IEC 61850 interoperability with IEC 104

IEC 61850 Server

WCC Lite can act as a IEC 61850 server to serve data to remote SCADA systems. For example, WCC Lite can be used to acquire data from various protocols (Modbus, IEC 60870-5-103, etc.), this data can be redirected and propagated further to a single or multiple IEC 61850 clients. IEC 61850 Server supports TCP and TLS connection types. TCP connection can be secured with password authentication.

Commands

WCC Lite **IEC 61850 Server** implementation defines four command types which are described by their control model:

- **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).

Normal security commands are considered for execution if the command signal is found in Excel configuration. There aren't any additional checks in command execution in any master protocol.

Enhanced security commands need feedback from master protocol to either to succeed or fail. If feedback is not received within **command_ack_timeout_ms** timeframe, the command is considered as failed.

Command value attributes (e.g. stVal) must be updated separately (if they need to be updated).

> ℹ When using SBO commands, select is not routed to master protocol and select logic is performed only in IEC 61850 Server protocol.

IEC 61850 Client

WCC Lite supports IEC 61850 Client command functionality that is used to control server devices such as protection relays. As relays require fast, secure and responsive interfaces, WCC Lite can be considered as a valid option.

Supported commands

Currently WCC Lite supports three types of commands:

- setVal command;
- setMag.f command;
- Oper.ctlVal commad.

If configured all commands will be added to excel using WCC-Utility.

How commands function

ctlModel	Description
`status-only` (0)	Signal cannot be controlled
`direct-with-normal-security` (1)	Direct execution of a command
`sbo-with-normal-security` (2)	Command is selected and then executed
`direct-with-enhanced-security` (3)	Direct execution with a force wait of command termination
`sbo-with-enhanced-security` (4)	Command is selected and then executed; waiting for command termination

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

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** and **sbo-with-enhanced-security** as well as setting functional constraint in `da_fc` column to CO.

Command "direct-with-normal-security"

As the IEC 61850 protocol states `direct-with-normal-security` command simply executes a command directly without any additional selection or execution logic. This is the most basic use of commands. Does not contain any **command termination** logic.

Provided below is command `direct-with-normal-security` standard logic of successful command and failed command:
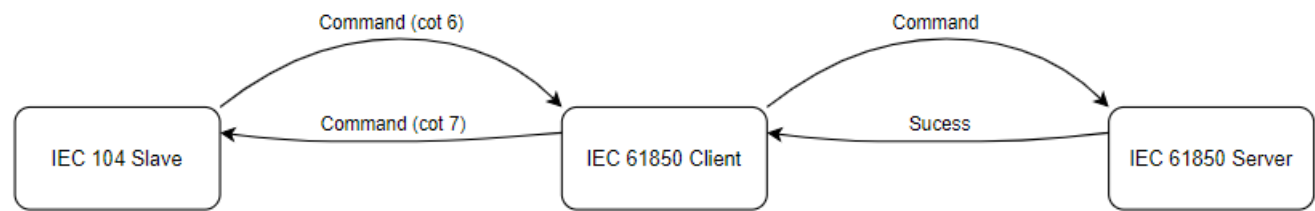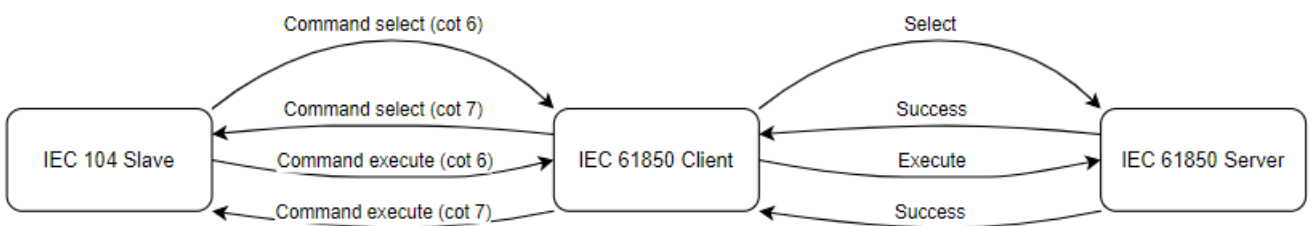

Successful command logic

Failed command logic

## Command "sbo-with-normal-security"

As the IEC 61850 protocol states `sbo-with-normal-security` command uses `select` and `execute` command logic. First, the command is selected, and then the execute command is sent to the server. Does not contain any **command termination** logic.

