*LIGO Laboratory / LIGO Scientific Collaboration*

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TwinCAT Library for
Port Protection

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| **Library** |
| Title | PortProtection |
| Version | 1 |
| TwinCAT version | 2.11 |
| Name space | – |
| Author | Daniel Sigg |
| Description | Monitors and checks the shutter protection for the AS port. This library:* checks for individual shutters,
* provides status logic,
* runs a shutter test upon demand, and
* checks that a high power lock loss triggers the shutters to close.

See [E1600247](https://dcc.ligo.org/LIGO-E1600247) for more details. |
| Error codes | 1 — No test information available (Test was never run)2 — Protection in fault (Test faulted or fault state requested)4 — Power interlock is on (2.5W maximum laser power) |
| Test faults | OK — Last test ran successfulTesting — New test is runningNot Ready — Protection system not ready at start of testNot Closing — Fast and PZT shutters were not closingNot Reopening — Protection system not ready at end of test  (shutters were not reopening)Aborted — Last test was aborted |
| Library dependencies | LaserPower, RotationStage, FastShutterControl, PSZShutterControl,ShutterControl, DCPower, ReadADC, WriteADC, Error, SaveRestore |

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| **Port Protection Status**TYPE PortProtectionStatusEnum : (PPS\_OK, PPS\_Fault, PPS\_Init, PPS\_Testing);END\_TYPE |
| Type name | PortProtectionStatusEnum |
| Description | Enumerates over port protection status |
| Definition | ENUM |
| Element | Name: PPS\_OKDescription: Port protection is OK |
| Element | Name: PPS\_FaultDescription: Port protection is in fault |
| Element | Name: PPS\_InitDescription: Port protection is in initialization state |
| Element | Name: PPS\_TestingDescription: Port protection is testing |

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| **Port Protection Faults**TYPE PortProtectionFaultEnum : (No\_Fault, Fault\_Testing, Fault\_Not\_Ready, Fault\_Not\_Closing,  Fault\_Not\_Reopening, Fault\_Aborted);END\_TYPE |
| Type name | PortProtectionFaultEnum |
| Description | Enumerates over port protection fault states |
| Definition | ENUM |
| Element | Name: No\_FaultDescription: Port protection test ran OK |
| Element | Name: Fault\_TestingDescription: Port protection test is running |
| Element | Name: Fault\_Not\_ReadyDescription: Protection system was not ready at start of test |
| Element | Name: Fault\_Not\_ClosingDescription: Fast and PZT shutters were not closing |
| Element | Name: Fault\_Not\_ReopeningDescription: Protection system was not ready at end of test (shutters were not reopening) |
| Element | Name: Fault\_AbortedDescription: Last test was aborted by user |

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| **User Interface Type**TYPE PortProtectionStatisticsStruct :STRUCT Total: UDINT; Successful: UDINT; Failed: UDINT; LastTime: TIMESTRUCT; LastTimeStr: STRING; ElapsedTime: UDINT; LastResult: BOOL; Reset: BOOL;END\_STRUCTEND\_TYPE |
| Type name | PortProtectionStatisticsStruct |
| Description | Structure of the user interface which describes a set of statistics values associated with the success of the protection tests and the results from lock loss analysis |
| Definition | STRUCT |
| Output Tag | Name: TotalType: UDINTDescription: Total number of test runs/lock loss triggers |
| Output Tag | Name: SuccessfulType: UDINTDescription: Number of successful test runs/lock loss triggers |
| Output Tag | Name: FailedType: UDINTDescription: Number of failed test runs/lock loss triggers |
| Output Tag | Name: LastTimeType: TIMESTRUCTDescription: Time of last test run/lock loss |
| Output Tag | Name: LastTimeStrType: STRINGDescription: Time of last test run/lock loss (string) |
| Output Tag | Name: ElapsedTimeType: UDINTDescription: Time elapsed since last test run/lock loss (sec) |
| Output Tag | Name: LastResultType: BOOLDescription: Result (success) of last test run/lock loss trigger |
| Input Tag | Name: ResetType: BOOLDescription: Reset the statistics counters back to zero |

