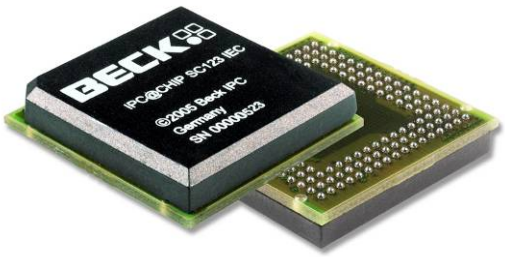
Getting Started
IPC@CHIP Embedded Web Controller Family
IEC 61850 Basics

Development Kit DK61



Documentation Control

Revision:	**1.00**
Revision History:	**1.00 – Initial release**
Revision Date:	**28 April 2010**
Document Status:	**RELEASE**

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1 Introduction

Congratulations on purchasing your IPC@CHIP DK61 Development Kit. The Development Kit is a complete ready-to-use development system for building applications based on the Embedded Web Controllers IPC@CHIP SC123 and IPC@CHIP SC143. It runs with the @CHIP-RTOS operating system, which includes features like a real-time kernel that is capable of running common DOS applications concurrently, a full TCP/IP stack with a UDP/TCP socket interface, DHCP, FTP, PPP, Telnet, Web server, APIs for CAN and USB controllers, and IEC 61850.

The Development Kit contains both hardware and software components required for a basic development. This document will introduce you to the basics of the standard IEC 61850 of the DK61. Chapter 3 gets you started with creating an IEC 61850 application with your DK61. Chapters 4 and 5 provide the basic concepts of IEC 61850 related to the DK61 with an example.

This document is intended to provide the basic knowledge on IEC 61850 in order to run the introductory example. The example provides basic information, communication and system configuration information.

The use of IEC 61850 requires the software loaded onto the DK61 board. After the DK61 board has been set up it will take only a few steps to run the first example to exchange the status values (on or off) of DIP Switches on board and to switch LEDs on and off. Basic knowledge of communication mechanisms is a prerequisite of the following description.

Further information on IEC 61850 standards can be found in the Appendix.

2 Abbreviations

IED	Intelligent Electronic Device
GOOSE	Generic Object Oriented Substation Events
HMI	Human Machine Interface
ICD	IED Capability Description
IEC	International Electro-technical Commission
IED	Intelligent Electronic Device
INS	Integer Status
IP	Internet Protocol
LN	Logical Node
SCL	System Configuration Language

3 System Start-up

3.1 What do we need to get started?

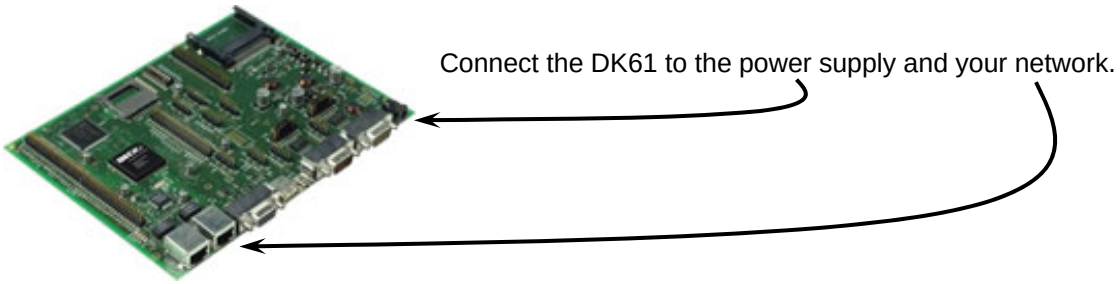
- The Development Kit DK61 consisting of:
  - Development Board DK60
  - Embedded Web Controller IPC@CHIP SC143 (on the DK60)
  - Serial null-modem cable
  - USB cable (A-to-Mini-B)
  - Ethernet patch cable(gray)TPFF FFPT
  - Ethernet crossover cable(red)
  - Secure digital memory card
  - Power supply unit
  - Paradigm C++ Beck IPC Edition CD (including IPC@CHIPTOOL, DEBUG@CHIP debugger,DK61 start-up documentation and drivers)
- Personal Computer:
  - Microsoft Windows NT/2000/XP Operating System
  - Ethernet network interface
  - Serial port
  - USB interface

  Software from the enclosed CD:
  - DemoCD.html
  - API User Manuals
    - Contains “IEC 61850 Protocol API User Manual.pdf” and PIS10API/index.html online manual
  - DK61 Client Application
  - DK61 Server Application
  - IEC 61850 Documents – PICS
  - IEC 61850 Library
    - Contains all the license files for your DK61 serial number
  - Presentation – Power Point Presentation: “61850 ICD Editor DK61 v3.pps”
    - Contains (movies) walk through slides creating ICD Designer files and using the DK61
  - ICD Designer Demonstration Software

Be aware that the Embedded Controller SC143 and the Development Board DK60 are electrostatic sensitive components. Observe general precautions for handling

3.2 Steps to run the IEC 61850 Software on the Development Kit

3.2.1 Set Up the Development Kit Hardware



3.2.2 Copy the contents from the DK61 DemoCD to your PC:

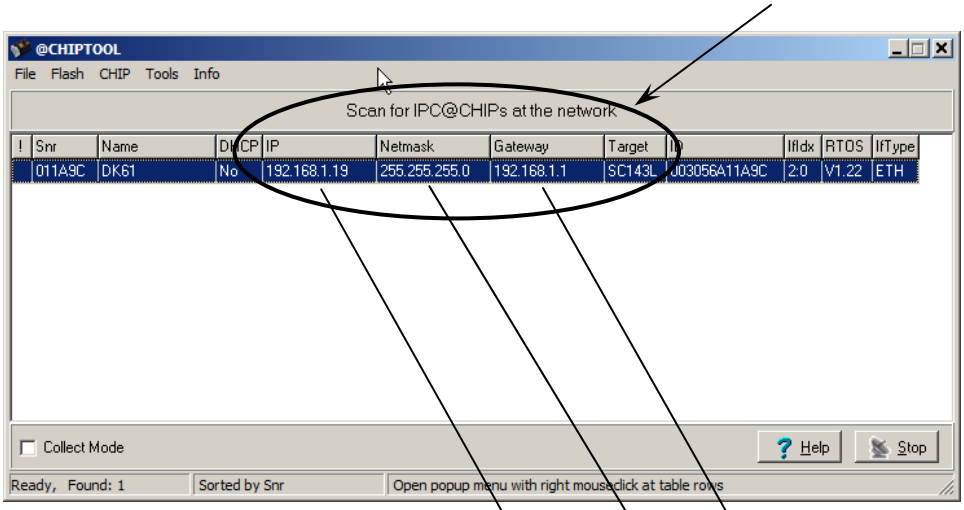
Copy the contents of the CD_DRIVE:|*.* to C:\DK61*.* to make all the files, presentation, and source code examples available on your computer.

Some files need to be customized and copied to the DK61 hardware for the example to work properly. Specifically, there is network address information on your PC and network to be edited. Also, there is a specific 'key' that matches your specific DK61 hardware.

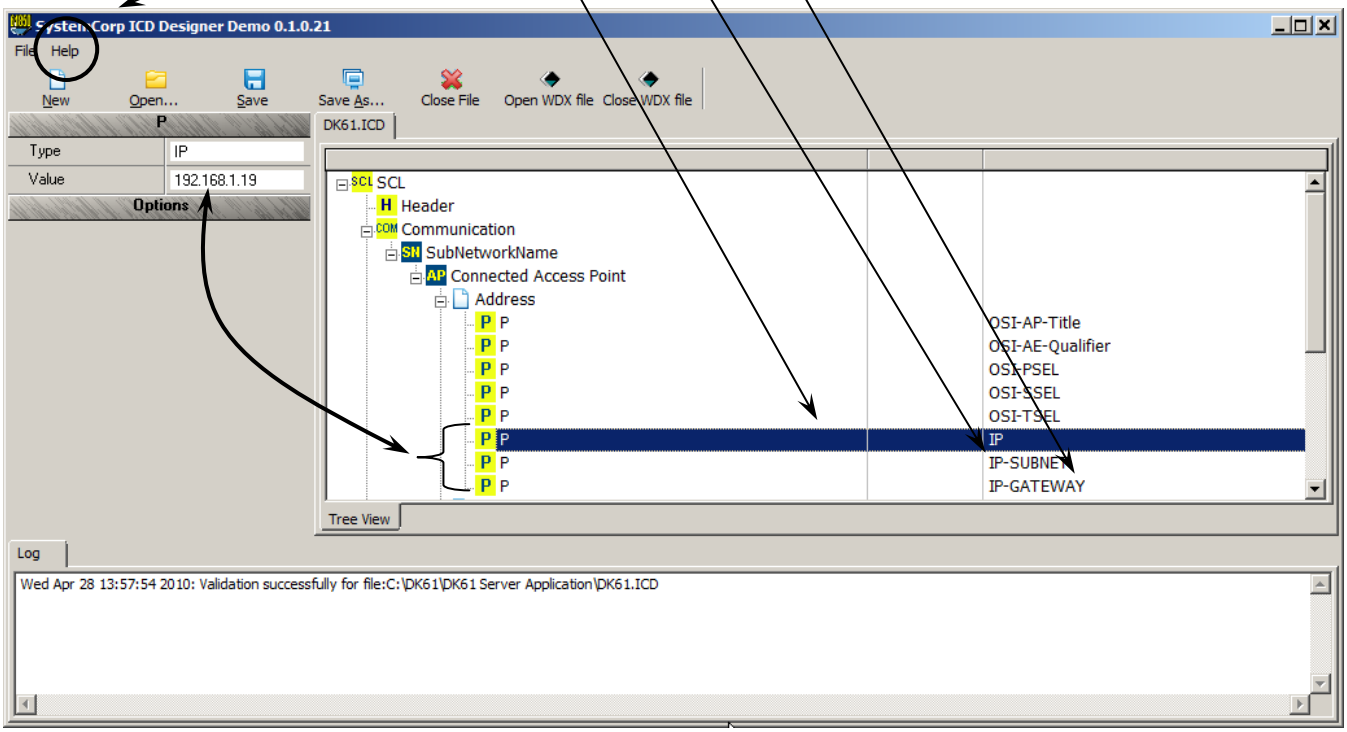
The following pages describe setting this information up.

3.2.3 Setting up the DK61 Device as Server

1. Open CHIPTOOL. Note your specific information for your network and DK61:



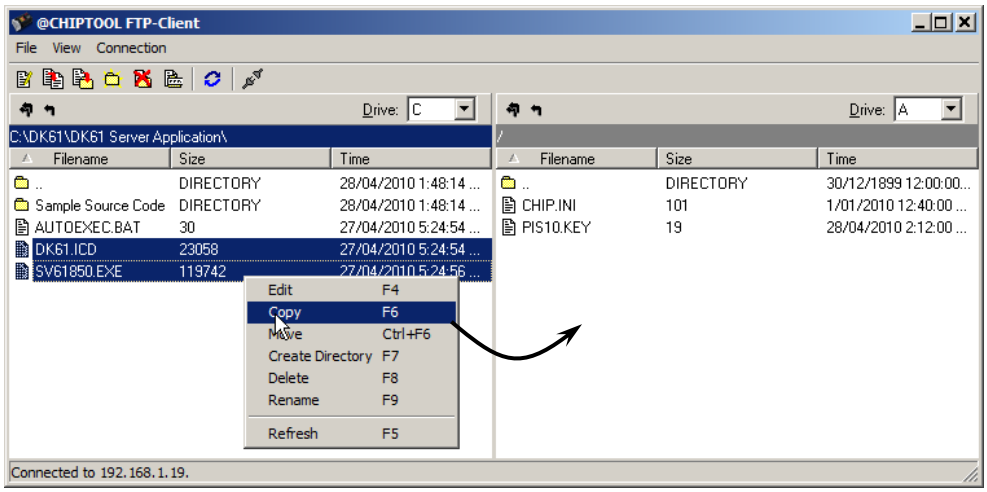
The ICD Designer User Manual is in CD_DRIVE:\ICD Designer\ICDDesigner.pdf and also under “Help”.



