IEC 61850 Client

Client connector for IEDs, RTUs and I/O devices that use IEC 61850 Edition 2 over MMS.

Modules Electrical Pack IEC 61850 Client

- Name: **IEC61850**
- Protocol: IEC 61850 Edition 2 Client (MMS)
- Interface: TCP/IP
- Configuration:
  - Devices / Protocols
  - Unified Namespace / Tag Providers

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Overview

The IEC 61850 Client connector implements the ACSI core services of the IEC 61850 standard, mapped to MMS as defined in part 8-1 of the standard, over TCP/IP. It acts as a client station and communicates with IEDs (Intelligent Electronic Devices), RTUs (Remote Terminal Units) and I/O devices that act as IEC 61850 servers.

Communication Driver Information	
Driver name	IEC 61850 Client Communication Protocol
Assembly Name	T.ProtocolDriver.IEC61850
Protocol interface	IEC 61850 Edition 2 over TCP/IP
Max number of nodes	User defined
Requirements	Ethernet port

Module Configuration

This page describes the device connection settings and the address syntax of this connector.

For further information, see:

- Devices Module
- Devices Module Reference

Tag Providers and Communication Channels

There are two independent ways to use this protocol:

- **Tag Provider**: connects directly to the data in the devices, without creating local tags, using the names defined in the remote device.
- **Device Channel**: maps solution tags to external data addresses, giving more flexibility in naming conventions and data block management.

This page covers the device configuration for both methods.

IEC 61850 Standard

This topic summarizes the parts of the IEC 61850 standard that directly affect the definition and implementation of this connector. For details and a formal description, refer to the standard or to the documentation of the server IEDs. The standard has ten parts:

Part	Description
1	Introduction and overview
2	Glossary
3	General requirements
4	System and project management
5	Communication requirements for functions and device models
6	Configuration description language for communication in substations related to IEDs

7.1	Basic communication structure for substation and feeder equipment: Principles and models
7.2	Basic communication structure for substation and feeder equipment: Abstract communication service interface
7.3	Basic communication structure for substation and feeder equipment: Common data classes
7.4	Basic communication structure for substation and feeder equipment: Compatible logical node classes and data classes
8.1	Mapping to MMS (ISO/IEC 9506-1 and ISO/IEC 9506-2) and to ISO/IEC 8802-3
9.1	Sampled values over serial unidirectional multidrop point-to-point link
9.2	Sampled values over ISO/IEC 8802-3
10	Conformance testing

For data communication between computers and IEDs, the standard defines the following message types:

Message	Description
GOOSE (Generic Object Oriented Substation Event)	Multicast messages that carry information between IEDs. They carry only the messages that report the operation of a protection function or a digital signal.
MMS (Manufacturing Message Specification)	Unicast messages that exchange measurement (analog) or state (digital) data, to report the state of equipment and process.

Point Structure

In IEC 61850, the points inside an IED are not addressed by numbers, as in other protocols. They are objects, addressed by names that the standard defines. An IEC 61850 IED holds a map of objects arranged in a hierarchy. In the communication between a client (for example, a SCADA system) and a server (for example, a digital relay IED), these object names travel in the protocol messages, at least while the communication is being established.

An object reference names each level of the hierarchy in order: logical device, logical node, functional constraint, data object and data attribute. For example, in `Relay1/XCBR1$ST$Pos$stVal`, `Relay1` is the logical device, `XCBR1` the logical node, `ST` the functional constraint, `Pos` the data object and `stVal` the data attribute.

- **LD, Logical Devices**: the logical devices within the physical server. They work as containers of functions (Logical Nodes) or as gateways between LNs of different LDs. The internal name of the IED is usually the prefix, with a suffix for the main function of the LD, such as CTRL or MEAS.
- **LN, Logical Nodes**: objects that implement well-defined basic functions within the Logical Device. LN names are standardized. Each LN contains objects, data sets, definitions of Reports, Logs, parameter groups and services. For example, a disconnect switch named Q0CSWI1 uses the LN CSWI (Switch controller). Other examples are measurement (MMXU), voltage transformer (TVTR), overcurrent protection (PTOC) and thermal protection (PTTR). IEC 61850 Part 5 lists every LN and its naming rules.
- **FC, Functional Constraints**: the objects of an LN are grouped in categories called Functional Constraints, for example CO for command objects, ST for digital signaling objects and RP for Report objects. The table below is based on IEC 61850 Part 7-2, Table 18.

FC	Description
ST	Status information
MX	Measurands (analog values)
CO	Control: the DataAttribute is operated (control model) and read
SP	Setpoint: the DataAttribute represents a set-point; the value may be controlled and read
SV	Substitution: the DataAttribute represents a substitution
CF	Configuration: the DataAttribute represents a configuration
DC	Description: the DataAttribute represents a description
SG	Setting group: logical devices that implement the SGCB class
SE	Setting group (editable)
EX	Extended definition
BR	Buffered report
RP	Unbuffered report
LG	Logging: the attribute represents a log control
GO	GOOSE control: the attribute represents a GOOSE control

GS	GSSE control: the attribute represents a GSSE control
MS	Multicast sampled value control
US	Unicast sampled value control

- **DO, Data Objects**: objects with standardized names that hold the information itself. They can be simple, such as Pos, which gives the circuit breaker position, or complex, such as A, a three-phase current made of four Data Attributes, each with child Data Attributes for each phase and the neutral. Examples of Data Objects:
  - Beh: behavior of the LN.
  - Health: state of the hardware and software related to the logical node.
  - Loc: switchover between local and remote operation.
  - Mod: mode and behavior: On, Blocked, Test, Test/Blocked, Off.
  - Pos: switch position.
  - A: current (neut for the neutral; phsA, phsB, phsC for phases A, B and C).
  - Hz: frequency.
  - PPV: phase to phase voltages.
  - PhV: phase to ground voltages for phases 1, 2 and 3, including the angle.
- **DA, Data Attributes**: each object below a Data Object or another Data Attribute. For example:
  - Pos has four Data Attributes: stVal (circuit breaker state), q (data quality), t (sampling timestamp) and ctlNum (status change sequence number).
  - The phase current phsC, itself a Data Attribute, contains four Data Attributes: cVal (current measurement), instCVal (instantaneous measurement at the last acquisition), q (data quality) and t (sampling timestamp).

