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 bandwidth. 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 behavior:

- 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 than 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.

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 behaviors 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 v1.8 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 identifier 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 specified)	Range	
					Min	Max
name	string	User-friendly name for a device	Yes			

Parameter	Type	Description	Required	Default value	Min	Max
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	
host	string (IP address format)	IP address of server device	Yes			
port	integer	TCP communication port	Yes	102		
auth	string	Authorization type	Yes		none, password, tls	
password	string	Authorization password for server device	Yes (for PASSWORD)			
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)			
ied_name	string	Name of an Intelligent Electronic Device	Yes			
originator	string	Origin identifier for device	No			
model_filename	string	Filename of client model uploaded to WCC (must contain .client extension)	Yes			

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		BOOLEAN, INT8, INT16, INT32, INT64, INT128, INT8U, INT24U, INT32U, FLOAT32, FLOAT64, ENUMERATED, OCTETSTRING6, OCTETSTRING8, OCTETSTRING64, VISIBLESTRING32, VISIBLESTRING64, VISIBLESTRING65, VISIBLESTRING129, VISIBLESTRING255, UNICODESTRING255, TIMESTAMP, QUALITY, CHECK, CODEDENUM, GENERICBITSTRING, CONSTRUCTED, ENTRYTIME, PHYCOMADDR, CURRENCY, OPTFLDS, TRGOPS
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, integer	Prefix of logical node string	No		
cdc	string	Common Data Class (CDC) name	Yes		SPS, DPS, INS, ENS, ACT, ACD, SEC, BCR, HST, VSS, MV, CMV, SAV, WYE, DEL, SEQ, HMV, HWYE, HDEL, SPC, DPC, INC, ENC, BSC, ISC, APC, BAC, SPG, ING, ENG, ORG, TSG, CUG, VSG, ASG, CURVE, CSG, DPL, LPL, CSD, UNDEF
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, SE
control_model	string	Model of output control	No	read-only	read-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	

> ℹ 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

Device status signals

IEC 61850 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 for IEC 61850 protocol, job_todo and tag_job_todo fields with string values are required. For IEC 61850 client required parameters for status signal will be: **signal_name, device_alias, signal_alias, number_type, job_todo** and **tag_job_todo**. Job_todo value must be *device_status* and for tag_job_todo there are 4 variations: communication_status, device_running, device_error, uknown_error. Each signal has 4 possible values and are based on the same logic. If signal returns value of 0, it means unknown error has appeared, 1 – device or protocol connection is on and working properly, 2 – device is off or protocol is disconnected, 3 – error or service is down.

Configuration

Configuration of IEC61850 Client for WCCLite is done via WCC Utility. Elseta WCC Utility has two IEC 61850 selections - IEC 61850 Config and IEC 61850 Excel:

- **IEC 61850 Config** is used to create a configuration model file, which IEC 61850 Client service will use to parse reports from the server.

- **IEC 61850 Excel** is used to generate excel configuration file which in turn will be used to generated configuration .json via excel-utility.
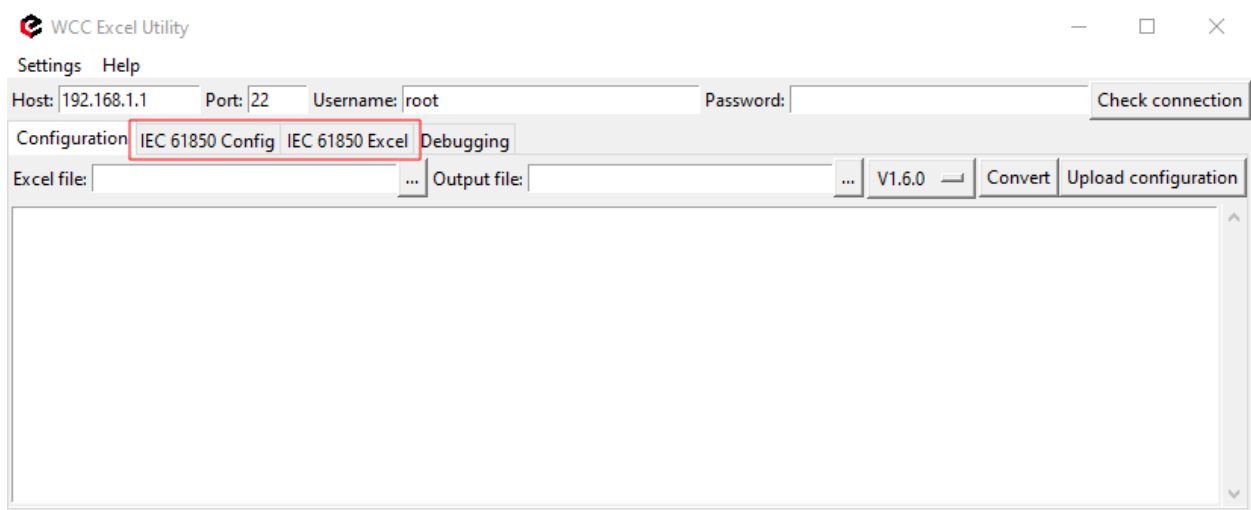
WCC Utility with IEC61850 selections

