15.3 IEC 61850 Client

WCC Lite can be used as a master station to collect data from IEC 61850 compatible server devices such as protection relays. As relays require fast, secure and responsive interfaces, WCC Lite can be considered as a valid option. For additional security a user can use encrypted transmission (TLS) or set up a password.

> ℹ️ As TCP (TLS) connection can encounter issues and break, automatic reconnection is implemented. After every failed reconnection attempt the fallback delay is doubled starting from 1 second up until 32 seconds. After that connection reestablishment will be attempted every 32 seconds until a successful connection.

Acquiring data via report control blocks

As per IEC 61850 standard, the report control block controls the procedures that are required for reporting values of data objects from one or more logical nodes to one client. Automatic reporting enables data servers (slave devices) to only send data on its (or its quality) change, thus saving network bandwith. Instances of report control blocks are configured in the server at configuration time.

Report control blocks send information that is defined in their respective datasets. Dataset is a set of data elements grouped to represent some data group. For example, it is a common practice to group measurements and events into different groups.

A server restricts access to an instance of a report control block to one client at a time. That client exclusively shall own that instance and shall receive reports from that instance of report control blocks. There are two classes of report control blocks defined, each with a slightly different behaviour:

- buffered-report-control-block (BRCB) - internal events (caused by trigger options data-change, quality-change, and data-update) issue immediate sending of reports or buffer the events (to some practical limit) for transmission, such that values of data object are not lost due to transport flow control constraints or loss of connection. BRCB provides the sequence-of-events (SOE) functionality;
- unbuffered-report-control-block (URCB) - internal events (caused by trigger options data-change, quality-change, and data-update) issue immediate sending of reports on a best efforts basis. If no association exists, or if the transport data flow is not fast enough to support it, events may be lost.

Buffered report control blocks are therefore useful to keep event data, for example, keeping the last known state of a relay switch where a loss of information might lead to a confusion and even financial losses. Unbuffered report control blocks are particularly useful for data which is useful only momentarily, e.g. measurements of voltages, current or power. This information can change frequently and old measurements might not reflect the real state of a substation.

To allow multiple clients to receive the same values of data object, multiple instances of the report control classes shall be made available.

Buffered report control blocks are usually configured to be used by a specific client implementing a well-defined functionality, for example, a SCADA master. The client may know the ObjectReference of the BRCB by configuration or by the use of a naming convention.

Parsing of report control blocks is based on types of Common Data Class (CDC). Some of these types can have more then one data point of interest. Table below shows what data attributes are supported from various Common Data Classes. To select which data attribute should be used a `da_value` column should be filled with a data attribute name. Common Data Classes consist of data attributes with different Functional Constraints therefore to get the status points of interest correctly the user must fill in a correct value in `da_fc` column.

IEC 61850 Client supported data attributes:

Common Data Class	Function Constraint	Data attributes
SPS DPS INS ENS	ST	stVal
ACT	ST	general phsA phsB phsC neut
ACD	ST	general dirGeneral phsA dirPhsA phsB dirPhsB phsC dirPhsC neut dirNeut

MV	MX	instMag mag
CMV	MX	instCVal cVal
SAV	MX	instMag
SPC DPC INC ENC	ST	stVal
BSC ISC	ST	valWTr
APC BAC	MX	mxVal

Some of data attributes are structures themselves, for example, `mag` attribute is a struct that can hold integer or float values. To select a fitting attribute the user should extend `da_value` parameter with additional attributes, for example, if float magnitude value is to be selected from MV Common Data Class, `da_value` column should be filled with `mag.f` value; if the user intends `cVal` magnitude value in float format from CMV Common Data Class, `da_value` should be filled with `cVal.mag.f` value. See IEC 61850-7-3 for more information about Common Data Classes.

To ensure the integrity of configuration, WCC Lite has additional checks implemented at configuration time. If report control block (or its dataset) with a predefined ObjectReference doesn't exist, it is considered that IEC 61850 Client has not been configured properly or configuration has been changed in either of IEC 61850 devices and cannot be matched, therefore should be considered invalid.

Number Types

IEC 61580 has a distinct number_type field when compared to other protocols.

number_type
BOOLEAN
INT8
INT16
INT32
INT64
INT128
INT8U
INT24U
INT32U
FLOAT32
FLOAT64
ENUMERATED
OCTET STRING 6
OCTET STRING 8
OCTET STRING 64
VISIBLE STRING 32
VISIBLE STRING 64

VISIBLE STRING 65
VISIBLE STRING 129
UNICODE STRING 255
TIMESTAMP
QUALITY
CHECK
CODEDENUM
GENERIC BITSTRING
CONSTRUCTED
ENTRY TIME
PHYCOMADDR
CURRENCY
OPTFLDS
TRGOPS

Controlling remote equipment via commands

The control model provides a specific way to change the state of internal and external processes by a client. The control model can only be applied to data object instances of a controllable Common Data Class (CDC) and whose ctlModel DataAttribute is not set to status - only. Such data objects can be referred to as control objects. If controls are enabled in a IEC 61850 Server device the user can configure controls by filling control_model column in Excel configuration with a control model (*direct-with-normal-security, sbo-with-normal-security, direct-with-enhanced-security, sbo-with-enhanced-security*) as well as setting functional constraint in `da_fc` column to CO.

