

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
4 October 2007 (04.10.2007)

PCT

(10) International Publication Number
WO 2007/111412 A1

(51) International Patent Classification:
G08C 17/02 (2006.01)

(21) International Application Number:
PCT/KR2007/000461

(22) International Filing Date: 26 January 2007 (26.01.2007)

(25) Filing Language: Korean

(26) Publication Language: English

(30) Priority Data:
10-2006-0019556
28 February 2006 (28.02.2006) KR

(71) Applicants (for all designated States except US):
KOREA ELECTRIC POWER CORPORATION [KR/KR]; 167, Samsung-1dong, Kangnam-gu, Seoul 133-835 (KR). **E-PIA CO.LTD.** [KR/KR]; 3F, 315-55, Sungsu2-ga3-dong, Sungdong-gu, Seoul 133-835 (KR).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **KIM, Young-Ro** [KR/KR]; 599, Sooib-ri, Seosong-myun, Yangpyung-gun, Kyungki-do 476-811 (KR). **CHO, Joong-Sam** [KR/KR];

6-Dong 505-Ho, HangYang-Apt., 338-33, Ssangmun-dong, Dobong-gu, Seoul 132-741 (KR). **YOO, Jae-Sik** [KR/KR]; 201-Ho, 961-18, Daechi-dong, Gangnam-gu, Seoul 135-280 (KR). **KIM, Young-Min** [KR/KR]; 605-Ho, UJung-MaeSueR, 18-1, Karak-dong, Songpa-gu, Seoul 138-160 (KR). **YOON, Jun-Chul** [KR/KR]; 610-603, 6-Danji, Mok-dong, Yangchun-gu, Seoul 158-756 (KR).

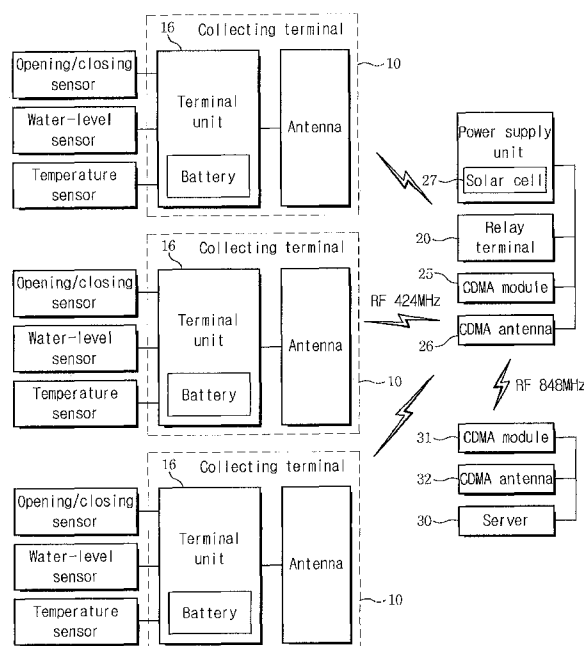
(74) Agents: **LEE, Woo-Young** et al.; 2F, SongGangWon Bldg., 827-49, Yeoksam-1dong, Gangnam-gu, Seoul 135-935 (KR).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,

[Continued on next page]

(54) Title: LOW POWER WIRELESS SYSTEM FOR MONITORING OF MANHOLE



(57) Abstract: The present invention relates to an antenna of a manhole monitoring system, and more particularly, to an antenna structure of a manhole monitoring system for reducing the size of an antenna used in a relay terminal and a collecting terminal that detects the position, state and history of a manhole using a sensor set inside the manhole and wirelessly transmits the detection result to an external device using an RF communication module and improving the characteristic of the antenna.

WO 2007/111412 A1



ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:

— *with international search report*

A STRUCTURE OF ANTENNA FOR MONITORING A MANHOLE

Technical Field

The present invention relates to a manhole monitoring system, and more particularly, to a low power manhole monitoring system using a low power sensor and a communication system, which detects the position, state and history of a manhole using a sensor set inside the manhole and wirelessly transmits the detection result to an external device using an RF communication module.

10 Background Art

Electric power facilities are increasingly installed underground in the downtown area because of the beauty of the town, safety, and high-rise buildings. While researches on utility-pipe conduits in which underground power lines and other facilities are installed are carried out, manholes are managed by human control because the environment is poor and it is difficult to go into manholes in order to confirm and inspect the states of the manholes. Furthermore, it is impossible to immediately confirm the state of a manhole when a person intrudes the manhole or an accident happens in the manhole.

To solve this problem and easily remotely manage a manhole, development of a remote alarm system for transmitting information detected by a sensor set in the manhole to a management center and a system for easily confirming information currently detected by the sensor are required.

A conventional system capable of easily confirming event contents of a manhole is disclosed in Korean Patent No. 10-0545911, entitled "Manhole state monitoring

system". This system has a remote monitoring terminal for monitoring the state of the inside of a manhole, which is located in the manhole, and a center server for receiving state information sensed by the remote monitoring terminal to manage the manhole. The manhole state monitoring system includes a communication network power extractor
5 connected to a communication network previously constructed in the manhole to extract power from current flowing through the communication network, a power stabilizer for stabilizing the power extracted by the communication network power extractor into a voltage used by the remote monitoring terminal and providing the voltage to the remove monitoring terminal, a sensor unit having a plurality of sensors for sensing the state of
10 the inside of the manhole in order to monitor and manage the manhole, and a central processing unit for transmitting a value sensed by the sensor unit to the center server and receiving a command from the center server to drive the sensor unit.

The conventional system installs remote monitoring terminals for monitoring states of manholes located over a wide range using the power supplied from the existing
15 PSTN and uses the existing communication networks as communication lines. Accordingly, the system construction cost can be minimized, communication manholes can be monitored and managed in real time, and an abnormal event occurring in a communication manhole can be rapidly handled. However, the conventional system has the following problems.

20 As described above, the conventional system uses the power extracted from the existing PSTN without having an additional power supply. A maximum power obtained from the PSTN is approximately 150mW. However, there are sensors that consume about 300mW. Accordingly, power left over after basic operations of the system is charged in a battery and the sensors use the power charged in the battery. This requires frequent

replacement of the battery. Furthermore, the manhole monitoring system does not operate due to discharge of the battery.

Moreover, the conventional system has problems that the wired PSTN that is the dedicated communication network of Korea Telecommunications must be secured to operate the manhole monitoring system and the current state of a manhole cannot be remotely managed by wireless. Accordingly, manholes that are not able to use the PSTN (for example, manholes of Korea Electric Power Corporation) cannot be provided with power so that batteries must be needed.

Therefore, development of an economical low power communication system with high reliability is required in order to collect information obtained from sensors and transmit the information to branches.

Disclosure of Invention

Technical Problem

Accordingly, the present invention has been made to solve the above-mentioned problems occurring in the conventional art, and a primary object of the present invention is to provide a low power manhole monitoring system using a low power sensor and a communication system, which can be used for a long time using a battery even in a manhole environment in which power is not provided through a wired communication network such as PSTN or a power supply is not additionally provided.

Technical Solution

To accomplish the objects of the present invention, there is provided a low power wireless system for monitoring manholes, which includes a terminal unit that has

at least one of an opening/closing sensor, a water-level sensor and a temperature sensor, senses the internal state of a manhole using the at least one sensor and includes a battery, and a collecting terminal for collecting information on the manhole sensed by the sensor, from the terminal unit and transmitting the collected information to an external device.

- 5 The collecting terminal includes a low power controller that operates at a predetermined time interval in an idle state to check information sensed by the sensors and converts the collecting terminal into the idle state.

Advantageous Effects

- 10 According to the present invention, an antenna is located inside a housing connected to the collecting terminal through a cable, a circuit board having a connector attached to one side thereof is integrally formed with the antenna, and the connector of the circuit board is connected to the collecting terminal using the cable penetrating the housing.

- 15 Accordingly, even when the antenna and the circuit board are included in the collecting terminal and laid under the ground, an additional connecting cable terminal box is located inside a manhole for the maintenance such as battery replacement and program upgrade to enable interface.

- Furthermore, the antenna is configured of a PIFA (Planar Inverting F Antenna)
20 type quarter wavelength monopole patch antenna that is obtained by grounding the patch center of a half wavelength microstrip patch antenna. Accordingly, the size of the antenna laid underground for monitoring a manhole can be reduced.

Moreover, a plurality of fins are attached to the bottom face of the monopole patch antenna, and thus a current path can be increased to induce a resonant frequency to

decrease due to an increase in a visual resonance length.

