CableLabs® Specification Engineering Change Details

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EC Identifier: PHYv1.0-N-18.0002-2
(to be inserted by CableLabs)

Title of EC: Full Duplex Coherent Optics (PHY)
(to be inserted by CableLabs)

Change Details - Revision History
If modifying the change details from the original submitted version of the EC, please complete the following information. Include a brief description of what is different in this version compared to the previously posted version:

Date of the revised EC: 11/26/18

Description of changes to latest version of EC only: Removed change #6, and moved that text into section 7.4.1.2 as a part of change #5.

Instructions for Proposed Specification Changes (PLEASE INCLUDE SECTION NUMBER, TITLE, AND PARAGRAPH)

- Engineering Changes may only address one technical issue in one specification, although it may require changes to multiple sections in the specification.
- Please itemize each change as follows. If you have multiple changes and all address the same issue, and if some are technical (may require a vendor to change the design of the product) and some are editorial (points of clarification/clean-up but would not under any circumstances require a change to the product), please select the "Both" option in the numbered Spec Change table(s) below.
- For more than 3 separate changes, copy a blank numbered change table and paste after last change. Please update the change number(s) appropriately.
- Word's Track Changes feature MUST be used! (if not used, this EC will be returned to author)
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- **In rare circumstances, if extensive changes are necessary in multiple sections or throughout the document, the entire document to be modified may be embedded in the EC form, *replacing* the existing embedded Changed Detail document.** Again, Track Changes MUST be used for ease of review and incorporation. Check with project spec lead for further details.
- **To create new TLV tables, use the 3 table templates**

Project and IPR information: Charter for the Optical Project. Note related info in the footer of this form. Contact legal@cablelabs.com.

EC Identifier: PHYv1.0-N-18.0002-2

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Specification Changes:

SPEC CHANGE #1	**TYPE OF CHANGE:** TECHNICAL:	EDITORIAL:	BOTH:
SECTION #	TITLE	PARAGRAPH / TABLE # / GRAPHIC #	
5.2	Reference Interfaces	Entire section	

The transceiver has multiple interfaces (IFs) that are specified in this document and depicted in ~~Figure 10~~Figure 10 and Figure 11. The line-side corresponds to the optical interfaces. The client-side (or host-side) corresponds to the electrical interfaces. In addition, there is a management interface that will be specified in detail in the OSSI specification **Error! Reference source not found.**.

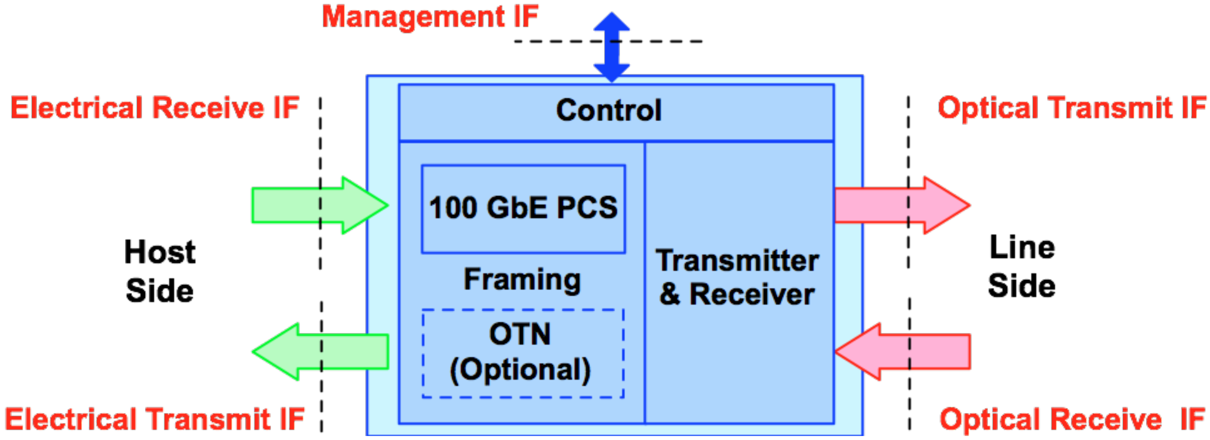


Figure 10~~10~~ — Dual Optical Interface Transceiver Optical, Electrical and Management Interfaces

The dual optical interface transceiver option is the transceiver design that has historically been most common, and utilizes separate optical interfaces for transmit and receive functions.

