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# Subscriber Line Terminal for Open Computer Network (OCN)

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**Abstract**

*We developed high-speed and low speed access units to connect subscribers to the Open Computer Network (OCN). The high-speed access unit, which has an interface speed of 1.5Mbit/s or 6Mbit/s, can accommodate a maximum of 12 lines. The low speed access unit, which has an interface speed of 128kbit/s, can accommodate a maximum of 36 lines. Both the high-speed and low-speed units have such features as (1) natural air-cooling despite high density package in a compact case, (2) satisfies VCCI class 1 specifications by EMI (Electro Magnetic Interference) countermeasures, and (3) has operation functions to monitor, test and control from a remote control terminal or direct control terminal..*

## 1. Introduction

The recent increase in the demand for computer-based communication represented by accessing WWW (World Wide Web) home pages and electronic mail services is explosive. Nippon Telegraph and Telephone Co. Ltd. (NTT) started the Open Computer Network (OCN) service as an infrastructure to support the demand for such multimedia communication services[1,2].

In addition to dial-up connection services accessed from a telephone network, including ISDN, OCN has fixed connection services depending on the transmission speed, which are accessed from leased circuits. To receive these fixed services, a subscriber line terminal to connect the subscriber and OCN is required.

This paper presents an outline of OCN, then describes the low speed type and high-speed type subscriber line terminals. The configuration of operation functions to supervise and control subscriber line terminals from a remote locations is also described.

## 2. Outline of OCN

### 2.1 Outline of Service

The basic concept of the OCN service is called the "best effort type", where service is provided inexpensively, however communication quality among subscribers is not guaranteed. OCN has a low-speed type (128 kbit/s) and a high-speed type (1.5M and 6M bit/s) fixed connection services, in addition to a dial-up connection that uses telephone circuits (analog or ISDN).

### 2.2 Routing System

On a telephone network, exchanges are used to perform routing among subscribers. Therefore, when a call is generated the routed circuit path is occupied. In OCN, on the other hand, an IP (Internet Protocol) routing system is used, where routers are used instead of exchanges. Subscriber information is stored in packets, and a circuit path is occupied only when packets flow through it. This makes the efficiency of network operation very high.

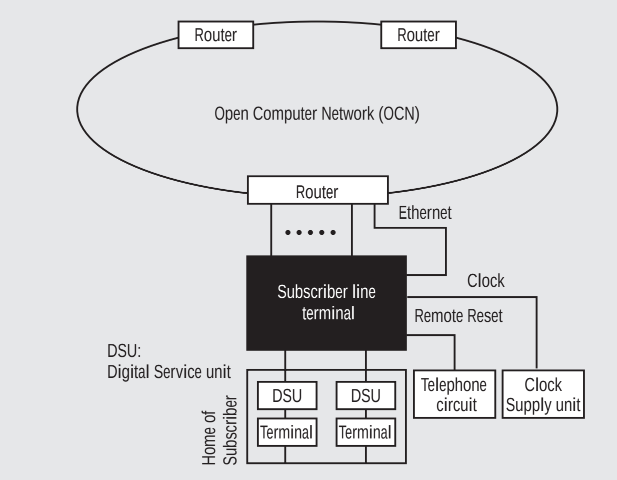


Figure 1: Network configuration of OCN

### 2.3 Configuration of OCN

Figure 1 shows the configuration of OCN.

For the transmit transmission line used for relaying between routers, a frame relay network is used for the low-speed type, and a high-speed digital leased line network is used for the high-speed type.

## 3. Outline of Subscriber Line Terminal

A subscriber line terminal for OCN was developed for short distance use as a means to access the OCN network.

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Physical Design Engineering Department, Transmission Systems Engineering Department, OKITEC (present position)
***** Manager, Network System Development Division, Telecom Business Group

| | Circuit speed | Interface |
|---|---|---|
| Low-speed type | 128kbit/s | TTC standard JT-1430-a |
| High-speed type | 1.5Mbit/s | TTC standard JT-G703-a |
| | 6Mbit/s | TTC standard JT-1430-a |

Table 1: Interface of other network provider

This terminal is installed at an NTT branch office, and is used when a customer requests a fixed connection to OCN. A fixed connection service is equivalent to the leased line connection service available from conventional Internet providers.

