# Development of a PC/104-Plus-based CPU Module with Power over Ethernet capability SPring

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#### Introduction

In SPring-8, the VMEbus system is the core system used to control accelerators and beamlines. Many VMEbus computers have been set up around the large facility site.

#### the VMEbus system...

#### In some cases, it is inappropriate!!

Even if we want to handle just a few I/O signals or a few motor axes, ... We have to set up a VMEbus computer with a chassis in a 19" rack. We have to keep the installation space. We may need the power work.

#### Basically it is expensive!!

#### What is PC/104-Plus?

- $\bullet$  It is a standard of embedded computer supporting an ISA bus (PC/104) and a PCI bus (PC/104-Plus).
- The form factor size is 90.17 mm x 95.89 mm.
- No backplane, which allows modules to be stacked together like building blocks.
- It can be used to stack up to four peripheral modules but not a CPU module.

What is the PoE?

#### New requirement...

It is compact. We want to have greater freedom of deployment.

It can construct a flexible control system by combining many modules.

It is low-cost.

We developed a PC/104-Plus-based CPU Module with PoE capability.

### CPU module (ND-PC104P-SH4)

Processor	Renesas Technology SH7751R (SH-4) 240MHz			
Memory	Flash Rom 16MB SDRAM 64MB (Main Memory)			
Interfaces	1 x 10/100 Mbps Ethernet 2 x USB 2.0 1 x RS-232C 1 x H-UDI/JTAG			
Power Supply	DC +5V, -5V, +12V, -12V			
Size	112.57mm x 95.89mm			

Specifications of ND-PC104P-SH4

The SH7751R processor is a 32-bit RISC microprocessor featuring a built-in PCI bus controller compatible with PCs.

PC/104-Plus connector



PC/104 connector

The PoE (IEEE 802.3af) is a technology that can used to supply the electric power to network-connected device via an Ethernet cable.

- Power Sourcing Equipment (PSE) can supply a power of up to 15W at 48Vdc to a Powered Device through a cable of length 100m.
- We can easily install a measurement instrument without the infrastructure necessary for an AC power line.
- PoE technology enables efficient remote power management via PSE such as a switching hub.

#### PoE power module (ND-PC104P-POE)



ND-PC104P-POE is a dedicated PoE module for ND-PC104-SH4.

The voltage received from PSE via the RJ45 connector of the ND-PC104P-SH4 is fed to a PoE module circuit (Texas Instruments) on an ND-PC104P-POE through the cable connection.

The PoE module circuit generates a voltage of 5Vdc. The DC/DC converters produce -5V, 12V and -12V.

Each power supply voltage (5V, -5V, 12V and -12V) is provided to stacked modules via a PC/104 connector and a PC/104-Plus connector.

If 5Vdc from an external power supply is provided, a switch circuit of power source stops output from a PoE module.

The SH-4 architecture is low power consumption CPU. It does not require a cooling function such as a heat sink and a fan.

The ND-PC104P-SH4 has power circuit to receive power from an external power supply (5Vdc).



The power consumed during the system boot-up is 4.1W.

## Porting of SH-Linux

- We successfully ported SH-Linux 2.6.16 to the ND-PC104P-SH4.
- Why Linux?
- ✓ Linux supports a development environment for SH-4 architecture.
- ✓ We can use the free and wide variety of utility software developed for Linux.
- ✓ We can develop suitable applications for MADOCA (the SPring-8 control framework based on UNIX).
- ✓ We can tune the operating system or applications by ourselves.
- For the system execution environment, we constructed a diskless root file system with a network boot (NFS root file system). Why NFS root file system?
  - ✓ We frequently recompile the kernel, drivers and applications during development and testing. It is not necessary to consider the write-cycle limitation of the storage device such as a built-in flash ROM or CompactFlash.
  - After installation, we can modify the embedded system remotely.
  - $\checkmark$  We can construct an application-rich system by mounting a large volume on a NFS server.

#### ✓ No disks crash

We implemented parts dependent on the ND-PC104P-SH4 hardware such as interrupt handling and address translation handling of the memory management unit.

#### Measurement of the accuracy of ADC

As a practical application of ND-PC104P-SH4 we will construct a precise analog-signal measurement instrument such as a digital voltmeter.

We compared the accuracy of analog-digital conversion (ADC) powered through the ND-PC104P-POE with that of ADC directly input 5Vdc to the ND-PC104P-SH4.

Module	MPC624* (Micro/sys)	ADM-616PC104 (Micro Science)			MPC624	ADM-616PC104
ADC	<b>24-bits</b> ΔΣ	16-bits	Direct 5Vdc power	SD	5.324x10 <sup>-6</sup> V	6.271x10 <sup>-3</sup> V
Sampling rate	6.9Hz	100kHz		Effective resolution(2 <b>0</b> )	20 bits	10 bits
Input voltage	+/-10.1V	+/-10.0V	V PoE )-4V	SD	5.862x10 <sup>-6</sup> V	9.832x10 <sup>-3</sup> V
LSB	3.7625x10⁻ <sup>8</sup> V	3.0517x10 <sup>-4</sup> V		Effective resolution(2 <b>0</b> )	20 bits	9 bits

Two types of PC/104 ADC module that we measured

**Results of measurement** 

For the MPC624 (low-rate sampling), we had good accuracy even if we used PoE. For the ADM-616PC104 (high-rate sampling), the accuracy decreased using PoE.

The ND-PC104P-POE mounts a DC/DC converter in a PoE module circuit to generate a voltage of 5Vdc. We consider that the switching noise from the DC/DC converter affects the ADC.

If we require both high-accuracy analog-signal measurement and PoE capability, we need to carry out a filtering process such as averaging.

We developed ND-PC104P-SH4 and ND-PC104P-POE in cooperation with Nichizou Electronic Control Corporation.

\* MPC624 generates the most accurate 29-bit data when the slowest sampling rate of 6.9Hz is selected.