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CASDAC SYSTEM
- MONITORING UNIT -
USER'S GUIDE

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Yoichi YAMAMOTO and Kinji KOYAMA

日本原子力研究所
Japan Atomic Energy Research Institute

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Yoichi YAMAMOTO and Kinji KOYAMA

Department of Fuel Safety Research
Tokai Research Establishment
Japan Atomic Energy Research Institute
Tokai-mura, Naka-gun, Ibaraki-ken

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The CASDAC (Containment And Surveillance Data Authenticated Communication) system has been developed by JAERI for nuclear safeguards and physical protection of nuclear material. This system is a remote monitoring system for continual verification of security and safeguards status of nuclear material.

The CASDAC system consists of two subsystems, one of them is a Grand Command Center (GCC) subsystem and the other is a facility subsystem.

This report describes the outline and usage of the Monitoring Unit (MU), which monitors continuously C/S sensor status in a facility subsystem. This work has been carried out in the framework of Japan Support Programme for Agency Safeguards (JASPAS) as a project, JA-1.

Keywords : CASDAC, Safeguards, Physical Protection, System, Verification, C/S (Containment/Surveillance), MU

CASDACシステム
－モニタリング・ユニット－
使用者の手引き

日本原子力研究所東海研究所燃料安全工学部
山本　洋一・小山　謹二

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CASDAC（封じ込め／監視データ認証通信）システムは，保障措置及び核物質防護の一環として日本原子力研究所が開発した。このシステムはRECOVERシステムとTRANSEAVERシステムを基に，改良RECOVERシステムとして設計，製作された，核物質の保全状況及び保障措置状況の検認を行うための遠隔監視システムである。

本システムは，2つのサブシステムからなり，1つは中央監視センター（GCC），他の1つは施設サブシステムである。

本報告書は，施設サブシステムのうちC／Sセンサの情報を連続監視しているモニタリング・ユニット（MU）について，その概要及び使用方法についてまとめたものである。なお，本研究は日本国のIAEA保障措置支援計画の一環としてプロジェクトJA－1として実施したものである。

東海研究所：〒319－11 茨城県那珂郡東海村白方字白根2－4

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1. Outline of CASDAC System

The CASDAC (Containment and Surveillance Data Authenticated Communication) system [1] is a secure and reliable communication system which continually monitors any changes in the status of containment and surveillance sensors and the status of integrity and health of the system itself.

Communication data must be secure and reliable, therefore all the data on public telephone line network are encrypted to prevent falsification and tapping by unauthorized persons, and the high level data link control (HDLC) procedures are adopted to detect tampering with the data or unauthorized polling trial through public telephone line. The system configuration is shown in Fig. 1.

The system is designed to realize requirements of secure communication, very low false alarm rates and of unattended operation of the facility subsystem. Together with these requirements, cost performance, easy maintenance and transportability of software system including the application programs are also important factors considered.

The system is divided into two subsystems, one is the Grand Command Center (GCC) system and the other is the facility subsystem including containment and surveillance sensor (C/S) system. The communication between two subsystems is controlled by means of a tamper resistant and secure way through the international public telephone line network.

The GCC system consists of two engineering workstations with graphic terminals and two communication control equipments (CCE).

The facility subsystem consists of: 1) The On-Site Multiplexer (OSM) composed of a personal computer, a modem, two HDLC boards, and a monitoring unit adapter (MU-ADP) which is designed for this system specially to make communication available between OSM and MUs (up to 30 MUs), 2) A set of the Monitoring Units (MU), which can monitor up to 8 bits binary (on/off) signals from C/S sensor, 3) The Data Terminal Equipment (DTE) for making message communication available between the GCC and the facility subsystem by a classified and secure way, which also consists of a personal computer with 40 M bytes hard-disk and a HDLC board, and 4) The Multiplexer Unit (MXU) which can link with computer controlled devices such as the global positioning system (GPS) and the satellite communication control equipments.