In addition, the cable penetrating the housing connected to the collecting terminal is enveloped by a waterproof cable, and thus the housing can be shielded even when it is laid under the ground.

5

Brief Description of the Drawings

Further objects and advantages of the invention can be more fully understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

10 FIG. 1 is a block diagram of a wireless system for monitoring manholes according to the present invention;

 FIG. 2 is a block diagram of a collecting terminal of the wireless system for monitoring manholes according to the present invention;

 FIG. 3 is a block diagram of a relay terminal of the wireless system for
15 monitoring manholes according to the present invention;

 FIG. 4 is a block diagram of a server of the wireless system for monitoring manholes according to the present invention;

 FIG. 5 is a cross-sectional view of the collecting terminal of the wireless system for monitoring manholes according to the present invention;

20 FIG. 6 illustrates a voltage sensing unit of the wireless system for monitoring manholes according to the present invention;

 FIG. 7 illustrates an operating state of a controller of the wireless system for monitoring manholes according to the present invention;

 FIG. 8 illustrates a write operation of the controller of the wireless system for

monitoring manholes according to the present invention;

FIG. 9 illustrates a read operation of the controller of the wireless system for monitoring manholes according to the present invention;

FIG. 10 illustrates interface of transmitting/receiving data signals of the wireless system for monitoring manholes according to the present invention;

FIG. 11 illustrates FSK modulation format of the wireless system for monitoring manholes according to the present invention;

FIGS. 12 and 13 illustrate the relationship between the patch width and frequency of an antenna according to the present invention; and

FIGS. 14 and 15 illustrate suburb and city range tests for the antenna according to the present invention.

Best Mode for Carrying Out the Invention

FIG. 1 is a block diagram of a low power wireless system for monitoring manholes according to the present invention, FIG. 2 is a block diagram of a collecting terminal of the low power wireless system for monitoring manholes according to the present invention, FIG. 3 is a block diagram of a relay terminal of the low power wireless system for monitoring manholes according to the present invention, and FIG. 4 is a block diagram of a server of the low power wireless system for monitoring manholes according to the present invention.

Referring to FIGS. 1, 2, 3 and 4, the low power wireless system for monitoring manholes (referred to as a "system" hereinafter) according to the present invention includes collecting terminals 10 each having an opening/closing sensor 2, a water-level sensor 4, a temperature sensor 6 and a terminal unit, a relay terminal 20, and a server 30.

Components other than these components can be added to the system.

Each of the collecting terminals 10 includes the terminal unit 16 that has at least one of the opening/closing sensor 2, the water-level sensor 4 and the temperature sensor 6 and senses the internal state of a manhole using the sensor, and an RF communication module 14 that collects information of the manhole, sensed by the sensor included in the terminal unit 16, and transmits the collected information to the relay terminal 20 using an antenna 13.

The opening/closing sensor 2 senses whether a manhole cover is opened or closed. The opening/closing sensor 2 is configured in the form of a lever type limit switch fixed to the manhole cover. The opening/closing sensor 2 is installed in a manner that the manhole cover pushes a roller lever and, when the manhole cover is opened, the roller lever is returned and a switch contact operates.

In addition, the opening/closing sensor 2 includes a hard case of die casting, which absorbs external impacts, and a 2-circuit dual-terminal basic switch made of heat-resistant phenol.

The opening/closing sensor 2 has oil-proof, heat-resistance and dustproof functions and high mechanical strength. Furthermore, a set position indicator is attached to the opening/closing sensor 2 for the purpose of preventing the lever from over-working and maintaining a long life span, and thus the opening/closing sensor 2 can be safely used for a long period of time.

The water-level sensor 4 senses the water level of the inside of the manhole and is configured in the form of a tumbler type level switch. The water-level sensor 4 is set at the bottom of the manhole and, when the manhole is flooded, the water-level sensor 4 stands erect according to buoyancy and an internal switch contact operates.

The water-level sensor 4 is light and corrosion-resistant because it is made of a synthetic resin. Furthermore, the water-level sensor 4 includes a float switch having a tack switch, and thus it is stronger than a conventional mercury switch.

The temperature sensor 6 senses the temperature of the inside of the manhole. In general, TGA130B that is a diode thermister whose resistance varies with temperature is used as a temperature sensor. However, the temperature sensor 6 of according to the present invention employs STH10 of SENSIRION of Swiss, which is a digital temperature sensor, in order to improve current consumption, linearity and accuracy. Accordingly, the temperature sensor 6 according to the present invention has high accuracy, low power consumption and it can measure even relative humidity.

The collecting terminal 10 further includes a voltage sensing unit for driving a battery with a minimum current, a low power controller 11 that operates at a predetermined time interval in an idle state to check information sensed by the sensors and convert the collecting terminal to the idle state, and a microcontroller 12 for wirelessly transmitting state information sensed by the sensors, received from the low power controller 11, to the relay terminal 20 using the antenna 13 and the RF communication module 14.

As illustrated in FIG. 6, the voltage sensing unit measures a battery voltage at an interval of five seconds and notifies the collecting terminal of an event when the battery voltage becomes lower than 2.7V.

The battery voltage sensing unit of the present invention drives the battery with a minimum current. When the battery voltage is V_{batt} , a ground voltage is GND, and a battery measurement ADC input voltage is B_{bat_adc} , the following equations are accomplished.

$$V_{bat_adc} = V_{batt} \times (15K) / (15K + 24K)$$

$$V_{batt} = V_{bat_adc} \times (39K / 15K)$$

$$V_{batt} = 2.60 \times V_{bat_adc}$$

Consequently, the battery voltage V_{batt} corresponds to 2.6 times the battery
 5 measurement ADC input voltage V_{bat_adc} .

The low power controller controls the collecting terminal to be in the idle mode
 for most of time in order to minimize a battery current. In the idle mode, a CPU operating
 current is less than $1\mu A$ and a current consumed by a peripheral circuit is approximately
 $10\mu A$ corresponding to a leakage current. That is, the collecting terminal of the present
 10 invention operates at an interval of one second in the idle state to check whether an event
 occurs for 2mS and returns to the idle state.

An average current consumed when the collecting terminal performs
 information transmission three times a day is calculated as follows.

Idle current: $11\mu A$

15 $11 \times 10^{-6} \times 3600 = 0.0396Ah$

Operation of checking event (2mS): 13mA (maximum)

$$13 \times 10^{-3} \times 2 \times 10^{-3} \times 3600 = 0.936Ah$$

Receiving operation (500mS): 40mA (maximum)

$$40 \times 10^{-3} \times 500 \times 10^{-3} \times 3/24 = 0.00083Ah$$

20 Transmitting operation (200mA): 60mA (maximum)

$$60 \times 10^{-3} \times 200 \times 10^{-3} \times 3/24 = 0.0005Ah$$

It can be known that the total consumption current per hour is 0.1353Ah. Thus,
 the average current is $0.1353Ah/3600 = 37.6\mu A$.

Consequently, the expected life span of the battery is $(8.5/37.5) \times 10^6 = 226,666$

hours when VITZRO CELL 8.5Ah is used as the battery. Accordingly, the battery can be used for 25 years. Even in the worst condition in consideration of temperature, the battery can be used for at least 10 years without replacement.

The collecting terminal 10 according to the present invention can be operated
5 with a low power because it has the aforementioned configuration. In addition, the collecting terminal 10 collects information on a manhole using the sensors and immediately transmits the collected information to the relay terminal 20 to which the collecting terminal belongs with a low power by wireless.

Specifically, when information sensed by the sensors is input to the
10 microcontroller 12 through the low power controller 11 that controls the sensors with a small current, the microcontroller 12 arranges the information and transmits the arranged information to the relay terminal 20 using the RF communication module 14 and the antenna 13.

The terminal unit of the collecting terminal 10 includes a battery 17 that supplies
15 power required for a sensor connected thereto and provides power required for blocks of the collecting terminal 10. The collecting terminal 10 can further include a power sensor 8 capable of sensing whether the battery is discharged. In this case, when the battery 17 is discharged, a manager is informed of it to prevent the collecting terminal 10 from being in an inoperative state due to the discharge of the battery 17.

20 The information on the manhole includes the ID number of the manhole, the inner temperature of the manhole, sensed by the temperature sensor, the water level of the inside of the manhole, sensed by the water-level sensor, and whether the manhole cover is opened or closed, sensed by the opening/closing sensor.

The operation of the collecting terminal is explained in more detail.