Provided below is command `sbo-with-normal-security` standard success and failure logic:
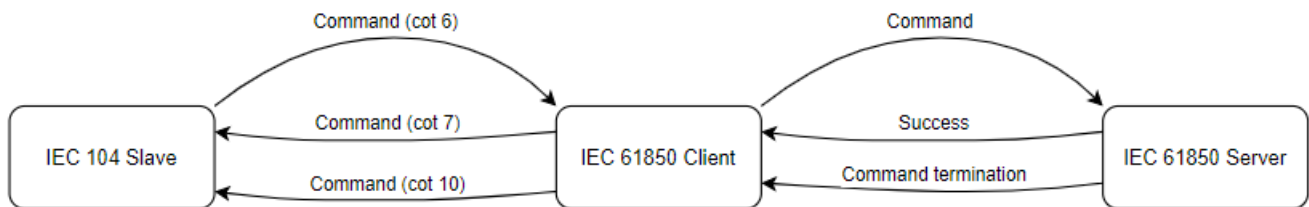

Successful command logic
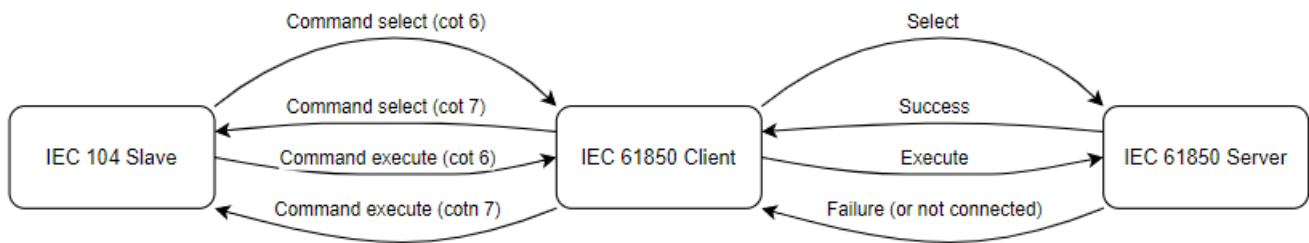
Failed command logic

Regarding failure, if server fails to select cotn 7 is returned the same way if an execute fails.
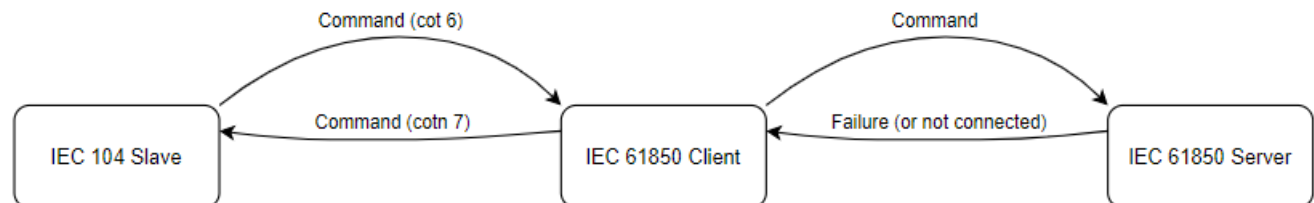
Command "direct-with-enhanced-security"

As the IEC 61850 protocol states `direct-with-enhanced-security` command uses `execute` command logic. Contain **command termination**. This means that command awaits for termination message. The execute command is sent to the server, and the command waits for a termination message from the server. If the termination message is received, the command is considered successful, and if not, the command is considered failed.

Provided below is command `direct-with-enhanced-security` standard success and failure logic:

Successful command logic

Failed command logic

In case of failure, no command termination is additionally provided.

Command "sbo-with-enhanced-security"

As the IEC 61850 protocol states `sbo-with-normal-security` command uses `select` and `execute` command logic. Contains **command termination**. This command is similar to the sbo-with-normal-security command, but it also responds with a termination message. If the command is successful, the termination message is sent to the client, and if not, the cotn 7 is returned.

