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Radiation Area Monitoring by wireless-communicating Area Monitor with Surveillance Camera

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Aiming at a dose reduction and a work efficiency improvement for nuclear power plants that have high dose regions, we have developed our system of wireless-communicating ***Area Monitor with Surveillance Camera***, and have performed an on-site test. Now we are implementing this ***Area Monitor with Surveillance Camera*** for a use as a TV camera in the controlled-area, which enables a personal computer to simultaneously display two or more dose values and site live images on the screen. For the radiation detector of this Area Monitor System, our wireless-communicating dosimeter is utilized. Image data are transmitted via a wireless Local Area Network (LAN). As a test result, image transmission of a maximum of 20 frames per second has been realized, which shows that this concept is a practical application. Remote-site monitoring also has been realized from an office desk located within the non-controlled area, adopting a Japan's wireless phone system, PHS (Personal Handy Phone) for the transmission interface.

KEYWORDS: radiation protection, area monitor, surveillance camera, personal dosimeter, Wireless Personal Dose Monitoring System, LAN, Radio communications

I. Introduction

From the perspective of an effective dose control for the sake of all nuclear power plant personnel engaging in areas with potentially high dose equivalent rates, we developed our product ***Wireless Personal Monitoring Dosimeter***. Refer to **Fig. 1**. This dosimeter can transmit worker's individual doses via radio interface to a personal computer for real time display and remote-site monitoring. The dosimeter contains a semiconductor detector with a measurement range of 0.01 to 99.99 mSv. A worker is required to wear this device with each job. All data collected is wirelessly transmitted to radiation control equipment.

In terms of conventional area monitoring device, many plant site supervisors are doing their remote monitoring through a surveillance camera in order to avoid exposures. A major drawback is the fact that the camera is connected with cables for image display, and this requires considerable workload each time of cabling work; cable protection for anti-contamination, and cable installation/removal.

In order for a cost cut in this kind of construction, we are implementing our ***Wireless Personal Monitoring Dosimeter*** to use as an area monitor in the controlled-are, and we call this implementation, ***<Wireless-communicating Area Monitor with Surveillance Camera>***.

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We have prototyped a remote-monitoring system for this area monitor, in which the data of dose measurement and the live images of the site are simultaneously transmitted via a radio interface. The field test was also carried out to validate the system effectivity.

The test result report will be described hereinafter.

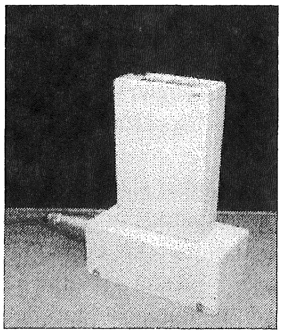

Fig. 1 Wireless Personal Monitoring Dosimeter

II. Contents of the development

1. Design outline

For the components of the system prototype, dosimeters, a surveillance camera, and a controller providing radio transmission were installed in the work area. A laptop computer and wireless LAN device were used to receive data. Refer to **Fig. 2**. We utilized as many of commercial product as possible for a cost cut, and as mentioned, Wireless Personal Monitoring Dosimeter was used for the

system as an area monitor. A laptop PC was used for radiation measurement and image data display. The wireless LAN conforms to the Standard of Institute of Electrical and Electronics Engineers, IEEE 802.11b (11Mbps) [1] Refer to the following URL for the wireless LAN standards (IEEE802.11). The description is available only in German language .
http://www.de.tomshardware.com/network/20030402/wlan2-08.html

We prototyped a dedicated controller because image data had to be compressed for a better transmission speed.

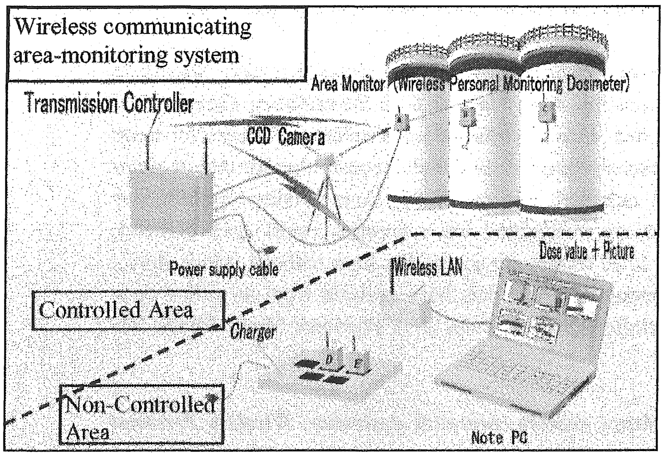

Fig. 2 Design outline

2. Selection from radio transmission methods and standards

We had to choose from the following interfaces for the system: wireless LAN, PHS System (Personal Handy phone), and Cellular phone system. After reviewing, we adopted the wireless LAN because of the following factors.