Generate model file

To generate IEC 61850 Client model file select "Client" in drop down selection tab. Then select where to output the generated model and upload file with extensions .icd, .scd or .cid.
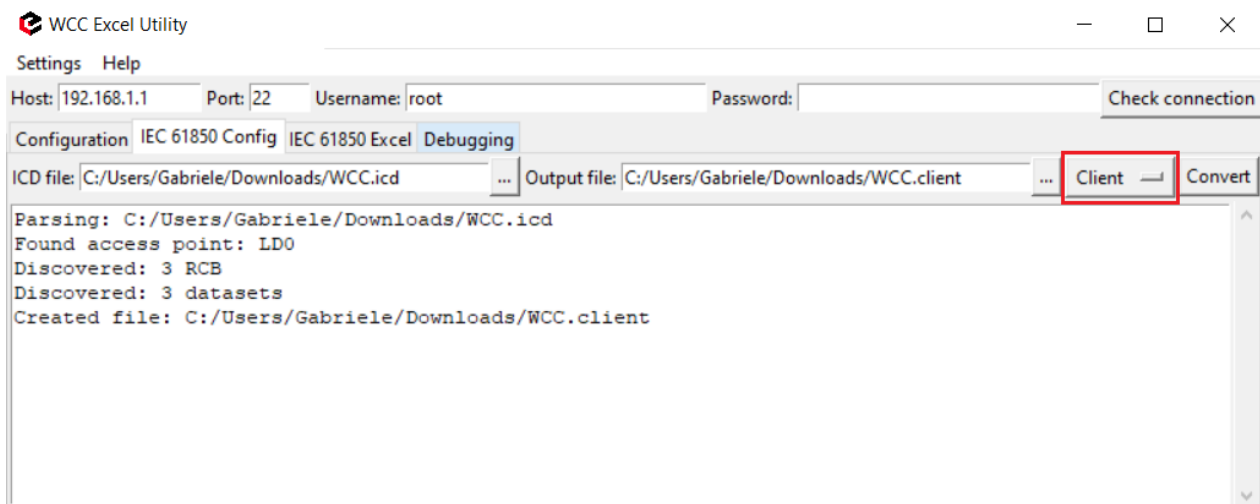
Generate IEC 61850 Client model file

Generate excel file

To generate IEC 61850 Client excel file select "Client" in drop down selection tab. Then select where to output the generated model upload file with extensions .icd, .scd or .cid.
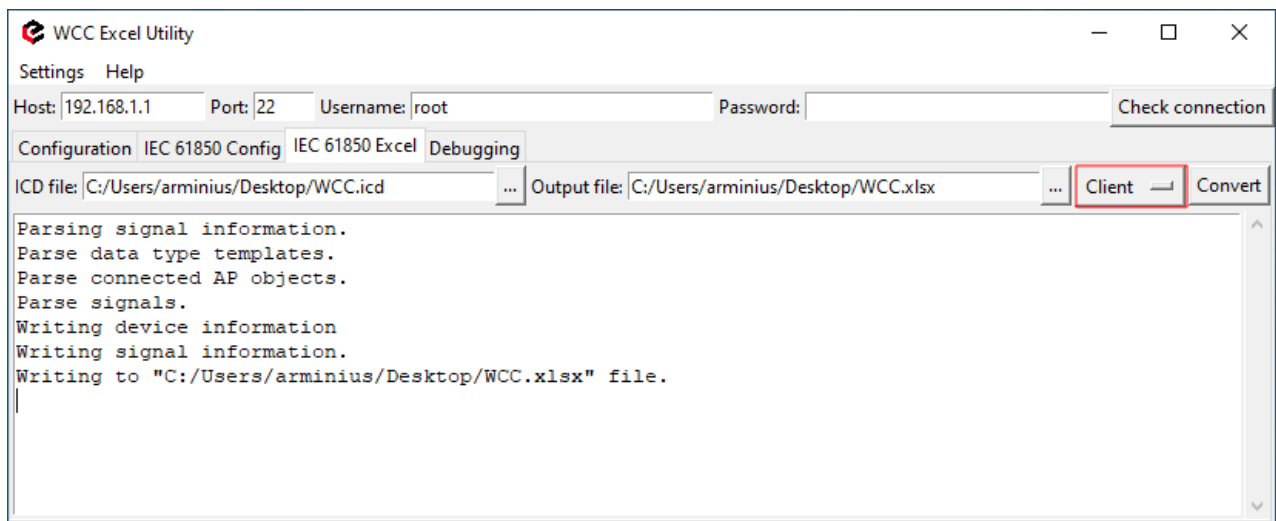
Generate IEC 61850 Client excel file

