



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-E1300482-v4

Advanced LIGO

12/5/2018

Laser Locking Library

Sheila Dwyer, Daniel Sigg

Distribution of this document:
LIGO Scientific Collaboration

This is an internal working note
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California Institute of Technology
LIGO Project – MS 18-34
1200 E. California Blvd.
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project – NW22-295
185 Albany St
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
P.O. Box 159
Richland WA 99352
Phone 509-372-8106
Fax 509-372-8137

LIGO Livingston Observatory
P.O. Box 940
Livingston, LA 70754
Phone 225-686-3100
Fax 225-686-7189

<http://www.ligo.caltech.edu/>

Library	
Title	LaserLocking
Version	2
TwinCAT version	V2.11.0
Name space	
Author	Sheila Dwyer
Description	Automatic locking for ALS PLL at end station and the squeezer PLL. See following section for more details.
Error Code	<p>0x0001 — Communications error (lost communication from corner PLC1 or cornerPLC2, or there is an error from the timing system)</p> <p>0x0002 — Reference cavity transmission PD error</p> <p>0x0004 — Fiber distribution error</p> <p>0x0008 — Reference cavity transmission below the limit (limit set in this autolocker)</p> <p>0x0010 — Fiber launch PD error (in the fiber distribution box, internal.DC)</p> <p>0x0020 — Fiber launch power below the limit (limit set in by the autolocker)</p> <p>0x0040 — Fiber transmission PD error (the limits are enforced in the DC PD library for the local PDs)</p> <p>0x0080 — Fiber transmission PD limits not set, they need to be set correctly</p> <p>0x0100 — Fiber rejected polarization PD error</p> <p>0x0200 — Fiber rejected PD limits not set</p> <p>0x0400 — % of the fiber light that is in the wrong polarization is too large</p> <p>0x0800 — Power transmitted by fiber in the correct polarization to interfere with ALS laser is too small</p> <p>0x1000 — Laser IR power PD error</p> <p>0x2000 — Laser IR power PD limits not set</p> <p>0x4000 — Locking PD error</p> <p>0x8000 — Locking PD limits not set</p> <p>0x00010000 — Noise eater oscillating</p> <p>0x00020000 — Phase Frequency Discriminator Error</p> <p>0x00040000 — Beat note power too low</p> <p>0x00080000 — Beat note out of range of frequency comparator</p> <p>0x00100000 — Laser Error</p> <p>0x00200000 — Temperature feedback limits reached</p>

	0x00400000 — Laser far above PSL, manually tune 0x00800000 — Laser far below PSL, manually tune 0x01000000 — Was not able to determine if ALS laser is above or below PSL frequency 0x02000000 — Auto Locker Failed, check message
Library Dependencies	ErrorHandler, SaveRestore, ReadADC, WriteDAC, DCPower, Demodulator, ALSLaser, CommonModeServo, TTFSSv4

1 Library Description

This library includes an autolocker for the ALS end station lasers, as well as a function block called temperature controls taken from Alexa Staley's ALSLaser library that implements a slow servo feeding back to the laser crystal temperature.

The use of this library has been extended to lock the squeezer laser. The main difference is that the nominal beat note frequency is twice the VCO frequency, where it is half for the ALS.

It implements the following equation, which results in a 1/f filter if TemperatureControls.PF is zero OR a 1/f response with a zero at Pf, which is intended to compensate for the thermal pole of the laser crystal:

$$u_i = u_{i-1} + g \times \begin{cases} e_i & h \leq 0 \\ (e_i - e_{i-1})/h & h > 0 \end{cases} \text{ with}$$

$$g = \pi f_{ugf} \Delta t \text{ and } h = \pi f_{Pf} \Delta t.$$

Δt : sampling interval,

f_{ugf} : unity gain frequency of integrator,

f_{Pf} : Knee frequency of proportional gain.

There is also a polarity switch that reverses the sign of the feedback, and an enum (TemperatureControls.ErrorSignal) which allows the user to choose what to use as an error signal: the options are the beat note frequency error measured by the frequency comparator ($\text{beat.frequency} - \text{beat.vcofrequency}/2$), the signal sent to the laser PZT calibrated in MHz, or the fast mon from the servo, also calibrated in MHz. There is also a reset that clears the integrator, and range limits for the output of the slow feedback.

The library also includes an error checking function block called locking conditions, which checks for a large number of error conditions that may prevent the PLL from locking, and sets the bit Logic.Conditions to FALSE if any of the locking conditions are not met.

The variable 'locked' is set to true if the common mode servo is not saturated and the beatnote is within tolerance.

A state diagram for the autolocker is below. The user can enable the autolocker so that it will run when the locking conditions are met, or force it so that it will disregard errors from the locking conditions function block. The user can also choose a polarity to lock the ALS laser above or below the PSL in frequency. This sets the polarity on the servo, the phase frequency discriminator, and the temperature feedback.

