

# IEC 61850 Interoperability Test Example Using ERLPhase Relays

## Introduction

This document gives an example of using ERLPhase 4000 series relays to demonstrate the principal of IEC 61850 communication protocol – interoperability. Although, two ERLPhase L-PRO 4000 relays will be used in this example, other relay could substitute for one L-PRO relay. A closed loop handshaking test will be done in this example. Sequence events will be captured in each relay's events log; the close loop time can be estimated by using the time stamps on the sequence events from both devices.

## Background

One goal of the IEC 61850 standard is to ensure interoperability of substation automation devices. The easiest way to demonstrate interoperability is to show the close loop handshaking sequence between two (or multiple) devices. Basically, two substation automation devices can send and receive GOOSE messages between each other, and their corresponding output contacts can be closed by each other only through the Ethernet connection. The following figure and text describe a typical scenario and its sequence of operation will be described as well:

## Theory of Operation

The purpose of this test example is to send a goose message from LPRO1 to LPRO2. Then, LPRO2 will acknowledge that it has received the goose by sending a goose message back to LPRO1. The details of the sequence of operation are described below.

### Definitions:

- **Publication:** Publish IED information to the network through GOOSE messages.
- **Subscription:** Acknowledge the information that was published by remote IED through GOOSE message and respond to the changes.

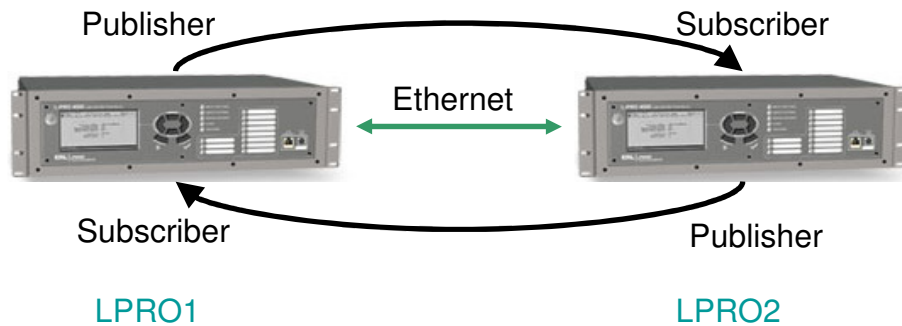


Figure 1: Sequence of operation

### Sequence of operation:

1. Unit LPRO1 will act as a 'Publisher' and send a trip signal to its subscriber LPRO2 via Ethernet connection.
2. Unit LPRO2 will act as a 'Subscriber' that can acknowledge the trip signal from LPRO1 and close its corresponding contact.
3. As soon as LPRO2 closes its contact, it also behaves as a 'Publisher' and sends a trip signal to LPRO1.
4. LPRO1 this time will act as a 'Subscriber' that can acknowledge the trip signal sent from LPRO2, and then close its corresponding contact.

### Test Setup

Test requirement:

- Two L-PRO 4000 relays must be on the same network: same subnet mask, same default gateway (as per IEC 61850 requirement).
- Latest version of L-PRO 4000 Offliner should be installed.
- Latest version of ERL IED Configuration Tool should be installed.
- Latest version of Relay 4000 Control Panel should be installed.
- HyperTerminal should be installed.

Logic device to be used:

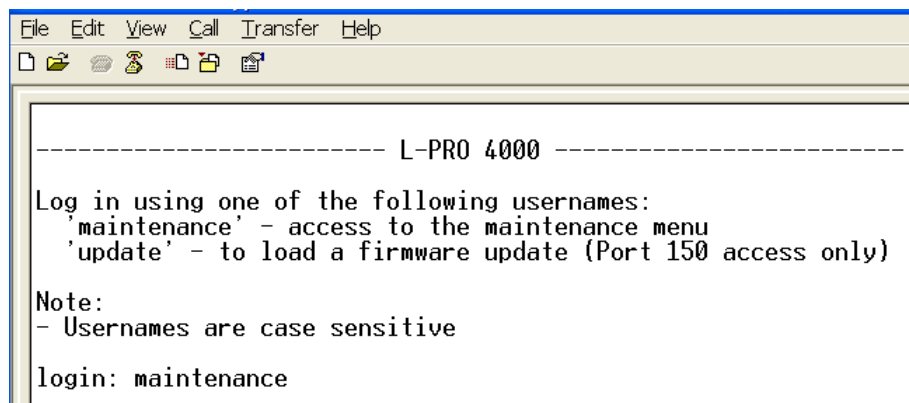
- Publication: *Output Contact* is used in this example; another element could be used instead.
- Subscription: *Virtual Input* is designed to be used for subscription; no other elements can be used for this purpose.

