SFF & SFP OPTICAL TRANSCEIVERS

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At the start of the 21st century, broadband services are beginning to take root in a real and significant way. Since last year, there has been a massive upsurge in the popularity of ADSL (Asymmetric Digital Subscriber Line) services targeting the general user, which provide at least 20 - 30 times the transmission capacity of ISDN lines at a fraction of the cost of FTTH (Fiber To The Home) systems. Consequently, this trend has obliged service providers to upgrade their processing capacity, and optical networks, such as Gigabit Ethernets, whichare being used increasingly for backbone communications.

On the other hand, the trend in the business world is moving into the construction of SANs (Storage Area Network) to enable centralized processing of their ballooning data loads, and backup in the event of server crashes or other emergency scenarios. Here too, we are seeing the introduction of optical links based on 2 Gb/s class Fibre Channels, which are capable of longer and faster communications than existing SCSI connections.

In the field of LANs (Local Area Network), high-end routers are already incorporating 2.48 Gb/s class optical transmitters, previously reserved for selected trunk networks only.

Optical communications operators, who moved successively into trunk networks in the 1990s due to the boom in voice traffic, have scaled down their activity in this area and are expanding into the development of new business contents systems (see Fig. 1) on a worldwide scale.

One of the key factors in supporting these networks has been the supply of low-cost, highly versatile optical communications devices. In February 1998, six leading global communications equipment manufacturers signed a Multi Service Agreement (MSA) defining standard specifications for small optical transceivers, known as Small Form Factor (SFF). In September 2000, another MSA was established for SFP (Small Form-factor Pluggable) devices, which are Hot-pluggable modules of the same size as SFF.

Sigma Links Inc. *1) has sought a rapid response to these new demands through the development of SFF and SFP optical transceivers which are compatible with gigabit ethernets, fibre channels and SONETs. This essay introduces the main characteristics of some of their key products in this area.

SFF Optical Transceivers

The SFF optical transceivers are about half the size of the old Duplex-SC optical transceivers and have optical connector interfaces for MT-RJ, Duplex-LC and other formats. The electrical interfaces include a 2 x 10 pin socket with a transmission quality

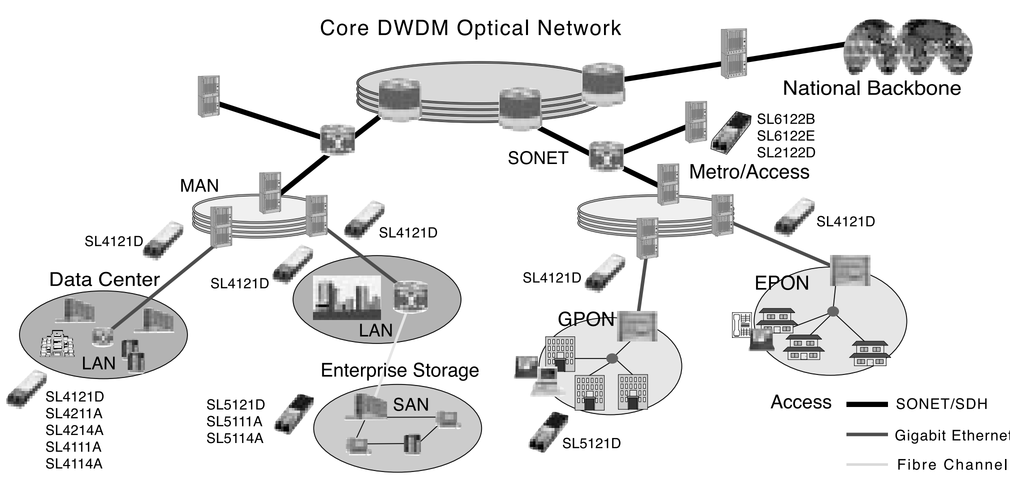


Fig. 1 Optical communications network for the broadband era

monitoring function, and a 2 x 5 pin socket without quality monitoring. These terminals are soldered directly onto the device circuit board.

SFF Short wavelength Optical Transceivers

Various SFF short wavelength optical transceiver products and their key features are shown in Table 1[1]. The electrical and optical characteristics conform to Gigabit Ethernet standards (IEEE 802.3) and Fibre Channel standards (ANSI FC-PI). The device has optical connectors compatible with MT-RJ and Duplex-LC. Fig. 2 shows the external appearance: the outer dimensions, pin layout and footprint are all MSA-compliant.

(1) Transmission and reception characteristics

Fig. 3 shows the transmission and reception eye patterns for the SL5111A operating at 2.125 Gb/s. Excellent characteristics are obtained, with a 30% or larger mask margin in the optical transmission waveform. In addition, the reception waveform has low jitter of just 35%.

