MARS OBC Operations Guiide

This is the key engineering document for the MARS out-of-band control system (OBC) and the Timing Distribution System. Additional information can be found in the "MARS OBC Schematics and Board Layouts Docuement".

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Date: 06/03/04

MARS OBC Operations Guiide - Contents

Out of Band Control and Timing Principles of Operation

The pages which follow give an overview and technical details of the operational characteristics of the Out of Band Control and Timing System for NEPTUNE.

It is readily apparent that upon deploying any deep ocean technologies, a need arises for operating, monitoring and diagnosing the equipment under all circumstances, especially conditions which prevail during a malfunction in the apparatus. For MARS, while the in-band, high speed data transport system is fully adequate for normal operation, a simple and reliable secondary system is required to operate during aforementioned conditions which preclude the use of the in-band system. This system is referred to as the out-of-band control system (OBC). The requirements which would be desirable of such a system are listed below along with the appropriate solution.

Additionally a medium for relaying timing data to the science equipment was required. After some investigation it became apparent that there was duplication in the implementation infrastructure for the timing system design, and it was decided to merge the timing system with the out-of-band system to share various modules and physical transport media.

REQUIREMENTS

<u>Access to the major in-band data communications modules in the nodes, exclusive of their proper functioning.</u>

Use of simple secondary modules independent of the primary data equipment such as routers and optical switches.

<u>Access to the modules in the node via their most primitive access methods and protocols.</u>

Use of the serial RS232 ports of the in-band equipment as the access port.

<u>Employment of a minimal suite of very simple pieces of equipment for the out-of-band system.</u>

Use of hardwired circuit boards with the minimalist SAIL protocol for OBC communications.

Use of low speed data signals, pushing optical distance without use of amplifiers,

<u>Use when possible of a separate physical access medium for the system.</u>

Adding a second independent fiber pair for OBC which does not pass through the in-band passive optics.

<u>Low power consumption permitting operation on auxiliary power such as a battery during malfunction of the power system.</u>

Use of CMOS technology permitting a system which runs at a few milliwatts, coupled with non-carrier based protocol for operating the lasers insuring a minimal duty cycle consuming power.

Timing Principles of Operation

As mentioned the timing distribution system was merged with the out-of-band system. Timing required by the scientific instruments attached to each node is circumscribed by the following requirements:

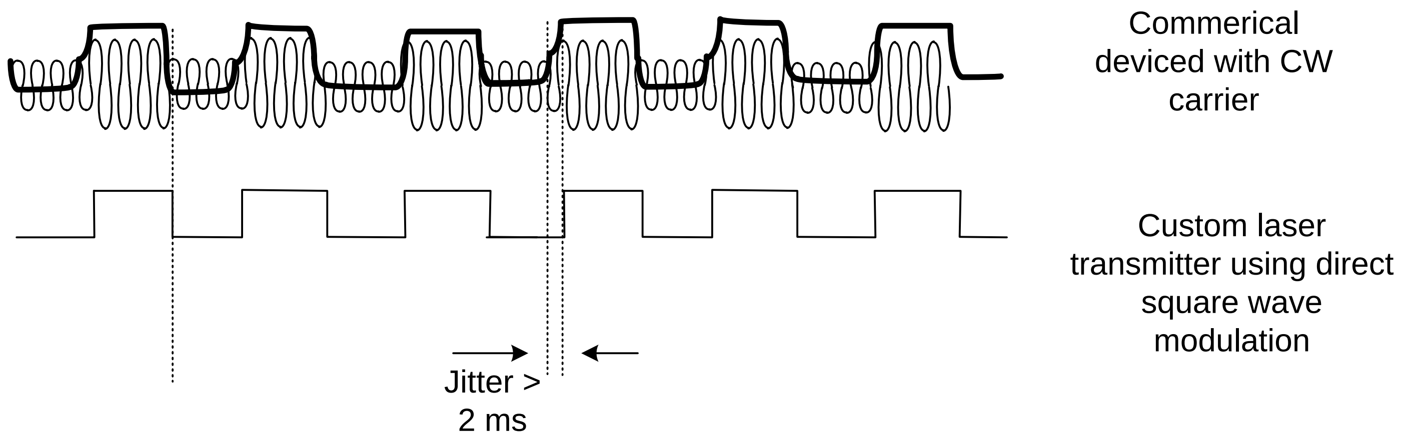
<u>A timing pulse of 1 pps shall be provided to a tier 1 NTP clock within the node</u>

A highly accurate pulse generator shall be provided in the OBC module and pass pulses to an in-node NTP server
The 1pps timing pulse shall also be ported to the science node wet connector

<u>Jitter measured at the node NTP server shall not exceed 2 micro-seconds</u>

A pulse provided from shore will be sent to each node clock to resynchronize it.
The physical transport of this pulse may not corrupt it by more than 2 micro-secs

In order to meet the stringent jitter requirement, a special low speed optical system was designed which employed the application of a direct square wave modulation to communications lasers. Use of commercial optical transceivers which employ a continuous wave carrier, were found to cause jitter. In addition, such commercial equipment maintains the carrier during the idle mode which consumes auxiliary power.



Out of Band Control and Timing Architecture

The out of band system consists of 2 fiber pairs entering the node, one from "east" and the other from "west". Each individual fiber can carry data or timing pulses in both directions allowing quadruple redundancy. Only one fiber is used at a time for communications. Fibers are desigated A-east A-west B-east and B-west.

OBC is initiated via an OBC Shore Manager Linux computer. Commands described later in this document connect the control screen of the OBC Shore Manager to a given node, and to the control port of a given device in the node. The operator determines the mode of the connection, in-band OBC or out-of-band OBC, and in the latter case, the fiber to use (A or B).

Upon completion of the connection a panel on the OBC Shore Manager allows the operator to enter commands to the node device as thought he/she was directly connected via and RS232-xterm session. Other commands terminate the session. More than one session my be operated at a time.

