

An Efficient Multi-Protocol Gateway System Design on the Zigbee

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Abstract— In this paper we propose the multi-protocol gateway system on intelligent zigbee. The proposed multi-protocol gateway system was designed that the gateway divided to independent into CPU board and base board for gather information for streetlight power control and environmental monitoring and verify the on-site situation and control as real time using the wired and wireless networks. The proposed multi-protocol gateway, the system's power, impact, continuous operation, the voltage stability test results, it were obtained reliable monitoring results with success rate of normal operation of over the 95%.

Keywords— Zigbee, Multi-protocol, Gateway, Interface, Multi sensor

I. INTRODUCTION

The wireless sensor network is an adaptive network that is composed of microprocessors, sensors, actuators, and wired or wireless communication devices achieved in the form of small devices. This is essential technology, not only for professional and technical fields such as inventory, collection and analysis of information related to human status, including areas such as ecological environment monitoring and military surveillance, but also for the establishment of ubiquitous computing of the future, next generation mobile communication, intelligent transportation systems and home networking [1-3].

The function of sensor networks is to collect peripheral information through an ambient sensor, and to manage the collected information through communication. Recently, the development of compact electronics, digital signal processing, and low power radio frequency technology have enabled implementation of a practical large-scale wireless sensor network. Looking at the applications, it can be used in urban planning, traffic measurement, disaster and disaster prevention, and lighting control, to name a few. For intelligent technique settlement, a flexible network system that can combine various devices and run them is required, including the running of applications and software operation, since different devices employ different hardware platforms. After collecting environmental data and a variety of situations received by the sensor, the system must synthesize, analyse and evaluate such data before the network modules forward it to central processing. The data is then divided appropriately by forwarding a control command [4-7].

Techniques are being developed that can be integrated with the existing wired networks, allowing wireless network development. Therefore, to use the new wireless devices for the collection of environmental data, development of a gateway that can be delivered and processed is required. A control method to support such technical development is also needed.

To solve this problem, this paper proposes an intelligent multi-protocol gateway for local communication systems. The multi-protocol gateway collects information for power control of streetlight systems and environmental monitoring. It was designed by dividing the base board and the CPU board for independently checking and controlling the real-time on-site conditions through a wireless network, which subsequently tests the forward power, and performs impact tests, tests of continuous operation, and voltage stability tests for reliability.

II. MULTI-PROTOCOL GATEWAY SYSTEM

The Multi-Protocol Gateway system proposed herein as the hardware of intelligent local area communication systems collects data using a composite wired and wireless communication process with a multi-sensor, employing CDMA and Ethernet (TCP/IP). It was designed for transfer to the main server. In addition, the communication module to be installed around the street light was equipped with a ZigBee antenna (2.4GHz band, 5dB) and a transceiver module (ZigBee module), and a radio protocol, Ethernet protocol and RS232 were designed to control the display or input interface in order to manage a set of sensor modules for the classified street lamp lighting control unit area.

Figure 1 shows the configuration of the multi-protocol gateway system. The gateway system was separated into the CPU board and the base board. The two boards were then combined to form a single gateway, which was designed to allow convenient debugging. The CPU board and base board were designed to be detachable through the connector. This makes replacement of hardware easy, because the boards were designed independently. The CPU board provides a communication interface and expansion I / O ports, such as ports for the performance of basic functions, as the board which performs the main function of the gateway and is the same as the brain, to compare with the human body. The base

board is composed of the applications based on the CPU board, and has the role of the arms and legs.

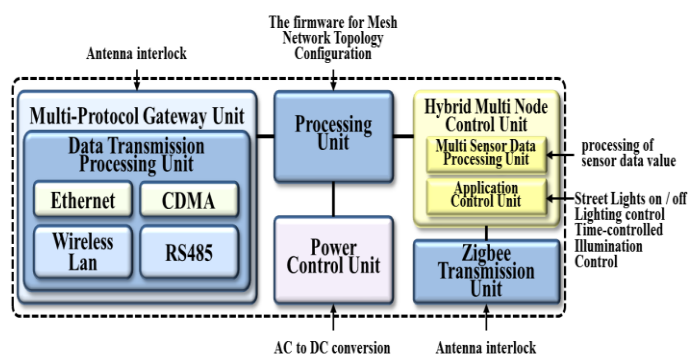


Figure 1. Multi-protocol communication and control configuration

Figure 2 shows the component layout of the CPU board. It was designed to be 90 x 62mm in size, while the thickness was designed as a six layer PCB board of 1.6T to reduce the standard size, because the CPU board's circuit was mounted on both sides due to complexity.

