*LIGO Laboratory / LIGO Scientific Collaboration*

LIGO- E1700243-v2 Advanced LIGO 2/7/2018

TwinCAT Library for   
PZT Driver

Daniel Sigg

Distribution of this document:

LIGO Scientific Collaboration

This is an internal working note  
of the LIGO Laboratory.

|  |  |
| --- | --- |
| **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 | PztDriver |
| Version | 1 |
| TwinCAT version | 2.11 |
| Name space | – |
| Author | Daniel Sigg |
| Description | Interfaces the PZT driver, [D1001200](https://dcc.ligo.org/LIGO-D1001200).  This library provides a function block to support a single channel of the 4‑channel PZT driver. The board has a voltage monitor that represents the PZT output driver voltage, and an offset adjustment. The offset adjustment is controlled locally or externally using the front panel D-sub connector.  Calibration parameters and min/max voltages are used to calibrate the voltage monitor and the offset adjustment.  Each PZT driver also supports optional low and high limits; the user chooses which ones to enforce.  The hardware readbacks of the power ok and external switch are daisy chained among the 4 channels of a board.  Each PZT implements a scan feature with an option trigger to stop the scan. This can be used to scan an optical resonator and trigger on the transmitted power to find a resonance. Both scan and trigger fuinctionality are supported at a fast update rate. |
| Error codes | PZT Driver:  0x01 – Power supply voltages out-of-range  0x02 – External offset adjustment switch  0x04 – PZT gain is zero  0x08 – PZT monitor gain is zero  0x10 – Drive voltage out-of-range  0x20 – PZT voltage too low  0x40 – PZT voltage too high  0x80 – Power limits exceeded (either too low or too high)  0x100 – Scan/trigger error  PZT Scan:  0x01 – Illegal period  0x02 – Trigger error  Trigger:  0x01 – Illegal parameters  0x02 – Timeout |
| Library dependencies | Error, ReadADC, WriteDAC, SaveRestore |

|  |  |
| --- | --- |
| **Hardware Input Type**  TYPE PztDriverInStruct:  STRUCT  Monitor: INT;  PowerOk: BOOL;  External: BOOL;  END\_STRUCT  END\_TYPE | |
| Type name | PztDriverInStruct |
| Description | Structure of the hardware inputs that are wired up for the PZT |
| Definition | STRUCT |
| Element | Name: Monitor  Type: INT  Description: Monitors the PZT voltage |
| Element | Name: PowerOk  Type: BOOL  Description: Voltage monitor readback |
| Element | Name: External  Type: BOOL  Description: Monitors the external switch state |

|  |  |
| --- | --- |
| **Hardware Output Type**  TYPE PztDriverOutStruct:  STRUCT  Offset: INT;  PowerOk: BOOL;  External: BOOL;  END\_STRUCT  END\_TYPE | |
| Type name | PztDriverOutStruct |
| Description | Structure of the hardware output that are wired up for the PZT |
| Definition | STRUCT |
| Element | Name: Offset  Type: INT  Description: Offset applied to the PZT |
| Element | Name: PowerOk  Type: BOOL  Description: Voltage monitor readback (daisy chained from input) |
| Element | Name: External  Type: BOOL  Description: Monitors the external switch state (daisy chained from input) |
| **User Interface Type**  TYPE PztDriverEnum : (HVPZT, MVPZT, LVPZT);  END\_TYPE | |
| Type name | PztDriverEnum |
| Description | List of available PZT driver configurations |
| Definition | ENUM |
| Enum Tag | Name: HVPZT  Description: High voltage PZT driver (-120V to +240V) |
| Enum Tag | Name: MVPZT  Description: Medium voltage PZT driver (-10V to +200V) |
| Enum Tag | Name: LVPZT  Description: Low voltage PZT driver (-10V to +120V) |

|  |  |
| --- | --- |
| **User Interface Type**  TYPE PztDriverLimitsEnum : (PztLimitsNone, PztLimitsLow, PztLimitsHigh, PztLimitsHiLo);  END\_TYPE | |
| Type name | PztDriverLimitsEnum |
| Description | List of optional limit choices |
| Definition | ENUM |
| Enum Tag | Name: PztLimitsNone  Description: No limit |
| Enum Tag | Name: PztLimitsLow  Description: Check low limit |
| Enum Tag | Name: PztLimitsHigh  Description: Check high limit |
| Enum Tag | Name: PztLimitsHiLo  Description: Check low and high limit |