Table 1 Main features of SFF short-wave optical transceivers

Product No.	SL4211A	SL4111A	SL5111A
Optical connector	MT-RJ	Duplex-LC	
Bit rate (Gb/s)	1.0625/1.25	1.0625/1.25	1.0625/2.125
Standard community	ANSI FC-PI / IEEE 802.3		ANSI FC-PI
Optical output power (dBm)	−9.5 ～ −4.0		
Receiver sensitivity (dBm)	0～−18		0～−16
No. of pin connections	2×5		
Power supply voltage (V)	+3.3 ±5%		
Laser type	λ =850nm VCSEL		
Compatible fibers	50/125, 62.5/125MMF		
Transmission distance	550		300

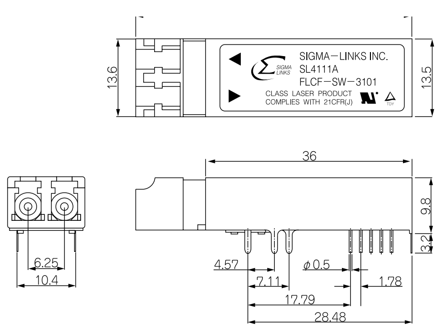
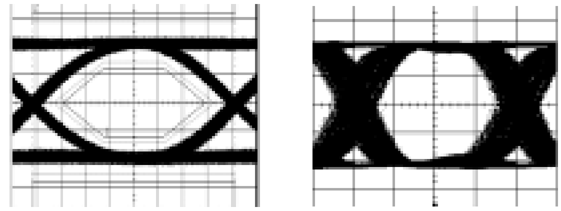


Fig. 2 External view of SFF short wavelength optical transceiver



(a) Optical transmission waveform (b) Reception waveform (at -16dB input)

Fig. 3 Transmission and reception eye patterns (2.125 Gb/s, PRBS 2^7-1, mark rate 1/2)

(2) EMI characteristics

Since an optical transceiver performs high-speed internal switching operations, it often represents a source of noise for both internal and external components, and hence it is a key criterion for equipment manufacturers when choosing an optical transceiver.

Fig. 4 depicts a Host Bus Adapter (HBA) fitted with an SL511A and attached to a PC for EMI testing. Fig. 5 shows the measurement results for the noise radiated from the rear face of the PC during loop-back operation at 2.125 Gb/s. The margin with respect to the standard value (0 dB) is more than 3dB superior to a rival product.

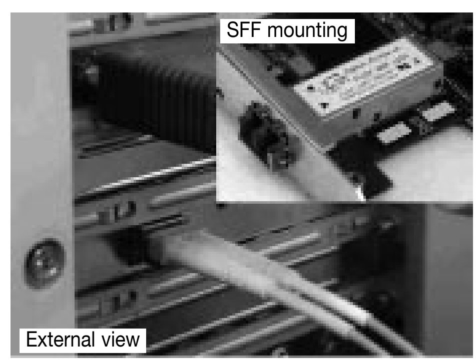


Fig. 4 Example of SFF optical transceiver in use

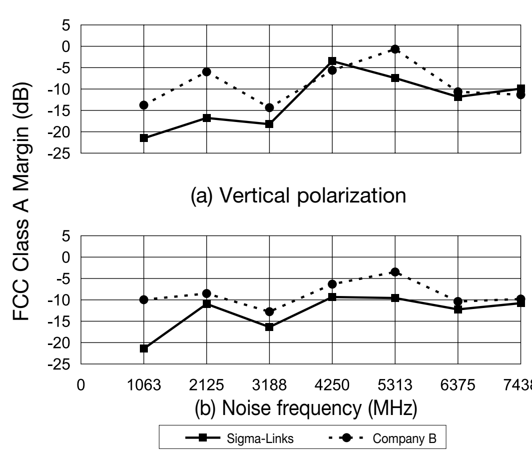


Fig. 5 Radiated noise from HBA (measured of frequency (1 GHz)

*1) The Sigma-Links logo is a Registered Trademark of Sigma-Links Inc.

SFF long wavelength optical transceivers

Table 2 lists Sigma-Links' SFF long wavelength optical transceiver products and their key features [2], and Fig. 6 shows an external view. The box is made from a plastic moulding suitable for mass production. An EMI shield is fitted onto the front end of the case.

