

How to Convert From Modbus TCP to IEC 61850 Using MGate 5119

Moxa Technical Support Team
support@moxa.com

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About Moxa

Moxa is a leading provider of edge connectivity, industrial computing, and network infrastructure solutions for enabling connectivity for the Industrial Internet of Things (IIoT). With over 30 years of industry experience, Moxa has connected more than 71 million devices worldwide and has a distribution and service network that reaches customers in more than 80 countries. Moxa delivers lasting business value by empowering industries with reliable networks and sincere service. Information about Moxa’s solutions is available at www.moxa.com.

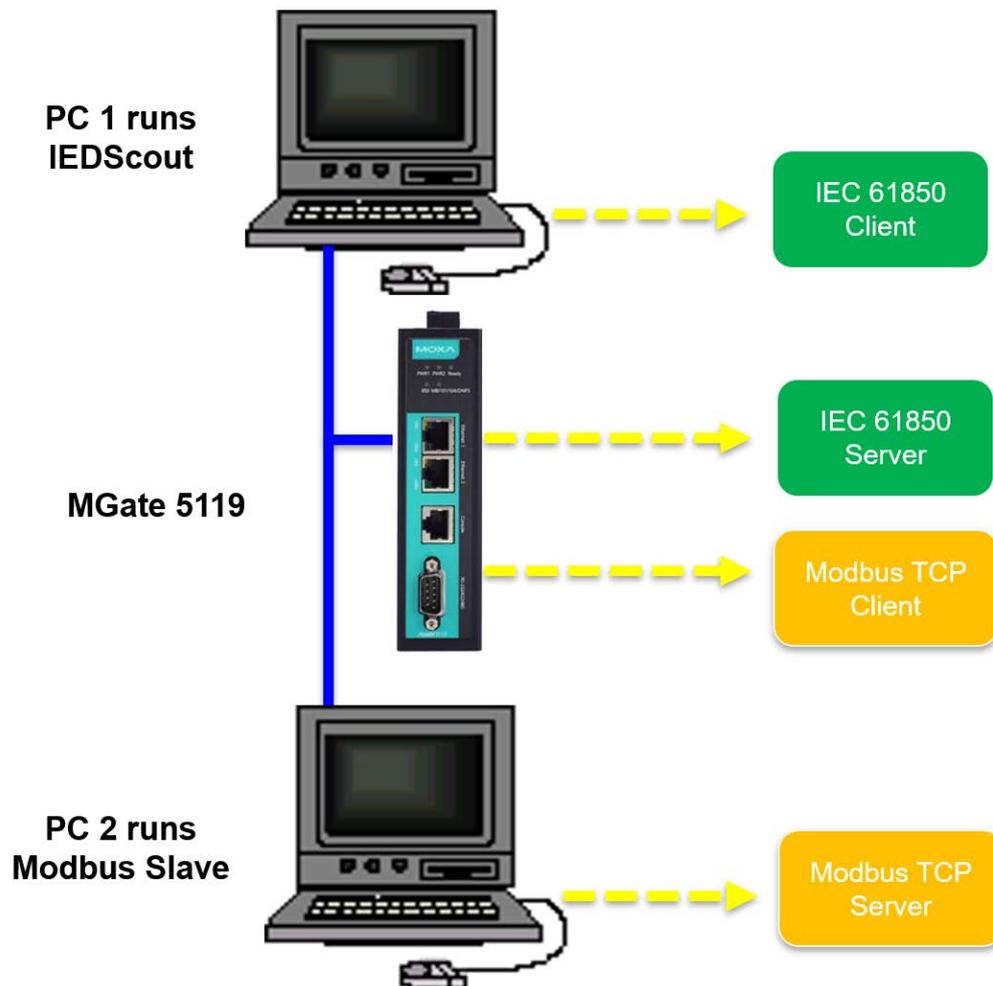
How to Contact Moxa

Tel: 1-714-528-6777
Fax: 1-714-528-6778



1 System Topology

In this technical note, we show how the MGate 5119 converts between an IEC 61850 client and Modbus TCP server. We use IEDScout (PC 1) as an IEC 61850 client and Modbus Slave (PC2) as the Modbus TCP server.



2 Protocol Simulators

2.1 IEDScout

[IEDScout](#) is an ideal tool for substation automation engineers working with IEC 61850 devices. IEDScout allows engineers to look inside the IED at its communication. All data modeled and exchanged becomes visible and accessible.

