Development of Data Communication Terminals Applicable to Low Power Wide Area (LPWA)

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Abstract

As a result of the recent proliferation of the Internet of Things (IoT) devices, various equipment and apparatus are connected to the Internet and a variety of gathered data and information are exchanged. Part of the gathered data is information not formerly available or too difficult to collect. As the result, new business opportunities are increasing with managing the analysis of such information.

According to the type of monitoring tool and kind of information being gathered, these newly developed systems deal with different timing and volume of data gathering. In addition, the market calls for cheaper communication costs and cost-effective data communication terminals that cost less in system installation and maintenance.

We realized a lower communication cost by adopting Long Term Evolution (LTE) and Low Power Wide Area (LPWA) communications conforming to relevant communication standards. In so doing, we realized a long-term battery drive and developed data communication terminals with minimum cost for the cabling work.

1 Preface

In recent times, information actively utilized in various maintenance work or services was formerly acquired manually by people, not collected automatically with the use of machines. A business called "sign diagnostic service" by which equipment temperature, vibration, and operating conditions are measured, compares the acquired values with the data of normal conditions and analyzes them to yield a final judgment. Such technical trends are expected to continue in the future. It is generally believed that information can be accumulated from many different directions and sources.

In order to acquire these data, measures taken must be easily realized. Since a variety of objects can be predicted for gathering data, the market calls for the omission of construction work for a power supply system and the elimination of cabling work.

In order to meet such market needs, we developed a data communication terminal that is a combination of an ultra-low power consumption microcomputer technology and a Low Power Wide Area (LPWA) communication system that realizes long-distance communications with low power consumption. Fig. 1 shows an external appearance of this terminal. This paper introduces the features of our data communication terminal.

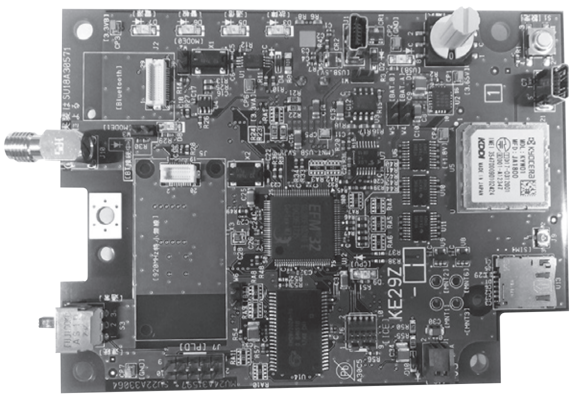

Fig. 1 Our Data Communication Terminal

Our data communication terminal is shown.

2 Low Power Consumption Type Microcomputer

Fig. 2 shows the outline of the monitoring system expected to be in demand in the future. For microcomputers adopted for our embedded type computer systems, the market calls for features such as high-speed processing and multiple functions.

These microcomputers tend to increase their power consumption. Practically, some hundreds of milliwatts (mW) is consumed. For this reason, it is indispensable to install a large-capacity battery cell for extended computer operation under the conditions of no source of power. Such a feature is not suitable for a data communication terminal. Unlike technical achievements in the past, a low power consumption microcomputer is based on a design concept to lower the power consumption though other functions are limited. The adopted Central Processing Unit (CPU) can lower the power consumption down to 10 mA during operation and approximately 1 μA in sleep mode. Using such a low power consumption microcomputer, we have developed a data communication terminal that can be used for an extended amount of time with minimal power consumption.

