Development of Industrial Embedded Controller, μPIBOC C3

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Abstract

Industrial systems such as manufacturing equipment and inspection equipment require high responsiveness to operate in synch with other equipment. Achieving high responsiveness requires real-time processing executed within the requested timeframe.

A real-time Operating System (OS) is an OS for building real-time capabilities. The industrial controller, μPIBOC C3, is a compact embedded controller equipped with a wide variety of interfaces as standard, equipped with Windows 10 IoT Enterprise LTSC2019. In addition, we have also made available INtime, a real-time OS, as part of our lineup responding to applications that require real-time performance on Windows environment.

1 Preface

We continue to sell Windows PCs as industrial controllers for equipment systems that operate 24/7/365. To incorporate the roles of a conventional industrial computer (PC) and a Programmable Logic Controller (PLC) into a single industrial PC, we developed μPIBOC C3, an industrial embedded controller that achieves high responsiveness and high reliability. This paper introduces the high responsiveness of μPIBOC C3 and INtime that is a real-time Operating System (OS).

2 Features of μPIBOC C3

2.1 Hardware Features

μPIBOC C3 is designed to be used as an embedded unit for system equipment and has an improved operability and efficient wiring work through front access. The main specifications are as follows.

(1) Processor

The processor is equipped with Intel 7th generation Xeon E3-1505M v6 (4 cores, 8 threads).

(2) Memory

For memory, 4 slots for ECC-compliant DDR4-2400 are provided. Memory can be expanded to 32 GB (4 × 8 GB SO-DIMMs).

(3) Drive unit

The drive unit is equipped with two Solid State Drives (SSDs) (1 TB). By adopting hardware mirroring, redundancy is achieved without consuming processor resources and without reducing application processing speed.

(4) Ethernet

Four (4) Ethernet 1000BASE-T ports are equipped as standard. Any port can be assigned exclusively for INtime when using INtime. Also, by installing an optional driver, a dedicated port for EtherCAT is possible.

(5) 7-segment LED displays

Power On Self Test (POST) code in two-digit hexadecimal numbers is shown. The status at the time of error occurrence and the elapsed status from power boot to OS boot is displayed.

(6) Built-in diagnostic tool

When a failure occurs, the diagnostic tool is used to help pinpoint the cause of the failure. Fig. 1 shows the system configuration. Table 1 shows the basic specifications. Table 2 shows the operating conditions.

2.2 Real-time OS

In addition to Windows 10 IOT Enterprise 2019 LTSC, INtime, a real-time OS, can also be installed.

2.2.1 INtime

INtime is a Real Time Operating System (RTOS) developed by TenAsys, that can run alongside Windows OS. The INtime kernel incorporates the Windows OS and Windows applications as a

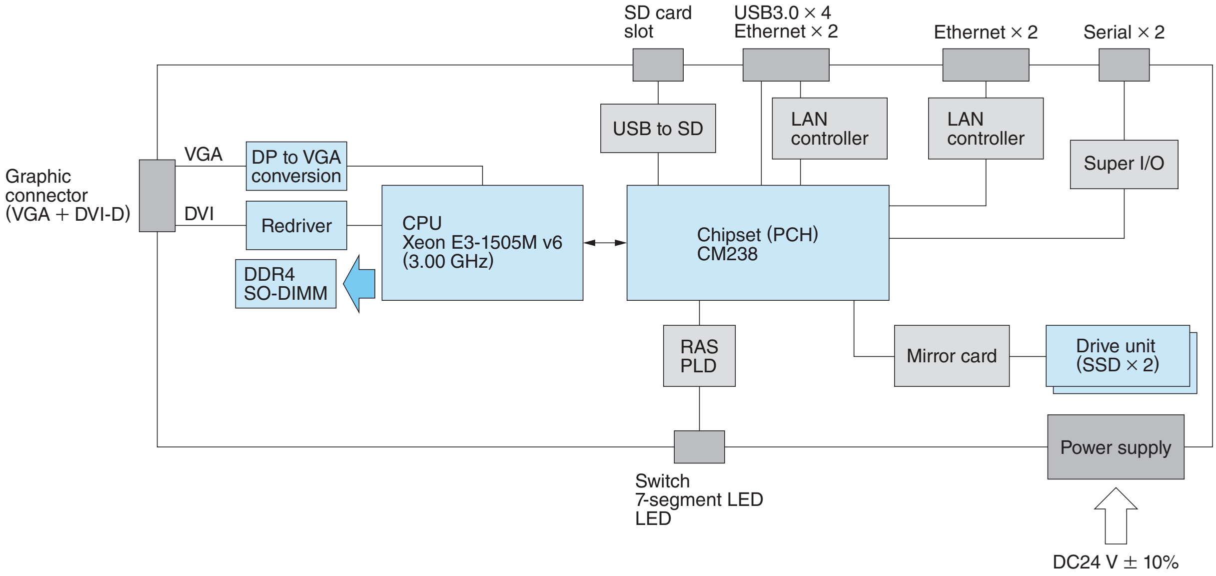

Fig. 1 System Configuration

A system configuration of μPIBOC C3 is shown. Based on the CPU and the chipset, it is possible to understand which interface is used.

