aLIGO Slow Controls Update/Status Report

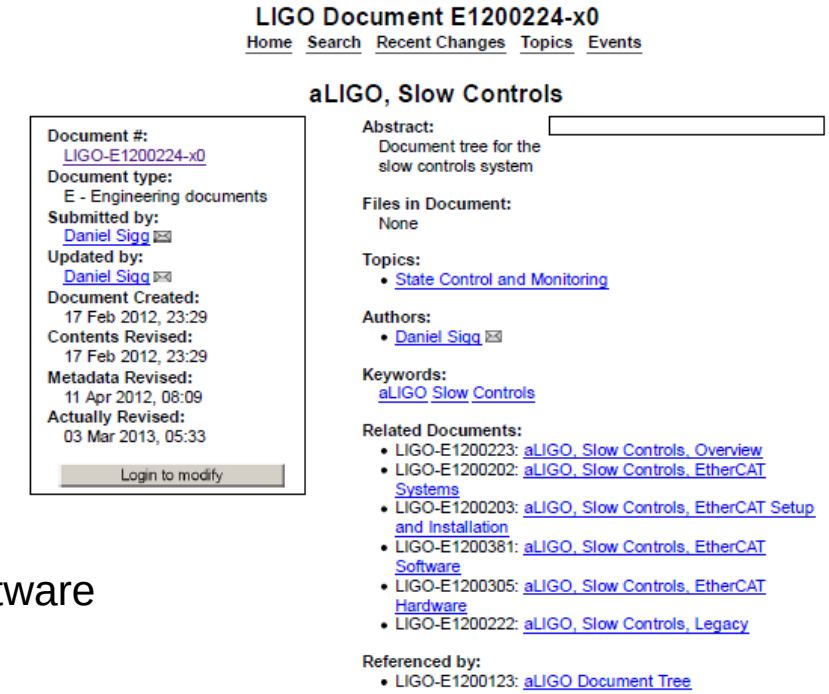
Presented by Vern Sandberg

Presentation given to the Systems Group on Wednesday, October 23, 2013

LIGO-G1301174-v2

Experience & Status of the LIGO Slow Controls System(s)
E1200224, aLIGO, Slow Controls
A few specific links that may prove generally useful:
D1100683, Block Diagram
D1102294, Network Diagram
G1200005, EtherCAT for advanced LIGO
G1100098, EtherCAT (Beckhoff) for advanced LIGO
E1200225, Coding Standard for TwinCAT Slow Controls Software
F1200003, Template for TwinCAT Library Documentation

Working Documentation is in the aLIGO WIKI


LIGO Document E1200224-x0

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aLIGO, Slow Controls

Document #: LIGO-E1200224-x0
Document type: E - Engineering documents
Submitted by: Daniel Sigg
Updated by: Daniel Sigg
Document Created: 17 Feb 2012, 23:29
Contents Revised: 17 Feb 2012, 23:29
Metadata Revised: 11 Apr 2012, 08:09
Actually Revised: 03 Mar 2013, 05:33
Login to modify

Abstract: Document tree for the slow controls system

Files in Document: None

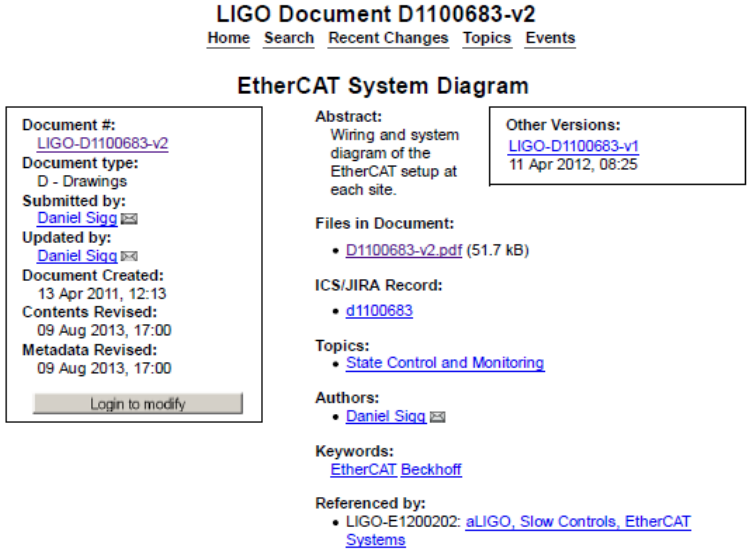
Topics: State Control and Monitoring

Authors: Daniel Sigg

Keywords: aLIGO Slow Controls

Related Documents:
- LIGO-E1200223: aLIGO, Slow Controls, Overview
- LIGO-E1200202: aLIGO, Slow Controls, EtherCAT Systems
- LIGO-E1200203: aLIGO, Slow Controls, EtherCAT Setup and Installation
- LIGO-E1200381: aLIGO, Slow Controls, EtherCAT Software
- LIGO-E1200305: aLIGO, Slow Controls, EtherCAT Hardware
- LIGO-E1200222: aLIGO, Slow Controls, Legacy

