

*LIGO Laboratory / LIGO Scientific Collaboration*

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TwinCAT Library for  
Port Protection

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of the LIGO Laboratory.

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<b>Library</b>	
Title	PortProtection
Version	1
TwinCAT version	2.11
Name space	–
Author	Daniel Sigg
Description	<p>Monitors and checks the shutter protection for the AS port. This library:</p> <ul style="list-style-type: none"> <li>• checks for individual shutters,</li> <li>• provides status logic,</li> <li>• runs a shutter test upon demand, and</li> <li>• checks that a high power lock loss triggers the shutters to close.</li> </ul> <p>See <a href="#">E1600247</a> for more details.</p>
Error codes	<p>1 — No test information available (Test was never run)</p> <p>2 — Protection in fault (Test faulted or fault state requested)</p> <p>4 — Power interlock is on (2.5W maximum laser power)</p>
Test faults	<p>OK — Last test ran successful</p> <p>Testing — New test is running</p> <p>Not Ready — Protection system not ready at start of test</p> <p>Not Closing — Fast and PZT shutters were not closing</p> <p>Not Reopening — Protection system not ready at end of test (shutters were not reopening)</p> <p>Aborted — Last test was aborted</p>
Library dependencies	LaserPower, RotationStage, FastShutterControl, PSZShutterControl, ShutterControl, DCPower, ReadADC, WriteADC, Error, SaveRestore

<b>Port Protection Status</b>	
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

<b>Port Protection Faults</b>	
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

<b>User Interface Type</b>	
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

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.

<b>Function Block</b> 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: Minimum 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