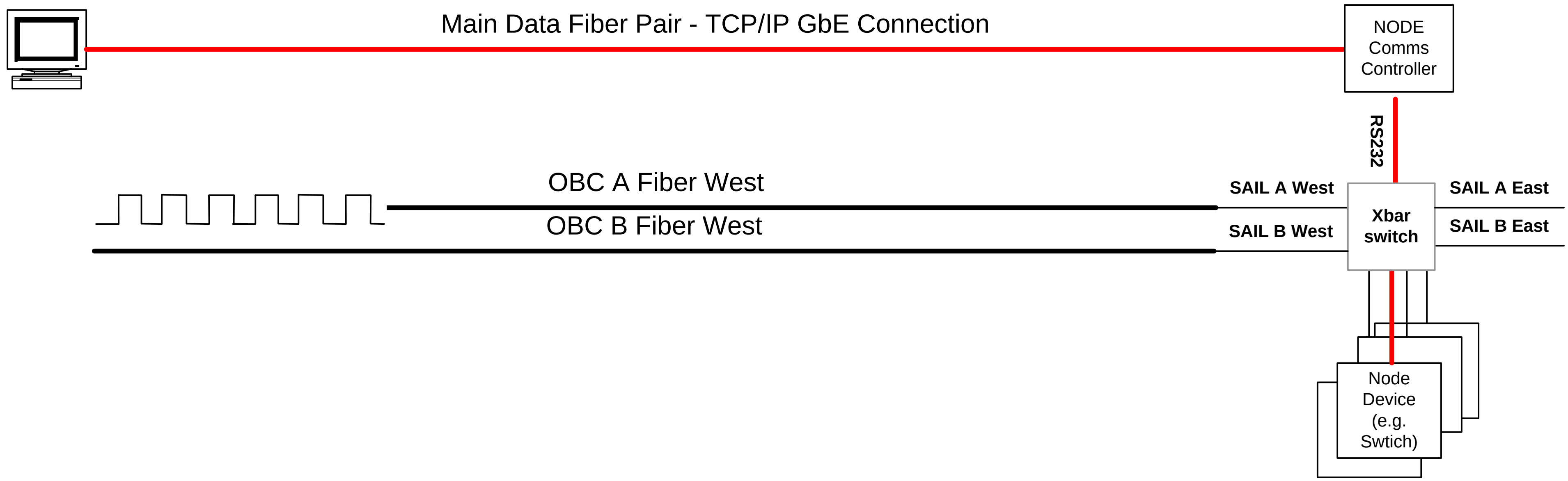
Included with the OBC system for practical reasons is the Timing Distribution system. The OBC Shore Manager is connected to a GPS clock. A device connected to the laser transmitters of the A and B fibers sends accurate 1pps pulses to all nodes

A note on In-band vs Out-of-band Control The use of the terms in-band out-of-band are as follows:

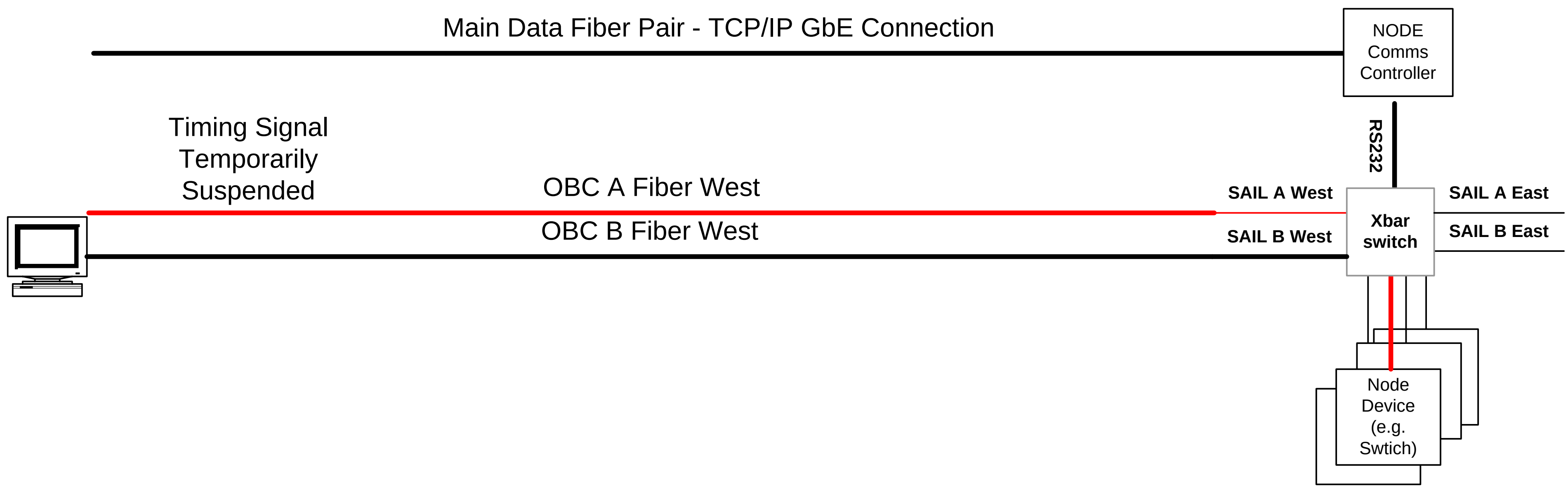
In-band out-of-band access is attained by connecting to the node resident Comms Controller PC via the ethernet data channel at the shore. The Comms Controller is instruected to connect via the crossbar switch to a given out-of-band port on a device such as the console port of a CISCO swtich.

Out-of-band out-of-band access is attained wihtout the Comms Controller PC . The shore control computer sends a command down the OBC fiber to the crossbar switch in the node asking it to connect the OBC channel to a given out-of-band port on a device such as the console port of a CISCO swtich. CISCO commands are then communicated from the shore control PC to the CISCO switch in the node.

In-Band out-of-band communications to node device



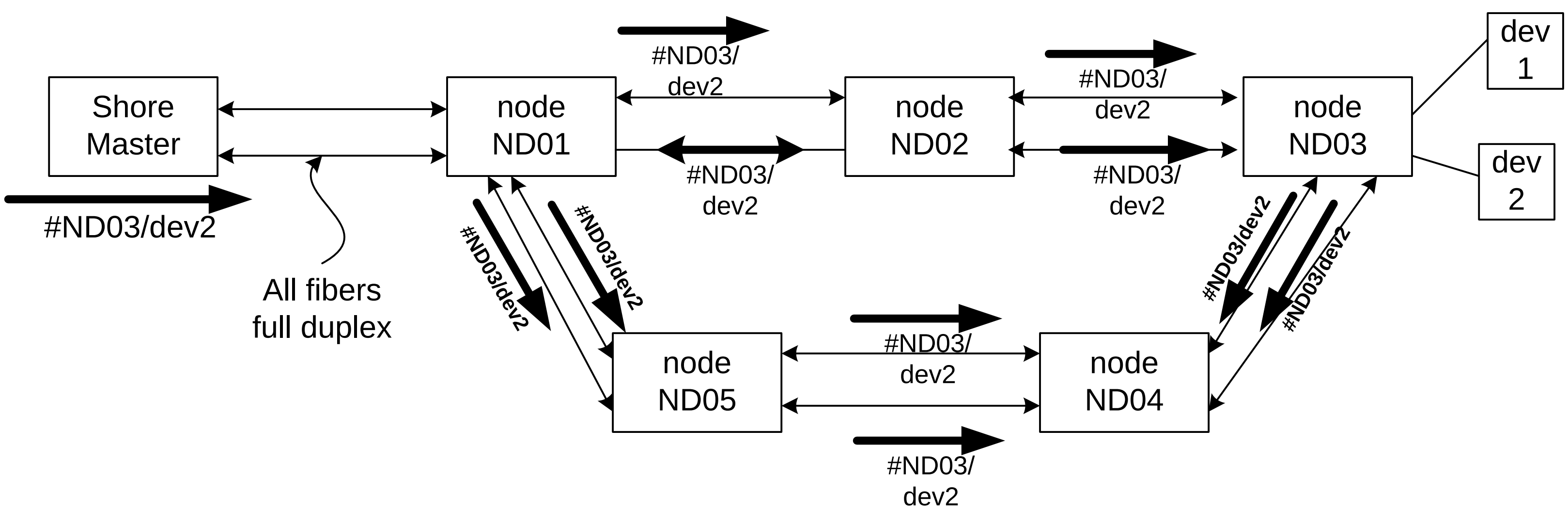
Out-of-band out-of-band communications to node device