Provided below is command `sbo-with-enhanced-security` standard success and failure logic:

Successful command logic

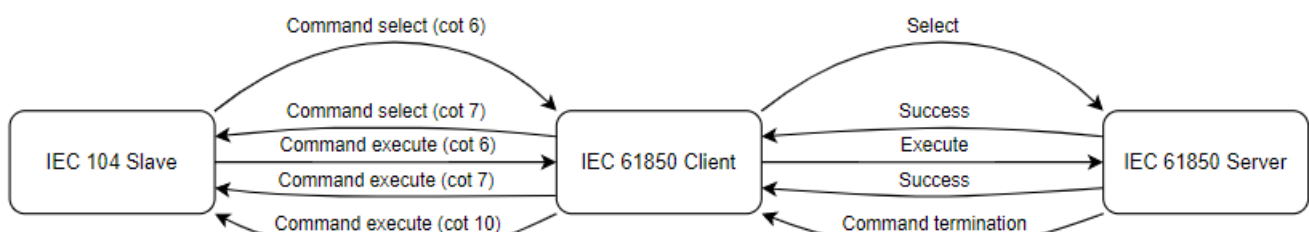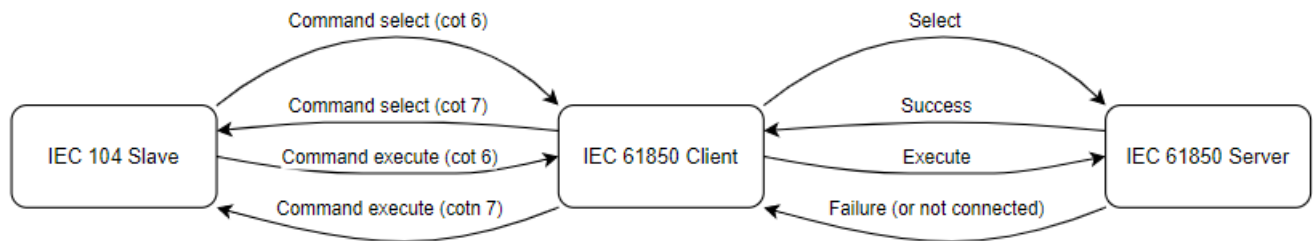Failed command logic

In the case of failure, `sbo` command acts the same way as `direct` command. It does not send command termination, only cotn 7.

Basic protocol functionality

The server (controlled station) delivers various data to the client.
• Data object values reported upon changes
• Data object values reported cyclically
• Responses to control commands
• Responses to read requests

To enable interoperability between IEC 61850 and IEC 60870-5-104, mapping between the two protocols is necessary. This mapping involves defining which data objects from one protocol correspond to which data objects in the other protocol.

name	description	device_alias	protocol	bind_address	ied_name	access_point	port	asdu_size	cot_size	ioa_size	rwt	swt	t1	t2	t3	time_sync	sp_time	dp_time	me_time	message_size	cache_size	host	auth	model_filename
IEC 61850 Client	IEC 61850 Client	iec_61850_client	iec 61850 client	0.0.0.0	WCCLITE	LD0	102															192.168.67.113	NONE	WCC
SCADA		SCADA_104	iec 60870-5-104 slave	0.0.0.0			2404	2	2	3	8	12	15	10	20	0	1	1	1	253	100	192.168.1.203		

Excel configuration Devices sheet

device_alias	signal_name	signal_alias	source_device_alias	source_signal_alias	log	gi	common_address	info_address	data_type	select_ms	ld_instance	ln_class	ln_instance	ln_prefix	cdc	data_object	da_fc	number_type	da_value	control_model	report_control_block	dataset
iec_61850_client	LD0__GGIO_2_SPC1_Oper.ctlVal	LD0__GGIO_2_SPC1_Oper.ctlVal	SCADA_104	CMD2							LD0	GGIO	2		SPC	SPC1	CO	BOOLEAN	Oper.ctlVal	direct-with-normal-security	WCCLITELD0/LLN0.BR.Events_SP1_RCB04	WCCLITELD0/LLN0.Events_SP1
iec_61850_client	LD0__GGIO_2_SPC2_Oper.ctlVal	LD0__GGIO_2_SPC2_Oper.ctlVal	SCADA_104	CMD3							LD0	GGIO	2		SPC	SPC2	CO	BOOLEAN	Oper.ctlVal	direct-with-enhanced-security	WCCLITELD0/LLN0.BR.Events_SP1_RCB04	WCCLITELD0/LLN0.Events_SP1
iec_61850_client	LD0__GGIO_4_DPC1_Oper.ctlVal	LD0__GGIO_4_DPC1_Oper.ctlVal	SCADA_104	CMD4							LD0	GGIO	4		DPC	DPC1	CO	BOOLEAN	Oper.ctlVal	sbo-with-normal-security	WCCLITELD0/LLN0.BR.Events_SP2_RCB04	WCCLITELD0/LLN0.Events_SP2
iec_61850_client	LD0__GGIO_4_DPC2_Oper.ctlVal	LD0__GGIO_4_DPC2_Oper.ctlVal	SCADA_104	CMD5							LD0	GGIO	4		DPC	DPC2	CO	BOOLEAN	Oper.ctlVal	sbo-with-enhanced-security	WCCLITELD0/LLN0.BR.Events_SP2_RCB04	WCCLITELD0/LLN0.Events_SP2
SCADA_104	CMD2	CMD2	iec_61850_client	LD0__GGIO_2_SPC1_Oper.ctlVal	1	1	1	2	45	3000												
SCADA_104	CMD3	CMD3	iec_61850_client	LD0__GGIO_2_SPC2_Oper.ctlVal	1	1	1	3	45	3000												
SCADA_104	CMD4	CMD4	iec_61850_client	LD0__GGIO_4_DPC1_Oper.ctlVal	1	0	1	4	46	3000												
SCADA_104	CMD5	CMD5	iec_61850_client	LD0__GGIO_4_DPC2_Oper.ctlVal	1	0	1	5	46	3000												