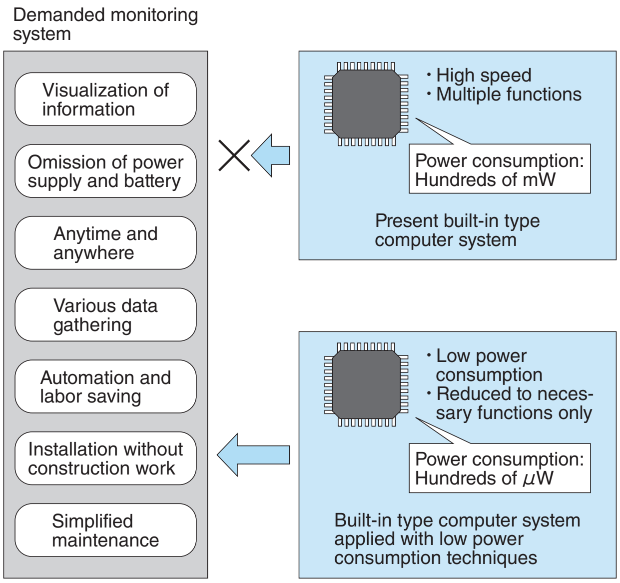

Fig. 2 Outline of Monitoring System Expected to be in Demand in the Future

The outline of the monitoring system demanded to realize an IoT society and the application to our built-in type computer systems are shown. Since a conventional built-in type computer system consumes very much electric power, it is not suitable for use in the IoT-based monitoring system.

3 Low Power Consumption Communications

Data communication terminals released in the past were based on the communication standard for mobile phones. At an early stage, a communication module conforming to the Code Division Multiple Access (CDMA) Standard was adopted. Because of recent trend changes in mobile phone networks, however, modules conforming to the Long Term Evolution (LTE) Standard have been adopted. Communication charges initially based on a data-volume charging system have been changed to flat-rates. Consequently, large-capacity and high-speed communication has been realized assuring a reduced communication cost.

In the case of communications through the Internet of Things (IoT) devices, however, there is not always the necessity for securing large capacity and high speed performance according to the information gathering device. Instead, lower power consumption and lower communication costs may be more important. As such, we have adopted the LPWA communication system featuring low power consumption, low bit rate, and a wide-area coverage. When the LPWA system is adopted, power consumption during communication can be reduced to 1/3 compared with conventional LTE and to 1/100 or lower during waiting period for some modes. There are multiple communication standards defined to correspond to LPWA. Our data communication terminal is capable of accommodating communication modules belonging to various communication systems that conform to LoRa, SIGFOX and Cat-M1.

3.1 Communication Standard “LoRa”

This is a communication system utilizing communication bands that don’t need any license. A nonprofit organization by the name of LoRa Alliance is promoting the activities for spreading this standard. The communication rate is some tens of kbps and the perspective communication distance is believed to be around 15km at the maximum.

3.2 Communication Standard “SIGFOX”

As for LoRa, this standard similarly does not require any license and is managed by SIGFOX Inc. in France. A featuring characteristic is that communication is repeated three times with different frequencies. The communication rate is 100bps and the communication distance is said to be around 50km at the maximum.

3.3 Communication Standard “Cat-M1”

This system uses a frequency band that requires a license. It is standardized by the 3rd Generation Partnership Project (3GPP) that is a standardization unit of communication systems for mobile phones. In Japan, services are offered by KDDI Corporation and other organizations. The communication rate is said to secure 1 Mbps and the communication distance is around several kilometers. This system is rich in the power-saving property by providing a sleep function in the communication module. Compared with versions of other standards, in many cases, communication cost is lower.

4 Development Concept for Data Communication Terminal

Fig. 3 shows the development concept. In order to reduce power consumption, power saving parts inclusive of microcomputer are adopted. In addition, power consumption is reduced by a function that produces a sleep mode while the device is out of service. **Table 1** shows specifications of the data communication terminal. In order to make this terminal applicable as a data communication terminal, it is provided with a Digital Input (DI) circuit, Digital Output (DO) circuit, and an Analog Input (AI) circuit so that various kinds of sensors can be connected. Since the data communication terminal is primarily assumed to permit intermittent operation, a periodic startup operation is carried out with the aid of a built-in calendar Integrated Circuit (IC). In addition, there is a function to enable the starting of a microcomputer at the time of a status change in the DI and variations in analog values of the AI.

