LIBERA Sync 3

Low-Jitter Continuous Wave
Reference Clock Transfer System

User Manual

Written by Dejan Tinta | January, 2021

Approved by Marko Vučković

Version 1.23

Release Libera Sync 3

Assistance

You can rely on our Technical support. Our core team consists of skilled engineers with full knowledge of the systems. We will help you with hardware, software, or system integration issues throughout the product's life cycle.

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Table of contents

Index of figures

Index of tables

1. Introduction

1.1 Capabilities and features overview

Libera Sync 3 is an extremely low drift and low phase noise continuous wave (CW) optical link used for transmission of 3GHz RF reference signal over long distance in the kilometre range. The system consists of a Transmitter (Tx) and a Receiver (Rx) units that are connected with two single mode fibers (SMF). Additional Ethernet connection between the units is needed for data exchange and control purposes.

Libera Sync 3 is meant to be used as an extremely low drift and low phase noise RF transmission link in FEL machines where long-term phase drift is in the range of 40fs/day peak to peak and added phase noise is below 7 fs in the range from 10Hz to 10MHz. The system is capable to compensate approximately 500 ps of optical link's phase drift. The latter depends on the environmental conditions that the optical cable is exposed to (temperature and moisture changes in the installation tunnel) and on the optical cable properties (optical fiber properties, cabling type, etc.).

Libera Sync 3 is completely self-tuning system. After proper installation of the optical and Ethernet link between the Tx and Rx units, defining the optical link length (OLL) and connecting sufficient RF input signal to the Tx unit it is capable to establish the phase compensated optical link on its own. Tuning procedure identifies best working points for the optical components and locks all internal control loops. It takes approximately 2 hours for all internal modules to thermally stabilize to the m°C temperature range and approximately one day for all the optical components to settle down. After one week of operation in stable environment all tensions in the RF cabling are relaxed and the Libera Sync 3 can provide long term stability according to specifications.

Libera Sync 3 has embedded microcontroller with LCD, keys and rotary knob for local parameter monitoring and system control and Ethernet port for remote supervision and control. Remote control is based on SCPI interface. USB port is intended for service use only. Additional micro SD card can be used for data logging.

Libera Sync 3 is built on proven technology and with extensive experience and knowledge in optical, PCB and mechanical design, temperature control and programming.

1.2 List of supplied items

The package contains the following items:

- Libera Sync 3 Transmitter
- Libera Sync 3 Receiver
- 2x External sensor with connection cable
- 2x Power cord (2 m)
- 2x Ethernet cable RJ45, 3 m
- 3x SMA 50 Ohm termination
- Micro SD card
- Mounting screws set (screws, plastic washers, nuts)
- Warranty and Test record
- CD with user documentation

1.3   How to use this document

This document is a step-by-step guide that familiarizes the user with Instrumentation Technologies' product Libera Sync 3. It helps the user to begin working with Libera Sync 3 quickly and effectively and to exploit all the possibilities it offers.

Chapter 2 describes how to connect, configure and start Libera Sync 3 for the first time. For proper installation refer to the system specifications and rest of the user manual.

Chapter 3 represents Libera Sync 3 physical and software architecture.

Chapter 4 defines Libera Sync 3 interfaces and features. Ethernet port with SCPI interface is used for remote supervision and control.

Chapter 5 represents installation of the system and basic maintenance procedures.

1.4   Abbreviations

Table 1: Abbreviations

Abbreviation	Description
CSV	Comma separated value
CW	Continuous wave
DFB	Distributed Feedback Laser
DHCP	Dynamic Host Configuration Protocol
IP	Internet Protocol address
MAC	Media Access Control address
MZM	Mach-Zehnder modulator
LCD	Liquid-crystal Display
PC	Personal Computer
PMD	Polarisation Mode Dispersion
RF	Radio Frequency
RMO	Reference Master Oscillator
SCPI	Standard Commands for Programmable Instruments
SMF	Single Mode Fiber
USB	Universal Serial Bus
VGA	Voltage Gain Amplifier
VOA	Variable Optical Attenuator
TCD	Temperature Coefficient of Delay

1.5   Safety symbols and terms

The ⚠ symbol on the instrument indicates that the user should refer to the operating instructions located in the manual.

The **WARNING** heading used in this manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading used in this manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

The **NOTE** heading used in this manual gives important explanations on the usage to avoid misunderstandings.

If the device is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

1.6   Warranty information

The manufacturer guarantees its customers that the products it supplies are free from defects in materials and workmanship for a period of 1 year.

This warranty shall not apply to any defect, failure or damage caused by improper use or inadequate maintenance and care. Instrumentation Technologies shall not be obliged to provide service under this warranty to repair damage resulting from maintenance by personnel other than Instrumentation Technologies representatives.

This warranty is limited to the repair and, if necessary, the replacement of the instrument based solely on the decision of Instrumentation Technologies. Each instrument is subjected to a quality test. Any early failures are detected by this method.

2. Starting Libera Sync 3 for the first time

Libera Sync 3 is very easy to use system. Once it is properly connected and configured (see Figure 1) it will phase lock the optical link on its own. There is no need for manual tuning of the system. If environmental conditions and installation cabling do not change with time there is no need for additional tuning of the system. System is equipped with rich diagnostics in case that something goes wrong (see Chapter 4.5 for statuses description and Chapter 4.5.1 for error messages description). In case of any error message red LED diode (ERROR) on the front panel is turned on (see Figure 6 for LED diodes position).
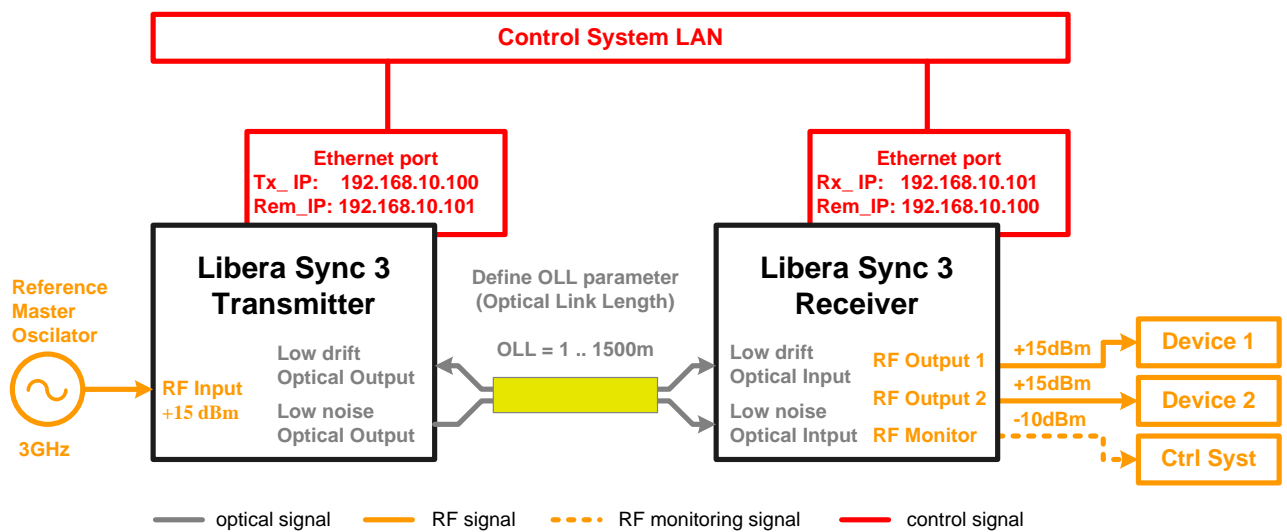
Figure 1: Connecting Libera Sync 3 for the first time.

2.1   Ethernet configuration

At first start of Tx/Rx unit the Ethernet port has to be configured. Select STATIC or DHCP mode of operation in the CONF/ETH/MODE menu page manually with the help of keys and rotary knob and restart or reset the unit to activate new mode of operation. See Chapter 4.3 to learn how to set parameters manually. In STATIC mode define Ethernet IP and MASK and restart/reset the unit again to implement the changes or simply use DHCP mode to enable DHCP server to assign these parameters to the unit. See Chapter 4.1 for more details about Ethernet port configuration.

> **NOTE: Restart or reset the unit to implement Ethernet settings. This procedure is needed after selecting operational mode as well.**

Fill the remote IP address in TX unit with the IP address of the Rx unit and vice versa. This can be done in CONF/ETH/REM_IP menu page or remotely as it is described in the example below. This action establishes Ethernet connection between the units and couples these two units in one Libera Sync 3 system.

NOTE: Always power on RX unit with attached Ethernet cable first, wait for a valid IP address and then power on the TX unit.

```
Example: define remote IP address in the unit
First establish telnet connection to the unit (Chapter 4.1)
ETH:REM_IP 010.000.001.100
Response
ETH:REM_IP 010.000.001.100
OK
```

2.2   RF connection

Provide +15 dBm 3 GHz RF signal to the RF Input SMA connector on the front panel of the Tx unit (see Chapter 5.4 for more details). Transferred RF signal is provided on RF Output 1 and RF Output 2 SMA connectors on the front panel of the Rx unit. RF Monitor output can be used for monitoring purposes. Terminate all unused RF outputs with 50 Ohm SMA terminations. For proper RF cabling please refer to the Chapter 5.4.1.

CAUTION: Maximum input signal power for Libera Sync 3 reference clock input is +20dBm. Please do not exceed this power since it may result in severe damage of the units.