Out of Band Control and Timing Architecture

Shown below is the high level architecture for the out-of-band/timing system.

- 1 fiber pair east and 1 fiber pair west carries the out-of-band data and time sync signals concurrently on each fiber. Each fiber is an independent half-duplex carrier, thus the system is quadruple redundant. An additional 'North' fiber pair is added in the case of branching nodes (not used in NEPTUNE)
- The system is a master/slave type communications system. The master, placed on shore, solicits data streams from the slaves placed in the nodes. The nodes cannot initiate communications.They hold their data in a buffer until solicited.
- The master terminal sends a node address prior to entering lines of data. (e.g. #ND01 addresses node 1).
- When the master transmits, the data is sent to the adjacent node(s). It is in turn relayed to the next adjacent nodes. This process continues until the data has reached all the nodes. "ring around' does not occur as will be discussed
- Each node listens' for it's address, which is embedded on a microprocessor containing the SAIL protocol
- Only the addressed node will respond. When it does, the process above is reversed and the response is relayed back upon solicitation from the shore.
- A 'steering module' on each node prevents it from transmitting when it is in the process of relaying data. If any data arrives at a node in the process of relaying data from another node, it ignores the received data unless it is coming in on the fiber for which it is relaying data.
- When a node receives data containing it's address, the frame is further broken down. A sub address contains the device within the node, such as a router, for which the data is destined.
- A cross-bar switch interprets the above address, and connects the received data stream from the SAIL module to the designated equipment.
- The shore station will also send out periodic (15min) timing sync updates which are processed by ALL nodes.



OBC Node Module Components

Optical Fibers - Four optical fibers enter the node for OCB (6 for a branching node). Each fiber carries an identical half duplex two-way conversation between the node and the shore master station. This allows for quadruple redundancy (sextuple for a branching node).

Opto-Electronic Module - In transmit mode the Opto Electronic Module is responsible for accepting a serial digital electrical signal, converting it to an optical signal and then duplexing it to an optical fiber. In receive mode the module accepts a duplex optical signal, and converts it to a serial digital signal. The module contains 1550nm fabry perot lasers and photo diodes. Duplexing is accomplished using an optical circulator. Speeds is at 9600 baud.

Steering Module - The Steering Module receives traffic on one half-duplex fiber and relays it out the other fibers. During the relay period the reception of traffic on the transmitting fibers is ignored.

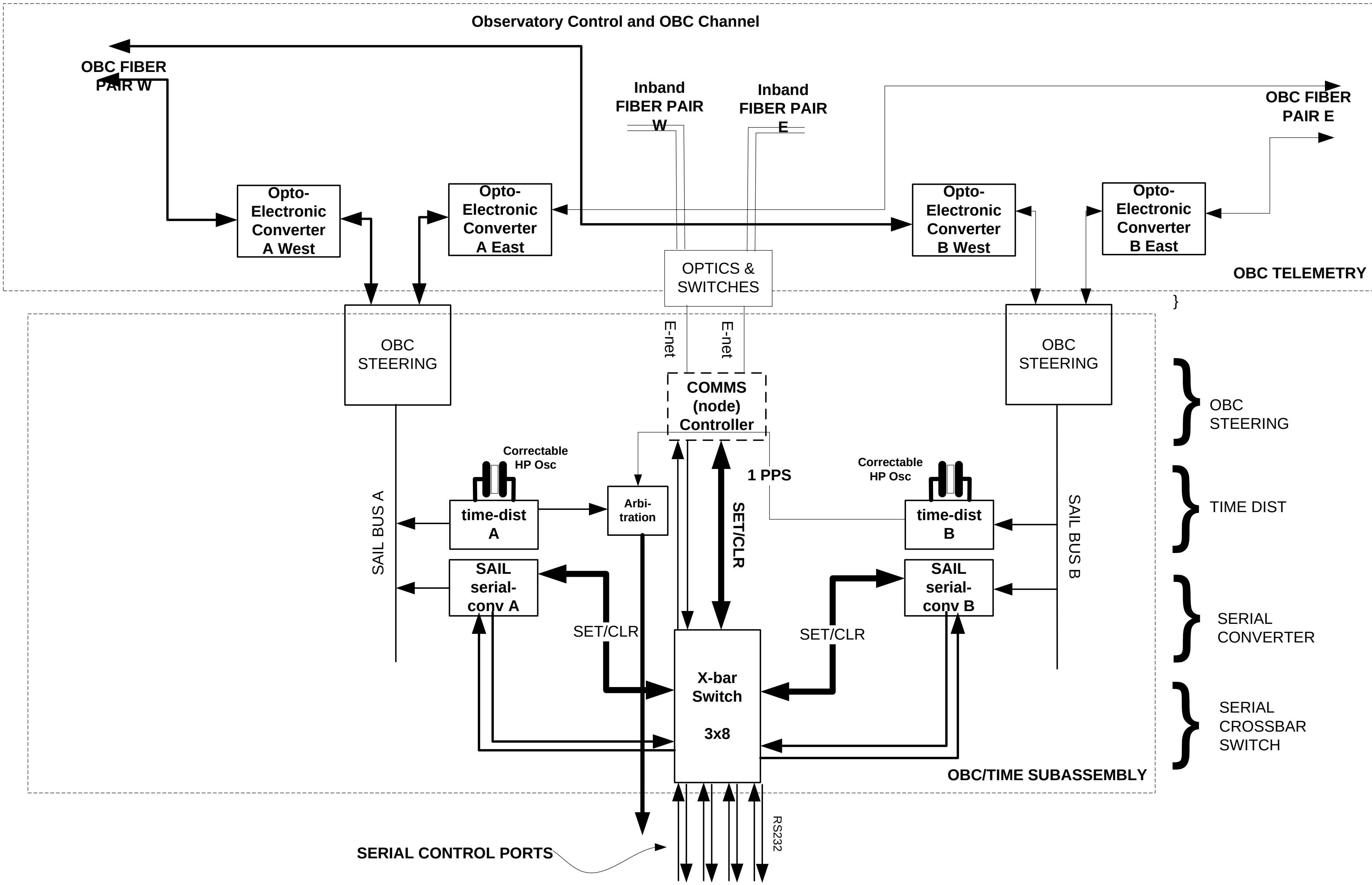
SAIL Serial Conversion Module - The SAIL module contains the communications logic accepting a digital bitstream from the Steering module and converting it to RS232. Each SAIL microprocessor has a programmable address. When data arrives to the node from the optical OBC network, the SAIL module will ignore communications which do not contain it’s address. If the module detects it’s address it analyzes the incoming frame for a device address, which points to the RS232 port for the node device that is to be communicated with (e.g. a router, EDFA, PC). This device address is passed to the CrossOver switch, and after a connection is established the SAIL module passes the data to the device over RS232.