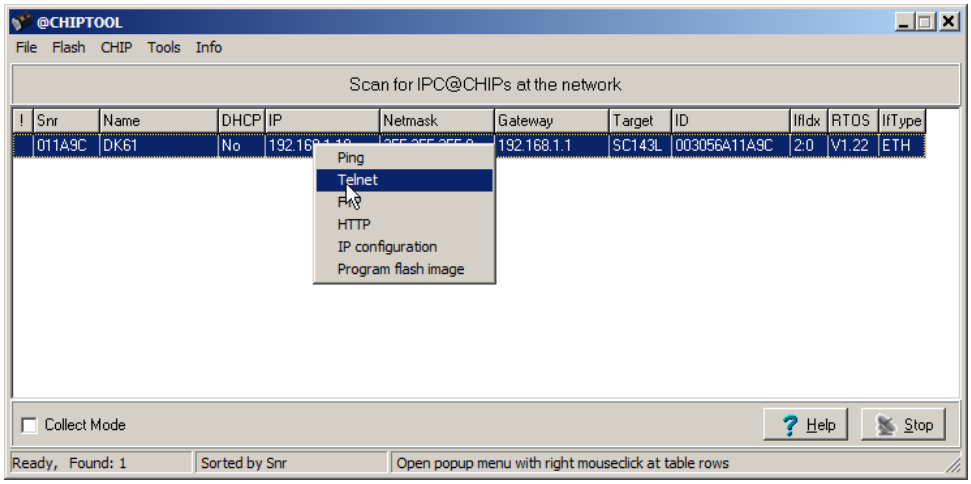
2. Open “DK61.ICD” file (copied earlier under C:\DK61\DK61 Server Application) with the ICD Designer application. According to your specific information in CHIPTOOL:
   a. Select then change the “IP”
   b. Select then change the “IP-SUBNET”
   c. Select then chance the “IP-GATEWAY”

3. Using CHIPTOOL download the specific “PIS10.key” file matching your DK61 serial number. From CD_Drive:\IEC 61850 Library\BECK_SSSSS, where “SSSSS” is the Serial number of your specific DK61 (Example if Serial Number is 0583C) copy the “PIS10.key” to the DK61

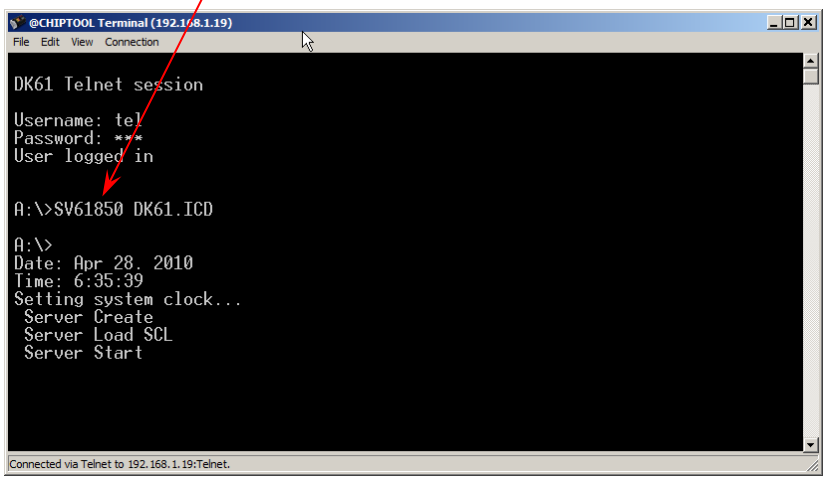
4. Next, download “DK61.ICD” that you edited above with ICD Designer and also the SV61850.EXE to your DK61.



5. Again using CHIPTOOL, right-click on your DK61 and open a Telnet session into the DK61



6. Start the server by typing “SV61850 DK61.ICD” at command prompt in Telnet.
   If there are any errors, please refer to API User Manual to resolve it.

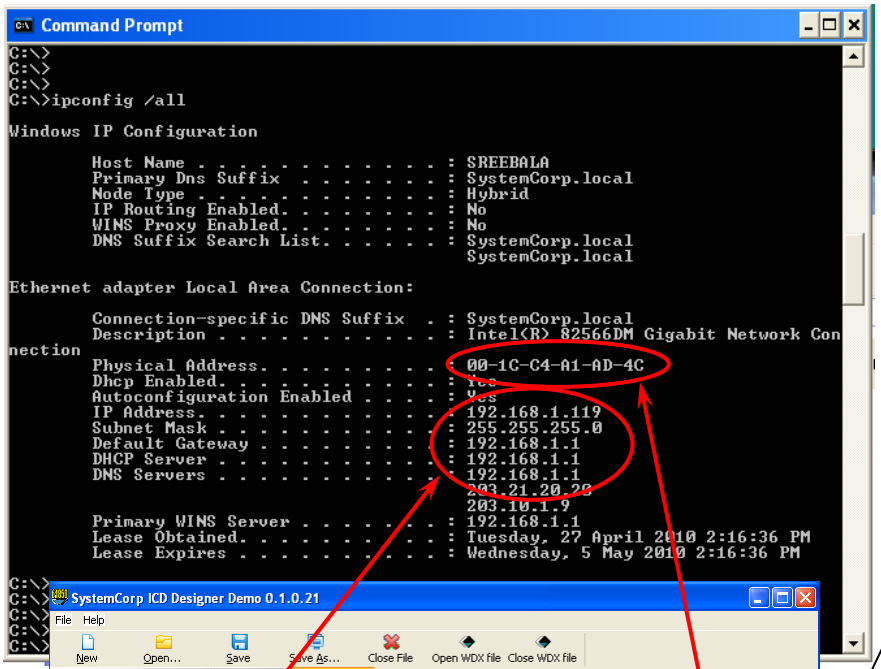


7. Start IEDScout or any other Client test application to see if you can connect to the 61850 Server on DK61

8. On successful connection, autoexec.bat can be downloaded so that server starts automatically on reboot of DK61.

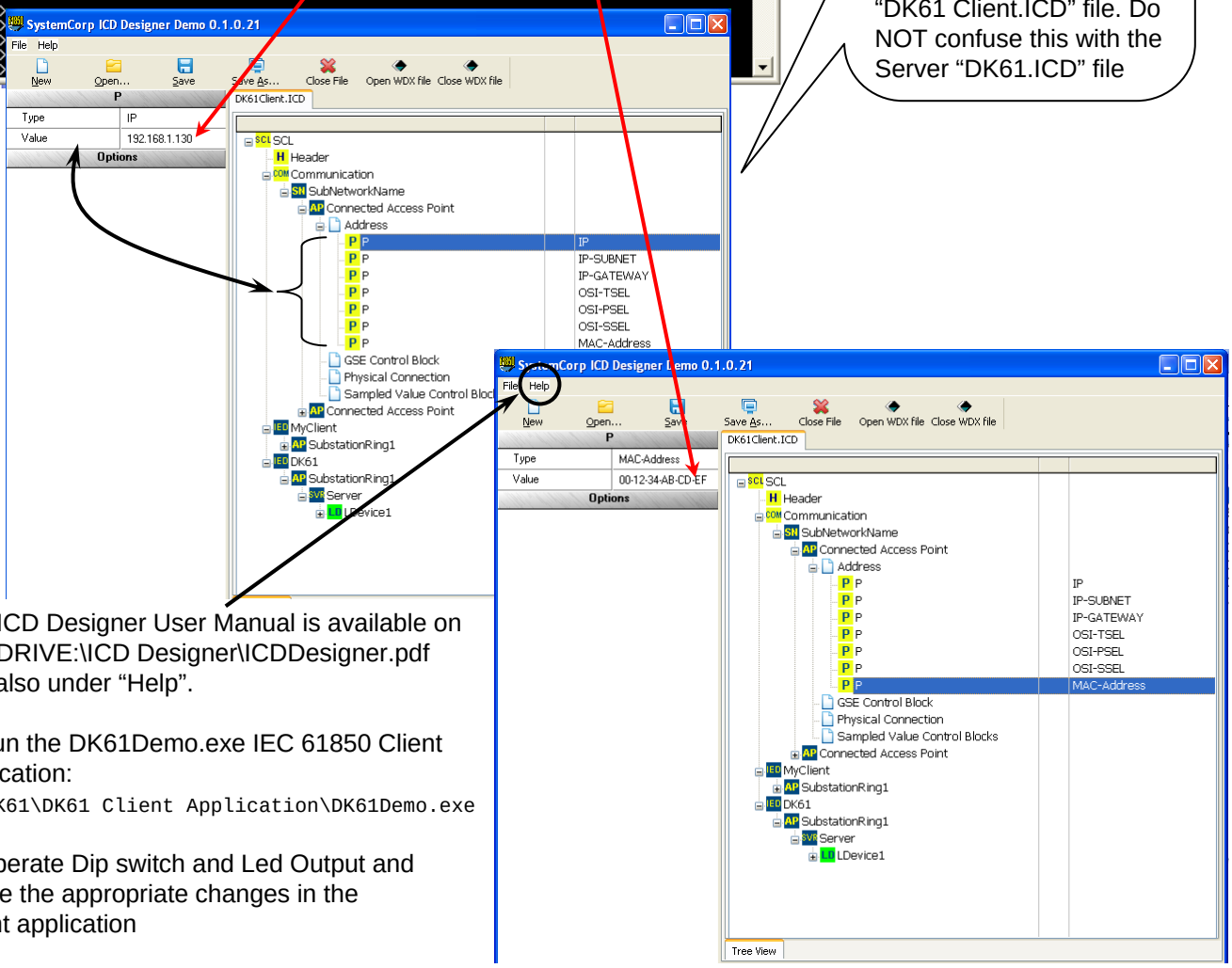
3.2.4 Setting up the Client

1. On the PC that you will use as the client type at the Command Prompt: "`ipconfig /all`"



2. Note the information from "`ipconfig /all`" then enter that information into ICD Designer.

NOTE: This shows the "DK61 Client.ICD" file. Do NOT confuse this with the Server "DK61.ICD" file

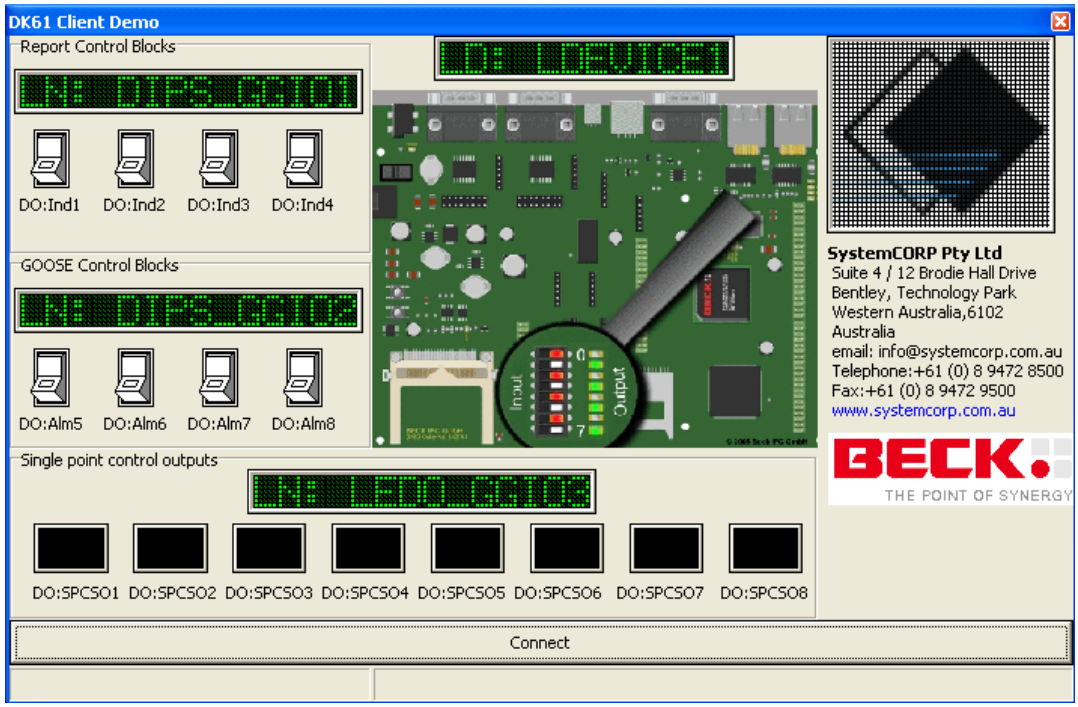


The ICD Designer User Manual is available on CD_DRIVE:\ICD Designer\ICDDesigner.pdf and also under "Help".

3. Run the DK61Demo.exe IEC 61850 Client application:
`C:\DK61\DK61 Client Application\DK61Demo.exe`

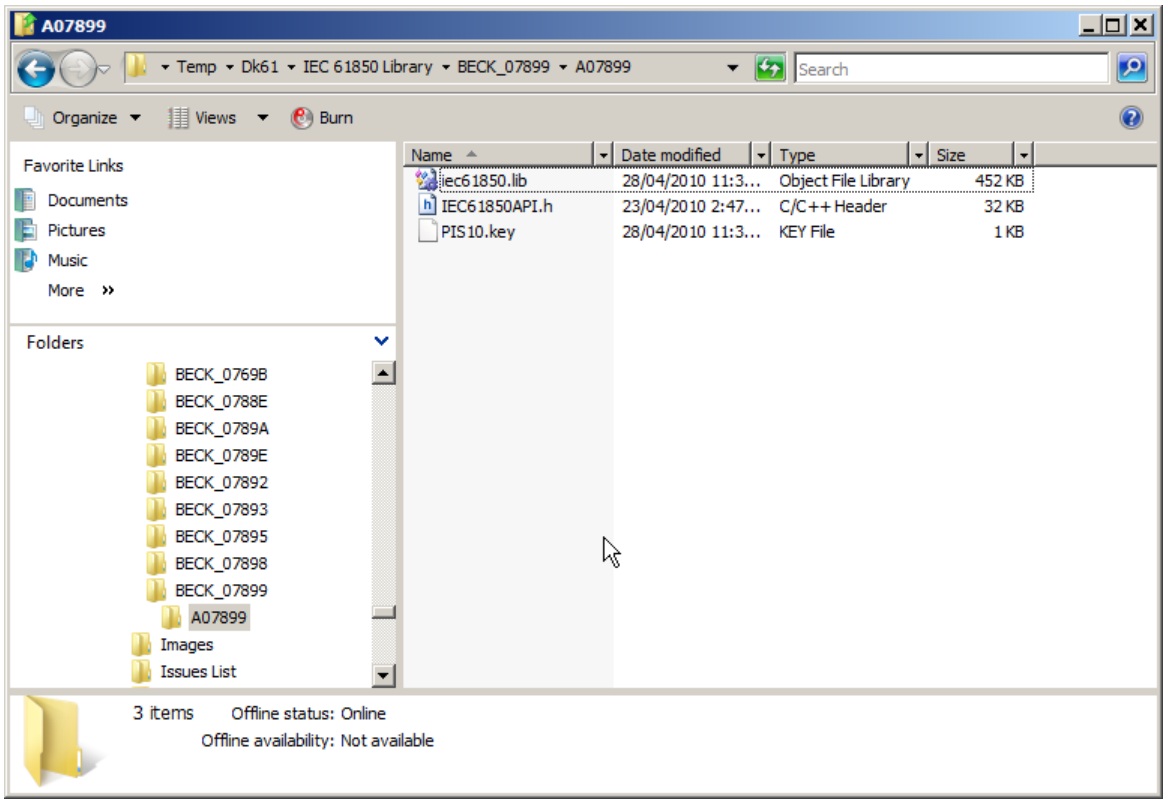
4. Operate Dip switch and Led Output and notice the appropriate changes in the Client application