### Use HyperTerminal to set IEC 61850 Port and modify IEC 61850 IED name:

In this test example, two L-PRO 4000's will be assigned an IEC 61850 port to 119, and IEC 61850 IED name to LPRO1, LPRO2. If this is the first time using an ERLPhase 4000 relay, a front USB driver must be installed on the computer (refer to the USB driver installation manual for a detailed description of how to install the USB driver). A front USB connection is needed in order to set up the IEC 61850 port and IED name.

Setup example:

1. Connect the USB cable from the computer to the front USB port of the relay.
2. Configure the HyperTerminal program (use baud rate 115,200, emulation VT100).
3. Login as 'maintenance' via HyperTerminal as follows:



```
File Edit View Call Transfer Help
----- L-PRO 4000 -----
Log in using one of the following usernames:
'maintenance' - access to the maintenance menu
'update' - to load a firmware update (Port 150 access only)
Note:
- Usernames are case sensitive
login: maintenance
```

Figure 2: login as 'maintenance' in HyperTerminal

4. On the *Maintenance* main menu, select 1 to assign a port for IEC 61850 publication.
5. On the *Maintenance* main menu, select 10 to change the IEC 61850 IED name.
6. Repeat steps 1-5 on the second L-PRO

## 7. Exit HyperTerminal

### Use ERL IED Configuration Tool to set up the GOOSE Subscription Mapping:

1. Launch ERL IED Configuration Tool program.
2. Drag and drop ERLPhaseLPRO4000.icd file from the *IED Palette* to the *Project Editor*. As soon as the file been dropped into the *Project Editor*, a setup window will pop up as follows; change the *Instance Name* to **LPRO1** and click **OK** to close the window.

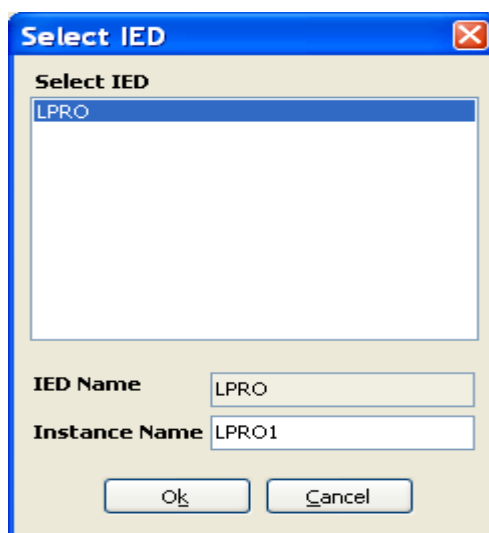


Figure 3: Change Instance Name for IED Name

3. When the above window is closed, the unit's properties will be shown on the right hand side of the *Project Editor*. Enter correct settings for LPRO1's IP address, subnet mask, default gateway and UTC offset.

