Communication Board Technologies for Loop Relays

Loop relay, Looped system protection

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Abstract

Since 1985, loop relays (digital protection relays for looped systems) have been applied to 22kV loop transmission systems in the Tokyo Metropolitan Area. Since 1989, they have been applied to 66kV loop transmission systems in both the Tokyo Metropolitan Area and at the Tokyo Seaside Industrial Complex. Recently, we developed a successor relay model for the relaying facilities that were operated for 25 years. This development is based on the communication board technologies for loop relays.

Conventionally, the Time Division multiplexing communication functions were constructed by a maximum of 16 boards. Such functions were put into a single board using Field Programmable Gate Array (FPGA). The single board provides for the elimination of communication units and terminal communication units, has realized a compact design, and is energy saving.

1. Preface

Because of an increased power demand due to economical growth, power systems went through system improvements, one of which is a larger capacity of facilities. Because of the role of providing a stable power supply, it opted for duplex and looped systems. In current power systems, the roles of protective relays utilizing communication technologies are vital in terms of high-speed system fault recovery and the prevention of dependent fault.

In 1985, Meidensha Corporation ("MEIDEN") developed a loop relay as a protective relay system for 22kV looped system protection. In 1989, MEIDEN developed a loop relay for a 66kV looped system protection.

For communications with loop relays, information is transmitted by the optical fiber and the Time Division multiplexing technologies. The loop relay has a function of synchronized sampling which realizes a time-synchronizing among substations in a looped system.

This paper introduces the communication board technologies applied to the loop relays.

2. Outline of a Loop Relay

The loop relay is a protective relay system which is applied to the looped systems in the Tokyo Metropolitan Area and Tokyo Seaside Industrial Complex, adopting a transformer substation side concentration judgment method. Fig. 1 shows an example of a loop relay system configuration.

The loop relay system is composed of central relay equipment installed in a transformer substation and of terminal units (involving up to 10 terminal units) on an end user site. Both equipment and units are combined through a looped optical fiber connection

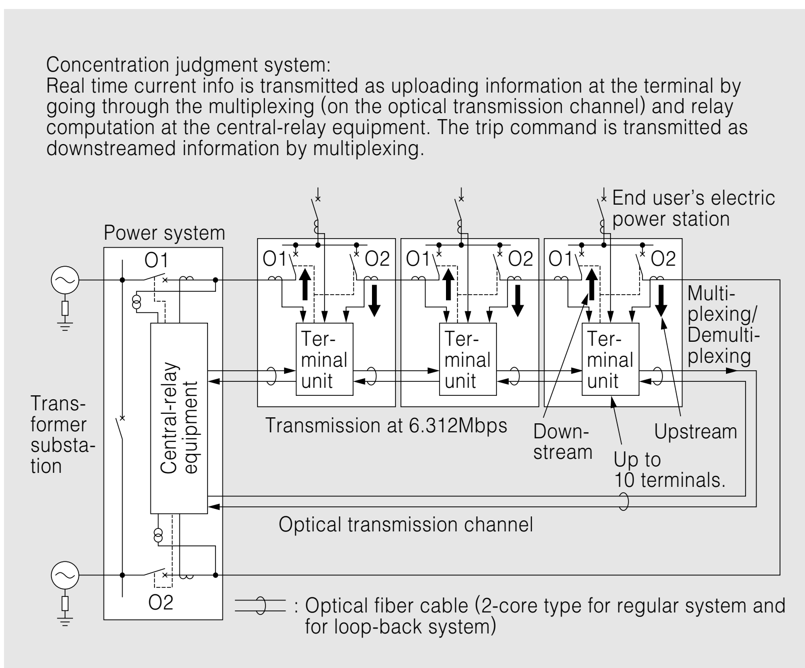

Fig. 1 Example System Configuration of Loop Relays

The loop system, optical fiber transmission, and equipment configuration are shown. The communication board realizes the communication between the central-relay equipment and terminal unit.

with a baud rate of 6.312 Mbps. Current data and trip commands are transmitted through this connection. It has been almost 25 years since the first system was installed. To prepare against the model change and discontinuance of the electronic parts, and for the maintenance of facilities, the overall system configuration was reviewed and we developed the successor model.