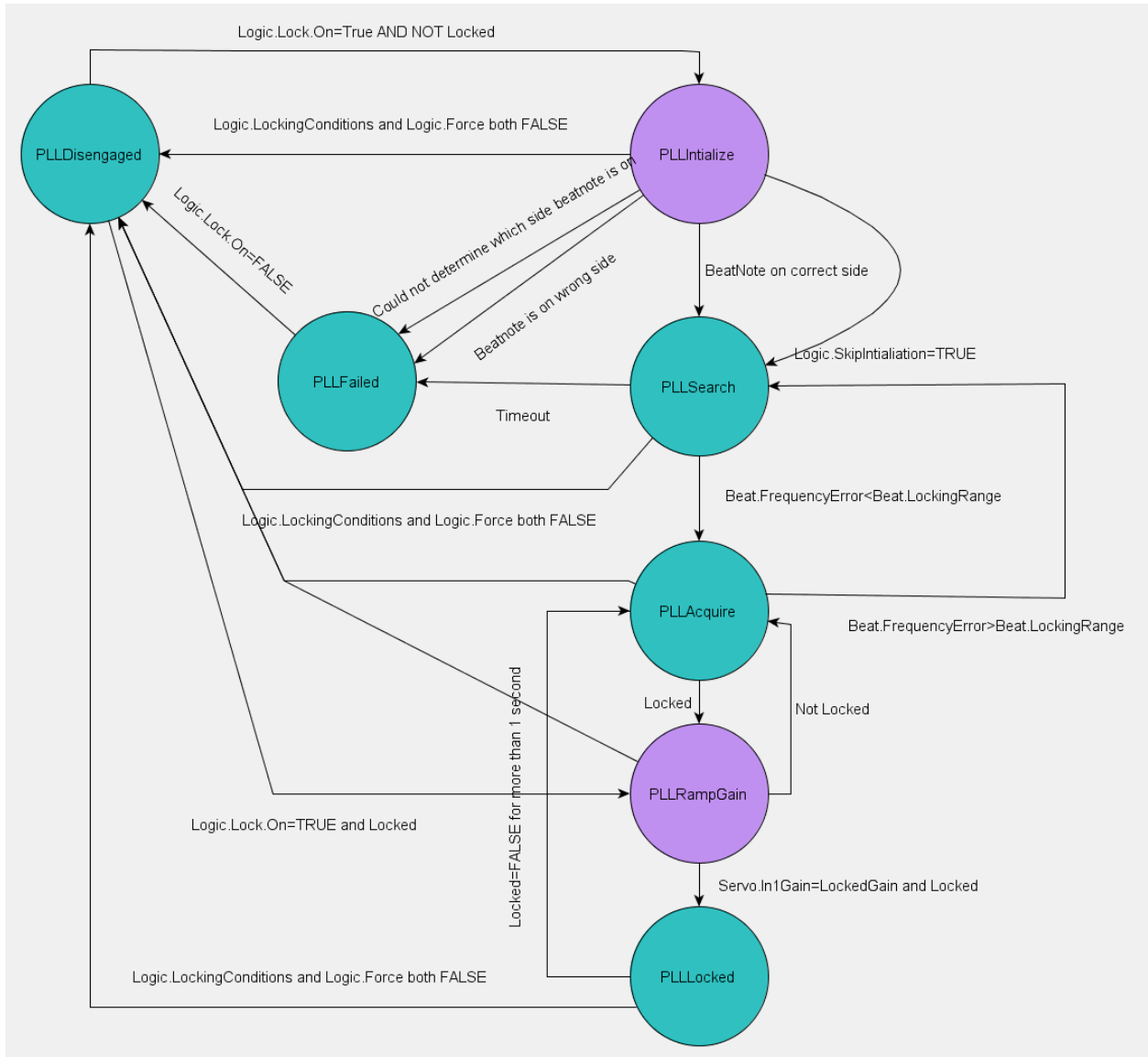


Figure 1: State diagram for PLL autolocking, transitional states in purple

When the autolocker state machine begins running, it either passes to the PLLInitialize state, if the PLL is unlocked or to the PLLGainRamp state, if it is locked.

The user can choose to skip initialization or to initialize the autolocker, in which case it begins by increasing the laser crystal temperature, waiting 30 seconds and determining based on the response of the beat note measured by the frequency comparator if the laser is above or below the PSL in frequency. If the laser is on the wrong side, or the autolocker cannot determine what side it is on, it goes to the failed state, and the user needs to manually tune the crystal temperature. Once the temperature is manually tuned the user can disengage the autolocker and re-engage it to begin the locking process.

When the laser is on the correct side, the autolocker passes to the PLLSearch state, and uses the temperature servo with the beat note measured by the frequency comparator as an error signal, with the common mode board feedback to the PZT disengaged. If the beat note error become less

than beat.LockingRange the state machine passes to PLLacquire, or if 20 minutes pass without the beatnote coming into range the autolocker goes to the PLLfailed state.

