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TwinCAT Library for ISC Whitening Chassis

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| **Library** |
| Title | IscWhitening |
| Version | 3 |
| TwinCAT version | 2.11 |
| Name space | IscWhitening |
| Author | Daniel Sigg |
| Description | Controls an ISC whitening chassis, [D1002559](https://dcc.ligo.org/cgi-bin/private/DocDB/ShowDocument?docid=21724), through the 384-channel binary IO chassis, [D1100251](https://dcc.ligo.org/cgi-bin/DocDB/ShowDocument?docid=33399). The binary IO chassis is controlled through a Modbus interface using four Acromag ES2113 that are connected to an EtherCAT-to-Modbus gateway, HMS AB9000. The setup instructions can be found in [T1100607](https://dcc.ligo.org/cgi-bin/private/DocDB/ShowDocument?docid=76566) and [C1107420](https://dcc.ligo.org/cgi-bin/private/DocDB/ShowDocument?docid=76567).The ISC whitening chassis contain 8 channels of whitening, [D1001530](https://dcc.ligo.org/cgi-bin/private/DocDB/ShowDocument?docid=12594). Each whitening channel employs a gain slider and 3 separately switchable filter stages. The ISC whitening chassis are used to interface the I and Q readouts of an LSC demodulator to the DAQ system, they are used to interface the I and Q readouts of a ASC wavefront sensor, and they are used to interface the 4 segments of a QPD (quad photodiode). Four LSC demodulators can be controlled from a single ISC whitening chassis, or one wavefront sensor, or two QPDs. Up to 6 ISC whitening chassis are controlled from a 384-channel binary IO chassis.This library is organized in two parts:- An interface to the binary IO chassis that controls individual IO lines and organizes them by ISC whitening chassis, and- Individual interfaces for the LSC PDs, ASC WFSs and QPDs which interface with the above binary IO chassis data structures. |
| Error codes | 0x0001 – Illegal chassis number0x0002 – Illegal channel index number0x0004 – Invalid data (first channel)0x0008 – Invalid data (second channel)…0x0102 – Invalid data (eighth channel) |
| Library dependencies | None |

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| **Hardware Input Type**TYPE IscWhiteningInStruct :STRUCT LiveList: ARRAY[1..8] OF BYTE; PCB: ARRAY[1..4,1..13] OF WORD; InfoDataState: WORD;END\_STRUCTEND\_TYPE |
| Type name | IscWhiteningInStruct |
| Description | Structure of the hardware inputs that mapped into the EtherCAT memory space by the EtherCAT-to-Modbus gateway. For mapping see next page. |
| Definition | STRUCT |
| Element | Name: LiveListType: ARRAY[1..8] OF BYTEDescription: Information about the active connections, see HMS AB9000 manual |
| Element | Name: PCBType: ARRAY[1..4,1..13] OF WORDDescription: Readbacks form the binary IO chassis, see HMS AB9000 and ES2113 manual |
| Element | Name: InfoDataStateType: WORDDescription: State information of the gateway. |

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| **Hardware Output Type**TYPE IscWhiteningOutStruct :STRUCT PCB: ARRAY[1..4,1..6] OF WORD;END\_STRUCTEND\_TYPE |
| Type name | IscWhiteningOutStruct |
| Description | Structure of the hardware outputs that mapped into the EtherCAT memory space by the EtherCAT-to-Modbus gateway. For mapping see next page. |
| Definition | STRUCT |
| Element | Name: PCBType: ARRAY[1..4,1..6] OF WORDDescription: Controls to the binary IO chassis, see HMS AB9000 and ES2113 manual |



Fig 1. Mapping of IO structures into the EtherCAT memory space.