3. Communication Board

Communication functions of conventional loop relays were configured by a maximum of 16 boards. At this time, major communication functions were integrated into a single board of FPGA (Field Programmable Gate Alley). Fig. 2 shows an external appearance of the board. The four major functions of time division demultiplexing communication, synchronized sampling, setup, and remote maintenance are described below.

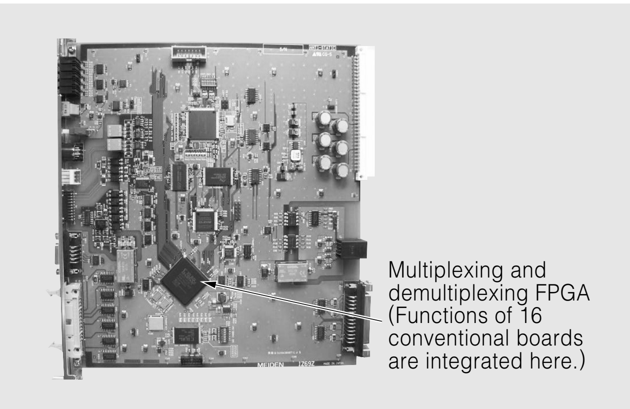

Fig. 2 External Appearance of the Board
This shows an external appearance of the board.

3.1 Time Division Demultiplexing Communication Function

Time division demultiplexing communication is a function of information multiplexing and demultiplexing as required for the transmission frame. Fig. 3 shows an outlined concept of the system. Information items to be

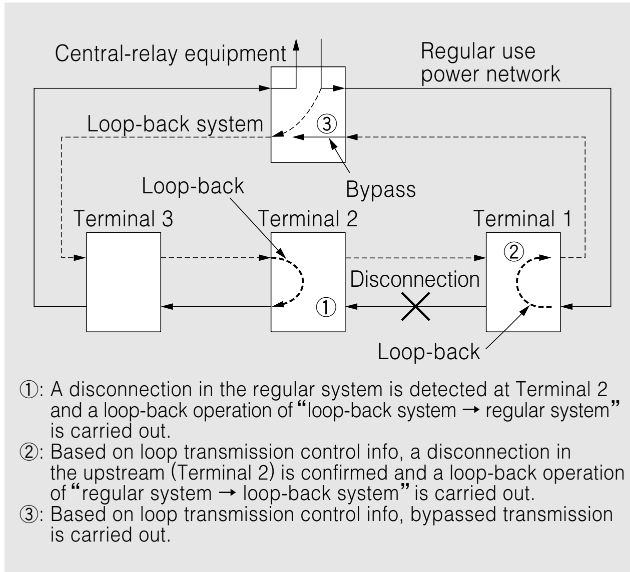

Fig. 4 Loop-Back Control
In the case of a disconnection between Terminal 1 and Terminal 2, terminal unit makes a loop-back operation so that another transmission channel is reconstructed through a bypass circuit at the central-relay equipment.