|  |  |
| --- | --- |
| **User Interface Type**  TYPE PztScanWaveformEnum : (ScanSawtooth, ScanTriangle, ScanSine, ScanSquarewave);  END\_TYPE | |
| Type name | PztScanWaveformEnum |
| Description | List of scan waveformt choices |
| Definition | ENUM |
| Enum Tag | Name: ScanSawtooth  Description: Sawtooth waveform |
| Enum Tag | Name: ScanTriangle  Description: Trinagular waveform |
| Enum Tag | Name: ScanSine  Description: Sinewave |
| Enum Tag | Name: ScanSquarewave  Description: Squarewave |

|  |  |
| --- | --- |
| **User Interface Type**  TYPE TriggerSelectionEnum : (TrigEdge, TrigLevel);  END\_TYPE | |
| Type name | TriggerSelectionEnum |
| Description | List of available trigger selection choices |
| Definition | ENUM |
| Enum Tag | Name: TrigEdge  Description: Triggers on edges only |
| Enum Tag | Name: TrigLevel  Description: Triggers on levele |

|  |  |
| --- | --- |
| **User Interface Type**  TYPE TriggerSlopeEnum : (TrigPositive, TrigNegative, TrigBoth);  END\_TYPE | |
| Type name | TriggerSlopeEnum |
| Description | List of available trigger slope choices |
| Definition | ENUM |
| Enum Tag | Name: TrigPositive  Description: Triggers on positive edges or upon an exceeded level |
| Enum Tag | Name: TrigNegative  Description: Triggers on negative edges or below a level |
| Enum Tag | Name: TrigBoth  Description: Triggers on either negative edges (not relevant for level) |

|  |  |
| --- | --- |
| **User Interface Type**  TYPE TriggerStruct :  STRUCT  Error: ErrorStruct;  Selection: TriggerSelectionEnum;  Slope: TriggerSlopeEnum;  Reset: BOOL;  Arm: BOOL;  Event: BOOL;  Timeout: LREAL;  TimeoutError: BOOL;  Value: LREAL;  Level: LREAL;  END\_STRUCT  END\_TYPE | |
| Type name | TriggerStruct |
| Description | Structure of the user interface tags that is used to define a trigger |
| Definition | STRUCT |
| Output Tag | Name: Error  Type: ErrorStruct  Description: Error handling |
| In/out Tag | Name: Selection  Type: TriggerSelectionEnum  Description: Type of trigger (Edge or level) |
| In/out Tag | Name: Slope  Type: TriggerSlopeEnum  Description: Select the slope/level for the trigger |
| In/out Tag | Name: Reset  Type: BOOL  Description: Resets the trigger (Arm, Event and TimeoutError) |
| In/out Tag | Name: Arm  Type: BOOL  Description: Arms the trigger (value is reset when trigger is met) |
| Output Tag | Name: Event  Type: BOOL  Description: A trigger event has happened |
| In/out Tag | Name: Timeout  Type: LREAL  Description: Timeout for trigger in sec |
| Output Tag | Name: TimeoutError  Type: BOOL  Description: Trigger has timed out |
| Output Tag | Name: Value  Type: LREAL  Description: Trigger input signal |
| In/out Tag | Name: Level  Type: LREAL  Description: Level to trigger at, above or below |

|  |  |
| --- | --- |
| **User Interface Type**  TYPE PztScanStruct :  STRUCT  Error: ErrorStruct;  Enable: BOOL;  UseTrigger: BOOL;  Reset: BOOL;  Waveform: PztScanWaveformEnum;  Period: LREAL;  Trigger: TriggerStruct;  Start: LREAL;  Stop: LREAL;  Offset: LREAL;  Previous: LREAL;  END\_STRUCT  END\_TYPE | |
| Type name | PztScanStruct |
| Description | Structure of the user interface tags that sets up a PZT scan |
| Definition | STRUCT |
| Output Tag | Name: Error  Type: ErrorStruct  Description: Error handling |
| In/out Tag | Name: Enable  Type: BOOL  Description: Enables the scanning |
| In/out Tag | Name: UseTrigger  Type: BOOL  Description: Use the trigger to stop the scan |
| In/out Tag | Name: Reset  Type: BOOL  Description: Resets the scan (Enable, Previous, Offset and Trigger) |
| In/out Tag | Name: Waveform  Type: PztScanWaveformEnum  Description: Selects the scanning waveform |
| In/out Tag | Name: Period  Type: LREAL  Description: Period of the waveform in sec |
| In/out Tag | Name: Trigger  Type: TriggerStruct  Description: Trigger parameters |
| In/out Tag | Name: Start  Type: LREAL  Description: Start offset for the scan waveform |
| In/out Tag | Name: Stop  Type: LREAL  Description: Stop offset for the scan waveform |
| Output Tag | Name: Offset  Type: LREAL  Description: Current offset of scanning waverform |
| Output Tag | Name: Previous  Type: LREAL  Description: Offset when last trigger event happened |

