Bi-Directional Transceivers

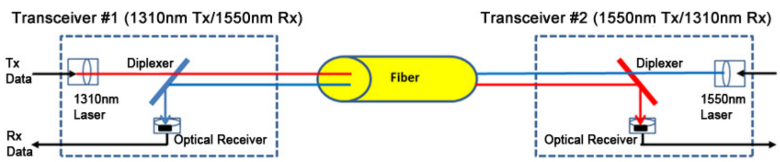
Working principle of a Bi-Directional transceiver

The primary difference between BiDi transceivers and traditional two-fibres optic transceivers is that BiDi transceivers are fitted with Wavelength Division Multiplexing (WDM) couplers which combine, and separate data transmitted over a single fibre based on the wavelengths of the light.

To work effectively, BiDi transceivers must be deployed in matched pairs with their diplexers tuned to match the expected wavelength of the transmitter and receiver, which they will be transmitting data from or to.

For example: If paired BiDi transceivers are being used to connect Device A (Upstream) and Device B (Downstream), as shown in the figure below, then:

- Transceiver A's diplexer must have a receiving wavelength of 1550 nm and a transmit of 1310 nm
- Transceiver B's diplexer must have a receiving wavelength of 1310 nm and a transmit of 1550 nm



Itectras portfolio of BiDi trancsceivers consists of:

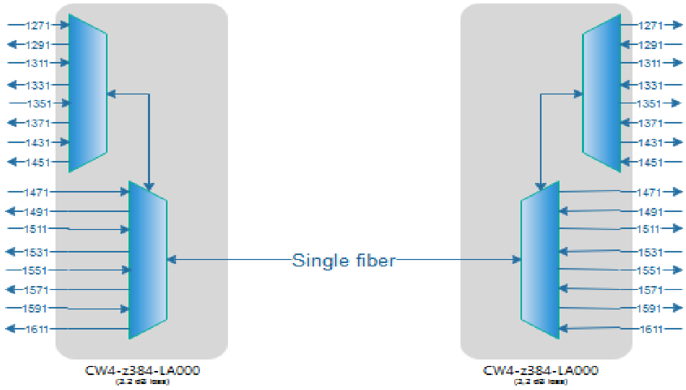
- 1 Gb BiDi SFP in both 1310 nm / 1490 nm and 1310 nm / 1550 nm versions Power budget: -33 dB
- 10 Gb BiDi SFP+ in 1270 nm / 1330 nm Power budget: -20 dB
- 10 Gb BiDi XFP in 1270 nm / 1330 nm Power budget: -20 dB

- 3 Gb CPRI BiDi SFP for all CWDM channels. Power budget: -20,5 dB
- 6 Gb CPRI BiDi SFP+ for all CWDM channels. Power budget: -23 dB
- 10 Gb CPRI BiDi SFP+ for all CWDM channels. Power budget: -23 dB

Bi-Directional C/DWDM Systems

In cases where there is shortage of fibre larger bandwidth, CWDM or DWDM can be installed as a single-strand system. This is done by utilising half of the systems channels as transmit (Tx) channels, whereas the other half are reserved for the receiving (Rx) channels.

This can be installed in CWDM system – as below depicted – and in DWDM system following the same installation principle.



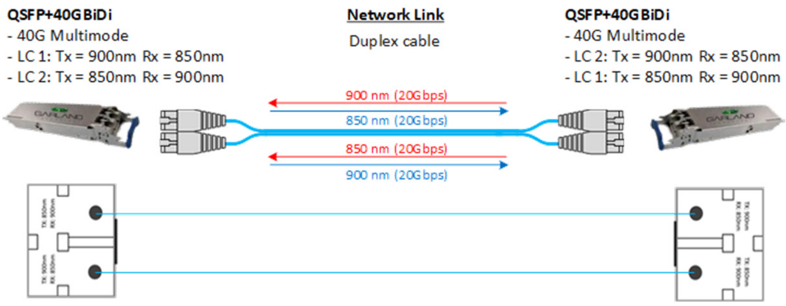
Please refer to the Itectra WDM data sheet for the full range of CWDM and DWDM modules and systems.

40 Gb / 100 Gb BiDi Transceivers

Short Reach

The above explained BiDi method is used also for 40 Gbps and 100 Gbps transport over Multimode fibres. By using two different wavelengths, each strand of fibre will both send and receive traffic at a rate of 20 Gbps (2×10) or 50 Gbps (2×25). These BiDi transceivers require OM3, OM4 or OM5 multimode fibres.

The below depicted scenario utilizes both 850 nm and 900 nm for transmit 40 Gbps over a distance up to 150 m (OM4) or 100 m (OM3).



Long Reach

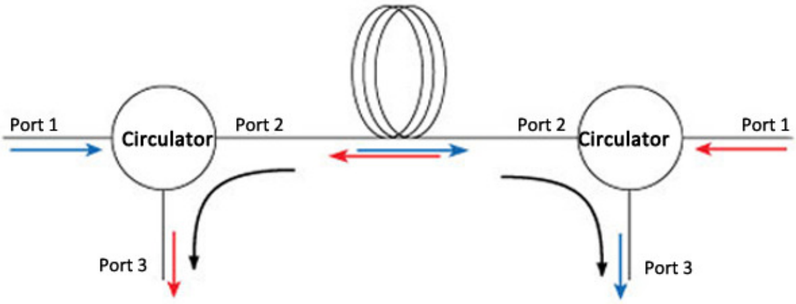
100Gbps single-lambda (e.g., 100GBase-LR1 BiDi) is utilising two wavelengths to transport the signal via a circulator.