Download website: <https://www.omicronenergy.com/en/products/iedscout/>

2.2 Modbus Slave

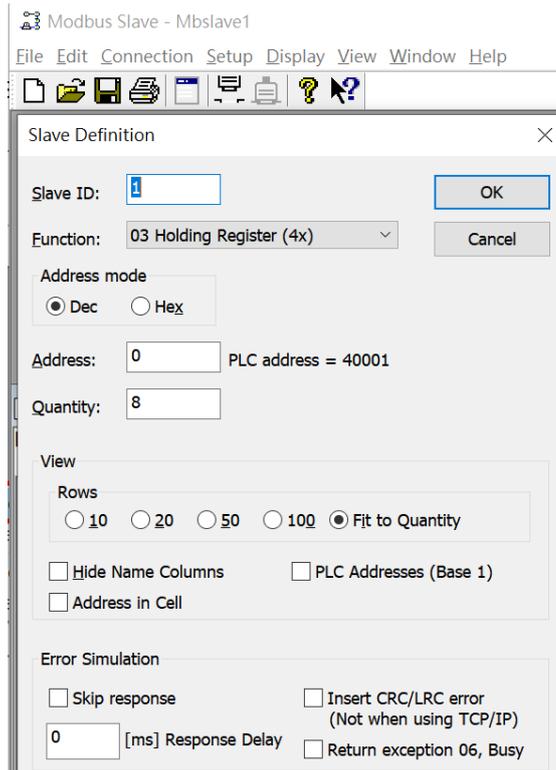
[Modbus Slave](#) is the very popular Modbus slave simulator to test and debug your Modbus devices. It supports Modbus RTU/ASCII and Modbus TCP/IP.

Download website: <http://www.modbustools.com/download.html>

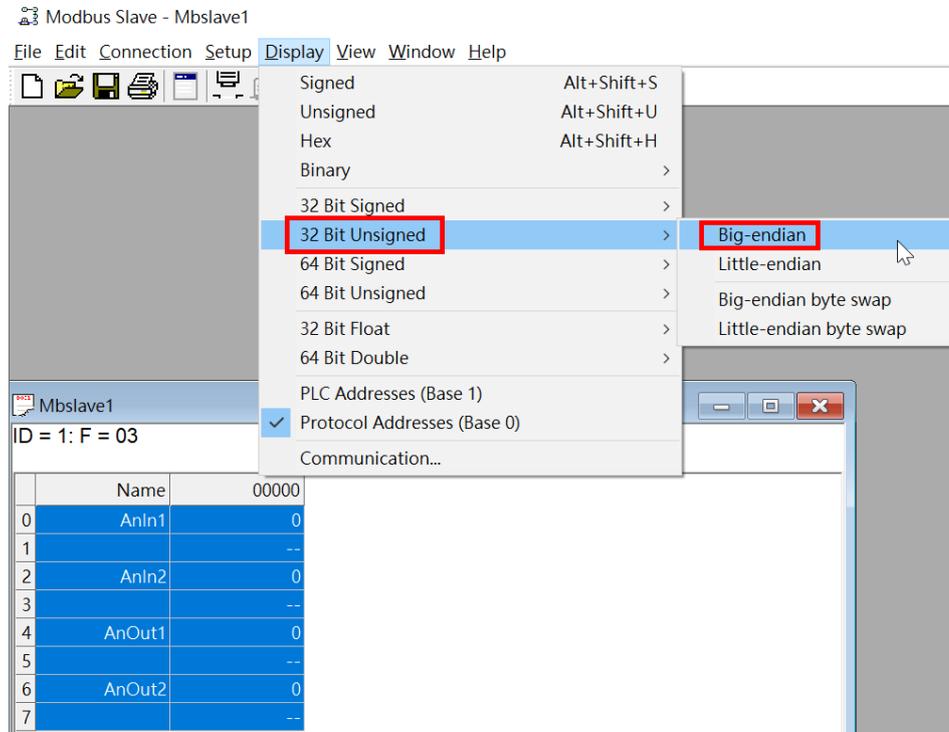
3 How to Simulate Modbus TCP Sever by Modbus Slave

After executing Modbus Slave, configure all related parameters in the **Slave Definition** window under the Setup tab:

- **Starting Address as 0**
- **Quantity as 8**



Then, set the **Display Format** as **32 Bit Unsigned** → **Big-endian** and configure their tag names as **AnIn1**, **AnIn2**, **AnOut1** and **AnOut2** respectively, as in the following figure.



4 How to Configure the MGate 5119

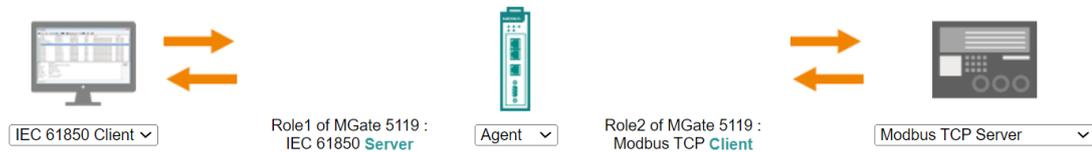
For the MGate 5119 settings, go to web console to configure. The setting steps are:

- Step 1. Select Protocols (Protocol Conversion)
- Step 2. Configure Protocol 2 (Modbus TCP Client Settings)
- Step 3. Configure Protocol 1 (IEC 61850 Sever Settings)
- Step 4. Map Tags

Step 1. Protocol Selection (Protocol Conversion)

We must configure each protocol’s role in the MGate 5119. In this demo, we want to bring a Modbus TCP server to an IEC 61850 network, so configure the settings as below. After protocol selection, the next step is to configure each role of the MGate.

⚙️ Protocol Conversion



Step 2. Configure Protocol 2 (Modbus TCP Client Settings)

In Client Settings, we use the default settings. For details, you can refer to the MGate 5119 User’s Manual.