CrossOver Switch Module - When data is directed to a particular node and device from the shore master, the CrossOver switch connects that devices RS232 port to the SAIL controller where it receives the data from the shore. The CrossOver switch consists of a matrix of electro-mechanical latching relays, which consume no power during the idle state.

Time Distribution Module - The time distribution module is responsible for maintaining a 1pps signal to the science equipment within a jitter tolerance of 1 micro-second. It also updates an NTP clock to a tolerance of 1ms. A crystal in the module provides the basic clock. Periodically updates are received from the shore station to sync the clock with all others. Logic in the time module accounts for transport delay when applying updates.

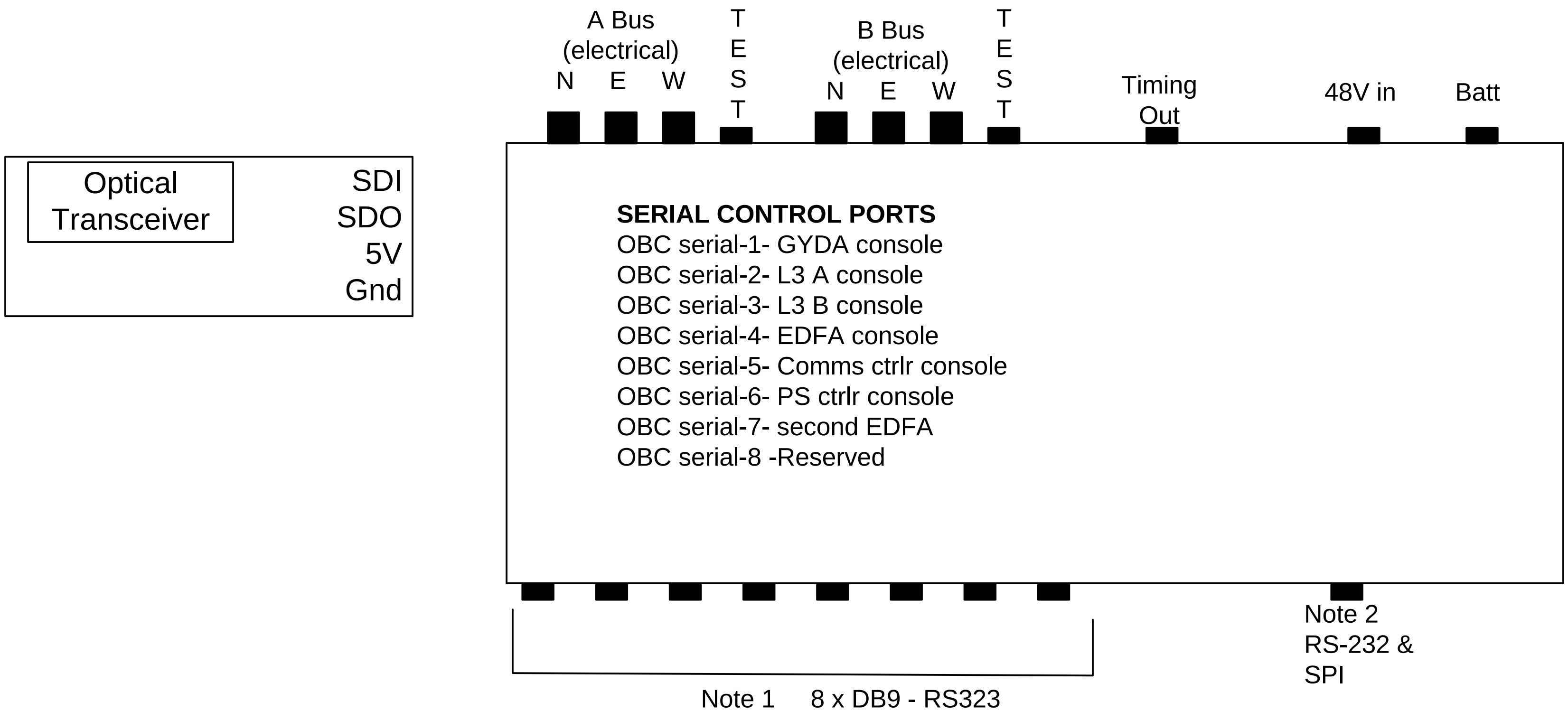
OBC Architecture - Schematic for one node showing east and west

The internals of the node OBC module which mounts in a 5x15x15cm box. The optical laser communicators with their square wave modulators, the steering modules, the SAIL processors and the X-bar switch are all present. Also the timing clocks are shown.



OBC Architecture - Physical Diagram for One Node

OBC module mounts in a 6"x 6" x12" box



Internal Board Inventory

Node Steering
Node Steering-RS232
8x3 X-connect
ISO power
Clock Board & Serial Board

NOTES

1-SGnd,Rx,Tx no-HW flow control
2-SGnd,TX,RX(serial),CD,DTR,RTS(SPI)
3-Available internally and not shown are 2 A/D input channels and 3 digital output channels from each clock