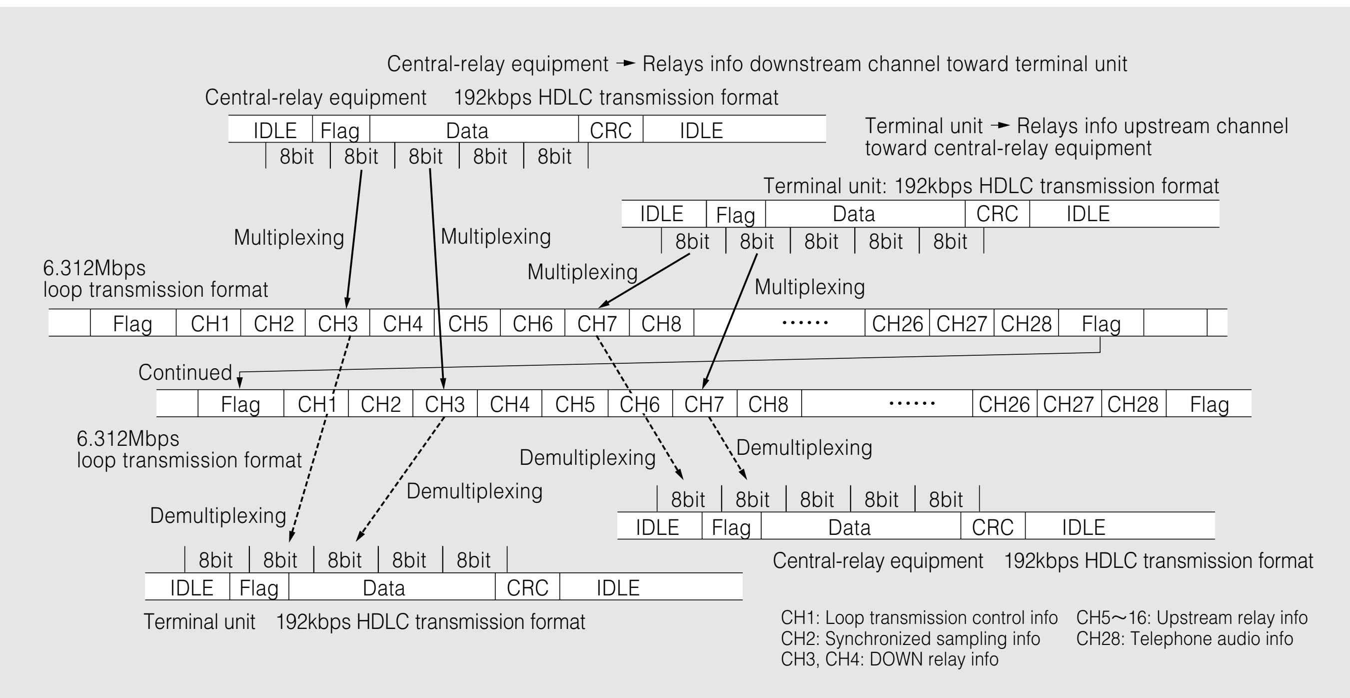

Fig. 3 Outlined Time Division Multiplexing Communication System
Regarding time division multiplexing communication that is a function of the communication board, each low-speed HDLC 8bit frame data at the transmitting side is transferred in cyclic time division multiplexing communication. Then the received data are demultiplexed at the receiving side and info of the original HDLC frame is reproduced.

managed are: loop transmission control, synchronized sampling, relay-based data, telephone audio data, as well as others. The transmission frame involves information equivalent of 28 communication lines.

3.2 Loop-Back Function

If there is a line error such as a transmission channel disconnection, the loop-back function is used to remove this error section in the line in order to reconstruct a normal communication line. When a fault is detected, the communication board performs loop-back operation at both ends of the faulty section (bypassing in the case of central-relay equipment) as shown in Fig. 4 and reconstruction of the transmission channel is accomplished within tens of milliseconds.

3.3 Synchronized Sampling Function

The loop relay is required to perform synchronized sampling of current data at each electric power station so that looped systems can be protected.

For synchronized sampling as shown in Fig. 5, an optimal sampling timing is calculated through clockwise and counter-clockwise measurements of delay time (T1 and T2) for transmission frames. Sampling point = Midpoint of delay time (T1, T2) = T1/2, T2/2. The arrival time difference T3 is measured between clockwise and counter-clockwise arrival time. Sampling point = Midpoint of delay time difference T3 = T3/2 for each terminal.

Regarding the synchronizing accuracy level in order to maintain the compatibility between the new and old model, accuracy level has been set within $\pm 25 \mu s$. Even in the case of a transmission connection error giving rise to a loop-back condition, this system controls the frame transmission timing to maintain a synchronizing accuracy level at each terminal.