DK61Demo.exe:

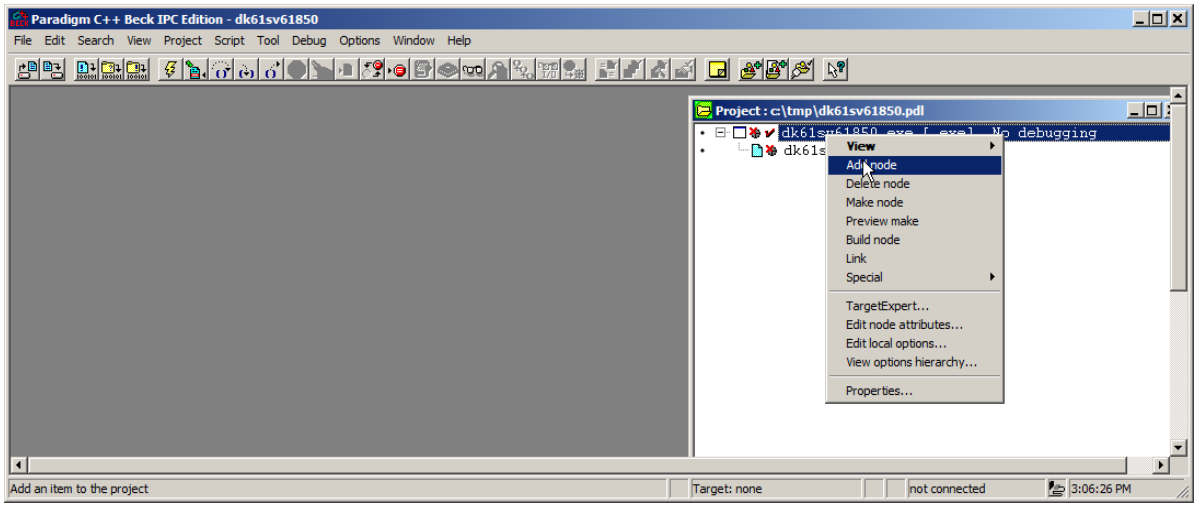


3.2.5 Building your own Server

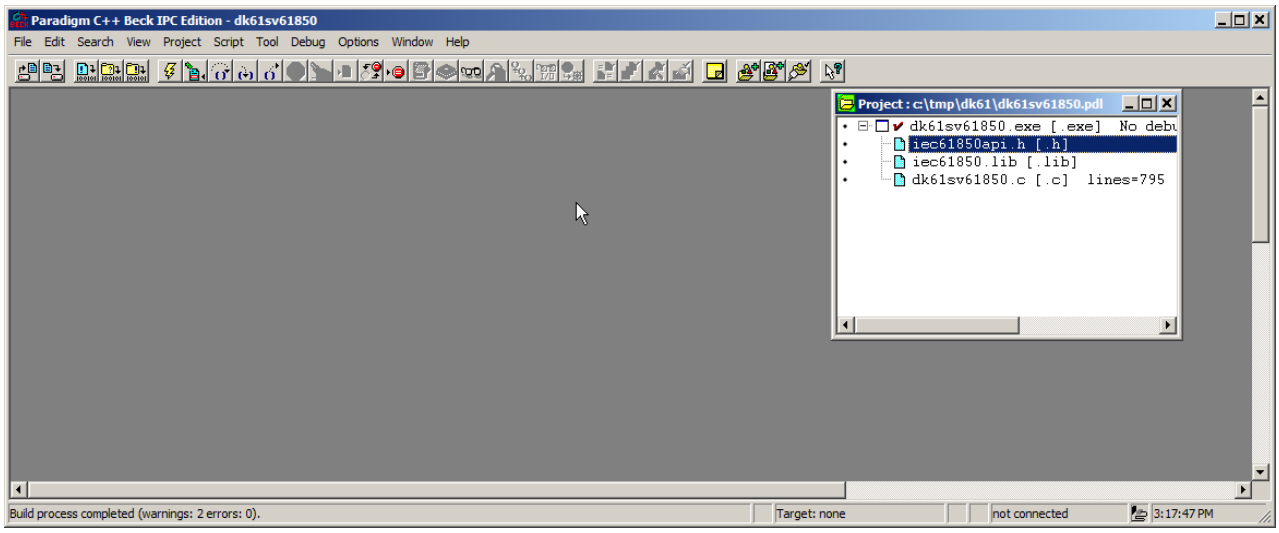
1. Copy to PC iec61850.lib and IEC61850API.h From CD_Drive:\IEC 61850 Library\BECK_SSSSS; where SSSSS is the Serial number of your DK61 (Example : If the Serial number is A07899)



2. Open paradigm , Create New Project and than Select Add Node



3. Add nodes iec61850.lib and iec61850Api.h



4. Add your server application source code to the project (sample available at CD_Drive:\ DK61 Server Application\Sample Source Code) .

5. Build your custom Server executable.

6. Download your executable to the DK61.

4 Basics of IEC 61850 related to the Example

4.1 General remarks

The standard series IEC 61850 provides a uniform framework for the specification, exchange and configuration of information. It applies to the Process level (actuators, sensors of any type), level of Control and Protection and higher levels as Station level, e.g., in substations (HMI and remote control link).

The standard comprises:

1. **General rules** (project management, environmental and EMC requirements, etc.)
2. **Common and domain specific information** for functions and devices (measured values, status and switching information, etc.),
3. **Information of and about primary devices** (switches, transformers and instrument transformers) and
4. **Information exchange** for protection, monitoring, control, measurement and metering
5. A **configuration language**.

Interoperability between devices and between engineering (configuration) tools is the main goal of IEC 61850. It is intended to enable two or more IEDs (Intelligent Electronic Devices) from one or more suppliers to exchange information which is defined in the IEC 61850 standard and to unambiguously interpret and use the information in order to implement the functionality required by the application.

4.2 The main parts of the standard

The standard covers general requirements relating to substations, engineering, data models, communications solutions and conformity testing. The original scope (substations) has been extended to power utility automation. It may be used in any application domain with similar requirements.
The first 16 parts of the standard series have been issued as official IEC standards. It is a toolkit that can be used to design open automation systems. In addition to describing the information flow between functions of automation devices, IEC 61850 provides communications mechanisms between the functions. It leaves a significant amount of freedom to implement communications, so that manufacturers can adapt their functions and system platform to a variety of markets and user requirements.
Parts 1 to 4 contain the introduction and all of the general requirements.
Part 5 describes the basic requirements for substation automation functions.
The substation configuration language is defined in Part 6.
Based on Part 5, Parts 7-1, 7-2, 7 3 ,7-4, 7410, 7-420, and IEC 61400-25-2 contain communication definitions for a variety of functions (data models and communications services).
Parts 8 and 9 define mappings of the definitions contained in Part 7 to real communications networks.
Part 10 defines the basics for conformance tests.
IEC 61850 standards are found in the Appendix 7.2 - IEC 61850 Standards.

4.3 Status and ongoing work

While the last sections of IEC 61850 were being published, work was already in progress on inclusion of applications outside of substations. Many of the world's major power utilities and manufacturers of automation systems are involved in the work to enhance the standards. All of the major manufacturers for electric power systems offer conforming products or are in the process of developing them. Widespread use of IEC 61850 has begun in 2007. The introduction of IEC 61850 compliant products and widespread use are now well underway. The parties who are involved in implementation and use of the standard now have the task of using the experience that they have gained with IEC 61850 to contribute to the ongoing work at IEC TC 57. Many international companies (users and manufacturers) are members of the UCA International Users Group. This organization supports the introduction of IEC 61850 and continued development of the standard (www.ucaiug.org).

4.4 Specification of signals for communication

It was common practice in the past to specify signals in long lists which were drawn up for a particular manufacturer, user or project. IEC 61850 takes a different approach. The standard uses a designator (readable text), a data type (such as double point) and other descriptive information to define the signals. The data models are independent of the communication services which are used to access actual data values or the models themselves. The data models represent the information which can be exchanged with a device. They essentially describe the device interface. Data models provide new ways of interacting with intelligent devices. IEC 61850 defines the following four key aspects which are independent of each other and which build on one other:

Standardized information: for circuit breakers: units, measured values, control, metadata, etc. including a self-description (IEC 61850- 7-4); standardized information is based on a general set of about 20 common data types (status, measured value, metering data (IEC 61850-7-3); some standardized information is specific to substations, and other information is more general. The definition of new information models, which reuse standardized information, is expressly supported.

Standardized services: for simple data access, reporting logging, querying, device control, etc. (IEC 61850-7-2). The standardized services can be used with standardized information (in 61850-7-4) or with any new or extended information models.

Standardized networks: suitable networks are selected for exchanging messages in the strict sense of the term. Standardized communication systems are used for the standardized services, standardized information and any other type of information (IEC 61850-8-1 and -9-2).

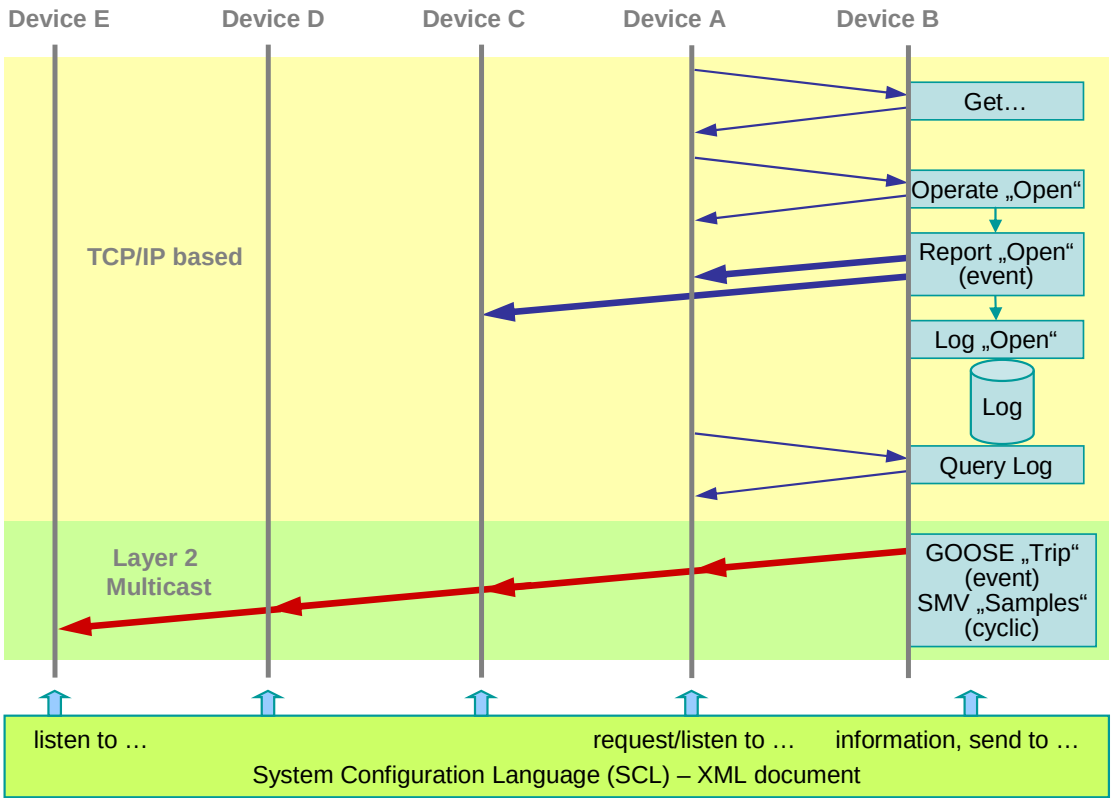
Standardized configuration: A complete, formal description is generated for the devices and the entire system. IEC 61850-6 defines an XML-based system description language (Substation Configuration Language, SCL), which is used to generate configuration files.

5 Introduction of Example

5.1 General remarks and basic definitions

The following example focuses on the signals to be described and exchanged with IEC 61850. IEC 61850 provides signal designations (names) for application information produced, exchanged and consumed by devices.
The communication services provide the exchange of values in real-time (GOOSE and Sampled Values, based on Layer 2 Multicast) and in a client-server relation based on TCP/IP and higher layer protocols.
The configuration language SCL describes all information of a system and the flow of the information between the devices of the system.

These basic features of IEC 61850 are depicted in the following figure:



Device B provides **information** (Status, 3-phase electrical Measurements, sensor information, Engineering and Configuration information, Nameplates, etc.) that can be retrieved (Get) by Device B. Device A may operate something in Device B (open a breaker, start a program, etc.) A change of the breaker position may cause a **report** of the new value to a specific Device; or the change may be **logged and queried** for retrieval later on. These services use a client-server communication **based on TCP/IP**.
IEC 61850 provides **two special services for real-time communication** based on Layer 2 multicast services (on publisher – to – many subscribers). GOOSE allows the exchange of any information in **short reaction times** (less 5 ms). Sample Measured Values (SMV) are intended to exchange values **cyclically in a high frequency** (typical sample rate: 4.000 messages per second for special functions).