Equipment called a DSU (Digital Service Unit) is installed on the customer premises, and is connected to the subscriber line terminal. The subscriber line terminal has an interface at the DSU side the router side, and data transparency is guaranteed by making both interfaces the same. Before starting the development of the subscriber line terminal, it was requested that these interfaces be open. Therefore, we adopted a standard interface for the high-speed digital leased line, as shown in Table 1. This interface has a 128 kbit/s low-speed type and a 1.5M and 6Mbit/s high-speed type. The subscriber line terminal differs depending on the speed of the interface. The low-speed type is called the “low-speed subscriber line terminal for OCN”, and the high-speed type is called the “high-speed subscriber line terminal for OCN”. A router for low-speed or high-speed is connected to the low-speed or high-speed subscriber line terminal respectively, and the subscriber line terminal is connected to OCN through this router.

The subscriber line terminal has a point of interface (POI) for connection with networks of other communication companies, and POI is used as the interface. Because of this POI, the subscriber line terminal for OCN may be installed as a supplementary access line of the OCN equivalent network service provided by another communication company.

The subscriber line terminal has supervisory, testing and control functions, and can therefore be managed by a remote operation terminal at a remote location via Ethernet. If a direct operation terminal is connected to the subscriber line terminal at the same location, then the subscriber line terminal can be managed from that direct operation terminal in the same manner. This is more fully described in Section 6.

## 4. Configuration of High-Speed Subscriber Line Terminal

Figure 2 shows the configuration of the high-speed subscriber line terminal for OCN, and Table 2 shows its specifications.

The high-speed subscriber line terminal for OCN does not have a multiplex or cross connection function, and merely performs conversion of the subscriber side interface and router side interface. The subscriber side of the terminal accommodates a DSU of the high-speed digital leased line. The router side has the TTC standard

| Category | | Specification | Remarks |
|---|---|---|---|
| Packaging | Mounting method to frame | Place this terminal on the shelf of the rack, and secure the lugs of the main unit to the front strut of the rack with screws | |
| Number of circuit accommodations | Number of subscriber accommodations | 1.5M or 6M x 12 circuits | Mounting position to share slots is not specified |
| | Extension unit | 1 circuit unit | |
| Main signal interface | Router side (R side) | JT-1431-a (1.5Mbit/s), JT-G703-a (6.3Mbit/s) | |
| | Subscriber side (L side) | LI-IF of HSD | |
| Supervisory control interface | Connection format with external unit | Ethernet | |
| | Externally connecting jack | 10BaseT | |
| | Communication protocol | TCP/IP | |
| Clock input | | 64 + 8 (-04)kHz one line system | |
| Power supply input | | AC100V±10% | |
| Alarm items | Terminal alarm | CPU abnormality, clock input stop, power supply abnormality | |
| | Communication abnormality | Generated when communication is disconnected | |
| Supervisory items | Alarm status | Currently detecting alarms can be supervised | |
| | Terminal status | Packaging status can be detected | |
| Test items | Loopback test function | (1) Loop 5 (OCU) (2) Loop 2 (DSU) (3) Loop IF (4) Router side IF loopback | Normalcy is checked for (1) ~ (3) using PN Pattern. Only loopback operation is tested for (4) |
| Control items | | Can handle PING command | |
| | | Has reset function for supervisory and control sections | |
| | | Has alarm INH function in circuit unit | |
| | | Has test setting function in circuit unit | |
| Operating environment | Temperature condition | 10~40°C | |
| | Humidity condition | 20~80% | |
| | EMC countermeasure | Equipment standard inside NTT Center | |

Table 2: Specifications of high speed subscriber line terminal for OCN

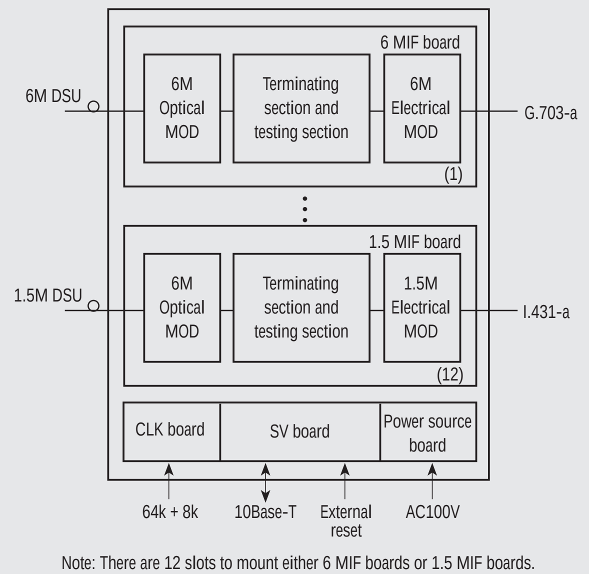


Figure 2: Block diagram of high speed subscriber line terminal for OCN

JT-I431-a or JT-G703-a interface, and is connected to a router.