3.4 Setup Function for Increased or Decreased Terminals

In looped systems, the number of terminals has to be defined and changes of terminal setup are needed because there is always an increase or decrease of end users (represented by the "terminal"). As shown in Fig. 6, terminal units are controlled by three types of code identifications such as power network location number, specific unit ID number, and transmission position number. In the case of a conventional terminal unit, board setup changes

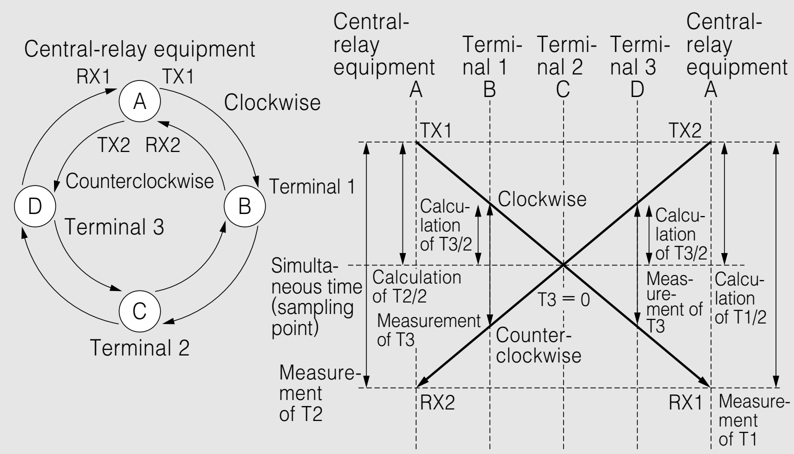

Fig. 5 Synchronized Sampling

Synchronized sampling is carried out based on a theorem that half the delay time caused between clockwise and counterclockwise optical fiber transmission paths, is equal to the simultaneous time.

Item	Code					Remarks
Power network location number	Terminal 1	Terminal 2	Terminal 3	Terminal 4	Terminal 5	Connection routing sequence order of power system
Specific (ID number)	Unit 1	Unit 2	Unit 5	Unit 3	Unit 4	Terminal installation sequence number
Transmission position number	RS2	RS1	RS3	RS4	RS5	Connection routing sequence order of optical cables

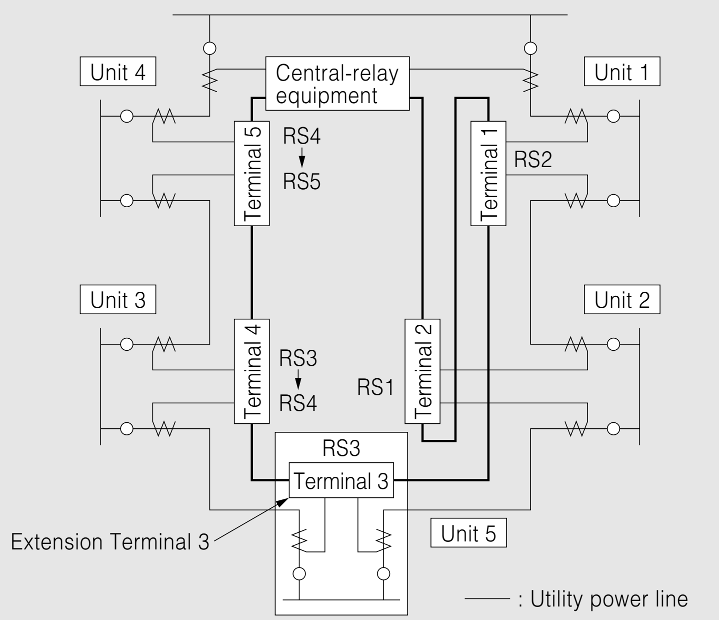

Fig. 6 Contents of Setup upon an Increase or Decrease in Terminals

The relationship is shown among the power network location number, specific unit ID number, and transmission position number.