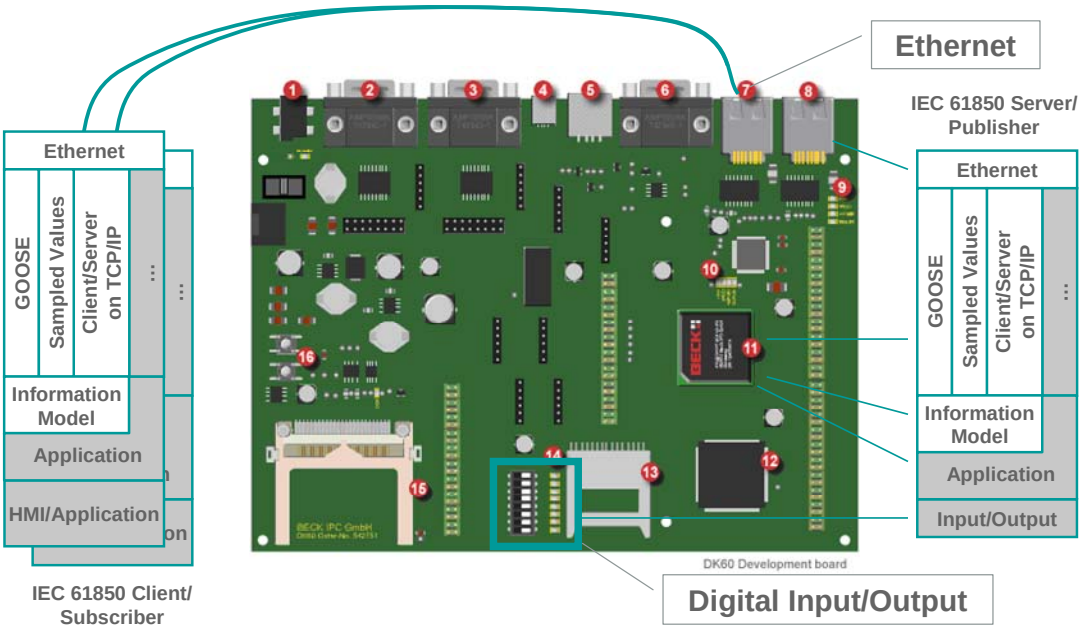
The **System Configuration Language** (SCL) describes the sources of the information, which services are to be used, who should listen to the information exchanged (information flow). Devices A, C, D and E are configured to listen to the red Multicast message sent by Device B. Devices could implement one or more of the following roles: Client, Server, Publisher, or Subscriber.
The version of the IEC 61850 in the DK61 for this description is V1.0. This version provides the roles Server, Publisher (GOOSE) and Subscriber (GOOSE).
The **example** introduces a Server that allows the access of information from DIP Switches and information for LEDs. The application between IEC 61850 and the Digital I/Os is implemented in “C”.

5.2 The DK61 Board, the Approach of IEC 61850 and the Example

5.2.1 Architecture

The crucial aspects shown in the following figure (related to the example in this document) are:

1. The Ethernet connectivity on the top; the devices (the DK61 and two other documents shown to the left) are understood to be connected to one subnet.
2. The Digital Inputs and Outputs shown at the bottom.
3. The Inputs are implemented as 8 DIP Switches and the Output signals are implemented as 8 LEDs. The position of the DIP Switches can manually be changed. The positions (information) are intended to be communicated by IEC 61850 services. The LEDs will be used to demonstrate the control services.
4. The physical Inputs and Outputs are connected to an application.
5. For the purpose of communication it is required to designate (name) and format the information to be exchanged (in the first example position inputs and control outputs).

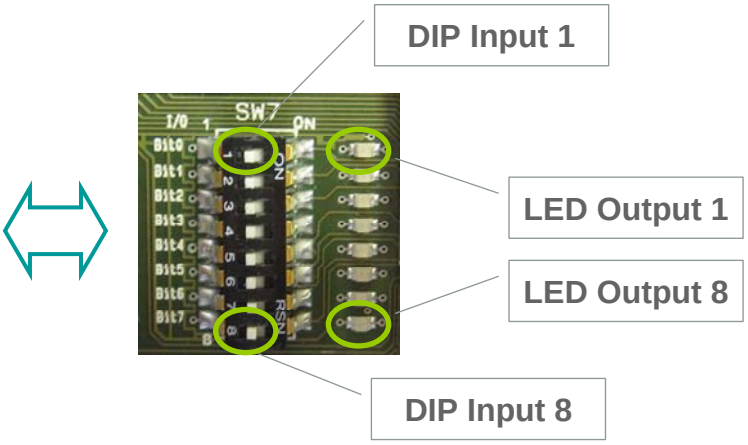


5.2.2 The process interface

The Digital Inputs and Outputs are shown in the following picture. The DIP Switches are shown on the left. The switches are identified as “DIP Input 1” to “DIP Input 8”. The LEDs are “LED Output 1” to “LED Output 8”. These names are defined and used in this description: the names in the corresponding C application are:

```
/* Object Types */
enum
{
   DIGITAL_INPUT   = 1,  // Digital Input  (DIP Switch )
   DIGITAL_OUTPUT  = 2,        // Digital Output (LED )
}eObjectTypes;
```

The access to the DIP Switches or LEDs from a client requires the access (path) information to identify (address) the right DIP Switch. The Application program may use any name for the DIP Switches. The programmer is free to choose any name. This name usually is not recommended to be used by a client – because it may be changed by the programmer at any time.



5.2.3 The IEC 61850 information model for general I/Os

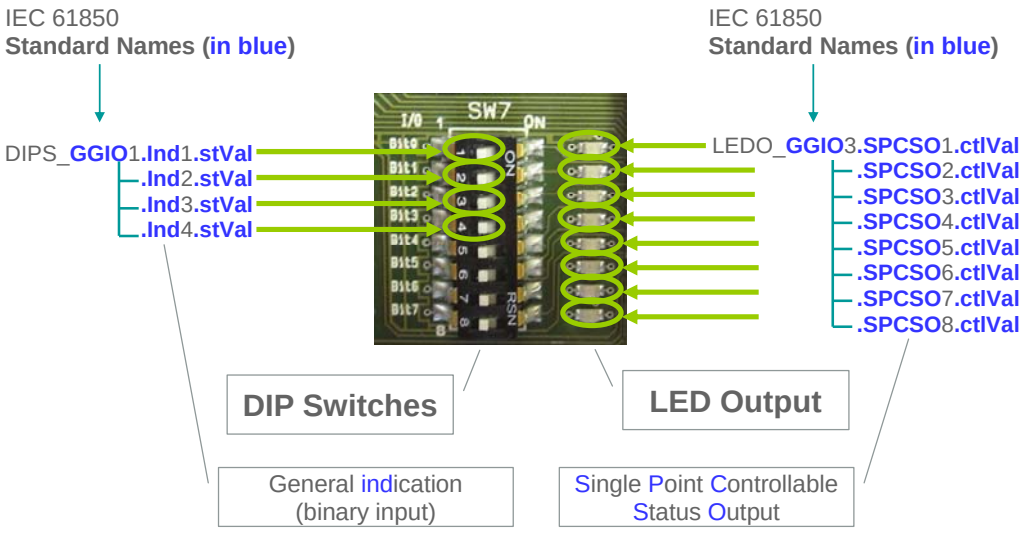
IEC 61850 provides standardized designations for this kind of information. The so-called standardized Logical Node (LN) “**GGIO**” (Generic Process Input Output) is used to designate input and output signals.

The following excerpt of the LN **GGIO** depicts three kinds of information (each having a Data Object (DO)):
Measured Values (**AnIn**), Controls (SPCSO) and Status Information (**Ind**).

Each has a Data Object has a suffix of “1” (e.g., **Ind1**) indicating that a LN **GGIO** may have four Data Objects (**Ind1**, **Ind2**, **Ind4**, and **Ind4**). These four Data Objects will represent the upper four of the eight DIP Switches in the example.

GGIO class			
Measured Values			
AnIn1	instMag	AnalogueValue	Analogue input
	q	Quality	
	t	TimeStamp	
	units	Unit	
Controls			
SPCSO1	ctlVal	BOOLEAN	Single point controllable status output
	stVal	BOOLEAN	
	q	Quality	
	t	TimeStamp	
Status information			
Ind1	stVal	BOOLEAN	General indication (binary input)
	q	Quality	
	t	TimeStamp	
IntIn1	stVal	INT32	Integer status input
	q	Quality	
	t	TimeStamp	

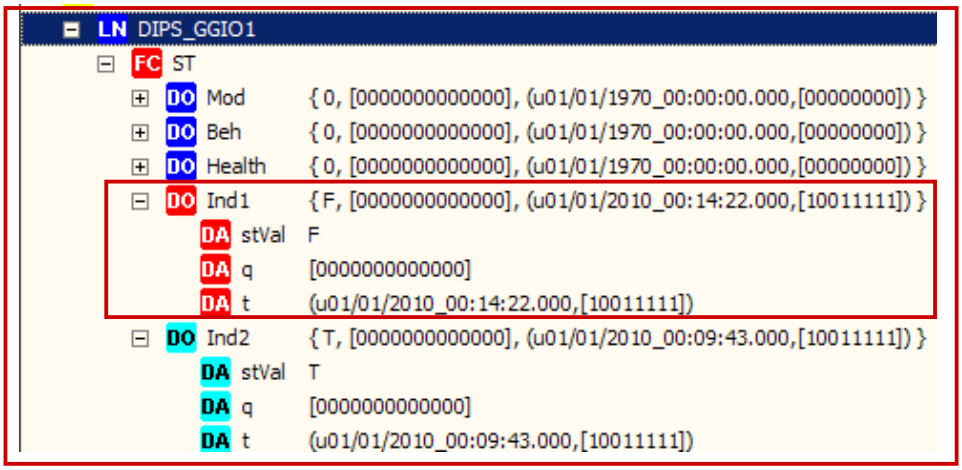
The eight LEDs are represented by eight Data Objects **SPCSO1** … **SPCSO8**.
The signal designations (names) for both are shown in the next figure.



The **blue parts** of the names are defined in the standard. The Logical Node **GGIO** has been extended by a prefix to relate the Logical Node to the DIP Switches respectively to the LEDs. Each Logical Node has also an instance number (1 and 3) – to differentiate several Logical Nodes that have the same class name.

5.2.4 Browsing the information of an device

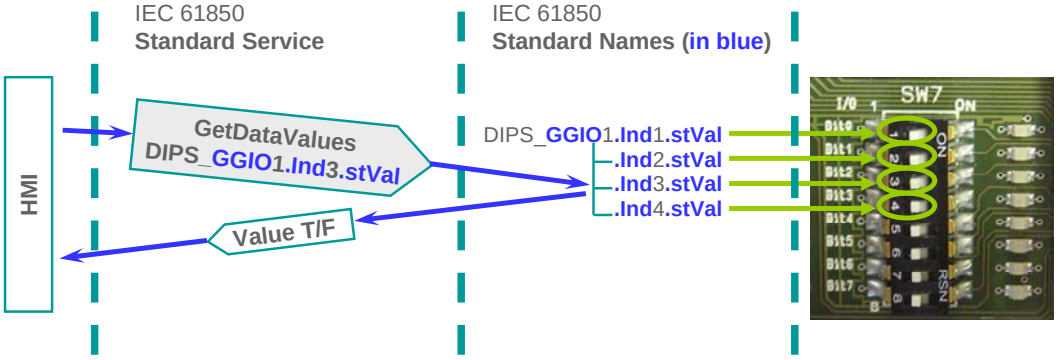
A browser (IED Scout) depicts the information accordingly. The Logical Node **DIPS_GGIO1** has Status Information (designated with the "FC=ST"). Besides common information **Mod**, **Beh**, **Health**, the Logical Node has a Data Object **Ind1** with three Data Attributes: **stVal**, **q**, and **t**.



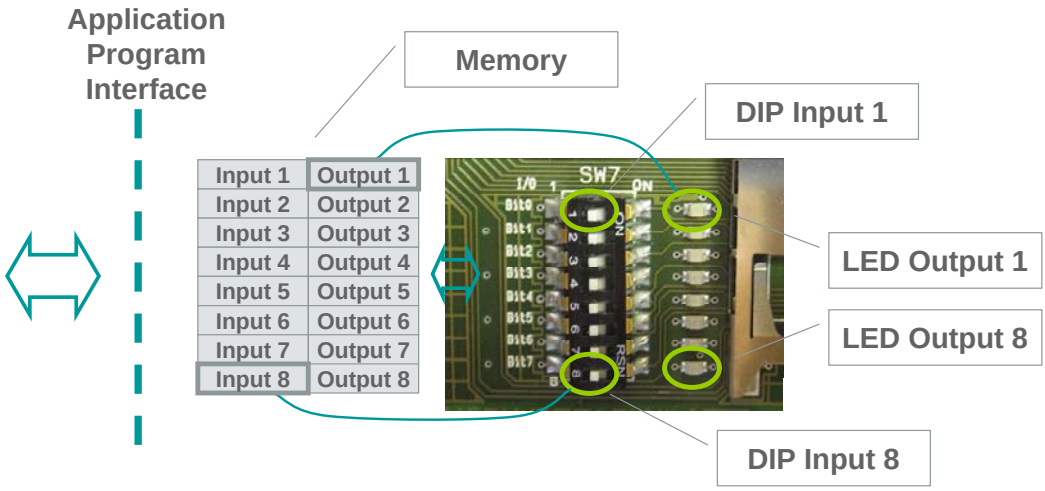
The browser has services to read the value of **Ind1** one or cyclically (Polling). To read the value of the **DIPS_GGIO1.ST.Ind1.stVal** requires to send this name to the DK61 using the appropriate IEC 61850 service (GetDataObjectValues).