Table 1 Basic Specifications

Basic specifications of μPIBOC C3 are shown. A maximum of 4 main memory boards can be installed. The drive unit comes in the RAID1 configuration.

Item	Specifications	
Processor	Intel Xeon E3-1505M v6 Base frequency: 3.00 GHz No. of core/thread: 4Core/8Thread	
Chipset	CM238	
Main memory	DDR4 SO-DIMM ECC-conforming A maximum of 4 8 GB boards can be mounted. Applicable chip standard: DDR4-2400 MT/s	
Drive unit	SSD (1 TB) × 2 units installed RAID1 (Hot swappable)	
Interface	Graphic	[DVI-D] Maximum resolution 1920 × 1200: 1 port [VGA] Maximum resolution 1920 × 1200: 1 port
	USB	USB3.0: 4 ports
	Serial	RS-232C conforming: 2 ports Max baud rate: 115.2 kbps
	Ethernet	10BASE-T/100BASE-TX/1000BASE-T 4 ports Wake On LAN, Jumbo frame applicable
	SD card	SDHC conforming: 1 slot
Switch	Front side: RESET/NMI/CLEAR/POWER Rear side: Power switch	
Display functions	LED display: DRIVE/SD/POWER/POST/ERROR, 7-segment LED	
OS	Windows10 IoT Enterprise LTSC 2019 (64 bit) INtime (Extension real-time OS 32 bit) ※Optional	
RAS functions	CPU chip temperature abnormal, drive temperature abnormal, casing temperature abnormal, WDT error (system level, application level), drive (SMART or Mirror) error, SSD lifetime abnormal, ECC error	
Built-in diagnostic tool	Memory diagnosis, SSD diagnosis, display (VGA, DVI-D) diagnosis, RTC diagnosis, serial port (RS-232C) diagnosis	
Power input	DC24 V ± 10%	
External dimensions	W267 × H85 × D297 mm	
Main-body weight	Approx. 4.5 kg	

single INtime RTOS process at boot. As a result, the real-time task achieves real-time performance in units of time called microseconds (μs) while it realizes the Windows environment. In addition, applications developed for INtime RTOS are protected by the memory protection function. As a result, each

Table 2 Operating Conditions

Operating conditions of μPIBOC C3 are shown.

Item	Specifications	
Ambient temperature	During operation	5～45℃
	During inactive	−10～60℃
Ambient temperature	During operation	20～80%RH (No dew condensation)
	During inactive	10～90%RH (No dew condensation)
Vibration durability	During operation	±0.625 mm (1～14 Hz), 4.9 m/s² (14～100 Hz) 2 both-way, XYZ directions 27 minutes each <JEITA IT-1004B ClassS>
	During inactive	14.7 m/s² (16.7 Hz) XYZ directions 30 minutes each
Shock durability	During operation	19.6 m/s² (11 ms sinusoidal half wave) in XYZ directions 3 times each
	During inactive	147 m/s² (11 ms sinusoidal half wave) in XYZ directions 3 times each
Ambient atmosphere	No rigorous dust float Freedom from corrosive gases and conductive dust No brine hazard environment	
Acoustic environment	Acoustic pressure 95 dB or below	
Insulation resistance	DC500 V 10 MΩ or higher (between LAN-SG)	
Withstand voltage	AC1500 V for 1 minute (between LAN-SG)	
Grounding	Class D grounding	
Current consumption	8 A Max.	
Inrush current	13 A Max. (within 50 ms)	

INtime RTOS process space is separated, and in the event of a memory corruption error, the effect is limited to the same process. Windows is isolated as an INtime RTOS process, so even if the Windows kernel stops functioning due to the dreaded Blue Screen Of Death (BSOD) by "Kernel Security Check Failure" issue, other INtime RTOS processes can continue unaffected. Fig. 2 shows a coexistence image of Windows and INtime.

