Development of optical transmission module for access networks

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Alongside the spread of the Internet in recent years, high-speed data transmission services for subscriber networks (access networks) have taken root in a real way. This has been accompanied by a growth in fibre-optic communications networks.

Fig. 1 illustrates an optical communications network. The core DWDM (Dense Wavelength Division Multiplexing) optical network is connected to LANs (Local Area Networks), metro (metropolitan) networks, metro access networks, and access networks.

Conversion of access networks to optical technology, which enables much faster services, is widely anticipated. In addition, Passive Optical Network (PON) systems are also being introduced, providing real-time communications of greater capacity, at a reasonable cost. In these systems, the adoption of single-fibre bi-directional communications methods reduces the number of fibres required, and by sharing network-sides and fibre transmission paths between a number of users, faster services can be achieved at the same low cost of metal cable systems.

Early installation of optical access networks is eagerly awaited worldwide, and the ITU-T and IEEE are actively discussing standardization in this field. The ITU-T has proposed standards for ATM-PON (G983.1) and B-PON (Broadband-PON) (G983.3). G983.1 relates to networks with a transmission path rate of 155 Mb/s or 622 Mb/s. In G983.3, these signals are multiplexed with CATV or other video signals.

This essay starts with a brief discussion of B-PON systems, and goes on to introduce the 155 Mb/s OLT/ONT optical transmission module developed by Oki, which is a key device in optical systems of this kind. We will also look briefly at burst signal reception, which is a core technology in our transmission modules for optical access networks.