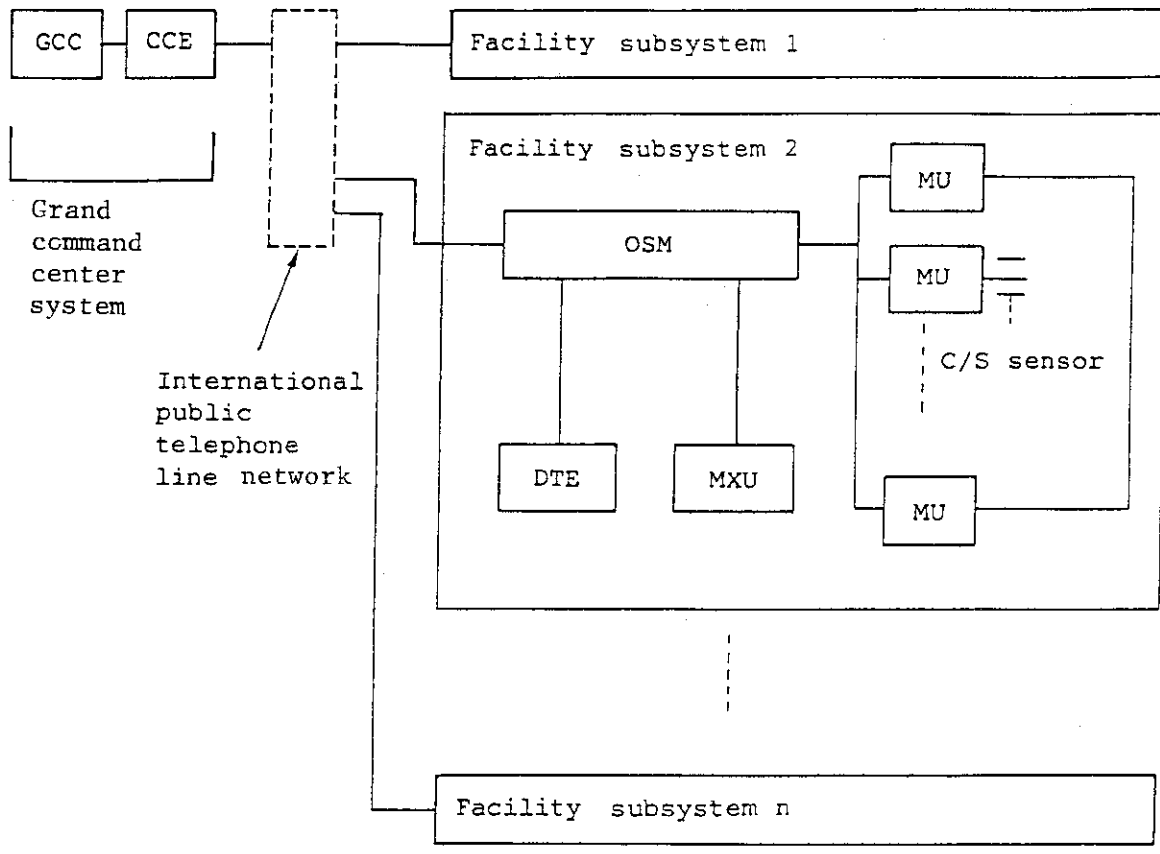

Fig. 1 Configuration of CASDAC System

2. Outline of Monitoring Unit (MU)

The monitoring unit (MU) is designed to monitor continuously sensor status up to 8 bits and store the status information in the temporary memory (RAM) with the last changes of the status as history records until transmission to the on-site multiplexer unit (OSM). The MU is built around a 8-bit microprocessor with 128 bytes RAM and 4 K bytes ROM. Up to 30 units of MUs are controlled and managed by one OSM through three set of MU control lines.

The status and history data stored in RAM of each MU are encrypted by using a pair of key data and random number with 16 and 8 bytes words length respectively, and transmitted to the OSM. Fig. 2 shows the profile of MU which is a wall-mount type equipment installed in a casing of about 80(W) x 200(D) x 60(H) mm in dimension. The general specifications of MU are shown in Table 1.

Basic functions of MU are summarized as follows:

1) MU has its own station number, by which the MU is polled from the OSM and it makes data communication available between them.

2) MU monitors continuously 8 independent bits of binary status from a sensor (or sensors) and stores them in RAM.

3) MU monitors its own status (normal or abnormal), including external power and battery status, and also the status of cable connections between MU and sensor(s).

4) MU maintains a historical data (records) of the identity of any sensor status bits to be reported to the OSM, even if that bit reverts to normal status before the next poll of the MU from the OSM.

5) MU maintains polling status data between OSM and MU (Number of Pollings on Polling Counter Register in MU).

6) MU reports encrypted status data to the OSM upon receipt of a request from the OSM, however it does not respond when other MUs are called by the OSM (A MU has its own station number).