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| **Internal Interface Type**TYPE IscWhiteningStruct :STRUCT Chassis: ARRAY[1..6] OF IscWhiteningRawChassisStruct;END\_STRUCTEND\_TYPE |
| Type name | IscWhiteningStruct |
| Description | Internal interface structure between the binary IO chassis function blocks and the ISC whitening chassis function blocks |
| Definition | STRUCT |
| Input/Output Tag | Name: ChassisType: ARRAY[1..6] OF IscWhiteningRawChassisStructDescription: Contains the binary IO data organized by chassis and channel. |

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| **Function Block**FUNCTION\_BLOCK IscWhiteningInterfaceFBVAR\_INPUT In: IscWhiteningInStruct;END\_VARVAR\_OUTPUT Out: IscWhiteningOutStruct;END\_VARVAR\_IN\_OUT Val: IscWhiteningStruct;END\_VAR |
| Name | IscWhiteningInterfaceFB |
| Description | Controls a 384-channel binary IO chassis. |
| Input argument | Name: InType: IscWhiteningInStructDescription: Input hardware structure |
| Output argument | Name: OutType: IscWhiteningOutStructDescription: Output hardware structure |
| In/out argument | Name: ValType: IscWhiteningStructDescription: Internal interface structure |

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| **User Interface Type**TYPE IscWhiteningChannelStruct :STRUCT Error: ErrorStruct; Gain: INT; GainStep: INT; Filter: ARRAY [1..3] OF BOOL; Set: ARRAY [1..3] OF BOOL; Toggle: ARRAY [1..3] OF BOOL; Readback: BYTE;END\_STRUCTEND\_TYPE |
|   | IscWhiteningChannelStruct |
| Description | Structure of the user interface tags that are used to control a single channel of the ISC whitening chassis |
| Definition | STRUCT |
| Output Tag | Name: ErrorType: ErrorStructDescription: Calls error handler |
| In/Out Tag | Name: GainType: INTDescription: Whitening gain in dB from 0 dB to 45 dB in 3 dB steps. This value is tight to GainStep. Any change in one of the two variables will updated the other. |
| In/Out Tag | Name: GainStepType: INTDescription: Whitening gain in steps from 0 to 15. This value is tight to Gain. Any change in one of the two variables will updated the other. |
| Output Tag | Name: FilterType: ARRAY [1..3] OF BOOLDescription: True if the whitening filter is on. Each array index represents a filter section. |
| Input Tag | Name: SetType: ARRAY [1..3] OF BOOLDescription: Set value for the whitening filters. Each array index represents a filter section. |
| Input Tag | Name: ToggleType: ARRAY [1..3] OF BOOLDescription: Set to True to toggle the state of a whitening filter. Each array index represents a filter section. |
| Output Tag | Name: ReadbackType: BYTEDescription: Bit encoded readback value from the whitening chassis |

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| **Function Block**FUNCTION\_BLOCK IscWhiteningChannelFBVAR\_INPUT Chassis: INT; (\* 1 to 6 \*) Index: INT; (\* 1 to 8 \*)END\_VARVAR\_IN\_OUT IscWhitening: IscWhiteningStruct; Channel: IscWhiteningChannelStruct;END\_VARVAREND\_VAR |
| Name | IscWhiteningChannelFB |
| Description | Controls a single channel in the whitening chassis (1 byte)Call this function block before IscWhiteningInterfaceFB. |
| In/Out argument | Name: IscWhiteningType: IscWhiteningStructDescription: Internal interface structure |
| Input argument | Name: ChassisType: INTDescription: Select the chassis: Values from 1 to 6 |
| Input argument | Name: IndexType: INTDescription: Select the channel: Index from 1 to 8 |
| In/out argument | Name: ChannelType: IscWhiteningChannelStructDescription: User Interface structure for a single channel of ISC whitening |

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| **User Interface Type**TYPE IscWhiteningDemodIQStruct :STRUCT Error: ErrorStruct; I: IscWhiteningChannelStruct; Q: IscWhiteningChannelStruct;END\_STRUCTEND\_TYPE |
| Type name | IscWhiteningDemodIQStruct |
| Description | Structure of the user interface tags that are used to control two channels of the ISC whitening chassis which are used for an LSC demodulator |
| Definition | STRUCT |
| Output Tag | Name: ErrorType: ErrorStructDescription: Calls error handler |
| In/Out Tag | Name: IType: IscWhiteningChannelStructDescription:  |
| In/Out Tag | Name: QType: IscWhiteningChannelStructDescription: Whitening gain in steps from 0 to 15. This value is tight to Gain. Any change in one of the two variables will update the other. |