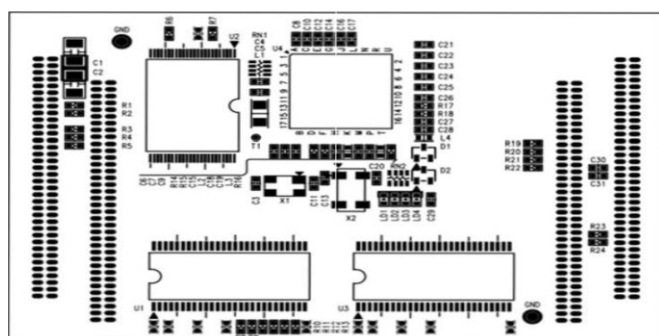


Figure 2. CPU board parts layout

Figure 3 shows the arrangement of the base board part. The base board was designed with a board size of 170x130mm, and the thickness was a four-layer board of 1.6T components, making the board's standard size larger than the CPU board because the CPU board or ZigBee module, as well as LCD are mounted on the base board. The components were mounted on both sides.

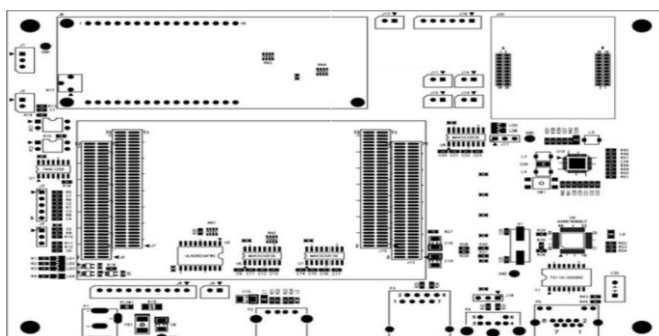


Figure 3. Base board parts layout

A data transmission and reception processing section interface is shown in Figure 4. JTAG, Console, CDMA, GPS, Ethernet, ZigBee, LCD, etc. were designed to be connected to an external device for integrated control of the wired or wireless communication protocol, or the input-output interface. At this time, CDMA, GPS, and the ZigBee interface were connected via the RS-232 port, and CDMA and GPS were connected with the UART0 port, but they were selectively used through resistance mounting because they cannot be used at the same time. A 16x2 LCD character display portion was used to display the information gathered by the gateway. This was used in the kernel and application SW download.

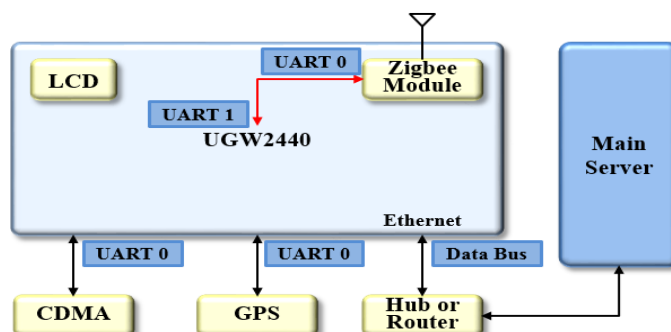


Figure 4. Process interface on the data transmit

Figure 5 shows the interface of the operation processing. In the gateway, a local area communication system and Intelligent Wireless Lan designed circuitry were used for the firmware technology with a feature for Mesh network configuration. Figure 5 refers to the marked General Process portion in the Gateway's CPU S3C2440. If an interrupt request is received through the IRQ port, an Ethernet communication action sequence activates the Address Line through AEN or PSEN. After that, the functions of the Read and Write are carried out in RDn and WRn, and it transmits and receives through the Data Bus.

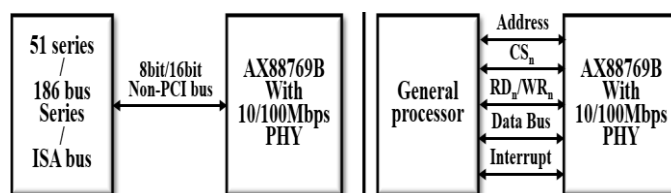


Figure 5. Operation processing interface

Figure 6 shows the ZigBee transceiver interface unit. The ZigBee transceiver, which performs the key function of the gateway, was designed to be a communication control unit using an intelligent local area communication system. The ZigBee interface circuit were transmits and receives data using the RS-232 communication method that UART1 of the gateway and UART0 of ZigBee modules. At this time, the communication mode between the CPU and the ZigBee module followed the RS-232 manner, connecting the UART0 and UART1 port with the ZigBee module of S3C2440.

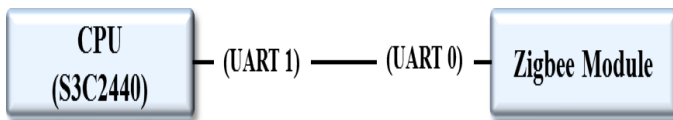


Figure 6. zigbee transceiver interface

Figure 7 shows a GPS module interface. CDMA and GPS on the CPU board were selectively configured with UART0, which was designed to be switched according to whether or not there was mounted resistance. At this time, if Ethernet communication was used, UART was connected with GPS as H/W because CDMA was not used.