2.3   Optics connection

Connect Tx and Rx units with two SMF optical fibers that are cabled together. Optical fibers have to be equipped with SC/APC connectors (Figure 2). Connect Low drift optical output on Tx unit with Low drift optical input on Rx unit with first fiber and Low noise Output/Input with second fiber.
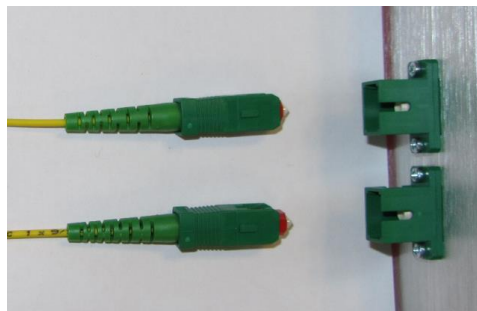
Figure 2: SC/APC optical connectors

> **CAUTION: Use recommended type of optical fibers and cabling to prevent excessive phase drift in the optical link. For more details check recommendations in Chapter 5.3.**

Fill the OLL (Optical Link Length) parameter in CONF/OLL menu page on Tx unit with the actual optical link length in meters or simply remotely set parameter as it is shown in the example below.

```
Example: define optical link length to 500 m
CFG:OLL 500
Response
CFG:OLL 0500 m
OK
Example:Check actual OLL parameter value
CFG:OLL?
Response
CFG:OLL 0500 m
OK
```

2.4   Connect environmental sensors

Each unit is equipped with external environmental sensor (Figure 3) that is used for humidity, temperature and pressure measurements in the rack or in the room, where the unit is installed. These sensors have to be attached to Tx and Rx units otherwise start-up procedure detects missing sensor and error is reported. Only the enclosed external sensors and connection cables may be used.
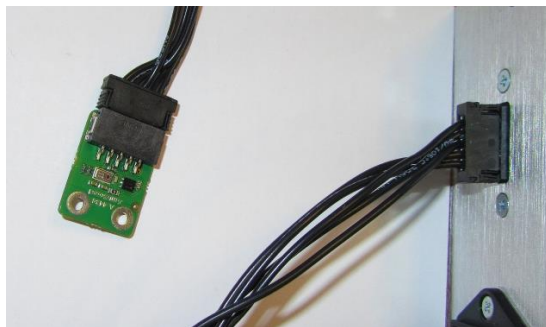
Figure 3: Connect environmental sensors at Tx and Rx back panel

2.5   Start-up and tuning procedure

In case of any error message red LED diode on the front panel is turned on. Chapter 4.5.1 describes system error messages in detail. If there is a problem with internal sensors error message is generated and system operates normally. In case of any failure in tuning procedure system hangs in state Tuning and one of its sub-states from 50 to 53. This enables user to check system parameters and helps to detect the cause of

tuning failure. Sub-states are described in Table 5. There are other error messages that are generated if input RF power is out of range, Ethernet connection between the units is not established for more than predefined amount of time, optical link is broken, external environmental sensor is not attached, etc. Such errors cause system shutdown. Find the solution for each error and start/restart the system. If the system is in state Shutdown then it can be started with CONF/RQS/STA selection in configuration menu page or remotely using command CFG:RQS STA. By restarting or resetting the Tx and Rx units all error messages are cleared and system start is enabled.

```
Example 1: start the unit that is in SHD state
CFG:RQS STA
Example 2: software reset of the unit
CFG:RST 1234
```

Wait until the green LED diode on the front panel of Tx and Rx units is turned on. This signalizes that optical link is operational and phase locked. It takes approximately 2 to 3 hours for the system to lock. This time depends on thermal conditions inside and outside of the units.

NOTE: System configuration is performed on the Tx unit only. However some parameter settings, that are unit dependent, like the Ethernet configuration, fans revolution setpoint and software reset of the unit, can also be set on the Rx unit.

3. Libera Sync 3 description

3.1   System description

As it was presented in Chapter 2 Libera Sync 3 consists of a Tx and a Rx units that are connected with two optical links and additional Ethernet connection (Figure 4). To achieve extremely low phase-noise performance of the system the RF signal is transferred through the unidirectional optical link. Low noise link is additionally stabilized against phase drifts with the bidirectional phase compensated optical link (Low drift link).
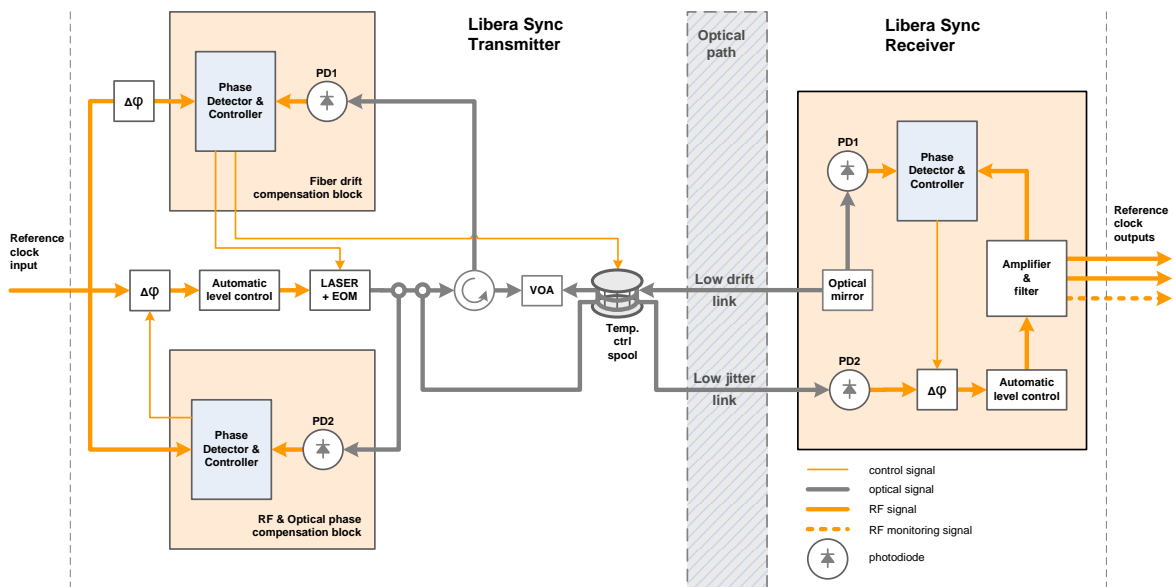
Figure 4: Libera Sync 3 block diagram

3.2   TX operation description

In Tx unit two phase compensation loops are present. The first one named RF & Optical phase compensation block locks the phase of the modulated optical signal to the input reference signal. The second one named Fiber drift compensation block locks the phase of the returned optical signal from the low drift link to the input reference signal. In modern SMF fibers with low PMD (Polarization Mode Dispersion) coefficient the propagating optical signal sees the same optical path as the reflected one. For that reason the optical signal in the Rx unit is also phase locked to the input reference signal.

A 1550 nm optical carrier is generated in the DFB (Distributed Feedback) laser and it is lead into the Electro-Optical Modulator (EOM) where it is modulated with the RF reference signal from an external master oscillator. Mach-Zehnder modulator (MZM) is used for EOM. Part of the modulated optical signal is lead from the optical coupler into RF & Optical compensation block where it is demodulated at the photodiode PD2 and used for phase and amplitude stabilization of the demodulated RF signal. Additional controller is used for optical power stabilization at that point of the optical path. Stable optical power reduces AM to PM conversion at photodiodes.

Part of the modulated optical signal from the second optical coupler is further lead into the low-noise optical link and the rest of the optical signal is used in the bidirectional low drift optical link. Bidirectional link consists of an optical circulator, variable optical attenuator (VOA) and thermally controlled optical spool in the Tx unit and of an optical circular mirror with additional optical coupler in the Rx unit.

To compensate phase drifts in the bidirectional optical link, the returned optical signal from the optical circulator is lead into the photodiode PD1 in the Fiber drift compensation block. The demodulated signal is then compared against the RF reference signal. Laser wavelength variations in combination with the transfer fiber's inherent chromatic dispersion (RF signal group delay) are used for link phase drift compensation. Slow phase drifts in the optical path are compensated by changing the fiber spool temperature.

3.3   RX operation description

In the Rx unit a fraction of the incoming optical signal from the low-drift link is decoupled, demodulated at the photodiode PD1 and used as a reference RF signal in phase controller. The optical signal from the low-noise link is demodulated at the photodiode PD2, additionally amplified and cleaned in the high Q dielectric resonator. At the output of the dielectric resonator the RF signal is amplified again and split into four paths, two for the users, one for phase corrections and one for amplitude stabilization and monitoring output. Phase controller locks the output RF signal to the reference RF signal that comes out of the low drift link. Additional controller is used for amplitude stabilization of the output RF signal.

3.4   Embedded state machine

Libera Sync 3 control system comprises state machine for proper initialisation, tuning and reliable operation of the system. State machine consists of 6 states and its structure is depicted in Figure 5.

State machine always starts in state Init where initialisation of the system is done. All temperature controllers are enabled at this point while all phase controllers are disabled.

In state Start up power supplies voltages, Ethernet connection between Tx and Rx units and environmental conditions are checked. All the units are equipped with external humidity, pressure and temperature sensors. Environmental conditions that are needed for proper operation of the Libera Sync 3 system are defined in System specifications.

After thermal stabilization of all internal modules (state Warming up) state Tuning is entered. This state consists of 30 sub-states that are specified in more detail in Table 5.