Excel configuration Signals sheet

The client can at any time request the present process data values by issuing interrogation commands. The command may be a general interrogation (GI) request, where all data objects with GI indication configured "1" are reported.

device_alias	signal_name	signal_alias	source_device_alias	source_signal_alias	log	gi	common_address	info_address	data_type	select_ms	ld_instance	ln_class	ln_instance	ln_prefix	cdc	data_object	da_fc	number_type	da_value
iec_61850_client	LD0__GGIO_2_SPC1_Oper.ctlVal	LD0__GGIO_2_SPC1_Oper.ctlVal	SCADA_104	CMD2							LD0	GGIO	2		SPC	SPC1	CO	BOOLEAN	Oper.ctlVal
iec_61850_client	LD0__GGIO_2_SPC2_Oper.ctlVal	LD0__GGIO_2_SPC2_Oper.ctlVal	SCADA_104	CMD3							LD0	GGIO	2		SPC	SPC2	CO	BOOLEAN	Oper.ctlVal
iec_61850_client	LD0__GGIO_4_DPC1_Oper.ctlVal	LD0__GGIO_4_DPC1_Oper.ctlVal	SCADA_104	CMD4							LD0	GGIO	4		DPC	DPC1	CO	BOOLEAN	Oper.ctlVal
iec_61850_client	LD0__GGIO_4_DPC2_Oper.ctlVal	LD0__GGIO_4_DPC2_Oper.ctlVal	SCADA_104	CMD5							LD0	GGIO	4		DPC	DPC2	CO	BOOLEAN	Oper.ctlVal
SCADA_104	CMD2	CMD2	iec_61850_client	LD0__GGIO_2_SPC1_Oper.ctlVal	1	1	1	2	45	3000									
SCADA_104	CMD3	CMD3	iec_61850_client	LD0__GGIO_2_SPC2_Oper.ctlVal	1	1	1	3	45	3000									
SCADA_104	CMD4	CMD4	iec_61850_client	LD0__GGIO_4_DPC1_Oper.ctlVal	1	0	1	4	46	3000									
SCADA_104	CMD5	CMD5	iec_61850_client	LD0__GGIO_4_DPC2_Oper.ctlVal	1	0	1	5	46	3000									

Signals sheet

IEC 60870-5-104 data objects

Single-point information
Single-point information is derived from several IEC 61850 boolean data attributes
• SPS.stVal
• SPC.stVal

Type	ASDU		
GI	1	M_SP_NA_1	Single point
Event	30	M_SP_TB_1	Single point with CP56Time2a

Single-point information

Double-point information
Double-point information is derived from several IEC 61850 data attributes.
• DPS.stVal
• DPC.stVal

Type	ASDU		
GI	3	M_DP_NA_1	Double point
Event	31	M_DP_TB_1	Double point with CP56Time2a

Double-point information

Control operations

Single command

Single-command controls are performed towards SPC (controllable single point) IEC 61850 target objects. The command can be given with or without a time stamp (C_SC_NA_1, C_SC_TA_1). Only direct type operations are allowed.