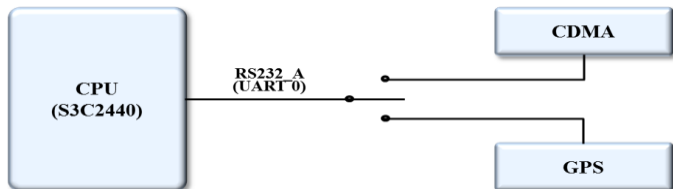


Figure 7. GPS Interface

Figure 8 shows the interface with the circuit of the Char LCD. A variable resistor of 10KΩ was designed to regulate the Light brightness, and pin 1 and pin 16 were connected to the ULN2803. The ULN2803 IC could drive the large current because the array was configured as a TR of Darlington type.

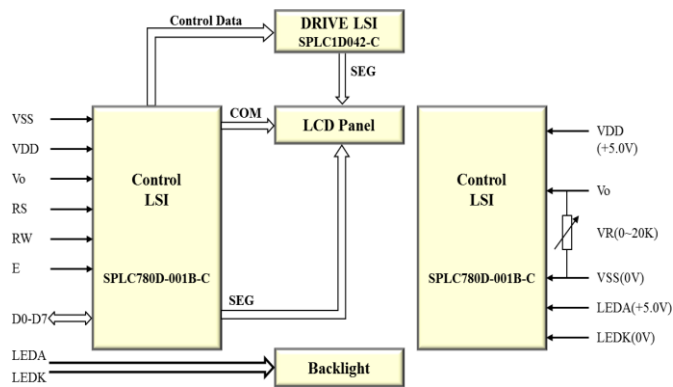


Figure 8. Char LCD interface

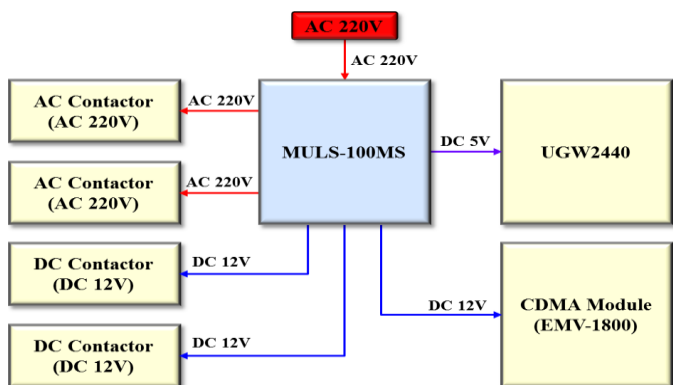


Figure 9. MUSL-100MS external interface

An external interface of the MUSL-100MS is shown in Figure 9. Gateway power was supplied from the power supply Power Board because it uses 5V. MUSL-100MS received 220V input, which was converted into DC 5V power through a regulator after it was converted into DC 12V power through the SMPS. MUSL-100MS was internally converted into 12V and 5V through a noise removal and regulator, so DC 12V was supplied to the AC switch, magnetic switch control, and CDMA module, while DC 5V was supplied to the gateway through the connector.

Figure 10 shows the interface of gateway power conversion, received from the DC 5V adapter or MUSL-100MS. The DC 5V supplied was stepped-down through TPS65021, which internally supplies the Chips implementing each of the functions or power in the module. For that reason, the Power Management module (ICULN2803) was mounted inside the gateway, and the signal of the GPIO port was designed to control the MUSL-100MS board.

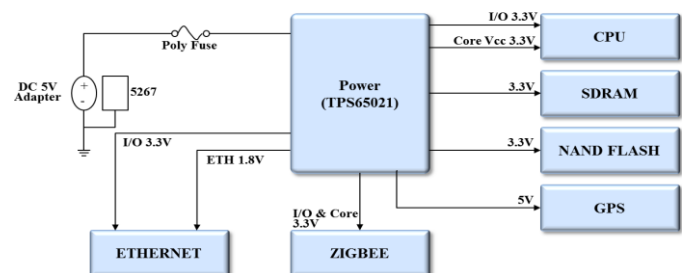


Figure 10. Power conversion interface

The gateway prototype is presented in Figure 11. The MCU of the gateway used an ARM915T (S3C2440), the OS designed to support Smarter, ZigBee, and CDMA or Ethernet interfaces through Linux. Further, the 16x2 Char LCD was used to confirm the status information of the gateway. The gateway was designed to transmit street light control commands and sensor node data, control the AC power of the transmission via transmission power consumption and magnetic switch sensor nodes through the Power meter, and perform its own independent control with a fail-safe timer. The display unit used a dual type Char LCD of 16x2, and the display screen was applied to improve the visibility of the blue color for reliability, and it represented the state information of a street lamp control system when street lamps were installed.

