



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-E1200226-v8

Advanced LIGO

3/21/2019

TwinCAT Library for Low Noise VCO

Daniel Sigg

Distribution of this document:
LIGO Scientific Collaboration

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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	LowNoiseVco
Version	8
TwinCAT version	2.11
Name space	–
Author	Daniel Sigg
Description	<p>Controls the low noise VCO, D0900605, the frequency difference mixer, D1600499, and the fixed ratio frequency source, D1700475.</p> <p>The low noise VCO is based on a frequency difference divider. It requires a 71MHz/10dBm reference source and a VCO source at either 125MHz or 79MHz. Both RF levels as well as the RF level at the output of the frequency difference divider are monitored. The only set value is an offset into the VCO which translates into a frequency offset at the output. A binary output is used to enable the excitation input. Additional monitors are available for the tune voltage, the state of the excitation switch, and a power ok bit.</p> <p>If a frequency counter has been setup through the timing system, the measured frequency can be stabilized by feeding back to the bias offset. This then allows the user to select a fixed output frequency.</p> <p>The frequency difference mixer is using the same RF mixer circuit but without a divider and a VCO. It implements none of the extra frequency controls of the VCO neither.</p> <p>The fixed ratio frequency source locks an OCXO to an RF signal using an internal PLL, in order to generate a clean higher order harmonics.</p> <p>The 3 RF power monitors which have the calibration</p> $P = 12 \text{ dBm} - 10 \text{ dBm/V} \times (U - 4 \text{ V})$ <p>The corresponding temperature readout has the calibration</p> $T = 20^\circ\text{C} + 50^\circ\text{C/V} \times (U * 1.10 - 6 \text{ V})$ <p>The factor 1.10 is due to the voltage divider at the temperature readout.</p> <p>The RF power levels should be alarmed when outside $\pm 1\text{dBm}$ of nominal.</p>
Error codes	<p>Low Noise VCO:</p> <ul style="list-style-type: none"> 0x01 – Power supply voltages out-of-range 0x02 – Reference RF power level out-of-range 0x04 – Divider RF power level out-of-range 0x08 – Output RF power level out-of-range 0x10 – Excitation switch enabled 0x20 – Invalid frequency 0x40 – RF Power is on 0x80 – Controls error <p>Frequency difference mixer:</p> <ul style="list-style-type: none"> 0x01 – Power supply voltages out-of-range 0x02 – Reference RF power level out-of-range 0x04 – Input RF power level out-of-range 0x08 – Output RF power level out-of-range

	<p>Fixed ratio frequency source:</p> <ul style="list-style-type: none">0x01 – Power supply voltages out-of-range0x02 – Output RF power level out-of-range0x04 – PLL unlocked <p>Controls errors:</p> <ul style="list-style-type: none">0x01 – Unity gain frequency too high0x02 – Unity gain frequency too low0x04 – High limit reached0x08 – Low limit reached0x10 – Invalid error signal0x20 – Invalid set frequency
Library dependencies:	Error, SaveRestore, ReadADC. WriteDAC

Hardware Input Type	
TYPE LowNoiseVcolnStruct :	
STRUCT	
ReferenceMon:	INT;
DividerMon:	INT;
OutputMon:	INT;
ReferenceTemp:	INT;
DividerTemp:	INT;
OutputTemp:	INT;
TuneMon:	INT;
Spare:	INT;
Frequency:	LREAL; (* not used *)
ExcitationSwitch:	BOOL;
PowerOk:	BOOL;
FrequencyLive:	BOOL; (* not used *)
END_STRUCT	
END_TYPE	
Type name	LowNoiseVcolnStruct
Description	Structure of the hardware inputs that are wired up for the low noise VCO
Definition	STRUCT
Element	Name: ReferenceMon Type: INT Description: Monitors the RF power at the reference input
Element	Name: DividerMon Type: INT Description: Monitors the RF power at the divider input
Element	Name: OutputMon Type: INT Description: Monitors the RF power after the output amplifier
Element	Name: ReferenceTemp Type: INT Description: Monitors the temperature of the reference RF detector
Element	Name: DividerTemp Type: INT Description: Monitors the temperature of the divider RF detector
Element	Name: OutputTemp Type: INT Description: Monitors the temperature of the output RF detector
Element	Name: TuneMon Type: INT Description: Monitor for the frequency offset