Not many frequency bands are assigned for private sector use in Japan, and the radio wave emission is strictly regulated. It is illegal to use any unauthorized devices unless otherwise by the national assay. The area monitor (Wireless Personal Dosimeter) implemented in our wireless LAN is classified as "Specified low-power" by the radio law of Japan.

Although there are other standards of which transmission rates are better, no standards other than IEEE802.11b were available for our wireless LAN or an outdoor use due to the factors mentioned. Refer to the Japanese Wireless Telegraph Law & regulation [2] for details. (described in Japanese language)

Focusing on the transmission speed for image displaying, wireless LAN is the best for its quickness yet, reasonable price. It is also one of the reasons that the wireless LAN has already been in use in our plants, and no technical interference with control devices had been observed.

Table. 1 Selection of a radio transmission method

Comparison result	Wireless LAN	PHS	Cellular phone
Frequency	2.484GHz	1.9GHz	800MHz
Transmitted power	10mW	10mW	Not announcing
Distance	100m	200m	2000m
Access speed	11Mbps	32kbps	9600bps
Comparison result	Adopted	Rejected	Rejected

3. Picture controller and CCD camera

The picture transmission controller is a modification of a commercial product. Modifications were done on the interface peripherals for interfacing with external apparatus. Refer to **Fig. 3**. The Central Processing Unit (CPU) is picture-compression dedicated, and made compact.

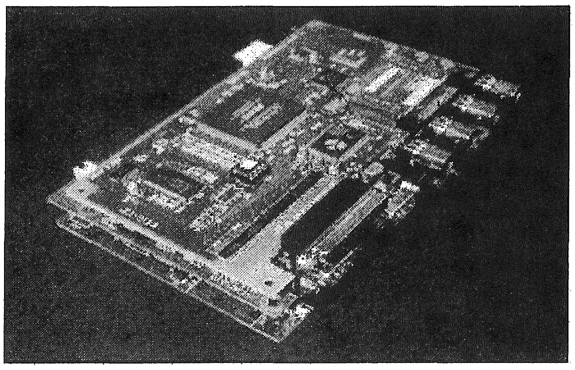

Fig. 3 Picture controller

A CCD camera that is commercially available and inexpensive was implemented to the system in consideration of CCD destruction and contamination through exposures. The camera actually used is shown in **Fig. 4**. Although the number of pixels decreases, this CCD camera costs merely around 10,000 Japanese yen at the market price, and made very compact. Approx. 50 × 50 × 100 (mm).

Fig.4 CCD camera

4. Dedicated transmission controller

The above mentioned picture controller and system key station of Wireless Personal Dosimeter were combined into one unit, the dedicated transmission controller, for easy handling and contamination prevention. Refer to **Fig. 5** for the internal structure.

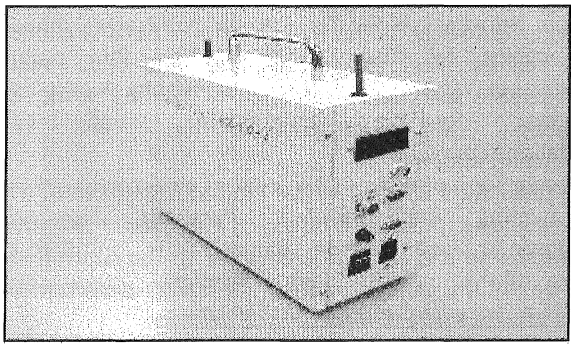

Fig. 5 Dedicated transmission controller

5. System configuration

The system prototype is designed so that the data of doses and live images from four locations can be transferred to one controller. **Fig. 6** is the block diagram.

These images and 600 measured dose data can be saved any time on a data storage device such as an MO disk. Radiation measurement range is from 0.01 mSv/h to 99.99 mSv/h.