Basic tasks that are performed in these sub-states are: starting laser, identification of MZM and VOA best working points, checking if optical power levels are sufficient, stabilizing optical powers at different photodiodes and closing phase and amplitude control loops for optical and RF signals in Tx and Rx units.

When all phase control loops are closed and RF output power P_RFOUT at Rx unit is stabilized system enters state Ready with two basic sub-states Locked and Unlocked. Sub-state Locked consists of two additional sub-states. In sub-state Locked - Green LED On all phase loops are locked and some other actuators are in their nominal working regions (laser and fiber spool temperatures in Tx module, RF phase shifters, RF attenuators, MZM bias voltage, VOA voltage). This state can be visualized as lighted green LED diode on the front panel of Tx and Rx units (LOCKED) and LOCKD caption on the LCD display (Lock notification parameter in Table 5).

LIBERA SYNC 3 STATE MACHINE

INIT
Load initial parameters

Restart
Reset

STARTUP
PWR = OK
Eth conn Tx - Rx = OK
Environment = OK

CFG:RQS STA

WARMING UP
Module temperatures = OK

TUNING
Optics = OK
RF = OK
Phs_Ctrl = OK

SHUTDOWN
Optics = OFF
Phase Ctrl = OFF
Load initial parameters

Reset all Error messages

DEVICE STATUSES

E – Ethernet rconnection TX- RX NOK
V – PWR supply voltages NOK
N – Environment sensors are missing
T – Temperature stabilization NOK
R – P_RFIN and/or P_RFOUT out of range
O – Inssufficient Optical powers
L – Laser is switched off
P – Phase loops are unlocked
F – Fans revolutions are too low
I – PWR currents are too high

ERROR MESSAGES

Tx_U_PC1 < 10mV AND
Tx_U_PC2 < 10mV AND
Rx_U_PC1 < 10mV AND
P_RFOUT > 5dBm

t _unlock > t_unlock_max = 15min

CFG:RQS SHD

READY

LOCKED

LOCKED
GREEN LED ON
25°C<T_LAS<35°C
15°C<T_SPM<65°C
0.05V<U_PHS<10.5V
0.02V<U_ATT<1.75V
0.05V<U_MZM<9.95V
30V<U_VOA<100V

SEMI-LOCKED
GREEN LED BLINKING
Any green condition broken

Tx_U_PC1 > 10mV OR
Tx_U_PC2 > 10mV OR
Rx_U_PC1 > 10mV OR
P_RFOUT <   5dBm

Tx_U_PC1 < 10mV AND
Tx_U_PC2 < 10mV AND
Rx_U_PC1 < 10mV AND
P_RFOUT >   5dBm

UNLOCKED

Start unlocked timer
t_unlock = 0

Figure 5: Libera Sync 3 State machine

If any of these actuators approaches its working region boundary and all the phase control loops are still closed and output RF power P_RFOUT at Rx unit is sufficient the system goes in sub-state Semi-locked - Green LED Blinking. This event represent warning for the user as Libera Sync 3 system is still locked but it is approaching some constraints that represent some threat for further operation of the system. This state can be visualized as blinking green LED on the front panel of Tx and Rx units (LOCKED) and as blinking LOCKD* caption on the LCD display.

In case that any of the phase control loops is unlocked or output RF power is too low the system goes in sub-state Unlocked, notification status P or R starts blinking and timer for unlocked state is started. If timer exceeds the 15 minutes limit the system goes in shutdown procedure. When sub-state Unlocked is reached the green LED diode on the front panel is turned off and blinking UNLCKD caption is put on the LCD display.

Tx unit receives data from RX unit through Ethernet connection. In case of broken Ethernet connection TX unit is missing Rx unit data. For that reason the system goes from state Locked to state Unlocked. This can cause the system to go in state Shut down if this connection is missing for more than 10 minutes.

CAUTION: If optical powers at photodiodes, measured as photocurrents Tx_I_PD1, Rx_I_PD1 and Rx_I_PD2, are below 2 mA, there is too high insertion loss in one or both optical links. Please clean all optical connectors and measure insertion loss of each optical link.

NOTE: If GREEN-BLINKING sub-state is entered, please check which condition for transition to this state has been fulfilled.

4. Libera Sync 3 interfaces and features

Figure 6 represents the Tx front panel and Figure 7 represents the Rx front panel. There are two differences between these two panels: the Tx unit has only one SMA connector (RF INPUT) and has micro SD memory slot for data logging while the Rx unit has three SMA connectors (two RF output and one monitoring RF output) and no micro SD memory slot.

Transmitter
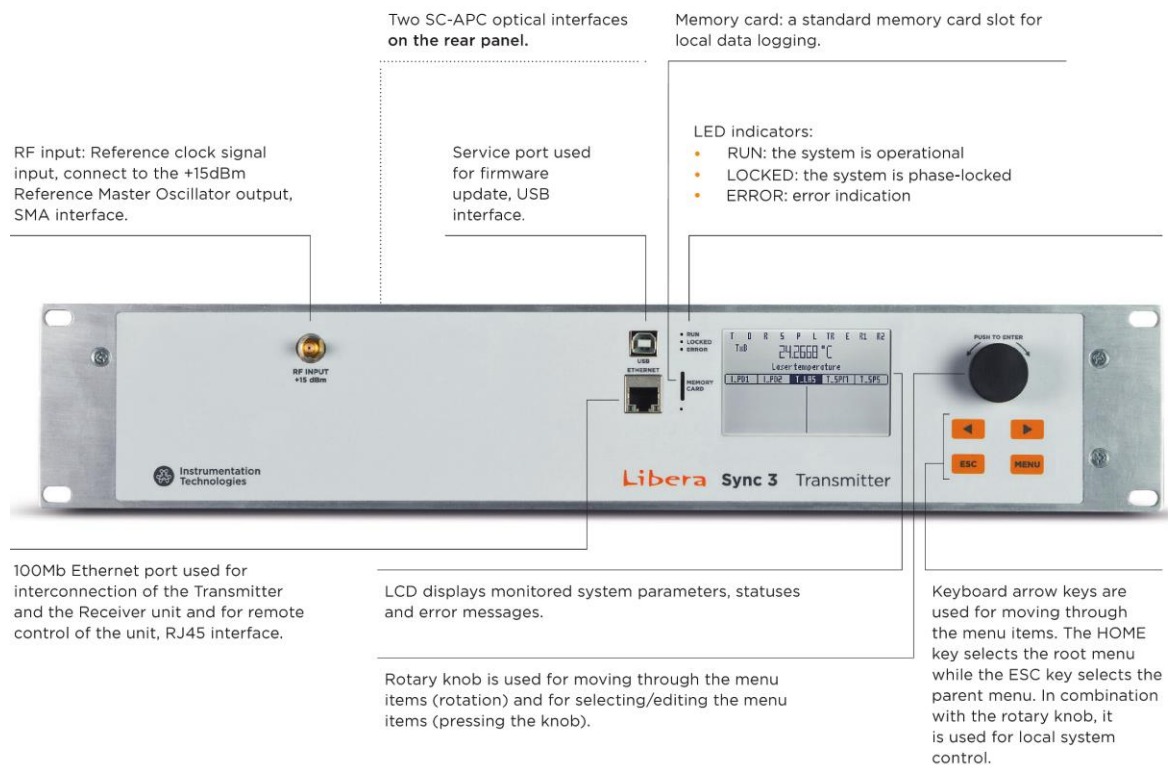
Figure 6: Libera Sync 3 Tx front panel

Receiver

RF Output 1 provides transferred RF signal, SMA interface.

RF Output 2 provides transferred RF signal, SMA interface.

Two SC-APC optical interfaces **on the rear panel.**

RF Monitoring Output provides transferred RF signal for monitoring purposes, SMA interface.
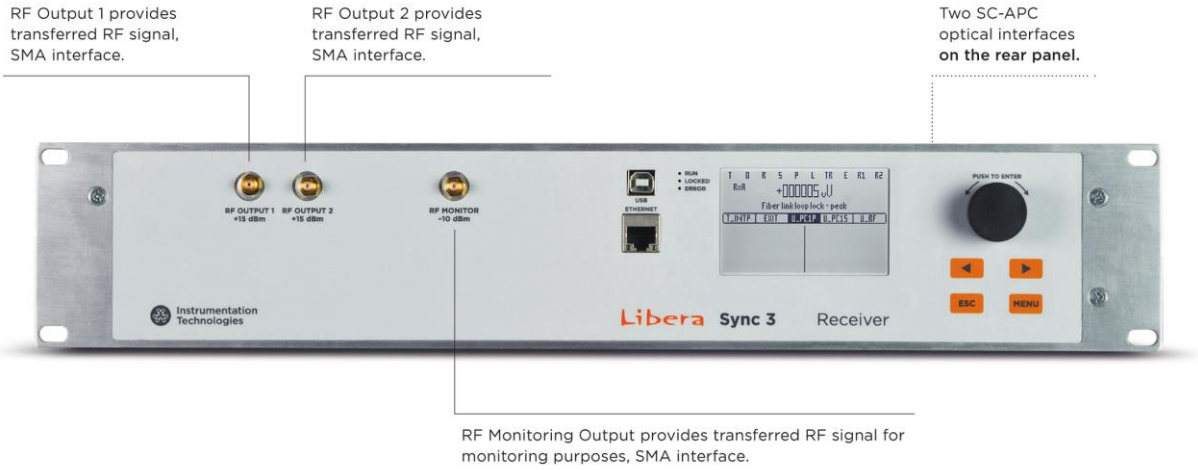
Figure 7: Libera Sync 3 Rx front panel

Figure 8 represents the Tx back panel. The Rx back panel is physically identical to the Tx one except the optical connectors are labelled as Optical Inputs instead of Optical Outputs.
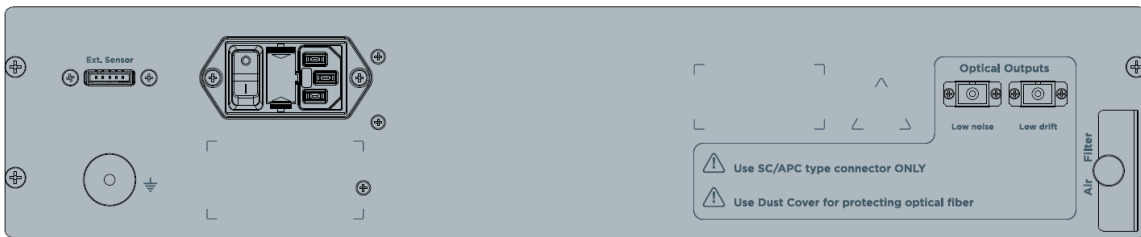
Figure 8: Libera Sync 3 Tx back panel

4.1   Ethernet connection

Ethernet connection between the Tx and Rx units is mandatory for proper operation of the Libera Sync 3. It is used for calibration and control purposes, for diagnostics (statuses and error messages), for service purposes, data logging, etc.