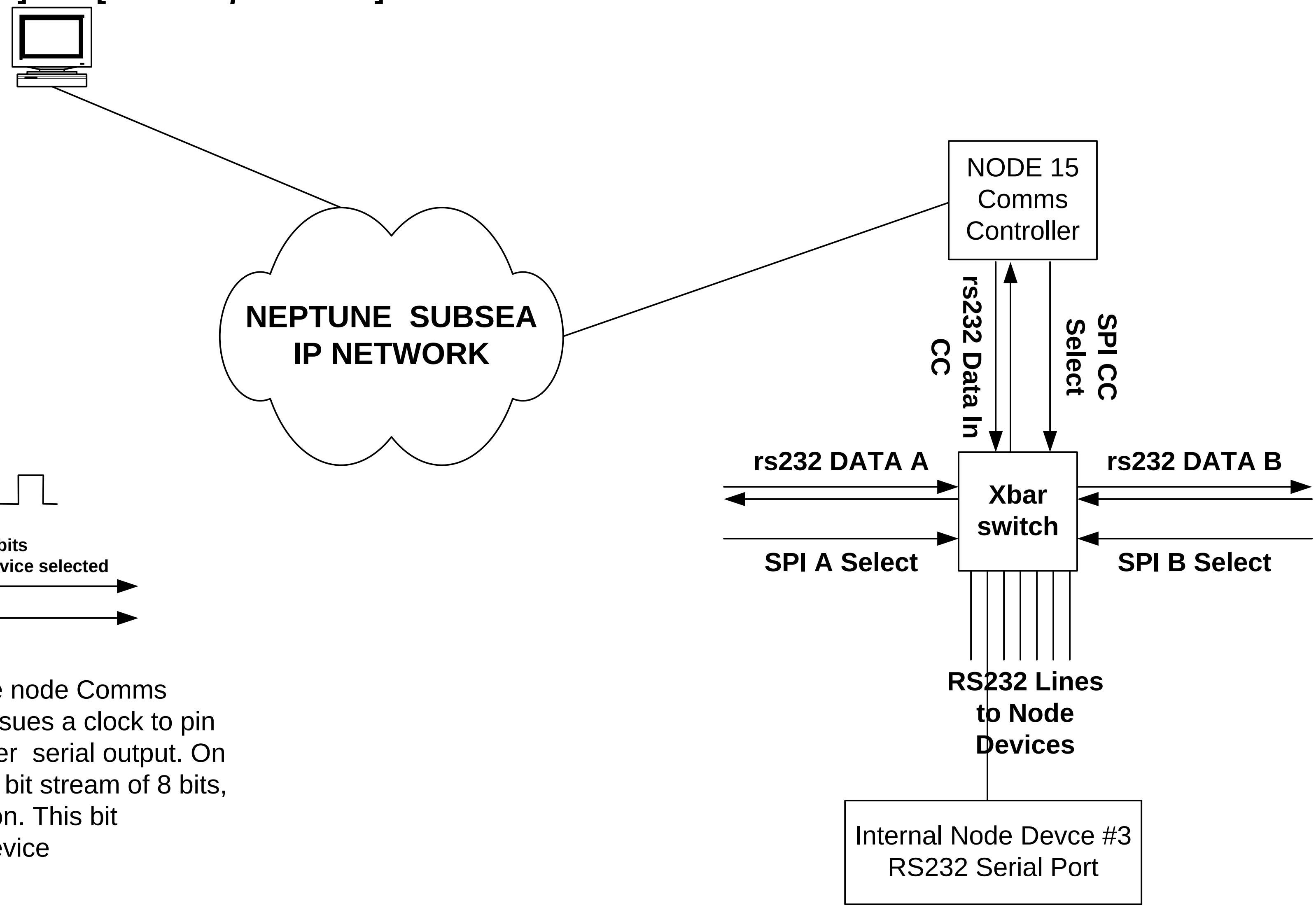
Operations Commands and Procedures for Shore Master

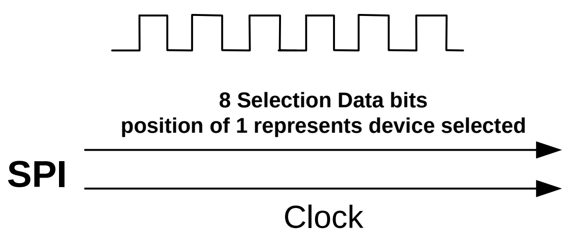
Steve Lerner Will Complete

In Band Selection of Node Devices for Serial Communications

command:

SET TYPE [*inband*] (set to inband comm)
TALK NODE *15* *(set the node IP to talk to)*
MAP [*CC RS232 Data*] TO [*Xbar output Port 3*]