5.2.5 Communication services

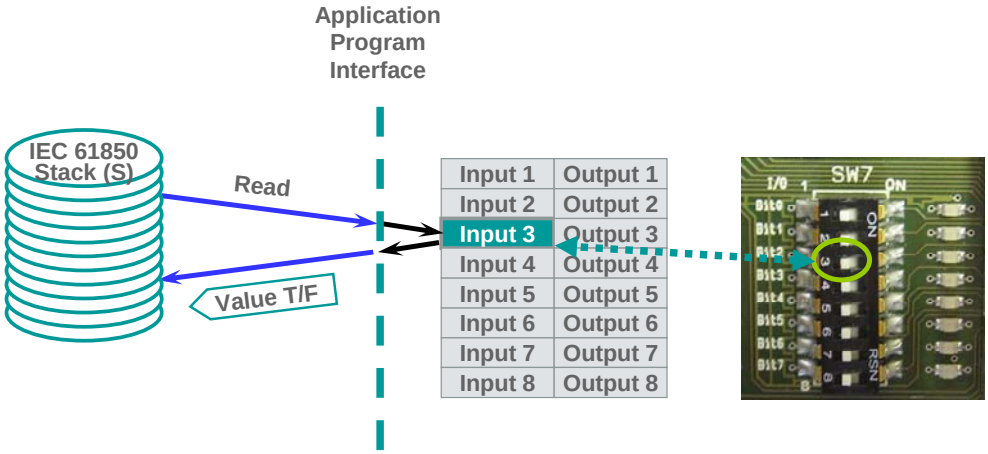
The next figure shows the communication for getting the value of the third DIP Switch.



The message received by the DK61 has to be interpreted by the IEC 61850 software to figure out which DIP Switch is addressed to return the right value. The arrows shown in the above figure are pointing to the hardware DIP Switches. These "arrows" need to be specified in a way that allows the software to address internally the right internal signal of the DIP Switch. The following figures show the relation between the physical I/Os, the internal memory and the name used in the communication. The following figure maps the physical I/Os to a list of inputs (1-8) and outputs (1-8). This list represents the memory location in which values may be stored.



The communication stack of the IEC 61850 server (as shown in the following figure) is in principle accessing the memory location. These names “Input 1” to “Output 8” do not provide and specific meaning. To do so, there is a need of a mapping of the local information (e.g., value of DIP Switch position, time stamp of last change and quality of value (good or bad)) to the standardized designation.



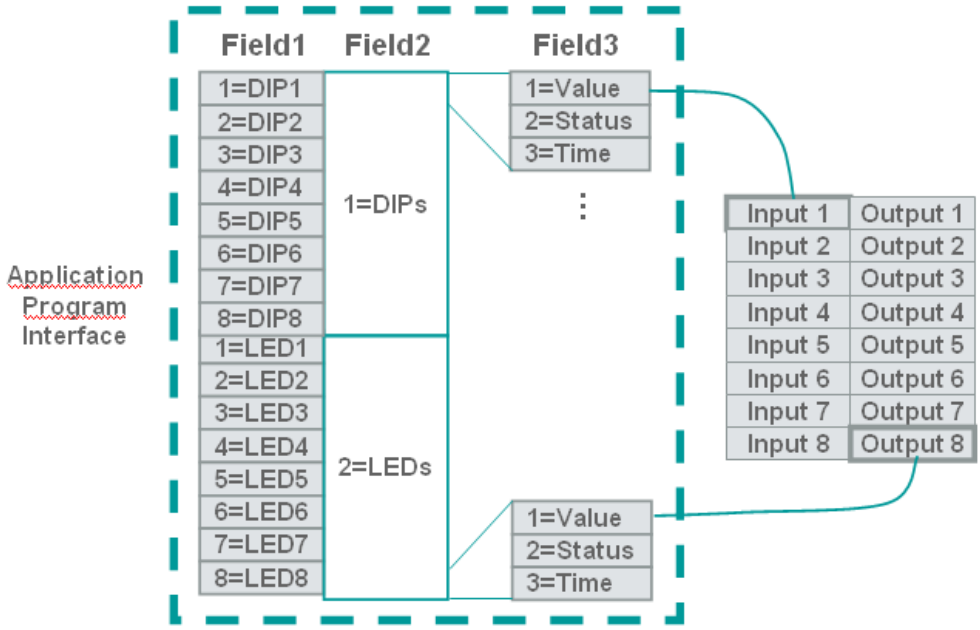
The Memory table with eight Inputs and eight Outputs is shown at the right side of the following picture. The relation between these “locations” and the access information of the standardized signal names need to be specified.
The Data Object **DIPS_GGIO1.ST.Ind1** of the corresponding Logical Node specifies three Data Attributes:

Ind1	stVal	BOOLEAN
	q	Quality
	t	TimeStamp

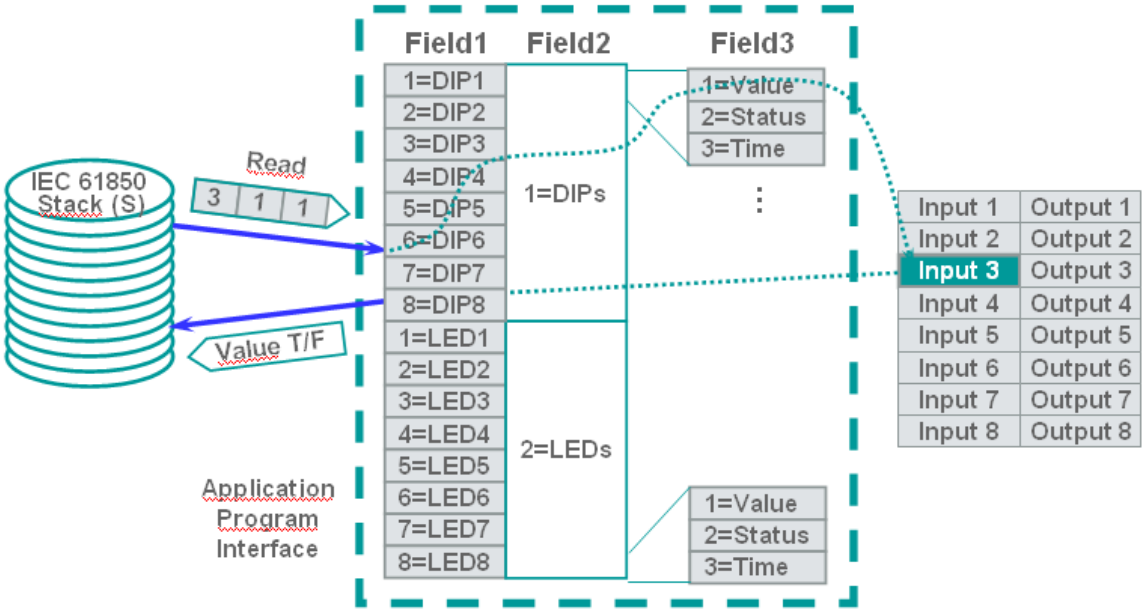
Each of the three attributes will be communicated when a client reads the Data Object **Ind1**. The value **stVal** represents the status of a DIP Switch. The information, if it refers to the first, second, or the eights is specified by the name **DIPS_GGIO1.ST.Ind1.stVal**. The other two attributes **q** and **t** are also required to be specified – and they need also be stored together with the status value.

5.2.6 Binding of process values to standard information models

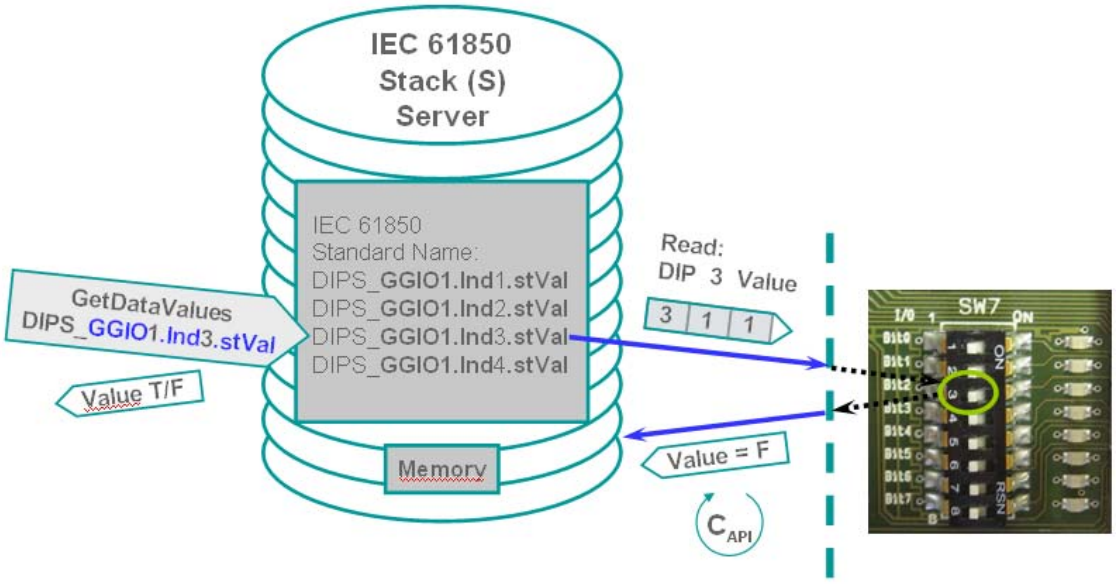
The binding of the memory to the access specific information is shown in the following figure. When the communication stack receives a GetDataValues request for the Data Object **DIPS_GGIO1.ST.Ind1**, then needs to get the corresponding reference to the memory locations for the **stVal**, **q** and **t**.
The API used for the first example uses a hierarchy of three fields: Field1 selects the position in the corresponding list between 1 and 8; Field2 (to identify if the value is related to the DIPs or to the LEDs; Field3 references to the values for **stVal**, **q** and **t**. This mapping is unique in order to refer to the correct memory location for any of the values.



The communication stack uses this hierarchical reference to get the value from the application. The following figure shows how the service <GetDataValues for **DIPS_GGIO1.Ind3.stVal**> is mapped the corresponding memory location (that is bound to the real DIP Switch 3).
The stack uses the local Read (at the API between the communication software and the real application) with the three fields: Field1=3 (means third DIP Switch), Field2=1 (means DIP Switches), and Field3=1 (means Value).
The returned value needs to be encoded according to the type of the Logical Node GGIO and **Ind1.stVal**. The type is a **BOOLEAN**. The Value TRUE or FALSE will be returned to the client that issued the GetDataValues request.



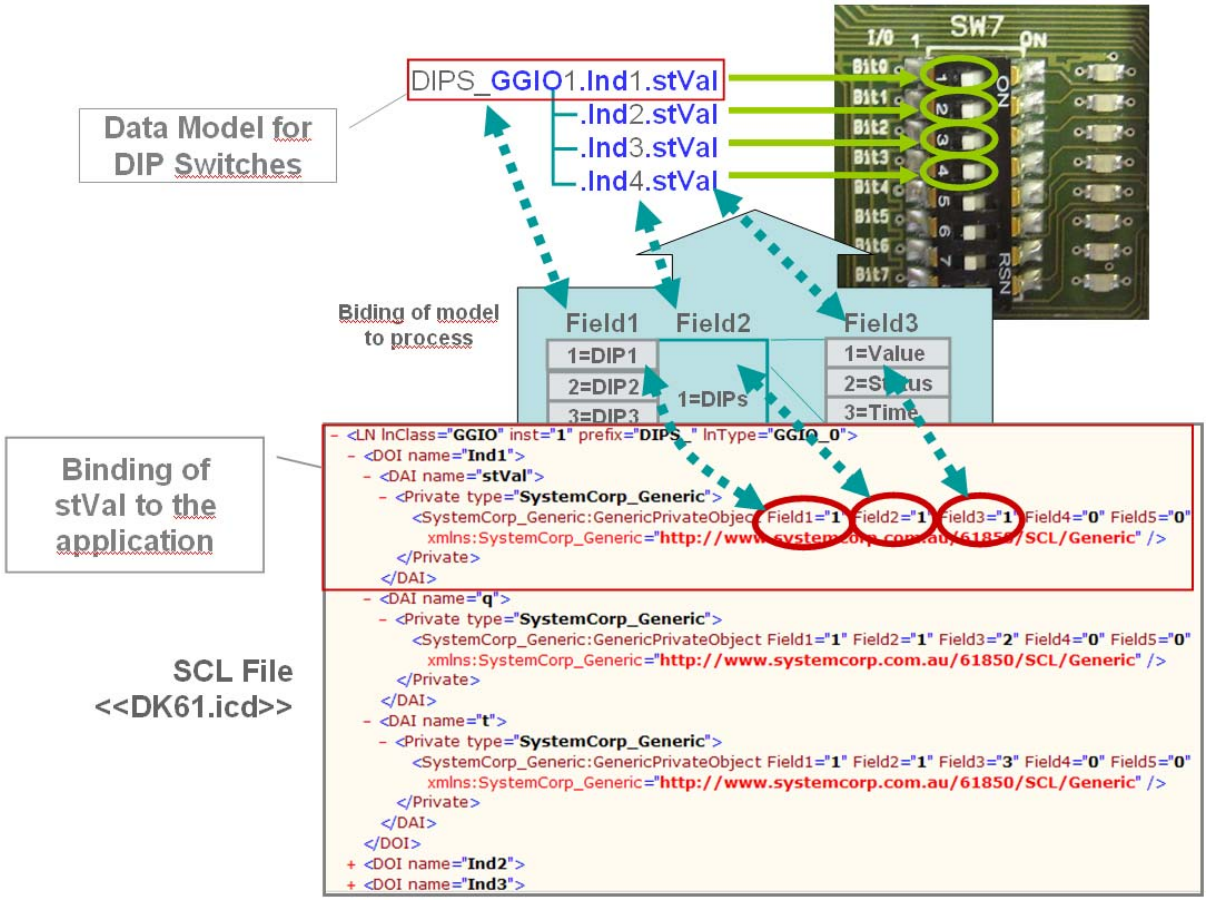
The IEC 61850 communication stack is part of an entity between the messages on the communication link (TCP/IP, Ethernet, …) and the local Application.
The concrete encoding of the request and response messages for the service <GetDataValues for **DIPS_GGIO1.Ind3**> is shown in the Appendix 7.3 - GetDataValues for DIPS_GGIO1.Ind3.
The mapping table in this example is defined by the system designer of the API between the IEC 61850 communication stack and the real application. It is up to the system designer how to organize the internal communication between the stack and the application. From a communication point of view it is not visible during the exchange of messages with that particular server device. As shown in the next figure, the client just needs to know the name of the Data Object **DIPS_GGIO1.Ind3.Ind3**. The name is "translated" into an internal access mechanism using a table to map between the standard name and the memory location of the value.