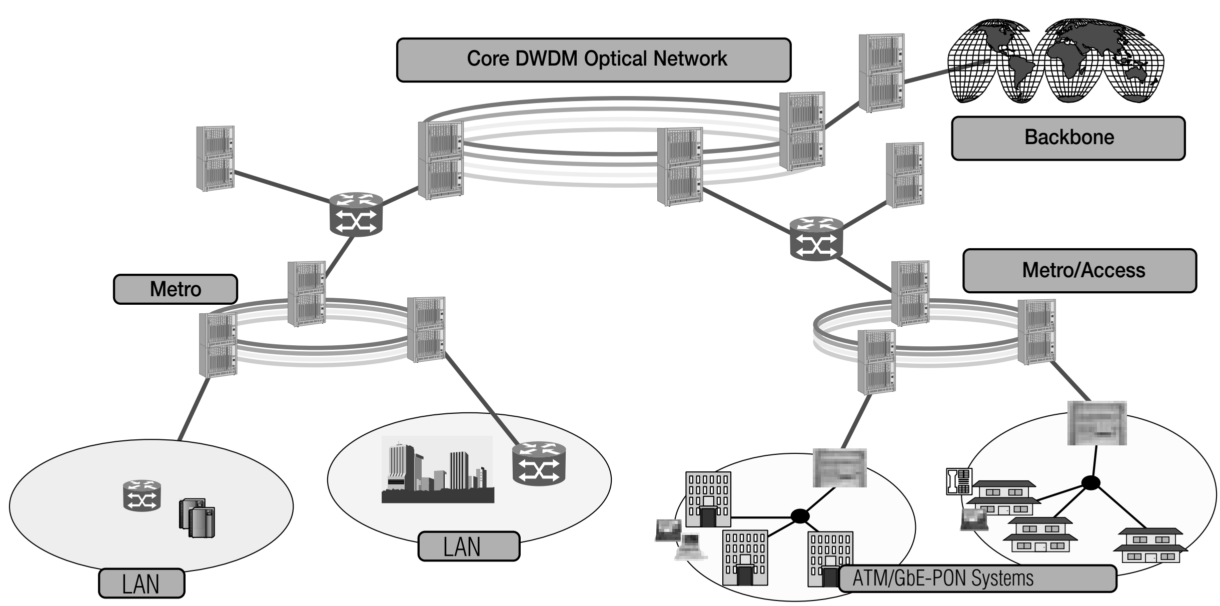

Fig. 1 Overview of optical communications network

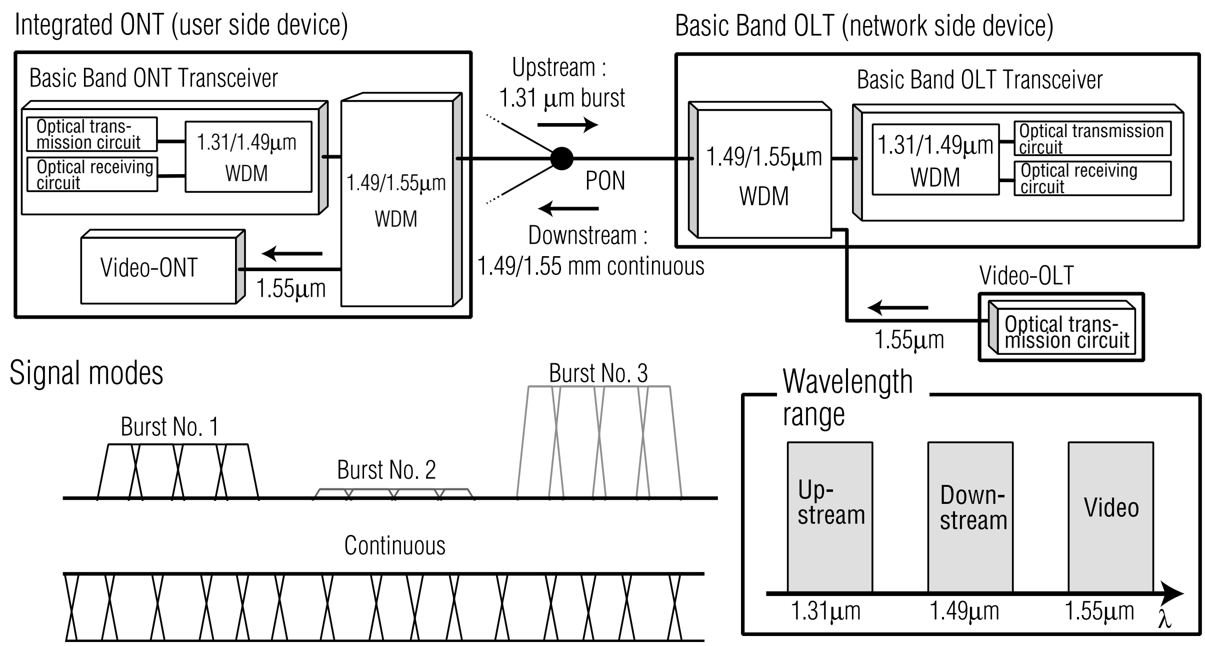

Fig. 2 Broadband PON system

Broadband PON systems

Fig. 2 shows the structure of a Broadband PON.

In PON systems, information is distributed from the network-side OLT to all subscribers after encryption to ensure security. The user-side ONT is controlled so that signals do not collide with each other, and it sends a burst-shaped signal like the signal modes illustrated in Fig. 2 to the network-side. The problem here is that the transmission distance, and other factors, differ for each subscriber, so as shown in Fig. 2, the information is transmitted by optical signals of different amplitudes. To achieve a transmission sequence of this kind in a single optical fibre, the signals are sent by wavelength division multiplexing. The 1.31 μm wavelength is used in the upstream direction, whilst the 1.49 μm band is used for downstream signals, as well as the 1.55 μm band for supplying video signals. Video signals from a CATV office are converted to an optical signal by a Video OLT, and multiplexed by WDM in the transmission path. On the ONT side, these signals are split by WDM and converted to electrical signals by a V-ONT, which enables the subscriber to view the video images.

Performance of OLT/ONT optical transmission module for 155 Mb/s communications

Oki is already manufacturing a 155 Mb/s-compatible OLT/ONT optical transmission module which is compliant with ITU-T standard G983.1. Table 1 lists the specifications of the155 Mb/s OLT optical transmission module, whilst Fig. 3 shows an optical output waveform, and Fig. 4 shows error rate characteristics. Similarly, Table 2 lists the specifications of the 155 Mb/s ONT optical transmission module, and its optical output waveform and error rate characteristics are shown in Fig. 5 and Fig. 6, respectively. All of the given data can be guaranteed with satisfactory margins with respect to the standard values.