After generating excel file additional configuration information must be written in the devices sheet:

- A valid host ip address must be provided.
- An authorization method must be provided (if it is a complex authorization method, additional parameters might be required).
- Model filename must be provided. The model filename must be exactly the same as that was generated one step earlier (Model filename can include extension, but it is not mandatory).

I	J	K
host	authorization	model_filename
192.168.122.146	none	WCC

Excel configuration (Devices sheet)

In the signals sheet, signals which are not used or needed can be removed. Their information might be modified as well.

	A	B	C	D	E	F	G	H	I	J	K
1	device_alias	signal_name	signal_alias	ld_instance	ln_class	ln_instance	ln_prefix	cdc	data_object	da_fc	number_type
2	iec 61850 client	LD0__GGIO_1_SPS1_stVal	LD0__GGIO_1_SPS1_stVal	LD0	GGIO	1		SPS	SPS1	ST	BOOLEAN
3	iec 61850 client	LD0__GGIO_1_SPS2_stVal	LD0__GGIO_1_SPS2_stVal	LD0	GGIO	1		SPS	SPS2	ST	BOOLEAN
4	iec 61850 client	LD0__GGIO_2_SPC1_origin.orCat	LD0__GGIO_2_SPC1_origin.orCat	LD0	GGIO	2		SPC	SPC1	ST	INT8
5	iec 61850 client	LD0__GGIO_2_SPC1_origin.orIdent	LD0__GGIO_2_SPC1_origin.orIdent	LD0	GGIO	2		SPC	SPC1	ST	OCTET STRING 6
6	iec 61850 client	LD0__GGIO_2_SPC1_ctlNum	LD0__GGIO_2_SPC1_ctlNum	LD0	GGIO	2		SPC	SPC1	ST	INT8U
7	iec 61850 client	LD0__GGIO_2_SPC1_stSeld	LD0__GGIO_2_SPC1_stSeld	LD0	GGIO	2		SPC	SPC1	ST	BOOLEAN
8	iec 61850 client	LD0__GGIO_2_SPC1_stVal	LD0__GGIO_2_SPC1_stVal	LD0	GGIO	2		SPC	SPC1	ST	BOOLEAN
9	iec 61850 client	LD0__GGIO_2_SPC1_Oper.ctlVal	LD0__GGIO_2_SPC1_Oper.ctlVal	LD0	GGIO	2		SPC	SPC1	CO	BOOLEAN
10	iec 61850 client	LD0__GGIO_2_SPC2_origin.orCat	LD0__GGIO_2_SPC2_origin.orCat	LD0	GGIO	2		SPC	SPC2	ST	INT8
11	iec 61850 client	LD0__GGIO_2_SPC2_origin.orIdent	LD0__GGIO_2_SPC2_origin.orIdent	LD0	GGIO	2		SPC	SPC2	ST	OCTET STRING 6
12	iec 61850 client	LD0__GGIO_2_SPC2_ctlNum	LD0__GGIO_2_SPC2_ctlNum	LD0	GGIO	2		SPC	SPC2	ST	INT8U
13	iec 61850 client	LD0__GGIO_2_SPC2_stSeld	LD0__GGIO_2_SPC2_stSeld	LD0	GGIO	2		SPC	SPC2	ST	BOOLEAN
14	iec 61850 client	LD0__GGIO_2_SPC2_stVal	LD0__GGIO_2_SPC2_stVal	LD0	GGIO	2		SPC	SPC2	ST	BOOLEAN
15	iec 61850 client	LD0__GGIO_2_SPC2_Oper.ctlVal	LD0__GGIO_2_SPC2_Oper.ctlVal	LD0	GGIO	2		SPC	SPC2	CO	BOOLEAN
16	iec 61850 client	LD0__GGIO_3_DPS1_stVal	LD0__GGIO_3_DPS1_stVal	LD0	GGIO	3		DPS	DPS1	ST	CODEDENUM
17	iec 61850 client	LD0__GGIO_3_DPS2_stVal	LD0__GGIO_3_DPS2_stVal	LD0	GGIO	3		DPS	DPS2	ST	CODEDENUM