The microcontroller 12 checks the opening/closing sensor and the water-level sensor once per second for 1/1000 seconds and checks the capacity of the battery (when the battery capacity becomes lower than 2.7V, it is immediately transmitted to the relay terminal) once per minute using the power sensor. In addition, the microcontroller 12
5 reads temperature data from the temperature sensor once per ten seconds and transmits information indicating whether the opening/closing sensor and the water-level sensor operate to the relay terminal right after the opening/closing sensor and the water-level sensor operate. Furthermore, when the temperature sensed by the temperature sensor exceeds 60°C, the microcontroller 12 transmits information representing it to the relay
10 terminal and, when more than 5°C changes for ten seconds, transmits information representing this temperature variation to the relay terminal. When any one of the sensors does not operate for 24 hours, the current state of the collecting terminal is automatically transmitted to the relay terminal 20.

As illustrated in FIG. 5, the sensors are set inside the manhole and the terminal
15 unit including the battery that supplies power to the sensors is set in the manhole. Circuits (including the antenna) connected to the sensors through cables to control the sensors are included in a housing 100 of the collecting terminal 10, which is buried around the manhole in the ground.

The housing of the collecting terminal includes a bottom plate made of stainless
20 steel and a cover made of acetalresin, and thus the housing can endure a pressed load of 21 ton without having any damage. Furthermore, the housing has waterproof of IP67 grade at which water is not infiltrated into the housing even when the housing sinks in the water for 30 minutes so that the housing can protect the internal circuit of the collecting terminal even when the manhole is flooded in the rainy season.

The microcontroller 12 uses ATmega16 that is a low power CMOS 8-bit microcontroller based on AVR RISC structure. Accordingly, a command is executed within a single clock cycle and a processing rate of 1MIPS/MHz is achieved according to ATmega16, and thus power consumption can be minimized.

5 Preferably, the RF communication module 14 for wireless communication between the collecting terminal 10 and the relay terminal 20 is constituted in a manner that a foundation of an RF transmitting/receiving apparatus is designed using CC1020 of CHIPCON and control firmware is constructed using ATMEAGE16 microcontroller of ATMEL. The RF communication module 14 employs an unauthorized communication
10 method using a frequency of RF 424MHz.

The relay terminal 20 wirelessly communicating with a plurality of collecting terminals 10 through the RF communication module 14 is located having a predetermined distance from the collecting terminals 10, collects and arranges information on a plurality of manholes, which is received from the collecting terminals
15 10, and wirelessly transmits the arranged information to the server 30 using a communication module, preferably, a CDMA module. Preferably, the relay terminal 20 is designed such that it can manage 250 collecting terminals.

The relay terminal 20 includes an antenna 21 for receiving state information in the form of a radio wave signal, sensed by each sensor, from each collecting terminal 10,
20 an RF communication module 22 and a microcontroller 23-1 for converting the radio wave signal into data, a CDMA module 25 connected to the microcontroller through a connecting means to wirelessly communicate with a CDMA module 31 of the server 30 using a CDMA antenna 26, and a power supply for supplying power to the aforementioned components.

The radio wave signal input through the antenna 21 of the relay terminal 20 is converted into data by the RF communication module 22 and the first microcontroller 23-1. The data is immediately transferred to a second microcontroller 23-2 and then transmitted to the server 30 through a connecting means, that is, RS232, the CDMA module 25 and the CDMA antenna 26. The first microcontroller 23-1 controls the RF communication module 22 and the second microcontroller 23-2 controls the CDMA module 25.

The multiple microcontrollers 23-1 and 23-2 are used in order to improve the reliability of data transmission.

External data input to the relay terminal 20 is interrupt-processed, and thus a data processing order is determined according to priority. However, since the priority of data input to the relay terminal 20 from the collecting terminal and the priority of data input to the relay terminal 20 from the server can compromise with each other, the data from the collecting terminal and the data from the server are respectively processed using separate microprocessors and they are connected through parallel handshake communication.

The CDMA module 25 uses BSM-800/850 of BELLWAVE. The CDMA module is connected through dialing using a CDMA public communication network and it transmits data using AT command as a general module does.

The power supply of the relay terminal 20 includes a solar cell 27 for converting solar energy into electric energy, a power controller 28 for receiving the electric energy from the solar cell 27 and charging a battery 29, and the battery 29 supplying power to blocks of the relay terminal using the power charged by the power controller 28.

The relay terminal 20 is installed at an electric pole or on the rooftop of a

building to which electric power cannot be easily provided, and thus the relay terminal 20 needs its own electric power plant. Accordingly, the power supply uses an amorphous solar cell.

The relay terminal 20 constructed as above employs multiple processors (the first and second microcontrollers) so that communication with the collecting terminal 10 and communication with the server 30 do not collide with each other. Furthermore, the site where the relay terminal 20 is installed is not restricted because the relay terminal 20 uses the solar cell, the CDMA module and the antenna. Accordingly, the relay terminal can be installed at the best radio wave transmission position to secure an excellent communication relay function.

Moreover, the relay terminal employs a PRFA (Planer Inverting F antenna) to improve communication reliability.

The relay terminal periodically reports its own state and the states of the collecting terminals to the server. Specifically, when the relay terminal is not communicated with a collecting terminal for 24 hours, the relay terminal reports breakdown of the collecting terminal to the server. Furthermore, the relay terminal transmits time information thereof to the server once per 24 hours even when any collecting terminal does not transmit any information such that the server confirms that the relay terminal is normally operated.

In addition, the relay terminal receives time information from the server and corrects the time information thereof using the received time information. Furthermore, when the relay terminal receives a collecting command from the server, the relay terminal reports contents of final communication with collecting terminals to the server.

The RF communication module can be operated with a low power. The RF

communication module is described in more detail.

Conventional systems for transmitting and receiving UHF signals have a complicated circuit configuration and low performance because the systems use lots of discrete components, and thus it is difficult to design and manufacture the systems.

5 However, recent development of semiconductor technology and application software chips has enabled wireless techniques to be easily applied to various fields.

In particular, according to notification No. 1998-90 of the Ministry of Information and Communication, 424.7MHz and 424.95MHz were allocated as frequencies of low power (lower than 10mW) data transmission wireless devices for
10 radio stations. These frequencies can be freely used without being authorized by the radio stations if technical conditions that 21 channels, a pulse width of 12.5KHz and spurious characteristic must be lower than the average power of the fundamental frequency by more than 40dB, a frequency for a control channel must have a transmission time within 0.2 seconds from when electric waves are transmitted, a communication channel
15 frequency must have a transmission time of shorter than 30 seconds and an idle time of longer than 1 second, and an occupied bandwidth of the communication channel frequency must be lower than 8.5KHz are satisfied. Accordingly, application of the frequencies 424.7MHz and 424.95MHz is rapidly spread.

As described above, a basic configuration of a wireless transmitting and
20 receiving device is designed using CC1020 of CHIPCON as the microcontroller.

CC1020 used in the aforementioned RF communication module is an intermediate frequency (IF) receiver having a low frequency. That is, an RF signal input through an RF input terminal RF_IN of the IF receiver is amplified by low noise amplifiers LNA1 and LNA2, which respectively correspond to a front end amplifier and

a variable amplifier and control the gain of the signal with a program in consideration of noise characteristic of hardware, and IF-converted into I and Q signals through quadrature modulation.

The I and Q signals are filtered and amplified in the IF stage and converted into
5 digital signals by an analog-to-digital converter (ADC).

Automatic gain control (AGC), fine channel filtering, demodulation and bit synchronization are all digitally processed.

Furthermore, CC1020 outputs a demodulated signal through a DIO pin. A DCLK pin can output a clock signal synchronized with the digital data output from the
10 DIO pin. RSSI (Received Signal Strength Indication) is digitally formatted and it can be read through DIO.

In a transmission mode, a synthesized radio frequency is directly provided to a power amplifier (PA), an RF output is a frequency that is frequency-shifted-keyed by a digital bit stream provided from the DIO pin, and a Gaussian-filtered GFSK can be used
15 as an option.

A frequency synthesizer includes an LC VCO completely mounted therein and a phase splitter that splits local oscillating signals LO_I and LO_Q sent to a down-conversion mixer in a receiving mode into 90°.

The VCO operates at a frequency of 1.608 to 1.880GHz. CHP_OUT is a charge
20 pump output and VC is a control node of the VCO mounted on a chip. Accordingly, an external loop filter is located between the CHP_OUT and VC. A crystal is connected between XOSC_Q1 and XOSC_Q2. When PLL lock is achieved, a signal can be output through a LOCK pin.

Signals for constructing and controlling the CC1020 use 4-wire SPI serial

interface.

The operating state of the microcontroller is described with reference to FIG. 7.