Referenced by:
- LIGO-E1200123: aLIGO Document Tree


LIGO Document D1100683-v2

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EtherCAT System Diagram

Document #: LIGO-D1100683-v2
Document type: D - Drawings
Submitted by: Daniel Sigg
Updated by: Daniel Sigg
Document Created: 13 Apr 2011, 12:13
Contents Revised: 09 Aug 2013, 17:00
Metadata Revised: 09 Aug 2013, 17:00
Login to modify

Abstract: Wiring and system diagram of the EtherCAT setup at each site.

Other Versions: LIGO-D1100683-v1 11 Apr 2012, 08:25

Files in Document:
- D1100683-v2.pdf (51.7 kB)

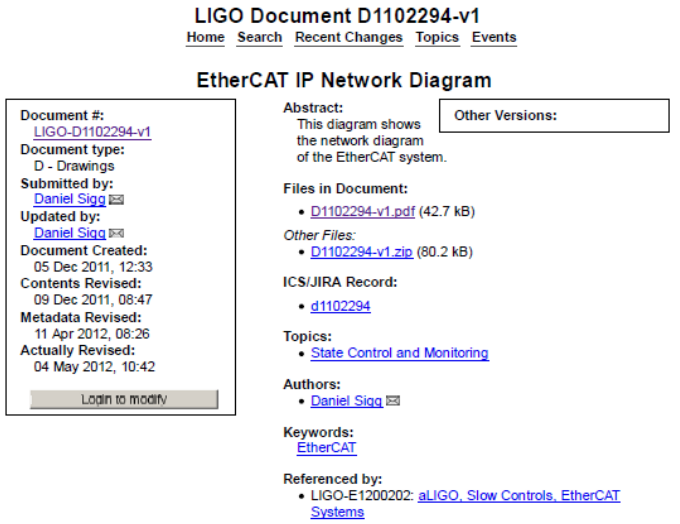
ICS/JIRA Record:
- d1100683

Topics:
- State Control and Monitoring

Authors:
- Daniel Sigg

Keywords: EtherCAT Beckhoff

Referenced by:
- LIGO-E1200202: aLIGO, Slow Controls, EtherCAT Systems


LIGO Document D1102294-v1

Home Search Recent Changes Topics Events

EtherCAT IP Network Diagram

Document #: LIGO-D1102294-v1
Document type: D - Drawings
Submitted by: Daniel Sigg
Updated by: Daniel Sigg
Document Created: 05 Dec 2011, 12:33
Contents Revised: 09 Dec 2011, 08:47
Metadata Revised: 11 Apr 2012, 08:26
Actually Revised: 04 May 2012, 10:42
Login to modify

Abstract: This diagram shows the network diagram of the EtherCAT system.

Other Versions:

Files in Document:
- D1102294-v1.pdf (42.7 kB)

Other Files:
- D1102294-v1.zip (80.2 kB)