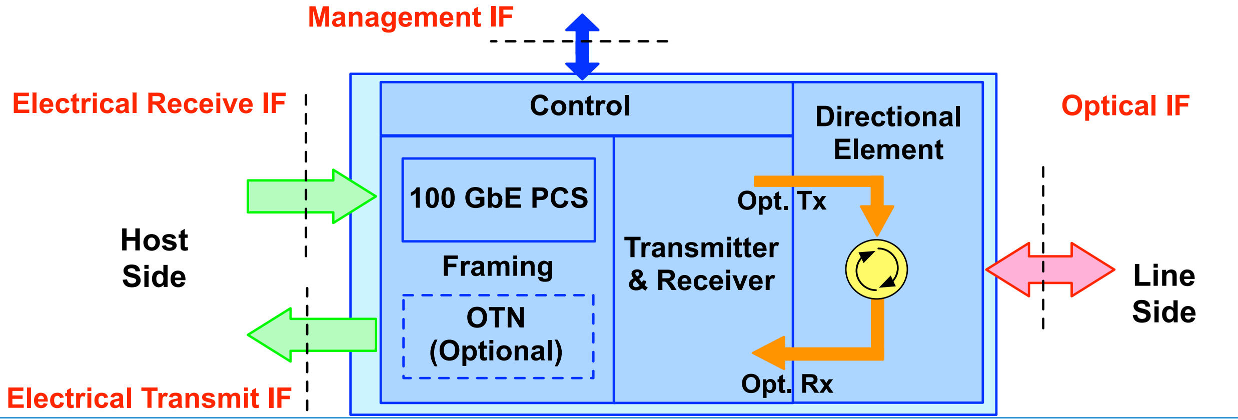


Figure 11– Single Optical Interface Transceiver Optical, Electrical and Management Interfaces

The single optical interface transceiver option addresses the deployment scenarios identified in Section 1.2, where there is only a single fiber available from hub to node. This option incorporates a signal direction function that allows the transmitter optical signal to be directed to the single optical interface and the signal incoming through the single optical interface to be directed to the receiver with negligible performance impact and while utilizing the same frequency in both directions. The architecture implications when using the single interface transceiver option are described in section 7.6 of [OPT-P2P-ARCH].

SPEC CHANGE #2	**TYPE OF CHANGE:** TECHNICAL:	EDITORIAL:	BOTH:
SECTION #	TITLE	PARAGRAPH / TABLE # / GRAPHIC #	
5.3	Functional Block Diagrams	Entire section	

The sequence of key processes that take place in the transmitter as well as the receiver are illustrated in ~~Figure 11~~Figure 12 and ~~Figure 12~~Figure 13. The transmitter and receiver process sequences are only provided as examples. Actual transmitter and implementations may follow different sequences and different feedback dependencies.

~~Figure 11~~Figure 12 shows functions that take place in the transmitter from the electrical input on the host-side to the optical output on the line-side. The "Directional Element" block on the line side is only applicable to the single optical interface transceiver option.

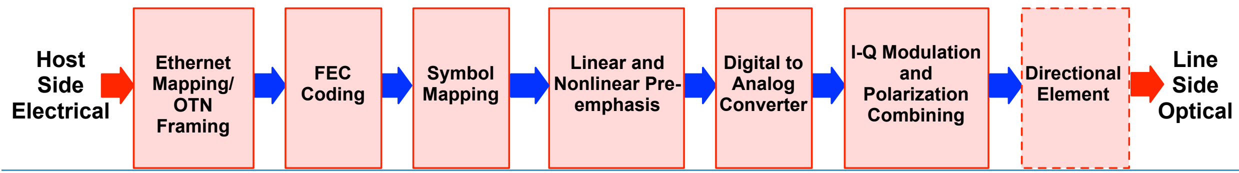
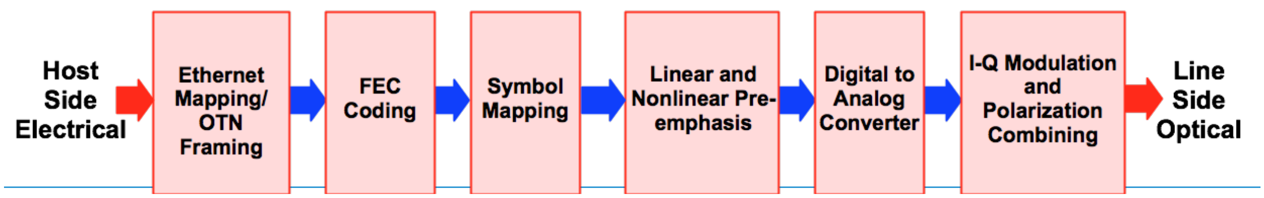