The subscriber line terminal has a one-unit configuration, which consists of a common section and an IF section where a maximum of 12 IF boards can be mounted. The common section consists of a cabinet, power source board, SV board and CLK board. There are two types of IF boards: a 1.5M IF board and 6M IF board, and they can be mounted at any mounting slot of the IF section inside the cabinet. Since the types of IF boards may increase in the future, the cabinet has an opening on its back side, and an IF board has a connector on the package to adjust itself to the opening. Whereby an office line cable can be directly connected without going through the backboard. The shape of the office line cable therefore does not matter.

The cost of the cabinet was decreased by providing a direct connection to an office line cable, which eliminates wiring inside the terminal. Considering EMC (electromagnetic compatibility), VCCI class 1 was satisfied. The temperature increase inside the cabinet is 25˚C or less under natural cooling conditions. This is realized by an efficient power supply, the electric power reduction of circuitry, and because of the waste heat structure of the cabinet.

The power source board has AC100V input and DC+5V output. Circuitry and parts were selected to make natural cooling possible, which implemented a high conversion efficiency. The basic operating voltage for the subscriber line terminal is DC+5V. Voltage is converted for each package as necessary, so that a minimum system with costs could be implemented. Backboard wiring is considered to make the addition of working voltage possible in the future.

The SV board has a 10Base-T interface, and makes it possible for a remote terminal to supervise the circuits inside the terminal, terminal failures, and to control the terminal status. The SV board also makes an initial status setting and downloads by an RS232C interface possible.

The CLK board generates the necessary clocks that synchronize with the clock from DCS / CSM, and distributes the clocks to each package. When the clock input from DCS / CSM stops, the CLK board operates in free running mode (an alarm is output). Free running without using external clocks is also possible, and in this mode an alarm is not output. Based on the same concept as the power source board, only the minimum required clock (1.5Mbit/s, 6Mbit/s) are generated and distributed so that a minimal system and costs could be implemented. An 8kHz clock is also distributed so that each package can mount the phase-locked loop oscillator (PLO).

The 1.5 MIF board has a 6M optical interface at the subscriber side, and a TTC standard JT-I431-a interface at the router side. The 1.5 MIF board terminates and converts these two interfaces, and has a loopback function inside the IF board. It also has two built-in testers that can insert and detect test patterns and can insert errors. With these testers, testing during construction can be executed by command.

The 6 MIF board has a 6M optical interface at the subscriber side, and a TTC standard JT-G703-a interface at the router side. Functions other than interface termination and conversion functions are the same as the 1.5 MIF board.

Photo 1 shows the appearance of the high-speed subscriber line terminal for OCN.

## 5. Configuration of Low-Speed Subscriber Line Terminal

### 5.1 Specifications

Table 3 shows the specifications of the low-speed subscriber line terminal that we developed this time. The interface that directly accommodates subscribers conforms to TTC standard JT-G961, and a DSU on the market can be used for this. The relay side has a JT-I430-a interface.

### 5.2 Functional Block Configuration

Figure 3 shows the functional block configuration of the low-speed subscriber line terminal. The central component is the COM section, which interconnects the main signals from the subscriber side and the relay side. This subscriber line terminal consists of the COM section, subscriber side interface section, relay side interface section, and the SV section, which executes supervisory, testing and control functions by firmware. The next section describes these functions.

Most of the major functions of the COM section are integrated on one large scale CMOS gate array LSI chip, which we newly developed. In addition to the interconnection functions for main signals, the functions of this section are collecting / distributing supervision, testing and control of the main signals related to hardware, receiving external clocks, distributing clocks and detecting when an interface package is mounted.

The SV section is a board computer which has a CPU that is currently available on the market. For the ROM used for programming, an EEPROM is used so that program updates, such as specification revisions, can be executed when the terminal is running. The basic architecture is the same as the SV board of the high-speed subscriber line terminal.

For the interface sections at the subscriber side and relay side, conventional interface packages are used with little modification.

The power supply is a commercial AC100V input power supply. A DC+5V / DC-48V power supply unit is inside the terminal to supply power to each interface package. Countermeasures against EMI (electromagnetic interference) have been taken for each interface package. Just like the cabinet structure that was designed considering EMI, the packages also cleared VCCI class 1.

### 5.3 Mounting Structure

The mounting structure of the low-speed subscriber line terminal consists of a cabinet, a unit for mounting the subscriber side interface package, a unit to mount the relay side interface package, and a power supply section. Considering extension and maintenance, covers are at the front and back, which can be removed by thumb screws.