ICS/JIRA Record:
- d1102294

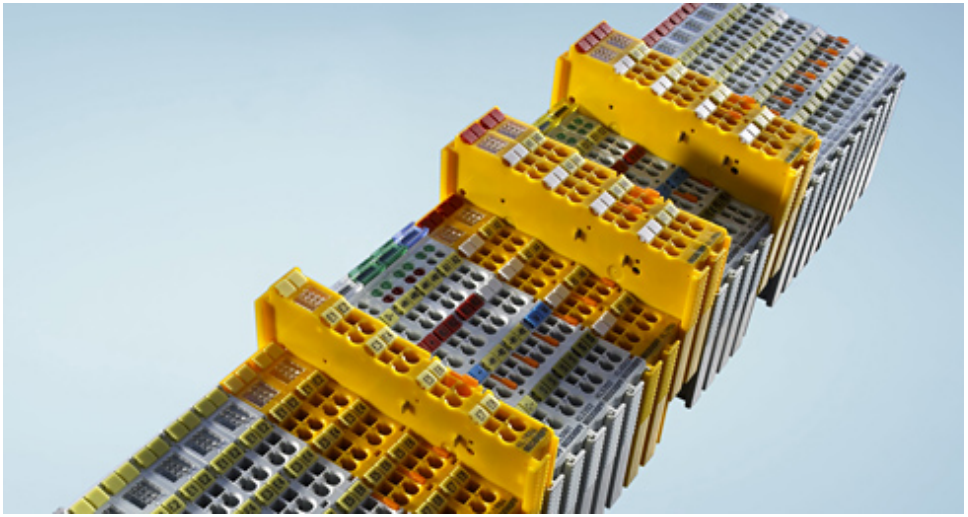
Topics:
- State Control and Monitoring

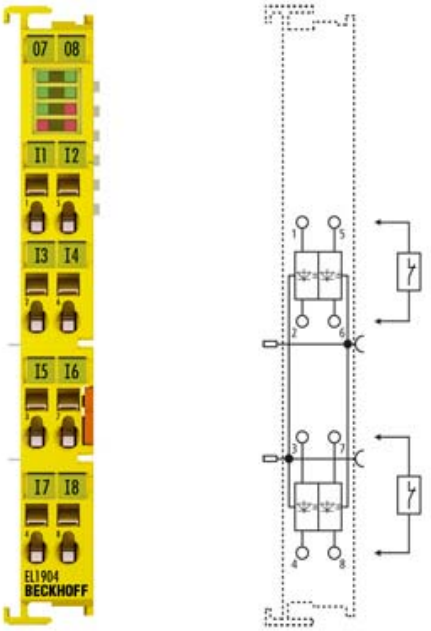
Authors:
- Daniel Sigg

Keywords: EtherCAT

Referenced by:
- LIGO-E1200202: aLIGO, Slow Controls, EtherCAT Systems

TwinSafe

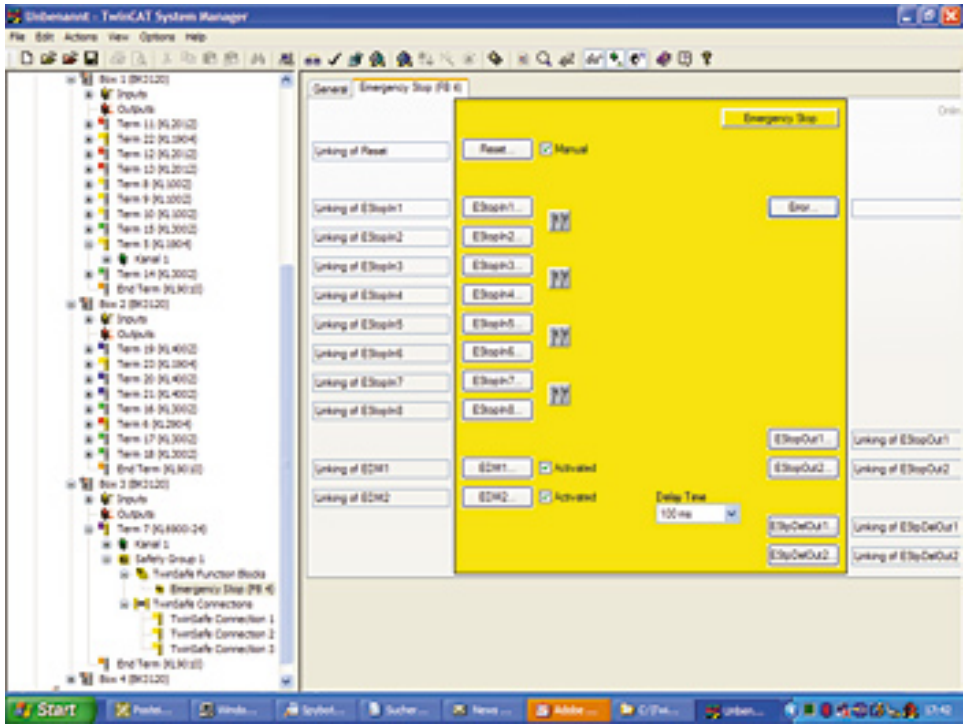




Allows Safety interlock to be used without having to install separate chassis though you can

EASY Setup with Pre-Existing Function Blocks

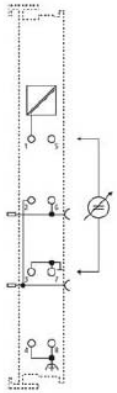
Select Function block like E-Stop
Allows you to select what inputs you are monitoring from any of the Safety input cards either in the corner station or end station.
Allows the you to change the state of any of the safety outputs either in the corner or end station. Monitors the network connections to safety inputs and disables outputs if lost. Very flexible and allows variables to communicate with MEDM screens.



DIN Rail and Packaging System

35 mm DIN rail with mounted circuit breaker (rear view)