Figure 12 - Transmitter Functional Diagram



~~*Figure 11 - Transmitter Functional Diagram*~~

The transmitter processes include:

- Ethernet Mapping and OTN Framing
- FEC Coding
- Symbol Mapping
- Linear and Non-linear Compensation
- Digital to Analog Conversion
- IQ Modulation and Polarization Combining

The parameters describing the transmitted optical signal include:

- Encoding Scheme
- Line Rate
- Polarization Imbalance
- Quadrature and Polarization Skew
- Tx Clock Jitter
- Frequency Tolerance

- Optical Output Power
- Laser Wavelength
- Laser Linewidth
- Tx OSNR

The optical distribution medium in cable may include fiber, optical splitters, optical circulators, wavelength multiplexers, demultiplexers and other optical passives. The impairments impacting the optical signals traversing the link include:

- Optical Loss or Gain
- Chromatic Dispersion
- Polarization Mode Dispersion
- Polarization Dependent Loss
- Polarization Rotation
- Optical Crosstalk
- Optical SNR degradation

The optical signal generated by an imperfect transmitter and degraded by impairments from the optical distribution medium enters the line-side of the transceiver for detection, compensation and processing.

~~Figure 12~~Figure 13 shows the functions that take place in the receiver from the optical input on the line side to the optical output on the host side. The "Directional Element" block on the line side is only applicable to the single optical interface transceiver option.

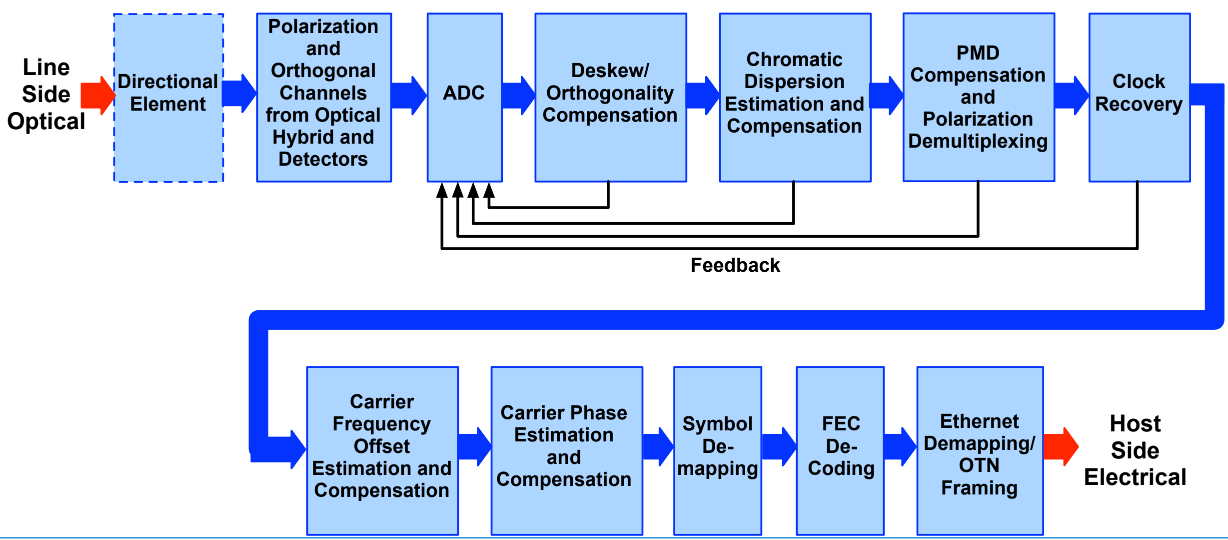
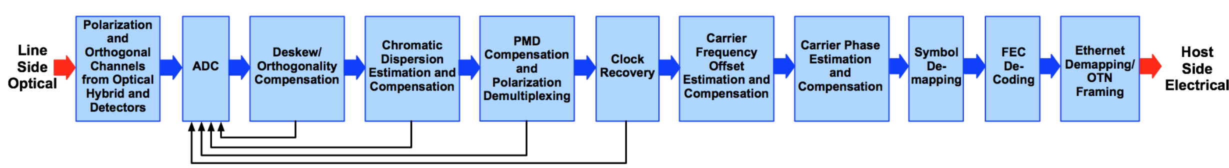