Connector Structure

The connector has two libraries that work together: the Communication library and the Integration library.

Communication Library

The Communication library handles the communication between the connector and the equipment. It follows edition 2 of the IEC 61850 standard series.

Supported objects

IEC 61850 Object	MMS Object
SERVER class	Virtual Manufacturing Device (VMD)
LOGICAL DEVICE class	Domain
LOGICAL NODE class	Named Variable
DATA class	Named Variable
DATA-SET class	Named Variable List
SETTING-GROUP-CONTROL-BLOCK class	Named Variable
REPORT-CONTROL-BLOCK class	Named Variable
LOG class	Journal
LOG-CONTROL-BLOCK class	Named Variable
GOOSE-CONTROL-BLOCK class	Named Variable
GSSE-CONTROL-BLOCK class	Named Variable
CONTROL class	Named Variable
Files	Files

Supported ACSI (Abstract Communication Service Interface) services

IEC 61850 Model	ID	IEC 61850 Service	AA: TP / MC	Client	Server
Server	S1	ServerDirectory	TP	?	?
Application association	S2	Associate	TP	?	?
	S3	Abort	TP	?	?
	S4	Release	TP	?	?
Logical device	S5	LogicalDeviceDirectory	TP	?	?
Logical node	S6	LogicalNodeDirectory	TP	?	?

	S7	GetAllDataValues	TP	?	?
Data	S8	GetDataValues	TP	?	?
	S9	SetDataValues	TP	?	?
	S10	GetDataDirectory	TP	?	?
	S11	GetDataDefinition	TP	?	?
Data set	S12	GetDataSetValues	TP	?	?
	S13	SetDataSetValues	TP	?	?
	S14	CreateDataSet	TP	?	?
	S15	DeleteDataSet	TP	?	?
	S16	GetDataSetDirectory	TP	?	?
Substitution	S17	SetDataValues	TP	?	?
Setting group control block	S18	SelectActiveSG	TP	?	?
	S19	SelectEditSG	TP	?	?
	S20	SetSGValues	TP	?	?
	S21	ConfirmEditSGValues	TP	?	?
	S22	GetSGValues	TP	?	?
	S23	GetSGCBValues	TP	?	?
Buffered report control block (BRCB)	S24	Report	TP	?	?
	S24-1	data-change (dchg)	TP	?	?
	S24-2	quality-change (qchg)	TP	?	?
	S24-3	data-update (dupd)	TP	?	?
	S25	GetBRCBValues	TP	?	?
	S26	SetBRCBValues	TP	?	?
Unbuffered report control block (URCB)	S27	Report	TP	?	?
	S27-1	data-change (dchg)	TP	?	?
	S27-2	quality-change (qchg)	TP	?	?
	S27-3	data-update (dupd)	TP	?	?
	S28	GetURCBValues	TP	?	?
	S29	SetURCBValues	TP	?	?
Log control block	S30	GetLCBValues	TP	?	?
	S31	SetLCBValues	TP	?	?
	S32	QueryLogByTime	TP	?	?
	S33	QueryLogAfter	TP	?	?
	S34	GetLogStatusValues	TP	?	?
GOOSE control block	S35	SendGOOSEMessage	MC	?	?
	S36	GetGoReference	TP		
	S37	GetGOOSEElementNumber	TP		
	S38	GetGoCBValues	TP	?	?
	S39	SetGoCBValues	TP	?	?
GSSE control block	S40	SendGSSEMessage	MC		
	S41	GetGsReference	TP		
	S42	GetGSSEElementNumber	TP		
	S43	GetGsCBValues	TP		
	S44	SetGsCBValues	TP		
Multicast SVC	S45	SendMSVMessage	MC		?
	S46	GetMSVCBValues	TP	?	?
	S47	SetMSVCBValues	TP	?	?

Unicast SVC	S48	SendUSVMessage	TP		?
	S49	GetUSVCBValues	TP	?	?
	S50	SetUSVCBValues	TP	?	?
Control	S51	Select	TP	?	?
	S52	SelectWithValue	TP	?	?
	S53	Cancel	TP	?	?
	S54	Operate	TP	?	?
	S55	Command-Termination	TP	?	?
	S56	TimeActivated-Operate	TP	?	?
File transfer	S57	GetFile	TP	?	?
	S58	SetFile	TP	?	?
	S59	DeleteFile	TP	?	?
	S60	GetFileAttributeValues	TP	?	?
Time	T1	Time resolution of internal clock		1 ms	1 ms
	T2	Time accuracy of internal clock			
	T3	Supported timestamp resolution		1 ms	1 ms

AA: application association. TP: two-party application association (MMS over TCP/IP, or Unicast Sampled Values over Ethernet). MC: multicast application association (GOOSE or Sampled Values using multicast messages over Ethernet). ?: supported.

Integration Library

The Integration library connects the connector to FrameworX. It transfers the values read from and written to the equipment. In the tables below, a check mark (?) means the object or service is implemented.