Ethernet physical layer with UDP/IP packet is used for communication. Tx unit always initiates the transfer by sending its status and data information to the Rx unit which responds to the Tx unit request by sending its status information and monitoring data back. If the Rx or Tx unit does not receive a message within the timeout, blinking old values are displayed for all counterpart's parameters on the LCD menu. All remote units' data statuses are disabled and start blinking too. In case the system is in Ready Locked state, it goes in Ready Unlocked sub-state until the Ethernet connection is available again. If Ethernet connection is lost for more than 10 minutes Libera Sync 3 system goes in shut down procedure.

Ethernet configuration is performed in the CONF/ETH/MODE menu page. With the help of keys and rotary knob manually select one of three possible modes of operation and restart or reset the unit to implement selection. Available modes of operation are:

- Off: Ethernet port is disabled

- DHCP: unit attempts to configure the network interface using DHCP protocol. If DHCP request times out, the IP address will be set to 000.000.000.000 and mask to 255.255.255.000. While the unit is waiting for the DHCP server to respond, LCD, keys and rotary knob on front panel are disabled.

- STATIC: manually set IP address, network GATEWAY and MASK in the CONF/ETH/MY_IP, CONF/ETH/GW_IP and CONF/ETH/MASK menu pages and restart or reset the unit.

NOTE: When the network settings are changed the unit has to be restarted for the changes to take effect. It can be done in a soft way with system reset.

NOTE: Only one Ethernet session at a time is possible.

```
Example: establish telnet connection to the Libera Sync 3 unit

IP address of the unit is set to 192.168.1.100 in the CONF/ETH/MY_IP menu. This
address has to be within the same network as your PC. Please verify that also the
CONF/ETH/MASK (255.255.255.0, for example) is in accordance with your network
settings.

In Windows you need to start a new command window with the Start/Run and entering
"CMD".By typing "telnet 192.168.1.100" in the command window the connection to the
unit is established and welcome message is displayed:

Libera Sync 3 by Instrumentation Technologies, Solkan, Slovenia

http://www.i-tech.si

By entering a SCPI command "*IDN?" the unit responds with:

*IDN LIBERA_SYNC_3_tx_M

OK
```

4.1.1 Interconnect Tx and Rx units in one Libera Sync 3 system

To establish Ethernet connection between Tx and Rx units the remote IP address in the CONF/ETH/REM_IP menu page of Tx unit have to be filled with the IP address of the Rx unit and vice versa. Booth units have to be in the same network. The remote IP address can be set remotely, too.

```
Example: set remote IP address in the unit
ETH:REM_IP 192.168.001.100
Answer
ETH:REM_IP 192.168.001.100
OK
```

4.2   USB port

USB port is dedicated for service purposes only and is not intended to be used by the end user. Connecting USB port to PC resets the unit if terminal reset setting is enabled.

4.3   LCD display and keys

On the Libera Sync 3 Tx/Rx front panels there are LCD, four capacitive keys and a rotary knob (see Figure 9). Moving through the menus (see Figure 10 for LCD structure) is possible with the use of the arrow keys or the rotary knob. By pressing the rotary knob, user enters the selected item in the menu structure and by turning it around user changes the parameter value or blinking digit of selected parameter. Arrow keys are used for moving from one to the other digit. "Exit" option in the menu structure or "ESC" key navigates to the menu hierarchically above the current menu. "MENU" key navigates to the root menu TxB.
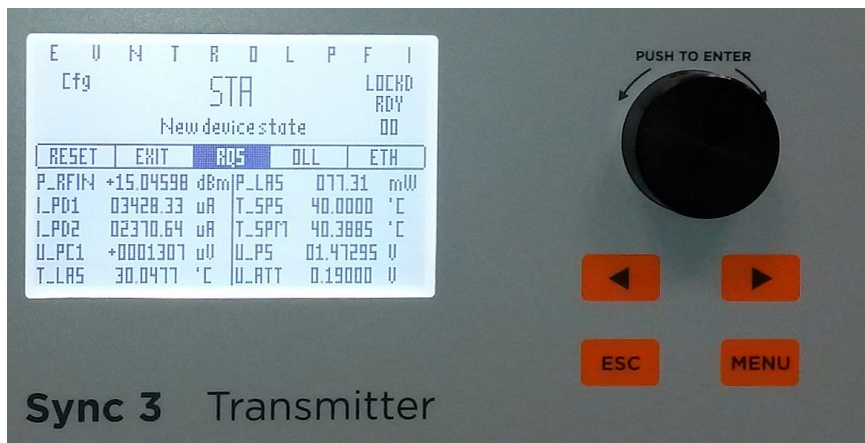
Figure 9: Libera Sync 3 LCD and front panel keys

Libera Sync Tx unit has five basic menus: "TX_B", "TX_A", "NOTIF", "CONF" and "INFO". Additionally, the Tx unit displays "RX_B" and "RX_A" menu pages where the basic and advanced operational parameters of the Rx unit can be read out. Under the "TX_B" menu user reads out basic Tx operational parameters, while under the "TX_A" menu user reads out advanced Tx operational parameters. Ethernet connection between the units has to be established for Rx parameters to be displayed on Tx unit and vice versa. In case that Ethernet connection is lost, old values of parameters from the opposite unit are displayed and are blinking. Device statuses that are dependent on data from both units are blinking, too.

Libera Sync 3 Rx unit has five basic menus; "RX_B", "RX_A", "NOTIF", "CONF" and "INFO". Additionally, the Rx unit displays "TX_B" and "TX_A" menu pages.

NOTE: System configuration is performed on the Tx unit only. However some parameter settings that are unit dependent, like the Ethernet configuration, fans revolution setpoint and software reset of the unit, can be set on the Rx unit, too.

4.3.1 LCD display structure

For the TX_B, TX_A, RX_B, RX_A and CONF menus the LCD structure is the same and is depicted in the Figure 10. At the top of the LCD there are health status items. If any of them is blinking, the status is active. At the right side there is Locking notification, current state and sub-state. At the left side there is parent menu notification. At the centre of the LCD selected parameter value and short parameter description are placed.

Menu items are placed in the row in the centre of the LCD display. There are two columns with five basic system parameters displayed below the menu. These parameters are different for Tx and Rx unit.
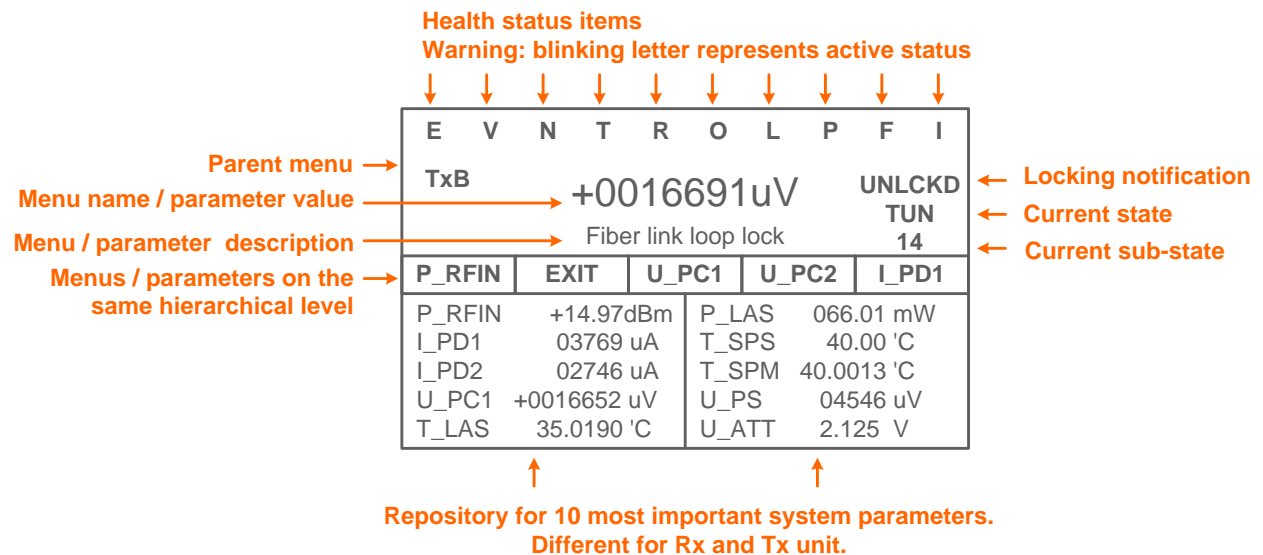
Figure 10: LCD structure