|  |  |
| --- | --- |
| **User Interface Type**  TYPE PztDriverStruct:  STRUCT  Error: ErrorStruct;  PztDriverType: PztDriverEnum;  Volts: LREAL;  Offset: LREAL;  Monitor: LREAL;  Drive: LREAL;  PztLow: LREAL;  PztHigh: LREAL;  PztGain: LREAL;  PztMonGain: LREAL;  PztOffset: LREAL;  Limits: PztDriverLimitsEnum;  Range: BOOL;  Low: LREAL;  High: LREAL;  Normalized: LREAL;  External: BOOL;  ExternalNom: BOOL;  PowerOk: BOOL;  END\_TYPE | |
| Type name | PztDriverStruct |
| Description | Structure of the user interface tags that are used to control the PZT driver |
| Definition | STRUCT |
| Output Tag | Name: Error  Type: ErrorStruct  Description: Error handling |
| Output Tag | Name: PztDriverType  Type: PztDriverEnum  Description: PZT driver type |
| Output Tag | Name: Volts  Type: LREAL  Description: Represents the PZT driver output voltage in V |
| In/out Tag | Name: Offset  Type: LREAL  Description: Offset to the PZT driver output in V |
| Output Tag | Name: Monitor  Type: LREAL  Description: Monitor readback voltage (used to derive Volts) |
| Output Tag | Name: Drive  Type: LREAL  Description: Output drive voltage for offset (derived from Offset) |
| Output Tag | Name: PztLow  Type: LREAL  Description: Low limit of PZT drive |
| Output Tag | Name: PztHigh  Type: LREAL  Description: High limit of PZT drive |
| Output Tag | Name: PztGain  Type: LREAL  Description: Gain of the PZT drive |
| Output Tag | Name: PztMonGain  Type: LREAL  Description: Inverse of the PZT monitor gain |
| Output Tag | Name: PztOffset  Type: LREAL  Description: Intrinsic offset of the PZT drive (usually 0) |
| Output Tag | Name: Limits  Type: PztDriverLimitsEnum  Description: Specifies optional limits |
| Output Tag | Name: Range  Type: BOOL  Description: True, if limits exceeded |
| Output Tag | Name: Low  Type: LREAL  Description: Low limit for PZT output voltage |
| Output Tag | Name: High  Type: LREAL  Description: High limit for PZT output voltage |
| Output Tag | Name: Normalized  Type: LREAL  Description: Normalized output voltage, 100% is the absolute maximum of the allowed output voltage |
| Output Tag | Name: External  Type: BOOL  Description: Monitors the external switch state |
| In/Out Tag | Name: ExternalNom  Type: BOOL  Description: Nominal setting of the external switch state |
| Output Tag | Name: PowerOk  Type: BOOL  Description: Voltages are ok |

|  |  |
| --- | --- |
| **Function Block**  FUNCTION\_BLOCK TriggerFB  VAR\_INPUT  Request: SaveRestoreEnum := NoOp;  END\_VAR  VAR\_IN\_OUT  Trigger: TriggerStruct;  TriggerInit: TriggerStruct;  END\_VAR | |
| Name | TriggerFB |
| Description | Controls the setup of a trigger and checks for errors, but does not evaluate the trigger condition |
| Input argument | Name: Request  Type: SaveRestoreEnum  Description: Save/restore command |
| In/out argument | Name: Trigger  Type: TriggerStruct  Description: Trigger parameters |
| In/out argument | Name: TriggerInit  Type: TriggerStruct  Description: Trigger initialization parameters |

|  |  |
| --- | --- |
| **Function Block**  FUNCTION\_BLOCK TriggerFastFB  VAR\_INPUT  Value: LREAL;  END\_VAR  VAR\_IN\_OUT  Trigger: TriggerStruct;  END\_VAR  VAR\_OUTPUT  Event: BOOL;  END\_VAR | |
| Name | TriggerFastFB |
| Description | Evaluates the trigger condition (called by a fast updating task) |
| Input argument | Name: Value  Type: LREAL  Description: Signal to trigger on |
| In/out argument | Name: Trigger  Type: TriggerStruct  Description: Trigger parameters |
| Output argument | Name: Event  Type: BOOL  Description: Indicates a trigger has happened |