Implemented objects

IEC 61850 Object	Implemented
SERVER class	
LOGICAL DEVICE class	?
LOGICAL NODE class	?
DATA class	?
DATA-SET class	?
SETTING-GROUP-CONTROL-BLOCK class	
REPORT-CONTROL-BLOCK class	?
LOG class	
LOG-CONTROL-BLOCK class	
GOOSE-CONTROL-BLOCK class	
GSSE-CONTROL-BLOCK class	
CONTROL class	?
Files	

Implemented ACSI services

IEC 61850 Model	ID	IEC 61850 Service	Implemented
Server	S1	ServerDirectory	?
Application association	S2	Associate	?
	S3	Abort	?
	S4	Release	?
Logical device	S5	LogicalDeviceDirectory	?

Logical node	S6	LogicalNodeDirectory	?
	S7	GetAllDataValues	?
Data	S8	GetDataValues	?
	S9	SetDataValues	?
	S10	GetDataDirectory	?
	S11	GetDataDefinition	?
Data set	S12	GetDataSetValues	?
	S13	SetDataSetValues	
	S14	CreateDataSet	
	S15	DeleteDataSet	
	S16	GetDataSetDirectory	?
Substitution	S17	SetDataValues	
Setting group control block	S18	SelectActiveSG	
	S19	SelectEditSG	
	S20	SetSGValues	
	S21	ConfirmEditSGValues	
	S22	GetSGValues	
	S23	GetSGCBValues	
Buffered report control block (BRCB)	S24	Report	?
	S24-1	data-change (dchg)	?
	S24-2	quality-change (qchg)	?
	S24-3	data-update (dupd)	?
	S25	GetBRCBValues	?
	S26	SetBRCBValues	?
Unbuffered report control block (URCB)	S27	Report	?
	S27-1	data-change (dchg)	?
	S27-2	quality-change (qchg)	?
	S27-3	data-update (dupd)	?
	S28	GetURCBValues	?
	S29	SetURCBValues	?
Log control block	S30	GetLCBValues	
	S31	SetLCBValues	
	S32	QueryLogByTime	
	S33	QueryLogAfter	
	S34	GetLogStatusValues	
GOOSE control block	S35	SendGOOSEMessage	
	S36	GetGoReference	
	S37	GetGOOSEElementNumber	
	S38	GetGoCBValues	
	S39	SetGoCBValues	
GSSE control block	S40	SendGSSEMessage	
	S41	GetGsReference	
	S42	GetGSSEElementNumber	
	S43	GetGsCBValues	
	S44	SetGsCBValues	
Multicast SVC	S45	SendMSVMessage	
	S46	GetMSVCBValues	

	S47	SetMSVCBValues	
Unicast SVC	S48	SendUSVMessage	
	S49	GetUSVCBValues	
	S50	SetUSVCBValues	
Control	S51	Select	?
	S52	SelectWithValue	?
	S53	Cancel	
	S54	Operate	?
	S55	Command-Termination	
	S56	TimeActivated-Operate	
File transfer	S57	GetFile	
	S58	SetFile	
	S59	DeleteFile	
	S60	GetFileAttributeValues	
Time	T1	Time resolution of internal clock	
	T2	Time accuracy of internal clock	
	T3	Supported timestamp resolution	

Implemented Functional Constraints: a check mark (?) means the connector reads or writes the attributes of that Functional Constraint.

Functional Constraint	Description	Read	Write
BL	Blocking		
BR	Buffered report	?	?
CF	Configuration	?	?
CO	Control		?
DC	Description	?	?
EX	Extended definition	?	?
LG	Log control blocks		
MS	Multicast SV		
MX	Measurands (analog values)	?	
OR	Operate received		
RP	Unbuffered report	?	?
SE	Setting group editable		
SG	Setting group		
SP	Setpoint	?	?
SR	Service response / Service tracking		
ST	Status information	?	
SV	Substitution		
US	Unicast SV		

Operation

The connector runs the following sequence:

Step	Purpose	Description
1	Channel initialization	The connector reads the channel settings and its configuration file, T.ProtocolDriver.IEC61850.config.xml, and validates them.
2	Node initialization	The connector connects to the equipment and reads its data structure. The connector needs this read to operate. This step repeats until it succeeds; only then does the connector go to the next step.

3	Point initialization	The connector reads and validates the registered points. It also checks that each point exists in the equipment and that the connector can read or write it.
4	Start of the read and write tasks	The task that reads COMTRADE files and points starts according to the node settings. The write task starts and runs when a point with write access changes value. The task that reads received reports starts, and the report points are subscribed.
5	Cyclic execution of the tasks	The read and write tasks run as configured. If the connection is lost, the connector returns to step 2.

Channels Configuration

Protocol Options

Item	Description	Default
Logging level	Debug: all messages are recorded in the log. Info: only Info, Warning and Error messages are recorded. Warning: only Warning and Error messages are recorded. Error: only Error messages are recorded.	Info
Log files	Maximum number of log files kept before the oldest one is deleted.	30
Log file size	Maximum size of each log file. Specify the size with the suffix KB, MB or GB.	35MB
Command password	Adds a check to commands. Enter a numeric password of up to 9 digits. When a command arrives, the connector compares it with the current value of the EstimatedValue property of the tag that sends the command. A display, script or other source that sends the command must first write the password to that property. After it runs the command, the connector sets EstimatedValue to zero. When the option is empty or zero, the check is not made.	Empty
Command timeout (s)	Maximum time, in seconds, for a command to run.	10
Command originator	Originator category that the connector sends with control commands: Remote or Station.	Station
Tls Enabled	Enables encryption of the communication based on TLS (Transport Layer Security). Client and server must both enable it. The next three options then name text files with the keys and certificates, placed in the solution folder.	Disabled
Tls OwnKey	Name of the file with the client's own key.	Empty
Tls OwnCertificate	Name of the file with the client's own certificate.	Empty
Tls CACertificate	Name of the file with the CA certificate used to validate the chain.	Empty

For command security, the connector also checks the timestamp of the output tag. This is the time of the tag's last value change, and the change must have happened at most 30 seconds before the connector receives the command request.