In the PLLacquire state the common mode board feeds back to the laser PZT with low gain and the temperature servo continues to use the beatnote error as measured by the frequency comparator as an error signal. If the beat notes goes out of the locking range, the state returns to PLLSearch, if the PLL locks it passes to PLLRampGain.

In PLLRampGain the temperature servo error signal is switched to the PZT feedback, and the input gain of the common mode board is ramped at 1dB per second until it reaches the gain used for locking. If the PLL is locked at the locking gain for 1 second, the state transitions to PLLLocked,

It will stay in the locked state unless the PLL becomes unlocked for more than 1 second, in which case it passes to PLLacquire, or if the locking conditions are no longer met it will pass to disengaged.

2 Example:

```

Comm.CommunicationError := Ifo.Sys.Communication.Y.Error <> 16#03;
Comm.VCOFrequency := RecieveFromCornerPLC1.VCOFrequency;
Comm.BeatFrequency:= RecieveFromCornerPLC1.BeatFrequency;
Comm.SplitMonFrequency:=
  Ifo.ALS.End.Fibr.Servo.SplitMon*(-0.979)*
  EXP(Ifo.ALS.End.Fibr.Servo.FastGain*LN(10)/20)*
  Ifo.ALS.End.Laser.Head.PZTTuningCoefficient;
Comm.CoarseFrequencyCheck := Ifo.ALS.End.Refl.Servo.In1En;
Comm.PZTVoltageInRange:= Abs(Ifo.ALS.End.Fibr.Servo.FastMon) < 9.99;
Comm.RefCavTransError := RecieveFromCornerPLC2.RefCavTransError;
...
AlsEndFibrLockFB (
  LaserType:=LLTypeALS,
  Request:=Request,
  Comm:=Comm,
  LaserLocking := Ifo.ALS.End.Fibr.Lock,
  LaserLockingInit := AlsEndFibrLockInit,
  FiberTrans:=Ifo.ALS.End.Fibr.Trans.Dc,
  FiberRejected:=Ifo.ALS.End.Fibr.Rejected.Dc,
  LaserIR:=Ifo.ALS.End.Laser.Ir.Dc,
  Fiber_A:=Ifo.ALS.End.Fiber_A.Dc,
  ALSLaser:=Ifo.ALS.End.Laser.Head,
  Demod := Ifo.ALS.End.Fibr_A.Demod,
  Servo := Ifo.ALS.End.Fibr.Servo);

```

3 LaserLocking Interface

Laser Type TYPE LaserLockingTypeEnum : (LLTypeALS, LLTypeSqueezer) END_TYPE;	
Type Name	LaserLockingTypeEnum
Description	Specifies the laser that has to be locked: ALS or Squeezer
Definition	ENUM
Element	Name: LLTypeALS Description: ALS laser
Element	Name: LLTypeSqueezer Description: Squeezer laser

Laser Locking State TYPE LaserLockingStateEnum : (PLLDisengaged, PLLInitialize, PLLSearch, PLLAcquire, PLLRampGain, PLLLocked, PLLFailed) END_TYPE;	
Type Name	LaserLockingStateEnum
Description	Specifies the state for the PLL
Definition	ENUM
Element	Name: PLLDisengaged Description: The autolocker is disengaged
Element	Name: PLLInitialize Description: Initialize the PLL autolocker
Element	Name: PLLSearch Description: Searching for resonance
Element	Name: PLLAcquire Description: PLL lock is acquired
Element	Name: PLLRampGain Description: Increase the gain of the PLL Common Mode Board
Element	Name: PLLLocked Description: PLL is locked
Element	Name: PLLFailed Description: Autolocker has failed to lock the auxiliary laser

Temperature Servo Error Signal	
TYPE TemperatureErrorSignalEnum : (PZTfrequency, BeatNoteError, SplitMon) END_TYPE;	
Type Name	TemperatureErrorSignalEnum
Description	Allows the user to specify what to use as an error signal for the temperature feedback
Definition	ENUM
Element	Name: PZTfrequency Description: Laser PZT actuation
Element	Name: BeatNoteError Description: Difference between the beat note and half the VCO frequency
Element	Name: SplitMon Description: Split mon of the common mode board which can be used when fast feedback is engaged

Laser Locking Servo Request	
TYPE LaserLockingServoRequestEnum : (LLServoNoOp, LLServoTurnOff, LLServoTurnOn, LLServoRampGain); END_TYPE;	
Type Name	LaserLockingServoRequestEnum
Description	Request to the laser locking servo
Definition	ENUM
Element	Name: LLServoNoOp Description: No operation
Element	Name: LLServoTurnOff Description: Turn servo off
Element	Name: LLServoTurnOn Description: Turn servo on in acquire mode
Element	Name: LLServoTurnRampGain Description: Ramp servo gain up and engage boosts

