

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	<p>Interfaces the PZT driver, D1001200.</p> <p>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.</p> <p>Calibration parameters and min/max voltages are used to calibrate the voltage monitor and the offset adjustment.</p> <p>Each PZT driver also supports optional low and high limits; the user chooses which ones to enforce.</p> <p>The hardware readbacks of the power ok and external switch are daisy chained among the 4 channels of a board.</p> <p>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 functionality are supported at a fast update rate.</p>
Error codes	<p>PZT Driver:</p> <ul style="list-style-type: none"> 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 <p>PZT Scan:</p> <ul style="list-style-type: none"> 0x01 – Illegal period 0x02 – Trigger error <p>Trigger:</p> <ul style="list-style-type: none"> 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 waveform 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