Interface

CustomTCPIP.

Initial State

Enabled.

Nodes Configuration

Primary Station

Open the PrimaryStation column of the node to set the following options:

Item	Description	Default
IP	IP address of the IED.	0.0.0.0
Port	TCP port of the IED.	102
Connection timeout (ms)	Maximum time, in milliseconds, to establish the TCP/IP connection with the IED. Minimum 1000.	5000
Connection password	Password used to authenticate the client with the IED (IEC 61850 Edition 2).	Empty
Reading mode	Polling/Report: reads by polling and by report. Polling: reads by polling only. Report: reads by report only.	Polling /Report
Analog read polling rate (ms)	Period, in milliseconds, of the read requests for analog input points (AI). A value of 0 disables this read.	60000
Digital read polling rate (ms)	Period, in milliseconds, of the read requests for binary input points (BI). A value of 0 disables this read.	30000
Datasets read polling rate (ms)	Period, in milliseconds, of the read requests for DataSet points of type DS. A value of 0 disables this read.	600000
Dataset T1 read polling rate (ms)	Period, in milliseconds, of the read requests for DataSet points of type DS1. A value of 0 disables this read.	660000
Dataset T2 read polling rate (ms)	Period, in milliseconds, of the read requests for DataSet points of type DS2. A value of 0 disables this read.	720000
Dataset T3 read polling rate (ms)	Period, in milliseconds, of the read requests for DataSet points of type DS3. A value of 0 disables this read.	780000
Dataset T4 read polling rate (ms)	Period, in milliseconds, of the read requests for DataSet points of type DS4. A value of 0 disables this read.	840000
Report polling rate (ms)	Period, in milliseconds, of the check that the report points are enabled. The connector reads the RptEna attribute of each report point. A value of 0 disables the cyclic check; the connector then enables and subscribes to the reports only once, during initialization.	5000
Communication status tag	Name of an existing Digital tag that receives the communication status: 0 = offline, 1 = online.	Empty
Last command error tag	Name of an existing Integer tag that receives the error code of the last command. See Command Errors (CO) under Error and Quality Codes.	Empty
SCL file name to config points	Name of the SCL file the address browser of the Points table reads. The connector looks for the file in the solution folder. To use another folder, enter the full path.	Empty
Force autodescription on connection loss	Enabled: the connector reads the data model of the IED again after a connection loss. Disabled: the connector keeps the data model it already read.	Disabled
Validate TimeQuality	Enabled: the connector checks the time quality of the timestamps and logs a warning when it reports ClockFailure or ClockNotSynchronized. Disabled: no check.	Disabled
Quality changes timestamp	Enabled: the timestamp of a point is updated when only its quality changes. Disabled: a change of quality alone does not update the timestamp.	Disabled
Ignore polling on points updated by reports	Enabled: polling read requests are skipped for points updated by enabled reports. Performance is better, but read data integrity is lower. Disabled: these points are also polled. Performance is lower, but read data integrity is better.	Disabled
COMTRADE files reading mode	Download: the connector transfers the COMTRADE files to the computer. Download/Delete: the connector transfers the COMTRADE files to the computer and deletes them from the IED after a successful transfer.	Download
COMTRADE files download folder	Folder on the computer where the transferred COMTRADE files are saved, for example `C:\Temp`.	Empty

COMTRADE files download polling rate (ms)	Period, in milliseconds, of the check for new COMTRADE files. A value of 0 disables this read.	0
FTP username	User allowed to read the COMTRADE files over FTP. When this field is filled in, the files are read over FTP; otherwise, they are read over MMS.	Empty
FTP password	Password of the FTP user.	Empty
Connection AP-Title	AP-Title used in the connection. When empty, the connector uses 1,1,1,999,1.	Empty
Connection AE-Qualifier	AE-Qualifier used in the connection. When empty, the connector uses 12.	Empty
Command interlock check	Enabled: the interlock check flag is set on Select and Operate commands. Disabled: the flag is not set.	Enabled
Command synchro check	Enabled: the synchrocheck flag is set on Operate commands. Disabled: the flag is not set.	Enabled
SampleValuesSubscriber	Enables the Sampled Values subscriber.	Disabled
Send PurgeBuf on Start	Disabled: when the connector starts, it sends the last EntryID received for each buffered report. The IED keeps the earlier events in its buffer but knows that this client already received the events up to that EntryID. Enabled: when the connector starts, and only then, it sends the PurgeBuf attribute to each report. The IED then purges all events still stored in the report buffer.	Disabled
Force float32 for SetPoints	Disabled: set points are sent in their native type, Float32 or Float64. Enabled: set points are always sent as Float32, for IEDs that accept only Float32.	Disabled

Backup Station

A secondary station, when the installation has one, accepts the same settings as the primary station.

Tag Provider Configuration

This protocol supports the Tag Provider function, which gives access to the data model of a device without creating solution tags.

How to Configure

To use the IEC 61850 protocol as a Tag Provider, go to Unified Namespace Tag Providers and create a provider for this protocol. Set the PrimaryStation column with the options below.