Laser Locking Servo State	
TYPE LaserLockingServoStateEnum : (LLServoInactive, LLServoBusy, LLServoFail); END_TYPE	
Type Name	LaserLockingServoStateEnum
Description	State of the laser locking servo
Definition	ENUM
Element	Name: LLServoInactive Description: No operation
Element	Name: LLServoBusy Description: Servo locking logic is busy
Element	Name: LLServoFail Description: Servo locking logic has failed

Laser Locking Servo State	
TYPE LaserLockingTtFssRequestEnum : (LLTtFssNoOp, LLTtFssFastBoostWait, LLTtFssLockWait, LLTtFssFastFilterWait, LLTtFssEomWait, LLTtFssComBoostWait); END_TYPE	
Type Name	LaserLockingTtFssRequestEnum
Description	Internal state of the servo locking logic
Definition	ENUM
Element	Name: LLTtFssNoOp Description: No operation
Element	Name: LLTtFssFastBoostWait Description: Wait before engaging the fast boost
Element	Name: LLTtFssLockWait Description: Wait for the servo to lock properly
Element	Name: LLTtFssFastFilterWait Description: Wait before engaging the fast filter
Element	Name: LLTtFssEomWait Description: Wait before engaging the eom path
Element	Name: LLTtFssComBoostWait Description: Wait before engaging the common boost

Laser Type TYPE FiberTransMonitorEnum: (FiberTransMonitorTotal, FiberTransMonitorCorrectPol) END_TYPE;	
Type Name	FiberTransMonitorEnum
Description	Specifies if the fiber trans PD measures the total power out of the fiber or just the light in the correct polarization
Definition	ENUM
Element	Name: FiberTransMonitorTotal Description: Fiber Trans PD measures the total power out of the fiber
Element	Name: FiberTransMonitorCorrectPol Description: Fiber Trans PD measures the power in the correct polarization

User Interface Type	
TYPE LaserLockingStatusStruct:	
STRUCT	
Message: STRING;	
Locked: BOOL;	
CoarseLocked: BOOL;	
LockLosses: INT;	
ResetLockLosses: BOOL;	
END_STRUCT;	
END_TYPE;	
Type Name	LaserLockingStatusStruct
Description	Structure used to represent status of laser locking
Definition	STRUCT
Output Tag	Name: Message Type: STRING Description: Message for operator
Output Tag	Name: Locked Type: BOOL Description: PLL is locked
Output Tag	Name: CoarseLocked Type: BOOL Description: PLL is coarsely locked
Output Tag	Name: LockLosses Type: INT Description: Counts the number of times lock has been lost
Input Tag	Name: ResetLockLosses Type: BOOL Description: Resets the lock loss counter

Auxiliary Interface Type TYPE LaserLockingRefCavStruct : STRUCT TransLim: LREAL; END_STRUCT; END_TYPE;	
Type Name	LaserLockingRefCavStruct
Description	Structure used in the user interface type to check the reference cavity
Definition	STRUCT
Input Tag	Name: TransLim Type: LREAL Description: Lower limit for ref cav power

Auxiliary Interface Type	
TYPE LaserLockingFiberStruct :	
STRUCT	
LaunchLim: LREAL;	
PolarizationPercent: LREAL;	
PolLim: LREAL = 30;	
TransRightPol: LREAL;	
TransRightPolLim: LREAL;	
END_STRUCT;	
END_TYPE;	
Type Name	LaserLockingFiberStruct
Description	Structure used in the user interface type to check the fiber transmission
Definition	STRUCT
Input Tag	Name: LaunchLim Type: LREAL Description: Lower limit for launched fiber power
Input Tag	Name: PolarizationPercent Type: LREAL Description: Fiber trans in the wrong polarization
Input Tag	Name: PolLim Type: LREAL Description: Limit for wrong polarization light
Output Tag	Name: TransRightPol Type: LREAL Description: Fiber trans power in right polarization
Input Tag	Name: TransRightPolLim Type: LREAL Description: Fiber trans power in right polarization limit

Auxiliary Interface Type	
TYPE LaserLockingBeatNoteStruct :	
STRUCT	
RFAmp: LREAL;	
RFMin: LREAL;	
Frequency: LREAL;	
VcoFrequency: LREAL;	
Tolerance: LREAL;	
LockingRange: LREAL;	
Low: LREAL;	
High: LREAL;	
FrequencyError: LREAL;	
END_STRUCT;	
END_TYPE;	
Type Name	LaserLockingBeatNoteStruct
Description	Structure used in the user interface type to control the autolocker
Definition	STRUCT
Output Tag	Name: RFAmp Type: LREAL Description: Beat note strength in dBm
In/Out Tag	Name: RFMin Type: LREAL Description: Beat note threshold
Output Tag	Name: Frequency Type: LREAL Description: Beat note frequency
Output Tag	Name: VcoFrequency Type: LREAL Description: VCO frequency
In/Out Tag	Name: Tolerance Type: LREAL Description: Beat note frequency tolerance
Output Tag	Name: LockingRange Type: LREAL Description: Frequency range for locking
Output Tag	Name: Low Type: LREAL Description: Low cut-off for acquisition