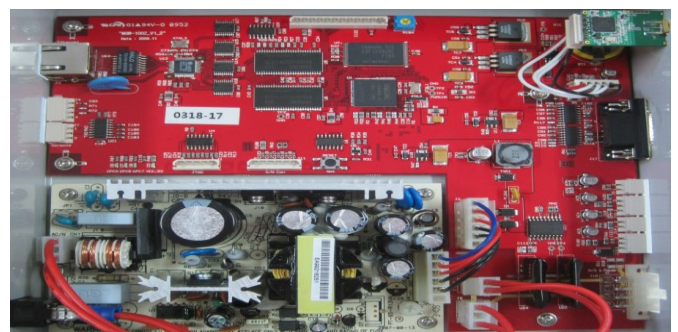


Figure 11. Multi-protocol gateway prototype

III. THE EXPERIMENTAL RESULT

In this paper, voltage stability tests were conducted regarding the test power for the normal operation of the multi-protocol gateway system, along with reliability tests, impact tests by free fall, a continuous operation test with the power On/Off set at a predetermined intervals, and automatic repeat reset tests.

Table 1 shows the results of the impact test and the gateway power. The power test simultaneously examined the 220V, 12V, 5V, 3.3V, and 1.8V power supply. A total of 76 times implementing normal operation achieved the success rate of 95%. The impact test was conducted by free-fall from 0.5m 100 times, from which normal operation was achieved a total of 95 times for the success rate of 95%.

Table 2 shows the results of continuous operation of the gateway. Experiments of the power turned on/off for one time interval of 12hours were carried out, and it was possible to obtain normal reception of the resulting data through the ZigBee

TABLE 1. POWER AND IMPACT TEST RESULT

Item	Power test	Impact test
Conditions	each power test (220V,12V,5V,3.3V,1.8V)	0.5M Freefall
Number of experiments	80 times	100 times
the number of normal operation	76 times	95 times
Success rate	95%	95%

TABLE 2. CONTINUOUS OPERATION TEST

Item	Contents	
Conditions	120 hours / 1 hour interval on/off	
Function	Data transmission and reception (zigbee)	Normal
	Magnetic switch control	Normal
	LCD Display	Normal

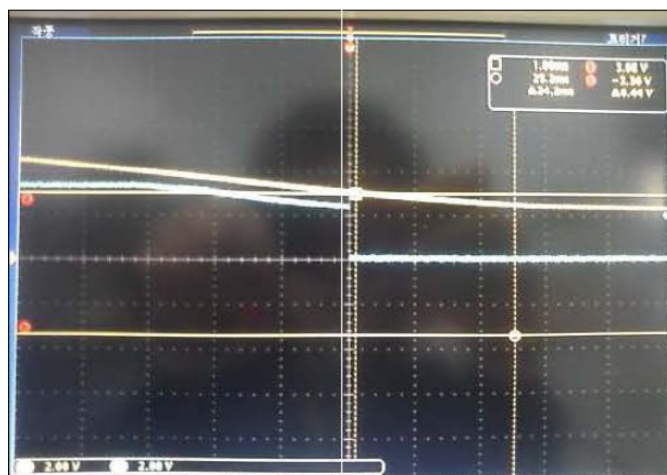


Figure 12. Voltage stability test result

The results of the voltage stability test is are presented in Figure 12. While supplying a voltage between DC 2V ~ 8V to the gateway, the waveform of the reset signal (RST_IN *) of the power and the gateway were measured. The reset signal was measured as the voltage drop from high to low moment, because instantaneous voltage drop from high to low means that the gateway automatically resets operation and it takes no action. Normal operation of the gateway was found to require voltage of 3.20V or more, because the reset signal dropping from high to low is 3.20V, and the gateway automatically undergoes repeated reset at voltages of 3.20V or less.

IV. CONCLUSION

An intelligent local communication multi-protocol gateway system was proposed herein. The proposed multi-protocol gateway system was divided into the CPU board and the base board, which were designed independently to allow disconnection through the connector for ease of hardware replacement. It was possible to obtain the power, impact, continuous operation, voltage stability and reliability test results at over 95% success rate.

The application of the proposed intelligent local communication multi-protocol gateway system will be able to secure energy-saving technologies through hybrid node control techniques and ZigBee, with a wireless network based on Mesh Network configuration, power savings achieved using firmware technology, reliable communication technology, and intelligent and efficient real-time monitoring and control techniques.

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