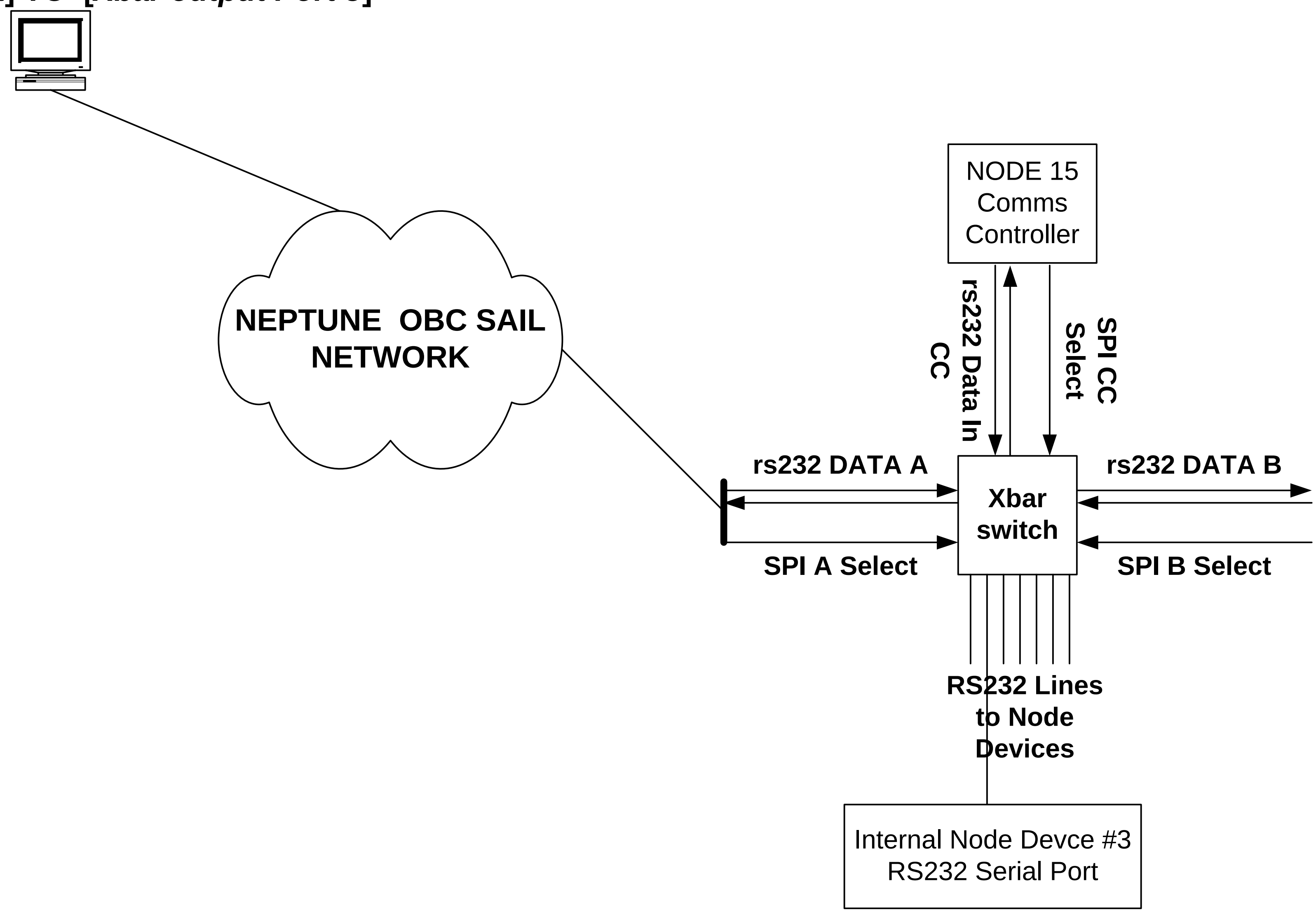




SPI interface logic is in the node Comms Controller. The program issues a clock to pin DTR of a Comms Controller serial output. On pin RTS it serially sends a bit stream of 8 bits, only one bit being turned on. This bit represents the selected device

Out of Band Selection of Node Devices for Serial Communications

command:
SET TYPE [*outband*] (set to outband comm)
TALK NODE *15* *(set for node)*
MAP [A *RS232 Data*] TO [*Xbar output Port 3*]



<u>OBC STEERING OVERVIEW</u> (See Block Diagram Next Page)

The steering boards are responsible for controlling the introduction of data on the transmission lines in an orderly fashion, insuring that no more than one line is active at a time. There are two OBC steering boards per node, one for the A network, and one for the redunant B network. Each steering board has three or four data lines designated A thru D, the latter extra line being used in a branching node. Two of the data lines, A and B, (and D for the branching node) are used to communicate to the shore from east and west (and north for the branching node). The remaining data line, C is the SAIL bus and communicates with the SAIL module, which in turns communicates to equipment in the node via RS232.

The four objectives of the steering board are to:

- Receive signals on one line, and retransmit it out the other three.
- Insure that no tranmission is allowed when other sections within the board are transmitting.
- Insure that no section can monoploize the line due to hardware or software malfunction
- Insure that a wait time occurs after a transmission to allow for propogation delays.

The block diagram on the next page represents the functionality of the steering board. The board is consituted of 4 sections, A-D, one for each line. A fifth "not-idle" section is on the board as well. Assume that one of the lines, say A, needs to transmit.

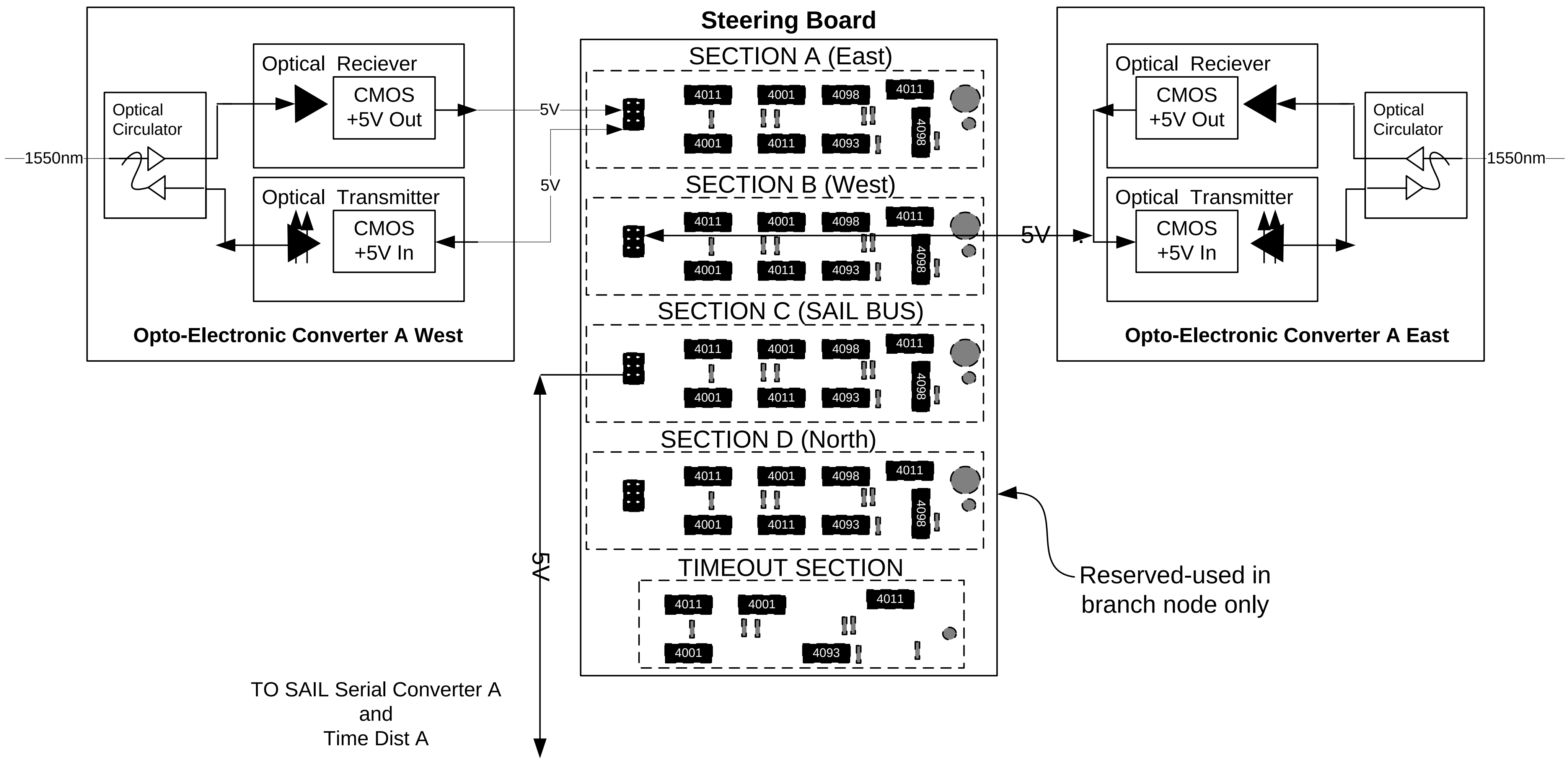
- A begins transmission, e.g. serialized bits are introduced at the input. Ain.
- This bitstream passes through a "transmit overrun timer" and then to the "transmit overide logic". The "transmit overrun timer"block will be described below.
- The bitstream is passed to the "has the floor" flip-flop as well.
- If the "has the floor" flip-flop is already set by the not-idle input or by sections B-D which could be already transmitting (Bhtf is true for example) then the "transmit overide logic" blocks the A transmission. However if all lines are quiet, the input to the "has the floor" flip-flop from A is accepted and the flip-flop sets Ahtf true.
- A is output at this point to Aout. This signal is coupled into the "transmit" blocks of sections B-D. Thus the signal received at A is transmitted out of all other ports.
- The Aout is also coupled to the input of the "not-idle holdown". It is the job of the "not-idle holdown" to lock all of the A-D section "has the floor" flip-flops to prevent other sections from transmitting at this time. The input at A is a toggling bitstream, however an RC circuit on the "not-idle holdown" smooths the toggling into a continuous low voltage. In addition, the RC circuit is designed to overrun the transmission by a A for a period of time so that the line is not relinquised immediately. This gives some spacing between transmission of the various sections. Note that due to propagation delays, this timer is necassary to prevent collisions with other nodes.
- The "transmit overrun timer" which is in front of the Ain input, is a monostable vibrator that begins to clock (via and RC circuit) on the leading edge of A's transmission. After some amount of time it sets and blocks any further transmission from A, the purpose being to prevent a "stuck mike" condition where A continuously holds the line due to hardware problems.