Table 2 Main features of SFF long wavelength optical transceivers

Product No.	SL2122E	SL4121D	SL5121D	SL6122B	SL6122E
Optical connector	Duplex-LC				
Bit rate (Gb/s)	0.622	1.25	2.125	2.488	2.488
Standard community	ITU-T G.957	IEEE 802.3	ANSI FC-PI	ITU-T G.957	ITU-T G.957
Optical output power (dBm)	-15～-8	-9.5～-3	-9～-3	-10～-3	-5～0
Receiver sensitivity (dBm)	-28～-8	-21.25～-3	-21.25～-3	-18～-3	-18～0
No. of pin connection	2×10	2×5	2×5	2×10	2×10
Power supply voltage (V)	+3.3±5%				
Laser type	1310nm FP-LD				1310nm DFB-LD
Compatible fibres	1310 nm zero dispersion SMF				
Transmission distance	15	10	10	2	15

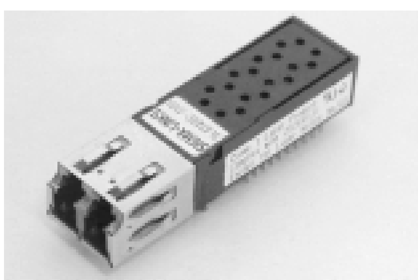
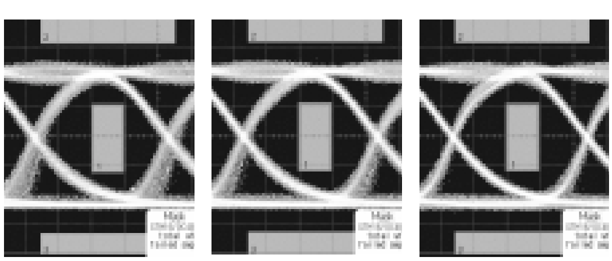


Fig. 6 External view of SFF long wavelength optical transceiver

(1) Optical transmission waveform

In a long-wavelength transceiver using an LD whose operating current characteristics fluctuate with temperature, it is essential that stable optical transmission waveform is maintained over a wide temperature range. Fig. 7 and Fig. 8 respectively show the temperature dependence of the transmission eye pattern at 2.488 Gb/s, and the extinction ratio. The transmission eye pattern exhibits virtually no change at different temperatures and has a satisfactory mask margin, whilst the extinction ratio is restricted to a variation of only 1.5 dB or so.



(a) 0°C (b) 25°C (c) 70°C

Fig. 7 Temperature dependence of transmission eye pattern (2.488 Gb/s, PRBS 2^23-1)

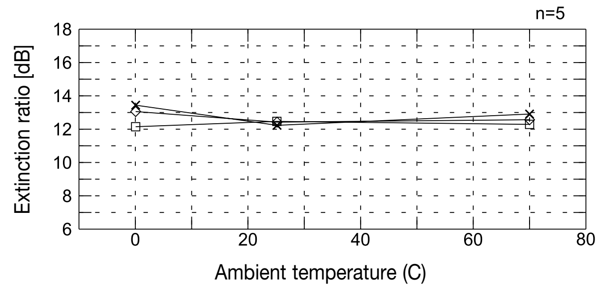


Fig. 8 Temperature dependence of extinction ratio

(2) Transmission characteristics

The SL6122E uses a DFB-LD having a narrow spectral width, and can transmit a 2.488 Gb/s signal over 15 km. Fig. 9 shows minimum sensitivity characteristics. Fig. 10 shows the reception waveform after 15 km transmission. The minimum optical reception power has a sufficient margin with respect to the standard value of -18 dBm. Transmission characteristics are very good, with error penalties being restricted to 0.5 dB after 15 km, and 0.8 dB after 30 km.

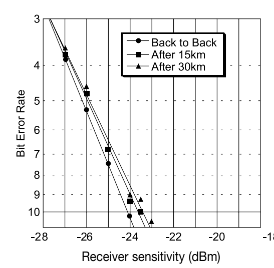


Fig. 9 Minimum optical reception power

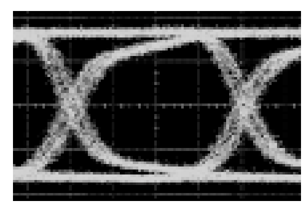


Fig. 10 Reception waveform

SFP optical transceivers

SFP are used by plugging into a receptacle in the communications equipment. Therefore, extending the transmission distance between two devices, for example, simply involves changing the transceiver, and hence SFPs have excellent advantages in terms of device expandability. What is more, they can be attached and detached whilst the equipment is active, so replacement and maintenance tasks are easy to carry out. Additional features include, amongst others, a Serial ID function (permitting external verification of information recorded in the product, such as transmission distance and transmission speed), and a TX_FAULT function (for detecting a fault when a LD peripheral circuit fails, or an LD shuts down).

SFP short wavelength optical transceivers

The SFP short-wave optical transceivers and their characteristics are listed in Table 3 [3]. These products use MT-RJ and/or Duplex-LC optical connectors.