To control temperature rises, we performed sufficient thermal simulations from the concept design stage, and we opened appropriate vent holes on the cabinet. Each unit has a guide rail structure, and natural cooling is implemented by optimizing the board mounting pitch of the units. To prevent EMI, a conductive purse is attached to the connector for the router on the back, and a core and noise filter are attached to the power cable. In this way VCCI class 1 was cleared.

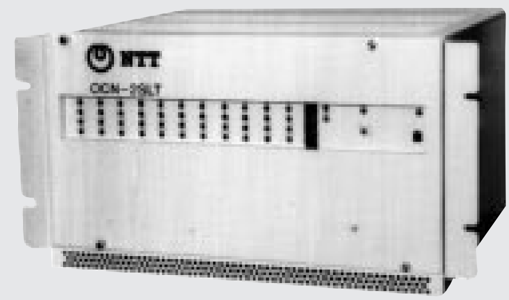


Photo 1: Appearance of high speed subscriber line terminal for OCN

| Category | Item | Specification | Remarks |
|---|---|---|---|
| Packaging | Structure | Height: 220mm, Width: 430mm, Depth: 430mm | When rack bracket is used: width, 486mm |
| | Packaging format | Access from front and back makes channel package exchange easier when rack is mounted | |
| | Cooling system | Natural cooling | |
| Number of circuit accommodations | Number of subscriber accommodations | 128kbit/s x 36 circuits | |
| Main signal interface | Subscriber side | (1) JT-G961 x 36<br>(2) CT~I-CTI interface x 4<br>(3) LXMIE ~ ISEB interface x 1 | (1) (2) are interchangeable<br>(3) accommodates dedicated slots |
| | Relay side | JT-1430-a x 36 | |
| Supervisory control section | Interface | IEEE802.3 (10 Base-T) | |
| | Communication protocol | TCP/IP protocol | |
| | Management protocol | SNMP (Simple Network Management Protocol) | |
| Working enviroment | Operating power supply voltage | AC100V ±10% | |
| | Temperature condition | 10 ~ 40•C | Can be used in communication machine room |
| | Humidity condition | 20 ~ 80% | |
| | EMI countermeasure | VCCI class 1 | |
| Clock interface | | 64 + 8 –0.4kHz x 1 | Directly input from DCS/CSM |
| Test items | Loopback test | (1) Loopback inside interface package<br>(2) DSU loopback, etc. | |
| Control items | Circuit setting | Setting depends on type of subscriber side interface | |
| | Operation/non-operation | Alarm stops for non-operating circuit | |
| Supervisory items | Terminal/communication alarm | Interface abnormality, terminal failure, etc. | |

Table 3: Specifications of low speed subscriber line terminal for OCN

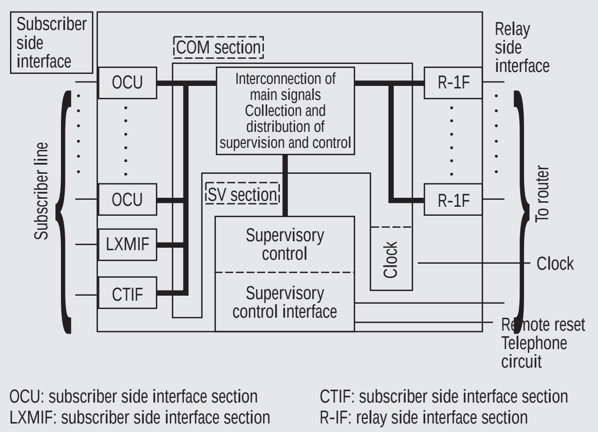


Figure 3: Block diagram of low speed subscriber line terminal for OCN

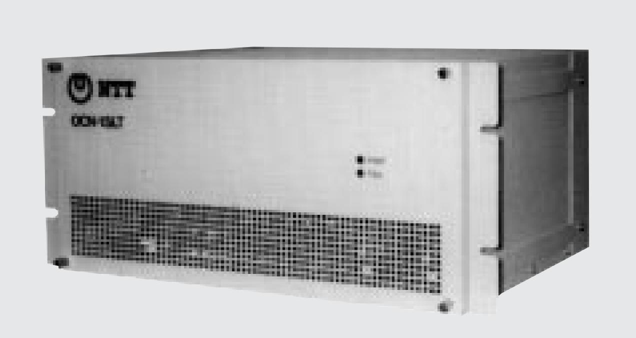

Photo 2: Appearance of low speed subscriber line terminal for OCN

Photo 2 shows the appearance of the low-speed subscriber line terminal for OCN.

## 6. Configuration of Operation Functions

### 6.1 Operation Functions

The operation functions of the subscriber line terminal consists of control from the remote operation terminal (WS), and control from the PC that is directly connected. Figure 4 shows the configuration of the operation functions.