Role	Client
Client Settings	
Initial delay	0 (0 - 30000 ms)
Max. retry	3 (0 - 5)
Response timeout	1000 (10 - 120000 ms)

This demo would like to monitor and control the Modbus slave device by the IEC 61850 client; and, therefore, configure the corresponding Modbus commands. We will create four commands: two for monitoring Analog Input data and two for controlling Analog Output data.

An example of the command settings for Analog Input is shown below:

Name
Slave IP address **Port**
Slave ID
Function
Trigger
Poll interval (100 - 1200000 ms)
Endian swap
Read starting address (0 - 65535)
Read quantity
Data type
Tags

Once tag count or data type is changed, related tags in the slave(server) will be deleted.



We input **Name** as **AnIn1**, input **Read quantity** as **2**, and **Data type** as **uint32** to create the **Tag** as **AnIn1**. Also, the **Endian Swap** should be configured as **Word** to meet the display style of the Modbus Slave data.

In this demo, we create the four Modbus commands as below:

Index	Name	Slave IP Address	Slave ID	Function	Address / Quantity	Trigger	Poll Interval	Endian Swap	Data Type
1	AnIn1	10.123.20.41 : 502	1	3	Read address 0, Quantity 2	Cyclic	1000	Word	uint32
2	AnIn2	10.123.20.41 : 502	1	3	Read address 2, Quantity 2	Cyclic	1000	Word	uint32
3	AnOut1	10.123.20.41 : 502	1	16	Write address 4, Quantity 2	Data Change	N/A	Word	uint32
4	AnOut2	10.123.20.41 : 502	1	16	Write address 6, Quantity 2	Data Change	N/A	Word	uint32

Step 3. Configure Protocol 1 (IEC 61850 Server Settings)

Under **IEC 61850 Sever Settings**, you will find the **SCL Source** settings:

The MGate 5119 as an IEC 61850 server must have its own substation configuration language (SCL) file, which can be imported or created by the MGate 5119 itself. In this demo, we select **Local SCL file generator** and click **Create & Edit** to configure the SCL file.

SCL Source

SCL file options SCL file import Local SCL file generator

Create & Edit **Export**

Under **SCL file settings – Basic Setting**, we keep the default settings:

Basic Setting

Header ID	mgate_project
IED name	ied1
Access point name	accessPoint1
Logical device name	IDevice1
Subnetwork name	subnetwork1

Under **SCL Source – Logical Node**, create logical nodes by clicking the **Add** button. The page with the settings will pop up.

Logical Node

+ Add **Edit** **Delete**

Class	Instance	Type
LLN0		LLN01
LPHD	1	LPHD1

To add a logical node, select the **Class** as **GGIO-Generic process I/O**, input the **Start instance number** as **1**, **Instance count** as **1**, choose **AnIn** and **AnOut** objects, and input their **Count** as **2**. Click **OK** to finish the adding.

Add Logical Node

Class GGIO - Generic process I/O

Start instance number 1

Instance count 1

New logical node type Existing logical node type duplication

GGIO1_1

- EEHealth
- Ind
- AnIn
Count: 2 (1 - 20)
- AnOut
Count: 2 (1 - 20)
- SPCSO
- DPCSO

Ok **Cancel**

To query these objects more efficiently, add **Dataset** and choose the objects and the attributes you are interested in. Under **SCL Source – Dataset**, click the **Add** button to add the dataset.

Dataset

+ Add Edit Delete

Dataset Name	Description
--------------	-------------

Then, input the **Dataset name** and **Description**, choose the **Logical node class** and **Logical node instance** that have been created, and select the **Data Objects** you want to add to the **FCDA** (functionally constrained data attribute) list.

Add Dataset

Dataset name

Description

Logical node class

Logical node instance

Delete

Data Objects

- DA q
- DA mag
 - DA f
- DO AnIn2
 - DA t
 - DA q
 - DA mag
 - DA i
- + DO AnOut1
- + DO AnOut2

FCDA List

GGIO1\$MX\$AnIn1\$mag\$f

If you want the MGate 5119 to automatically notify the IEC 61850 client when an event has been triggered, add a buffer or unbuffered report. Under **SCL Source – Reports**, configure **Reports** by clicking the **Add** button. The page with the settings will pop up.

Reports

Add **Edit** **Delete**

Report Control Block Name	Data Set	Report ID	Buffered Type
---------------------------	----------	-----------	---------------

Then, input the **Report name**, **Description** and **Report ID** to identify this report. Choose the **Dataset name** as **D1**, which is added via the above Dataset adding procedure. You can define which data to include in the report through the settings for **Optional Fields**.