Table 3 Features of SFP short wavelength optical transceivers

Product No.	SL4214A	SL4114A	SL5114A
Optical connector	MT-RJ	Duplex-LC	
Bit rate (Gb/s)	1.0625/ 1.25	1.0625/1.25	1.0625/2.125
Standard Commninity	ANSI FC-PI/ IEEE 802.3		ANSI FC-PI
Optical output power (dBm)	-9.5～-4.0		
Light-emitting element	λ =850nm VCSEL		
Receiver sensitivity (dBm)	0～-18		0～-16
Power supply voltage (V)	3.3±5%		
Compatible fibres	50/125, 62.5/125 MMF		
Transmission distance	550		300

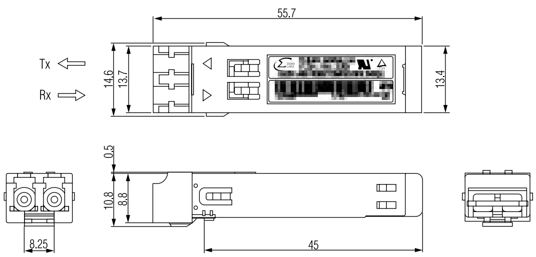


Fig. 11 External view of SFP short wavelength optical transceiver (Duplex-LC)

Fig. 11 shows an external view. As in the SFF transceivers, the outer dimensions and electric wiring, etc. all comply with the MSA.

(1) Transmission and reception characteristics

Fig. 12 shows the reception sensitivity characteristics of the SL5114A at 2.125 Gb/s. The minimum receiver sensitivity is -22.2 dBm, which is a satisfactory margin with respect to the standard value, and cross-talk between transmission and reception is a low value of 0.2 dB.

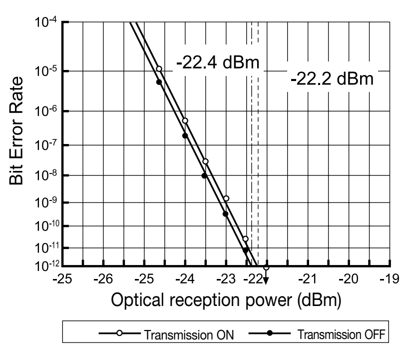


Fig. 12 Minimum sensitivity characteristics

(2) Power source noise tolerance

Fig. 13 shows power noise tolerance characteristics. The transmitter and receiver both function normally at power noise frequencies between 1 kHz and 1 MHz, and therefore have a suitable margin with respect to tolerable power noise specifications which are generally 100 mVp-p or lower.

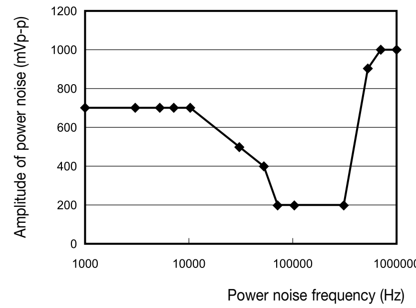


Fig. 13 Power noise tolerance

SFP long wavelength optical transceivers

SFP long wavelength optical transceiver products which are compatible with fibre channels, gigabit ethernets, or SONET applications have already been developed. These long wavelength products have been designed for use in systems demanding very high reliability, and they incorporate functions for monitoring the LD bias current, optical output power, receiver sensitivity, and other factors.

Reliability tests

All of the products described in this essay have undergone reliability test conforming to a Bellcore standards illustrated in Table 4. They were all confirmed to have good long-term reliability.

Table 4 Reliability test items and conditions

Item	Conditions
Mechanical shock test	1500 G, 0.5 msec, 5 times/axis
Vibration test	Peak acceleration 20G Frequency 20 - 2000 Hz 4 min./cycle; 4 cycle/axis
High temperature storage test	Stored at +85°C for 2000 hours
Low temperature storage test	Stored at -40°C for 2000 hours
Thermal shock test	△T = 100°C or above 15 cycles 2 min./cycle or less
Temperature cycle test	-40°C to +85°C , 1000 cycles
Damp heat test	Operated at +85°C, 85%RH for 1000 hours
High temperature operation test	Operated at +85°C for 2000 hours

References

1) Abe, et. al.: ECTE 2001, The 51st "Short Wave SFF Small Form Factor Transceivers"

2) Matusmoto, et. al.: IEICE General Conference B-10-53 "Development of 2.5 Gbit/s LC-SFF optical transceivers"

3) Haneda, et. al.: Technical Report of the IEICE, OCS2001-09, "2.125 Gb/s SFP short-wave optical transceivers", p. 25

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