Figure 13 - Receiver Functional Diagram



~~*Figure 12 - Receiver Functional Diagram*~~

The receiver processes include:

- Detection of in-phase and quadrature orthogonal channels for each X and Y polarizations

- Analog to Digital conversion
- Deskew and Orthogonality Compensation
- Chromatic Dispersion Estimation and Compensation
- Polarization Mode Dispersion Compensation and Polarization Demultiplexing
- Clock Recovery
- Carrier Frequency Offset Estimation and Compensation
- Symbol Demapping
- FEC Decoding
- Ethernet Demapping and OTN Framing

The parameters describing the received optical signal include:

- Modulation
- Symbol Rate
- Symbol Mapping
- FEC
- Line Rate
- Encoding Scheme
- Frequency Tolerance
- Frame Format and Mapping
- Optical Input Power
- Laser Wavelength
- Laser Linewidth
- Rx OSNR
- Polarization Imbalance
- Quadrature and Polarization Skew
- Tx Clock Jitter
- Chromatic Dispersion
- Polarization Dispersion
- Polarization Rotation (SOP Track)

There are some general transceiver characteristics as well. The end-to-end link latency consists of the transmitter and receiver latencies along with the optical channel transmission delay. The reflectances of transmitter and receiver optical interfaces are characterized by its optical return loss. Transceiver operation may be impacted by ambient temperature which may require compensation. In the receiver, the data re-acquisition time is a useful metric that indicates the time the receiver takes to turn back on after loss of signal.

SPEC CHANGE #3	**TYPE OF CHANGE:** TECHNICAL:	EDITORIAL:	BOTH:
SECTION #	TITLE	PARAGRAPH / TABLE # / GRAPHIC #	
6.3	Optical Ports and Frequencies	Entire section	

As discussed in Section 5.2, two different line side interface options have been defined in this specification: a dual optical interface option, and a single optical interface option. Both options can support either a single frequency for transmitting and receiving, or separate frequencies for transmitting and receiving.

This specification supports both of the line side interface options. It also requires support for using the same frequency for transmitting and receiving, but allows the option of transmitting and receiving with different frequencies.

~~Transceivers compliant with this specification can have either one or two optical ports to handle transmit and receive functions. A typical transceiver has two separate ports for transmit and receive so that they can use the same frequency. It is also possible to develop a transceiver that uses a single port for both transmit and receive, either by using two separate frequencies or by using some technology to support bi-directional transmission on a single fiber at the same frequency. A two-frequency, two-port solution is also possible. All of these approaches are permitted by the specification.~~

The transceiver MUST support either dual optical interfaces or a single optical interface for transmit and receive functions.

~~The transceiver MUST support either one or two optical ports for transmit and receive functions.~~

The transceiver MUST support using the same frequency for transmit and receive functions.

The transceiver MAY support transmitting and receiving on two different frequencies.

SPEC CHANGE #4	**TYPE OF CHANGE:** TECHNICAL:	EDITORIAL:	BOTH:
SECTION #	TITLE	PARAGRAPH / TABLE # / GRAPHIC #	
7.3.1	Transmitter Optical Output Power	Entire Section	

Transmitter optical output power defines the total optical launch power measured in dBm from the output port of a transceiver while it is operating.