To use and control ATMEGA16 microcontroller applied to the present invention, four signals PCLK, PDI, PDO and PESL for controlling and constructing CC1020, two
5 signals DIO and DCLK carrying transmitting/receiving data bits and a single signal LOCK for monitoring PLL lock are used.

(1) 4 wire serial configuration interface

CC1020 transmits and receives configuration data through a 4 wire SPI compatible interface. A configuration register is provided with a 7-bit address and
10 initializes an R/W bit in a write or read mode. There are 33 configuration registers each of which transmits a 16-bit data frame. The data frame includes 7 address bits, one R/W bit and 8 data bits.

FIG. 8 illustrates a write operation of a configuration register. 16 bits are sent to a PDI line for each write cycle. 7 most significant bit (MSB) A6:0 are address bits and
15 A6 is transmitted first as the MSB of the address bits. The following bit is the R/W bit which represents a write operation when it is logic high and represents a read operation when it is logic low. Then, the 8 data bits D7:0 are transmitted. While this operation is carried out, the signal PSEL must be maintained at a low level. This operation is represented as the timing diagram illustrated in FIG. 8. Data clocking of the signal PDI is
20 achieved at a rising edge of the signal PCLK. When the last bit D0 of the 8 data bits is loaded, this data word is located into the configuration register.

FIG. 9 illustrates the read operation of the configuration register. The microcontroller can perform the read operation of the configuration register through the same interface. When the microcontroller transmits the 7 address bits to CC1020 and

then initializes the R/W bit to a low level, a configuration register value of a corresponding address in CC1020 is read. The signal PDO is set at a falling edge of the signal PCLK and read data is acquired at a rising edge of the signal PCLK. The signal PSEL must be maintained at a low level even in the read operation and set to a high level
5 between read operations or write operations.

(2) Transmitting/receiving data signal interface

While a data coding method that can be used in CC1020 includes NRZ, Manchester and UART modes, Manchester mode having the smallest receiving error is adopted in the present invention because a transmission rate is not concerned in the
10 present invention.

As illustrated in FIG. 10, CC1020 synchronizes data from a demodulator and provides a data clock signal DCLK. A data format is controlled by DATA_FORMAT[1:0] bit of a modem register. Manchester coding applied to the present invention is used when RF modulation is performed, converts data "0" into a high
15 level and converts data "1" into a low level, as illustrated in FIG. 10.

(3) FSK format modulation

As illustrated in FIG. 11, a data modulator of CC1020 can use FSK or GFSK employing a Gaussian filter. The present invention uses GFSK because GFSK can minimizes an occupied bandwidth, as illustrated in FIG. 11. Modulation and Gaussian
20 filtering are automatically carried out in CC1020 when TX_SHAPING bit of a deviation register is enabled.

The server 30 that wirelessly communicates with the relay terminal 20 through the CDMA module 31 includes the CDMA module 31 receiving information on manholes from the relay terminal using the CDMA antenna 32, a storage unit 33 storing

the information on the, manholes received from the CDMA module 31, a map data storage unit 36 storing map data used to indicate the positions of the manholes on an electronic map, a central processing unit 35 for controlling the information on the manholes to be displayed using the electronic map of the map data storage unit 36, and
5 an alarm unit 34 for generating an alarm sound corresponding to the information on the manholes.

Referring to FIG. 5, the antenna of the collecting terminal, which is used for wireless communication between the collecting terminal and the relay terminal, is set in the housing of the collecting terminal and a circuit board having a connector attached to
10 one side thereof is integrally formed with the antenna. The connector of the circuit board is connected to the collecting terminal using a cable penetrating the housing.

The collecting terminal 10 is located inside a manhole, and the housing 100 connected to the collecting terminal through the cable includes the circuit board 110 and is laid under the ground. Thus, an additional connecting cable terminal box is located
15 inside the manhole for maintenance such as replacement of the battery 17 set in the collecting terminal 10 and program upgrade to enable interface.

The cable 130 penetrating the housing 100 is enveloped by a waterproof cable 140 for shielding the cable 130 from the housing 100. The antenna 13 of the collecting terminal 10 and the antenna 21 of the relay terminal 20 have the same configuration.

20 Preferably, the antenna 13 uses a small and low microstrip patch antenna to wirelessly transmit information on a manhole to an external collecting device. A half wavelength patch antenna is very large at a frequency as low as 425MHz corresponding to an RF frequency band of the collecting terminal and the relay terminal. Accordingly, a dielectric material having a high dielectric constant is used in order to reduce the size of

the antenna. In this case, however, the gain and radiation efficiency of the antenna are decreased due to dielectric loss, and thus it is required to change a patch structure in order to reduce the size of the patch antenna.

Accordingly, a PIFA type quarter wavelength monopole patch antenna is used
5 as the antenna 13 of the collecting terminal 10 according to the present invention. The PIFA type quarter wavelength monopole patch antenna is obtained by grounding the patch center of a half wavelength microstrip patch antenna.

Since the antenna of the relay terminal is located higher than the collecting
terminal all the time, a plurality fins are attached to the bottom face of the monopole
10 patch antenna in order to increase a current path to induce a resonant frequency to decrease due to an increase in a visual resonant length.

Experiments on the performance of the antenna are explained in detail with reference to FIGS. 12 and 13.

While the length of the quarter wavelength monopole patch antenna, which is
15 required to determine the width of the patch antenna, is determined by the frequency of the antenna, a test is carried out as follows in order to find out the effect of the width of the patch antenna.

When a feeding point and the frequency of the antenna are fixed and the width
of the antenna is gradually reduced, the resonant frequency of the antenna is slightly
20 varied at an antenna width of greater than 40mm and abruptly increased when the antenna width becomes smaller than 40mm. Thus, it is preferable that the patch width is 50mm.

A fin interval must be greater than 22.5mm because an antenna current path is normal only when the fin interval is greater than $3/100$ of the wavelength. However, it is

confirmed from an experimental result that there is no problem if the fin interval is greater than 17.5mm. Furthermore, saturation does not occur for maximum 12 fins at half wavelength. Accordingly, the quarter wavelength monopole patch antenna is constructed such that it has six fins.

- 5 A distance between the antenna and a ground plane is determined as 20.0mm because the radiation resistance of the antenna decreases when the distance is large and increases when the distance is small.

 The radiation resistance decreases and the antenna becomes inductive as the feeding point of the antenna is close to a ground point of the antenna. On the contrary,
10 the radiation resistance increases and the antenna becomes capacitive as the feeding point becomes distant from the ground point of the antenna.

 A test for the antenna of the collecting terminal according to the present invention, constructed as above, was carried out in such a manner that a transmitter and a receiver of the collecting terminal both used power of 10mW and unlicensed low power
15 RF of 424.7500MHz and employed a half wavelength patch antenna having fins attached thereto.

(1) Visibility range test

 It was confirmed that communication over about 4,700m from a railway crossing at Yangsoori of Gyeonggido to KOFIC Namyangju studios was executed
20 without having error, as illustrated in FIG. 15. It is expected that communication over more than 5,000m can be performed if visibility range is increased.

(2) City range test

 Communication over about 400m was achieved around the building of e-pia tech., Ltd., as illustrated in FIG. 15. It can be known that the range is remarkably shorter

than the visibility range because the building of e-pia tech, Ltd. is low and high-rise buildings and an elevated electric railway station are located around the building of e-pia tech, Ltd.

While the theoretical visibility range of the RF communication module
5 according to the present invention is 12Km, approximately 5Km is achieved in practice due to circumstances.

Furthermore, although the city range is remarkably reduced due to test conditions, it is expected that at least 800m is secured if the relay terminal is located as high as more than the tenth floor and the antenna is adjusted downward. However,
10 continuous test and research are required because radio waves are varied according to circumstances.

The PIFA proposed by the present invention is small, less affected by circumstances and has reliability. While conventional linear antennas cannot function as an antenna when they are located close to a ground plane or a metal plate, the PIFA
15 according to the present invention can serve as an antenna even when laid underground because it is rarely affected by the ground plane. Thus, the PIFA according to the present invention can be applied to even iron plates and concrete walls.

The relay terminal 20 and the server 30 wirelessly communicate with each other in a frequency band of 848MHz using the CDMA modules 25 and 31.

20 The CDMA module 31 of the server includes an RF transmitter, an RF receiver and a mode converter. The RF transmitter collects data from a transceiver module and wirelessly transmits an acknowledgement signal corresponding to the collected data. The RF receiver collects data from the transceiver module, processes the collected data and transmits the processed data to a CDMA interface. The mode converter converts a

receiving mode to a transmission mode and converts the transmission mode to a receiving mode when RF transmission and reception are carried out.