1. Remote operation terminal interface

SNMP (Simple Network Management Protocol) is used for the interface between the remote operation terminal (WS) and the subscriber line terminal. The remote operation terminal has a manager function, and the subscriber line terminal has an agent function.

Part of the SNMP standard database (DB) and an extended DB (high-speed, low-speed) for the subscriber line terminal are mounted on the subscriber line terminal. Status setting, status reading and test control are performed by a GET and SET operation from the manager. Alarm and test results are notified to the manager by a TRAP generated from the agent. An access guard function was included to control conflicts in test control from different control terminals.

To decrease the number of TRAP messages to notify alarms, we defined a channel representative alarm, which is the logical sum of alarms of all channels, rather than setting a TRAP for the individual alarms of each channel. The number of TRAPS to be generated was also decreased by masking the circuit alarm by the terminal alarm, making the alarm supervision period one second.

Test control is performed by the SET command that has multiple sequences, therefore a function to control the sequences is included in SNMP command processing.

2. Direct operation terminal interface

RS232C is the interface between the direct operation terminal (PC) and the subscriber line terminal. From the direct operation terminal, information setting (IP address,

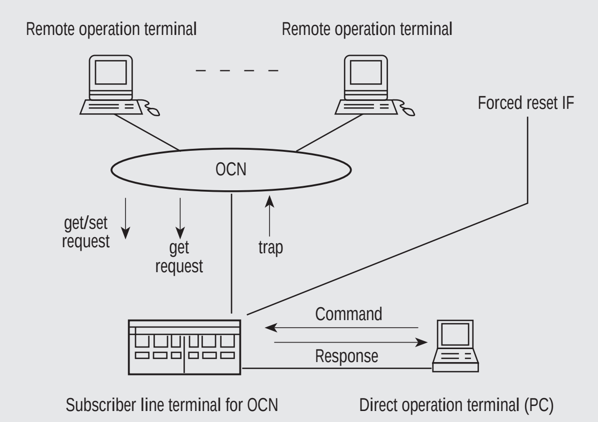


Figure 4: System configuration of OCN operation function

etc.) at initial startup, circuit testing (batch, individual), alarm supervision status setting (constant, individual), reading/writing DB information, reading communication logs, downloading software and reading memory content are performed. To improve operability, display and input are all based on a menu format.

### 6.2 Software Configuration

Figure 5 shows the software configuration of the subscriber line terminal for OCN. The μCTRON platform was used for the OS. This platform has LAN control, file management, SIO control, task control and other functions. The AP consists of a status setting section to directly control hardware, a test control section, a periodic supervisory section to read alarm status periodically, an NMS-IF section that has an interface with the remote operation terminal, a console IF section that has an interface with the direct operation terminal, a function to analyze and edit command input and ASN.1 syntax, a restart function and DB data.

## 7. Conclusion

We developed a compact and inexpensive subscriber line terminal for OCN in a short delivery time to contribute to providing OCN service. This terminal is used to access

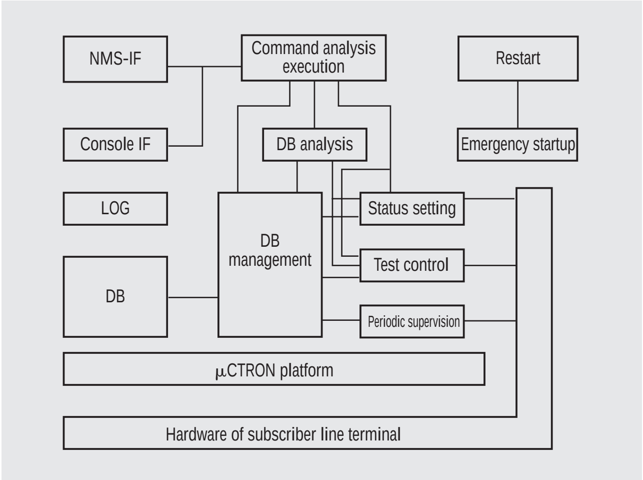


Figure 5: Software block diagram of subscriber line terminal for OCN

OCN, which aims to provide services for the era of true multimedia. In this development, we fully utilized conventional technologies, design assets and standard interfaces for the main signal interface, software and for the architecture of the CPU that mounts the software. This resulted in numerous advantages in terms of meeting the requirements of delivery time, and had economic pluses as well. We made the terminal compact by high density packaging, considering implementing natural cooling without deteriorating operability.

Finally, we would like to thank personnel of the Service Network Project Group of NTT's Technical Development Support Center, who provided us with constant assistance.

## 8. References

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