Output Tag	Name: High Type: LREAL Description: High cut-off for acquisition
Input Tag	Name: FrequencyError Type: LREAL Description: Frequency error of beat note

Auxiliary Interface Type	
TYPE LaserLockingLogicStruct :	
STRUCT	
Conditions: BOOL;	
Enable: BOOL;	
Force: BOOL;	
IgnorePSL: BOOL;	
On: BOOL;	
Polarity: BOOL;	
SkipInitialization: BOOL;	
END_STRUCT;	
END_TYPE;	
Type Name	LaserLockingLogicStruct
Description	Structure used in the user interface type to control the laser locking logic
Definition	STRUCT
Output Tag	Name: Conditions Type: BOOL Description: Pre-conditions for locking
Input Tag	Name: Enable Type: BOOL Description: Enable autolocker
Input Tag	Name: Force Type: BOOL Description: Force autolocker on even if conditions are not met
Input Tag	Name: IgnorePSL Type: BOOL Description: Ignored PSL conditions
Output Tag	Name: On Type: BOOL Description: Autolocker is on
Input Tag	Name: Polarity Type: BOOL Description: Polarity for laser PLL
Input Tag	Name: SkipInitialization Type: BOOL Description: Check laser on right size

Auxiliary Interface Type	
TYPE TemperatureControlsStruct :	
STRUCT	
On: BOOL;	
Enabled: BOOL;	
Run: BOOL;	
Reset: BOOL;	
Low: LREAL;	
High: LREAL;	
Range: BOOL;	
Ugf: LREAL;	
Pf: LREAL;	
Polarity: BOOL;	
ErrorSignal: TemperatureErrorSignalEnum;	
END_STRUCT;	
END_TYPE;	
Type Name	TemperatureControlsStruct
Description	Structure used in the user interface type to control the laser temperature
Definition	STRUCT
Input Tag	Name: On Type: BOOL Description: On/off button
Input Tag	Name: Enabled Type: BOOL Description: Controls enabled button
Output Tag	Name: Run Type: BOOL Description: Temperature feedback running
Input Tag	Name: Reset Type: BOOL Description: Reset the integrator
Input Tag	Name: Low Type: LREAL Description: Low control value in Hz
Input Tag	Name: High Type: LREAL Description: High control value in Hz
Input Tag	Name: Range Type: BOOL Description: Controls range exceeded

Output Tag	Name: Ugf Type: LREAL Description: Unity gain frequency in Hz
Output Tag	Name: Pf Type: LREAL Description: Knee of proportional gain in Hz
Output Tag	Name: Polarity Type: BOOL Description: Polarity of slow feedback
Input/Output Tag	Name: ErrorSignal Type: TemperatureErrorSignalEnum Description: Error signal for temperature feedback

Auxiliary Input Type	
TYPE LaserLockingCommStruct :	
STRUCT	
CommunicationError:	BOOL := TRUE;
VCOFrequency:	LREAL := 0;
BeatFrequency:	LREAL := 0;
RfAmp:	LREAL := -100;
SplitMonFrequency:	LREAL := 0;
CoarseFrequencyCheck:	BOOL := FALSE;
PZTVoltageInRange:	BOOL := TRUE;
RefCavTransError:	BOOL := TRUE;
RefCavTransNorm:	LREAL := 0;
FiberLaunchError:	BOOL := TRUE;
FiberLaunchNorm:	LREAL := 0;
FiberDistErr:	BOOL := TRUE;
END_STRUCT	
END_TYPE;	
Type Name	LaserLockingCommStruct
Description	Structure used as input to the laser locking function block. It contains frequency readbacks and the state of the reference cavity.
Definition	STRUCT
Input Tag	Name: CommunicationError Type: BOOL Description: True, if a communication error prevented good input data
Input Tag	Name: VCOFrequency Type: LREAL Description: Readback of the VCO frequency
Input Tag	Name: BeatFrequency Type: LREAL Description: Readback of the beat note frequency
Input Tag	Name: RfAmp Type: LREAL Description: Readback of the beat note strength
Input Tag	Name: SplitMonFrequency Type: LREAL Description: PZT frequency offset derived from the CM split monitor
Input Tag	Name: CoarseFrequencyCheck Type: BOOL Description: Uses a coarser frequency check for lock condition. Useful, when VCO is used as a laser frequency actuator.