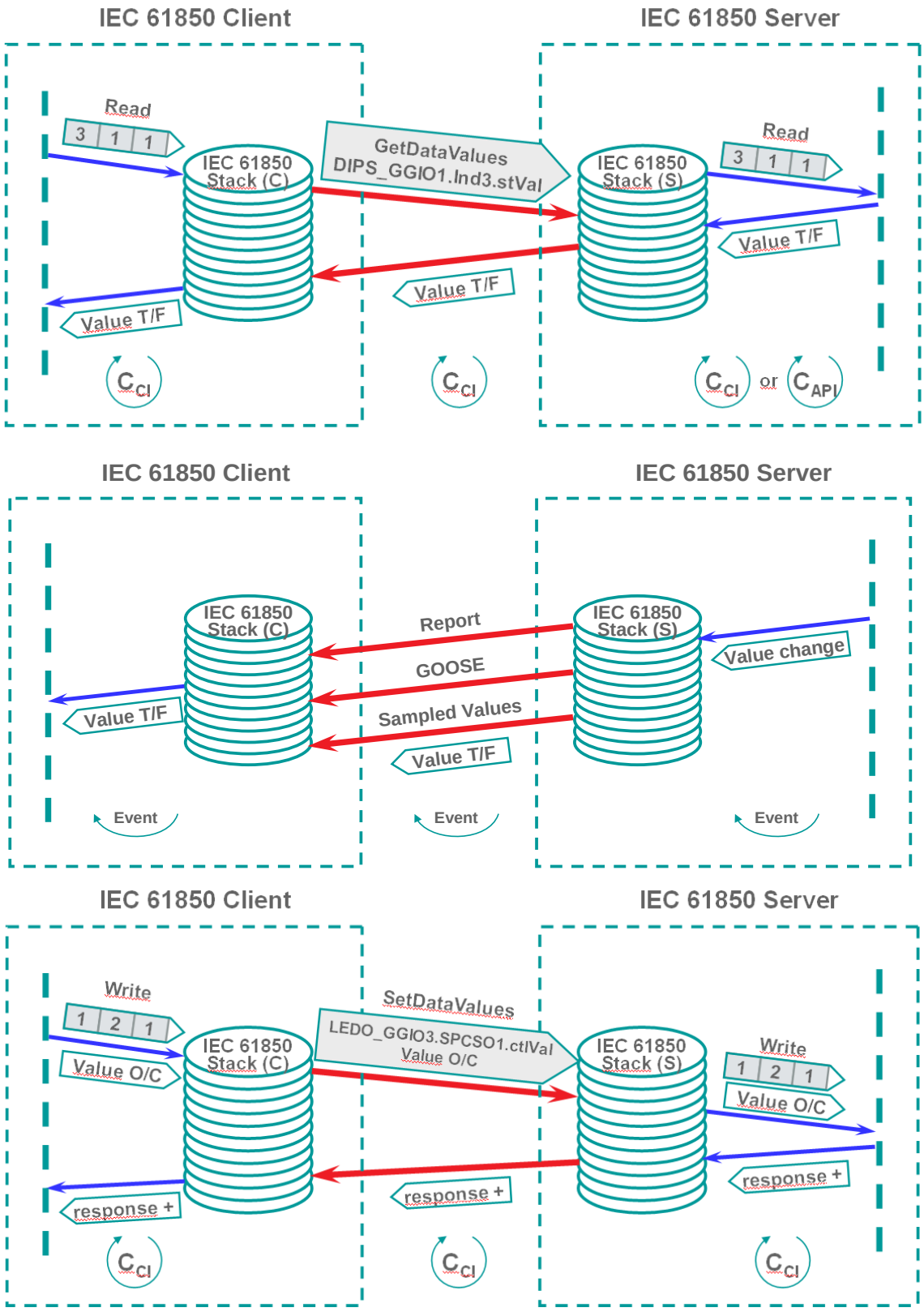
The communication stack may have its own memory that holds a copy of the real value from the application. The copy could be updated cyclically, on request by the communication stack, or by an event from the application. The service <GetDataValues for **DIPS_GGIO1.Ind3**> does not care about the implementation of the API. The difference between the three update mechanisms is not visible in the standard communication – except that the delay is longer or shorter depending on the mechanism used.
The timestamp and the quality information associated with the data value are provided the same way as the process value.

5.2.7 System Configuration Language (SCL)

The configuration of the information model and the binding of the model to the real values are described by the System Configuration Language (SCL). The following figure shows the formal syntax of the binding based on the three Fields: Field1 (position), Field2 (DIP or LED), and Field3 (value, quality or timestamp).



6 Communication services



6.1.1 Setting up the serial communication

To set up serial communication to your Development Kit DK61 you need the enclosed null-modem cable.

1. Connect the null-modem cable to a free serial port of your PC and with the COM1 interface of the DK61.
2. Choose *Tools* → *Terminal* from the IPC@CHIPTOOL main menu
3. In the connection dialog that now opens choose the following settings:
    - *Connection Type*: Serial
    - *Port*: The serial port of your PC that you connected the null-modem cable to, e.g. COM1
    - *Baudrate*: 19200

7 Appendix

7.1 Where to get further Information

7.1.1 Getting Started

All software referred to in this document can be downloaded from out Getting Started website at http://www.beck-ipc.com/gettingstarted.

7.1.2 Updates, tools and examples

Regularly check out IPC@CHIP website at http://www.beck-ipc.com/ipc for:

- @CHIP RTOS updates
- New APIs
- Example programs that you may use as a base for your own applications
- Useful tools for your development
- Application notes

7.1.3 Support

If you need support please…

1. Check our support website at http://www.beck-ipc.com/ipc/support including a FAQ.
2. Visit our newsgroup at http://www.beck-ipc.com/ipc/support/forum. Here you will find a lot of answers to customer problems and you can also add your own ideas and questions.
3. Contact our support at support@beck-ipc.com. Of course you may also contact us by phone. But please use email if possible. This not only reduces the time you spend on the phone, it also allows us to easily manage the questions and identify problem areas. Important or frequent questions and the corresponding answers are becoming part of our FAQ that is published on the Internet.

7.1.4 Order numbers

Most parts of the Development Kit DK61 can be ordered separately. Please visit our online shop. These are the order numbers.

DK61 Development Kit	542750
DK60 Development Board	542751
ZK14 serial null-modem cable	195837
PSE10 power supply	538934
Paradigm C++ Beck Edition	541522

7.1.5 Tools related to IEC 61850

The following tools may be used for the communication between an IEC 61850 server and client:

- IED Scout – IEC 61850 Browser; Download demo version: http://www.omicron.at/en/products/pro/communication-protocols/iec-61850/iedscout-v210/
- Wireshark – IEC 61850 Network Analyser; Download open source version: http://sourceforge.net/projects/wireshark/
- UNICA Network Analyser; Download of demo version: http://www.nettedautomation.com/solutions/uca/products/netana/index.html

7.2 IEC 61850 Standards

IEC 61850-1
Introduction and Overview
Introduction and overview of all of the parts of IEC 61850

IEC 61850-2
Glossary
Terminology

IEC 61850-3
General Requirements
Quality requirements (reliability, maintainability, system availability, portability, IT security), operating conditions, auxiliary services and other engineering standards

IEC 61850-4
System and Project Management
Engineering services requirements (parameter classification, engineering tools, documentation), system Basics usage cycle (product versions, factory setup, support after factory setup), quality assurance (responsibilities, test systems, type tests, system tests, factory acceptance tests (FAT) and site acceptance tests (SAT)

IEC 61850-5
Communications Requirements for Functions and Device Models
The logical nodes principle, logical communications links, items of information for communications (PICOM), logical nodes and associated PICOMs, functions, performance requirements (response times, etc.), dynamic scenarios (information flow requirements under various operating conditions)

IEC 61850-6
Configuration Description Language for Communication
Communication in Electrical Substations Formal description of the single-line schemas, devices, system structure and how they fit into the single-line schema

IEC 61850-7-1
Basic Communication Structure for Substation and Feeder Equipment
Introduction to IEC 61850-7-x, communications principles and models

IEC 61850-7-2

Basic Communication Structure for Substation and Feeder Equipment – Abstract Communication Service Interface (ACSI)Description of the Abstract Communication Service Interface (ACSI), specification of the Abstract Communication Service Interface, server database model

IEC 61850-7-3
Basic Communication Structure for Substation and Feeder Equipment – Common Data Classes
Common data classes and attribute definitions

IEC 61850-7-4
Basic Communication Structure for Substation and Feeder Equipment
Definition von compatible logical node classes and data classes and their logical addressing. General and typical station abstract classes for logical nodes and data

IEC 61850-7-410
Hydroelectric power plants - Communication for monitoring and control
Extension of Information models for Hydro Power Plants.

IEC 61850-7-420
Communications systems for distributed energy resources (DER) - Logical nodes
Extension of Information models for decentralized Energy resources like PV, Fuel Cells, Solar, etc.

IEC 61400-25-2
Communications for monitoring and control of wind power plants
Extension of Information models for Wind Power Plants.

IEC 61850-8-1
Specific Communication Service Mapping (SCSM) – Mappings to MMS
(ISO/IEC 9506- Part 1 and Part 2) and to ISO/IEC 8802-3
Communication mapping in the entire station (client-server communication for SCADA functions and GOOSE and GSSE data exchange for real time requirements, for example for tripping signals

IEC 61850-9-2
Specific Communication Service Mapping (SCSM) – Sample Values over ISO/IEC 8802-3
Mapping for bus-type, flexible communication of sample values from instrument transformers (with and without Merging Unit)

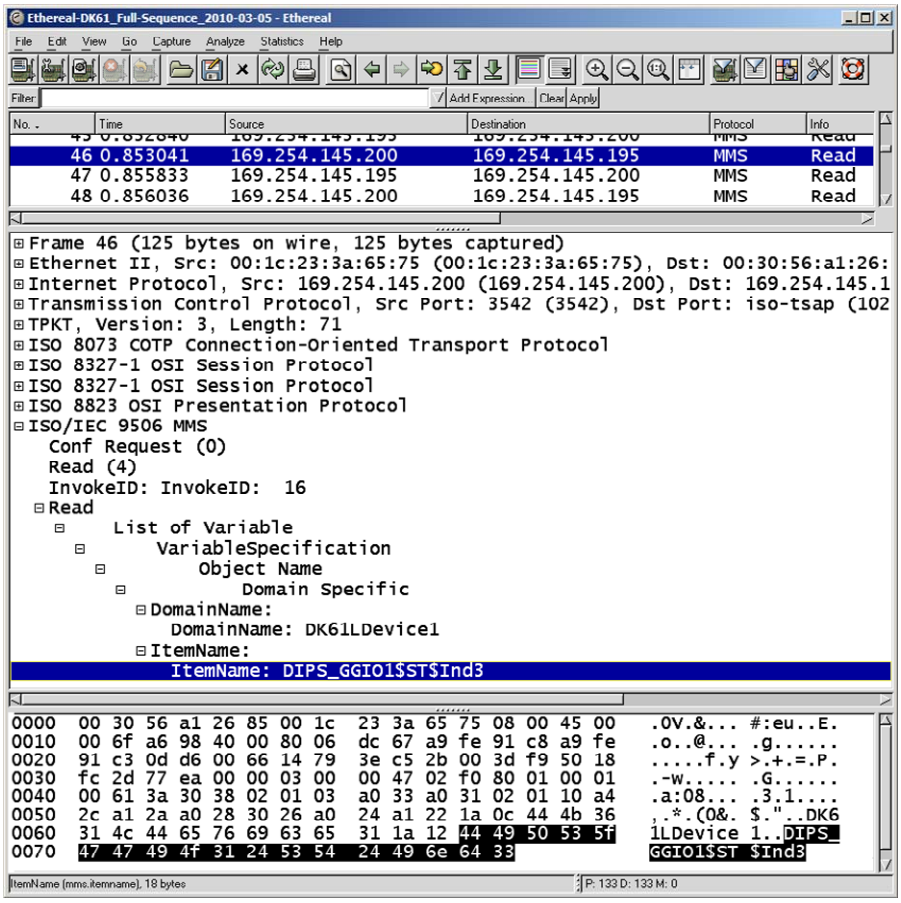
IEC 61850-10
Conformance Testing
Basic Conformance testing methods

7.3 GetDataValues for DIPS_GGIO1.Ind3

The following figures show the request and response messages of the service <GetDataValues for **DIPS_GGIO1.Ind3**>. This message comprises all layers from Data Link (Ethernet), over IP, TCP, upper layers including MMS.