As a means of transferring the gathered information, a wireless communication function is accommodated. On the assumption that operation is conducted with a power supply of the primary battery, the working period of several years with a built-in primary battery cell is realized, though this depends on the period of intermittent operation. For software, the T-Kernel of the built-in type real-time OS is adopted.

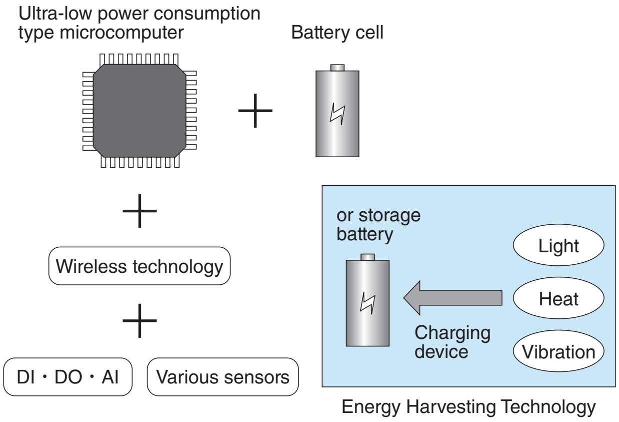

Fig. 3 Development Concept for Data Communication Terminal

A development concept for a data communication terminal developed by us is shown. In order to enable application to a monitoring system demanded by an IoT society, ultra-low power consumption type microcomputer and low power consuming devices are adopted. By making intermittent operation, system operation is made possible only with a primary battery. As a measure taken to eliminate a power supply, energy saving technology is utilized to make it possible to charge up the secondary battery (storage battery).

Table 1 Specifications of Data Communication Terminal

Specifications of our data communication terminal are shown.

Item		Specifications
CPU	CPU	32 bit RISC 48 MHz
	Built-in flash memory	1024 KB
	Built-in SRAM	128 KB
	SRAM	512 KB
	FRAM	256 KB
	A/D converter	12 bit 8 ch
Wireless/wired	Cat-M1 communications	Cat-M1 communication module
	Specific low-power wireless	LoRaWAN communication module, SIGFOX communication module
	Serial port for maintenance	CPU built-in UART
Monitoring and control	AI	4 ch (0~5 V or 4~12 mA), Source voltage monitoring
	DI	8 ch
	DO	4 ch
	I2C	1 ch
Power source circuit		3.3 VA・3.3 VB・3.65 V・24 V
Energy harvesting source	Thermal power generation	30~500 mV
	Vibration power generation	2.6~23 V
	Photovoltaic generation	0.3~4.75 V, 2.6~23 V
	Secondary battery	Various lithium batteries
Primary source	14.4 V, 5 V	Lithium battery 3.6 V, 4-serial pack
OS		T-Kernel2.0

5 Energy Harvesting Technology

The “Energy Harvesting Technology” is a technique to “collect” minute energy in a variety of modes available in the surrounding environment, and convert the collected energy into electric power. Since the electric power obtained from this expertise is substantially feeble, this method is not suitable for actuating large equipment. It is, however, possible to utilize this power for equipment that is designed to realize reduced power consumption. If this method is realized, no cost is required for power generation and cabling for power supply can be omitted. As a result, the degree of freedom is increased in terms of equipment installations. For our data communication terminals also, we have devised a power source configuration by which energy (of light, heat, and vibration) scattered in the surrounding environment is selected and converted into electric power to charge up the secondary battery for use.

6 Postscript

Data communication equipment of the low power consumption type is considered an indispensable tool in an IoT society in the future and various kinds of developments are anticipated to arise accordingly.

While our applications are promoted to the systems of reduced power consumption and energy harvesting technologies, we will continue to promote the development of products by incorporating new technologies meeting the needs of industrial markets.

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