Primary Station

Item	Description	Default
IP	IP address of the IED.	0.0.0.0
Port	TCP port of the IED.	102
ConnectionTimeout	Maximum time, in milliseconds, to establish the TCP/IP connection with the IED. Minimum 1000.	5000
ConnectionPassword	Password used to authenticate the client with the IED (IEC 61850 Edition 2).	Empty
ReadingMode	Polling/Report: reads by polling and by report. Polling: reads by polling only. Report: reads by report only.	Polling /Report
AnalogReadPollingRate	Period, in milliseconds, of the read requests for analog points. A value of 0 disables this read.	60000
DigitalReadPollingRate	Period, in milliseconds, of the read requests for digital points. A value of 0 disables this read.	30000
DatasetsReadPollingRate	Period, in milliseconds, of the read requests for DataSets. A value of 0 disables this read.	600000
ReportPollingRate	Period, in milliseconds, of the check that the reports are enabled, made by reading the RptEna attribute. A value of 0 disables the cyclic check; the reports are then enabled and subscribed only once, during initialization.	5000

CommandPassword	Numeric password that allows commands.	Empty
UseSCLfileToConfiguration	Enabled: the provider reads the data model from the SCL file named in SCLConfigFileName. Disabled: the provider reads the data model from the IED.	Not set
SCLConfigFileName	Full path and name of the SCL configuration file.	Empty
SCLServerName	Name of the IED server for this provider, used when the SCL file describes more than one IED.	Empty
ConnectionAPTitle	AP-Title used in the connection. When empty, the connector uses 1,1,1,999,1.	Empty
ConnectionAEQualifier	AE-Qualifier used in the connection. When empty, the connector uses 12.	Empty
CommandInterlockCheck	Enabled: the interlock check flag is set on Select and Operate commands. Disabled: the flag is not set.	Disabled
CommandSynchroCheck	Enabled: the synchrocheck flag is set on Operate commands. Disabled: the flag is not set.	Disabled
SampleValuesSubscriber	Enables the Sampled Values subscriber.	Disabled



The command interlock and synchrocheck options default to Enabled on a device node and to Disabled on a Tag Provider.

Secondary Station (Backup Station)

A secondary station, when the installation has one, accepts the same settings as the primary station.

Points Configuration

The Points table maps each tag to the name of an IEC 61850 data object in a remote IED, which is either the source of the information or the target of a command.

The point address has two fields separated by a colon: Type and Address. Some point types add fields after the address.

Types

The point type groups and classifies the IEC 61850 addresses. Points with write access are written when the tag changes value. Points with read access are read at the polling rate set in the node configuration.

Acronym	Name	Tag Type	Access	Description
AI	Analog input	Double	Read	Analog input.
BI	Binary input	Integer	Read	Digital input.
AO	Analog output	Double	Write	Analog output.
BO	Binary output	Digital	Write	Digital output.
RP	Unbuffered report	Digital	Read	Unbuffered report. 0: report not subscribed. 1: report subscribed.
BR	Buffered report	Digital	Read	Buffered report. 0: report not subscribed. 1: report subscribed.
RPF	Unbuffered report flag	Digital, Integer or Text	Read	Attribute of an unbuffered report.
BRF	Buffered report flag	Digital, Integer or Text	Read	Attribute of a buffered report.
DS	DataSet	Digital	Read	Reads all points of the DataSet.
DS1	DataSet T1	Digital	Read	Reads all points of the DataSet.
DS2	DataSet T2	Digital	Read	Reads all points of the DataSet.
DS3	DataSet T3	Digital	Read	Reads all points of the DataSet.
DS4	DataSet T4	Digital	Read	Reads all points of the DataSet.
INC	Integer output control	Integer	Write	32-bit integer.
BSC	Binary step position control	Integer	Write	0: Stop. 1: Lower. 2: Higher. 3: Reserved.

ISC	Integer step position control	Integer	Write	8-bit integer, from -64 to 63.
ASG	Analog setting	Double	Write	32-bit real (single float).

Binary Output (BO)

The BO type has an extra field, Command Parameter, which sets a fixed value that the command sends when the digital tag of the point changes value. In the address editor of the Points table, a BO point shows three fields: Type (BO), Item name (the object reference) and Command parameter. For example:

Step	Description	Column	Value
1	Create a tag in Unified Namespace Tags	Name Type	BREAKER_OFF Digital
2	Create a tag in Unified Namespace Tags	Name Type	BREAKER_ON Digital
3	Create a point in Devices Points	TagName Address	BREAKER_OFF `BO:IED7SJ63CTRL/Q0CSWI1$CO$Pos:0`
4	Create a point in Devices Points	TagName Address	BREAKER_ON `BO:IED7SJ63CTRL/Q0CSWI1$CO$Pos:1`

Link BREAKER_OFF to an Off button and BREAKER_ON to an On button, both with a ToggleValue action. Each time the tag toggles between 0 and 1, the connector sends a command with the fixed value set in the address.



When the command parameter is empty, the connector sends the new value of the tag as the command parameter.

Command Mode

The name of the control object in the point address selects the command mode:

- **Cancel**: sends a Cancel of the selection to the IED.
- **Oper**: sends a command in DIRECT_NORMAL or DIRECT_ENHANCED mode.
- **SBOw**: sends a Select command followed by an Operate command (SBO_NORMAL or SBO_ENHANCED mode).

Examples of addresses for each mode:

Mode	Address
Cancel	`BO:DemoProtCtrl/Obj3CSWI2$CO$Pos$Cancel$ctlVal`
Oper	`BO:DemoProtCtrl/Obj3CSWI2$CO$Pos$Oper$ctlVal`
SBOw	`BO:DemoProtCtrl/Obj3CSWI2$CO$Pos$SBOw$ctlVal`

To send only a Select, without the Operate, use an address that contains SBOw and add SO (Select Only) to the command parameter, for example `BO:DemoProtCtrl/Obj3CSWI2$CO$Pos$SBOw$ctlVal:1:SO`.

