INNOVA

LINK
FAMILY
USER MANUAL

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1 Introduction

The Innova LINK family consists of a series of products for transferring electrical signals (video, Ethernet, serial communication, etc.) over optical fibre.

A typical application consists of a remote location with a control / data acquisition system where it is desirable to transfer data to and from the remote location via optical fibre. The LINK family consists of 2 sets of boards; a set of input boards used at the remote end, and a set of output boards used at the local end. The input boards converts the electrical signals to optical signals and the output boards converts the optically signals back to electrical signals. During the design process emphasis has been put on transferring the data with as little alterations and delay as possible.

Please refer to the individual products user manuals for detailed descriptions, see Appendix 2.

The figure below shows a set of Ethernet LINK boards.

Figure 1, Example boards (Ethernet).

1.1 Definitions

1.1.1 Abbreviations

MUX	Multiplexer
SFP	Small Form-factor Pluggable (electrical to optical converter module)
WDM	Wave Division Multiplexing
CWDM	Coarse Wave Division Multiplexing

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2 Fibre optic components

The Innova LINK family of fibre optic multiplexer cards utilise industry standard SFP (Small Form-factor Pluggable) fibre optic modules. This ensures flexibility when choosing wavelengths and fibre type. Multi mode fibre can be used for short distances. But for longer distances and high throughput systems, single mode fibre must be used. In the following it is assumed that single mode fibre is used.

2.1 SFP (Small Form-factor Pluggable)

A SFP module provides the electrical to optical interface. The SFP is plugged into a cage on the PCB allowing for easy selection of suitable wavelength and optic power budget.

An SFP has and optical transmitter (laser) and an optical receiver. The optic fibres are plugged into the SFP by the use of LC connectors. Standard SFP’s require 2 fibres to be connected for 2 way communication, 1 for transmit data and 1 for receive data. See Figure 2 below for the physical outline of an SFP.

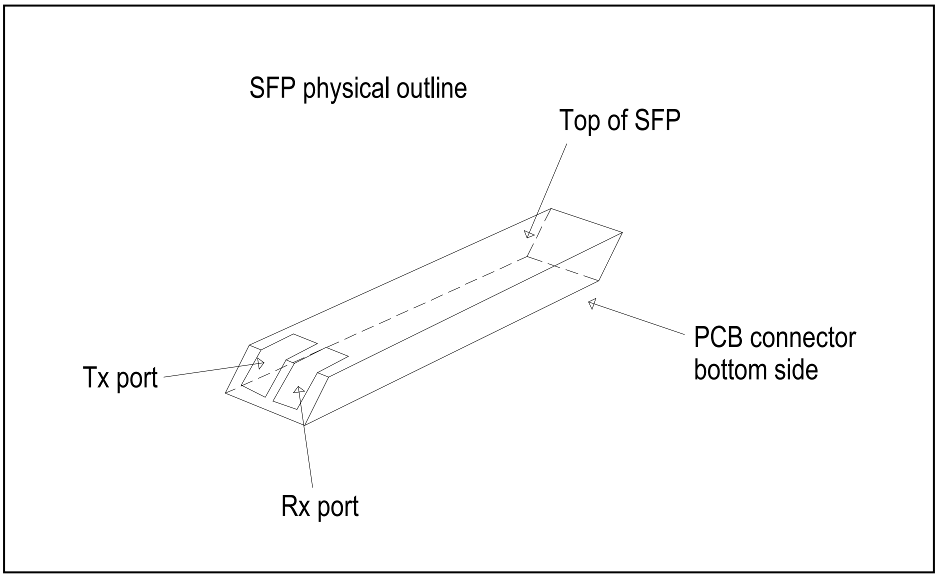

Figure 2, SFP.

In some cases only 1 way communication is used, in these cases only 1 fibre is necessary. The fibre is connected to the transmitter at the input (source) end and to the receiver at the output end.