Element	Name: Spare Type: INT Description: Readback of RF power status: 0V: VCO and FDD off -3V: VCO on and FDD off -6V: VCO off and FDD on -9V: VCO on and FDD on
Element	Name: Frequency Type: LREAL Description: Measured frequency
Element	Name: ExcitationSwitch Type: BOOL Description: Monitors the excitation input enable
Element	Name: PowerOk Type: BOOL Description: Voltage monitor readback
Element	Name: FrequencyLive Type: BOOL Description: Keep alive for frequency measurement

Hardware Input Type	
TYPE FixedRatioFrequencySourceInStruct :	
STRUCT	
OutputMon: INT;	
TuneMon: INT;	
Alarm: INT;	
OutputTemp: INT;	
PowerOk: BOOL;	
END_STRUCT	
END_TYPE	
Type name	FixedRatioFrequencySourceInStruct
Description	Structure of the hardware inputs that are wired up for the fixed ratio frequency source
Definition	STRUCT
Element	Name: OutputMon Type: INT Description: Monitors the RF power after the output amplifier
Element	Name: TuneMon Type: INT Description: PLL voltage monitor
Element	Name: Alarm Type: INT Description: PLL lock status, TTL
Element	Name: OutputTemp Type: INT Description: Monitors the temperature of the output RF detector
Element	Name: PowerOk Type: BOOL Description: Voltage monitor readback

Hardware Output Type TYPE LowNoiseVcoOutStruct : STRUCT TuneOfs: INT; ExcitationEn: BOOL; END_STRUCT END_TYPE	
Type name	LowNoiseVcoOutStruct
Description	Structure of the hardware outputs that are wired up for the low noise VCO
Definition	STRUCT
Element	Name: TuneOfs Type: INT Description: Setpoint for the frequency offset
Element	Name: ExcitationEn Type: BOOL Description: Enables the excitation input; This is used by the relay to turn on and off the RF power

User Interface Type	
TYPE LowNoiseVcoStruct :	
STRUCT	
Error:	ErrorStruct;
VCOType:	LowNoiseVcoTypeEnum;
HasRelay:	BOOL;
ReferenceNom:	LREAL;
DividerMon:	LREAL;
DividerNom:	LREAL;
OutputMon:	LREAL;
OuptutNom:	LREAL;
ReferenceTemp:	LREAL;
DividerTemp:	LREAL;
OutputTemp:	LREAL;
TuneOfs:	LREAL;
TuneMon:	LREAL;
TuneLimit:	LREAL;
ExcitationSwitch:	BOOL;
ExcitationEn:	BOOL;
PowerDisable:	BOOL;
PowerOk:	BOOL;
PowerVCO:	LowNoiseVcoPowerEnum;
PowerFDD:	LowNoiseVcoPowerEnum;
Frequency:	LREAL;
FrequencyFault:	BOOL;
Controls:	LowNoiseVcoControlsStruct;
END_STRUCT	
END_TYPE	
Type name	LowNoiseVcoStruct
Description	Structure of the user interface tags that are used to control the low noise VCO
Definition	STRUCT
Output Tag	Name: Error Type: ErrorStruct Description: For error handler
Output Tag	Name: VCOType Type: LowNoiseVcoTypeEnum Description: VCO or FDD
Output Tag	Name: HasRelay Type: BOOL Description: Implements a VCO relay board