Input Tag	Name: PZTVoltageInRange Type: BOOL Description: True, when the PZT voltage isn't railed.
Input Tag	Name: RefCavTransError Type: BOOL Description: Reference cavity transmission PD is in error
Input Tag	Name: RefCavTransNorm Type: LREAL Description: Normalized reference cavity transmission
Input Tag	Name: FiberLaunchError Type: BOOL Description: Fiber launch PD is in error
Input Tag	Name: FiberLaunchNorm Type: LREAL Description: Normalized fiber launching power
Input Tag	Name: FiberDistErr Type: BOOL Description: Error in the fiber distribution subsystem

User Interface Type	
TYPE LaserLockingStruct :	
STRUCT	
Error: ErrorStruct;	
State: LaserLockingEnum;	
Status: LaserLockingStatusStruct;	
RefCav: LaserLockingRefCavStruct;	
Fiber: LaserLockingFiberStruct;	
Beat: LaserLockingBeatNoteStruct;	
Logic: LaserLockingLogicStruct;	
TemperatureControls: TemperatureControlsStruct;	
END_STRUCT;	
END_TYPE;	
Type Name	LaserLockingStruct
Description	Structure used in the user interface type to control the laser locking
Definition	STRUCT
Output Tag	Name: Error Type: ErrorStruct Description: Error information
Output Tag	Name: State Type: LaserLockingEnum Description: Autolocker state
Input/Output Tag	Name: Status Type: LaserLockingRefCavStruct Description: Structure of limits and calculations for the reference cavity
Input/Output Tag	Name: RefCav Type: LaserLockingStatusStruct Description: Structure of limits and calculations for the reference cavity
Input/Output Tag	Name: Fiber Type: LaserLockingFiberStruct Description: Structure of limits and calculations for fiber transmission
Input/Output Tag	Name: Beat Type: LaserLockingBeatNoteStruct Description: Structure for achieving a beat note
Input/Output Tag	Name: Logic Type: LaserLockingLogicStruct Description: Structure for logic behind autolocker
Input/Output Tag	Name: TemperatureControls Type: TemperatureControlsStruct Description: Temperature controls structure

Function Block	
TYPE LaserLockingFB :	
VAR_INPUT	
LaserType:	LaserLockingTypeEnum;
Request:	SaveRestoreEnum;
Comm:	LaserLockingCommStruct;
Demod:	DemodulatorLscStruct;
FiberTransMon:	FiberTransMonitorEnum := FiberTransMonitorTotal;
FiberTrans:	DCPowerStruct;
FiberRejected:	DCPowerStruct;
LaserIR:	DCPowerStruct;
Fibr_A:	DCPowerStruct;
ServoState:	LaserLockingServoStateEnum := LLServoinactive;
END_VAR;	
VAR_IN_OUT	
Laser:	LaserStruct;
LaserLockingInit:	LaserLockingStruct;
LaserLocking:	LaserLockingStruct;
END_VAR;	
VAR_OUTPUT	
ServoRequest:	LaserLockingServoRequestEnum;
END_VAR	
END_TYPE;	
Type Name	LaserLockingFB
Description	Function block for the autolocker
Definition	Function Block
Input Argument	Name: Request Type: SaveRestoreEnum Description: Request save/restore/safemood or noop
Input Argument	Name: Comm Type: LaserLockingCommStruct Description: Common external parameters for laser locking
Input Argument	Name: Demod Type: DemodulatorLscStruct Description: Demodulator structure for laser locking error signal
Input Argument	Name: FiberTransMon Type: FiberTransMonitorEnum Description: Specifies what light the Fiber Trans PD measures
Input Argument	Name: FiberTrans Type: DCPowerStruct Description: PD monitoring total fiber transmission power

Input Argument	Name: FiberRejected Type: DCPower Struct Description: PD monitoring total fiber rejected power
Input Argument	Name: LaserIR Type: DCPowerStruct Description: PD monitoring the ALS laser power in IR path
Input Argument	Name: Fibr_A Type: DCPowerStruct Description: DC output of broad band PD
Input Argument	Name: ServoState Type: LaserLockingServoStateEnum Description: State of top level servo controller
Input Argument	Name: PDHServo Type: CommonModeStruct Description: User interface structure
In/Out Argument	Name: Laser Type: ALSlaserStruct Description: User interface structure
In/Out Argument	Name: LaserLockingInit Type: AlsLaserLockingStruct Description: Save/restore variable in persistent memory
In/Out Argument	Name: LaserLocking Type: ALSLaserLockingStruct Description: User interface structure
Out Argument	Name: ServoRequest Type: LaserLockingServoRequestEnum Description: Request to top level servo controller

4 Configurations

4.1 Common Mode Servo

User Interface Type TYPE LaserLockingCMConfStruct: STRUCT ServoRequest: LaserLockingServoRequestEnum; SelectInput: BOOL; AcquireGain: INT; LockedGain: INT; BoostOn: BOOL; END_STRUCT; END_TYPE;	
Type Name	LaserLockingCMConfStruct
Description	Structure used in the user interface the servo board
Definition	STRUCT
Output Tag	Name: ServoRequest Type: LaserLockingServoRequestEnum Description: Request by the (generic) auto locker to the PLL servo locking logic
Input Tag	Name: SelectInput Type: BOOL Description: Use In2 (True) or In1 (False) of the servo board
Input Tag	Name: AcquireGain Type: INT Description: Acquire gain in dB
Input Tag	Name: LockedGain Type: INT Description: Gain when locked in dB
Input Tag	Name: BoostOn Type: BOOL Description: Use boost gain stage in servo