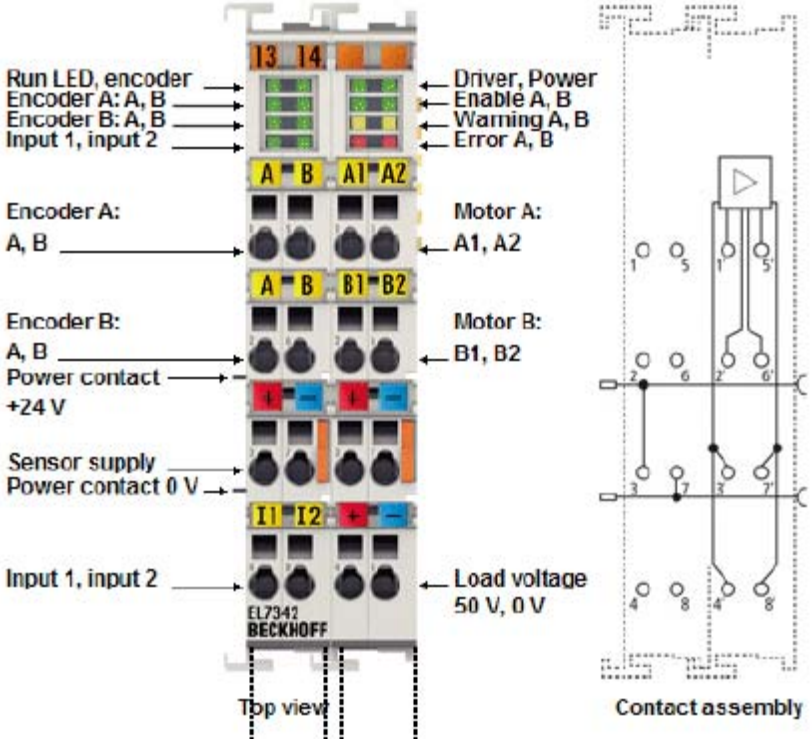
EK1501 | EtherCAT Coupler with ID switch, fibre optic



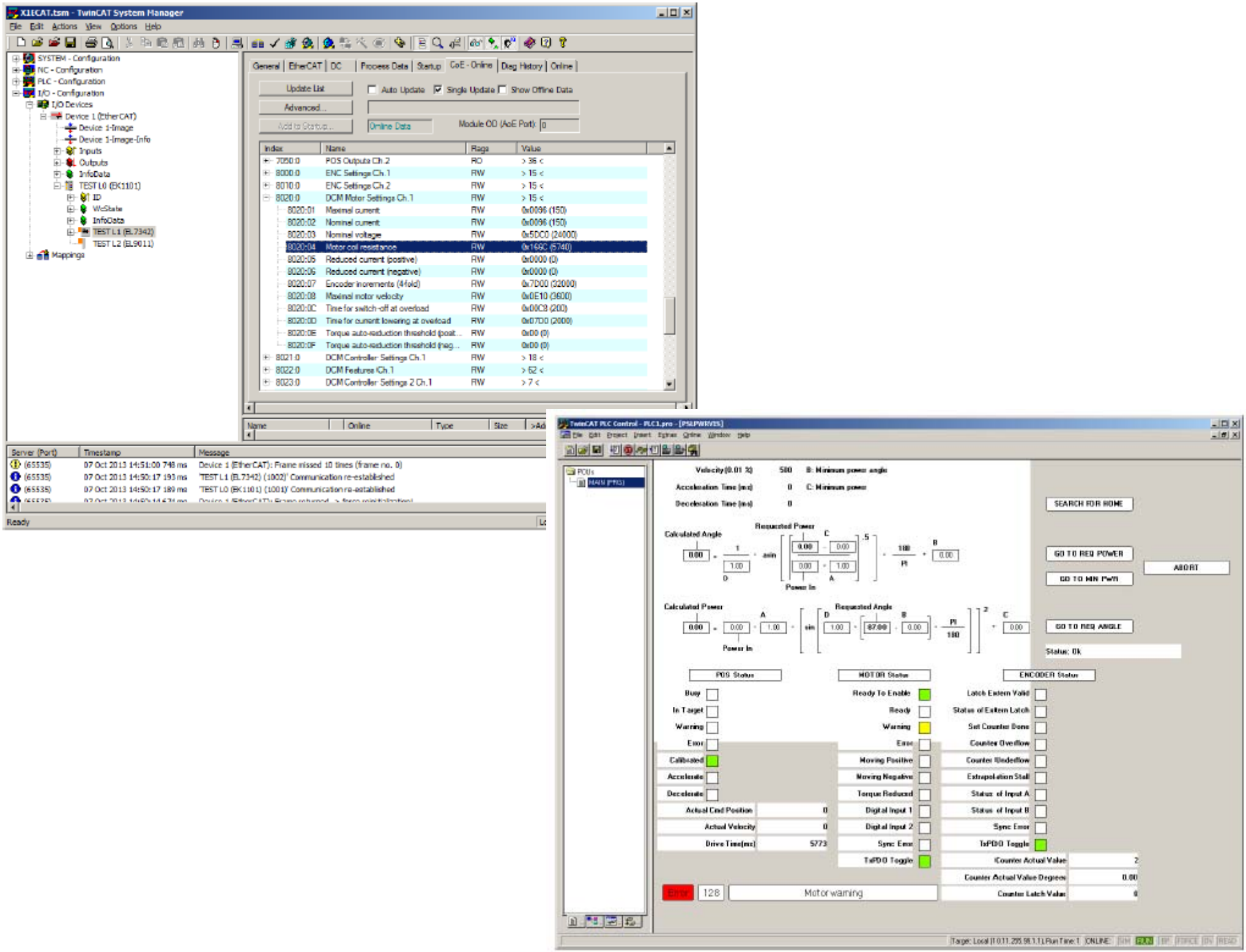
EL3061, EL3062 | 1-, 2-channel analog input terminals 0…10 V, single-ended, 12 bits