Single command
Single-command control operations can be performed towards SPC (controllable single point) data class objects. Only direct controls are allowed.
• SPC.Oper.ctlVal

Type	ASDU		
Control	45	C_SC_NA_1	Single command
Control	58	C_SC_TA_1	Single command with CP56Time2a

Single command

device_alias	signal_name	signal_alias	source_device_alias	source_signal_alias	log	gi	common_address	info_address	data_type	select_ms	ld_instance	ln_class	ln_instance ln_prefix	cdc	data_object	da_fc	number_type	da_value
iec_61850_client	LD0__GGIO_2_SPC1_Oper.ctlVal	LD0__GGIO_2_SPC1_Oper.ctlVal	SCADA_104	CMD2							LD0	GGIO	2	SPC	SPC1	CO	BOOLEAN	Oper.ctlVal
iec_61850_client	LD0__GGIO_2_SPC2_Oper.ctlVal	LD0__GGIO_2_SPC2_Oper.ctlVal	SCADA_104	CMD3							LD0	GGIO	2	SPC	SPC2	CO	BOOLEAN	Oper.ctlVal
iec_61850_client	LD0__GGIO_4_DPC1_Oper.ctlVal	LD0__GGIO_4_DPC1_Oper.ctlVal	SCADA_104	CMD4							LD0	GGIO	4	DPC	DPC1	CO	BOOLEAN	Oper.ctlVal
iec_61850_client	LD0__GGIO_4_DPC2_Oper.ctlVal	LD0__GGIO_4_DPC2_Oper.ctlVal	SCADA_104	CMD5							LD0	GGIO	4	DPC	DPC2	CO	BOOLEAN	Oper.ctlVal
SCADA_104	CMD2	CMD2	iec_61850_client	LD0__GGIO_2_SPC1.ctlVal	1	1	1	2	45	3000								
SCADA_104	CMD3	CMD3	iec_61850_client	LD0__GGIO_2_SPC2.ctlVal	1	1	1	3	45	3000								
SCADA_104	CMD4	CMD4	iec_61850_client	LD0__GGIO_4_DPC1.ctlVal	1	0	1	4	46	3000								
SCADA_104	CMD5	CMD5	iec_61850_client	LD0__GGIO_4_DPC2.ctlVal	1	0	1	5	46	3000								

Double command

Double-command controls are performed towards DPC (controllable double point) IEC 61850 target objects, that is, circuit breakers and controllable disconnector objects. The command can be given with or without a time stamp (C_DC_NA_1, C_DC_TA_1). If time tagged commands are used, it is important to ensure the master and the relay times are synchronized.

Each double-point DPC object has two predefined IEC 60870-5-104 control objects: one intended for direct operation and the other one for select-execute (select-before-operate) operation.

Double command
Double-command control operations can be performed towards DPC (controllable double point) data class objects. Direct controls are always possible. Two-step select-execute controls are also possible if the target DPC object allows it. There are two different control objects available for the direct and select-execute alternatives.
• DPC.Oper.ctlVal

Type	ASDU		
Control	46	C_DC_NA_1	Double command
Control	59	C_DC_TA_1	Double command with CP56Time2a

Double command

Direct operation
Direct operation is always possible for the double command regardless of the control model (direct or SBO) configured for the target IEC 61850 DPC object. If the control model is SBO, the IEC 60870-5-104 stack automatically performs the two needed operations (select and operate) towards the DPC object.

Select-execute operation
A two-step select-and-execute operation is possible only if the target DPC object's control model is configured as select-before-operate (SBO). For most target DPC objects, the default control model setting mode is SBO. IEC 60870-5-104 selection timeout is defined by the protocol instance's Selection Timeout setting parameter. When a command is performed from the IEC 60870-5-104 instance, the selection timeout setting configured for the IEC 61850 DPC target object is overridden. Cause of transmission and selected status The relay's native IEC 61850 data model does not include any cause of transmission (COT) information data. Therefore, monitoring object transmissions from the IEC 60870-5-104 stack can only include the following cause of transmission values.
• 1 = Cyclical
• 3 = Spontaneous
• 20 = General interrogation
• 21...36 = Group 1...16 interrogation
The control command's response message returned to the controlling client includes COT value 11 = Remote command, but the controlled object value change in monitoring direction is always COT=3 (Spontaneous). While this information is not so important for the controlling client, it can be for another client in a multiple-client environment.