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| **User Interface Type**TYPE ASPortProtectionStruct :STRUCT Error: ErrorStruct; Status: PortProtectionStatusEnum;  FaultType: PortProtectionFaultEnum;  RunTest: BOOL;  SetToFault: BOOL; Tests: PortProtectionStatisticsStruct; TriggerPresent: BOOL; TriggerPD: BOOL;  FastShutterReady: BOOL;  PztShutterOpen: BOOL; LowPowerReady: BOOL; FastShutterBlocked: BOOL; PztShutterClosed: BOOL;  BothShutterClosed: BOOL;  TestOutdated: BOOL; TestNeeded: BOOL;  PowerInterlock: BOOL;  HighPowerLock: BOOL; LockLoss: PortProtectionStatisticsStruct;END\_STRUCTEND\_TYPE |
| Type name | ASPortProtectionStruct |
| Description | Structure of the user interface which describes the anti-symmetric port protection system |
| Definition | STRUCT |
| Output Tag | Name: ErrorType: ErrorStructDescription: Error messages and code |
| Output Tag | Name: StatusType: PortProtectionStatusEnumDescription: Status of the AS protection system |
| Output Tag | Name: FaultTypeType: PortProtectionFaultEnumDescription: Type of fault during last shutter test run |
| Input Tag | Name: RunTestType: BoolDescription: Set to true to request a test |
| Input Tag | Name: SetToFaultType: BOOLDescription: Set to true to set protection system into fault state |
| Output Tag | Name: TestsType: PortProtectionStatisticsStructDescription: Accumulated success statistics of past test runs |
| Output Tag | Name: TriggerPresentType: BOOLDescription: True if the trigger photodetector is above threshold |
| Output Tag | Name: TriggerPDType: BOOLDescription: Trigger photodetector is at nominal power level for a 2W lock. |
| Output Tag | Name: FastShutterReadyType: BOOLDescription: True if the trigger photodetector is above threshold |
| Output Tag | Name: FastShutterReadyType: BOOLDescription: Fast shutter is ready (no fault and capacitor charged)  |
| Output Tag | Name: PztShutterOpenType: BOOLDescription: The PZT shutter is in the open state (high voltage) |
| Output Tag | Name: LowPowerReadyType: BOOLDescription: AS protection is in the low power ready state, i.e., no trigger present, trigger PD at nominal power, fast shutter ready and the PZT trigger is in open state |
| Output Tag | Name: FastShutterBlockedType: BOOLDescription: Fast shutter is in the blocked state (no light) |
| Output Tag | Name: PztShutterClosedType: BOOLDescription: The PZT shutter is in the closed state (zero voltage) |
| Output Tag | Name: BothShutterClosedType: BOOLDescription: True if fast shutter is blocked and PZT shutter is in closed state |
| Output Tag | Name: TestOutdatedType: BOOLDescription: Last test was more than 48 hours ago |
| Output Tag | Name: TestNeededType: BOOLDescription: True if a test is needed before going to high laser power. The AS protection could be in the fault or initialization state, or the last test was too long ago. |
| Output Tag | Name: PowerInterlockType: BOOLDescription: Indicates that the laser power should be limited to 2.5W. |
| Output Tag | Name: HighPowerLockType: BOOLDescription: Indicates that the interferometer is locked at high power (>2W) |
| Output Tag | Name: LockLossType: PortProtectionStatisticsStructDescription: Accumulated statistics of past high power lock losses. Checks, if both shutters were closed after a lock loss. |

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| **Function Block**FUNCTION\_BLOCK ASPortProtectionFBVAR\_INPUT Request: SaveRestoreEnum; CurrentTime: DT; PZT: PZTShutterStruct;END\_VARVAR\_IN\_OUT AS: ASPortProtectionStruct; Trig: ShutterControlStruct; Fast: FastShutterControlStruct;END\_VARVAR CONSTANT TestLivetime: UDINT := 48; MinHighPower: TIME := TIME#1s; LockLossDelay: UDINT := 50; END\_VAR |
| Name | ASPortProtectionFB |
| Description | AS Port Protection System |
| Input argument | Name: RequestType: SaveRestoreEnumDescription: Request save/restore/safemode or noop |
| Input argument | Name: CurrentTimeType: DTDescription: current date/time |
| Input argument | Name: PZTType: PZTShutterStructDescription: PZT shutter status |
| In/out argument | Name: ASType: ASPortProtectionStructDescription: User Interface structure for AS protection system |
| In/out argument | Name: TrigType: ShutterControlStructDescription: Trigger interface |
| In/out argument | Name: FastType: FastShutterControlStructDescription: Fast shutter interface |
| Constant | Name: TestLivetimeType: UDINTValue: 48Description: Valid lifetime of a test in hours |
| Constant | Name: MinHighPowerType: TIMEValue: 1sDescription: Minimim time the trigger photodiode needs to exceed its high value to count as a high power lock |
| Constant | Name: LockLossDelayType: UDINTValue: 50Description: Delay after a lock loss in number of 10ms-cycles, until the shutters are checked to have closed. This event will update the LockLoss statistics |