Add Report

Report name	<input type="text" value="R1"/>
Description	<input type="text" value="AI_Status"/>
Logical node class	<input type="text" value="LLN0"/>
Logical node instance	<input type="text" value="-"/>
Configuration revision	<input type="text" value="1"/>
Report ID	<input type="text" value="AI_Status"/>
Dataset name	<input type="text" value="D1"/>
Buffered	<input type="text" value="True"/>
Integrity period	<input type="text" value="1000"/> (ms)
Buffer time	<input type="text" value="1"/> (ms)

Trigger Options

<input checked="" type="checkbox"/> Enable	<input type="checkbox"/> Quality Change	<input checked="" type="checkbox"/> Period
<input checked="" type="checkbox"/> Data Change		

Optional Fields

<input checked="" type="checkbox"/> Sequence Number	<input checked="" type="checkbox"/> Time Stamp	<input checked="" type="checkbox"/> Dataset	<input checked="" type="checkbox"/> Reason Code
<input checked="" type="checkbox"/> Data Attribute Reference	<input checked="" type="checkbox"/> Entry ID	<input checked="" type="checkbox"/> Configuration Revision	

Report Enabled

Number of clients	<input type="text" value="1"/>
--------------------------	--------------------------------

Ok **Cancel**

Under **IEC 61850 Client Settings**, make a trusted client list. Click **Add** to add the trusted client and input the client's **IP address**.

If you want to use SSL to encrypt IEC 61850 MMS communication, enable **Encryption (SSL)** and **Authentication certificate** and import the client's certification.

If you only want to use certification to identify the client but not encryption, enable **Authentication certificate** and import the client's certificate. For the above two conditions, you should also import **CA certificate** and **Server certificate**. In this demo, we don't use SSL encryption and certificate authentication.

IEC 61850 Client Settings

+ Add

Name	Client41	⊗
IP address	10.123.20.41	
<input type="checkbox"/> Encryption (SSL)		
<input type="checkbox"/> Authentication Certificate		

Certificate Authorization

CA certificate	No file chosen	Import	Delete
Server certificate	No file chosen	Import	Delete

Step 4. IO Data Mapping

After finishing step 2 and step 3 of the setting procedure, map these two protocol objects in **SLC Data setting**.

Here is an example of mapping IEC 61850 to Modbus:

1. Select **Data → IDevice1 → GGIO1 → MX → AnIn1 → mag → f** from IEC 61850 side.
2. Select **modbus_tcp_client/10.123.20.41:502-sid1/AnIn1** from the Modbus side.
3. Click **Data Mapping** to map them.

SCL Data

Header ID mgate_project

IED ied1

Access point accessPoint1

Data Objects (from IEC 61850)	Tag List (from Modbus, DNP3, IEC101/104)
+ LPHD1	modbus_tcp_client/10.123.20.41:502-sid1/AnIn1
- GGIO1	modbus_tcp_client/10.123.20.41:502-sid1/AnIn2
+ ST	modbus_tcp_client/10.123.20.41:502-sid1/AnOut1
+ CF	modbus_tcp_client/10.123.20.41:502-sid1/AnOut2
- MX	modbus_tcp_client/10.123.20.41:502-sid1/status
- AnIn1	
t	
q	
- mag	

Data Mapping

We use the same way to map the AnIn1, AnIn2, AnOut1 and AnOut2 tags. See below:

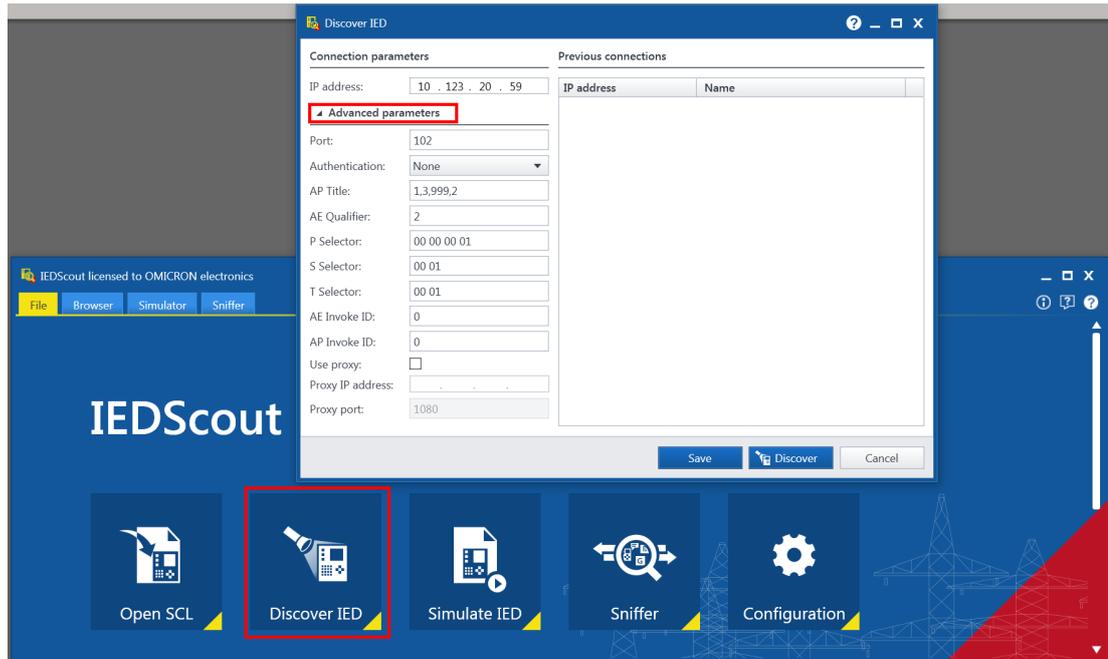
Mapping List

 Select all  Delete

Data (from IEC 61850)	Tags (from Modbus, DNP3, IEC101/104)
ied1 Device1/GGIO1\$MX\$AnIn1\$mag\$f	modbus_tcp_client/10.123.20.41:502-sid1/AnIn1
ied1 Device1/GGIO1\$MX\$AnIn2\$mag\$f	modbus_tcp_client/10.123.20.41:502-sid1/AnIn2
ied1 Device1/GGIO1\$CO\$AnOut1\$Oper\$ctlVal\$f	modbus_tcp_client/10.123.20.41:502-sid1/AnOut1
ied1 Device1/GGIO1\$CO\$AnOut2\$Oper\$ctlVal\$f	modbus_tcp_client/10.123.20.41:502-sid1/AnOut2

5 How to Simulate an IEC 61850 Client by IEDScout

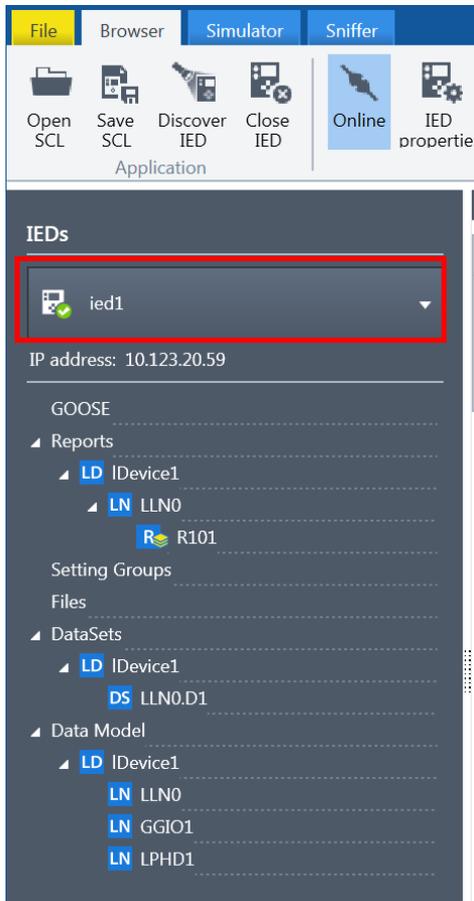
Click **Discover IED**, and the window for setting **Connection parameters** will pop up. Input the MGate 5119's **IP Address**. Click **Advanced parameters** to change the IED's other connection parameters, which must be the same as MGate 5119's **Connection Parameters** settings.



Connection Parameters

Non-security TCP port	102
Security TCP port	3782
OSI ACSE AP title	1,3,999,2
OSI ACSE AE qualifier	2
OSI presentation selector	00 00 00 01
OSI session selector	00 01
OSI transport selector	00 01

After completing the settings, click **Discover** to connect the MGate 5119. IEDScout will get the MGate 5119's IED device data dictionary.



6 Communication Test

6.1 Read Data Test

Change the value of Modbus Slave **AnIn1** and **AnIn2** as below:

Mbslave1		
ID = 1: F = 03		
	Name	00000
0	AnIn1	1111
1		--
2	AnIn2	2222
3		--

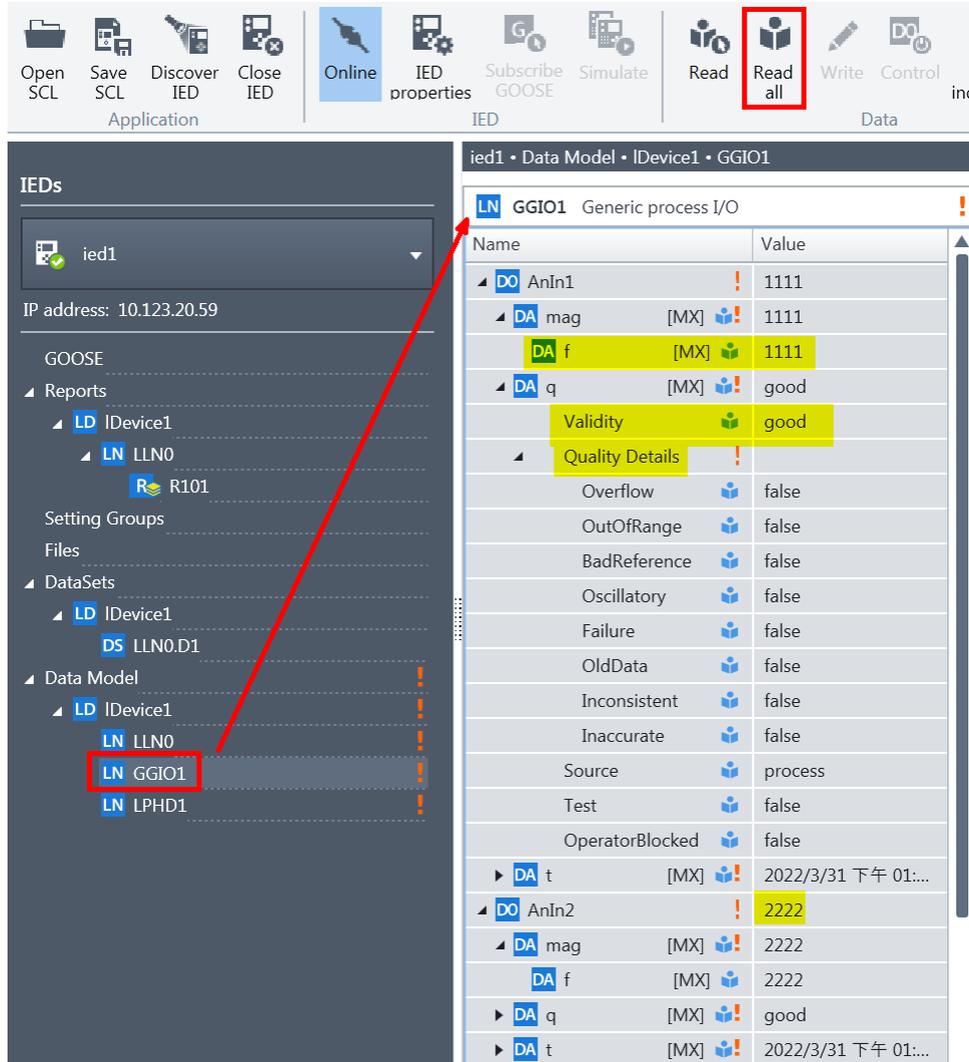
Go to the **System Monitoring** → **Protocol Status** → **Tag View** page to check whether the values have been updated. Under the **Quality** column, **valid** means the Modbus command response works perfectly. The **Source Timestamp** shows the latest updated time of Modbus values. The **Gateway Timestamp** is the latest Modbus response time.