According to the above-described configuration of the server, the central processing unit 35 displays information on manholes, received from the relay terminal, using a display unit 37 such as a monitor and generates an alarm sound using the alarm unit 34. The display unit 37 can display current positions corresponding to the ID numbers of the manholes using the electronic map of the map data storage unit 36.

When the central processing unit 35 receives information obtained by the collecting terminal 10 from the relay terminal 20, the central processing unit 35 transmits and displays the position and information corresponding to the ID number of a corresponding manhole to a manager and generates the alarm sound.

The central processing unit 35 stores received information on manholes in the storage unit 33 and manages the history of the information. When communication between the server and the relay terminal is cut off for 24 hours, the central processing unit 35 recognizes that the relay terminal 20 is out of order and generates an alarm sound to notify a server manager of the breakdown of the relay terminal 20. Furthermore, when time data transmitted from the relay terminal 20 is wrong for longer than 5 minutes, the central processing unit 35 instructs the relay terminal to correct the time data.

The operation of the wireless system for monitoring manholes according to the present invention will now be explained in more detail.

The opening/closing sensor 2, the temperature sensor 4 and the water-level sensor 6 connected to each collecting terminal 10 sense whether a manhole cover is opened or closed, the temperature of the inside of a manhole, and the water level of the inside of the manhole, and the power sensor 9 senses whether the battery 17 included in

the collecting terminal 10 is discharged or not. The collecting terminal 10 collects information including the sensing results and transmits the information to the relay terminal 20 through the RF communication module 14 and the antenna 15.

5 The relay terminal 20 collects and arranges the information on the manhole, received from the collecting terminal 10, and transmits the arranged information to the server 30 through a CDMA communication network using the CDMA module 25 and the CDMA antenna 26.

10 The server receives the information on the manhole from the relay terminal 20 through the CDMA module and displays the information in real time using a display means such as a monitor to inform the manager of the current position of the manhole and whether the manhole is normally operated in real time.

Any means capable of performing wireless communication other than the CDMA module and the CDMA antenna can be used as a communication module that carries out wireless communication between the relay terminal 20 and the server 30.

What Is Claimed Is:

1. An antenna structure of a manhole monitoring system, comprising:
a plurality of collecting terminals each of which is connected to a sensor set in a
5 manhole and collects information on the manhole from the sensor;
a relay terminal for collecting and arranging information on a plurality of
manholes, received from the plurality of collecting terminals; and
an antenna used for communication between each collecting terminal and the
relay terminal,
10 wherein the antenna is included in a housing of each collecting terminal, a
circuit board having a connector attached to one side thereof is integrally formed with the
antenna, and the connector of the circuit board is connected to the sensor through a cable
penetrating the housing.
- 15 2. The antenna structure of a manhole monitoring system according to claim 1,
wherein the antenna is a PIFA (Planar Inverting F Antenna) type quarter wavelength
monopole patch antenna constructed by grounding the patch center of a half wavelength
microstrip patch antenna.
- 20 3. The antenna structure of a manhole monitoring system according to claim 2,
wherein a plurality of fins are attached to the bottom face of the monopole patch antenna
in order to increase a current path to induce a resonant frequency of the antenna to
decrease due to an increase in a visible resonant length.

4. The antenna structure of a manhole monitoring system according to claim 3,
wherein the patch width of the monopole patch antenna is approximately 50mm.

5. The antenna structure of a manhole monitoring system according to claim 4,
5 wherein a fin interval of the monopole patch antenna is in the range of 17.7mm to
22.5mm, and the number of fins is 6.

6. The antenna structure of a manhole monitoring system according to one of
claims 3 and 4, wherein a distance between the monopole patch antenna and a ground
10 plane is approximately 20.0mm.

7. The antenna structure of a manhole monitoring system according to claim 1,
wherein the cable penetrating the housing is enveloped by a waterproof cable for
shielding the cable from the housing.

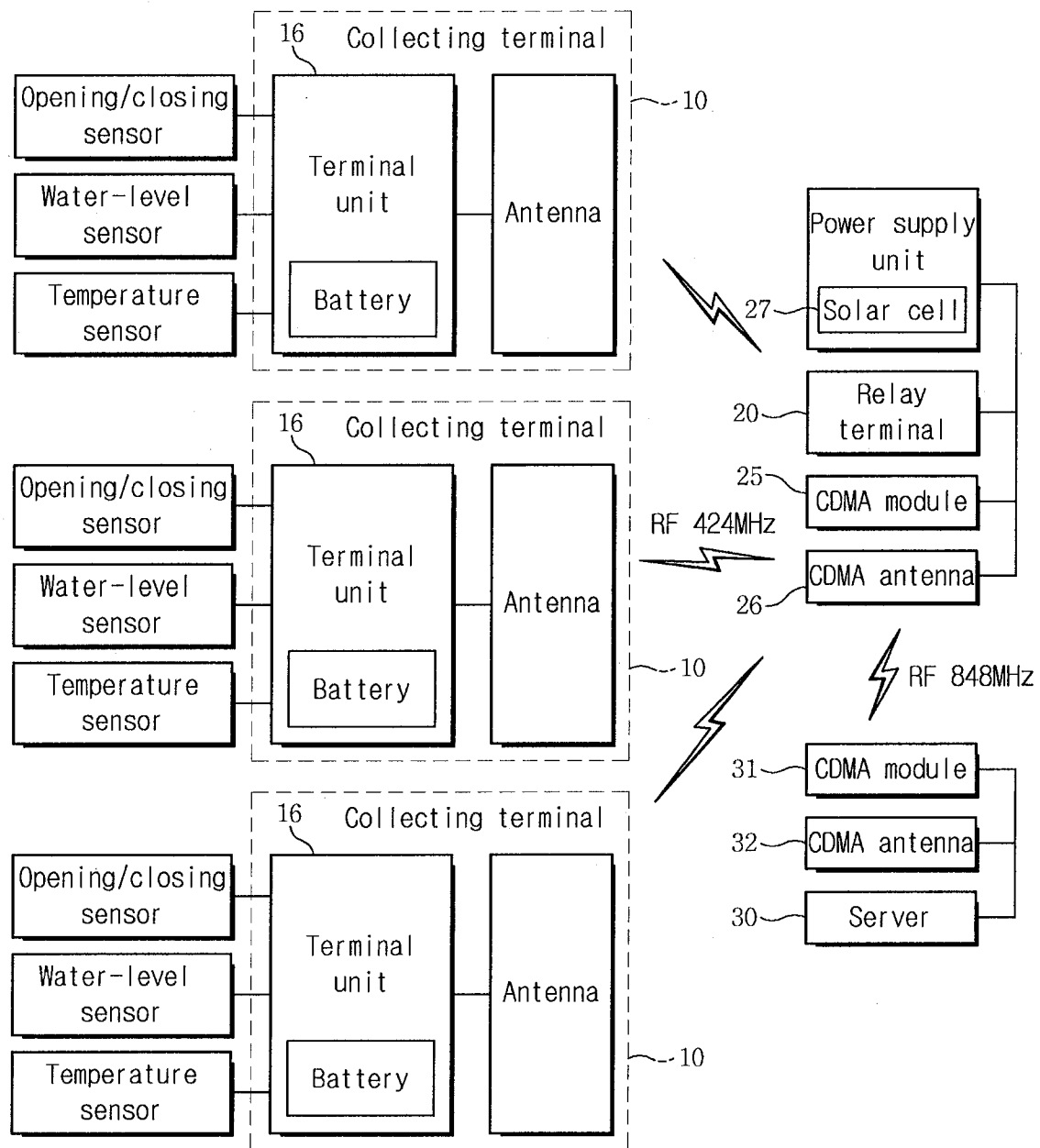
15

8. The antenna structure of a manhole monitoring system according to claim 1,
wherein the housing of the collecting terminal includes a stainless steel bottom plate and
an acetalresin cover such that the housing has strength and a waterproofing function.

