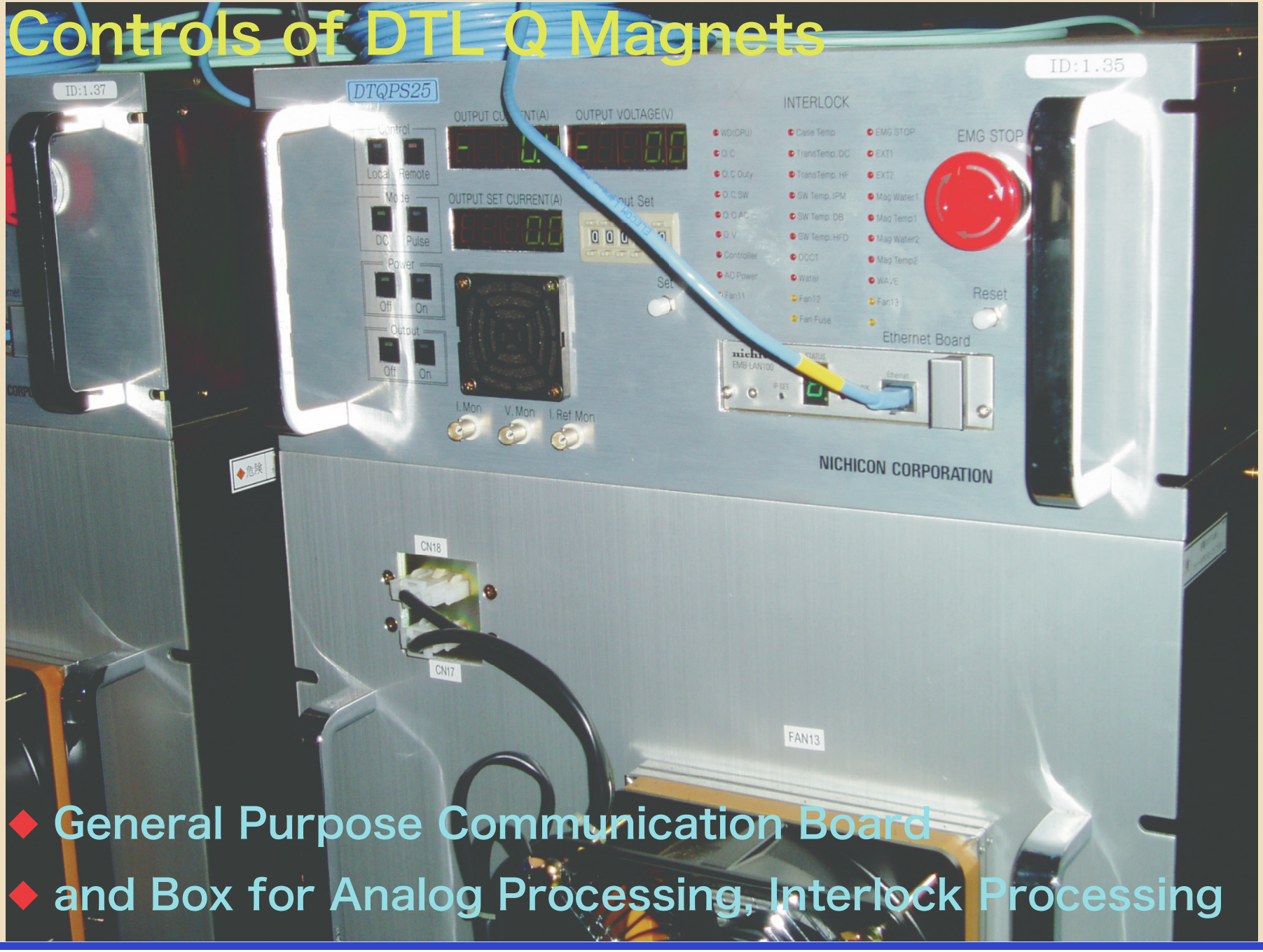


- 324MHz
- 3～50MeV
- ～9m Long
- 3 Tanks
- ～150 Q Magnets
- 1000 A max. ～30V

Power Supplies for DTL Q Magnets

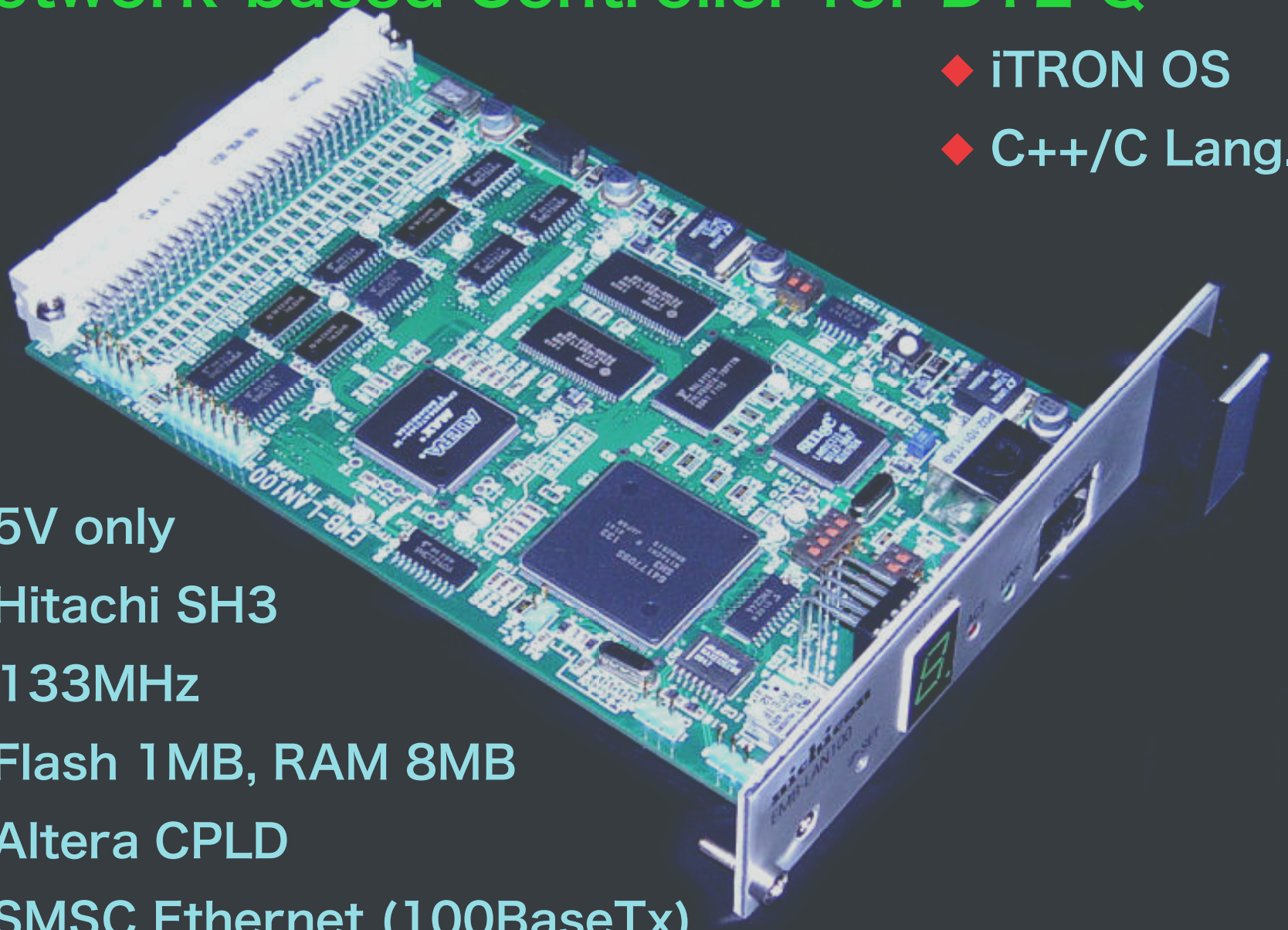
- ~150 Q Magnets
- 1000 A max. ~30V

Controls of DTL Q Magnets



- General Purpose Communication Board
- and Box for Analog Processing, Interlock Processing