2.2.2 INtime RTOS I/O Interface

Since industrial systems exchange external signals such as sensor signals, contact signals, and motor control signals, real-time processing can be applied to these external Input/Output (I/O) signals. INtime RTOS supports a variety of I/O interfaces, covering everything from standard I/O such as RS-232C and RS422/RS485 to industry standard fieldbuses such as EtherCAT and CC-Link. Fig. 3 shows the I/O interfaces supported by INtime RTOS.

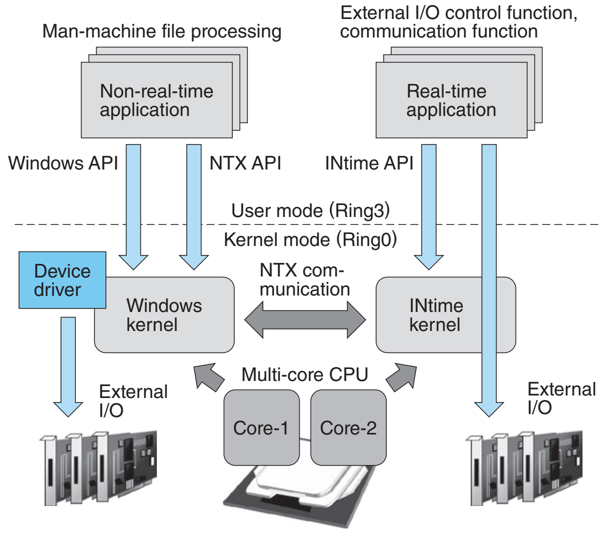

Fig. 2 Coexistence Image of Windows and INtime

Features of INtime RTOS are shown. Apart from the CPU core, both Windows OS and INtime RTOS can be assigned. In this arrangement, a real-time task with a real-time property in μs unit can be realized while the Windows environment is maintained. Since Windows is separated as an INtime RTOS process, other INtime RTOS processes can be continued even if the Windows kernel stops functioning due to the dreaded BSOD (Blue Screen of Death) by "Kernel Security Check Failure" issue.

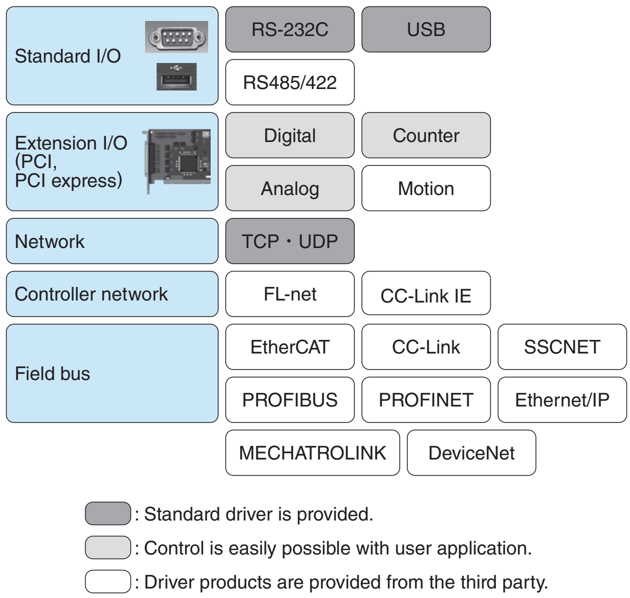

Fig. 3 I/O Interfaces Supported by INtime RTOS

The I/O interface supported by INtime RTOS is shown. In industrial systems, data exchange is carried out in conjunction with external signals (I/O signals) such as sensor signals and contact-point signals.

2.2.3 Performance Comparison between INtime RTOS and Windows

Comparing the real-time performance of INtime RTOS and Windows, we started the application with a timer of 5 ms cycle and conducted a confirmation test of timer accuracy and application execution accuracy. Three cores of μPIBOC C3 processor were assigned to Windows and one core to INtime RTOS. When the application started, it sent communication packets to the other device via Ethernet. At that time, INtime RTOS and Windows used separate Ethernet ports. **Fig. 4** shows the test configuration and **Fig. 5** shows the measurement results. In the Windows test, we used a multimedia timer, which is well known as a high-precision timer. According to the results, we confirmed that there were variations in both the timer activation time and the packet transmission period from the application.

We confirmed that INtime RTOS performed highly accurate periodic transmissions. Since INtime RTOS can run alongside Windows, it is possible to implement a Windows Graphical User Interface (GUI) and file system. At the same time, we believe that it is possible to build a system that can ensure high-precision responsiveness, such as sensor control and communication with devices, on the INtime RTOS side.

