LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

LIGO- E1200632-v5 | Advanced LIGO | 02/6/2014

TwinCAT Library for the ALS Laser

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Library	
Title	ALSLaser
Version	4
TwinCAT version	2.11
Name space	–
Author	Alexa Staley, Daniel Sigg
Description	Monitors the ALS Laser Controls the crystal and doubler temperature A slow feedback servo is implemented to offload the fast PZT feedback to the slow temperature controls. It implements the following equation: $u_i = (1 - h)\, u_{i-1} + e_i\, (h - g)$ Or if the polarity is false: $u_i = (1 - h)\, u_{i-1} + e_i\, (h + g)$ with $g = \pi f_{ugf} \Delta t$ and $h = \pi f_{Pf} \Delta t$ Δt: sampling interval, f_{ugf}: unity gain frequency of integrator, f_{Pf}: Knee frequency of proportional gain. (only used for control of the laser crystal, not the doubler)
Error codes	0x0001 – Safety interlock engaged 0x0002 – Laser diode 1 guard alarm 0x0004 – Laser diode 2 guard alarm 0x0008 – Laser diode 1 current out-of-range 0x0010 – Laser diode 2 current out-of-range 0x0020 – Laser crystal TEC error signal out-of-range 0x0040 – Doubler crystal TEC error signal out-of-range 0x0080 – Laser diode 1 TEC error signal out-of-range 0x0100 – Laser diode 2 TEC error signal out-of-range 0x0200 – Noise eater readback signal out-of-range 0x0400 – Unity gain frequency too high 0x0800 – Proportional gain knee frequency too high 0x1000 – Temperature feedback limit exceeded
Library dependencies	ReadADC, WriteADC, SaveRestore, Error

Hardware Input Type

```
TYPE ALSLaserInStruct :
STRUCT
        LaserDiode1PowerMonitor:        INT;
        LaserDiode2PowerMonitor:        INT;
        LaserCrystalTECErrorSignal:     INT;
        DoublingCrystalTECErrorSignal:  INT;
        LaserDiode1TECErrorSignal:      INT;
        LaserDiode2TECErrorSignal:      INT;
        NoiseEaterMonitor:              INT;
        LaserDiode1TempGuard:           BOOL;
        LaserDiode2TempGuard:           BOOL;
        InterLock:                      BOOL;
END_STRUCT
END_TYPE
```

Type name	ALSLaserInStruct
Description	Structure of the hardware input that are wired up for the ALS laser
Definition	STRUCT
Element	Name: LaserDiode1PowerMonitor Type: INT Description: Laser diode 1 power monitor
Element	Name: LaserDiode2PowerMonitor Type: INT Description: Laser diode 2 power monitor
Element	Name: LaserCrystalTECErrorSignal Type: INT Description: Laser crystal, TEC error signal
Element	Name: DoublingCrystalTECErrorSignal Type: INT Description: Doubling crystal, TEC error signal
Element	Name: LaserDiode1TECErrorSignal Type: INT Description: Laser diode 1, TEC error signal
Element	Name: LaserDiode2TECErrorSignal Type: INT Description: Laser diode 2, TEC error signal
Element	Name: NoiseEaterMonitor Type: INT Description: Noise eater monitor

Element	Name: LaserDiode1TempGuard Type: BOOL Description: Laser diode 1, temp guard
Element	Name: LaserDiode2TempGuard Type: BOOL Description: Laser diode 2, temp guard
Element	Name: InterLock Type: BOOL Description: InterLock

Hardware Output Type TYPE ALSLaserOutStruct : STRUCT CrystalTemperature: INT; DoublerTemperature: INT; NoiseEaterRelayOn: BOOL; NoiseEaterRelayOff: BOOL; END_STRUCT END_TYPE	
Type name	ALSLaserOutStruct
Description	Structure of the hardware output that are wired up for the ALS laser
Definition	STRUCT
Element	Name: CrystalTemperature Type: INT Description: Crystal Temperature
Element	Name: DoublerTemperature Type: INT Description: Doubler Temperature
Element	Name: NoiseEaterRelayOn Type: BOOL Description: External relay to flip noise eater ON
Element	Name: NoiseEaterRelayOff Type: BOOL Description: External relay to flip noise eater OFF

User Interface Type

```
TYPE ALSLaserFrequencyControlsStruct:
STRUCT
        On:                     BOOL;
        Enabled:                BOOL;
        Run:                    BOOL;
        Reset:                  BOOL;
        Low:                    LREAL;
        High:                   LREAL;
        Range:                  BOOL;
        Ugf:                    LREAL;
        Pf:                     LREAL;
        Polarity:               BOOL;
END_STRUCT
END_TYPE
```

Type name	ALSLaserFrequencyControlsStruct
Description	Structure used in the user interface that are used for the slow temperature controls
Definition	STRUCT
In/out Tag	Name: On Type: BOOL Description: On/Off button for temperature feedback
Output Tag	Name: Enabled Type: BOOL Description: Enabled by the autolocker
Output Tag	Name: Run Type: BOOL Description: Servo is running
In/out Tag	Name: Reset Type: BOOL Description: Reset the integrator and zero the output
In/out Tag	Name: Low Type: LREAL Description: Low limit for feedback controls in Hz
In/out Tag	Name: High Type: LREAL Description: High limit for feedback controls in Hz
Output Tag	Name: Range Type: BOOL Description: Feedback controls exceeds range