4.3.2 Information menu page INFO

In the information menu page INFO (Figure 11) basic information regarding Libera Sync 3 system is listed; date and time, firmware version, MAC address, IP and remote IP addresses, operational frequency (not measured) and up time.
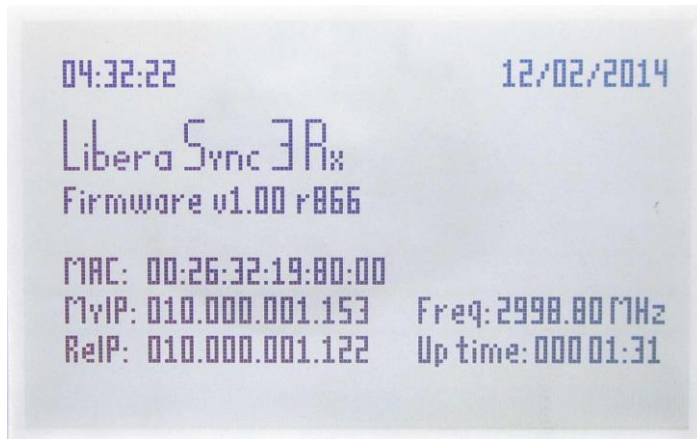
Figure 11: Information menu page INFO

4.3.3 Notification menu page NOTIF

In the notification menu page NOTIF (Figure 12) all active error messages of the Libera Sync 3 system are displayed. Date and time stamp in front of each error message shows the date and time of message generation. If one message is persistent, the time stamp is updated each time the message is generated. Red LED diode ERROR on the front panel is notifying the user that an error message has been put into the NOTIF menu page. Each unit of the Libera Sync 3 system shows all system error messages. With system restart/reset or start all error messages are cleared. There is less important error message *Arm ctrl sensor failure* that can be acknowledged and removed from the notification menu page locally by pressing the rotary knob or remotely with the command NOT:CLR. Error message can be only cleared on the unit where the error has occurred. The list and description of all error messages can be found in Chapter 4.5.1.
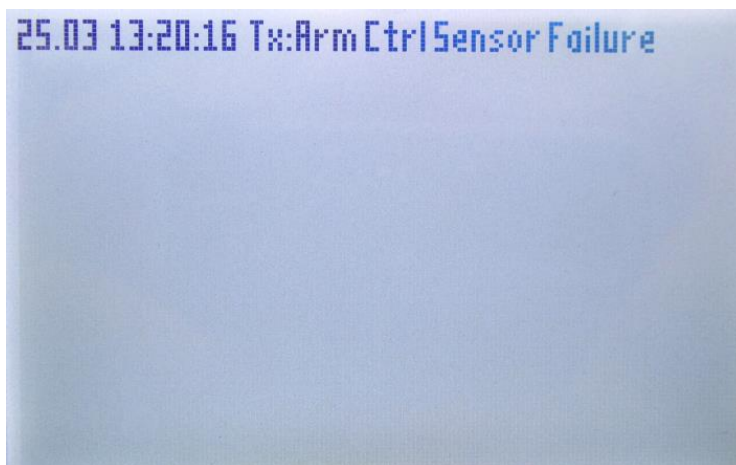
Figure 12: Notification menu page NOTIF.

4.3.4 Tx menu diagram

```
                          ┌──────┐
                          │ TX_B │
                          └──┬───┘
   ┌────────┬────────┬──────┼───────┬────────┬────────┬────────┐
┌──────┐┌──────┐┌──────┐┌──────┐┌──────┐┌──────┐┌──────┐┌──────┐┌───────┐
│U_PC1 ││U_PC2 ││I_PD1 ││I_PD2 ││I_LDS ││T_LAS ││T_SPM ││T_SPS ││P_RFIN │
└──────┘└──────┘└──────┘└──────┘└──────┘└──────┘└──────┘└──────┘└───────┘
```

```
                          ┌──────┐
                          │ TX_A │
                          └──┬───┘
   ┌────────┬────────┬──────┼───────┬────────┬────────┬────────┐
┌──────┐┌──────┐┌──────┐┌──────┐┌──────┐┌──────┐┌──────┐┌──────┐┌───────┐
│P_PD1 ││P_PD2 ││P_LAS ││P_RFO ││I_LAS ││U_PS  ││U_ATTS││U_ATT ││U_PSI  │
└──────┘└──────┘└──────┘└──────┘└──────┘└──────┘└──────┘└──────┘└───────┘
┌──────┐┌──────┐┌──────┐┌──────┐┌──────┐┌──────┐┌──────┐┌──────┐┌───────┐
│U_MZM ││I_VOAS││U_VOA ││T_STP ││T_TX  ││T_OPT ││H_EXT ││T_EXTH││P_EXT  │
└──────┘└──────┘└──────┘└──────┘└──────┘└──────┘└──────┘└──────┘└───────┘
              ┌───────┬──────┼───────┬────────┐
           ┌──────┐┌──────┐┌──────┐┌──────┐┌──────┐
           │T_EXTP││H_INT ││T_INTH││P_INT ││T_INTP│
           └──────┘└──────┘└──────┘└──────┘└──────┘
```

```
                          ┌──────┐
                          │ CONF │
                          └──┬───┘
      ┌────────┬──────┼──────┬────────┬────────┐
   ┌──────┐┌──────┐┌──────┐┌──────┐┌──────┐┌──────┐
   │ RQS  ││ OLL  ││ ETH  ││FAN_SP││SD_LOG││RESET │
   └──────┘└──────┘└──────┘└──────┘└──────┘└──────┘
```

Figure 13: Tx menu diagram.

Figure 13 represents the content of Tx menus TX_B, TX_A and CONF and Table 2 specifies each parameter in more details.

Table 2: The content of TX Basic, Advanced and Configuration menus

TX BASIC		
Parameter	**Unit**	**Meaning**
U_PC1	uV	Low-drift optical link loop lock
U_PC2	uV	Laser and modulator loop lock
I_PD1	uA	PD1 current - returned optical signal
I_PD2	uA	PD2 current - transmitted optical signal
I_LDS	uA	Laser diode setpoint
T_LAS	°C	Laser temperature
T_SPM	°C	Compensation spool temperature
T_SPS	°C	Compensation spool temperature setpoint
P_RFIN	dBm	Input RF power
EXIT		Return to parent directory
TX ADVANCED		
Parameter	**Unit**	**Meaning**
P_PD1	dBm	PD1 RF power - returned optical signal
P_PD2	dBm	PD2 RF power - transmitted optical signal
P_LAS	mW	Laser optical power

TX BASIC		
P_RFO	dBm	RF output power to MZM
I_LAS	mA	Laser current
U_PS	V	Electrical phase shifter voltage
U_ATTS	V	Variable RF attenuator controller setpoint voltage
U_ATT	V	Variable RF attenuator voltage
U_PSI	V	Input phase shifter voltage
U_MZM	V	MZ modulator bias voltage
I_VOAS	mA	VOA controller setpoint
U_VOA	V	VOA voltage
T_STP	°C	Temperature setpoint for internal modules
T_TX	°C	Tx board temperature
T_OPT	°C	Optical assembly temperature
H_EXT	%	External relative humidity
T_EXTH	°C	External temperature (humidity sensor)
P_EXT	mbar	External pressure
T_EXTP	°C	External temperature (pressure sensor)
H_INT	%	Internal relative humidity
T_INTH	°C	Internal temperature (humidity sensor)
P_INT	mbar	Internal pressure
T_INTP	°C	Internal temperature (pressure sensor)
EXIT		Return to parent directory

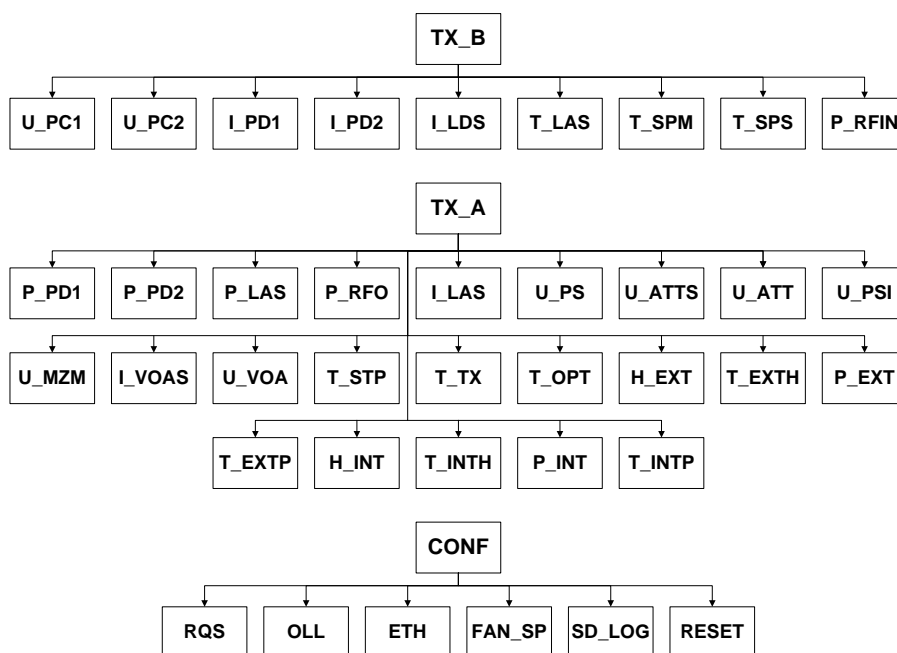| TX CONFIGURATION			
Parameter		**Unit**	**Meaning**
RQS	STA		Request Startup device state
	SHD		Request Shutdown device state
OLL		m	Define optical link length in meters
ETH	MODE	Off, Static, DHCP	Disable Ethernet port or select Static or DHCP Ethernet mode of operation
	MY_IP	xxx.xxx.xxx.xxx	Local unit IP
	MASK	xxx.xxx.xxx.xxx	Ethernet mask
	REM_IP	xxx.xxx.xxx.xxx	Remote unit IP
	GW_IP	xxx.xxx.xxx.xxx	Gateway IP
FAN_SP		rpm	Set fan speed
SD_LOG	ON/OFF		Enable/disable data logging on micro SD card
RESET	1234		Software reset of the unit
EXIT			Return to parent directory