EtherCAT Terminal, analog output EL4xxx | ES4xxx

EL7342 Parameter Table



Index	Name	Flags	Value
8000:0	ENC Settings Ch.1	RW	> 15 <
8000:08	Disable filter	RW	FALSE
8000:0A	Enable micro increments	RW	FALSE
8000:0E	Reversion of rotation	RW	FALSE
8010:0	ENC Settings Ch.2	RW	> 15 <
8020:0	DCM Motor Settings Ch.1	RW	> 15 <
8020:01	Maximal current	RW	**0x0096 (150)**
8020:02	Nominal current	RW	**0x0096 (150)**
8020:03	Nominal voltage	RW	**0x5DC0 (24000)**
8020:04	Motor coil resistance	RW	**0x1982 (6530)**
8020:05	Reduced current (positive)	RW	0x0000 (0)
8020:06	Reduced current (negative)	RW	0x0000 (0)
8020:07	Encoder increments (4-fold)	RW	**0x7D00 (32000**)
8020:08	Maximal motor velocity	RW	**0x0E10 (3600)**
8020:0C	Time for switch-off at overload	RW	0x00C8 (200)
8020:0D	Time for current lowering at overload	RW	0x07D0 (2000)
8020:0E	Torque auto-reduction threshold (positive)	RW	0x00 (0)
8020:0F	Torque auto-reduction threshold (negative)	RW	0x00 (0)
8021:0	DCM Controller Settings Ch.1	RW	> 18 <
8021:01	Kp factor (curr.)	RW	0x00C8 (200)
8021:02	Ki factor (curr.)	RW	0x0002 (2)
8021:03	Inner window (curr.)	RW	0x00 (0)
8021:05	Outer window (curr.)	RW	0x00 (0)
8021:06	Filter cut off frequency (curr.)	RW	**0x0064 (100)**
8021:11	Voltage adjustment enable	RW	FALSE
8021:12	Current adjustment enable	RW	FALSE
8022:0	DCM Features Ch.1	RW	> 62 <
8022:01	Operation mode	RW	**Position controller (3)**
8022:09	Invert motor polarity	RW	FALSE
8022:0A	Torque error enable	RW	FALSE
8022:0B	Torque auto reduce	RW	FALSE
8022:11	Select info data 1	RW	Motor coil voltage (1)
8022:19	Select info data 2	RW	Motor coil current (2)

