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Development of a multi-purpose compact board for robot control systems

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Abstract: This paper presents development of a multi-purpose compact board for robot control systems and its applications. Advanced robot system with many actuators and sensors require complicated control system. Different sensor has different specification of signal output. Advanced robots have to accept many kinds of signals. Prototype robots in the laboratory are often extended and modified for the research. Common computer hardware for many kinds of actuators and sensors contributes to the efficiency of its software development. We have developed the multi-purpose Micro Control Unit (MCU) board that can be used for many kinds of actuators and sensors. The MCU board is designed so that it can be used for many devices and many applications. Two applications of the MCU board are presented to show its effectiveness.

Keywords: Distributed control system, Micro control unit, Robot control system, noise suppression

1 INTRODUCTION

Previously, large-sized computer boards and interface boards are used for control of various robots. These boards are so large that they are not easy to be located in the arms and legs of robots. Lots of long cables are required between the boards and various devices such as sensors and motors.

Recently, performance of small-sized one-chip microcontrollers is increasing. The microcontrollers have the function of CPU, RAM, Digital I/O, A/D converter and so on. Many kinds of microcontroller such as dsPIC by Microhip Technology Inc., H8 by Renesas Electronics Corporation, AVR by Atmel Corporation and ARM architecture are available for robot control.

Various MCU boards for sensing and control have been developed [1][2][3]. Lin at el. developed inertial measurement unit for human body motion tracking [1] and wireless inertial measurement unit for mastication analysis [2]. Faudzi et al. have developed the system using PSoC [3].

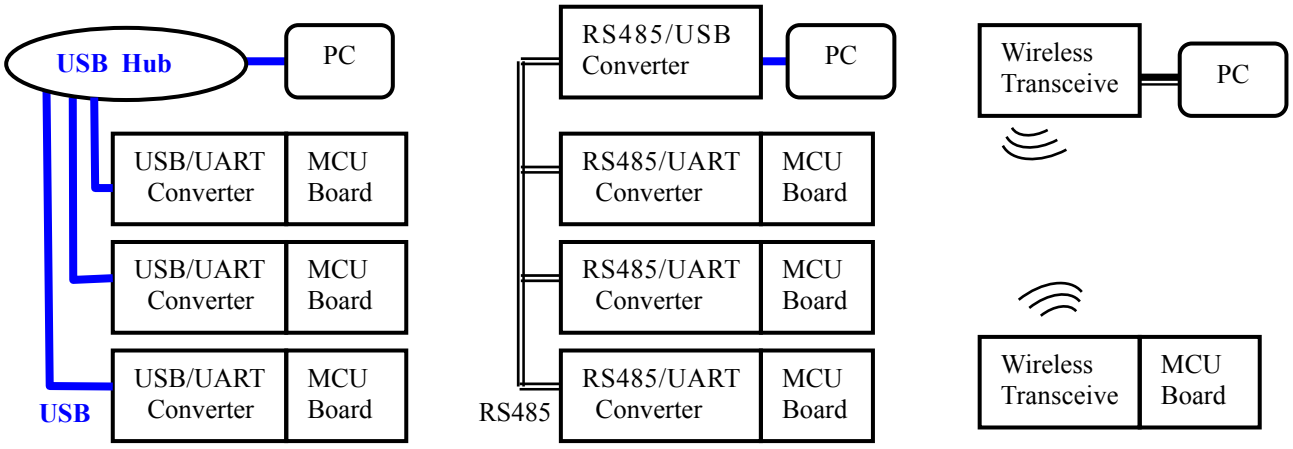
We have proposed the control system using a PC and MCUs (Micro Control Units)[4]. The PC are used for calculation of whole robot, and the MCU boards are used for local calculation and digital/analog interface. We also developed MCU boards [4] [5] and they are used in our humanoid robot [4], a robot hand [5], iWalker-2 [6] by Tanaka et al. and Omnidirectional Driving Gear by Tadakuma et al [7]. In this paper, a design and application of a new MCU board are presented. The board is more compact and more convenient than that presented in [5].

2 ROBOT CONTROL SYSTEM USING MCU BOARDS

If a MCU board can be designed for multiple purposes, various robots can be controlled using same boards. For a simple robot with a small number of actuators and sensors, stand-alone MCU board is embedded to control it. For a medium-scale robot, small number of MUC boards can be used for the control using communication standard such as UART (Universal Asynchronous Receiver Transmitter), I2C and SPI(Serial Peripheral Interface). For advanced robots using complicated control algorithms, PC are used for calculation. The advantages of PC are high computing power and wealth of software. The disadvantages of that are its largeness and high consumed power.