Tag View

Auto refresh

Provider Name	Source Name	Tag Name	Access	Type	Size(Bytes)	Value	Quality	Source Timestamp	Gateway Timestamp
modbus_tcp_client	10.123.20.41:502-sid1	AnIn1	r	uint32	4	1111	valid	2022-03-31 05:33:56	2022-03-31 05:39:23
modbus_tcp_client	10.123.20.41:502-sid1	AnIn2	r	uint32	4	2222	valid	2022-03-31 05:33:56	2022-03-31 05:39:23
modbus_tcp_client	10.123.20.41:502-sid1	AnOut1	w	uint32	4	0	invalid	2022-03-31 01:49:44	2022-03-31 05:33:56
modbus_tcp_client	10.123.20.41:502-sid1	AnOut2	w	uint32	4	0	invalid	2022-03-31 01:49:44	2022-03-31 05:33:56
modbus_tcp_client	10.123.20.41:502-sid1	status	r	uint16	2	Valid(1)	valid	2022-03-31 05:33:56	2022-03-31 05:33:56

Under IEDScout, select **Data Model** → **IDevice1** → **GGIO1** node. Click **Read All**. It will poll this node and show the latest data. If the communication works, the **AnIn1.q** validity will show **good**.



If you disconnect the Modbus TCP connection, the **Tag List** shows **Quality** as **invalid**.

Tag List

Provider Name	Source Name	Tag Name	Access	Type	Size(Bytes)	Value	Quality	Source Timestamp	Gateway Timestamp
modbus_tcp_client	10.123.20.41:502-sid1	AnIn1	r	uint32	4	1111	invalid	2022-03-31 05:51:38	2022-03-31 05:51:48
modbus_tcp_client	10.123.20.41:502-sid1	AnIn2	r	uint32	4	2222	invalid	2022-03-31 05:51:38	2022-03-31 05:51:48
modbus_tcp_client	10.123.20.41:502-sid1	AnOut1	w	uint32	4	0	invalid	2022-03-31 01:49:44	2022-03-31 05:51:48
modbus_tcp_client	10.123.20.41:502-sid1	AnOut2	w	uint32	4	0	invalid	2022-03-31 01:49:44	2022-03-31 05:51:48
modbus_tcp_client	10.123.20.41:502-sid1	status	r	uint16	2	Invalid(0)	valid	2022-03-31 05:51:38	2022-03-31 05:51:38

Under IEDScout, click **Read All** again. AnIn1.q **Validity** shows **invalid** and **Quality** shows **Failure**.

ied1 • Data Model • IDevice1 • GGIO1

LN GGIO1 Generic process I/O			
Name			Value
DO AnIn1		!	1111
DA mag	[MX]	!	1111
DA f	[MX]	!	1111
DA q	[MX]	!	invalid
Validity			invalid
Quality Details		!	
Overflow			false
OutOfRange			false
BadReference			false
Oscillatory			false
Failure			true
OldData			false
Inconsistent			false
Inaccurate			false
Source			process
Test			false
OperatorBlocked			false

You also can poll the dataset by selecting the **DataSets** → **IDevice1** → **LLN0.D1** node:

IEDs

ied1

IP address: 10.123.20.59

GOOSE

Reports

Setting Groups

Files

DataSets

LD IDevice1

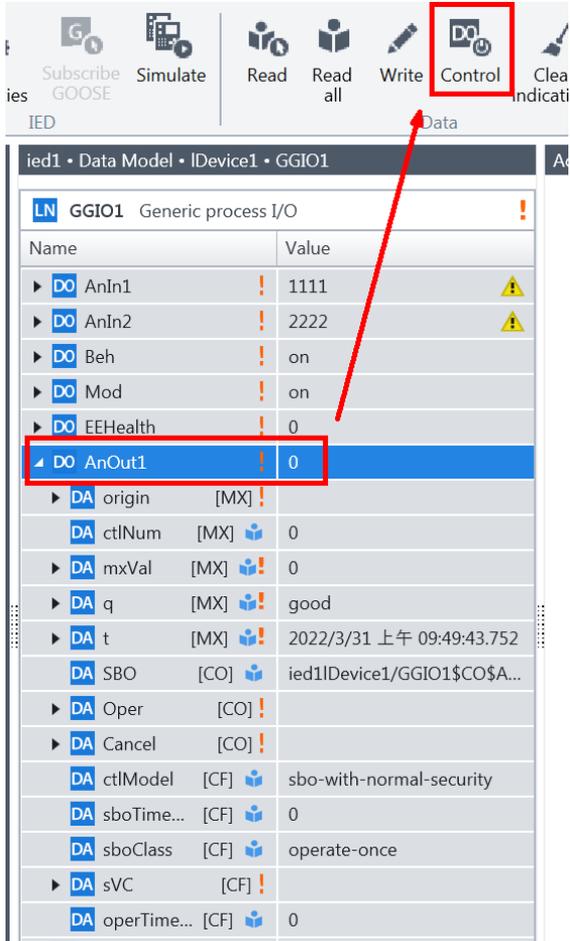
DS LLN0.D1

ied1 • DataSets • IDevice1 • LLN0.D1

DS LLN0.D1			
Name			Value
DA GGIO1.AnI...	[MX]	!	1111
DA GGIO1.AnI...	[MX]	!	2222

6.2 Write Test

If you want to output value on AnOut1, select **AnOut1**, and click **Control**.



The screenshot shows the MGate software interface. The top toolbar contains several icons: 'Subscribe GOOSE', 'Simulate', 'Read', 'Read all', 'Write', 'Control', and 'Clear Indicators'. The 'Control' button is highlighted with a red box. A red arrow points from the 'Control' button to the 'AnOut1' row in the data table below. The table is titled 'ied1 • Data Model • IDevice1 • GGIO1' and contains the following data:

Name	Value
▶ DO AnIn1	1111
▶ DO AnIn2	2222
▶ DO Beh	on
▶ DO Mod	on
▶ DO EEHealth	0
▶ DO AnOut1	0
▶ DA origin [MX]	
DA ctlNum [MX]	0
▶ DA mxVal [MX]	0
▶ DA q [MX]	good
▶ DA t [MX]	2022/3/31 上午 09:49:43.752
DA SBO [CO]	ied1IDevice1/GGIO1\$CO\$A...
▶ DA Oper [CO]	
▶ DA Cancel [CO]	
DA ctlModel [CF]	sbo-with-normal-security
DA sboTime... [CF]	0
DA sboClass [CF]	operate-once
▶ DA sVC [CF]	
DA operTime... [CF]	0

Then, the **Control** window pops up:

The screenshot shows a 'Control' window with the following fields and controls:

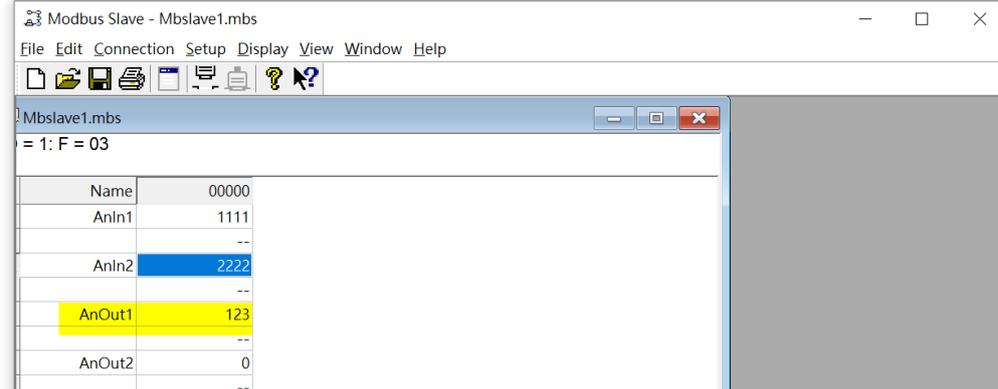
- IED: ied1
- Control object: ied1IDevice1/GGIO1.AnOut1
- Control model: Select Before Operate (SBO) control with normal security.
- Status value: 0
- Control parameters**
 - Originator category: station-control (dropdown)
 - Originator identification: 13 D5 C0 07 (text field)
 - Control sequence number: 0 (spin box)
 - Check condition: Synchrocheck Interlock-Check
 - Test status: Test
- Value:** 123 (text field)
- Buttons: Select, Operate, Cancel
- Status**
 - Select succeeded. (with a green checkmark icon)
- Close button

Since the MGate 5119 uses the **SBO Control model**, execute **Select** first and then **Operate**. Input **123** in the **Value** field and click **Select**. The value's background validation process elapses and displays its result in the Status section, which will fold out when you click **Select**. If **Select** succeeds, click **Operate** to write your selected value for the MGate 5119.