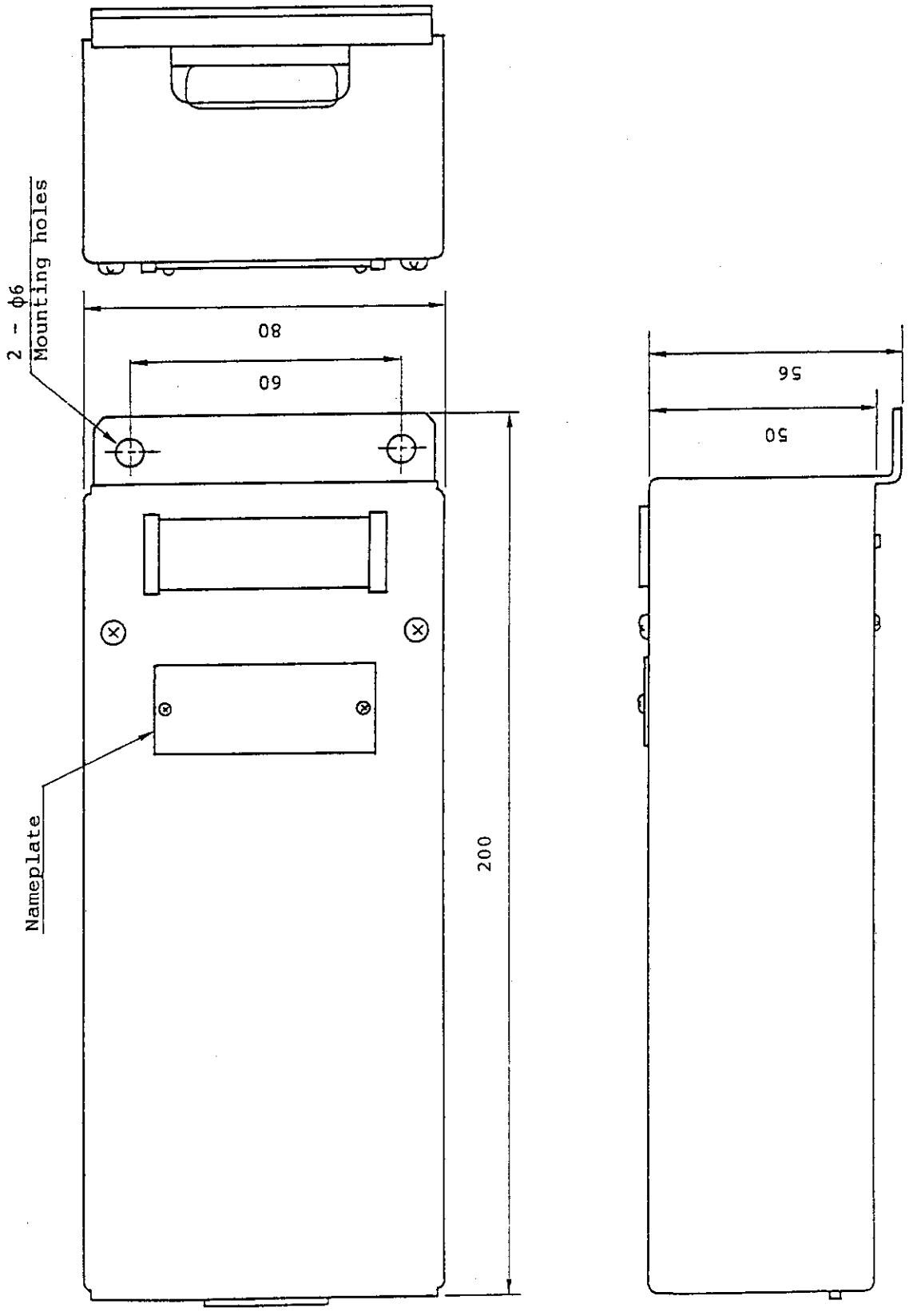

Fig. 2 Profile of the MU

Table 1. General Specifications of MU

Item		Specifications
Supply voltage		DC 12V ± 20%
Power consumption		Approx. 0.1 W
Environmental conditions	Temp.	0 to 40°C
	Humidity	30 to 90%
Weight		Approx. 0.5 kg
Outside dimensions		80(W) x 56(D) x 200(H) mm

Table 2. Communication Control with OSM

Item	Specifications
Port	1
Signal standard	0 - 5 V interface
Communication type	Half duplex
Synchronization	Asynchronous
Communication speed	300 bit/sec
Stop bit	2 bits
Commu. Protocol	Special
Downward:(OSM to MU)	Humming code (7 bits) + parity (odd) without encryption
Upward:(MU to OSM)	Encrypted JIS 8 bits code + BCC (Odd), (the key and the random numbers are used for the encryption of data)

3. Data Transmission

3.1 Communication between MU and OSM

A special communication protocol is developed for making reliable and secure data transmission available between MU and OSM. And it is built on rather a simple communication control mode such as Half Duplex, Asynchronous communication mode, and 300 bits/sec as shown in Table 2 in order to reduce the overhead of the 8-bit CPU in MU.