OPTO-ELECTRONICS AND STEERING MODULE Detail (A Side Shown Only)

The Steering module regulates data flow in and out of the node, insuring that only 1 section transmits at a time. Data enters from a line into that line's section and is then relayed out via all the remaining sections. During this process the receive is blocked on the remaining sections preventing them from attempting to relay data.

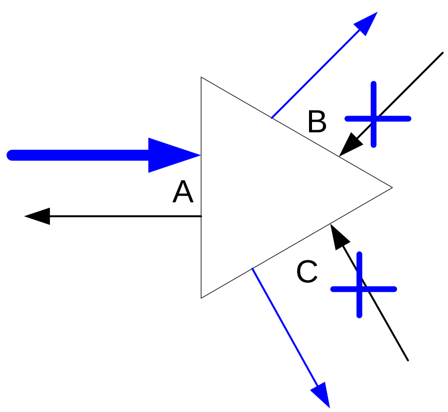
When section A is transmitting it sends out ports B-D. Meanwhile B-D cannot receive and relay other transmissions during this time. A Timeout circuit prevents monopolization by A.

The Opto-electronic converters transform a half duplex optical signal on a single fiber into a 9600 baudot square-wave at CMOS levels

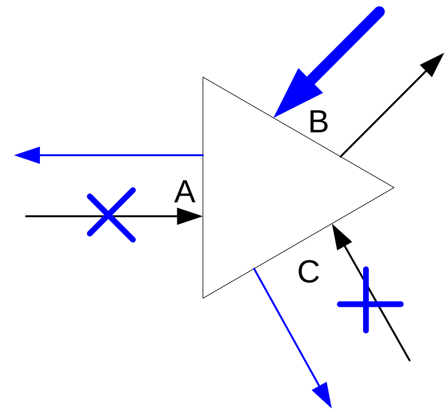


STEERING MODULE PATH DIAGRAM

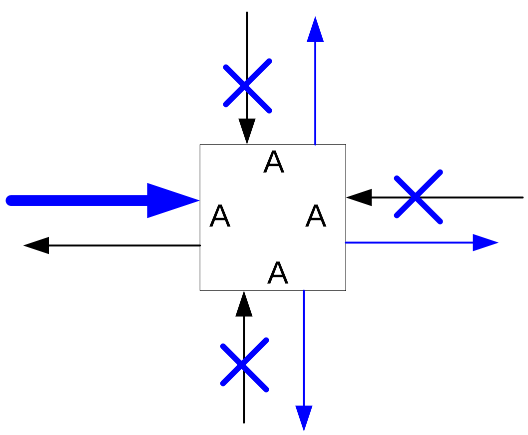
The diagrams below show a simple way of thinking of the steering boards in a network. Data is received on one branch and relayed through to the other branches. During that time the receivers on the other branches are blocked to prevent them from relaying information back through the transmitting branch.