Output Tag	Name: ReferenceMon Type: LREAL Description: Monitors the RF power at the reference input in dBm
Input Tag	Name: ReferenceNom Type: LREAL Description: Nominal value for the RF power at the reference input in dBm
Output Tag	Name: DividerMon Type: LREAL Description: Monitors the RF power at the divider input in dBm
Input Tag	Name: DividerNom Type: LREAL Description: Nominal value for the RF power at the divider input in dBm
Output Tag	Name: OutputMon Type: LREAL Description: Monitors the RF power after the output amplifier dBm
Input Tag	Name: OutputNom Type: LREAL Description: Nominal value for the RF power at the output amplifier in dBm
Output Tag	Name: ReferenceTemp Type: LREAL Description: Monitors the temperature of the reference RF detector in C
Output Tag	Name: DividerTemp Type: LREAL Description: Monitors the temperature of the divider RF detector in C
Output Tag	Name: OutputTemp Type: LREAL Description: Monitors the temperature of the output RF detector in C
Input Tag	Name: TuneOfs Type: LREAL Description: Setpoint for the frequency offset in V
Output Tag	Name: TuneMon Type: LREAL Description: Monitor for the frequency offset in V
Input Tag	Name: TuneLimit Type: LREAL Description: Limit for the frequency offset in V
Input Tag	Name: ExcitationEn Type: BOOL Description: Enables the excitation input

Output Tag	Name: ExcitationSwitch Type: BOOL Description: Monitors the excitation input enable
Input Tag	Name: PowerDisable Type: BOOL Description: Disable RF power, if VCO relay is implemented
Output Tag	Name: PowerOk Type: BOOL Description: Voltage monitor readback
Output Tag	Name: PowerVCO Type: LowNoiseVcoPowerEnum Description: True if the VCO is powered on (relay only)
Output Tag	Name: PowerFDD Type: LowNoiseVcoPowerEnum Description: True if the FDD is powered on (relay only)
Output Tag	Name: Frequency Type: LREAL Description: Frequency of the VCO output
Output Tag	Name: FrequencyFault Type: BOOL Description: Indicates if the frequency of the VCO is no longer updating correctly
Input Tag	Name: Controls Type: LowNoiseVcoControlsStruct Description: VCO frequency controls parameters

User Interface Type TYPE LowNoiseVcoControlsStruct: STRUCT Error: ErrorStruct; FDDStages: DINT; UseSigmaDelta: BOOL; Fault: BOOL; SetFrequency: LREAL; SetFrequencyOffset: LREAL; DiffFrequency: LREAL; Enable: BOOL; UnityGain: LREAL; ClearInt: BOOL; END_STRUCT END_TYPE	
Type name	LowNoiseVcoControlsStruct
Description	Structure of the user interface that is used to control the frequency of the low noise VCO
Definition	STRUCT
Output Tag	Name: Error Type: ErrorStruct Description: For error handler
Output Tag	Name: FDDStages Type: DINT Description: Number of FDD stages
Output Tag	Name: UseSigmaDelta Type: BOOL Description: Uses a sigma-delta algorithm to control the frequency
Output Tag	Name: Fault Type: BOOL Description: Indicated a servo fault
Input Tag	Name: SetFrequency Type: LREAL Description: Set frequency in Hz
Input Tag	Name: SetFrequencyOffset Type: LREAL Description: Set frequency offset in Hz
Output Tag	Name: DiffFrequency Type: LREAL Description: Difference between measured and set frequency in Hz

Input Tag	Name: Enable Type: BOOL Description: Enable the servo
Input Tag	Name: UnityGain Type: LREAL Description: Unity gain frequency in Hz
Input Tag	Name: ClearInt Type: BOOL Description: Clear the history of the integrator

User Interface Type TYPE LowNoiseVcoTypeEnum: (VCO, FDD); END_TYPE	
Type name	LowNoiseVcoTypeEnum
Description	Enumerated type to describe the type of the low noise VCO
Definition	ENUM
Enum Tag	Name: VCO Description: Standard VCO
Enum Tag	Name: FDD Description: Frequency-difference divider

User Interface Type TYPE LowNoiseVcoPowerEnum : LowNoiseVcoPowerUnknown, LowNoiseVcoPowerOff, LowNoiseVcoPowerOn); END_TYPE	
Type name	LowNoiseVcoPowerEnum
Description	Enumerated type to describe the power type of the low noise VCO
Definition	ENUM
Enum Tag	Name: Unknown Description: Unknown state of power supply
Enum Tag	Name: Off Description: Power is off
Enum Tag	Name: On Description: Power is on