SFP’s are available with different transmitter wavelengths (or frequencies). In order to reduce the number of fibres required between 2 systems, several wavelengths can be multiplexed into a single fibre by use of WDMs (Wave Division Multiplexer). SFP’s are most commonly used with CWDM (Coarse WDM) it is then possible to multiplex up to 16 wavelengths onto a single fibre.

2.2 WDM (Wave Division Multiplexer)

A WDM is a unit that couples different optical wavelengths (λ) from 2 or more fibres into a common optical fibre. A WDM can also recover the different optical wavelengths in the common fibre into separate fibres again. WDMs used in conjunction with the Innova LINK boards are entirely passive units, typically smaller than a match box.

WDMs are used in pairs, with 1 WDM in each end of a fibre. At one end a WDM couples different optical wavelengths into a fibre. At the other end a compatible WDM recovers the different optical wavelengths back into separate fibres (see Figure 3).

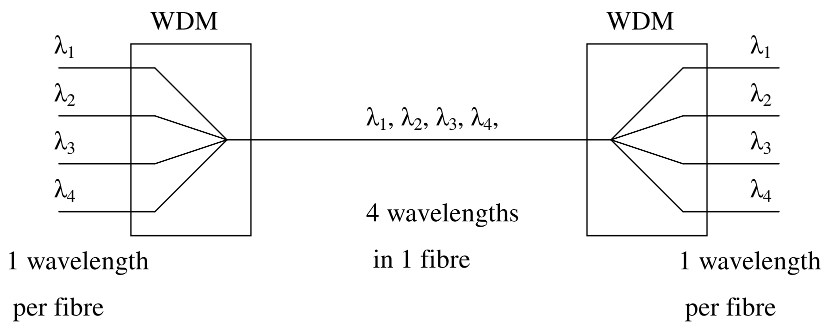

Figure 3, 4 channel WDM configuration.

Each channel in a WDM is designed to only pass light within a specific wavelength band. It is thus important to select the used wavelengths in a system to match the WDM wavelengths.

WDMs are available with a number of different configurations and number of channels.

2.2.1 CWDM (Coarse Wave Division Multiplexer)

The most likely WDM arrangement to be used together with the Innova LINK products utilises the CWDM wavelengths. The CWDM band is divided into 16 (18) different wavelengths. Common CWDM configurations are 4, 8 and 16 wavelengths. A 16 wavelengths WDM is often accomplished by using 2 units with 8 wavelengths in each end, one for the Band 1 wavelengths and 1 for Band 2 wavelengths. In this case 1 of the 8 wavelengths units have a dedicated input for the combined 8 wavelengths from the other unit. An 8 wavelengths system can be realised in a similar way using 2 units with 4 wavelengths.

The CWDM wavelengths start at 1271nm with 20nm spacing between wavelengths. The wavelengths are subdivided in 2 bands, Band 1 (red band) and Band 2 (blue band). Table 1 below lists all the available CWDM wavelengths, according to ITU-T G.694.2. Older standards used wavelengths ending with 0 (1270, 1290, ...), these are still commonly used to day and have the same meaning as Table 1.

Band 1 (red band) wavelengths [nm]	Band 2 (blue band) wavelengths [nm]
1471	1271
1491	1291
1511	1311
1531	1331
1551	1351
1571	1371
1591	1391
1611	1411
	1431
	1451

Table 1, CWDM wavelengths

Older fibre cables can be troubled by increased attenuation in the region close to 1400mn due to water absorption in the optical fibre. It was therefore common to avoid the 1391mn and 1411mn wavelengths. Thus Band 2 contains 10 wavelengths to compensate for this. This is not a problem with newer “zero water peak” fibres (fibres manufactured according to ITU-T G.652.C or G.652.D).

The receivers are wideband and will accept signals of all wavelengths within the CWDM band. It is thus only necessary to specify the transmitter wavelength, which is what the SFP manufacturers specify.