DataSet (DS, DS1, DS2, DS3, DS4)

A DataSet is an object that holds a list of Data Object names, normally preconfigured in the server IEDs. The contents (state, measurement, timestamp, quality) of the Data Objects of a DataSet can be obtained in two ways:

- By a read request for the DataSet, by name. Configure a DataSet point in the Points table, plus a point for each Data Object of interest.
- By enabling a Report that points to this DataSet, which then sends these contents unsolicited (see Reports).

DataSet points are read by polling and use the DS type. The DS1, DS2, DS3 and DS4 types allow a different read period for each group of DataSet points.

Reports (BR, RP)

For each Report configured in the server that the client must receive, add an entry to the Points table. At runtime, this point holds the state of the Report (0: disabled, 1: enabled), read from the RptEna attribute of the Report at the Report polling rate set in the node configuration. The OptFlds and TrgOps attributes have these default values:

- OptFlds = SEQ_NUM, TIME_STAMP, REASON_FOR_INCLUSION, DATA_SET, DATA_REFERENCE, ENTRY_ID and CONF_REV
- TrgOps = DATA_CHANGED and GI

You can change these fields for each Report in the browser window of the Address column (see Reports Attributes Window).

Report Flags (BRF, RPF)

Register these Report attributes as points to monitor and control the Report:

Attribute	Tag	Description
EntryID	Text	Identifier of the received Report. It is required for the correct control of a Buffered Report: after a disconnection, the connector subscribes to the Report again from the last EntryID stored in the tag. Because the value must be kept, register the tag, make it retentive, and include it in the Points table.
SqNum	Integer	Sequence number of the Reports.
PurgeBuf	Integer	Required to send the PurgeBuf attribute to the enabled reports (see Send PurgeBuf on Start). Register a point with this address, like the other report flags.

Create tags to receive these values, and register them in the Points table with the Report address followed by $ and the attribute name. For example:

Address	Use
`BR:F95_02CTRL/LLN0$BR$Report_101`	Buffered report
`BRF:F95_02CTRL/LLN0$BR$Report_101$EntryID`	EntryID of the report
`BRF:F95_02CTRL/LLN0$BR$Report_101$SqNum`	Sequence number of the report

Address

Addresses follow the IEC 61850 format:

`LogicalDevice/LogicalNode$FunctionalConstraint$DataObject$DataAttribute`

Create a point in the Points table for each Data Object you need. Complex Data Objects, such as current or three-phase voltage measurements, have more than one level of Data Attributes. The connector recognizes some structures and reads each phase, but each Data Attribute in the first level below the Data Object must be a point in the Points table.

When the connector cannot tell which value of a structure to read, the point reports an error at initialization. In that case, register the address down to the attribute that holds the value. The quality and time are read from the structure that contains the attribute.

Example of an address registered down to the structure, `IED7SJ63MEAS/MMXU1$MX$PhV$phsA`:

- Ignored: `IED7SJ63MEAS/MMXU1$MX$PhV$phsA$instCVal$mag$f`
- Value: `IED7SJ63MEAS/MMXU1$MX$PhV$phsA$cVal$mag$f`
- Quality: `IED7SJ63MEAS/MMXU1$MX$PhV$phsA$q`
- Time: `IED7SJ63MEAS/MMXU1$MX$PhV$phsA$t`

Example of an address registered down to the attribute, `IED7SJ63MEAS/MMXU1$MX$PhV$phsA$cVal$mag$f`:

- Value: `IED7SJ63MEAS/MMXU1$MX$PhV$phsA$cVal$mag$f`
- Quality: `IED7SJ63MEAS/MMXU1$MX$PhV$phsA$q`
- Time: `IED7SJ63MEAS/MMXU1$MX$PhV$phsA$t`

Access Types

Create two Access Types, Read and Write, and assign one of them to each point.

Property	Read	Write
ReadOnStartup	True	False
ReadEnable	Always	Never
ReadPollingRate	00:00:01.00 (one second)	
WriteEventEnabled	False	True
WriteEvent	Changed	Changed
AcceptUnsolicited	False	False
UseStaticBlocks	False	False

Leave the other Access Type properties empty: ReadTrigger, ReadStatus, ReadCompleted, WriteTrigger, WriteStatus, WriteCompleted, BlockCommand and Description.

Browser Window

The IEC 61850 Browser Window helps you register the objects of an IEC 61850 server (IED). To open it from a record of the Points table:

1. Click the Address column.
2. Click the green arrow next to the Item name field.

The browser can navigate an IED or an SCL file. When the SCL file name to config points option holds a valid file name, the file button opens that file. When the node has an IED IP address, the IED button connects to the IED. The third button, with the circular arrow, reads the data again.

The window has two panels side by side. The left panel shows a tree with the IED data. When you click a branch, the right panel lists the objects available at that level. When it opens, the left panel shows the server of the node set in the Node field of the point record. Click the server name to expand the branch, which follows the IEC 61850 hierarchy:

- LD, Logical Devices: the logical devices within the physical server.
- LN, Logical Nodes: basic functions within the LD.
- FC, Functional Constraints.
- DO, Data Objects.
- DA, Data Attributes.

Data Sources

The browser loads the Data Objects, Reports and DataSets configured in the server IED either by connecting to the IED or by reading an SCL (Substation Configuration Language) file. The supported files are ICD (IED Capability Description), SCD (Substation Configuration Description) and CID (Configured IED Description). Right-click the name of the current server to choose the source.

Connection to the IED

When you click the name of a server for the first time, the browser connects to the IED of that server. When the connection succeeds, the tree shows the Logical Devices of the server. Clicking a Logical Device reads all its objects.