Circulator

Working principle

Optical circulators have been on the market since the 1980th. The principle of the circulator is that Port 1 is forwarded to port 2 only, and port 2 is forwarded to port 3 only, as depicted below. Port reflection is negligible.

Optical circulators are in some cases used in higher orders systems for transporting over single-strand WDM, where the use of a deflextor is inappropriate.

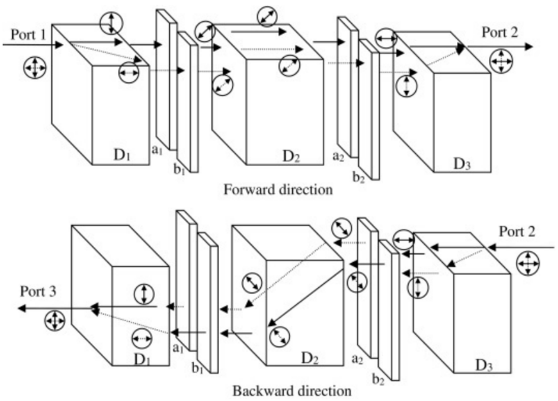


The working principle of an optical circulator is that the incoming signal is polarised in order to separate the various wavelengths in question.

Optical circulators have an insertion loss less than 1 dB, and a port reflection of ~55 dB.

Build

A usual build of a circulator consists of three YVO4 beam displacers (which is a specific Bifringent crystal), which each splits the unpolarized light beam into two orthogonally polarized beams parallel to each other, and two pairs of Faraday rotators each shifting the polarized signal 45° clockwise/counter-clockwise, as depicted below.

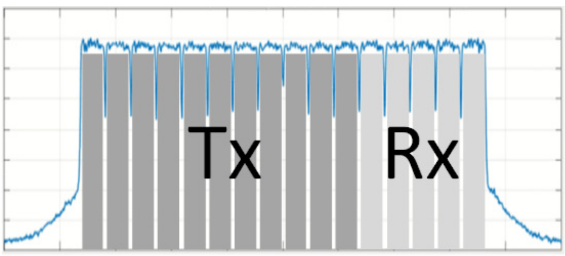


In the forward-propagation direction, the incoming light beam into port 1 is first split into ‘o’ and ‘e’ beams by the first YVO4-beam displacer. (These two beams are shown as the solid and the dashed lines respectively. The polarization state is labelled near each light beam.) These two beams are separated in the horizontal direction after passing through the first YVO4 displacer (*D1*). They then pass through a pair of separate Bi:YIG Faraday rotators. The left Faraday rotator (*a1*) rotates the ‘o’ beam by +45°, where the right Faraday rotator (*b1*) rotates the ‘e’ beam by -45° without shifting their beam spatial positions. In fact, after passing through the first pair of Faraday rotators, the two beams become co-polarized, and they are both ‘o’ beams in the second YVO4 displacer (*D1*). Since these two separate beams now have the same polarization state, they will pass the second displacer (*D2*) without further divergence. At the second set of Faraday rotators, the left beam will rotate an additional +45° at (*a2*), where the right beam will rotate an additional -45° at (*b2*), then their co-polarization states become orthogonal with each other. The third beam displacer (*D3*) will then combine these two separate beams into one at the output, which recreates the input optical signal but with a 90° polarization rotation.

For the reflected optical signal into port 2, which propagates in the backward direction, the light beam is separated into two after passing through *D3*. However, because of the non-reciprocal characteristic, the Faraday rotator *a2* rotates the reflected beam by +45°, where *b2* rotates the reflected beam by -45°, all in the same direction as rotating the forward-propagated light beams. The total polarization rotation is then 90° after a round-trip through the second pair of Faraday rotators. Thus, in the second beam displacer *D2*, the backward-propagated beams are again polarized, but their polarization orientations are both ‘e’ beams (recall that the two beams are both ‘o’ beams in the forward-propagating direction). Because of this 90° difference in the polarization orientation, the backward-propagated beams will not follow the same routes as the forward-propagated beams in the second beam displacer *D2*, as depicted above. After passing through the first set of Faraday rotators and the first beam displacer *D1*, the backward-propagated beams are eventually recombined at port 3 at the input side, which is in a different spatial location than port 1.

XR

The nature of coherent optics dictate that it must transmit and receive on the same frequency, due to the reference frequency for the MZM. This means that there is a chance that the reflection of Tx signal (reflection factor approx. -55 dB) will interfere with the Rx signal from the far end.



XR Sub-Carriers, where 11 sub-carriers (275Gbps) is transmitted, whereas 5 carriers (125Gbps) is used for receive.

To eliminate this possible source of error Infinera has chosen to use different sub-carriers for transmit and receive so that the transmit sub-carriers will not be used as receive. In this manner the receiver will never expect information on the sub-carriers used by the transmit, hence any possible reflection errors are thereby eliminated.