One important aspect with SFP’s and CWDM is that only SFP’s specified for CWDM use have transmitter wavelengths within the required ±6.5nm CWDM specification. SFP’s not designed for CWDM use may have a much wider transmitter wavelength specification and cannot be reliably used in CWDM applications. For instance, a system with only 2 wavelengths can be realised with 1310nm and 1550nm SFP’s and a 2 channel (wideband) WDM using a single fibre.

If these SFP's are "standard" SFP's and not CWDM specified SFP's they will have a wide transmitter wavelength specification. If one attempts to use such SFP's with a 4 or more channels CWDM the transmitter wavelength may fall outside the pass band of the WDM and thus there will be no data coming through. If a 2 channel wideband WDM system is to be upgraded to more channels the SFP's will have to be replaced. When choosing SFP's for a 2 channel system one should keep this in mind. If it is anticipated that one later may want to upgrade the system to more SFP's and a CWDM with more wavelengths it may be best to use CWDM specified SFP's from the start.

2.3 Optical budget

All fibre optic components have some degree of loss of light intensity. Especially WDMs and slip rings have high losses. A successful implementation of a fibre optic transmission system requires a suitable balance between transmitter light power output, the optic receiver sensitivity and losses between transmitter and receiver. Optic power for the SFP's is usually specified in dBm, i.e. a ratio referenced to 1 mW. For transmitters the optic output power is given and for receivers the optic sensitivity is given.

Optic transmitter power is specified in a range from minimum to maximum. This means that a given SFP will have a transmitting power somewhere in this range.

Optic receiver sensitivity is also specified in a range from minimum to maximum. For instance this can be specified with 0 dBm as minimum and -20 dBm as maximum. In this case 0 dBm refers to the strongest signal the receiver can accept before the receiver saturates. -20 dBm refers to the lowest signal level the receiver is able to detect.

The optical budget for a transmitter / receiver combination is given as the difference between the minimum transmitted power and the maximum receiver sensitivity. All optic components used for transferring the signal will introduce loss of optic power. The light power output from the transmitter must be sufficiently high to ensure that enough light power reached the receiver. The insertion loss by optic components is expressed in dB. Thus the sum of all the losses (in dB) must be less than the SFP's optic budget (in dBm) with some safety margin. At the same time one must make sure that the optic power level at the receiver is below the saturation level. If the loss in the transmission line is to low extra loss must be introduced by the use of attenuator(s).

A fibre optic transmission line for use in ROV or similar subsea system may typically consist of the components listed in the table below.

Optical unit	Insertion loss [dB]
Patch cable SFP -> CWDM	0,40
Connector	0,20
CWDM 8 way	2,40
Connector	0,40
CWDM 8 way UG	2,50
Connector	0,20
Patch / deck cable	0,40
Winch slipring	3,50
3000 m cable (0,35 dB/km)	1,05
Patchcable	0,40
TMS / garage slipring	3,50
Patch / tether cable	0,80
Connector	0,20
CWDM 8 way UG	2,70
Connector	0,40
CWDM 8 way	2,40
Connector	0,20
Pacth cable CWDM -> SFP	0,40
Safetymargin	3,00
Sum	25,05

As an example take a SFP with the following specification:

Transmitter power: 0 - 5 dBm

Receiver sensitivity: -9 - -26 dBm

This SFP gives an optic budget of 26 dB. The minimum attenuation required to prevent saturation of the receiver is 14 dB.

This SFP would be suitable for the typical ROV system listed above. But if the top-side and subsea system are directly connected together during testing one must use an attenuator to ensure minimum 14 dB total loss in the line.

2.3.1 Combining different SPFs

If different models / make are to be used in the same system care must be taken when selecting these. It is not enough to only look at the optic budget as different SFP's with the same optic budget may have different transmitter power and receiver sensitivity. So in this case one must compare transmitter power and receiver sensitivity of the actual transmitters and receivers connected together to ensure proper operation.