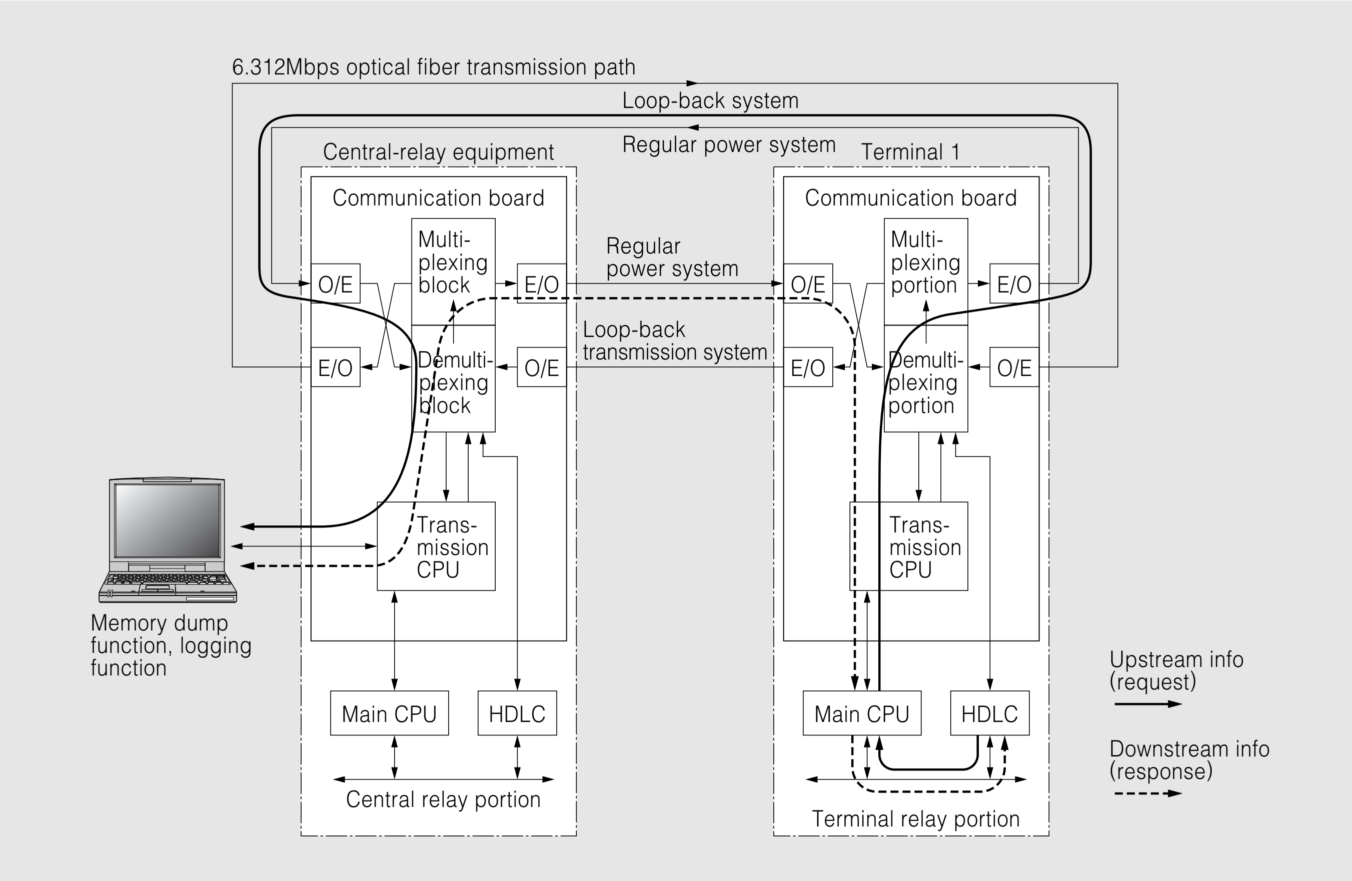

Fig. 7 Remote Maintenance Function

A memory dump function is provided to allow the maintenance of each CPU in the terminal unit from the central relay equipment in the side of transformer substation, without visiting the end user's electric power station by the servicing staff.

and optical fiber connection changeover in equipment were complicated for servicing personnel. On the other hand for new terminal units, Web-based user interface are available for easy remote setup changes.

3.5 Remote Maintenance Function

The terminal unit installed in an end user's electric power station is located far away from a transformer substation. Therefore, as shown in Fig. 7, a function to collect terminal data ("memory dump function") is installed to communicate with each CPU in the terminal unit. With this function, data collection is possible among units at the time of equipment fault without visiting the end user's electric power station by servicing personnel.

4. Postscript

Since this development of a new communication board, we can reduce the number of enclosures and realize the compact and light weight design. Compared with conventional equipment, this allows more freedom in the footprint. In addition, the reduction of power consumption reduces the environmental impact. Going forward, we will continue to develop products which contribute to better maintenance and operation, to better facility management, and maintenance for the benefit of customer.