Depending on the application, different behaviours of a control object shall be used. Therefore, different state machines are defined. Four cases are defined:

- **Case 1**: Direct control with normal security (direct-operate);
- **Case 2**: SBO control with normal security (operate-once or operate-many);
- **Case 3**: Direct control with enhanced security (direct-operate);
- **Case 4**: SBO control with enhanced security (operate-once or operate-many).

IEC 61850 standard enables the user to plan command transmission in advance - set the timer when the command should be issued. However, as this possibility is rarely used in practice, it is not implemented as of version v1.5.0. All issued commands are executed immediately.

For more information on control class model, please consult IEC 61850-7-2 standard.

If ctlModel is read-only, messages from internal database will be ignored for this point, otherwise a subscribe callback will be launched to handle commands as soon as they are sent. If CDC of a signal does not have means of control, ctlModel parameter is ignored.

Originator identification can be attached to a station so that replies to command requests could be forwarded to only one device. To use this functionality a user should select an origin identificator by filling value in Excel configuration, originator column. Originator category is always enforced to tell that <u>remote control</u> command is issued.

Configuring datapoints

To use IEC 61850 Client in WCC Lite, it has to be configured via an Excel configuration. This configuration contains two Excel sheets where parameters have to be filled in - Devices and Signals tables.

Table IEC 61850 Client parameters for *Devices* tab

Parameter	Type	Description	Required	Default value (when not	Range

Parameter	Type	Description	Required	Default value (when not specified)	Range	
					Min	Max
name	string	User-friendly name for a device	Yes			
description	string	Description of a device	No			
device_alias	string	Alphanumeric string to identify a device	Yes			
enable	boolean	Enabling/disabling of a device	No	1	0	1
protocol	string	Protocol to be used	Yes		IEC 61850 Client	
tls	string	Selecting if TLS should be used	No	0	0	1
ip	string (IP address format)	IP address of server device	Yes	0.0.0.0		
port	integer	TCP communication port	Yes	102		
tls_local_certificate	string	Local certificate for TLS connection	Yes (for TLS)			
tls_peer_certificate	string	Certificate authority file for TLS connection	Yes (for TLS)			
tls_private_key	string	File consisting of private key for TLS connection	Yes (for TLS)			
event_history_size	integer	Event log size	No			
ied_name	string	Name of an Intelligent Electronic Device	Yes			
authorization	string	Authorization type	No		password	
password	string	Authorization password for server device	No			
originator	string	Origin identificator for device	No			

Table IEC 61850 Client parameters for *Signals* tab

Parameter	Type	Description	Required	Default value (when not specified)	Range	
					Min	Max
signal_name	string	User-friendly signal name	Yes			
device_alias	string	Device alias from a Devices tab	Yes			
signal_alias	string	Unique alphanumeric name of the signal to be used	Yes			
enable	boolean	Enabling/disabling of an individual signal	No	1	0	1
log	boolean	Allow signal to be logged. If **log is 0 signal** will not be logged. If **log is more than 0** signal will be logged	No	0		

number_type	string	Number format type	Yes			
ld_instance	string	Instance of a logical device	Yes			
ln_class	string	Logical node class type	Yes			
ln_instance	integer	Instance of a logical node	No			
ln_prefix	string	Prefix of logical node string	No			
cdc	string	Common Data Class (CDC) name	Yes		SPS, DPS, INS, ENS, ACT, ACD, MV, CMV, SAV, SPC, DPC, INC, ENC, BSC, ISC, APC, BAC	
data_object	string	Name of data object in dataset	Yes			
da_value	string	Name of a data attribute value node	Yes			
da_fc	string	Functional constrain for data object	Yes		ST,MX, CO, SP	
control_model	string	Model of output control	No	status-only	status-only, direct-with-normal-security, sbo-with-normal-security, direct-with-enhanced-security, sbo-with-enhanced-security	
dataset	string	Full object reference of a dataset	Yes			
report_control_block	string	Full object reference of a report control block	Yes			
intgPd	integer	Integrity period in milliseconds	No	0		

> ℹ️ It should be noted that ACT and ACD messages can only be parsed from report if either only 'general' attribute or all attributes attached to all three phases and neutral can be found in report

IEC 61850 Client has an additional signal which can be configured to show communication status. It is used to indicate if the server device has disconnected from client (WCC Lite). To configure such signal, two columns should be filled with particular values. To a newly created additional signal one should make `job_todo` equal to device_status and `tag_job_todo` equal to communication_status. Communication error status is set after a disconnection of a server device.

Debugging a IEC 61850 Client application

If configuration for IEC 61850 Client is set up, handler for protocol will start automatically. If configuration is missing or contains errors, protocol will not start. It is done intentionally to decrease unnecessary memory usage.

IEC 61850 Client command line debugging options

`iec61850-client`

```
 -h [ —help ] Show help message
 -c [—config] arg Configuration file location
 -V [—version] Show version
 -d [—debug] arg Set debugging level
 -r [—redis] Show Redis messages
 -C [—commands] Show command messages
 -D [—datasets] Show dataset messages
 —report Show report messages
 -R [—readyfile] arg Ready notification file
```

⚠ If IEC 61850 Client does not work properly (e.g. no communication between devices, data is corrupted, etc.), a user can launch a debug session from command line interface and find out why link is not functioning properly.

ℹ To launch a debugging session, a user should stop `iec61850-client` process and run `iec61850-client` command with respective flags as was shown above.