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LIGO-E1300482-v4 Advanced LIGO 12/5/2018

Laser Locking Library

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| **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 | 0x0001 — Communications error (lost communication from corner PLC1 or cornerPLC2, or there is an error from the timing system)  0x0002 — Reference cavity transmission PD error  0x0004 — Fiber distribution error  0x0008 — Reference cavity transmission below the limit (limit set in this autolocker)  0x0010 — Fiber launch PD error (in the fiber distribution box, internal.DC)  0x0020 — Fiber launch power below the limit (limit set in by the autolocker)  0x0040 — Fiber transmission PD error (the limits are enforced in the DC PD library for the local PDs)  0x0080 — Fiber transmission PD limits not set, they need to be set correctly  0x0100 — Fiber rejected polarization PD error  0x0200 — Fiber rejected PD limits not set  0x0400 — % of the fiber light that is in the wrong polarization is too large  0x0800 — Power transmitted by fiber in the correct polarization to interfere with ALS laser is too small  0x1000 — Laser IR power PD error  0x2000 — Laser IR power PD limits not set  0x4000 — Locking PD error  0x8000 — Locking PD limits not set  0x00010000 — Noise eater oscillating  0x00020000 — Phase Frequency Discriminator Error  0x00040000 — Beat note power too low  0x00080000 — Beat note out of range of frequency comparator  0x00100000 — Laser Error  0x00200000 — Temperature feedback limits reached  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 |

# 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:

with

and .

: sampling interval,

: unity gain frequency of integrator,

: 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 (beat.frequency-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.

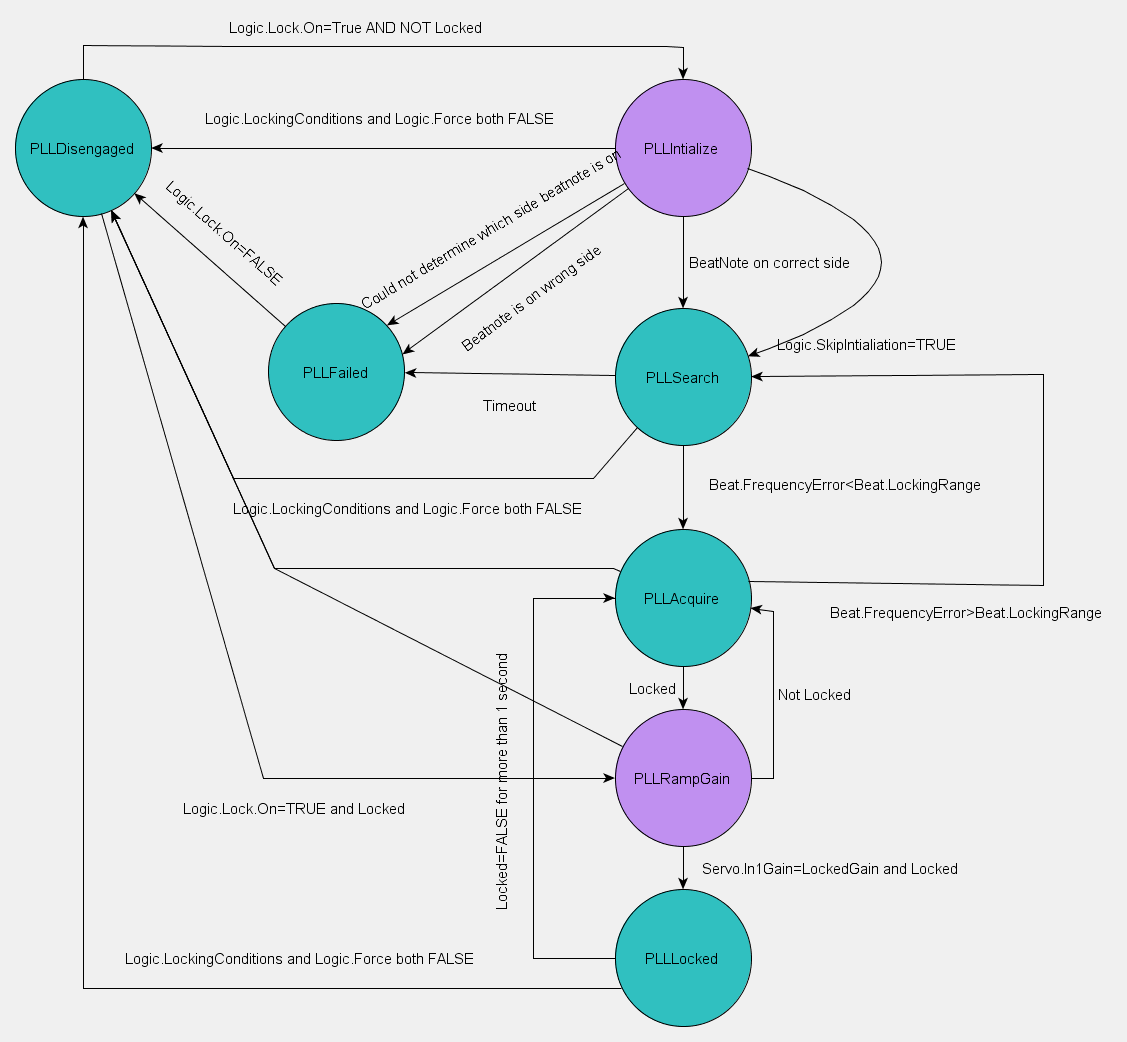


Figure : State diagram for PLL autolocking, transitional states in purple

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 feedsback 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 PLLaquire, or if the locking conditions are no longer met it will pass to disengaged.

# 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);

# LaserLocking Interface

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| **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 |

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| **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 |

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| **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 neat 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 |

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| **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 booosts |

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| **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 |

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| **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 |

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| **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 |

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| **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 |

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| **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 |

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| **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 |

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| **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 |

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| **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 |

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| **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: TemerpatureErrorSignalEnum  Description: Error signal for temperature feedback |

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| **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 |

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| **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 |

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| **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 |

# Configurations

## Common Mode Servo

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| **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 |

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| **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 |

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| **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 |

## TTFSS V4 Servo

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| **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 |

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| **User Interface Type**  TYPE LaserLockingTtFssStruct :  STRUCT  Error: ErrorStruct;  State: LaserLockingEnum;  Status: LaserLockingStatusStruct;  RefCav: LaserLockingRefCavStruct;  Fiber: LaserLockingFiberStruct;  Beat: LaserLockingBeatNoteStruct;  Logic: LaserLockingLogicStruct;  TemperatureControls: TemperatureControlsStruct;  Conf: LaserLockingTtFssConfStruct;  END\_STRUCT;  END\_TYPE; | |
| 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 |

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| **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 |

# Auxiliary Functions

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| **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 |

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| **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 |