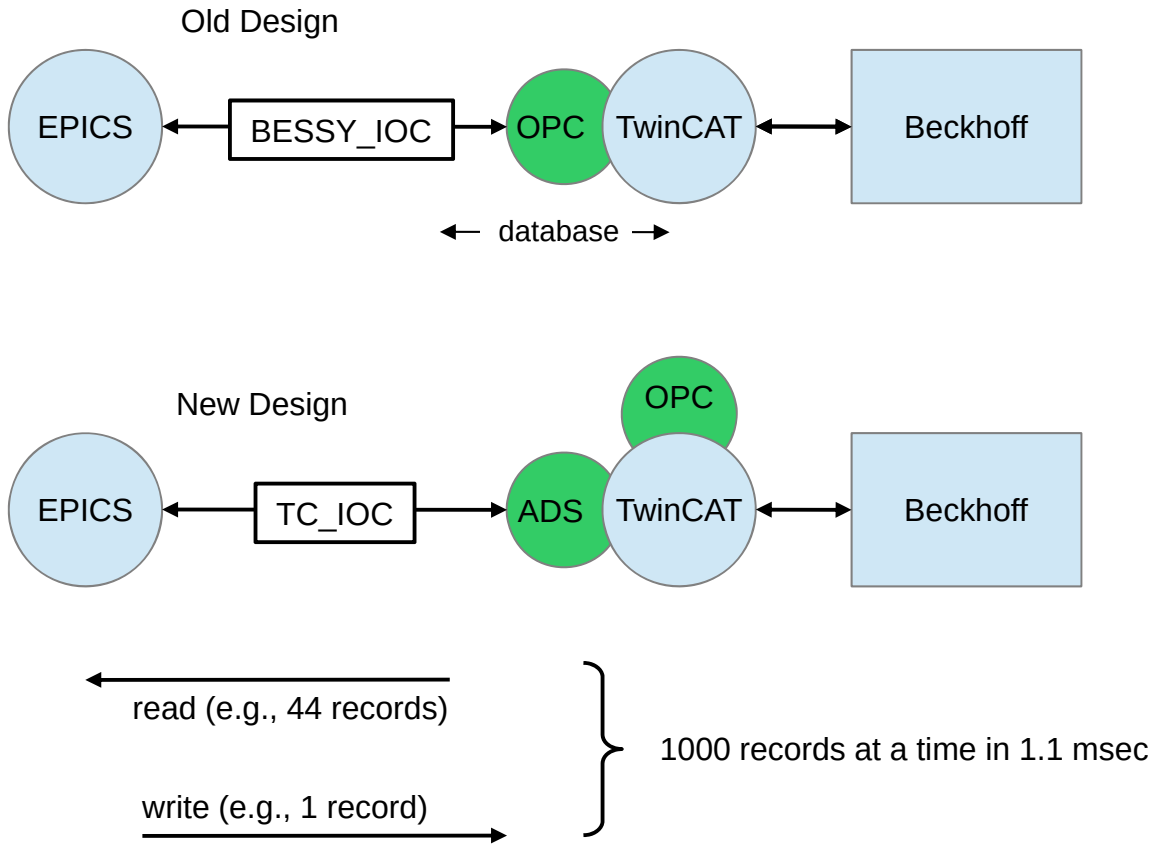

X1ECAT.tsm - TwinCAT System Manager
File Edit Actions View Options Help
SYSTEM - Configuration
NC - Configuration
PLC - Configuration
I/O - Configuration
I/O Devices
Device 1 (EtherCAT)
Device 1-Image
Device 1-Image-Info
Inputs
Outputs
InfoData
TEST L0 (EK1101)
ID
WcState
InfoData
TEST L1 (EL7342)
TEST L2 (EL9011)
Mappings
General EtherCAT DC Process Data Startup CoE - Online Diag History Online
Update List
Auto Update
Single Update
Show Offline Data
Advanced...
Add to Startup...
Online Data
Module OD (AoE Port):
Index Name Flags Value
8020:01 Maximal current RW 0x0096 (150)
8020:02 Nominal current RW 0x0096 (150)
8020:03 Nominal voltage RW 0x5DC0 (24000)
8020:04 Motor coil resistance RW 0x199C (6540)
8020:05 Reduced current (positive) RW 0x0000 (0)
8020:06 Reduced current (negative) RW 0x0000 (0)
8020:07 Encoder increments (4fold) RW 0x7D00 (32000)
8020:08 Maximal motor velocity RW 0x0E10 (3600)
8020:0C Time for switch-off at overload RW 0x00C8 (200)
8020:0D Time for current lowering at overload RW 0x07D0 (2000)
8020:0E Torque auto-reduction threshold (posit... RW 0x00 (0)
8020:0F Torque auto-reduction threshold (neg... RW 0x00 (0)
8021:0 DCM Controller Settings Ch.1 RW > 18 <
8022:0 DCM Features Ch.1 RW > 62 <
8023:0 DCM Controller Settings 2 Ch.1 RW > 7 <
Name Online Type Size
Server (Port) Timestamp Message
(65535) 07 Oct 2013 14:51:00 748 ms Device 1 (EtherCAT): Frame missed 10 times (frame no. 0)
(65535) 07 Oct 2013 14:50:17 193 ms 'TEST L1 (EL7342) (1002)' Communication re-established
(65535) 07 Oct 2013 14:50:17 189 ms 'TEST L0 (EK1101) (1001)' Communication re-established
Ready
TwinCAT PLC Control - PLC1.pro - [PSEPWM1]
PLC1
MAIN (PRG)
Velocity (0.01 %)
Acceleration Time (ms)
Deceleration Time (ms)
Calculated Angle
Requested Power
Power In
Calculated Power
Requested Angle
SEARCH FOR HOME
GO TO REQ POWER
GO TO MIN PWR
ABORT
GO TO REQ ANGLE
Status: Ok
POS Status
Busy
In Target
Warning
Error
Calibrated
Accelerate
Decelerate
Actual Cmd Position
Actual Velocity
Drive Time[ms]
MOTOR Status
Ready To Enable
Ready
Warning
Error
Moving Positive
Moving Negative
Torque Reduced
Digital Input 1
Digital Input 2
Sync Error
TxPDO Toggle
ENCODER Status
Latch Extern Valid
Status of Extern Latch
Set Counter Done
Counter Overflow
Counter Underflow
Extrapolation Stall
Status of Input A
Status of Input B
Sync Error
TxPDO Toggle
Counter Actual Value
Counter Actual Value Degrees
Counter Latch Value
Error
128
Motor warning
Target: Local (10.11.205.98.1.1), Run Time 1
ONLINE