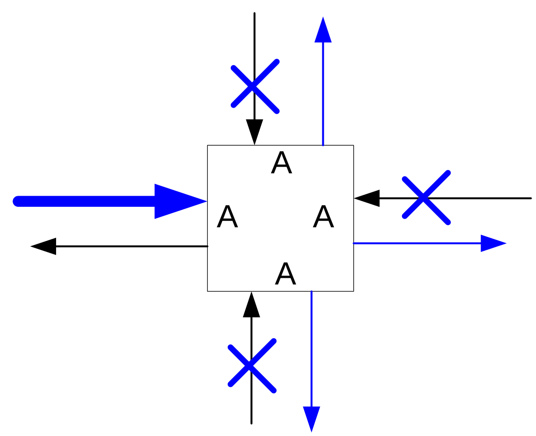
A relays in 3 way node



B relays in 3 way node



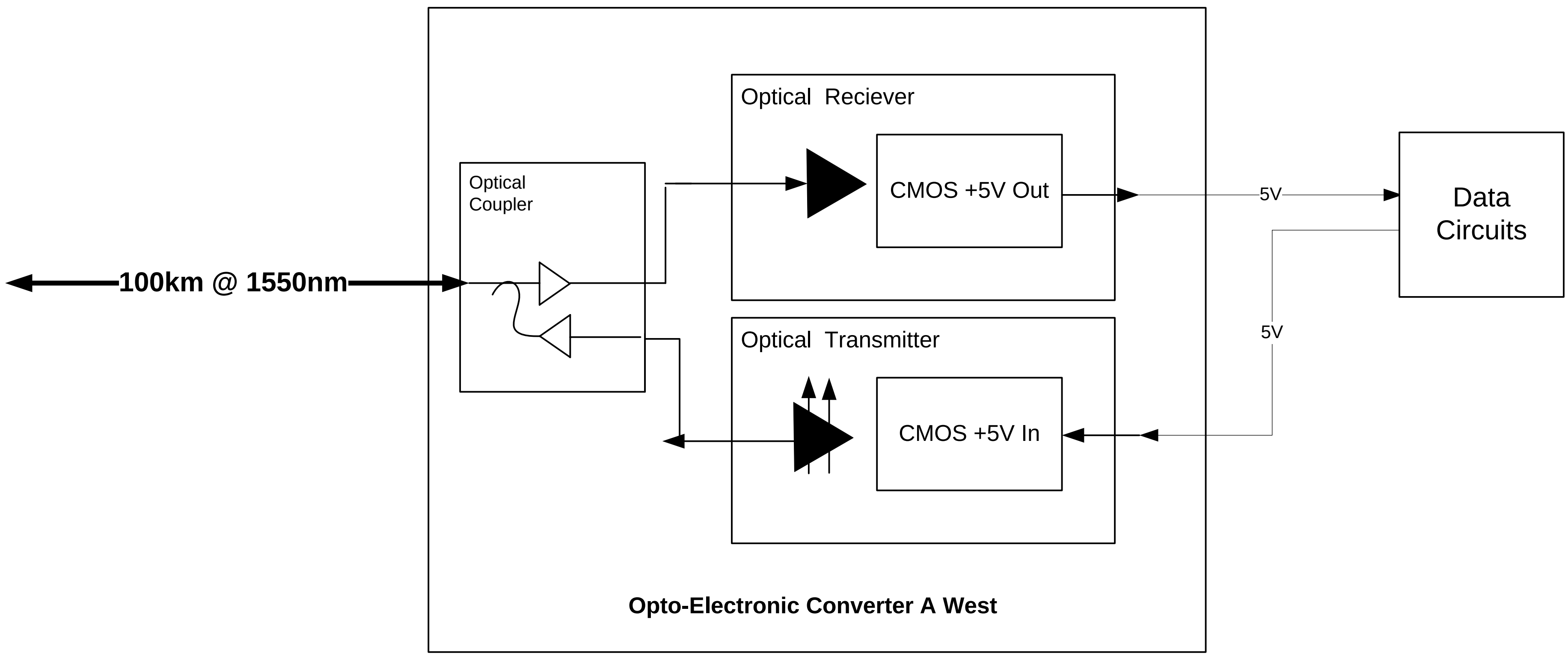
A relays in 4 way node



B relays in 4 way node

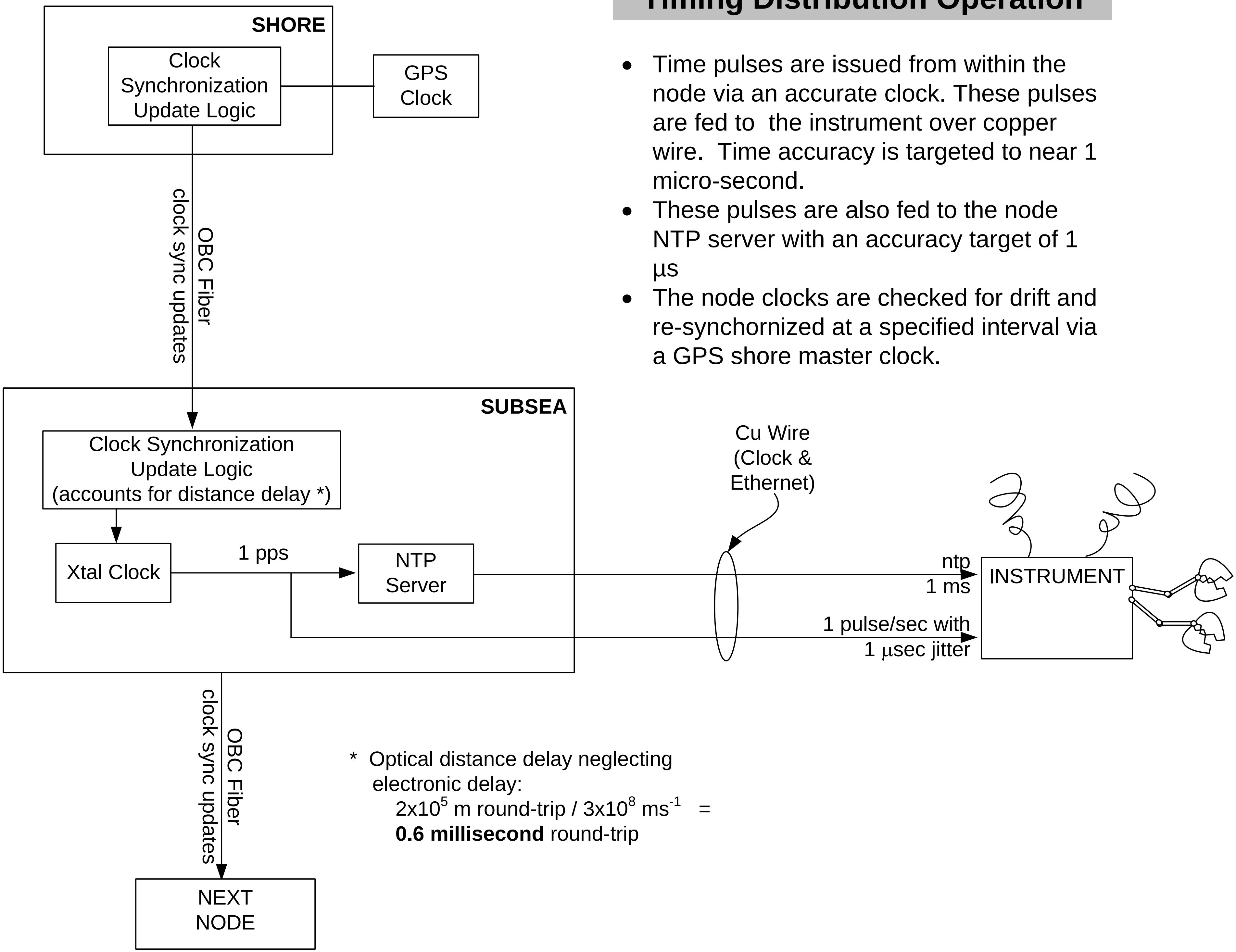
OPTO-ELECTRONICS Detail

The Opto-electronic converters transform a half duplex optical signal on a single fiber into a 9600 baudot square-wave at CMOS levels



Timing Distribution Operation

- Time pulses are issued from within the node via an accurate clock. These pulses are fed to the instrument over copper wire. Time accuracy is targeted to near 1 micro-second.
- These pulses are also fed to the node NTP server with an accuracy target of 1 µs
- The node clocks are checked for drift and re-synchornized at a specified interval via a GPS shore master clock.



* Optical distance delay neglecting electronic delay:

$2x10^5$ m round-trip / $3x10^8$ ms^{-1} =

0.6 millisecond round-trip

High Precision Time Ideas-Extending

- Output is 1 pps TTL
- Node to convert to optical
- Can use coupler
- Must propagate to 100m
- Clock must be optically isolated or equivalent

NTP Time

- Sourced by stratum 0 GPS on shore servers
- Distributed via stratum 1 or greater on CISCO switches