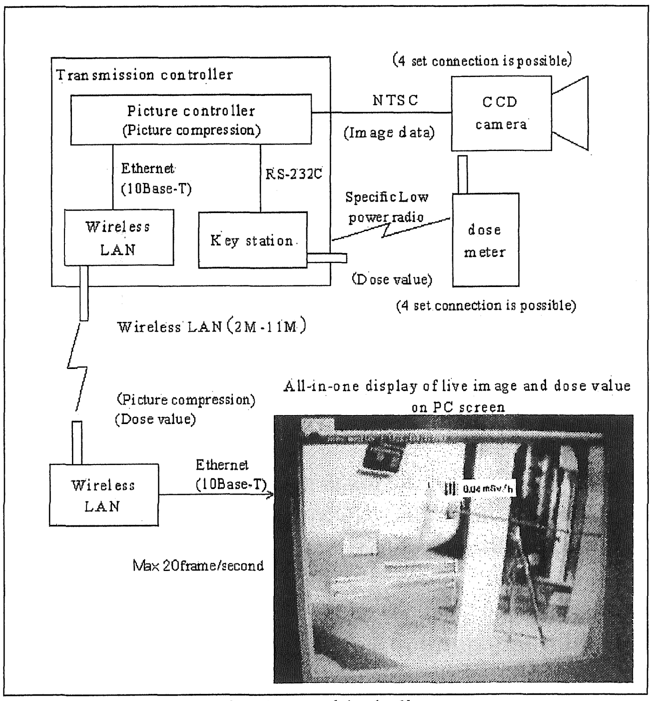

Fig. 6 System block diagram

III. Field test result

1. The system configuration

The system configuration of the prototypes is shown in **Fig. 7**. One Transmission Controller is capable of four dosimeters and four cameras.

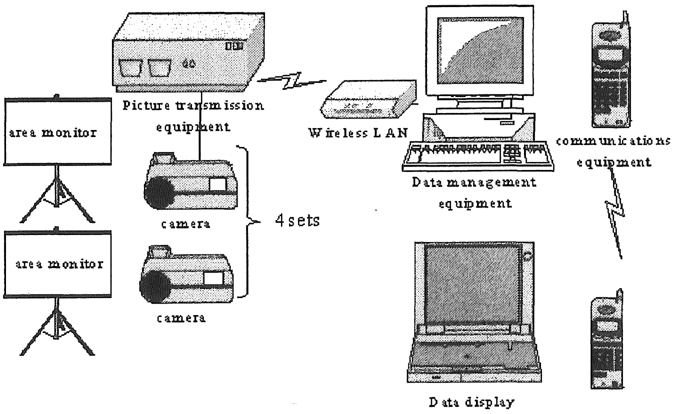

Fig. 7 The system configuration of the prototypes

2. Cold test in a factory

Prior to the test run in an actual controlled zone, we subcontracted a third party to perform a cold test in their factory. Refer to **Fig. 8**. Picture display of 20 frames per second was realized from a maximum of 30 m distance.

During the test, two kinds of notebook PC having different capabilities were used to compare the performance. The installed memory of each PC was 128MB, yet the CPU clock differed: one was 500MHz and the other was 950MHz. We assumed that the clock difference would interfered with the number of display frames, however, almost no difference was observed. The factor maybe an effect by image data compression.

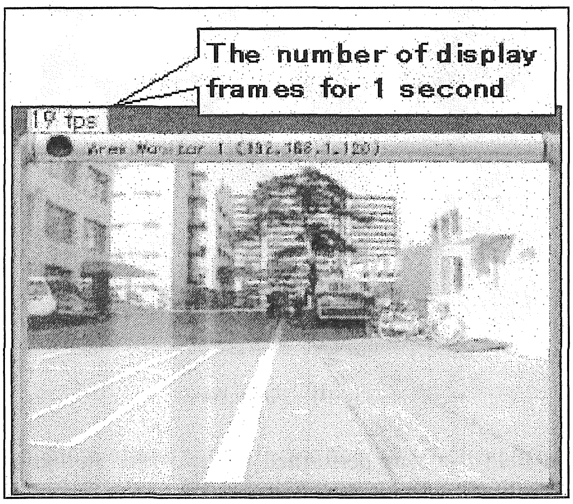

Fig. 8 The cold test in the factory

Table 2 Change in the number of display frames by difference of CPU clock.

Type	IBM ThinkPad	FMV-BIBLO NB9/95L
CPU	500MHz	950MHz
Memory	128MB Fix	128MB Fix
LAN I/F	10Mbps Fixation	10Mbps Fixation
Survey frame rate	10FPS - 19FPS	16FPS - 20FPS

3. Noise test

We had confirmed that noise emitted from the prototypes would not interfere with plant control systems prior to the field test. Refer to **Fig. 9**.