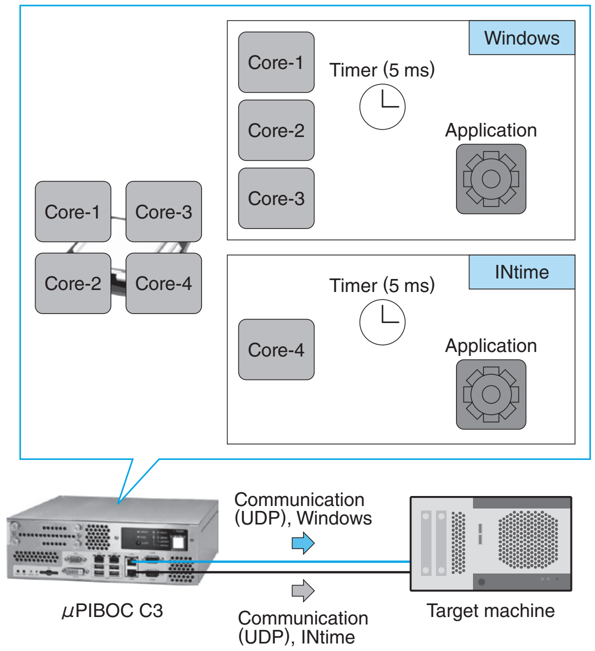

Fig. 4 **Test Configuration**

A configuration to evaluate the real-time property of INtime RTOS is shown.

3 Postscript

We introduced the features of the industrial controller, μPIBOC C3, and INtime RTOS. As a set package, we will promote both our controller and INtime RTOS in fields where the real time fast OS is required, such as manufacturing equipment and inspection equipment.

In the future, we will continue to realize further functional improvements of embedded controllers and a better range of optional products and promote product development that meets customer requirements.

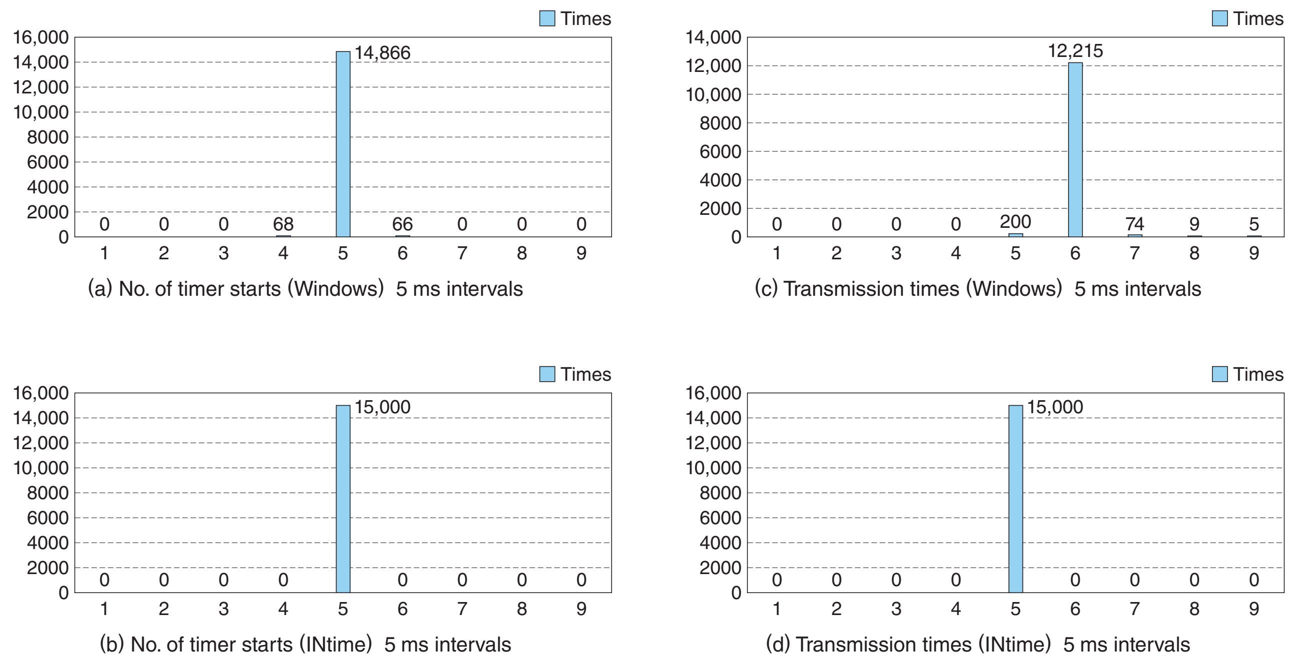

Fig. 5 **Measurement Results**

The results of evaluation on real-time property of INtime RTOS are shown.