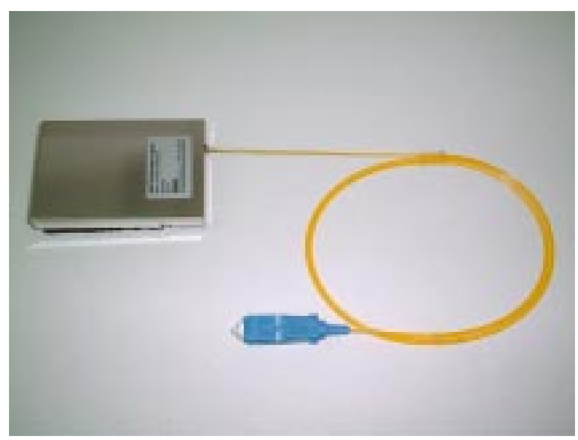

Photo 1 155 Mb/s ONT optical transmission module

Oki's burst data receiving technology

As stated previously, the most important, but most difficult, technological challenge in creating a PON system is ensuring that burst signals from ONTs (user-side) of different levels are all received with good sensitivity and good quality.

Table 1 Specifications of 155 Mb/s OLT optical transmission module

Parameter	Unit	Specifications
Operating wavelength	nm	Tx : 1480-1580/Rx : 1260-1360
Mask of the transmitter eye diagram		ITU-T G.983 Downstream
Maximum reflectance of equipment, measured at transmitter wavelength	dB	—
Mean launched power range	dBm	-4 ~ +2
Minimum extinction ratio	dB	10
Tolerance to the transmitter incident light power	dB	more than -15
Launched optical power w/o input to the transmitter	dBm	—
Maximum spectral width	nm	1 (@-20dB)
Side mode suppression ratio	dB	more than 30
Jitter tranfer		—
Jitter generation in 1.3kHz bandwidth	UIpp	—
Maximum reflectance of equipment, measured at receiver wavelength	dB	less than 20
Bit error ratio	—	less than 10^{-10}
Minimum sensitivity	dBm	-30
Minimum overload	dBm	-8
Consecutive identical digit immunity	bit	more than 72
Jitter tolerance	—	—
Tolerance to the reflected optical power	dB	less than 10