User Interface Type	
TYPE LaserLockingCMStruct :	
STRUCT	
Error:	ErrorStruct;
State:	LaserLockingEnum;
Status:	LaserLockingStatusStruct;
RefCav:	LaserLockingRefCavStruct;
Fiber:	LaserLockingFiberStruct;
Beat:	LaserLockingBeatNoteStruct;
Logic:	LaserLockingLogicStruct;
TemperatureControls:	TemperatureControlsStruct;
Conf:	LaserLockingCMConfStruct;
END_STRUCT;	
END_TYPE;	
Type Name	LaserLockingCMStruct
Description	Extends the Laser Locking Structure
Definition	STRUCT
Input/Output Tag	Name: Conf Type: LaserLockingCMConfStruct Description: Structure of servo parameters for acquiring lock

Function Block TYPE LaserLockingCMFB : VAR_INPUT LaserType: LaserLockingTypeEnum; Request: SaveRestoreEnum; Comm: LaserLockingCommStruct; Demod: DemodulatorLscStruct; FiberTransMon: FiberTransMonitorEnum := FiberTransMonitorTotal; FiberTrans: DCPowerStruct; FiberRejected: DCPowerStruct; LaserIR: DCPowerStruct; Fibr_A: DCPowerStruct; END_VAR; VAR_IN_OUT Laser: ALSLaserStruct; LaserLockingInit: LaserLockingCMStruct; LaserLocking: LaserLockingCMStruct; Servo: CommonModeStruct; END_VAR; END_TYPE;	
Type Name	LaserLockingCMFB
Description	Function block for the autolocker using a common mode board Extends the functionality of the LaserLocking FB by adding the specific locking controls for a common mode board. The two parameters ServoRequest and ServoBusy have been dropped, but a parameter for the servo controls has been added.
Definition	Function Block
In/Out Argument	Name: Servo Type: CommonModeStruct Description: Controls for the servo board

4.2 TTFSS V4 Servo

User Interface Type	
TYPE LaserLockingTtFssConfStruct:	
STRUCT	
ServoRequest: LaserLockingServoRequestEnum;	
LockingRequest: LaserLockingTtFssRequestEnum;	
ComAcquireGain: LREAL;	
ComSwitchGain: LREAL;	
ComLockedGain: LREAL;	
FastAcquireGain: LREAL;	
FastLockedGain: LREAL;	
UseFastBoost: BOOL;	
FastBoostDelay: LREAL;	
FastLockTimeout: LREAL;	
UseFastFilter: BOOL;	
FastFilterDelay: LREAL;	
UseEomPath: BOOL;	
EnableEomDelay: LREAL;	
UseComBoost: BOOL;	
DisableAntiBoost: BOOL;	
ComBoostDelay: LREAL;	
END_TYPE;	
Type Name	LaserLockingTtFssConfStruct
Description	Structure used in the user interface the servo board
Definition	STRUCT
Output Tag	Name: ServoRequest Type: LaserLockingServoRequestEnum Description: Request by the (generic) auto locker to the PLL servo locking logic
Output Tag	Name: LockingRequest Type: LaserLockingTtFssRequestEnum Description: State of the servo locking logic
Input Tag	Name: ComAcquireGain Type: LREAL Description: Common gain during acquire in dB
Input Tag	Name: ComSwitchGain Type: LREAL Description: Common gain when switching on the EOM path in dB
Input Tag	Name: ComLockedGain Type: LREAL Description: Common gain when locked in dB

Input Tag	Name: FastAcquireGain Type: LREAL Description: Fast gain during acquire and EOM switch in dB
Input Tag	Name: FastLockedGain Type: LREAL Description: Fast gain when locked in dB
Input Tag	Name: UseFastBoost Type: BOOL Description: Use the fast boost gain stage of the servo
Input Tag	Name: FastBoostDelay Type: LREAL Description: Time to wait before engaging the fast boost in sec
Input Tag	Name: FastLockTimeout Type: LREAL Description: Timeout in sec for the beat note frequency to reach the locked state after fast boost is engaged
Input Tag	Name: UseFastFilter Type: BOOL Description: Use the fast filter stage of the servo
Input Tag	Name: FastFilterDelay Type: LREAL Description: Time to wait before engaging the fast filter stage in sec
Input Tag	Name: UseEomPath Type: BOOL Description: Use the EOM path of the servo
Input Tag	Name: EnableEomDelay Type: LREAL Description: Time to wait before engaging the EOM path in sec
Input Tag	Name: UseComBoost Type: BOOL Description: Use the common boost stage of the servo
Input Tag	Name: DisableAntiBoost Type: BOOL Description: Disable the anti-boost stage of the servo, the anti-boost stage is required to make a PFD loop stable (compared to the demodulator locking to a cavity). When the anti-boost is disabled it acts as an additional boost.
Input Tag	Name: ComBoostDelay Type: LREAL Description: Time to wait before engaging the common boost stage and disabling the anti-boost stage in sec