4.3.5 Rx menu diagram
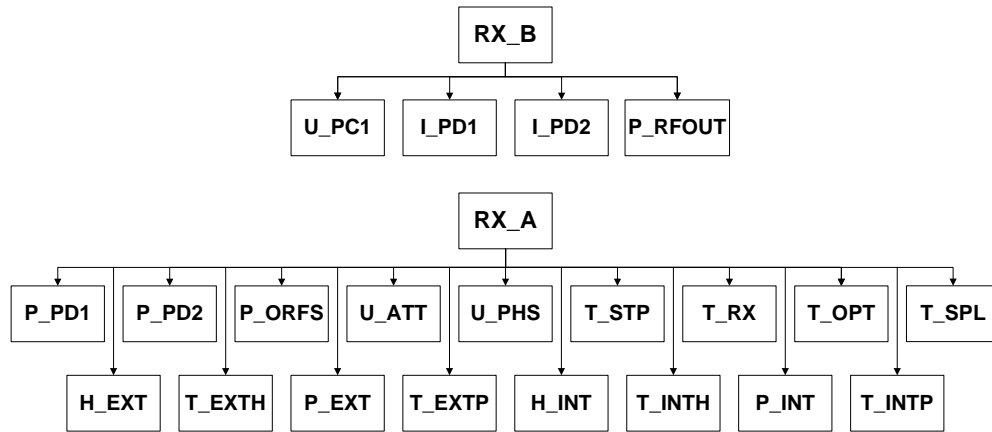
Figure 14: Rx menu diagram

Figure 14 represents the content of Rx menus RX_B and RX_A and Table 3 specifies each parameter in more details.

Table 3: The content of Rx Basic and Advanced menus.

RX BASIC		
Parameter	**Unit**	**Meaning**
U_PC1	uV	Rx internal lock
I_PD1	uA	Compensated link photodiode current
I_PD2	uA	Low-noise link photodiode current
P_RFOUT	dBm	Output RF power
EXIT		Return to parent directory
RX ADVANCED		
Parameter	**Unit**	**Meaning**
P_PD1	dBm	Compensated link photodiode RF power
P_PD2	dBm	Low-noise link photodiode RF power
P_ORFS	dBm	Output RF power setpoint
U_ATT	V	Variable attenuator voltage
U_PHS	V	Phase shifter voltage
T_STP	°C	Modules temperature setpoint
T_RX	°C	Rx board temperature
T_OPT	°C	Optical assembly temperature
T_SPL	°C	Rx spool temperature
H_EXT	%	External relative humidity

T_EXTH	°C				External temperature (humidity sensor)
P_EXT	mbar				External pressure
T_EXTP	°C				External temperature (pressure sensor)
H_INT	%				Internal relative humidity
T_INTH	°C				Internal temperature (humidity sensor)
P_INT	mbar				Internal pressure
T_INTP	°C				Internal temperature (pressure sensor)
EXIT					Return to parent directory

4.4   Commands

Table 4 represents the list of all commands used for control purposes and for setting or retrieving the parameters of the unit.

Table 4: Libera Sync 3 list of commands for general settings

Command	Parameters	Min	Max	Def	Meaning
FIR:VER?	None			None	Get firmware version
WPE:MAC?	None			None	Get MAC address
TIM:SET *	HH:MM:SS	00:00:00	23:59:59	00:00:00	Set current time
TIM:GET?	None			None	Get current time
DAT:SET *	DD/MM/YYYY	01/01/2015	31/12/2065	01/01/2000	Set current date
DAT:GET?	None			None	Get current date
STXS:FAN1?	None			None	Get Tx fan1 speed
STXS:FAN2?	None			None	Get Tx fan2 speed
STXS:FAN3?	None			None	Get Tx fan3 speed
SRXS:FAN1?	None			None	Get Rx fan1 speed
SRXS:FAN2?	None			None	Get Rx fan2 speed
SRXS:FAN3?	None			None	Get Rx fan3 speed
CFG:FANSP	x	0	3600	3200	Set fan speed setpoint in rpm
CFG:FANSP?				None	Get fan speed setting
CFG:RST	1234			None	Software reset of the unit
CFG:OLL	x	1	9999	1	Optical link length in meters
CFG:OLL?				None	Get optical link length?
CFG:RQS	SHD STA			None	Shutdown the system (from any state) Start the system (only from SHD state)
ETH:MY_IP	xxx.xxx.xxx.xxx			000.000.000.000	Set IP address of the unit (fill all bits)

Command	Parameters		Min	Max	Def	Meaning
ETH:MY_IP?					None	Get IP address of the unit
ETH:REM_IP	xxx.xxx.xxx.xxx				255.000.255.000	Set IP address of the remote unit (fill all bits)
ETH:REM_IP?					None	Get IP address of the remote unit
ETH:MASK					255.255.255.0	Set mask IP address (fill all bits)
ETH:MASK?					None	Get mask IP address
ETH:GW_IP					192.123.0.254	Set gateway IP address (fill all bits)
ETH:GW_IP?					None	Get gateway IP address
ETH:MODE	Off Static DHCP				DHCP	Set ethernet mode of operation
ETH:MODE?					None	Get current ethernet mode of operation
LOG:ENA	ON OFF				OFF	Enable/disable memory card logging
LOG:ENA?					None	Get memory card logging status
LOG:PER			1	99	1	Set data logging period in seconds
LOG:PER?					None	Get data logging period in seconds
LOG:SEL	abcde		0	1	11111	a=RX advanced b=RX basic c=TX advanced d=TX basic e=health status items
LOG:SEL?					None	Get logging data set selection
DEV:RMO	k,n				None	Device remote monitoring
	k	0 1 2	Item names Item units Item values			Data type
	n	1 2 3 4	Tx basic Tx advanced Rx basic Rx advanced			Data selector
DEV:STA?	a,b,c,d,e,f				None	Device status returns 6 parameters
	a		0	FFFF	0	Health status
	b		0	2	0	Lock notification

Command	Parameters	Min	Max	Def	Meaning
	c	0	6	0	Main state
	d	0	53	0	Sub-state
	e	0	FFFF FFFF	0	Error status
	f	0	9999	0	Up time in minutes
NOT:CLR				None	Clear *Arm ctrl sensor failure* error message

* Every time the system is started or rebooted the time and date are reset to default value 00:00:00 and 1/1/2000.

4.5   Device status explanation

Device statuses are different for micro SD card logging and for remote monitoring. Table 5 represents the structure of statuses that are logged on the micro SD card.

Table 5: Device status structure for data logging

Parameter	Description	Value - description	
1	Health status	E – Tx/Rx Ethernet connection failure	
2	Health status	V – Power supply voltages are out of range	
3	Health status	N – Environmental conditions are out of range	
4	Health status	T – Internal modules' temperatures are out of range	
5	Health status	R – RF power is out of range	
6	Health status	O – Optical power is too low	
7	Health status	L – Laser is switched off	
8	Health status	P – Phase loops are not locked	
9	Health status	F – Fan revolutions are too low	
10	Health status	I – Power supply currents are too high	
11	Lock notification	**Lock notification**	**LCD lock notification**
		0 – Unlocked 1 – SemiLocked 2 – Locked	UNLCKD LOCKD* LOCKD
12	State machine state	**State name**	**LCD state abbreviation**
		0 – Start 2 – Shutdown 3 – Init 4 – Warming up 5 – Tuning 6 – Ready	STA SHD INT WAR TUN RDY
13	State machine sub-state	**State machine sub-state description**	**LCD sub-state notification**
		0 – Init sub-state 1 – Check RF sources 2 – Start laser 3 – Wait for 60s 4 – MZM identifie operational point 5 – Wait for MZM to stabilize 6 – Set MZM operational point 7 – Enable Tx_I_PD2 controller 8 – Start Tx_P_PD2 RF controller 9 – Enable MZM controller 10 – Wait for MZM controller to stabilize 11 – Tx Internal phase controller identification 12 – Enable Tx internal phase controller 13 – Tx internal phase loop closed 14 – Find VOA operational point	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

Parameter	Description	Value - description	
		15 – Enable VOA -TX I_PD1 optical power controller	15
		16 – Check Rx I_PD1 optical power	16
		17 – Enable Rx RF amplitude controller	17
		18 – Check RF in whole Libera Sync 3 system	18
		19 – Find reference phase shifter operational point	19
		20 – Enable laser temperature based phase controller	20
		21 – Check the optical link phase loop	21
		22 – Enable fiber spool phase controller	22
		23 – Check if spool phase controller is locked	23
		24 – Enable Rx phase controller,	24
		25 – Check if all phase control loops are locked	25
		50 – MZM operational point identification failed	50
		51 – Tx internal phase loop controller identification failed	51
		52 – VOA operational point identification failed	52
		53 – Reference phase shifter operational point failed	53

Device statuses for remote monitoring are grouped in 6 parameters. Parameters 2, 3, 4 and 6 are in decimal numeral system format while parameters 1 and 5 are in hexadecimal numeral system format. Parameter in the hexadecimal numeral system format has to be translated into binary numeral system format and each bit represents one status or error message. Bit 0 represents LSB bit. For example, $0001_{HEX}=0000\ 0000\ 0001_{BIN}$. Bit 0 is set to 1 and represents Tx/Rx Ethernet connection failure. Table 6 specifies device statuses for remote monitoring in details.