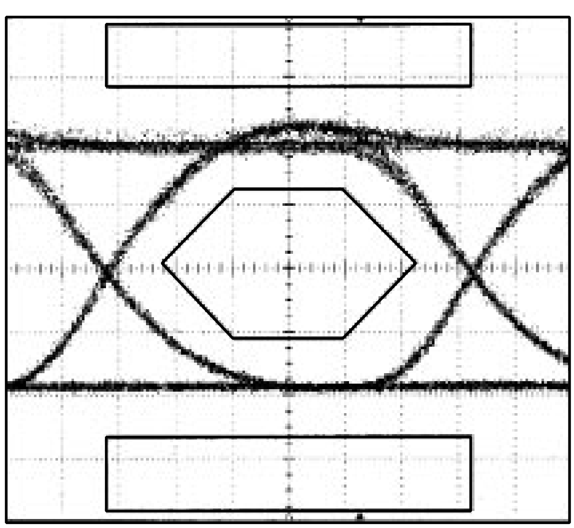

Fig. 3 155 Mb/s OLT optical output waveform

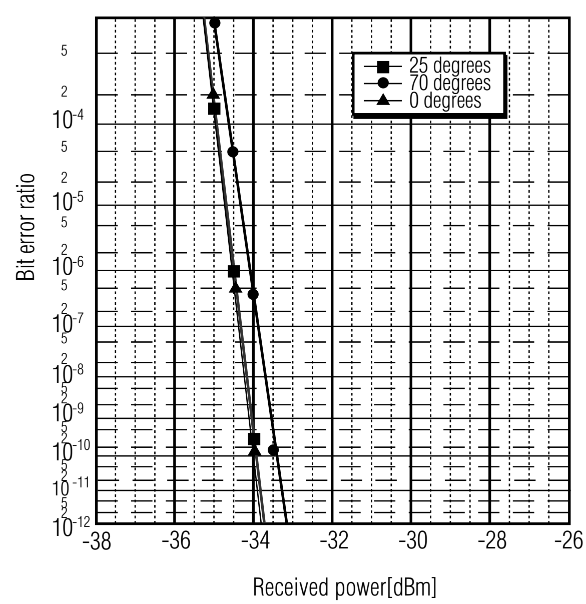

Fig. 4 Error rate characteristics

Table 2 Specifications of 155 Mb/s ONT optical transmission module

Parameter	Unit	Specifications
Operating wavelength	nm	Tx : 1260-1360/Rx : 1480-1580
Mask of the transmitter eye diagram	—	ITU-T G.983 Upstream
Maximum reflectance of equipment, measured at transmitter wavelength	dB	-10
Mean launched power range	dBm	-4 ~ +2
Minimum extinction ratio	dB	25
Tolerance to the transmitter incident light power	dB	more than -15
Launched optical power w/o input to the transmitter	dBm	less than -43
Maximum spectral width	nm	5.8 (@rms)
Side mode suppression ratio	dB	—
Jitter transfer	dB	0.1 (fc=130kHz)
Jitter generation in 1.3kHz bandwidth	UIpp	0.2
Maximum reflectance of equipment, measured at receiver wavelength	dB	less than 20
Bit error ratio	—	less than 10^{-10}
Minimum sensitivity	dBm	-30
Minimum overload	dBm	-8
Consective identical digit immunity	bit	more than 72
Jitter tolerance	—	0.75UIp-p (f0=6.5kHz) 0.075UIp-p (ft=65kHz)
Tolerance to the reflected optical power	dB	less than 10

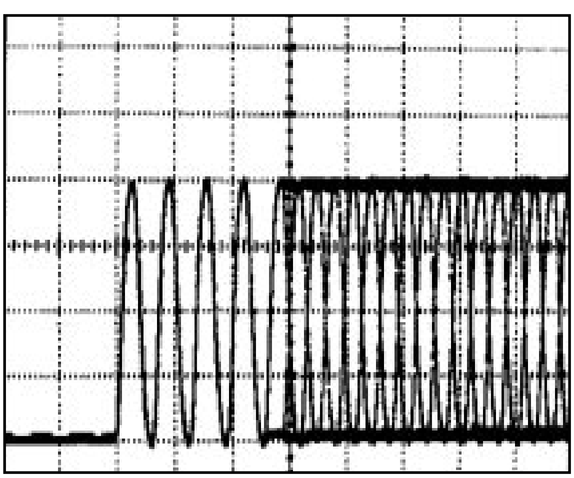

Fig. 5 155 Mb/s ONT optical output waveform

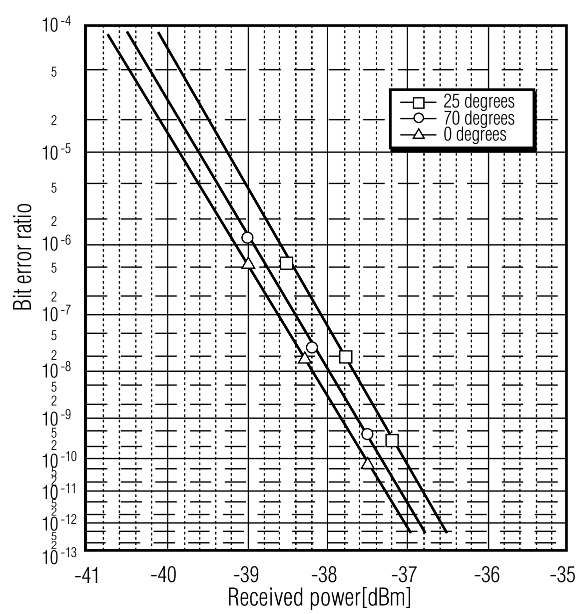

Fig. 6 Error rate characteristics

When burst type signals are received in a conventional receiving circuit, it is impossible to regenerate accurately a small burst signal which follows a large burst signal, as depicted in Fig. 2. However, the newly developed ATC (Automatic Threshold Control) circuit enables faithful signal regeneration, even when there are differences in level between the burst signals. This ATC circuit is an automatic threshold level control circuit, which sets an optimal threshold level, automatically, in accordance with the changing signal amplitudes.