Fig. 9 Noise test

4. Field test

The field test was performed with collaboration from the Tokyo Electric Power Company. (TEPCO) The test was carried out to verify our prototypes in an actual environment, that is, a controlled zone in their nuclear power plant. Refer to **Fig. 10**.

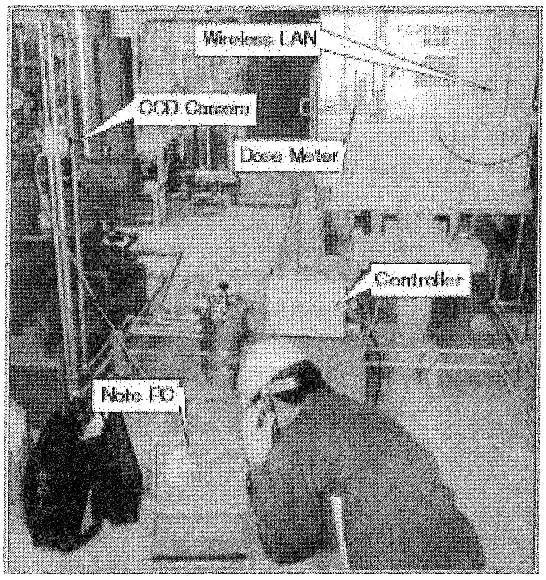

Fig. 10 Field test

The field test was performed at the waste storage tank room with obstacles as shown in **Fig. 11**.

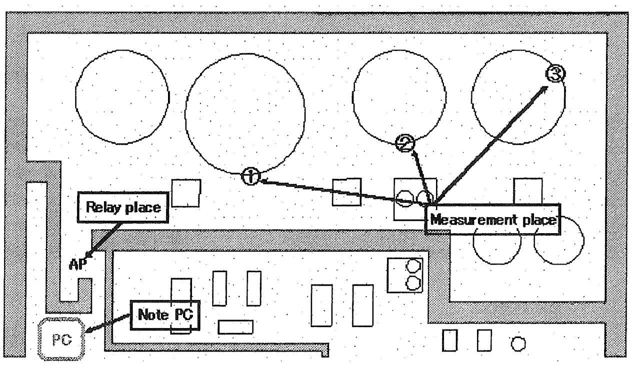

Fig. 11 Field test area

As a test result, we confirmed that the radio communications for radiation measurement data and image data per second at a maximum of 20 frames is feasible, and we verified that the system is applicable. Refer to **Table 3**.

IV. Review

The picture transmission system was examined using Moving Picture Experts Group (MPEG[3]), Motion Joint Photographic Experts Group(MJPEG[4]), and Joint Photographic Experts Group (JPEG[5]). At the current stage, use of MJPEG has been verified that it is the best for transmission. Wireless picture transmission has its limit in hardware-wise; thus a data compression and expansion by a better software is desired.

The system developed this time has acquired a patent.

Our ***Area Monitor with Surveillance Camera*** and its monitoring system will allow plant operators, not to mention their site supervisors, to reduce the risk of exposures, to response promptly to any environmental changes, and to evaluate any dose status in real-time. A technical improvement will be reflected at the phase of product test regarding image display size expansion on the PC screen, additional functionalities to the camera such as zoom/pan, size/weight reduction of the system devices, etc.

Acknowledgements

The authors wish to thank for the courtesy of TOKYO ELECTRIC POWER COMPANY that offered their facilities for the related test.

Reference

1) IEEE: Institute of Electrical and Electronic Engineers , URL http://www.ieee.org/
2) Japanese Wireless Telegraph Law & regulation, URL http://www.houko.com/00/01/S25/131.htm
3) Moving Picture Experts Group , URL http://www.chiariglione.org/mpeg/index.htm
4) Motion Joint Photographic Experts Group , URL http://www.axis.com/documentation/whitepaper/video/video_compression_article.pdf
5) Joint Photographic Experts Group , URL http://www.jpeg.org/
6) ISORD-2 , URL http://ri.cyric.tohoku.ac.jp/ISORD2/

Table 3 Field test result

No.	Area Monitor Measurement place	Distance	Wireless LAN Modem Measurement place	The number of transmitted packets	The number received packets	The number of transmission errors	The number of reception errors	The rate of error	Picture display	Result evaluation
1	①	6m	AP	1265	1426	42	131	6.20%	Good	Good
2	①	5.5m	AP	1042	1125	39	20	2.70%	Good	Good
3	②	11m	AP	1605	1042	129	108	8.90%	Good	Good
4	③	17m	AP	1120	1141	75	85	7%	Good	Good