Table 6: Device status structure for remote monitoring and LCD notification

Parameter	Description	Value description		LCD status abbreviation
		Bit	Description enumeration: 0=LSB, 9=MSB	
		0	Tx/Rx Ethernet connection failure	E
		1	Power supply voltages are out of range	V
		2	Environmental conditions are out of range	N
1	Health statuses	3	Internal modules' temperatures are out of range	T
		4	RF power is out of range	R
		5	Optical power is too low	O
		6	Laser is switched off	L
		7	Phase loops are not locked	P
		8	Fan revolutions are too low	F
		9	Power supply currents are too high	I
2	Lock notification	**Lock notification**		**LCD lock notification**
		0 - Unlocked		UNLCKD
		1 - SemiLocked		LOCKD*

Parameter	Description	Value description	
		2 - Locked	LOCKD
3	State machine state	**State name**	**LCD state abbreviation**
		0 - Start 2 - Shutdown 3 - Init 4 - WarmingUp 5 - Tuning 6 - Ready	STA SHD INT WAR TUN RDY
4	State machine sub-state	**State machine sub-state description**	**LCD sub-state notification**
		0 – Init sub-state 1 – Check RF sources 2 – Start laser 3 – Wait for 60s 4 – MZM identifie operational point 5 – Wait for MZM to stabilize 6 – Set MZM operational point 7 – Enable TX_I_PD2 controller 8 – Start Tx_PD2 RF amplitude controller 9 – Enable MZM controller 10 – Wait for MZM controller to stabilize 11 – Tx Internal phase loop controller identification 12 – Enable Tx internal phase loop controller 13 – Tx internal phase loop closed 14 – Find VOA operational point 15 – Enable TX I_PD1 optical power controller 16 – Check Rx I_PD1 optical power 17 – EnableRx RF amplitude controller 18 – Check RF in whole system 19 – Find reference phase shifter operational point 20 – Enable laser temperature based phase controller 21 – Check the optical link phase loop 22 – Enable fiber spool phase controller 23 – Check if spool phase controller is locked 24 – Enable Rx phase controller 25 – Check if all phase control loops are locked 50 – MZM operational point identification failed 51 – Tx internal phase loop controller identification failed 52 – VOA operational point identification failed 53 – Reference phase shifter operational point failed	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 50 51 52 53
5	Error status	See Table 7 for detailed classification	
6	Up time	Minutes elapsed since the unit has been powered on	

4.5.1 Error status description

Table 7 classifies all error messages in four categories according to its origin (TX RF_CTRL, TX ARM_CTRL, RX RF_CTRL and RX ARM_CTRL board).

Error messages inform user that something in the system didn't work fine. There are three groups of error messages according to the final state the system ends in:

- SHD state: the system is in Shutdown state

- TUN/sub-state 50-53 : one of the system identifications failed, system is in state Tuning

- Normal operation: one of the Arm internal sensors failed, system operates normally

If one of the system identifications fails the system hangs up in state Tuning and one of the sub-states from 50 to 53. This solution gives the user ability to check all system parameters. In case the cause of such error is not identified and removed please contact Instrumentation Technologies support. Restart or reset the unit to repeat the tuning procedure.

All error messages are only cleared when device enters START state. This can be done with system shutdown (CFG:RQS SHD) and new system start (CFG:RQS STA) or power cycle or system reset (CFG:RST 1234).

Error messages are displayed in the notification menu NOTIF as it is depicted in Figure 12.

NOTE: In case of any error message please check it before you restart the system. After restarting the system all error messages are cleared and are no longer available.

Table 7: Error status classification

Error status bit number	Tx Rf Ctrl Error messages	
	LCD note	**Detailed description**
0	Eth Sync Failure	Ethernet synchronization between Tx and Rx units lost for more than 10 min
1	Rf Input Is Too Low	RF Input is out of range for more then 60 s
2	Tec Protection	Temperature sensors are not working properly and TEC protection is activated
3	Reserved	
4	Reserved	
5	Reserved	
6	Rf Ctrl Ident Failed	Tx: RF control identification failed
7	Rf Ctrl Sensor Failure	Tx: RF control sensor failure
	Tx Arm Ctrl	
	LCD note	**Detailed description**

Error status bit number	Tx Rf Ctrl Error messages	
8	Reserved	
9	Reserved	
10	Reserved	
11	Reserved	
12	Reserved	
13	Reserved	
14	Arm Ctrl Ident Failed	Tx: Arm control Identification failed
15	Arm Ctrl Sensor Failure	Tx: Arm control sensor failure
	Rx Rf Ctrl	
	LCD note	**Detailed description**
16	Eth Sync Failure	Ethernet synchronization between Tx and Rx units lost for more than 10 min
17	Rf Output Too Low	RF output out of range for more than 10 min
18	Tec Protection	Temperature sensors are not working properly and TEC protection is activated
19	Unlocked For Too Long	The system is unlocked for more than 15 min
20	reserved	
21	reserved	
22	Rf Ctrl Ident Failed	Rx: RF control identification failed
23	Rf Ctrl Sensor Failure	Rx: RF control sensor failure
	Rx Arm Ctrl	
	LCD note	**Detailed description**
24	reserved	
25	reserved	
26	reserved	
27	reserved	
28	reserved	
29	reserved	
30	Arm Ctrl Ident Failed	Rx: Arm control Identification failed
31	Arm Ctrl Sensor Failure	Rx: Arm control sensor failure

4.6   Data logging on micro SD memory card

On the front panel of Libera Sync 3 Tx unit there is a slot for micro SD card, marked as "Memory Card". Next to it is a blue LED diode, which is turned on when micro SD card is inserted and logging is enabled. In the CONF/SD_LOG menu or remotely (LOG:ENA ON) it is possible to enable memory card logging even if there is no memory card. In such case the logging starts automatically when the memory card is inserted.

User can select the groups of system parameters (STA, TX_B, TX_A, RX_B and RX_A) to be logged to the memory card. The data is stored in CSV file format. First line is populated with data description; second line represents units for measured parameters and all other lines represent measured values. Logging period can be set in the range from 1 to 99s.

Log file data naming convention is date-hour-ip.txt, where the date and hour represent the beginning of data logging and IP is the IP of the TX unit where data logging has been done.

SD card data organisation is the following: Time, Date, STA, TX_B, TX_A, RX_B and RX_A.

Status parameters description is R, V, E, T, R, O, L, P, F, C, LCK, MAINS, SUBS and is in accordance to Table 5. Letter is written only in case the status is active otherwise no value is written.

The maximum number of files that can be written on micro SD card is 64.

```
Example 1: Select TX_A and RX_B data sets to be logged on the memory card
LOG:SEL 01100
Example 2: Set logging period to 10s
LOG:PER 10
Example 3: Start data logging
LOG:ENA ON
Example 4: Example of logged data on micro SD card where active statuses are R,O and
P, the system is unlocked and in state Shut-down.
Time,Date,E,V,N,T,R,O,L,P,F,I,LOCKD,MAINS,SUBS,U_PC1,U_PC2,I_PD1,I_PD2
h:m:s, d/m/y, , , , , , , , , , , , , , , uV, uV, uA, uA, uA
15:49:36,15/05/2015,,,,,R,O,,P,,,UNLCKD,SHD,00,+0000054,+0000011,03559.78,02221,02329
```

NOTE: Not all micro SD cards are working with Libera Sync 3 unit. Use micro SD card that has been provided with the unit.

4.7   Remote data monitoring

Remote data monitoring is useful for integration of the Libera Sync 3 in the user's control system. User can monitor remotely TX_B, TX_A, RX_B and RX_A data groups and STA statuses.

```
Example 1: retreive description of TX_B data set
DEV:RMO 0,1
DEV:RMO Time, U_PC1, U_PC2, I_PD1, I_PD2, I_LDS, T_LAS, T_SPM, T_SPS, P_RFIN
Example 2: retreive units of RX_B data set
DEV:RMO 1,3
DEV:RMO h:m:s, uV, uA, uA, dBm
Example 3: retreive values of RX_B data set
DEV:RMO 2,3
DEV:RMO 10:40:43, +0005409, 03418, 03533, +14.98
```

NOTE: The remote unit data is only valid, if the Ethernet connection between Tx and Rx units is operational, i.e. the status E is not blinking on the LCD display.

```
Example:
DEV:STA?
0328,2,6,0,00000000,97
The meaning of each parameter is:
```
0328_{hex} = 0000 0011 0010 1000$_{bin}$

      bit 3 – T: Internal modules temperatures are out of range

      bit 5 – O: Optical power is too low

      bit 8 – F: Fan revolutions are too low

      bit 9 – I: Power supply currents are too high

2 – LockState is Locked

6 – State machine state is Ready

0 – Subinit state 0

00000000_{hex} = 0000 0000 0000 0000 0000 0000 0000 0000$_{bin}$ - There is no error status active

97 – up time is 97 min

5. Installation and maintenance

Electronic devices such as Libera Sync 3 need proper maintenance to keep their functionality and measurement accuracy unaffected during their lifetime. The very sensitive electronics, optics and mechanics inside Libera Sync 3 should therefore not be exposed to rough handling or environmental conditions out of the predefined specifications described below.