There may be so much electro-magnetic noise in the field where MUs will be set. The communication protocol must be tough enough to keep reliable communication. Therefore, Hamming data conversion method is applied to transmit MU control commands and data from OSM to MU in order to minimize data communication errors. And the data to be transferred from MU to OSM which consist of 8-byte length are packed into one block in MU and encrypted by a set of key and random number with 16 and 8 bytes words length respectively, then attached one byte BCC(Block Check Character). This block data are finally transferred to OSM by demand polling after attached a preamble as "Start of Text" and a postamble as "End of Text" with it.

The time periods needed to complete a communication with an MU are about 15 seconds from the beginning of the demand call to the end of the communication. The polling rates of a MU depend on the number of MUs connected with an OSM and the order of pollings is assigned randomly by the OSM within a series of MU polling.

3.2 Monitor of Sensor Status

MU monitors sensor status every one second and status of cable connection by intervals of 170 ms (Table 3). The status bits in sensor register are updated when a unique status is consecutively observed four times in order to minimize false alarms.

4. Hardware

The MU's hardware is composed of a casing and a 8-bit micro-computer based communication control logic consisting of MU and INF unit boards as shown in Fig. 3.

(1) Casing

The casing is made of steel plates. It mainly consists of a chassis, case, brackets, etc.

(2) Communication control logic

The communication control logic is composed of two different boards, MU and INF.

1) MU board
This board has a 8-bit CPU with memory (4 K Bytes ROM and 128 Bytes RAM) for control of monitoring C/S sensor status and of data transmission between MU and OSM.

2) INF board
This board is located between OSM and MU board as well as between C/S sensors and MU board. It protects the signal line from abnormal current or voltage level and remove noise from the power and communication lines.

Figs. 4 and 5 show the block and the circuit diagrams respectively in order to get an image of how to link with OSM and C/S sensor.

The specification of the interface with C/S sensors is summarized in Table 3. And the pin assignment of MU connector is given in Table 4.

5. Software

The MU's software is designed to monitor the status of C/S sensor, to store them into memory to keep the record of their history, and to report the status data to the OSM by a demand poll from the OSM. The program is made up of a set of modular programs which are written by the Assembler Language. The outline of function is summarized for each module as follows:

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Module Name	Outline of Function
Initialization	Checks and clears the RAM. Initializes the register and other peripheral devices.
S/W UART	Transmits or receives 1-byte data via the I/O port to link with the OSM.
Received message analysis	Carries out humming conversion of a received message and checks its contents. Executes processing in accordance with the contents, if it is addressed to the MU. Abandons the data if it is addressed to other MU.
Send message composition	Composes and encodes a message, and send it to the OSM.
Timer interruption	Serves as a timer for activating S/W UART, C/S data input and self diagnosis modules.
C/S data input	Read status data from the C/S sensors.
Power failure interruption	Interruption in case power supply to the MU is cut off or recovered.
Stop mode processing	Activated by the power failure interruption. Lowers power consumption, in case of power supply cut-off, and enters the stop mode to protect data in the RAM. Executes fault recovery processing if power is recovered.
Data updating	Updates data upon receipt of a command from the system control module.
Self diagnosis	Carries out self check of data in the RAM.
System control module	Processing in the MU is done by means of phase control. This module controls this phase, executes suitable module, and advances to the next phase.