EPICS to Beckhoff Communication

Hardware Bus (fieldbus) = EtherCAT

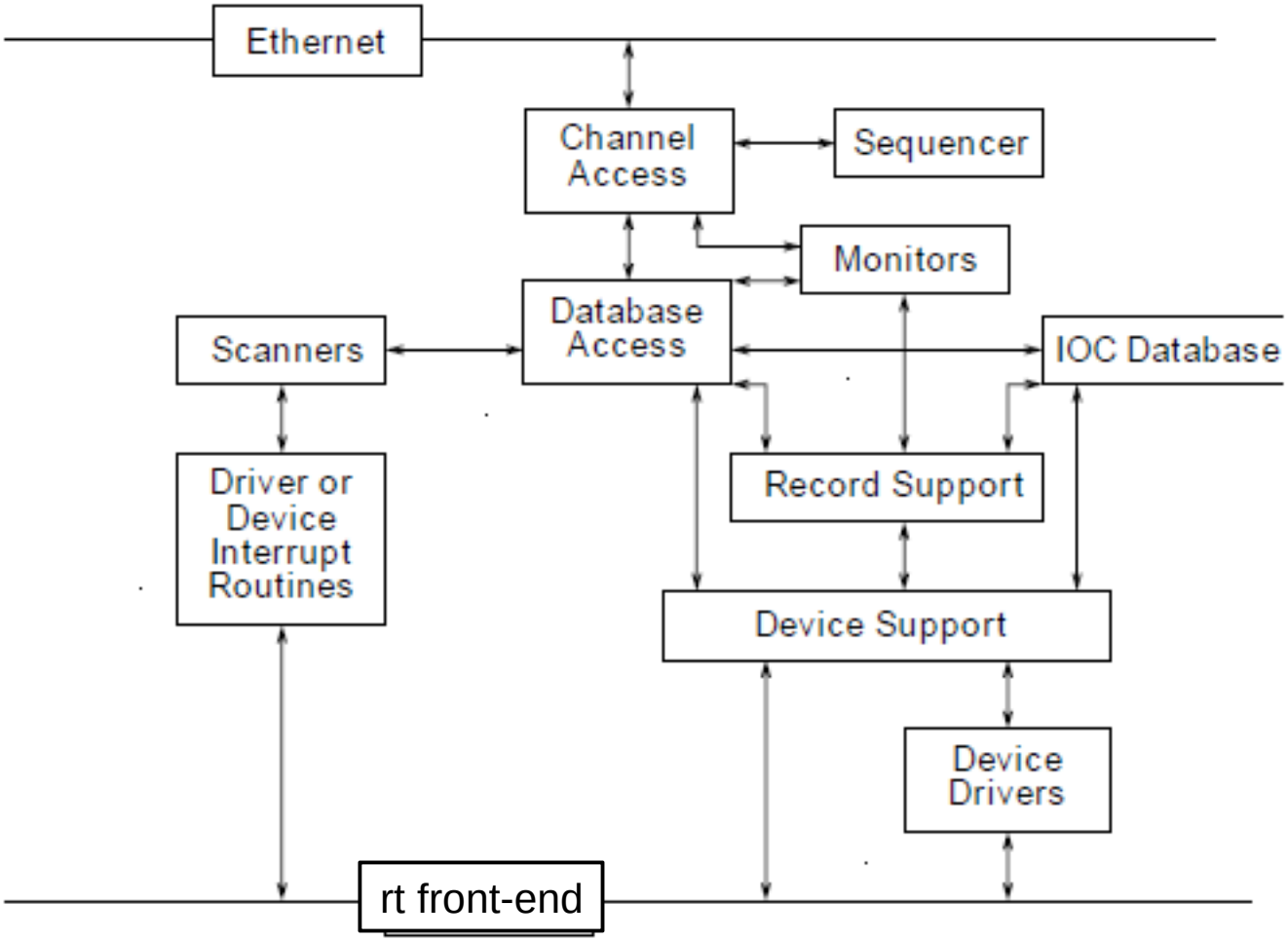
Communications & Control Software = TwinCAT

Export Modules: OPC, ADS



T1300690-v1, **TwinCAT EPICS IOC Documentation**

EPICS IOC Software Components



we use the real time linux system created by Alex Ivanov

BESSY

Berliner Elektronenspeicherring-Gesellschaft
für Synchrotronstrahlung m.b.H.

Administration of Soft IOCs under Linux

Ralph Lange (BESSY)

Leibniz Gemeinschaft

EPICS OPC Device Support

Module Owner:
Carsten Winkler *Support*
Bernhard Kuner *Author*

This page is the home of the EPICS OPC Device Support module, which provides Device Support for the Windows platform to access variables located on an OPC server.

This site gives access to the software source code, information on other modules which are needed to install and run it, and documentation on the how to include and use it in your EPICS applications. Please email any comments and bug reports to the module owner who is responsible for coordinating development and releases.