2.3.2 Optical back reflections

When the light passes through connectors some light may be reflected back to the transmitter instead of passing through. This phenomenon is called optical return loss (ORL) or Fresenl loss. Back reflection is not much of a problem at low communication speeds, but becomes an increasing problem at higher communication speeds. As most of the LINK boards communicate at 1 Gpbs or higher it is important that connections have low back reflections. Thus high quality terminations are essential to ensure proper fibre communication. For instance 'hot melt' connectors and hand polishing cannot be relied upon to give reliable connections at 1 Gpbs speeds. If this termination method is used it is essential to measure the back reflections of each connector after termination.

Losses due to back reflections do not show up in simple attenuation measurement techniques, but can be measured with an OTDR (Optical Time Domain Reflectometer). A terminated cable can give excellent attenuation measurements and still give high levels of back reflections.

High levels of back reflections can cause problems for the laser in the transmitter and result in erratic communication. This is especially an issue with CWDM system as the lasers in these units are more vulnerable to back reflections.

3 Power supply

The LINK boards require a 12VDC (6 - 12V) power supply. A high quality power supply is recommended, especially for the analogue video board. As the boards utilise onboard switch mode power supplies the initial current drawn will be higher than the steady state current consumption. Because of this the power supply must be dimensioned with a safety margin to supply the start up current.

4 Output rack

The output boards are designed to be mounted in a 19” rack system. Innova supplies a 4U high unit for the output boards. This unit has internal power supply and is designed to fit 1 AV board with a full set of expansion board plus 4 other type of LINK boards. Only 1 AV board can be used in this rack unit. The unit can be configured for either front or rear connections. The unit with rear connections can also be configured with a front panel PC for display of diagnostics information.

The figure below shows an example of a rack with rear connections.

Figure 4, output rack.

The boards slide in and out and connect to the mother board as in a ‘normal’ rack system. But the fibre optics enters the boards at the same side as the mother board connections and must be connected / disconnected manually. When inserting a board the fibre optics must be connected after a board is inserted into its slot and correspondingly disconnected before removing a board. **Remember to disconnect the fibre optics from a board before removing it.** Failing this may cause damage to the (fragile) optical fibres.

5 Appendix 1, PN numbers for LINK products

Description	PN
LINK Motherboard Input	2100101
LINK Motherboard connector Input	2101101
LINK Motherboard Output	2100301
AV 6 ch Input	2110101
Ext 2 ch AV Input	2111101
Ext 12 ch RS232 Input	2112101
Ext 12 ch RS-422/485 FD Input	2113101
Ext 12 ch RS-422/485 HD Input	2114101
AV 6 ch PR Input	2110201
Ext 2 ch AV PR Input	2111201
Ext 12 ch RS232 PR Input	2112201
Ext 12 ch RS-422/485 FD PR Input	2113201
Ext 12 ch RS-422/485 HD PR Input	2114201
AV 6 ch Output	2110301
Ext 2 ch AV Output	2111301
Ext 12 ch RS232 Output	2112301
Ext 12 ch RS-422/485 FD Output	2113301
Ext 12 ch RS-422/485 HD Output	2114301
DV HD-SDI 4 ch Input	2120101
DV HD-SDI 4 ch PR Input	2120201
DV HD-SDI 4 ch Output	2120301
Ethernet Base-T 4 ch Input	2130101
Ethernet Base-T 4 ch PR Input	2130201
Ethernet Base-T 4 ch Ouput	2130301
PECL Bi-dir 2ch Input	2140101
PECL, Bi-dir 2ch PR Input	2140201
PECL Bi-dir 2ch Output	2140301

6 Appendix 2, user manuals for LINK products

Description	Manual doc. #
AV 6 ch	604368-man-002
Ext 12 ch RS232	604368-man-003
Ext 12 ch RS485 HD	604368-man-004
Ext 12 ch RS422 FD	604368-man-005
Ext 2 ch Video	604368-man-006
DV HD-SDI 4 ch	604368-man-007
Ethernet Base-T 4 ch	604368-man-008
PECL Bi-dir 2ch	604368-man-009