User Interface Type TYPE FrequencyDifferenceMixerStruct : STRUCT Error: ErrorStruct; ReferenceMon: LREAL; ReferenceNom: LREAL; InputMon: LREAL; InputNom: LREAL; OutputMon: LREAL; OuptutNom: LREAL; ReferenceTemp: LREAL; InputTemp: LREAL; OutputTemp: LREAL; PowerOk: BOOL; END_STRUCT END_TYPE	
Type name	FrequencyDifferenceMixerStruct
Description	Structure of the user interface tags that are used to control the frequency difference mixer
Definition	STRUCT
Output Tag	Name: Error Type: ErrorStruct Description: For error handler
Output Tag	Name: ReferenceMon Type: LREAL Description: Monitors the RF power at the reference input in dBm
Input Tag	Name: ReferenceNom Type: LREAL Description: Nominal value for the RF power at the reference input in dBm
Output Tag	Name: InputMon Type: LREAL Description: Monitors the RF power at the input in dBm
Input Tag	Name: InputNom Type: LREAL Description: Nominal value for the RF power at the input in dBm
Output Tag	Name: OutputMon Type: LREAL Description: Monitors the RF power after the output amplifier dBm
Input Tag	Name: OutputNom Type: LREAL Description: Nominal value for the RF power at the output amplifier in dBm

Output Tag	Name: ReferenceTemp Type: LREAL Description: Monitors the temperature of the reference RF detector in C
Output Tag	Name: InputTemp Type: LREAL Description: Monitors the temperature of the input RF detector in C
Output Tag	Name: OutputTemp Type: LREAL Description: Monitors the temperature of the output RF detector in C
Output Tag	Name: PowerOk Type: BOOL Description: Voltage monitor readback

User Interface Type	
TYPE FixedRatioFrequencySourceStruct :	
STRUCT	
Error: ErrorStruct;	
OutputMon: LREAL;	
OuptutNom: LREAL;	
OutputTemp: LREAL;	
Locked: BOOL;	
TuneMon: LREAL;	
PowerOk: BOOL;	
END_STRUCT	
END_TYPE	
Type name	FixedRatioFrequencySourceStruct
Description	Structure of the user interface tags that are used to monitor the fixed ratio frequency source
Definition	STRUCT
Output Tag	Name: Error Type: ErrorStruct Description: For error handler
Output Tag	Name: OutputMon Type: LREAL Description: Monitors the RF power after the output amplifier dBm
Input Tag	Name: OutputNom Type: LREAL Description: Nominal value for the RF power at the output amplifier in dBm
Output Tag	Name: OutputTemp Type: LREAL Description: Monitors the temperature of the output RF detector in C
Output Tag	Name: Locked Type: BOOL Description: Indicates that the PLL is locked
Output Tag	Name: TuneMon Type: LREAL Description: Monitors the voltage of the OCXO control signal in V
Output Tag	Name: PowerOk Type: BOOL Description: Voltage monitor readback

Function Block FUNCTION_BLOCK LowNoiseVcoFB VAR_INPUT LowNoiseVcoType: LowNoiseVcoTypeEnum := VCO; Request: SaveRestoreEnum; LowNoiseVcoIn: LowNoiseVcoInStruct; Frequency: LREAL := 0.0; FrequencyError: BOOL := TRUE; ExtUpdateRate: INT := 1; FddStages: INT := 1; VcoGain: LREAL := 140E3; VcoMin: LREAL := 78.159E6; VcoMax: LREAL := 80.276E6; UseSigmaDelta: BOOL := TRUE; UseRelay: BOOL := FALSE; DefaultExcitation: BOOL := FALSE; END_VAR VAR_OUTPUT LowNoiseVcoOut: LowNoiseVcoOutStruct; END_VAR VAR_IN_OUT LowNoiseVcoInit: LowNoiseVcoStruct; LowNoiseVco: LowNoiseVcoStruct; END_VAR	
Name	LowNoiseVcoFB
Description	Controls the low noise VCO. One function block for each low noise VCO chassis needs to be instantiated. An FDD unit is usually the second stage of a multi stage VCO/FDD setup. It does not implement a frequency servo.
Input argument	Name: LowNoiseVcoType Type: LowNoiseVcoTypeEnum Description: Type of low noise VCO chassis Default: VCO
Input argument	Name: Request Type: SaveRestoreEnum Description: Save restore command
Input argument	Name: LowNoiseVcoIn Type: LowNoiseVcoInStruct Description: Input hardware structure
Input argument	Name: Frequency Type: LREAL Description: Externally measured frequency of VCO Default: 0