|  |  |
| --- | --- |
| **Function Block**  FUNCTION\_BLOCK PztScanFB  VAR\_INPUT  Request: SaveRestoreEnum;  PztMin: LREAL := -1E9;  PztMax: LREAL := +1E9;  END\_VAR  VAR\_IN\_OUT  Scan: PztScanStruct;  ScanInit: PztScanStruct;  END\_VAR | |
| Name | PztScanFB |
| Description | Controls the setup of a PZT scan, but does not calculate the waveform |
| Input argument | Name: Request  Type: SaveRestoreEnum  Description: Save/restore command |
| Input argument | Name: PztMin  Type: LREAL  Description: Minimum voltage of the PZT output |
| Input argument | Name: PztMax  Type: LREAL  Description: Maximum voltage of the PZT output |
| In/out argument | Name: Scan  Type: PztScanStruct  Description: PZT scan parameters |
| In/out argument | Name: ScanInit  Type: PztScanStruct  Description: PZT scan initialization parameters |

|  |  |
| --- | --- |
| **Function Block**  FUNCTION\_BLOCK PztScanFastFB  VAR\_INPUT  Value: LREAL;  Tick: LREAL := 0.001;  END\_VAR  VAR\_IN\_OUT  Scan: PztScanStruct;  END\_VAR | |
| Name | PztScanFastFB |
| Description | Calculates the scan waveform (called by a fast updating task) |
| Input argument | Name: Value  Type: LREAL  Description: Signal to trigger on |
| Input argument | Name: Tick  Type: LREAL  Description: Tick of update task in sec |
| In/out argument | Name: Scan  Type: PztScanStruct  Description: Scan parameters |

|  |  |
| --- | --- |
| **Function Block**  FUNCTION\_BLOCK PztDriverFB  VAR\_INPUT  Request: SaveRestoreEnum;  PztDriverIn: PztDriverInStruct;  END\_VAR  VAR\_IN\_OUT  PztDriverInit: PztDriverStruct;  PztDriver: PztDriverStruct;  END\_VAR | |
| Name | PztDriverFB |
| Description | Sets up a channel of the PZT driver and checks for errors, but doesn’t apply the offset |
| Input argument | Name: Request  Type: SaveRestoreEnum  Description: Save/restore command |
| Input argument | Name: PztDriverIn  Type: PztDriverInStruct  Description: Input hardware structure |
| In/out argument | Name: PztDriverInit  Type: PztDriverStruct  Description: Interface structure for save/restore |
| In/out argument | Name: PztDriver  Type: PztDriverStruct  Description: User Interface structure |

|  |  |
| --- | --- |
| **Function Block**  FUNCTION\_BLOCK PztDriverFastFB  VAR\_INPUT  PztType: PztDriverEnum := LVPZT;  PztMin: LREAL := -1E9;  PztMax: LREAL := +1E9;  PztGain: LREAL := 0;  PztMonGain: LREAL := 0;  PztOffset: LREAL := 0;  Value: LREAL;  Tick: LREAL := 0.001;  END\_VAR  VAR\_OUTPUT  PztDriverOut: PztDriverOutStruct;  END\_VAR  VAR\_IN\_OUT  PztDriver: PztDriverStruct;  END\_VAR | |
| Name | PztDriverFastFB |
| Description | Outputs the PZT voltage and applies the scan and trigger functions.  Called by a fast updating task.  The values for min, max, gain, mongain and offset will be initialized according to the selected PZT driver type, if left untouched. |
| Input argument | Name: PztType  Type: PztDriverEnum  Default: LVPZT  Description: PZT driver type |
| Input argument | Name: PztDriverIn  Type: PztDriverInStruct  Description: Input hardware structure |
| Input argument | Name: PztMin  Type: LREAL  Description: Minimum voltage of the PZT output |
| Input argument | Name: PztMax  Type: LREAL  Description: Maximum voltage of the PZT output |
| Input argument | Name: PztGain  Type: LREAL  Description: PZT gain |
| Input argument | Name: PztMonGain  Type: LREAL  Description: Inverse of PZT monitor gain |
| Input argument | Name: PztOffset  Type: LREAL  Description: Intrinsic PZT offset (usually 0) |
| Input argument | Name: Value  Type: LREAL  Description: Signal to trigger on (used by the scan/trigger feature) |
| Input argument | Name: Tick  Type: LREAL  Description: Tick of update task in sec (used by the scan) |
| Output argument | Name: PztDriverOut  Type: PztDriverOutStruct  Description: Output hardware structure |
| In/out argument | Name: PztDriver  Type: PztDriverStruct  Description: User Interface structure |