A long load can mean a communication failure. Messages such as "Not connected" or "Time-out" appear at the bottom of the window, and the IED icon can show a red X. To try again, click the LD items again. If the connection problems persist, close and reopen the Browser Window.

Reading an SCL File

To load the browser from an SCL file, enter its name in the SCL file name to config points option of the node, and place the file in the solution folder. When you click the server name, the browser reads the file and shows the Logical Devices. When you click an LD, the browser reads all the data objects below it.

To read the file from another folder, enter the full path in SCL file name to config points. The user that runs the application needs read and execute permission on that folder.

The server name in the channel does not need to match the name configured in the IED. When the names differ, or when an SCD file describes several IEDs, a window lists the IED names found in the file, and you choose the one for the node.

Data Objects

Navigate from the Logical Devices node to the Data Object you need, select it in the right panel and click OK to copy it to the Address field of the current record. The Node field must already hold the name of the target node. The right panel allows multiple selection: when you select more than one object, the browser creates a record in the Points table for each selected item.

The browser suggests the point type from the FC of the selected object. You can change the suggested type.

DataSets

In the tree, after the data description, branches show the Reports (buffered and unbuffered) and the DataSets. A DataSet is a set of Data Objects preconfigured in the IED.

Clicking a DataSet name shows the Data Objects it contains, which are also listed in the right panel. To read a DataSet by polling, choose the DataSet name and create a record in the Points table, as described in Points Configuration.

Reports

Reports send unsolicited data from the server IEDs to the clients that enabled them. Each Report has attributes that define its behavior, including the name of the DataSet it sends. Each time the state of an object of that DataSet changes, the server sends a new instance of the Report to the client.

Click the RP (Unbuffered Reports) or BR (Buffered Reports) branch to see the Reports configured in the server IED. With a direct connection to the IED, first load the LDs that contain the Reports. If some reports do not appear, right-click the RP or BR branch and choose Refresh. An ICD file loads all data at once.

To choose a Report, use its name as it appears in the tree under the Logical Nodes, in BR or RP, or in the RP or BR branches after the LDs, where the names of the report control blocks appear in the right panel.

Reports Attributes Window

When you click a Report in the browser tree, the window with the attributes of the report control block opens. The left column lists the attribute names, and the center column (Current Values) shows their current values. Clicking an attribute in the right column opens a window to set a new value. The connector writes the new value to the server at the next runtime start of the client.

The connector stores the changed attributes in the Report address of the point: after the Report name, the address lists the name and value of each changed attribute. For example, this address changes the TrgOps and BufTm attributes:

```
BR:IED7SJ63CTRL/LLN0$BR$BRCBA01 $TRGOPS=[011110] $BUFTM=[+105]
```

COMTRADE Files

COMTRADE File Format

The COMTRADE standard (IEEE Standard Common Format for Transient Data Exchange) defines a format for the data files and other files that describe faults, tests or simulations. Up to four file types can be generated:

- **HDR (Header)**: optional ASCII text file with general information about the event, in no specific order.
- **CFG (Configuration)**: mandatory ASCII text file, organized for automated reading. It holds data such as the substation name, the number of analog and digital channels, channel names, units, conversion factors, power system frequency, sampling rates, date and time, and the format of the data file.
- **DAT (Data)**: mandatory file, in ASCII or binary format, with the samples of the analog and digital quantities. The configuration file defines how to convert the values into real quantities, such as volts and amperes. Digital data is 0 or 1.
- **INF (Information)**: optional ASCII or UTF-8 text file with extra information, divided into public sections, for any equipment or software, and private sections, for one manufacturer only.

Oscillography Data Collection

When a protection relay records a disturbance in the power system, it stores a new oscillography file in its file directory. The connector checks the IED file directories periodically and transfers the new files to the computer.

The COMTRADE settings are in the node configuration (Primary Station):

- **COMTRADE files reading mode**: Download or Download/Delete.
- **COMTRADE files download folder**: destination folder of the files.
- **COMTRADE files download polling rate (ms)**: when greater than zero, how often the connector checks for COMTRADE files.
- **FTP username** and **FTP password**: when set, the files are read over FTP instead of MMS.

Reading and Writing

At each check, the connector scans the IED file directories, over MMS or FTP, for files with the extensions HDR, CFG, DAT and INF, and saves them in the folder set in the node configuration.

When the file already exists in the folder, the connector compares its name and last modification date with those of the file in the IED to decide whether to transfer the file, or to delete it when the Download/Delete mode is set.

When the channel log level is Debug, these operations are recorded at Debug level in the log file. When FTP is used, a separate log file named FTP.log is created in the folder of each channel.

Diagnostic Tools

Operation Logs

The connector records its log in text files and in the Windows Event Log. There are four message types:

Type	Description
Debug	Lowest-level messages, to follow each process in detail. Used mainly by developers, testers and integrators.
Info	Information messages to monitor the operation of the connector.
Warning	Warning messages, to check or to ignore.
Error	Error messages that need immediate attention and correction for the connector to operate correctly.

Trace Window

The Trace Window runs on the server and shows the live operation log of each channel and node. Its columns Info 1, Info 2, Info 3 and Info 4 show the channel, the node, the point address and the method that the driver ran.

Windows Event Log

The connector always records all Warning and Error messages in the Windows Event Log, whatever the configured log level. The message format is: channel, node (when applicable), point address (when applicable), date and time, message type, thread, method and message.

Text File

Messages are recorded according to the Logging level of the channel.

The log folder has a subfolder for each channel and node that was initialized. The root is the `Logs\Drivers\` folder of the solution.