Check the **Tag List**; the **AnOut1** value is updated as **123**. The MGate 5119 triggers the Modbus write command, and **Modbus Slave AnOut1** is updated as **123**.

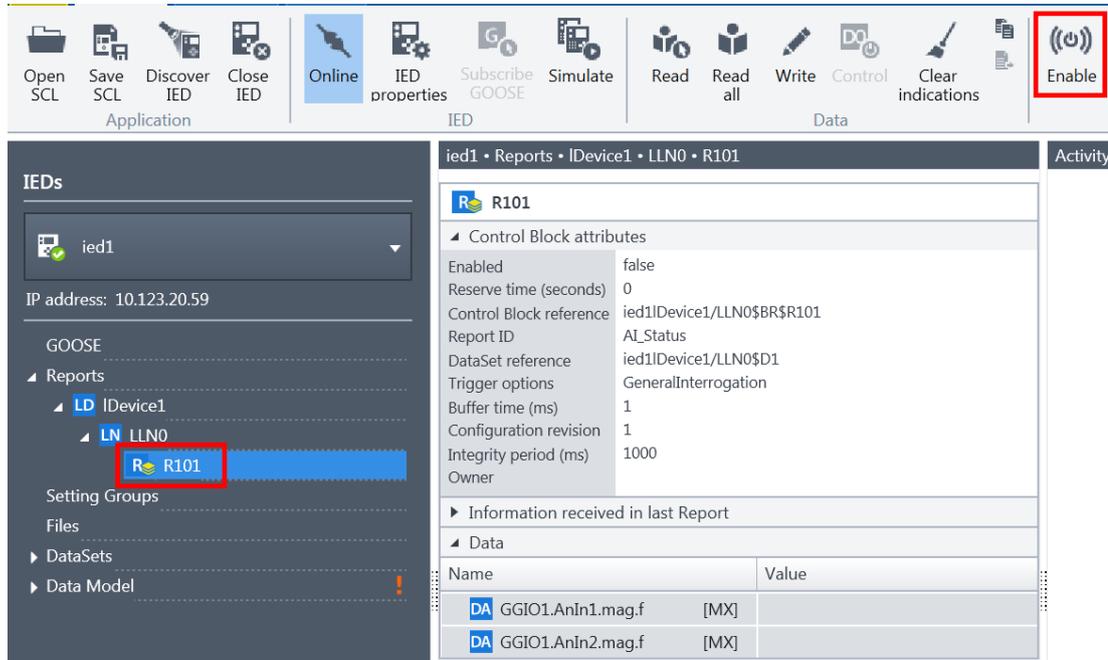
Tag List

Provider Name	Source Name	Tag Name	Access	Type	Size(Bytes)	Value	Quality	Source Timestamp	Gateway Timestamp
modbus_tcp_client	10.123.20.41:502-sid1	AnIn1	r	uint32	4	1111	valid	2022-03-31 05:51:38	2022-03-31 06:16:52
modbus_tcp_client	10.123.20.41:502-sid1	AnIn2	r	uint32	4	2222	valid	2022-03-31 05:51:38	2022-03-31 06:16:52
modbus_tcp_client	10.123.20.41:502-sid1	AnOut1	w	uint32	4	123	valid	2022-03-31 06:16:36	2022-03-31 06:16:36
modbus_tcp_client	10.123.20.41:502-sid1	AnOut2	w	uint32	4	0	invalid	2022-03-31 01:49:44	2022-03-31 06:16:23
modbus_tcp_client	10.123.20.41:502-sid1	status	r	uint16	2	Valid(1)	valid	2022-03-31 06:16:23	2022-03-31 06:16:36



6.3 Report Test

In this demo, the MGate 5119 has a static report instance. We choose this report instance from **Reports** → **IDevice1** → **LLN0** → **R101** and click **Enable**:



The **Enable Report** window pops up:

Enable Report

Report: ied1|Device1/LLN0\$BR\$R101

Report ID: AI_Status

DataSet: ied1|Device1/LLN0\$D1

Trigger options	Optional fields
<input checked="" type="checkbox"/> Data change	<input checked="" type="checkbox"/> Sequence number
<input type="checkbox"/> Quality change	<input checked="" type="checkbox"/> Time of entry
<input type="checkbox"/> Data update	<input checked="" type="checkbox"/> Reason for inclusion
<input checked="" type="checkbox"/> Integrity	<input checked="" type="checkbox"/> DataSet name
<input checked="" type="checkbox"/> General Interrogation	<input checked="" type="checkbox"/> Data reference
	<input checked="" type="checkbox"/> Buffer overflow
	<input checked="" type="checkbox"/> Entry ID
	<input checked="" type="checkbox"/> Config revision

Integrity period (ms): 10000

Perform General Interrogation

Default Enable Cancel

Enable the **Data change** trigger option, and the MGate 5119 will send the report when the dataset value is updated. Enable the **Integrity** trigger option and change **Integrity period** to 10000 ms. The MGate 5119 will send report every 10 seconds. Click the **Enable** button, and the MGate 5119 acts on the report process.