1 / 8

FIGs

Fig. 1



2 / 8

Fig. 2

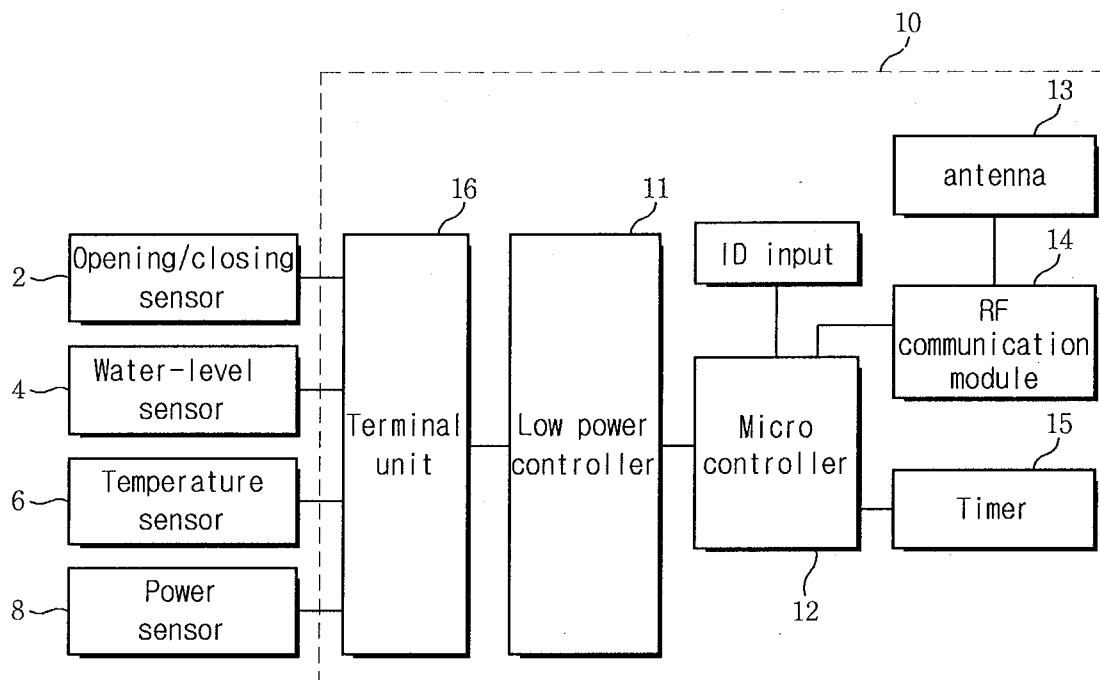
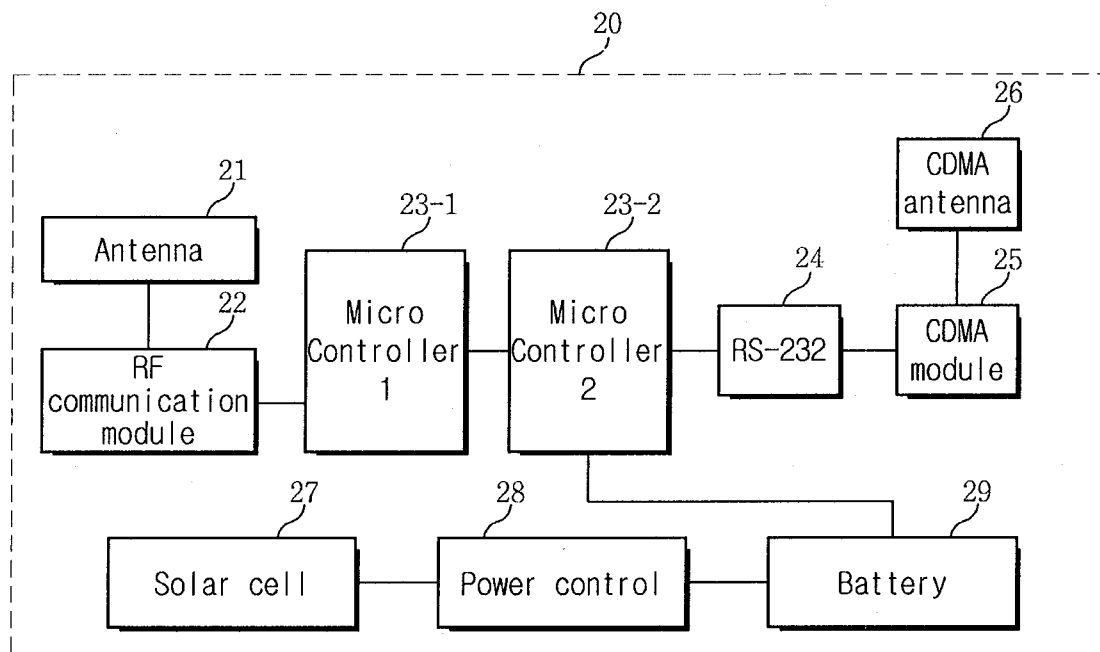


Fig. 3



3 / 8

Fig. 4

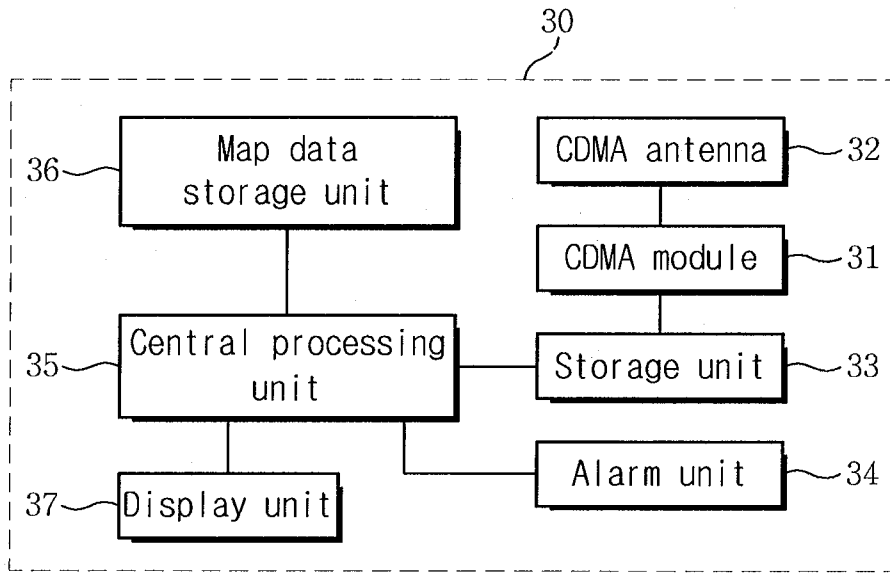
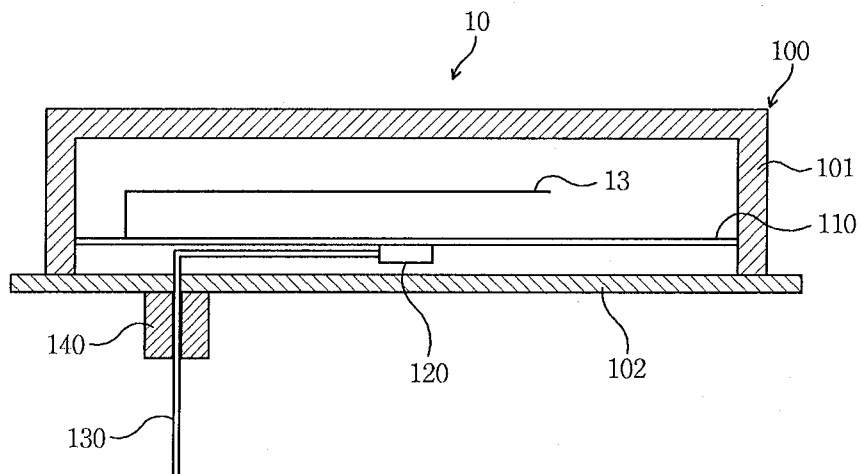


Fig. 5



4 / 8

Fig. 6

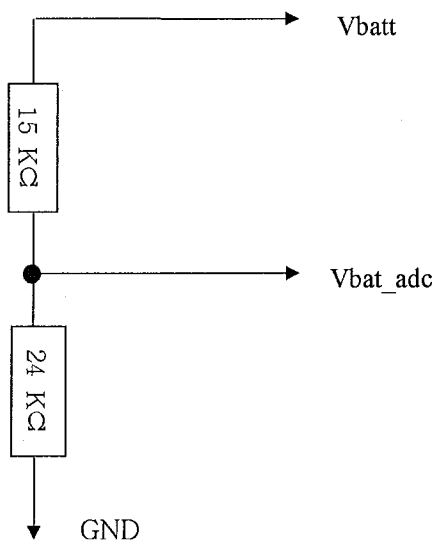
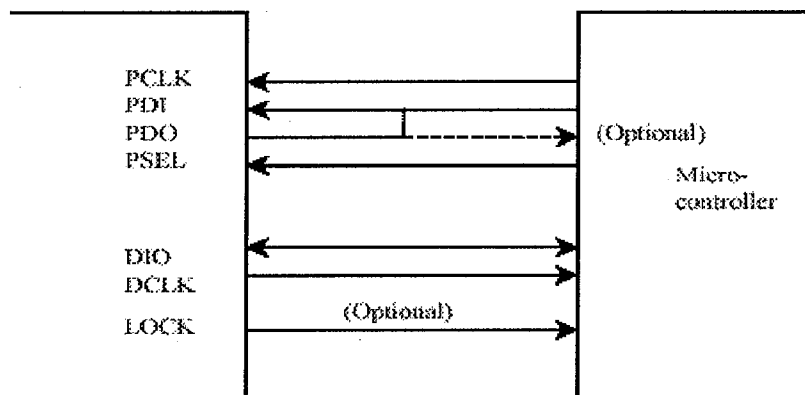