18	iec 61850 client	LD0__GGIO_4_DPC1_origin.orCat	LD0__GGIO_4_DPC1_origin.orCat	LD0	GGIO	4		DPC	DPC1	ST	INT8
19	iec 61850 client	LD0__GGIO_4_DPC1_origin.orIdent	LD0__GGIO_4_DPC1_origin.orIdent	LD0	GGIO	4		DPC	DPC1	ST	OCTET STRING 6
20	iec 61850 client	LD0__GGIO_4_DPC1_ctlNum	LD0__GGIO_4_DPC1_ctlNum	LD0	GGIO	4		DPC	DPC1	ST	INT8U
21	iec 61850 client	LD0__GGIO_4_DPC1_stSeld	LD0__GGIO_4_DPC1_stSeld	LD0	GGIO	4		DPC	DPC1	ST	BOOLEAN
22	iec 61850 client	LD0__GGIO_4_DPC1_stVal	LD0__GGIO_4_DPC1_stVal	LD0	GGIO	4		DPC	DPC1	ST	CODEDENUM
23	iec 61850 client	LD0__GGIO_4_DPC1_Oper.ctlVal	LD0__GGIO_4_DPC1_Oper.ctlVal	LD0	GGIO	4		DPC	DPC1	CO	BOOLEAN
24	iec 61850 client	LD0__GGIO_4_DPC2_origin.orCat	LD0__GGIO_4_DPC2_origin.orCat	LD0	GGIO	4		DPC	DPC2	ST	INT8
25	iec 61850 client	LD0__GGIO_4_DPC2_origin.orIdent	LD0__GGIO_4_DPC2_origin.orIdent	LD0	GGIO	4		DPC	DPC2	ST	OCTET STRING 6
26	iec 61850 client	LD0__GGIO_4_DPC2_ctlNum	LD0__GGIO_4_DPC2_ctlNum	LD0	GGIO	4		DPC	DPC2	ST	INT8U
27	iec 61850 client	LD0__GGIO_4_DPC2_stSeld	LD0__GGIO_4_DPC2_stSeld	LD0	GGIO	4		DPC	DPC2	ST	BOOLEAN
28	iec 61850 client	LD0__GGIO_4_DPC2_stVal	LD0__GGIO_4_DPC2_stVal	LD0	GGIO	4		DPC	DPC2	ST	CODEDENUM
29	iec 61850 client	LD0__GGIO_4_DPC2_Oper.ctlVal	LD0__GGIO_4_DPC2_Oper.ctlVal	LD0	GGIO	4		DPC	DPC2	CO	BOOLEAN
30	iec 61850 client	LD0__GGIO_5_AnIn1_mag.f	LD0__GGIO_5_AnIn1_mag.f	LD0	GGIO	5		MV	AnIn1	MX	FLOAT32
31	iec 61850 client	LD0__GGIO_5_AnIn2_mag.f	LD0__GGIO_5_AnIn2_mag.f	LD0	GGIO	5		MV	AnIn2	MX	FLOAT32

Signals sheet

Important! Information such as ld_instance and other data taken directly from SCD configuration files should not be modified, otherwise access to info of these reports can be broken.

Uploading configuration

First upload the model configuration file.

Uploading model configuration file

After uploading the model configuration file it should appear under *the DOWNLOAD CONFIGURATION* tab.

Uploaded IEC 6180 Client configuration file

Then upload the excel configuration (same as with every other protocol).

Uploading excel configuration

After successful configuration upload, both configurations should appear under *DOWNLOAD CONFIGURATION* tab. If any errors occur during excel upload, fix them along excel utility guidelines.

Uploaded configurations

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.

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

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