<p>User Interface Type</p> <p>TYPE LaserLockingTtFssStruct :</p> <p>STRUCT</p> <p> Error: ErrorStruct;</p> <p> State: LaserLockingEnum;</p> <p> Status: LaserLockingStatusStruct;</p> <p> RefCav: LaserLockingRefCavStruct;</p> <p> Fiber: LaserLockingFiberStruct;</p> <p> Beat: LaserLockingBeatNoteStruct;</p> <p> Logic: LaserLockingLogicStruct;</p> <p> TemperatureControls: TemperatureControlsStruct;</p> <p> Conf: LaserLockingTtFssConfStruct;</p> <p>END_STRUCT;</p> <p>END_TYPE;</p>	
Type Name	LaserLockingTtFssStruct
Description	Extends the Laser Locking Structure
Definition	STRUCT
Input/Output Tag	Name: Conf Type: LaserLockingTtFssConfStruct Description: Structure of servo parameters for acquiring lock

Function Block TYPE LaserLockingTtFssFB : VAR_INPUT LaserType: LaserLockingTypeEnum; Request: SaveRestoreEnum; Comm: LaserLockingCommStruct; Demod: DemodulatorLscStruct; FiberTrans: DCPowerStruct; FiberRejected: DCPowerStruct; LaserIR: DCPowerStruct; Fibr_A: DCPowerStruct; END_VAR; VAR_IN_OUT Laser: LaserStruct; LaserLockingInit: LaserLockingTtFssStruct; LaserLocking: LaserLockingTtFssStruct; Servo: TtFssV4Struct; END_VAR; END_TYPE;	
Type Name	LaserLockingTtFssFB
Description	Function block for the autolocker using a TTFSS V4 servo. Extends the functionality of the LaserLocking FB by adding the specific locking controls for a TTFSS servo. The two parameters ServoRequest and ServoBusy have been dropped, but a parameter for the servo controls has been added.
Definition	Function Block
In/Out Argument	Name: Servo Type: TtFssV4Struct Description: Controls for the servo board

5 Auxiliary Functions

Function Block TYPE LockingConidtionsFB : VAR_IN_OUT LaserLocking: LaserLockingStruct; ErrorHandler: ErrorHandlerFB; END_VAR VAR_INPUT FiberTrans: DCPowerStruct; FiberRejected: DCPowerStruct; LaserIR: DCPowerStruct; Fibr_A: DCPowerStruct; Comm: LaserLockingCommStruct; Laser: ALSLaserStruct; Demod: DemodulatorLscStruct; END_VAR END_TYPE;	
Type Name	LockingConditionsFB
Description	Function block for the conditions of the autolocker
Definition	Function Block
In/Out Argument	Name: LaserLocking Type: LaserLockingStruct Description: Laser locking user interface
In/Out Argument	Name: ErrorHandler Type: ErrorHandlerFB Description: Error handler
Input Argument	Name: FiberTrans Type: DCPowerStruct Description: PD monitoring total fiber transmission power
Input Argument	Name: FiberRejected Type: DCPower Struct Description: PD monitoring total fiber rejected power
Input Argument	Name: LaserIR Type: DCPowerStruct Description: PD monitoring the ALS laser power in IR path
Input Argument	Name: Fibr_A Type: DCPowerStruct Description: DC output of broad band PD

Input Argument	Name: Comm Type: LaserLockingCommStruct Description: Interace structure for external parameters
Input Argument	Name: Laser Type: ALSlaserStruct Description: User interface structure
Input Argument	Name: Demod Type: DemodulatorLscStruct Description: User interface structure

Function Block TYPE TemperatureControlsFB : VAR_INPUT Request: SaveRestoreEnum; SplitMonFrequency: LREAL; END_VAR; VAR_IN_OUT Laser: ALSLaserStruct; LaserLocking: LaserLockingStruct; END_VAR; END_TYPE;	
Type Name	TemperatureControlsFB
Description	Function block for laser temperature controller
Definition	Function Block
Input Argument	Name: Request Type: SaveRestoreEnum Description: Request save/restore/safemood or noop
Input Argument	Name: SplitMonFrequency Type: LREAL Description: Frequency as measured by the split monitor (CM board)
In/out Argument	Name: ALSLaser Type: ALSLaserStruct Description: User interface type
In/out Argument	Name: ALSLaserLocking Type: ALSLaserLockingStruct Description: User interface type