This parameter is measured with a calibrated optical power meter (OPM) that is capable of power measurement in 1550 nm wavelength range. The minimum requirement is defined to allow for low cost options while ensuring that solutions meet minimum cable access network requirements; the maximum requirement is defined for safety purposes. Different transmit power requirements for the traditional dual optical interface and single optical interface options are included to account for the loss incurred by the directional element within the single optical interface transceiver.

Note that during startup, the transmitter may generate “fast transients,” or sudden spikes in power across a range of frequencies, which could briefly impact any operating channels that are on the same optical plant as the transceiver that is starting up. As a result, some transceivers might include the ability to do blanking, the suppressing of optical output until such time as the transceivers output has stabilized.

If the transceiver supports dual optical interfaces, the transceiver MUST support a transmitter optical output power of -6 dBm or higher. If the transceiver supports a single optical interface, then the transceiver MUST support a transmitter optical output power of -6.75 dBm or higher. ~~The transceiver MUST support a transmitter optical output power of -6 dBm or higher.~~ The transceiver MUST NOT permit a transmitter optical output power of +7 dBm or higher.

The transceiver MUST report its minimum and maximum supported optical output power.

The transceiver MUST report the transmitter optical output power with an accuracy of ±1.5 dB.

The transceiver SHOULD support adjustment of the transmitter optical output power. If adjustment of transmitter optical output power is supported, the transceiver SHOULD support adjustments in steps of 0.1 dB.

The transceiver MAY support blanking to protect the optical plant during startup.

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SPEC CHANGE #5	**TYPE OF CHANGE:** TECHNICAL:	EDITORIAL:	BOTH:
SECTION #	TITLE	PARAGRAPH / TABLE # / GRAPHIC #	
7.4.1.2	Received OSNR Baseline	Entire section	

Under other conditions — such as when there is an optical amplifier close to the receiving transceiver — the optical received power may be high, but the OSNR may be low (since the optical amplifier amplifies both the signal and the noise). In this case, the transceiver is limited by it's sensitivity to OSNR rather than power. This is referred to as an "OSNR-limited case," and represents the baseline requirement for received OSNR.

In addition to the baseline received OSNR requirement that applies to the dual optical interface transceiver option, an adjustment in the receive power requirement of the single optical interface option is introduced. This adjustment accounts for the loss incurred by directional elements within the transceiver to enable the single optical interface option. Operators should also be aware that in a single optical interface transceiver option, a performance degradation in OSNR is expected due to discrete optical reflections and from back scattering caused by fiber imperfections. High-quality fiber splicing, cleanliness of fiber-optic connectors' mating surfaces and the use of angle-polished connectors, contributes to a lower back-reflection power. In an optical link using single optical interface transceivers, with an aggregate back-reflection power of -33 dBm and a receive optical power of ≥ -9.25 dBm, a 0.5 dB penalty in link OSNR is observed. In this scenario, a link OSNR ≥ 15 dB can be used to overcome this back-reflection power level.

If the transceiver supports dual optical interfaces, the transceiver MUST achieve a post-FEC bit-error-ratio (BER) of ≤ 10^{-15} when the received optical power is ≥ -10 dBm and link OSNR is ≥ 14.5 dB, which is referred to as the baseline received OSNR requirement. If the transceiver supports a single optical interface, the transceiver MUST achieve a post-FEC bit-error-ratio (BER) of ≤ 10^{-15} when the received optical power is ≥ -9.25 dBm and link OSNR is ≥ 14.5 dB.~~The transceiver MUST achieve a post-FEC bit-error-ratio (BER) of ≤ 10^{-15} when the received optical power is ≥ -10 dBm and link OSNR is ≥ 14.5 dB, which is referred to as the baseline received OSNR requirement.~~

The transceiver MAY report the received OSNR.

NOTE TO EC AUTHORS regarding TLV tables: To ensure consistency in our specs, please copy and use the appropriate table as shown below when inserting new TLV tables in ECs.

DO NOT change column widths as they have been set exactly for our requirements software.

TLV Type	Length	Units	Access	Value

TLV Type	Length	Access	Value

Type	Length	Value