In/out Tag	Name: Ugf Type: LREAL Description: Unity gain frequency of temperature servo in Hz
In/out Tag	Name: Pf Type: LREAL Description: Knee frequency of proportional feedback in Hz; zero is none

User Interface Type

```
TYPE ALSLaserStruct :
STRUCT
    Error:                          ErrorStruct;
    LaserDiode1PowerMonitor:        LREAL;
    LaserDiode2PowerMonitor:        LREAL;
    LaserDiodePowerNominal:         LREAL;
    LaserDiodePowerTolerance:       LREAL;
    LaserCrystalTECErrorSignal:     LREAL;
    DoublingCrystalTECErrorSignal:  LREAL;
    LaserDiode1TECErrorSignal:      LREAL;
    LaserDiode2TECErrorSignal:      LREAL;
    TECTolerance:                   LREAL;
    NoiseEaterMonitor:              LREAL;
    NoiseEaterNominal:              LREAL;
    NoiseEaterTolerance:            LREAL;
    NoiseEaterRelay:                BOOL;
    LaserDiode1TempGuard:           BOOL;
    LaserDiode2TempGuard:           BOOL;
    InterLock:                      BOOL;
    CrystalTemperature:             LREAL;
    CrystalCalibration:             LREAL;
    CrystalFrequency:               LREAL;
    FrequencyControl:               ALSLaserFrequencyControlsStruct;
    PZTTuningCoefficient:           LREAL;
    PZTFrequency:                   LREAL;
    DoublerTemperature:             LREAL;
END_STRUCT
END_TYPE
```

Type name	ALSLaserStruct
Description	Structure of the user interface tags that are used to control the ALS Laser
Definition	STRUCT
Output Tag	Name: Error Type: ErrorStruct Description: For error handler
Output Tag	Name: LaserDiode1PowerMonitor Type: LREAL Description: Laser diode 1 power monitor in A
Output Tag	Name: LaserDiode2PowerMonitor Type: LREAL Description: Laser diode 2 power monitor in A

Input Tag	Name: LaserDiodePowerNominal Type: LREAL Description: Laser diode power nominal in A
Input Tag	Name: LaserDiodePowerTolerance Type: LREAL Description: Laser diode power tolerance in A
Output Tag	Name: LaserCrystalTECErrorSignal Type: LREAL Description: Laser crystal, TEC error signal in C
Output Tag	Name: DoublingCrystalTECErrorSignal Type: LREAL Description: Doubling crystal, TEC error signal in C
Output Tag	Name: LaserDiode1TECErrorSignal Type: LREAL Description: Laser diode 1, TEC error signal in C
Output Tag	Name: LaserDiode2TECErrorSignal Type: LREAL Description: Laser diode 2, TEC error signal in C
Input Tag	Name: TECTolerance Type: LREAL Description: TEC error signal tolerance in C
Output Tag	Name: NoiseEaterMonitor Type: LREAL Description: Noise eater monitor in V
Input Tag	Name: NoiseEaterNominal Type: LREAL Description: Noise eater nominal value in V
Input Tag	Name: NoiseEaterTolerance Type: LREAL Description: Noise eater tolerance in V
Output Tag	Name: NoiseEaterRelay Type: BOOL Description: External relay to switch noise eater on/off
Output Tag	Name: LaserDiode1TempGuard Type: BOOL Description: Laser diode 1, temp guard, high is alarm
Output Tag	Name: LaserDiode2TempGuard Type: BOOL Description: Laser diode 2, temp guard, high is alarm
Output Tag	Name: InterLock Type: BOOL

	Description: InterLock, high represent an interlock
In/out Tag	Name: CrystalTemperature Type: LREAL Description: Crystal Temperature in C or V
Output Tag	Name: CrystalCalibration Type: LREAL Description: Crystal temperature coefficient at 1064nm in MHz/C; nominal -3000 MHz/C
In/out Tag	Name: CrystalFrequency Type: LREAL Description: Laser frequency as set by crystal temperature in MHz; updating the CrystalFrequency will update the CrystalTemperature and vis versa
In/out Tag	Name: FrequencyControl Type: ALSLaserFrequencyControlsStruct Description: Controls parameters for slow temperature feedback network
Output Tag	Name: PZTTuningCoefficient Type: LREAL Description: PZT tuning coefficient at 1064nm in MHz/V; nominal 1.5 MHz/V
Output Tag	Name: PZTFrequency Type: LREAL Description: Laser frequency as set by the PZT actuator in MHz
Input Tag	Name: DoublerTemperature Type: LREAL Description: Doubler Temperature