Hybrid system using a PC and MCUs are effective for robot control. The PC carries out complicated calculation and MCUs input and output digital/analog signals. Because many kinds of MCU have UART and most PCs have USB (Universal Serial Bus), a PC can communicate with MCUs using USB/UART shown Fig. 1 (a). Many MCUs can be connected with a PC using USB hub and maximum length of USB cables is 5 m. For large-scale robots such as humanoid robots, the control system using a PC, MCUs and RS485 (EIA-485) shown Fig. 1 (b) is effective [4]. Maximum length of RS485 cable is 1.2 km.

RS485 cable can be connected with MCU via RS485/UART converter. Conversion between USB and RS485 is possible by connecting USB/UART converter and UART/RS485 converter.



(a) system using USB (b) system using RS485 (c) wireless system

Fig. 1. Sensing and control system using a PC and MCU boards

MCU boards are desired to have the function of wireless communication shown Fig. 1 (c). For example, sensor network system to detect the human behavior is important for the robot control in human environment. Many MCU boards with sensors should be located in rooms. Many long cables for communication of MCU are inconvenient in the rooms. Wireless MCU board is easy to be located in the rooms.

MCUs for robot control are desired to have the many I/O function such as digital I/O, A/D converter, pulse counter, PWM output. A/D converters are used for reading the sensor signals. Pulse counters and PWM modules are used for feedback control of servo motors. D/A converter can be replaced by the integration of PWM and low-pass filter.

3 DESIGN OF MCU BOARD

Considering the requirements written in previous section, we have developed a new MCU board shown in Fig 2. Size of the board is 59 mm by 26 mm. A MCU, linear regulator, DC jack, pin headers, pin sockets for UART and pin sockets for writing program are mounted on a double-sided board. The MCU is dsPIC33FJ128MC204 by Microchip. Most of MCU pins are connected to the pin headers. The basic specification of the board is shown in Table 1. This board can control two DC motors with rotary encoders.

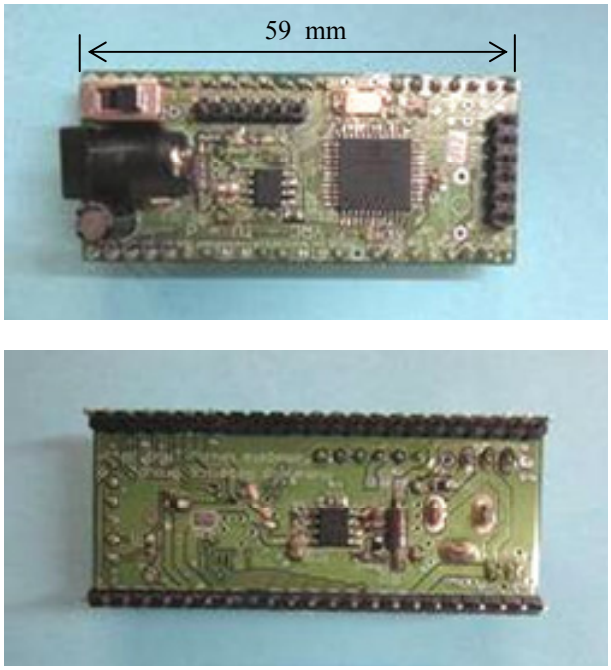


Fig. 2. Top and bottom biew of the MCU board.

Table 1. The specification of the MCU board

function	number of channels	main use
12bit A/D converter	9	Sensors
QEI counter	2	rotary encoders
PWM	8	H-bridge Circuits Analog input drivers
Digital I/O	32	Sensors and actuators
UART	2	USB, RS485, XBee
SPI	2	
I2C	1	

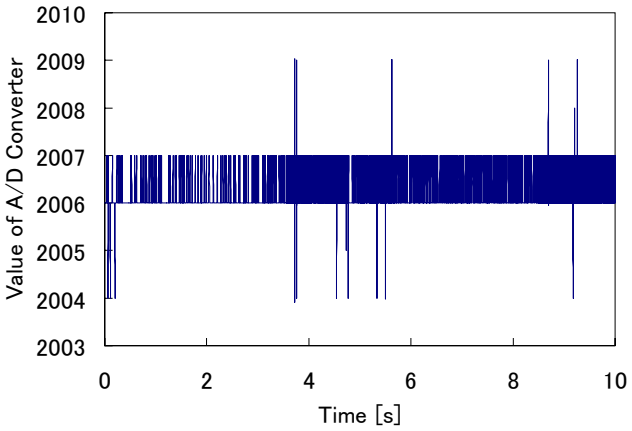


Fig. 3. The result of the experiment.