Where to Find It

You can download the software directly from the links in the table below:

Module Version	EPICS Release	Sources	Windows Installable	Documentation
0-9-beta	3.14.2 win32-x86	opcApp0-9-beta.zip	-	readme0-9-beta
2.1	3.14.2 win32-x86	OPCIocShellApp.tar	OpcApp_2_1.exe	readme2.1
2.0.1	3.14.6 win32-x86	included in setup	OpcApp_2_BASE_3_14_6.exe	readme2.01.html
3.3	3.14.7 win32-x86	included in setup	opcIocShell_3_3.exe	readme3.3.html
3.5	3.14.8 win32-x86	included in setup	opcIocShell_3_5.exe	readme3.5.html
3.5i_4_9	3.14.8 win32-x86	included in setup	opcIocShell_3_5_4_9.exe	readme3.5.html
3.6	3.14.9 win32-x86	included in setup	opcIocShell_3_6_0_1.exe	readme3.6.html
3.8.0.0	3.14.12 win32-x86	included in setup	opcIocShell_3_8_0_0.exe	readme3.8.html
3.8.0.1	3.14.12.2 win32-x86	included in setup	opcIocShell_3_8_0_1.exe	readme3.8.0.1.html
		C:\Program Files (x86)\HZB\OpcIocShell\demo\startDemo.cmd (replacement for Windows 7)		

TS6000 | TwinCAT ADS Communication Library
Overview

"TwinCAT ADS Communication Library" is a collection of all ADS components and is delivered with default TwinCAT installation. It enables to develop own application (e.g. visualization, scientific automation), which can communicate with TwinCAT devices (e.g. PLC, NC or IO-devices). Alternatively we provide the free of charge TC1000 | TC3 ADS Setup with all libraries and the ADS router, if you only need the ADS functionalties.

Components of "TwinCAT ADS Communication Library"

After installation these components will be available in folder "..\TwinCAT\AdsApi".

The ADS libraries are provided for following operating systems and technologies:

Windows (32-Bit/64-Bit)

TcAdsDll	C/C++	Windows XP, Vista, 7, 8	ADS components (DLL / Header / Library) to create C/C++ applications	..\TwinCAT\AdsApi\TcAdsDll

IEC-1131 - The First Universal Process Control Language

INTRODUCTION

IEC-1131 is the first international standard for process control software. By using IEC-1131, a programmer can develop a control algorithm for a particular brand of controller, and import that same program to another brand with minimum modifications, primarily to process input/output subsystems.

DESCRIPTION OF THE FUNDAMENTAL CONCEPTS OF IEC-1131

The basic principle of IEC-1131 is that a programmer can develop a control algorithm (referred to as a "Project") using any combination of five control languages; Instruction List, Structured Text, Ladder Diagram, Function Block Diagram, and Sequential Function Chart.

EtherCAT - Ethernet for Control Automation Technology - is an open high performance Ethernet-based fieldbus system. The development goal of EtherCAT was to apply Ethernet to automation applications which require short data update times (also called cycle times) with low communication jitter (for synchronization purposes) and low hardware costs.

Test system

Hardware:

Processor: Intel Xeon CPU X5650
Cores: 6 HT
Threads: 12
Speed: 2.67GHz
Mmeory: 12 GB; 2.99GB usable

Software:

OS: Windows 7
Version: 32-bit operating system
TwinCAT: 2.11

Speed tests

TwinCAT *(test performed on 6/21/2013)*

This test was performed to see how much data we can read from TwinCAT in a single request before overloading the system.

1 channel

1.076ms to read data

TwinCAT System Real Time Usage: was not monitored

1000 channels (~10kB)

1.084ms to read data out in one request

Speed tests continued

TwinCAT *(test performed on 6/21/2013)*

This test was performed to see how much data we can read from TwinCAT in **one request** before overloading the system.

1 channel

1.076ms to read data

TwinCAT System Real Time Usage: was not monitored

1000 channels (~10kB)

1.084ms to read data out in one request

TwinCAT System Real Time Usage: no noticeable change

3,200 channels (~30kB)

1.087ms to read data out in one request

TwinCAT System Real Time Usage: +1-2%

7,500 channels (~70kB)

1.099ms to read data out in one request

TwinCAT System Real Time Usage: +3-4%

15,000 channels (~150kB)

1.121ms to read data out in one request

TwinCAT System Real Time Usage: +4-5%

Speed Tests continued

TwinCAT *(test performed on 6/20/2013)*

This test was performed to see how generating **individual requests for each channel** can overload the TwinCAT system. In this example we specified the memory location for each channel, instead of requesting one large memory region as above. This method proved to be too taxing on the TwinCAT system, so we do not recommend using this mode. Compare to the above performance figures.

1000 channels

1.306ms to get data for all channels

TwinCAT System Real Time Usage: +20%

4000 channels

1.483ms to get data for all channels

TwinCAT System Real Time Usage: +60-80%

EPICS record transfer *(test performed on 7/30/2013)*

It takes ~1.33s to process 1,000,000 records

Thus in a 10ms cycle it can process ~7500 records