The IEC 61850-7-2 service <GetDataValues for **DIPS_GGIO1.Ind3**> is mapped to a MMS Read Request message. The Item Name at the bottom (ItemName) is "**DIPS_GGIO1STnd3**". The **$** is used as the MMS-Separator (instead of a "**.**"). The "**ST**" is indicating the status information (**stVal**, **q** and **t**). The DomainName is used to carry the Logical Device Name of the IEC 61850. The Logical Device is (as for now) a container that contains Logical Nodes.

Read Request:



The MMS response message contains a Structure of three components with the value and the corresponding Type. The first value is of type BOOLEAN (it represents the stVal). The second type is a Bitstring (that represents the quality information). The last component is the UTC time stamp – note that the time of the clock was not synchronized during the test.

7.4 Standardized Logical Nodes

LN Group	#	Clause	Description	Name	Document
L System LNs	1	5.3.2	Physical device information	LPHD	7-4 Ed2 FDIS
	2	5.3.3	Common Logical Node	Common LN	7-4 Ed2 FDIS
	3	5.3.4	Logical node zero	LLN0	7-4 Ed2 FDIS
	4	5.3.5	Physical Communication channel Supervision	LCCH	7-4 Ed2 FDIS
	5	5.3.6	GOOSE subscription	LGOS	7-4 Ed2 FDIS
	6	5.3.7	Sampled value subscription	LSVS	7-4 Ed2 FDIS
	7	5.3.8	Time management	LTIM	7-4 Ed2 FDIS
	8	5.3.9	Time master supervision	LTMS	7-4 Ed2 FDIS
	9	5.3.10	Service tracking	LTRK	7-4 Ed2 FDIS
A Automatic Control	10	5.4.2	Neutral current regulator	ANCR	7-4 Ed2 FDIS
	11	5.4.3	Reactive power control	ARCO	7-4 Ed2 FDIS
	12	5.4.4	Resistor control	ARIS	7-4 Ed2 FDIS
	13	5.4.5	Automatic tap changer controller	ATCC	7-4 Ed2 FDIS
	14	5.4.6	Voltage control	AVCO	7-4 Ed2 FDIS
C Control	15	5.5.2	Alarm handling	CALH	7-4 Ed2 FDIS
	16	5.5.3	Cooling group control	CCGR	7-4 Ed2 FDIS
	17	5.5.4	Interlocking	CILO	7-4 Ed2 FDIS
	18	5.5.5	Point-on-wave switching	CPOW	7-4 Ed2 FDIS
	19	5.5.6	Switch controller	CSWI	7-4 Ed2 FDIS
	20	5.5.7	Synchronizer controller	CSYN	7-4 Ed2 FDIS
D Decentralized Energy Resources	21	5.2.2	DER plant corporate characteristics at the ECP	DCRP	7-420 Ed1 IS
	22	5.2.3	Operational characteristics at ECP	DOPR	7-420 Ed1 IS
	23	5.2.4	DER operational authority at the ECP	DOPA	7-420 Ed1 IS
	24	5.2.5	Operating mode at ECP	DOPM	7-420 Ed1 IS
	25	5.2.6	Status information at the ECP	DPST	7-420 Ed1 IS
	26	5.2.7	DER economic dispatch parameters	DCCT	7-420 Ed1 IS
	27	5.2.8	DER energy and/or ancillary services schedule control	DSCC	7-420 Ed1 IS
	28	5.2.9	DER energy and/or ancillary services schedule	DSCH	7-420 Ed1 IS
	29	5.3.2	DER controller characteristics	DRCT	7-420 Ed1 IS
	30	5.3.3	DER controller status	DRCS	7-420 Ed1 IS
	31	5.3.4	DER supervisory control	DRCC	7-420 Ed1 IS
	32	6.1.2	DER unit generator	DGEN	7-420 Ed1 IS
	33	6.1.3	DER generator ratings	DRAT	7-420 Ed1 IS
	34	6.1.4	DER advanced generator ratings	DRAZ	7-420 Ed1 IS
	35	6.1.5	Generator cost	DCST	7-420 Ed1 IS
	36	6.2.2	Excitation ratings	DREX	7-420 Ed1 IS
	37	6.2.3	Excitation	DEXC	7-420 Ed1 IS
	38	6.3.2	Speed/Frequency Controller	DSFC	7-420 Ed1 IS
	39	7.1.3	Reciprocating Engine	DCIP	7-420 Ed1 IS
	40	7.2.3	Fuel cell controller	DFCL	7-420 Ed1 IS
	41	7.2.4	Fuel cell stack	DSTK	7-420 Ed1 IS
	42	7.2.5	Fuel processing module	DFPM	7-420 Ed1 IS
	43	7.3.3	Photovoltaics module ratings	DPVM	7-420 Ed1 IS

LN Group	#	Clause	Description	Name	Document
	44	7.3.4	Photovoltaics array characteristics	DPVA	7-420 Ed1 IS
	45	7.3.5	Photovoltaics array controller	DPVC	7-420 Ed1 IS
	46	7.3.6	Tracking controller	DTRC	7-420 Ed1 IS
	47	7.4.3	CHP system controller	DCHC	7-420 Ed1 IS
	48	7.4.4	Thermal storage	DCTS	7-420 Ed1 IS
	49	7.4.5	Boiler	DCHB	7-420 Ed1 IS
	50	7.1.3	Reciprocating Engine	DCIP	7-420 Ed1 IS
	51	7.2.3	Fuel cell controller	DFCL	7-420 Ed1 IS
	52	8.1.3	Fuel delivery system	DFLV	7-420 Ed1 IS
F Functional Blocks	53	5.6.2	Counter	FCNT	7-4 Ed2 FDIS
	54	5.6.3	Curve shape description	FCSD	7-4 Ed2 FDIS
	55	5.6.4	Generic Filter	FFIL	7-4 Ed2 FDIS
	56	5.6.5	Control function output limitation	FLIM	7-4 Ed2 FDIS
	57	5.6.6	PID regulator	FPID	7-4 Ed2 FDIS
	58	5.6.7	Ramp function	FRMP	7-4 Ed2 FDIS
	59	5.6.8	Set-point control function	FSPT	7-4 Ed2 FDIS
	60	5.6.9	Action at over threshold	FXOT	7-4 Ed2 FDIS
	61	5.6.10	Action at under threshold	FXUT	7-4 Ed2 FDIS
	62	7.2.2	Counter	FCNT	7-410 Ed1 IS
	63	7.2.3	Curve shape description	FCSD	7-410 Ed1 IS
	64	7.2.4	Generic Filter	FFIL	7-410 Ed1 IS
	65	7.2.5	Control function output limitation	FLIM	7-410 Ed1 IS
	66	7.2.6	PID regulator	FPID	7-410 Ed1 IS
	67	7.2.7	Ramp function	FRMP	7-410 Ed1 IS
	68	7.2.8	Set-point control function	FSPT	7-410 Ed1 IS
	69	7.2.9	Action at over threshold	FXOT	7-410 Ed1 IS
	70	7.2.10	Action at under threshold	FXUT	7-410 Ed1 IS
	71	8.4.2	Sequencer	FSEQ	7-420 Ed1 IS
G Generic	72	5.7.2	Generic automatic process control	GAPC	7-4 Ed2 FDIS
	73	5.7.3	Generic process I/O	GGIO	7-4 Ed2 FDIS
	74	5.7.4	Generic log	GLOG	7-4 Ed2 FDIS
	75	5.7.5	Generic security application	GSAL	7-4 Ed2 FDIS
H Hydro Power	76	7.3.2	Turbine - generator shaft bearing	HBRG	7-410 Ed1 IS
	77	7.3.3.	Combinator	HCOM	7-410 Ed1 IS
	78	7.3.4	Hydropower dam	HDAM	7-410 Ed1 IS
	79	7.3.5	Dam leakage supervision	HDLS	7-410 Ed1 IS
	80	7.3.6	Gate position indicator	HGPI	7-410 Ed1 IS
	81	7.3.7	Dam gate	HGTE	7-410 Ed1 IS
	82	7.3.8	Intake gate	HITG	7-410 Ed1 IS
	83	7.3.9	Joint control	HJCL	7-410 Ed1 IS
	84	7.3.10	Leakage supervision	HLKG	7-410 Ed1 IS
	85	7.3.11	Water level indicator	HLVL	7-410 Ed1 IS
	86	7.3.12	Mechanical brake	HMBR	7-410 Ed1 IS
	87	7.3.13	Needle control	HNDL	7-410 Ed1 IS
	88	7.3.14	Water net head data	HNHD	7-410 Ed1 IS
	89	7.3.15	Dam over-topping protection	HOTP	7-410 Ed1 IS
	90	7.3.16	Hydropower / water reservoir	HRES	7-410 Ed1 IS
	91	7.3.17	Hydropower unit sequencer	HSEQ	7-410 Ed1 IS
	92	7.3.18	Speed monitoring	HSPD	7-410 Ed1 IS
	93	7.3.19	Hydropower unit	HUNT	7-410 Ed1 IS

LN Group	#	Clause	Description	Name	Document
	94	7.3.20	Water control	HWCL	7-410 Ed1 IS
I Interfacing and Archiving	95	5.8.2	Archiving	IARC	7-4 Ed2 FDIS
	96	5.8.3	Human machine interface	IHMI	7-4 Ed2 FDIS
	97	5.8.4	Safety alarm function	ISAF	7-4 Ed2 FDIS
	98	5.8.5	Telecontrol interface	ITCI	7-4 Ed2 FDIS
	99	5.8.6	Telemonitoring interface	ITMI	7-4 Ed2 FDIS
	100	5.8.7	Teleprotection communication interfaces	ITPC	7-4 Ed2 FDIS
	101	7.4.2	Safety alarm function	ISAF	7-410 Ed1 IS
K Mechanical and non-electric primary equipment	102	5.9.2	Fan	KFAN	7-4 Ed2 FDIS
	103	5.9.3	Filter	KFIL	7-4 Ed2 FDIS
	104	5.9.4	Pump	KPMP	7-4 Ed2 FDIS
	105	5.9.5	Tank	KTNK	7-4 Ed2 FDIS
	106	5.9.6	Valve control	KVLV	7-4 Ed2 FDIS
	107	7.5.2	Fan	KFAN	7-410 Ed1 IS
	108	7.5.3	Filter	KFIL	7-410 Ed1 IS
	109	7.5.4	Pump	KPMP	7-410 Ed1 IS
	110	7.5.5	Tank	KTNK	7-410 Ed1 IS
	111	7.5.6	Valve control	KVLV	7-410 Ed1 IS
M Metering and measurement	112	5.10.2	Environmental information	MENV	7-4 Ed2 FDIS
	113	5.10.3	Flicker Measurement Name	MFLK	7-4 Ed2 FDIS
	114	5.10.4	Harmonics or interharmonics	MHAI	7-4 Ed2 FDIS
	115	5.10.5	Non phase related harmonics or interharmonics	MHAN	7-4 Ed2 FDIS
	116	5.10.6	Hydrological information	MHYD	7-4 Ed2 FDIS
	117	5.10.7	DC measurement	MMDC	7-4 Ed2 FDIS
	118	5.10.8	Meteorological information	MMET	7-4 Ed2 FDIS
	119	5.10.9	Metering	MMTN	7-4 Ed2 FDIS
	120	5.10.10	Metering	MMTR	7-4 Ed2 FDIS
	121	5.10.11	Non phase related Measurement	MMXN	7-4 Ed2 FDIS
	122	5.10.12	Measurement	MMXU	7-4 Ed2 FDIS
	123	5.10.13	Sequence and imbalance	MSQI	7-4 Ed2 FDIS
	124	5.10.14	Metering Statistics	MSTA	7-4 Ed2 FDIS
	125	7.6.2	Environmental information	MENV	7-410 Ed1 IS
	126	7.6.3	Hydrological information	MHYD	7-410 Ed1 IS
	127	7.6.4	DC measurement	MMDC	7-410 Ed1 IS
	128	7.6.5	Meteorological information	MMET	7-410 Ed1 IS
	129	8.1.2	Fuel characteristics	MFUL	7-420 Ed1 IS
	130	8.5.3	Pressure measurements	MPRS	7-420 Ed1 IS
	131	8.5.4	Heat measured values	MHET	7-420 Ed1 IS
	132	8.5.5	Flow measurements	MFLW	7-420 Ed1 IS
	133	8.5.7	Emissions measurements	MENV	7-420 Ed1 IS
P Protection functions	134	5.11.2	Differential	PDIF	7-4 Ed2 FDIS
	135	5.11.3	Direction comparison	PDIR	7-4 Ed2 FDIS
	136	5.11.4	Distance	PDIS	7-4 Ed2 FDIS
	137	5.11.5	Directional overpower	PDOP	7-4 Ed2 FDIS
	138	5.11.6	Directional underpower	PDUP	7-4 Ed2 FDIS
	139	5.11.7	Rate of change of frequency	PFRC	7-4 Ed2 FDIS
	140	5.11.8	Harmonic restraint	PHAR	7-4 Ed2 FDIS
	141	5.11.9	Ground detector	PHIZ	7-4 Ed2 FDIS