The pin sockets for UART is designed so that USB/UART converter "FTDI Basic Breakout - 5V" by Sparkfun Electronics or compatible board can be attached to it. The connecter for program writing is designed for the writer of PICkit2 by Microchip. The PICkit2 is connected a PC using a USB cable. Because the pitch of the pin headers is 2.54 mm, the board can be inserted to bread board or 2.54-mm pitch universal board.

The measure against noise is important for MCU board, because the noise have a bad effect on accuracy of A/D converter. To reduce power-supply noise, linear regulator and ferrite bead are utilized. The ground of analog circuit has a single connection to that of digital circuit so that the bad effect of the digital current to analog circuit is reduced.

4 EXPERIMENT

To evaluate the MCU board, we have performed an experiment. In the experiment, voltage of battery cell is measured in order to see the effects of noise. The result of the experiment is shown in Fig. 3. If the effect of the noise is large, variation of the voltage becomes large in the board. In 10 seconds, 4876 times A/D converter data were obtained. Maximum value was 2008 and minimum one was 2004. Most of obtained digital values were 2006 or 2007. Digital value of 2004 was obtained 10 times, 2005 was obtained once, 2008 was obtained once and 2009 was obtained 5 times.

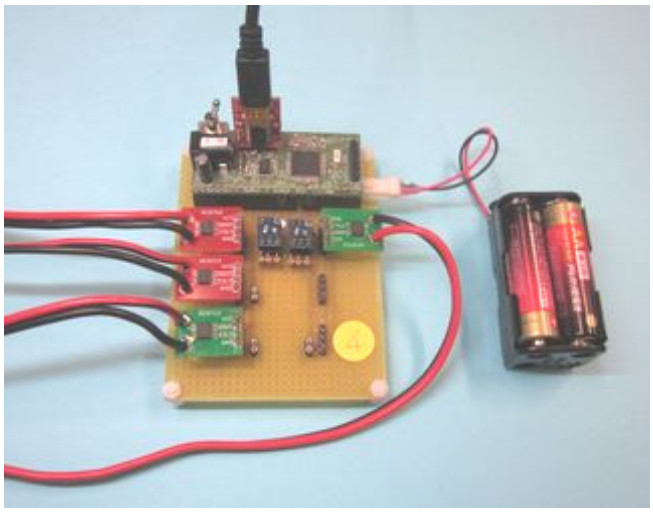
5 APPLICATION OF THE MCU BOARD

We show two application of the MCU board. First one is the system to measure the current of DC servo motors. The photograph of the system is shown in Fig. 4 (a). Motor current is measured by hall effect-based linear current sensor IC. The IC output the voltage signal and the MCU measured the voltage using A/D converter. The values of A/D converter are transmitted to the PC via UART/USB converter.

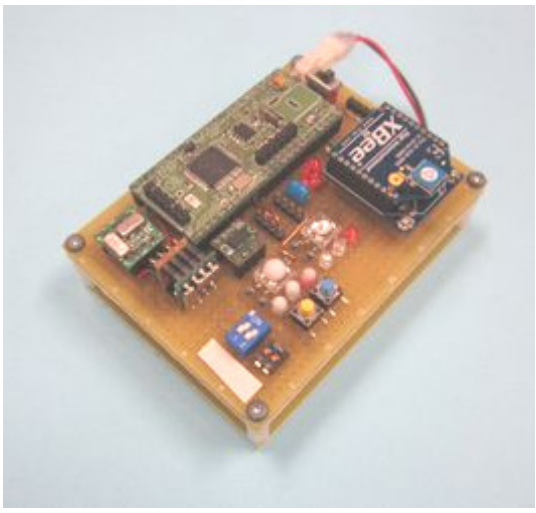
The other application is sensing system of acceleration and angular velocity with wireless transceiver. The photograph of the system is shown in Fig. 4 (b). The system includes 3-Axis analog output acceleration sensor and analog output vibrational gyroscope. The acceleration sensor is MMA7361LC by Freescale Semiconductor, Inc. and gyroscope is ENC-03R by Murata Manufacturing Co., Ltd. The signals of acceleration sensor and gyroscope are obtained by A/D converter of the MCU. The MCU transmits A/D converter value using UART. For wireless communication, XBee by Digi International Inc. is utilized. XBee receives the data from UART and converts it to wireless signal.

6 CONCLUSION

The development of a multi-purpose compact MCU board has been presented. Requirements of multi-purpose MCU boards have been discussed. The design and specification of the MCU board have been presented. The experimental result of the MCU board shows that variation of A/D converter value is very small when the voltage of battery cell was measured. This result indicates that the bad effect of noise is small. Two applications of the MCU board show that the board can be used for multiple purposes. In future work, we will use the board for the control of a humanoid robot and sensor network systems.



(a) measurement system of motor current



(b) wireless sensor system

Fig. 4 Application of the MCU board.

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