Input argument	Name: FrequencyError Type: BOOL Description: Externally measured frequency is invalid Default: TRUE (invalid)
Input argument	Name: ExtUpdateRate Type: INT Description: How much is the update rate of external frequency readback slower than the processing clock. For 10 ms processing clock, a value of 100 corresponds to 1s updates, such as through the timing system. Default: 1 (10ms)
Input argument	Name: FddStages Type: INT Description: Number of frequency difference dividers used. This is to normalize the gain of the frequency servo. Default: 1
Input argument	Name: VcoGain Type: LREAL Description: Vco gain in Hz/V. First stage only. Default: 140E3
Input argument	Name: VcoMin Type: LREAL Description: Minimum of VCO frequency range in Hz. Default: 78.159E6
Input argument	Name: VcoMax Type: LREAL Description: Maximum of VCO frequency range in Hz. Default: 80.276E6
Input argument	Name: UseSigmaDelta Type: BOOL Description: Use a sigma delta modulator for averaging the control signal Default: TRUE
Input argument	Name: UseRelay Type: BOOL Description: True if VCO implements relay board Default: FALSE
Input argument	Name: DefaultExcitation Type: BOOL Description: Default excitation is on (TRUE) or off (FALSE) Default: FALSE
Output argument	Name: LowNoiseVcoOut Type: LowNoiseVcoOutStruct Description: Output hardware structure

In/out argument	Name: LowNoiseVcoInit Type: LowNoiseVcoStruct Description: Save/restore variables in persistent memory
In/out argument	Name: LowNoiseVco Type: LowNoiseVcoStruct Description: User Interface structure

Function Block FUNCTION_BLOCK FrequencyDifferenceMixerFB VAR_INPUT Request: SaveRestoreEnum; FrequencyDifferenceMixerIn: LowNoiseVcolnStruct; END_VAR VAR_IN_OUT FrequencyDifferenceMixerInit: FrequencyDifferenceMixerStruct; FrequencyDifferenceMixer: FrequencyDifferenceMixerStruct; END_VAR	
Name	FrequencyDifferenceMixerFB
Description	Controls the frequency difference mixer. One function block for each frequency difference mixer chassis needs to be instantiated.
Input argument	Name: Request Type: SaveRestoreEnum Description: Save restore command
Input argument	Name: FrequencyDifferenceMixerIn Type: LowNoiseVcolnStruct Description: Input hardware structure
In/out argument	Name: FrequencyDifferenceMixerInit Type: FrequencyDifferenceMixerStruct Description: Save/restore variables in persistent memory
In/out argument	Name: FrequencyDifferenceMixer Type: FrequencyDifferenceMixerStruct Description: User Interface structure

Function Block FUNCTION_BLOCK FixedRatioFrequencySourceFB VAR_INPUT Request: SaveRestoreEnum; FixedRatioFrequencySourceIn: FixedRatioFrequencySourceInStruct; END_VAR VAR_IN_OUT FixedRatioFrequencySourceInit: FixedRatioFrequencySourceStruct; FixedRatioFrequencySource: FixedRatioFrequencySourceStruct; END_VAR	
Name	FixedRatioFrequencySourceFB
Description	Controls the fixed ratio frequency source. One function block for each fixed ratio frequency source chassis needs to be instantiated.
Input argument	Name: Request Type: SaveRestoreEnum Description: Save restore command
Input argument	Name: FixedRatioFrequencySourceIn Type: LowNoiseVcoInStruct Description: Input hardware structure
In/out argument	Name: FixedRatioFrequencySourceInit Type: FixedRatioFrequencySourceStruct Description: Save/restore variables in persistent memory
In/out argument	Name: FixedRatioFrequencySource Type: FixedRatioFrequencySourceStruct Description: User Interface structure

Visual	
Name	LowNoiseVcoVis
Description	Displays several MON and temperature readings, power and excitation status, and error alarms
Placeholder	Name: LowNoiseVCO Type: LowNoiseVCOStruct Description: Low Noise VCO structure