Instrumentation Technologies takes no responsibility for damage occurred by improper installation and/or maintenance.

Libera Sync 3 uses 19'' 2U height and 456mm long chassis designed for rack mount. As the chassis is heavy (14 kg) and deep it is necessary to mount the device on the rack shelves.

Fresh air is entering the chassis on the left side of the unit and it is leaving it on the right side. All RF and communication connections are on the front panel and all optic connections and power cord are on the back panel.

5.1   Operating environment

Libera Sync 3 should be rack mounted. Rack environmental constraints are:

- Operating temperature range: 20-30°C
- Operating temperature stability: ±1 °C
- Relative Humidity range: 0-80 %
- Relative Humidity stability: ±5 %
- Dry and dust free area

Protect Libera enclosure from adverse weather conditions. The instrument is not water resistant.

5.2   Power supply

Libera Sync 3 features power supply that can be connected directly to the AC voltage in the range between 90 V and 240 V with the frequency in the range between 47 Hz and 63 Hz. Installed power of the unit is approximately 200 W for each unit, while the consumption in the steady state depends on the environmental conditions (temperature stabilization) and is around 100 W normally.

5.3   Connect the optics

Commercial telecom business fibers for 1550 nm wavelength with a low PMD factor (0.02ps/$\sqrt{km}$) are needed. Optical fibers should be from jelly filled cable or loose tube cable to preserve low temperature coefficient of delay (TCD) in the range of 42ps/km/K. For some standard cablings TCD coefficient can be increased to the value of 130 ps/km/K or even more. In case of transferring the signal over long distance (in the km range) or in the case of major changes in environment temperature (a few °C) and relative humidity (few tens of %) on the transferring path the phase drift of normal SMF fiber exceeds the phase compensation ability of the Libera Sync 3 system (500 ps). Using special temperature compensated SMF fiber with TCD in the range of 5 – 7 ps/km/K can solve this problem. Furukawa is a known provider of such fibers.

Special care has to be paid to the lengths of the fiber spools within patch panels. In general, the best contribution to long term stability is achieved if the fibers are in the same cable along the entire path, without any interconnections. Figure 15 represents recommendations for laying the fibers.

Only use quality SC/APC connectors with low insertion loss for the optical links. In case of high loss in the optical cabling the optical powers in the Tx and Rx units are significantly decreased and performance of the system can be decreased.
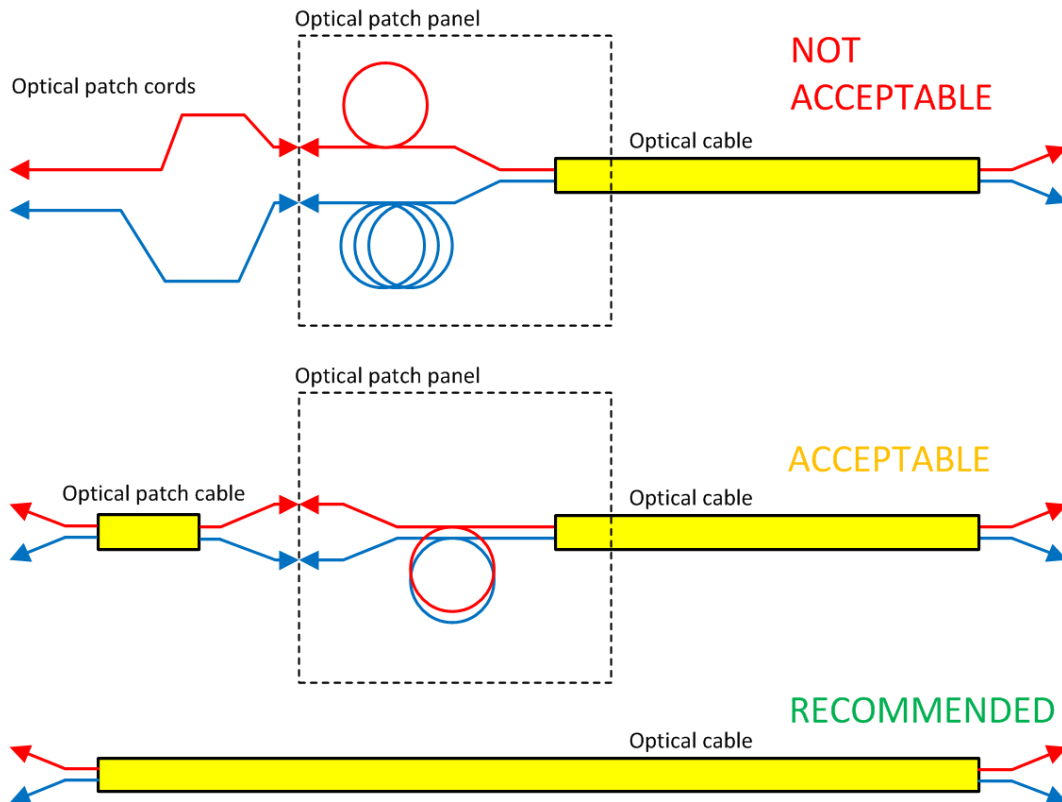

Figure 15: Recommendation for laying the fibers

CAUTION: Always check the type of connectors on the optical cables that are plugged into Libera Sync 3 connectors. The connectors must be SC/APC type.

CAUTION: Before installation please validate the insertion loss of each optical link. Only use quality SC/APC connectors.

> **CAUTION: Clean the optical connectors on both sides with appropriate optical cleaner before every plugging.**

5.4   Connect RF

Libera Sync 3 system is tuned to the customer RF frequency that is provided from the Reference Master Oscillator (RMO).

> **NOTE: Only use RF frequency that is in accordance to the Libera Sync 3 Specifications. The Rx unit comprises high Q dielectric resonator that is tuned to specified frequency.**

There is one RF input on the front panel of the Libera Sync 3 Tx unit. It should be connected to an adequate output of the master oscillator unit. The input signal level must be in the range of +15 dBm ± 1 dBm and of the customer dependent frequency. Female SMA connector is used for this input. Please refer to the Libera Sync 3 Specifications for exact system frequency.

> **CAUTION: Maximum input signal level is +20dBm. Please never exceed this level; it may result in severe damage of the instrument.**

There are two equal RF outputs and one monitoring output on the front panel of the Rx unit. Female SMA Connectors are used for these outputs. These outputs provide the transmitted clock signal that should be connected to the clock input of the user's devices. The output signal level is +15 dBm ± 0.1 dBm and the monitoring output signal level is -10 dBm. Unused outputs must be terminated with the 50Ω SMA terminations.

5.4.1 Selection of RF cables

It is very important to use ultra-low phase vs. temperature dependent RF cables to connect Libera Sync 3 system with RF source and destination devices. RF cables with air-filled PTFE dielectric show extremely low phase vs. temperature dependence in the range of a few fs/m/K for the temperature window of some °C between 23 and 30 °C. Out of this window there is normally a steep dependence in the range of a few hundreds of fs/m/K. Such cables also demonstrate ultra-low loss. Optimum temperature with minimum phase dependence differs from cable to cable and from manufacturer to manufacturer. The selection of proper RF cable is so highly correlated with the selection of the rack temperature where Libera Sync 3 and other RF devices are installed.

> **NOTE: Select RF cables in accordance to environmental temperature where the cables will be used to achieve minimum phase vs. temperature dependence. Improper system design can result in excessive RF transfer link drift.**

5.5   Connector care

Visual inspection and cleaning the connectors should be done every time a connection is made. This is addressed for all optical connectors on Libera Sync.

Special care is needed for RF signal connectors as well. Use isopropyl or ethyl alcohol on a swab to clean the connectors. Carefully clean the conductive surfaces and avoid wetting the plastic parts inside the connector with alcohol. After cleaning, be sure connector is blown dry before reassembly.

Optical connectors need special care. Please follow these instructions to get flawless operation of the unit and optimal performance:

- When not in use, the optical connectors have to be covered all the time with original caps, provided with the unit.
- Clean connectors on the fiber before any connection to the unit to prevent the counterpart connector pollution.
- After several connection/disconnection cycles it is advised that also the optical connectors on the unit (the ferules) are cleaned using a special cleaning tool, like "HUXCleaner".

5.6   Cleaning the unit

WARNING: Before cleaning, make sure Libera Sync 3 is switched off and has power cord disconnected.

Alcohol should be used in liquid rather than spray form. If a spray must be used, always spray the alcohol onto a cloth, never directly into a connector or air inlets.

- Remove loose dust using a soft cloth or paper towel dampened with water. You can also use 75% isopropyl alcohol solution for more efficient cleaning.
- To avoid damage, do not expose it to sprays, liquids, or solvents.

Use original package for any kind of transportation. For shipments via mail the box must be marked as fragile.

While the instrument is not in use for longer periods of time, we advise you to keep it in its original package and stored in an appropriate place.

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