The file name format is `Log-DAY-MONTH-YEAR.log`.

A new file starts each day. When the file reaches the Log file size, the connector copies it to a file with the suffix .1 and starts a new file. If the size is reached again on the same day, the new copy replaces the previous one. The Log files option limits how many files are kept: with 30 files of 35 MB, for example, the logs of each node use up to about 1050 MB of disk.

The message format is: point address (when applicable), date and time, message type, thread, method and message.

Error and Quality Codes

Command Errors (CO)

The connector reads command error codes from the LastApplError attribute, which only command data classes have. Its value shows the status of the last command and is updated when command responses arrive. Points with Functional Constraint CO use these codes, and the Last command error tag of the node receives them.

Code	Cause	Description
0	UNKNOWN	Unknown.
1	NOT_SUPPORTED	Not supported.
2	BLOCKED_BY_SWITCHING_HIERARCHY	Not successful, because one of the downstream Loc switches has the value TRUE.
3	SELECT_FAILED	Canceled because the selection (Select service) failed.
4	INVALID_POSITION	The control action is aborted because the switch position is invalid.
5	POSITION_REACHED	The switch is already in the intended position.
6	PARAMETER_CHANGE_IN_EXECUTION	The control action is blocked because a parameter change is running.
7	STEP_LIMIT	The control action is blocked because the tap changer has reached the limit EndPosR or EndPosL.
8	BLOCKED_BY_MODE	The control action is blocked because the LN is in a mode (Mod) that allows no switching.
9	BLOCKED_BY_PROCESS	The control action is blocked by an external event at process level that prevents a successful operation.
10	BLOCKED_BY_INTERLOCKING	The control action is blocked by the interlocking of switching devices.
11	BLOCKED_BY_SYNCHROCHECK	The control action with synchrocheck is aborted because the time limit was exceeded without the synchronism condition.
12	COMMAND_ALREADY_IN_EXECUTION	The Select or Cancel service is rejected because a control action is already running.
13	BLOCKED_BY_HEALTH	The control action is blocked by an internal event that prevents a successful operation (Health).
14	1_OF_N_CONTROL	The control action is blocked because another control action in the same domain (for example, the substation) is already running.
15	ABORTION_BY_CANCEL	The control action is aborted by the Cancel service.
16	TIME_LIMIT_OVER	The control action is terminated because a time limit was exceeded.
17	ABORTION_BY_TRIP	The control action is aborted by a trip.
18	OBJECT_NOT_SELECTED	The control action is rejected because the control object was not selected.
19	OBJECT_ALREADY_SELECTED	The Select action is not run because the object is already selected.
20	NO_ACCESS_AUTHORITY	The control action is blocked because of missing access authority.
21	ENDED_WITH_OVERSHOOT	The control action ran, but the end position overshot.

22	ABORTION_DUE_TO_DEVIATION	The control action is aborted because of a deviation between the command value and the measured value.
23	ABORTION_BY_COMMUNICATION_LOSS	The control action is aborted because the connection with the client that issued it was lost.
24	ABORTION_BY_COMMAND	The control action is blocked because the data attribute CmdBlk.stVal is TRUE.
25	NONE	The command was not successful, for an unknown cause.
26	INCONSISTENT_PARAMETERS	The parameters of successive control services are not consistent, for example the ctlNum of the Select and the Operate services differ.
27	LOCKED_BY_OTHER_CLIENT	Another client has already reserved the object.
99	CONTROL_MODEL_STATUS_ONLY	The object is not controllable: only the services for a status object are supported, and the attribute ctlVal does not exist.

Qualities

The connector reports quality with the OPC (Open Platform Communications) quality codes. The table below maps the IEC 61850 qualities to the OPC codes.

IEC 61850 Quality	OPC Code	OPC Name	Description
Validity Invalid, Detail Overflow	0	Bad [Non-Specific]	The value is bad, with no specific reason known.
Config Error	4	Bad [Configuration Error]	There is a server-specific problem with the configuration, for example the item was deleted from the configuration.
	8	Bad [Not Connected]	The input must be logically connected to a source but is not, so no value is available.
Detail Failure	12	Bad [Device Failure]	A device failure was detected.
Time Quality (Clock Failure, Clock Not Synchronized)	16	Bad [Sensor Failure]	A sensor failure was detected.
	20	Bad [Last Known Value]	Communication failed, but the last known value is available.
	24	Bad [Communication Failure]	Communication failed, and no last known value is available.
	28	Bad [Out of Service]	The item is off scan, locked or inactive.
	32	Bad [Waiting For Initial Data]	The source has not yet provided a first value for the item.
Validity Questionable	64	Uncertain [Non-Specific]	The value is uncertain, with no specific reason.
Detail Old Data, Operator Blocked	68	Uncertain [Last Usable]	The source stopped updating the value, so the value is stale.
Detail Out of Range, Detail Bad Reference, Detail Oscillatory, Detail Inconsistent, Detail Inaccurate	80	Uncertain [Sensor Not Accurate]	The value is at a sensor limit, or the sensor is known to be out of calibration.
	84	Uncertain [EU Exceeded]	The value is outside the limits defined for the parameter.
	88	Uncertain [Sub-Normal]	The value comes from several sources and has fewer good sources than required.
Validity Good, Validity Test	192	Good [Non-Specific]	The value is good, with no special conditions.
Source Substituted	216	Good [Local Override]	The value was overridden, typically with a manually entered value.

Communication failure: when the connector has connected to the equipment and the communication then fails, the quality of the points changes to 24, Bad [Communication Failure]. The value and timestamp of the points do not change. If the connector never connected to the equipment, this is not a communication failure, and the quality of the points does not change.

In this section...