Fig. 7



5 / 8

Fig. 8

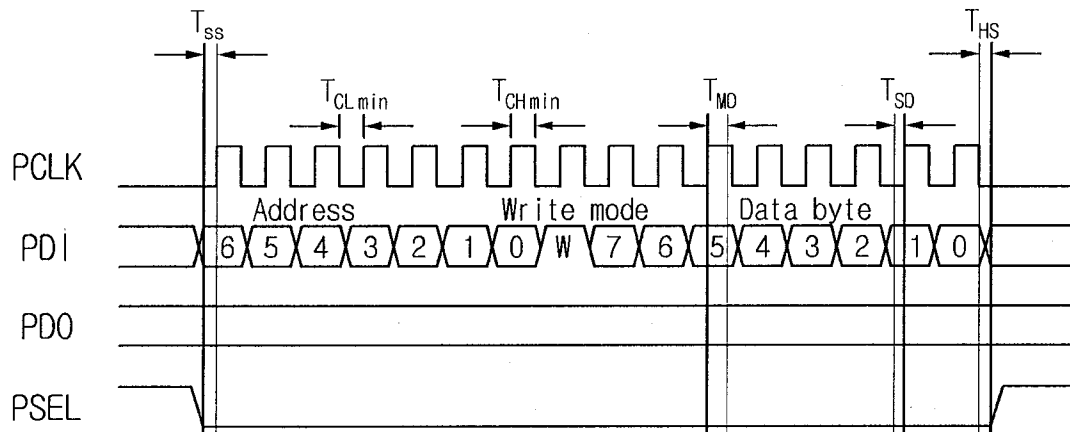
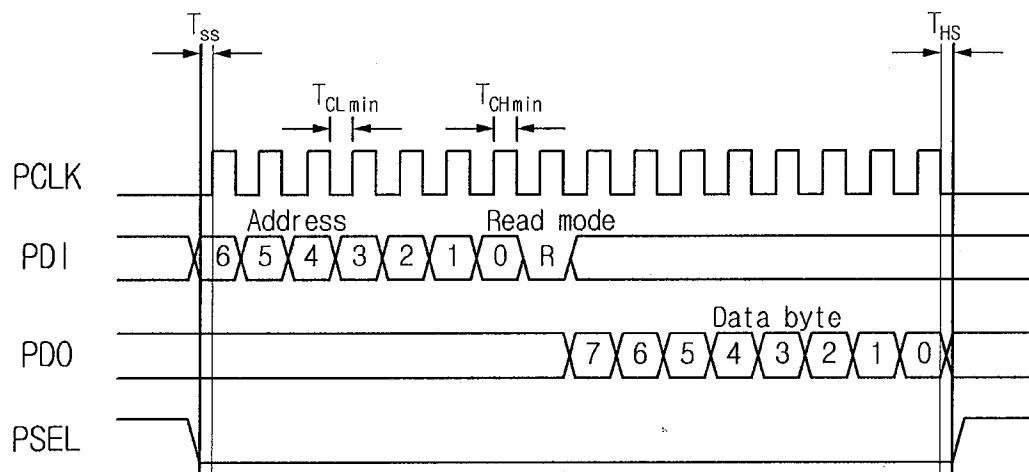


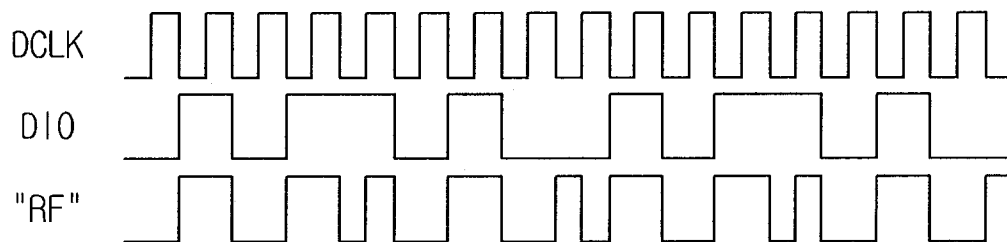
Fig. 9



6 / 8

Fig. 10

Transmitter side:



Receiver side:

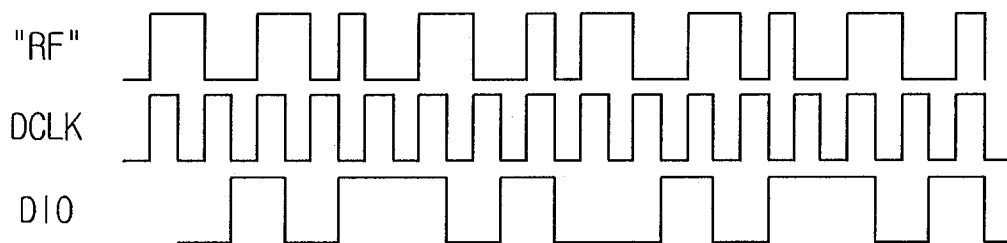
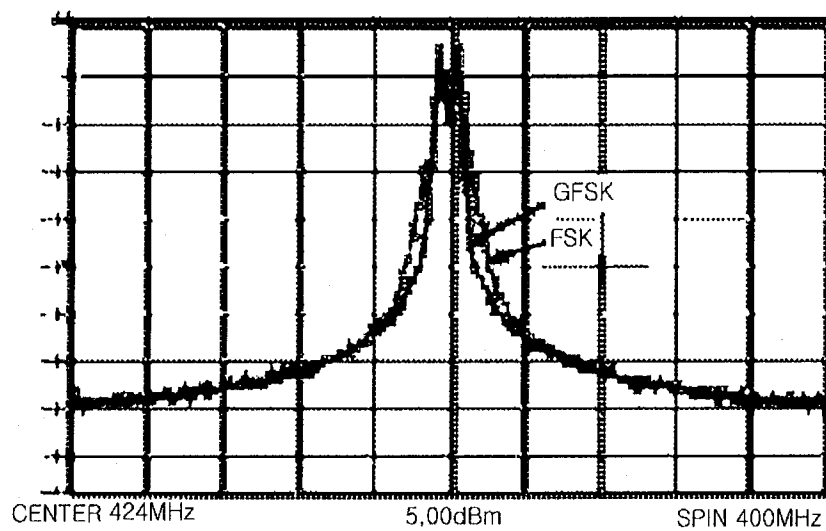