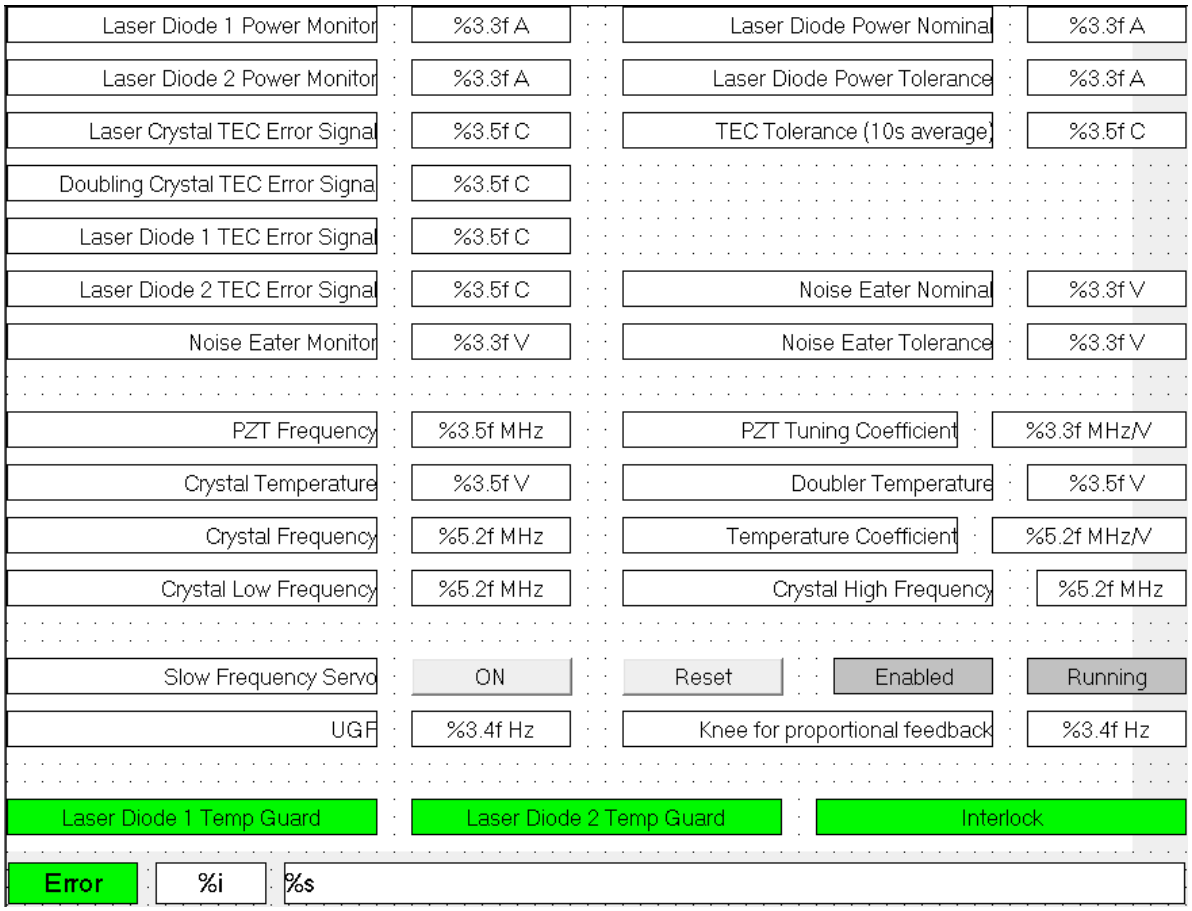
Function Block

```
FUNCTION_BLOCK ALSLaserFB
VAR_INPUT
        Request:            SaveRestoreEnum;
        ALSLaserIn:         ALSLaserInStruct;
        ConstrolsEnable:    BOOL:= FALSE;
        PZTVoltage:         LREAL := 0.0;
END_VAR
VAR_OUTPUT
        ALSLaserOut:        ALSLaserOutStruct;
END_VAR
VAR_IN_OUT
        ALSLaserInit:       ALSLaserStruct;
        ALSLaser:           ALSLaserStruct;
END_VAR
```

Name	ALSLaserFB
Description	Monitors the ALS laser and computes the slow controls feedback
Input argument	Name: Request Type: SaveRestoreEnum Description: Request for save/restore/safemode or noop
Input argument	Name: ALSLaserIn Type: ALSLaserInStruct Description: Input hardware structure
Input argument	Name: ControlsEnable Type: BOOL Description: Enables the slow controls feedback Default: FALSE
Input argument	Name: PZTVoltage Type: LREAL Description: PZT controls voltage in V (error signal for slow controls feedback) Default: 0
Output argument	Name: ALSLaserOut Type: ALSLaserOutStruct Description: Output hardware structure
In/out argument	Name: ALSLaser Type: ALSLaserStruct Description: User Interface structure
In/out argument	Name: ALSLaserInit Type: ALSLaserStruct

	Description: Save/restore variable in persistent memory

Visual



Name	ALSLaserVis
Description	Displays power monitors, TEC error signals, noise eater status, crystal temperatures, slow temperature controls parameters, and alarms for temperature guards, interlock and error.
Placeholder	Name: ALSLaser Type: ALSLaserStruct Description: ALS laser structure