Network-based Controller for DTL-Q



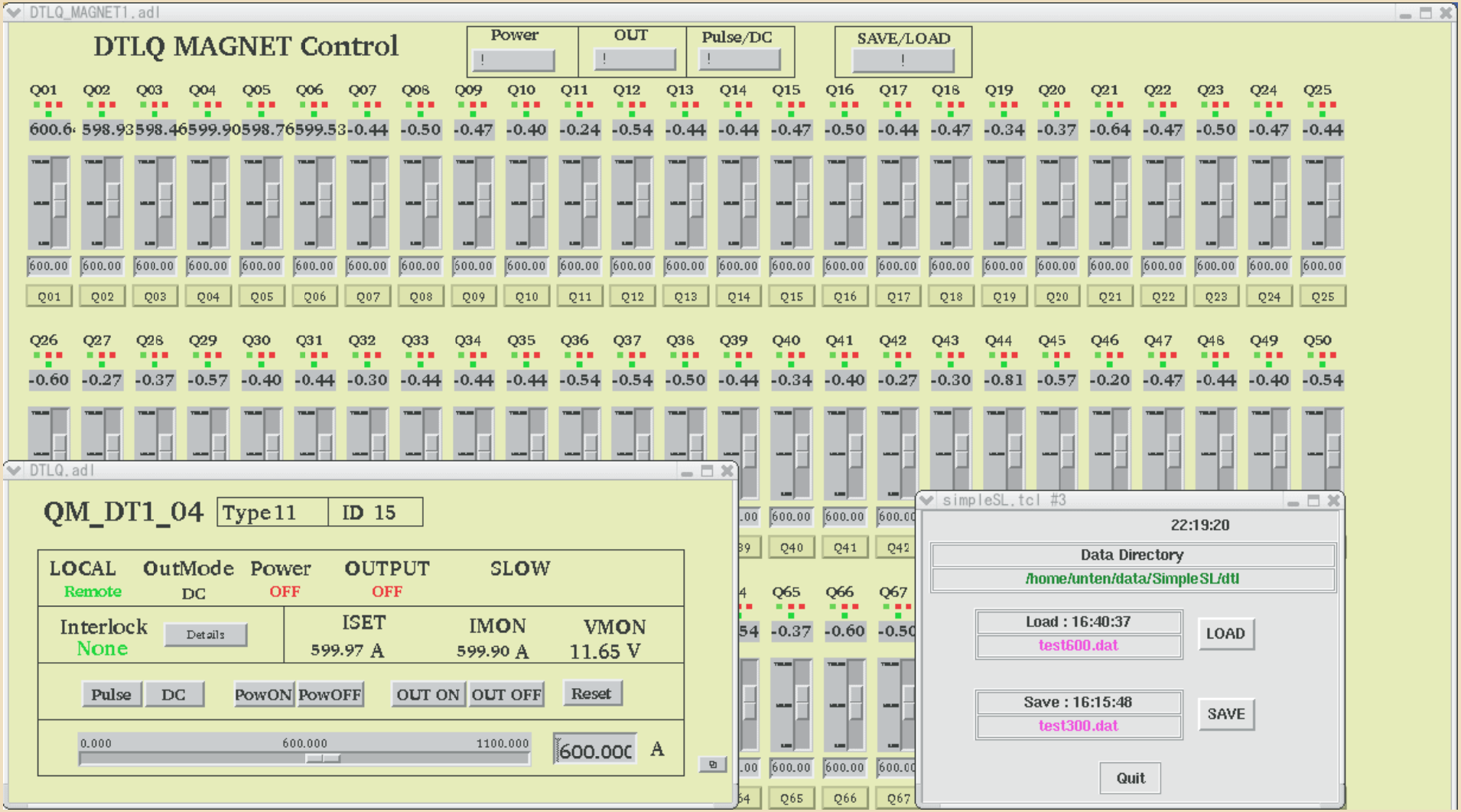
- iTRON OS
- C++/C Lang.
- 5V only
- Hitachi SH3
  133MHz
- Flash 1MB, RAM 8MB
- Altera CPLD
- SMSC Ethernet (100BaseTx)

EPICS Software

- General Device Support
- Both for VxWorks and Linux
- Controller for DTL-Q, PLC, etc. are Covered
- Being Used for Commissioning of DTL

Application Software for DTL Operation

- Status Display, Manual Adjuster, Save/Restore...



Summary

- The Board works as Expected
- Simplify Design of Control System
- Should be Careful to Speed-Negotiation Setting

  (Combination of Fixed and Auto was Bad)
- The Firmware is Field-upgradable
- Can Process > 3000 requests per Second
- Planned to be Used in Other Devices