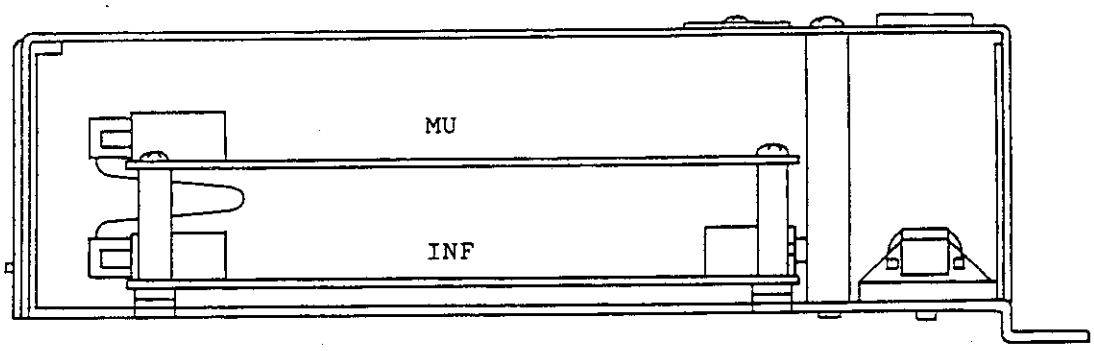

Fig. 3 Internal Layout of the MU

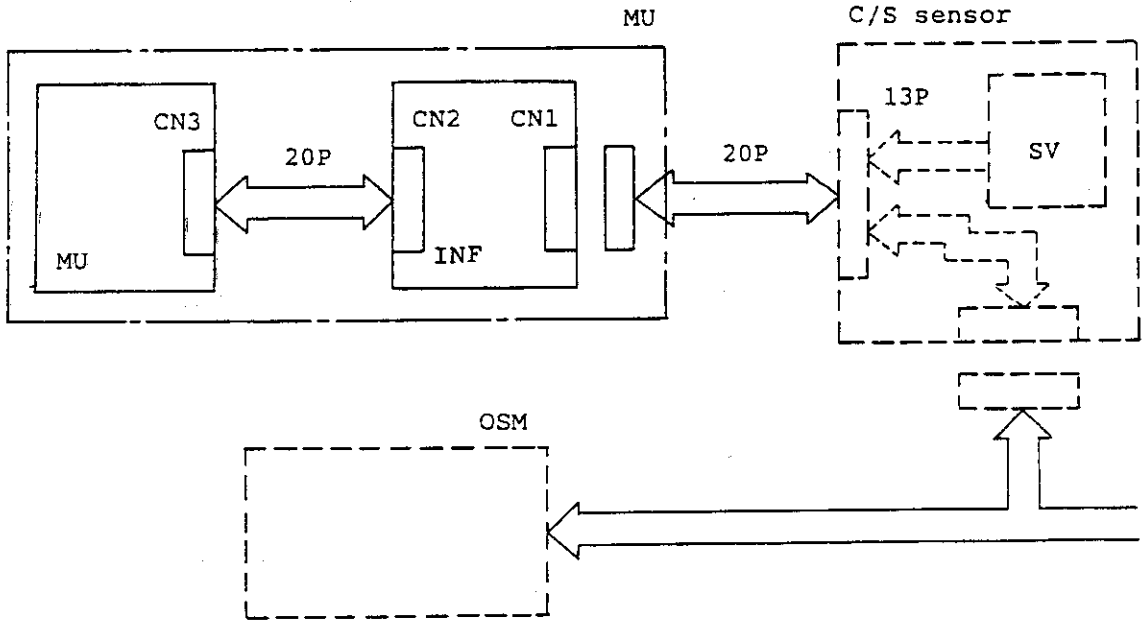

Fig. 4 Hardware Block Diagram of the MU

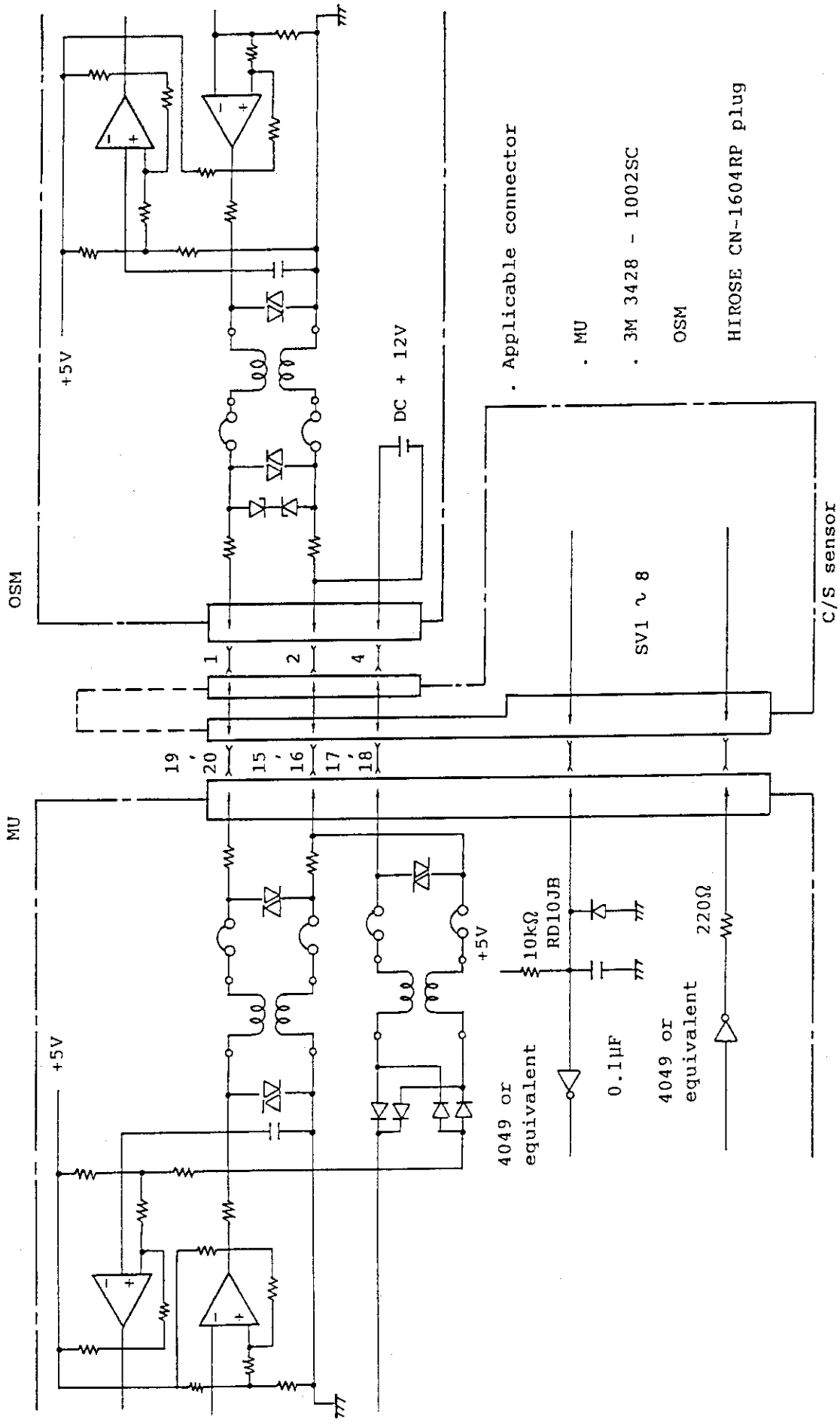

Fig. 5 Circuit Diagram of the MU

Table 3. Specification of C/S Sensor Interface

Item	Specifications
Input signal	8 bits independent signals + one interlock
Signal standard	High level input voltage: 2.7 V or more Low level input voltage : 0.9 V or less Input current : less than 1 mA
Signal level	SV1 to SV8: Low level at the normal Interlock : Low level at the normal
	ACK : High Level at sampling, Low Level in other state
Alarm detecting time	SV1 to SV8: 4 sec $^{+0}_{-1}$sec
	Interlock : 680 ms $^{+\ 0}_{-170}$ ms

Table 4. Signal Pin Assignment of MU Connector

Item	ID	Pin No.	Signal Direction	Notes
Communication line	L1	19, 20	MU<->OSM	To-OSM communication line
Interface power	Vcc(+)	17, 18	"<--"	Power supply line to MU
Ground	G	15, 16	"---"	Ground
Interface power supply	SP	14	MU-->C/S	Power supply line to C/S sensor
MU status	ACK	11	"-->"	Flag: Ready to receive sensor status
Reference voltage REF	+5V	13	"-->"	Reference voltage supply for C/S sensor(if needs)
Connector disconnection	INTER LOCK	2	"<--"	Flag for connector disconnection
Sensor signal No.8	SV8	10	"<--"	A signal from C/S sensor
Sensor signal No.7	SV7	9	"<--"	ditto