Fig. 11



7/8

Fig. 12

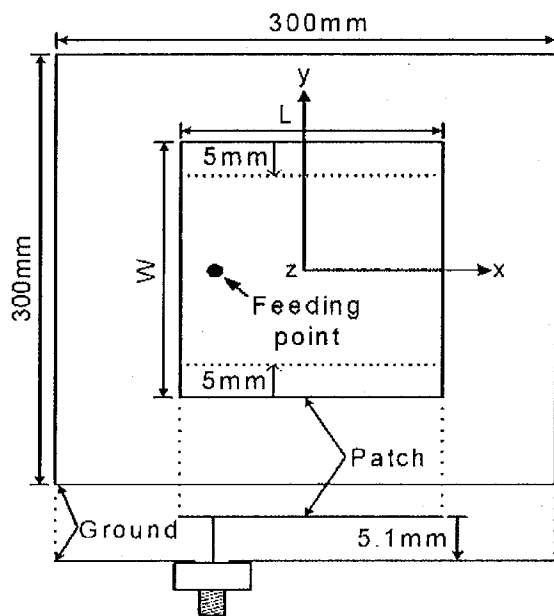


Fig. 13

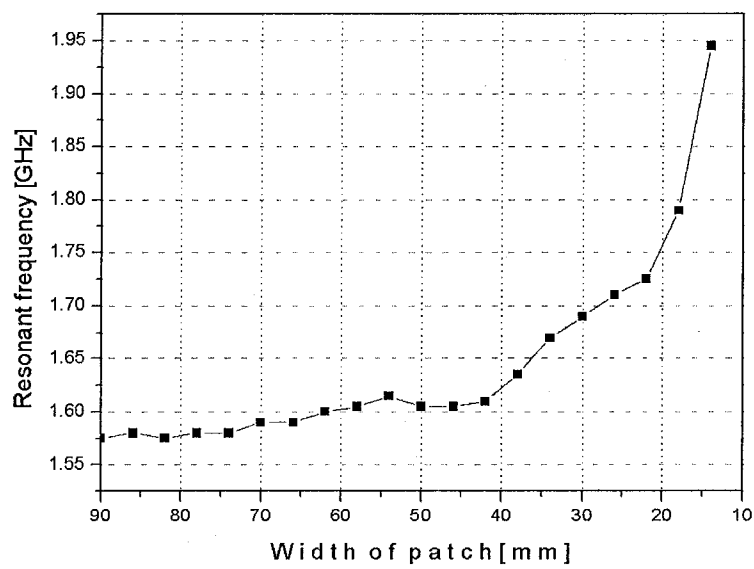


Fig. 14

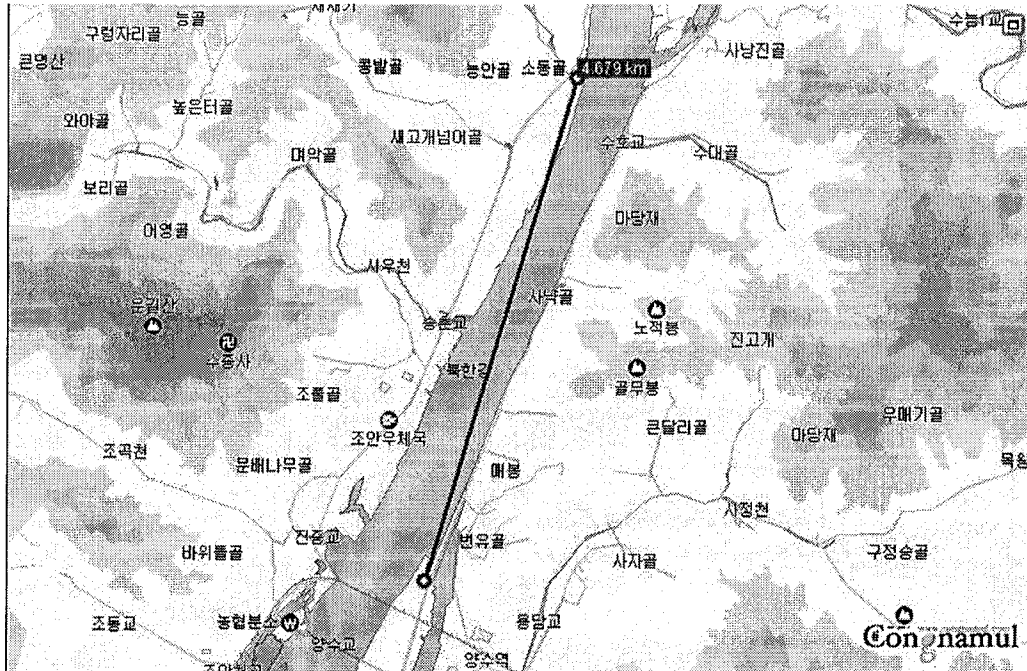
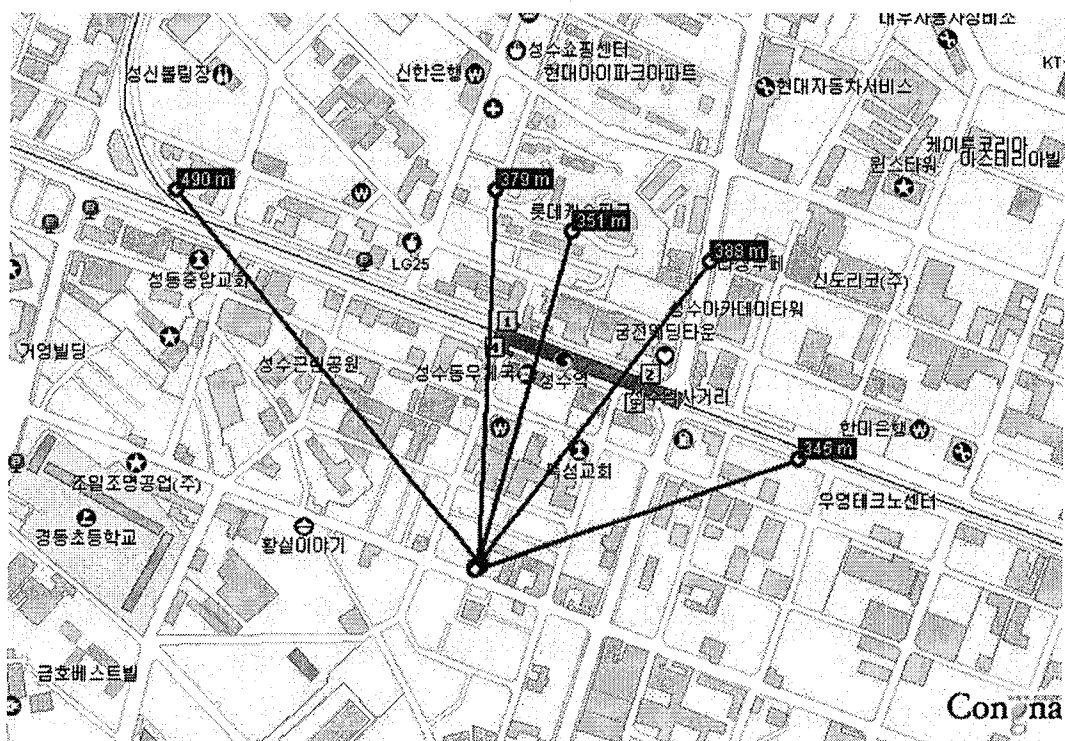


Fig. 15



A. CLASSIFICATION OF SUBJECT MATTER**G08C 17/02(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC8 G08C 17/02; G08B 21/00; G08B 23/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Utility models and applications for Utility models since 1975

Japanese Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKIPASS "MANHOLE, MONITORING, WIRELESS"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 7002481 B1 (Patrick R. et al.) 21 February 2006 See the abstract; claims 1, 16-17; figures 1, 5.	1-8
A	US 5583492 A (Yutaka Nakanishi et al.) 10 December 1996 See the abstract; claim 1; figures 1-6.	1-8
A	US 6272346 B1 (Akira Fujinami) 07 August 2001 See the abstract; claims 1-2; figures 1-6.	1-8
A	JP 2005-074081 A (C-CUBE CO.) 12 March 2003 See the abstract; paragraphs 0007, 0008 and 0019; claims 1-2; figures 1-2.	1-8
A	JP 2005-133418 A (TOSHIBA HOME TECHNOLOGY CO.) 26 March 2005 See paragraphs 6-10; claim 1; figures 1-5.	1-8
A	JP 09289676 A (MITSUBISHI ELECTRIC CO. et al.) 04 November 1997 See the abstract; paragraph 0012; claim 2; figures 1-6.	1-8
A	KR 10-2003-0054212 A (ZARADA CO., LTD.) 02 July 2003 See the abstract; claims 3-10; figures 4-6. (English version is available on K-PION: http://kposd.kipo.go.kr:8088/up/kpion/)	1-8



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

16 MAY 2007 (16.05.2007)

Date of mailing of the international search report

17 MAY 2007 (17.05.2007)

Name and mailing address of the ISA/KR

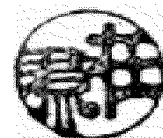
Korean Intellectual Property Office
920 Dunsan-dong, Seo-gu, Daejeon 302-701,
Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

LEE, Jae Hoon

Telephone No. 82-42-481-5791



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2007/000461

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 7002481 B1	21.02.2006	US 20060181425 A1	17.08.2006
US 5583492 A	10.12.1996	JP 07143631 A	02.06.1995
US 06272346 B1	07.08.2001	JP 11127100 A2	11.05.1999
		JP 3099789 B2	16.10.2000
JP 2003-074081 A	12.03.2003	None	
JP 2005-133418 A	26.05.2005	None	
JP 09289676 A	04.11.1997	AU 685725 B1	22.01.1998
		FR 2747867 A1	24.10.1997
		FR 2747867 B1	02.11.2001
		US 20010011009 A1	02.08.2001
KR 10-2003-0054212 A	02.07.2003	None	