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| **Function Block**FUNCTION\_BLOCK IscWhiteningDemodIQFBVAR\_INPUT Chassis: INT; (\* 1 to 6 \*) Index: INT; (\* 1, 3, 5 or to 7 \*)END\_VARVAR\_IN\_OUT IscWhitening: IscWhiteningStruct; Demod: IscWhiteningDemodIQStruct;END\_VARVAREND\_VAR |
| Name | IscWhiteningDemodIQFB |
| Description | Controls two channels in the whitening chassis (2 bytes)Call this function block before IscWhiteningInterfaceFB. |
| In/Out argument | Name: IscWhiteningType: IscWhiteningStructDescription: Internal interface structure |
| Input argument | Name: ChassisType: INTDescription: Select the chassis: Values from 1 to 6 |
| Input argument | Name: IndexType: INTDescription: Select the channel: Index is 1, 3, 5, or 7The selected index represents the quad-phase channel, whereas Index+1 represents the in-phase channel. |
| In/out argument | Name: DemodType: IscWhiteningDemodIQStructDescription: User Interface structure for two channels of ISC whitening describing the I and Q channels of a LSC demodulator. |

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| **User Interface Type**TYPE IscWhiteningDemodWfsStruct :STRUCT Error: ErrorStruct; Seg: ARRAY [1..4] OF IscWhiteningDemodIQStruct;END\_STRUCTEND\_TYPE |
| Type name | IscWhiteningDemodWfsStruct |
| Description | Structure of the user interface tags that are used to control eight channels of the ISC whitening chassis which are used for an ASC wavefront sensor demodulator |
| Definition | STRUCT |
| Output Tag | Name: ErrorType: ErrorStructDescription: Calls error handler |
| In/Out Tag | Name: SegType: ARRAY [1..4] OF IscWhiteningDemodIQStructDescription: The four segments of a wavefront sensor  |

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| **Function Block**FUNCTION\_BLOCK IscWhiteningDemodWfsFBVAR\_INPUT Chassis: INT; (\* 1 to 6 \*)END\_VARVAR\_IN\_OUT IscWhitening: IscWhiteningStruct; DemodWfs: IscWhiteningDemodWfsStruct;END\_VARVAREND\_VAR |
| Name | IscWhiteningDemodWfsFB |
| Description | Controls eight channels in a whitening chassis (8 bytes)Call this function block before IscWhiteningInterfaceFB. |
| In/Out argument | Name: IscWhiteningType: IscWhiteningStructDescription: Internal interface structure |
| Input argument | Name: ChassisType: INTDescription: Select the chassis: Values from 1 to 6 |
| In/out argument | Name: DemodWfsType: IscWhiteningDemodWfsStructDescription: User Interface structure for eight channels of ISC whitening describing the I and Q channels of a four segment ASC wavefront sensor demodulator. |

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| **User Interface Type**TYPE IscWhiteningQpdStruct :STRUCT Error: ErrorStruct Seg: ARRAY [1..4] OF IscWhiteningChannelStruct;END\_STRUCTEND\_TYPE |
| Type name | IscWhiteningQpdStruct |
| Description | Structure of the user interface tags that are used to control eight channels of the ISC whitening chassis which are used for an ASC wavefront sensor demodulator |
| Definition | STRUCT |
| Output Tag | Name: ErrorType: ErrorStructDescription: Calls error handler |
| In/Out Tag | Name: SegType: ARRAY [1..4] OF IscWhiteningChannelStructDescription: The four segments of a QPD sensor  |