Sensor signal No.6	SV6	8	"<--"	ditto
Sensor signal No.5	SV5	7	"<--"	ditto
Sensor signal No.4	SV4	6	"<--"	ditto
Sensor signal No.3	SV3	5	"<--"	ditto
Sensor signal No.2	SV2	4	"<--"	ditto
Sensor signal No.1	SV1	3	"<--"	ditto
Ground	GND	1	"---"	Common Ground for signals

6. Operation

6.1 Initial Setting of Hardware Switches

Since plural (up to 30) MUs can be connected to an OSM, each MU must be identified uniquely. On this matters, the station number of each MU must be set by strapping from S1 to S6 on the MU board before its operation.

The MU board is accessible by removing the unit case. Fig. 6 shows the profile of the MU board and the location of the strap switches for station number setting.

This number is expressed in BCD (Binary Coded Decimal) within the range from 1 to 30. Where S1 to S4 are used to set the low-order digit of the address, and S5 and S6 are used to set the high-order digit as shown in Table 5.

6.2 Connection with OSM

As shown in Fig. 7, three connectors with four pins are prepared for MU connection on the rear panel of OSM. The pin assignment of this connector is as follows:

Pin number 1 : for signal line
Pin number 2 : common ground line
Pin number 3 : not assigned
Pin number 4 : for power supply to sensor (DC +12V)

Each connector allows to connect up to 10 MUs in parallel.