Fig. 7 shows an illustration of the actual regeneration of a burst signal. We can see clearly that both the large burst signal and the small burst signal are regenerated correctly.

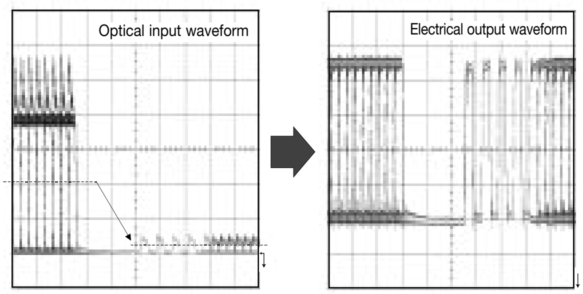

Fig. 7 ATC circuit operating characteristics

Video ONT for Broadband-PON

Oki is also developing a Video ONT for Broadband-PON to receive video signals. As illustrated in Fig. 2, video signals created by passing signals from a CATV office through a Video OLT are distributed to each subscriber home, where they are regenerated by a Video ONT. Our new Video ONT has completed prototype evaluation and achieved excellent results which easily meet the G983.3 (155 Mb/s) standards. The main features of this prototype are given in Table 3.

In our future plans, we aim to offer an interface transceiver designed for the broadband age, with an integrated ONT which incorporates the Video ONT described above, an ONT optical transmission module, and a WDM filter.

Future Issues

Future challenges in this field are expected to include:

(1) Cost reduction of ONT modules
(2) High-speed

Table 3 Specifications of Video ONT

Parameter	Unit	Specifications
User Interface		
Frequency range	MHz	Analog channel : 54-550, Digirtal Channel : 550-750
Modulation Scheme	-	Analog channel : VSB-AM, Digirtal Channel : 64QAM
RF Output Power	dBμV	+75 ~ +85
Characteristic Impedance	Ω	75 (unbalance)
CNR	dB	48 (Optical input : 0dBm, fc=189.25MHz single carrier)
Network Interface		
Optical connector	—	SC type
Receiver wavelength	mm	1535-1565
Optical moduration method	—	Direct optical power modulation
Maximum received power	dBm	+6
Minimum received power	dBm	-5
Power Condition		
DC Input Voltage	V	Analog : ±5, +9, Digital : ±5
Consumption	W	<4
Over Condition		
AGC method	—	PILOT AGC
PILOT frequency	MHz	73.0
Dimension	mm	150x75x17

(3) High-sensitivity

PLC (Planar Lightwave Circuit) technology which are optical components is adopted for reduced costs of ONT modules.

By using a system known as “passive alignment”, PLC technology enables self-align coupling to optical fibres, which makes it highly suitable for low-cost high-volume production.

As for high speed, by providing faster services, it is possible to improve transmission efficiency and reduce service costs. At Oki, we plan to upgrade from our current products operating at 155 Mb/s, to speeds of 622 Mb/s and 1.25 Gb/s.

High sensitivity, on the other hand, means that the split ratio can be expanded in line with increased operating speeds, enabling common facilities to be shared amongst a greater number of users, and thereby reducing infrastructure costs.

Conclusion

This essay has looked at transmission modules for optical access networks, with a particular focus on modules for PON systems and V-ONT modules. We already have a 155 Mb/s-compatible product on the market, and have scheduled the successive release of 622 Mb/s and 1.25 Gb/s versions in the future. Development of an Integrated ONT is also under way.

PC and Internet use is predicted to carry on expanding in the future, and the drive towards lower costs and higher operating speeds is likely to increase momentum. At Oki, we aim to meet these demands by working towards 2.5 Gb/s and 10 Gb/s optical burst transmission modules, based on burst signal transmission technology and high-speed analogue IC technology which we own.

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