LN Group	#	Clause	Description	Name	Document
	142	5.11.10	Instantaneous overcurrent	PIOC	7-4 Ed2 FDIS
	143	5.11.11	Motor restart inhibition	PMRI	7-4 Ed2 FDIS
	144	5.11.12	Motor starting time supervision	PMSS	7-4 Ed2 FDIS
	145	5.11.13	Over power factor	POPF	7-4 Ed2 FDIS
	146	5.11.14	Phase angle measuring	PPAM	7-4 Ed2 FDIS
	147	5.11.15	Rotor protection	PRTR	7-4 Ed2 FDIS
	148	5.11.16	Protection scheme	PSCH	7-4 Ed2 FDIS
	149	5.11.17	Sensitive directional earthfault	PSDE	7-4 Ed2 FDIS
	150	5.11.18	Transient earth fault	PTEF	7-4 Ed2 FDIS
	151	5.11.19	Tyristor protection	PTHF	7-4 Ed2 FDIS
	152	5.11.20	Time overcurrent	PTOC	7-4 Ed2 FDIS
	153	5.11.21	Overfrequency	PTOF	7-4 Ed2 FDIS
	154	5.11.22	Overvoltage	PTOV	7-4 Ed2 FDIS
	155	5.11.23	Protection trip conditioning	PTRC	7-4 Ed2 FDIS
	156	5.11.24	Thermal overload	PTTR	7-4 Ed2 FDIS
	157	5.11.25	Undercurrent	PTUC	7-4 Ed2 FDIS
	158	5.11.26	Underfrequency	PTUF	7-4 Ed2 FDIS
	159	5.11.27	Undervoltage	PTUV	7-4 Ed2 FDIS
	160	5.11.28	Underpower factor	PUPF	7-4 Ed2 FDIS
	161	5.11.29	Voltage controlled time overcurrent	PVOC	7-4 Ed2 FDIS
	162	5.11.30	Volts per Hz	PVPH	7-4 Ed2 FDIS
	163	5.11.31	Zero speed or underspeed	PZSU	7-4 Ed2 FDIS
	164	7.7.2	Rotor protection	PRTR	7-410 Ed1 IS
	165	7.7.3	Thyristor protection	PTHF	7-410 Ed1 IS
Q Power quality events	166	5.12.2	Frequency Variation	QFVR	7-4 Ed2 FDIS
	167	5.12.3	Current Transient	QITR	7-4 Ed2 FDIS
	168	5.12.4	Current Unbalance Variation	QIUB	7-4 Ed2 FDIS
	169	5.12.5	Voltage Transien	QVTR	7-4 Ed2 FDIS
	170	5.12.6	Voltage Unbalance Variation	QVUB	7-4 Ed2 FDIS
	171	5.12.7	Voltage Variation	QVVR	7-4 Ed2 FDIS
R Protection related functions	172	5.13.2	Disturbance recorder channel analogue	RADR	7-4 Ed2 FDIS
	173	5.13.3	Disturbance recorder channel binary	RBDR	7-4 Ed2 FDIS
	174	5.13.4	Breaker failure	RBRF	7-4 Ed2 FDIS
	175	5.13.5	Directional element	RDIR	7-4 Ed2 FDIS
	176	5.13.6	Disturbance recorder function	RDRE	7-4 Ed2 FDIS
	177	5.13.7	Disturbance record handling	RDRS	7-4 Ed2 FDIS
	178	5.13.8	Fault locator	RFLO	7-4 Ed2 FDIS
	179	5.13.9	Differential measurements	RMXU	7-4 Ed2 FDIS
	180	5.13.10	Power swing detection/blocking	RPSB	7-4 Ed2 FDIS
	181	5.13.11	Autoreclosing	RREC	7-4 Ed2 FDIS
	182	5.13.12	Synchronism-check	RSYN	7-4 Ed2 FDIS
	183	7.8.2	synchronising or synchro-check device	RSYN	7-410 Ed1 IS
S Supervision and monitoring	184	5.14.2	Monitoring and diagnostics for arcs	SARC	7-4 Ed2 FDIS
	185	5.14.3	Circuit breaker supervision	SCBR	7-4 Ed2 FDIS
	186	5.14.4	Insulation medium supervision (gas)	SIMG	7-4 Ed2 FDIS
	187	5.14.5	Insulation medium supervision	SIML	7-4 Ed2 FDIS

LN Group	#	Clause	Description	Name	Document
			(liquid)		
	188	5.14.6	Tap changer Supervision	SLTC	7-4 Ed2 FDIS
	189	5.14.7	Supervision of Operating Mechanism	SOPM	7-4 Ed2 FDIS
	190	5.14.8	Monitoring and diagnostics for partial discharges	SPDC	7-4 Ed2 FDIS
	191	5.14.9	Power Transformer Supervision	SPTR	7-4 Ed2 FDIS
	192	5.14.10	Circuit Switch Supervision	SSWI	7-4 Ed2 FDIS
	193	5.14.11	Temperature supervision	STMP	7-4 Ed2 FDIS
	194	5.14.12	Vibration supervision	SVBR	7-4 Ed2 FDIS
	195	7.9.2	temperature supervision	STMP	7-410 Ed1 IS
	196	7.9.3	vibration supervision	SVBR	7-410 Ed1 IS
	197	8.5.6	Vibration conditions	SVBR	7-420 Ed1 IS
	198	8.5.2	Temperature measurements	STMP	7-420 Ed1 IS
T Instrument Ttransformers and sensors	199	5.15.2	Angle	TANG	7-4 Ed2 FDIS
	200	5.15.3	Axial displacement	TAXD	7-4 Ed2 FDIS
	201	5.15.4	Current transformer	TCTR	7-4 Ed2 FDIS
	202	5.15.5	Distance	TDST	7-4 Ed2 FDIS
	203	5.15.6	Liquid flow	TFLW	7-4 Ed2 FDIS
	204	5.15.7	Frequency	TFRQ	7-4 Ed2 FDIS
	205	5.15.8	Generic sensor	TGSN	7-4 Ed2 FDIS
	206	5.15.9	Humidity	THUM	7-4 Ed2 FDIS
	207	5.15.10	LMedia level	TLVL	7-4 Ed2 FDIS
	208	5.15.11	Magnetic field	TMGF	7-4 Ed2 FDIS
	209	5.15.12	Movement senso	TMVM	7-4 Ed2 FDIS
	210	5.15.13	Position indicator	TPOS	7-4 Ed2 FDIS
	211	5.15.14	Pressure sensor	TPRS	7-4 Ed2 FDIS
	212	5.15.15	Rotation transmitter	TRTN	7-4 Ed2 FDIS
	213	5.15.16	Sound pressure sensor	TSND	7-4 Ed2 FDIS
	214	5.15.17	Temperature sensor	TTMP	7-4 Ed2 FDIS
	215	5.15.18	Mechanical tension / stress	TTNS	7-4 Ed2 FDIS
	216	5.15.19	Vibration sensor	TVBR	7-4 Ed2 FDIS
	217	5.15.20	Voltage transformer	TVTR	7-4 Ed2 FDIS
	218	5.15.21	Water acidity	TWPH	7-4 Ed2 FDIS
	219	7.10.2	Angle sensor	TANG	7-410 Ed1 IS
	220	7.10.3	Axial displacement sensor	TAXD	7-410 Ed1 IS
	221	7.10.4	Distance sensor	TDST	7-410 Ed1 IS
	222	7.10.5	Flow sensor	TFLW	7-410 Ed1 IS
	223	7.10.6	Frequency sensor	TFRQ	7-410 Ed1 IS
	224	7.10.7	Humidity sensor	THUM	7-410 Ed1 IS
	225	7.10.8	Level sensor	TLEV	7-410 Ed1 IS
	226	7.10.9	Magnetic field sensor	TMGF	7-410 Ed1 IS
	227	7.10.10	Movement sensor	TMVM	7-410 Ed1 IS
	228	7.10.11	Position indicator	TPOS	7-410 Ed1 IS
	229	7.10.12	Pressure sensor	TPRS	7-410 Ed1 IS
	230	7.10.13	Rotation transmitter	TRTN	7-410 Ed1 IS
	231	7.10.14	Sound pressure sensor	TSND	7-410 Ed1 IS
	232	7.10.15	Temperature sensor	TTMP	7-410 Ed1 IS
	233	7.10.16	Mechanical tension /stress sensor	TTNS	7-410 Ed1 IS
	234	7.10.17	Vibration sensor	TVBR	7-410 Ed1 IS

LN Group	#	Clause	Description	Name	Document
	235	7.10.18	Water pH sensor	TWPH	7-410 Ed1 IS
W Wind Turbines	236	Table 7	Wind turbine general information	WTUR	61400-25-2 Ed1 IS
	237	Table 8	Wind turbine rotor information	WROT	61400-25-2 Ed1 IS
	238	Table 9	Wind turbine transmission information	WTRM	61400-25-2 Ed1 IS
	239	Table 10	Wind turbine generator information	WGEN	61400-25-2 Ed1 IS
	240	Table 11	Wind turbine converter information	WCNV	61400-25-2 Ed1 IS
	241	Table 12	Wind turbine transformer information	WTRF	61400-25-2 Ed1 IS
	242	Table 13	Wind turbine nacelle information	WNAC	61400-25-2 Ed1 IS
	243	Table 14	Wind turbine yawing information	WYAW	61400-25-2 Ed1 IS
	244	Table 15	Wind turbine tower information	WTOW	61400-25-2 Ed1 IS
	245	Table 16	Wind power plant meteorological information	WMET	61400-25-2 Ed1 IS
	246	Table 17	Wind power plant alarm information	WALM	61400-25-2 Ed1 IS
	247	Table 18	Wind turbine state log information	WSLG	61400-25-2 Ed1 IS
	248	Table 19	Wind turbine analogue log information	WALG	61400-25-2 Ed1 IS
	249	Table 20	Wind turbine report information	WREP	61400-25-2 Ed1 IS
	250	Table 21	Wind power plant active power control information	WAPC	61400-25-2 Ed1 IS
	251	Table 22	Wind power plant reactive power control information	WRPC	61400-25-2 Ed1 IS
X Switchgear	252	5.16.2	Circuit breaker	XCBR	7-4 Ed2 FDIS
	253	5.16.3	Circuit switch	XSWI	7-4 Ed2 FDIS
	254	8.3.2	Fuse	XFUS	7-420 Ed1 IS
Y Power transformers	255	5.17.2	Earth fault neutralizer (Petersen coil)	YEFN	7-4 Ed2 FDIS
	256	5.17.3	Tap changer	YLTC	7-4 Ed2 FDIS
	257	5.17.4	Power shunt	YPSH	7-4 Ed2 FDIS
	258	5.17.5	Power transformer	YPTR	7-4 Ed2 FDIS

LN Group	#	Clause	Description	Name	Document
Z further power system equipment	259	5.18.2	Auxiliary network	ZAXN	7-4 Ed2 FDIS
	260	5.18.3	Battery	ZBAT	7-4 Ed2 FDIS
	261	5.18.4	Bushing	ZBSH	7-4 Ed2 FDIS
	262	5.18.5	Power cable	ZCAB	7-4 Ed2 FDIS
	263	5.18.6	Capacitor bank	ZCAP	7-4 Ed2 FDIS
	264	5.18.7	Converter	ZCON	7-4 Ed2 FDIS
	265	5.18.8	Generator	ZGEN	7-4 Ed2 FDIS
	266	5.18.9	Gas insulated line	ZGIL	7-4 Ed2 FDIS
	267	5.18.10	Power overhead line	ZLIN	7-4 Ed2 FDIS
	268	5.18.11	Motor	ZMOT	7-4 Ed2 FDIS
	269	5.18.12	Reactor	ZREA	7-4 Ed2 FDIS
	270	5.18.13	Resistor	ZRES	7-4 Ed2 FDIS
	271	5.18.14	Rotating reactive component	ZRRC	7-4 Ed2 FDIS
	272	5.18.15	Surge arrestor	ZSAR	7-4 Ed2 FDIS
	273	5.18.16	Semi-conductor controlled rectifier	ZSCR	7-4 Ed2 FDIS
	274	5.18.17	Synchronous machine	ZSMC	7-4 Ed2 FDIS
	275	5.18.18	Thyristor controlled frequency converter	ZTCF	7-4 Ed2 FDIS
	276	5.18.19	Thyristor controlled reactive component	ZTCR	7-4 Ed2 FDIS
	277	7.11.2	Neutral resistor	ZRES	7-410 Ed1 IS
	278	7.11.3	Semiconductor rectifier controller	ZSCR	7-410 Ed1 IS
	279	7.11.4	Synchronous machine	ZSMC	7-410 Ed1 IS
	280	6.4.2	Rectifier	ZRCT	7-420 Ed1 IS
	281	6.4.3	Inverter	ZINV	7-420 Ed1 IS
	282	8.2.2	Battery systems	ZBAT	7-420 Ed1 IS
	283	8.2.3	Battery charger	ZBTC	7-420 Ed1 IS

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