Sensor simulators are also available to test the functions of MU and OSM by turning on/off toggle switches on the sensor simulator manually. Fig. 8 shows how to connect a sensor simulator with MU and OSM. A sensor simulator must be connected by cables to one of the three MU connectors on OSM as shown in the figure, and MU is connected with the sensor simulator by the flat cable which is supplied with sensor simulator.

6.3 Preparation before Use

All of the program modules have been installed into ROM before shipping out. Therefore, there is no required procedure on the MU but initialization of the MUs through the OSM from the GCC (Grand Command Center) by the assigned port address. Therefore, the number of MUs and those station number should be informed to the GCC before operation.

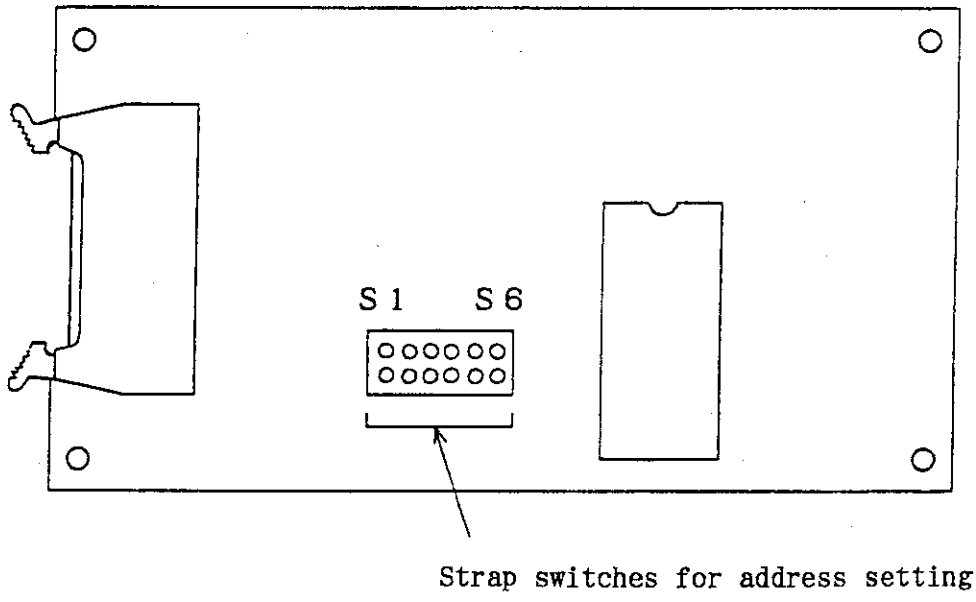

Fig. 6 Layout of Strap Switches on MU Board

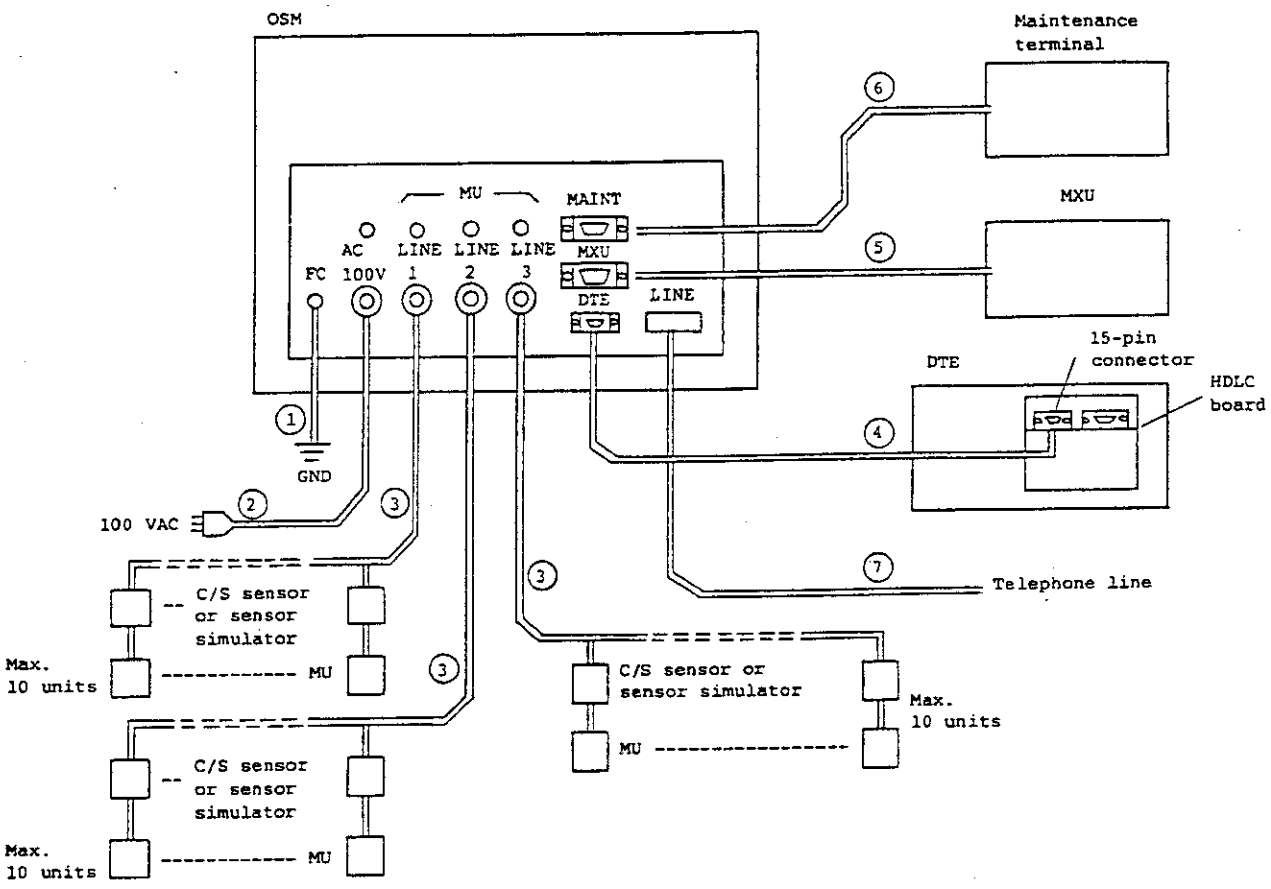

Fig. 7 Cable Connection Diagram with OSM

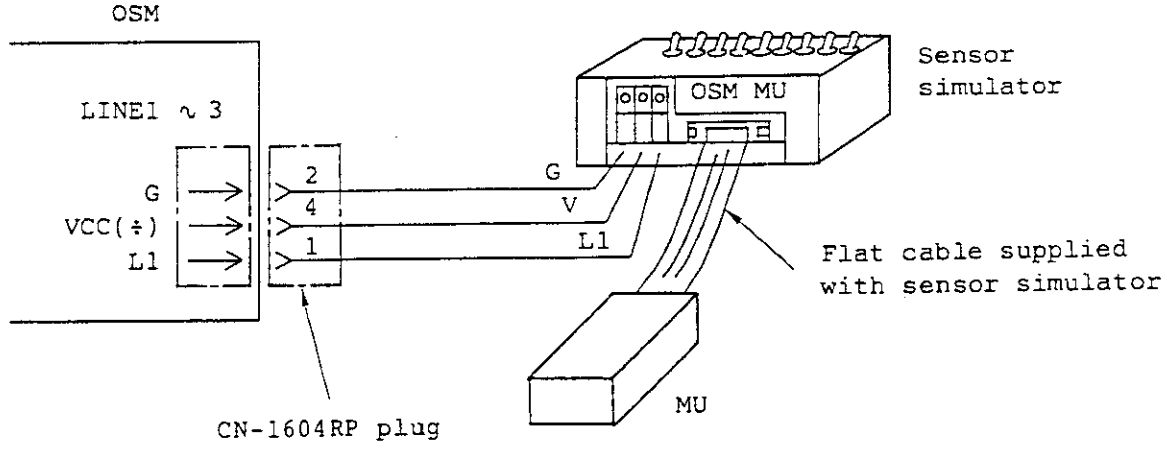

Fig. 8 Cable Connection with Sensor Simulator

Table 5. Strapping for the MU Address Setting

Example: Address setting = 26

S6	S5	S4	S3	S2	S1
o			o	o	

Circles, o, indicate straps.

Address Setting (High-order)	S6	S5
0		
1		o
2	o	
3	o	o

Address Setting (Low-order)	S4	S3	S2	S1
1				o
2			o	
3			o	o
4		o		
5		o		o
6		o	o	
7		o	o	o
8	o			
9	o			o
0				

Circles, o, indicate straps.

7. Maintenance

This system is designed to offer quite stable for long-term service and does not require any periodical maintenance. However, the following points must be taken care of:

(1) If the supply voltage is not within the standard range, the system does not work properly. Note that rising of the supply voltage over the standard value may cause deterioration or breakage of ICs, capacitors and other electric parts.

(2) This system is precisely adjusted in the factory. Never touch any part, except switches for address setting. Otherwise, satisfactory system operation may not be ensured.

References

1. Y. YAMAMOTO and K. KOYAMA: "Upgraded RECOVER System - CASDAC System -", JAERI-M 92-026, JASPAS 91-2 (1992).

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