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| **Function Block**FUNCTION\_BLOCK IscWhiteningQpdFBVAR\_INPUT Chassis: INT; (\* 1 to 6 \*) Index: INT; (\* 1 or 5 \*)END\_VARVAR\_IN\_OUT IscWhitening: IscWhiteningStruct; Qpd: IscWhiteningQpdStruct;END\_VARVAREND\_VAR |
| Name | IscWhiteningQpdFB |
| Description | Controls four channels in a whitening chassis (4 byte)Call this function block before IscWhiteningInterfaceFB. |
| In/Out argument | Name: IscWhiteningType: IscWhiteningStructDescription: Internal interface structure |
| Input argument | Name: ChassisType: INTDescription: Select the chassis: Values from 1 to 6 |
| Input argument | Name: IndexType: INTDescription: Select the channel: Index from 1 or 5The selected index represents the first channel of a QPD, whereas Index+1, Index+2 and Index+3 represent the second, third and forth channel, respectively. |
| In/out argument | Name: QpdType: IscWhiteningQpdStructDescription: User Interface structure for four channels of ISC whitening describing the channels of a four segment ASC quad photodiode. |

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| **Program Example:**PROGRAM WhiteningVAR IscWhiteningIn AT %IB0: IscWhiteningInStruct; IscWhiteningOut AT %QB0: IscWhiteningOutStruct; IscWhitening: IscWhiteningStruct; IscWhiteningChassis: IscWhiteningInterfaceFB; LenSensor: ARRAY [1..4] OF IscWhiteningDemodIQStruct; Power: IscWhiteningChannelStruct; Wfs: ARRAY [1..2] OF IscWhiteningDemodWfsStruct; Qpd: ARRAY [1..2] OF IscWhiteningQpdStruct; DemodLen: ARRAY [1..4] OF IscWhiteningDemodIQFB; MonitorPower: IscWhiteningChannelFB; DemodWfs: ARRAY [1..2] OF IscWhiteningDemodWfsFB; MonitorQpd: ARRAY [1..2] OF IscWhiteningQpdFB; I: INT;END\_VAR(\* Process individual sensors \*)FOR I := 1 TO 4 DO DemodLen[I] (IscWhitening := IscWhitening, Chassis := 1, Index := I, Demod := LenSensor[I]);END\_FOR;MonitorPower (IscWhitening := IscWhitening, Chassis := 1, Index := 5, Channel := Power);FOR I := 1 TO 2 DO DemodWfs[I] (IscWhitening := IscWhitening, Chassis := I+1, DemodWfs := Wfs[I]);END\_FOR;FOR I := 1 TO 2 DO MonitorQpd[I] (IscWhitening := IscWhitening, Chassis := 4, Index := I+4, Qpd := Qpd[I]);END\_FOR;(\* Process whitening chassis after individual sensors \*)IscWhiteningChassis (In := IscWhiteningIn, Out => IscWhiteningOut, Val := IscWhitening); |

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| **Visual****IscWhiteningVis.jpg** |
| Name | IscWhiteningVis |
| Description | Displays the tags of an 384-channel binary IO chassis organized in six ISC whitening chassis which in turn show a list of 8 channels each. Each channel has 8 bits (1 byte) and shows the readback value. It lets you choose a new set value or apply a toggle value. The channel background turns red if the value is invalid. |
| Placeholder | Name: whiteningType: IscWhiteningStructDescription: Internal interface structure |

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| **Visual** |
| Name | IscWhiteningChannelVis |
| Description | Displays the tags of single channel of whitening |
| Placeholder | Name: channelType: IscWhiteningChannelStructDescription: ISC whitening channel structure |

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| **Visual** |
| Name | IscWhiteningDemodIQVis |
| Description | Displays the tags of two channels of whitening |
| Placeholder | Name: demodType: IscWhiteningDemodIQStructDescription: ISC whitening IQ demodulator structure |

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| **Visual** |
| Name | IscWhiteningDemodWfsVis |
| Description | Displays the tags of eight channels of whitening |
| Placeholder | Name: wfsType: IscWhiteningDemodWfsStructDescription: ISC whitening WFS demodulator structure |

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| **Visual** |
| Name | IscWhiteningQpdVis |
| Description | Displays the tags of four channels of whitening |
| Placeholder | Name: qpdType: IscWhiteningQpdStructDescription: ISC whitening quad photodiode structure |