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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 successful  Testing — New test is running  Not Ready — Protection system not ready at start of test  Not Closing — Fast and PZT shutters were not closing  Not 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\_OK  Description: Port protection is OK |
| Element | Name: PPS\_Fault  Description: Port protection is in fault |
| Element | Name: PPS\_Init  Description: Port protection is in initialization state |
| Element | Name: PPS\_Testing  Description: 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\_Fault  Description: Port protection test ran OK |
| Element | Name: Fault\_Testing  Description: Port protection test is running |
| Element | Name: Fault\_Not\_Ready  Description: Protection system was not ready at start of test |
| Element | Name: Fault\_Not\_Closing  Description: Fast and PZT shutters were not closing |
| Element | Name: Fault\_Not\_Reopening  Description: Protection system was not ready at end of test (shutters were not reopening) |
| Element | Name: Fault\_Aborted  Description: 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\_STRUCT  END\_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: Total  Type: UDINT  Description: Total number of test runs/lock loss triggers |
| Output Tag | Name: Successful  Type: UDINT  Description: Number of successful test runs/lock loss triggers |
| Output Tag | Name: Failed  Type: UDINT  Description: Number of failed test runs/lock loss triggers |
| Output Tag | Name: LastTime  Type: TIMESTRUCT  Description: Time of last test run/lock loss |
| Output Tag | Name: LastTimeStr  Type: STRING  Description: Time of last test run/lock loss (string) |
| Output Tag | Name: ElapsedTime  Type: UDINT  Description: Time elapsed since last test run/lock loss (sec) |
| Output Tag | Name: LastResult  Type: BOOL  Description: Result (success) of last test run/lock loss trigger |
| Input Tag | Name: Reset  Type: BOOL  Description: 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\_STRUCT  END\_TYPE | |
| Type name | ASPortProtectionStruct |
| Description | Structure of the user interface which describes the anti-symmetric port protection system |
| Definition | STRUCT |
| Output Tag | Name: Error  Type: ErrorStruct  Description: Error messages and code |
| Output Tag | Name: Status  Type: PortProtectionStatusEnum  Description: Status of the AS protection system |
| Output Tag | Name: FaultType  Type: PortProtectionFaultEnum  Description: Type of fault during last shutter test run |
| Input Tag | Name: RunTest  Type: Bool  Description: Set to true to request a test |
| Input Tag | Name: SetToFault  Type: BOOL  Description: Set to true to set protection system into fault state |
| Output Tag | Name: Tests  Type: PortProtectionStatisticsStruct  Description: Accumulated success statistics of past test runs |
| Output Tag | Name: TriggerPresent  Type: BOOL  Description: True if the trigger photodetector is above threshold |
| Output Tag | Name: TriggerPD  Type: BOOL  Description: Trigger photodetector is at nominal power level for a 2W lock. |
| Output Tag | Name: FastShutterReady  Type: BOOL  Description: True if the trigger photodetector is above threshold |
| Output Tag | Name: FastShutterReady  Type: BOOL  Description: Fast shutter is ready (no fault and capacitor charged) |
| Output Tag | Name: PztShutterOpen  Type: BOOL  Description: The PZT shutter is in the open state (high voltage) |
| Output Tag | Name: LowPowerReady  Type: BOOL  Description: 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: FastShutterBlocked  Type: BOOL  Description: Fast shutter is in the blocked state (no light) |
| Output Tag | Name: PztShutterClosed  Type: BOOL  Description: The PZT shutter is in the closed state (zero voltage) |
| Output Tag | Name: BothShutterClosed  Type: BOOL  Description: True if fast shutter is blocked and PZT shutter is in closed state |
| Output Tag | Name: TestOutdated  Type: BOOL  Description: Last test was more than 48 hours ago |
| Output Tag | Name: TestNeeded  Type: BOOL  Description: 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: PowerInterlock  Type: BOOL  Description: Indicates that the laser power should be limited to 2.5W. |
| Output Tag | Name: HighPowerLock  Type: BOOL  Description: Indicates that the interferometer is locked at high power (>2W) |
| Output Tag | Name: LockLoss  Type: PortProtectionStatisticsStruct  Description: 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 ASPortProtectionFB  VAR\_INPUT  Request: SaveRestoreEnum;  CurrentTime: DT;  PZT: PZTShutterStruct;  END\_VAR  VAR\_IN\_OUT  AS: ASPortProtectionStruct;  Trig: ShutterControlStruct;  Fast: FastShutterControlStruct;  END\_VAR  VAR CONSTANT  TestLivetime: UDINT := 48;  MinHighPower: TIME := TIME#1s;  LockLossDelay: UDINT := 50;  END\_VAR | |
| Name | ASPortProtectionFB |
| Description | AS Port Protection System |
| Input argument | Name: Request  Type: SaveRestoreEnum  Description: Request save/restore/safemode or noop |
| Input argument | Name: CurrentTime  Type: DT  Description: current date/time |
| Input argument | Name: PZT  Type: PZTShutterStruct  Description: PZT shutter status |
| In/out argument | Name: AS  Type: ASPortProtectionStruct  Description: User Interface structure for AS protection system |
| In/out argument | Name: Trig  Type: ShutterControlStruct  Description: Trigger interface |
| In/out argument | Name: Fast  Type: FastShutterControlStruct  Description: Fast shutter interface |
| Constant | Name: TestLivetime  Type: UDINT  Value: 48  Description: Valid lifetime of a test in hours |
| Constant | Name: MinHighPower  Type: TIME  Value: 1s  Description: Minimim time the trigger photodiode needs to exceed its high value to count as a high power lock |
| Constant | Name: LockLossDelay  Type: UDINT  Value: 50  Description: 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 |