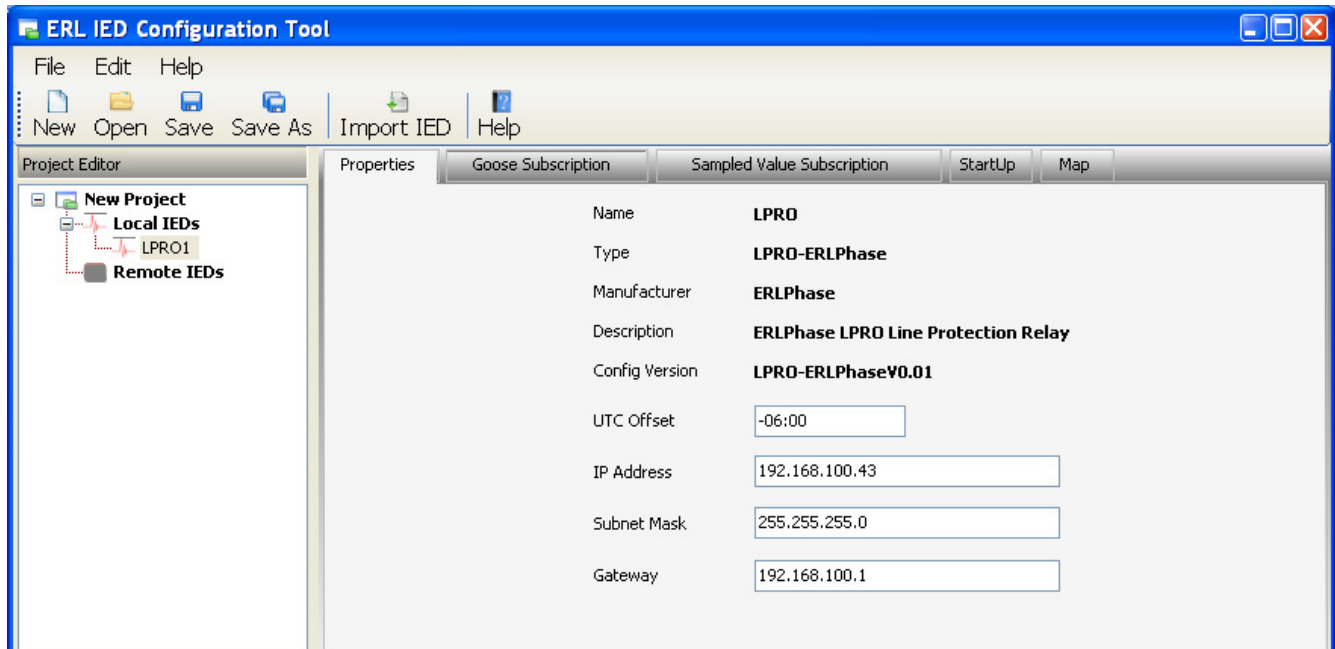


Figure 4: Put correct unit network configuration on the Properties tab

4. Repeat step 2 and 3, but change the *Instance Name* to **LPRO2** for step 2 along with the corresponding Network setting on the *Properties* tab for step 3.
5. Select **LPRO2** under *Project Editor*, and then click on *Goose Subscription* tab beside *Properties* tab.
6. Open up the *Incoming Goose* tree for 'LPRO1.System.OutputContacts'> 'System/OutputContacts\_Data'> 'GGIO4\$ST\$Ind1'.
7. Open up the *Local Goose* tree for 'Data'> 'GGIO2'> 'ST'> 'Ind1'.
8. Drag 'stVal' under 'GGIO4\$ST\$Ind1' from *Incoming Goose* and drop to 'stVal' under 'Ind1' from *Local Goose*. Once successful, mapping will look as shown:

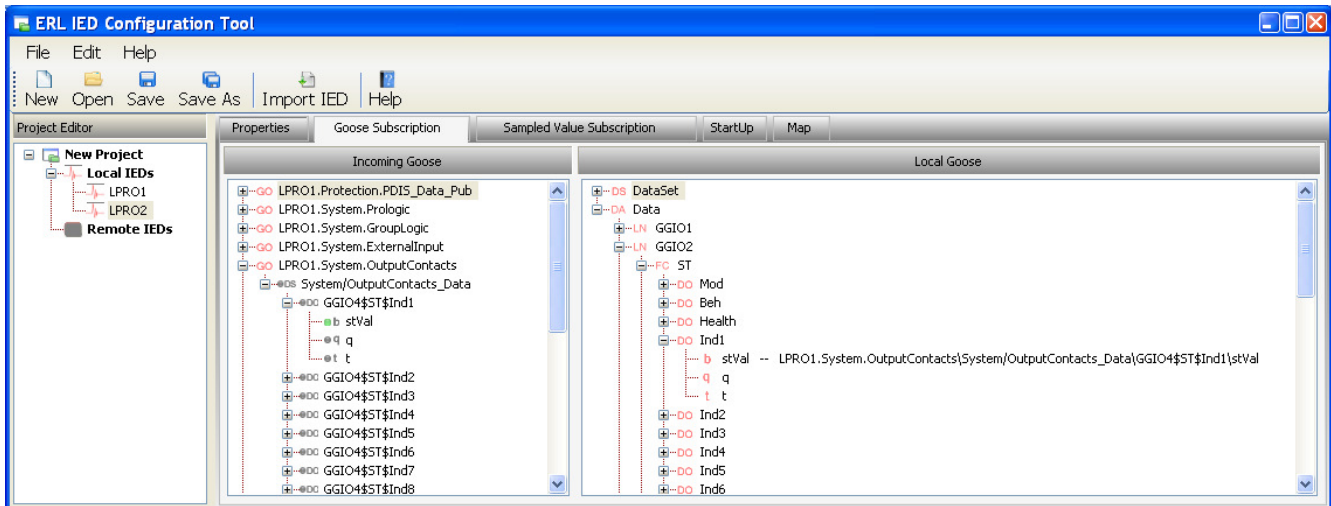


Figure 5: Goose mapping from incoming to local

9. Select **LPRO1** under *Project Editor* and repeat step 6 to 8. But instead of selecting **LPRO1.System.OutputContacts** from *Incoming Goose*, select **LPRO2.System.OutputContacts**.
10. Right click on **LPRO1** under *Project Editor*, select **Send CID**; the configured CID file will be sent to the unit LPRO1. Make sure your PC is connected to the network.
11. Right click on **LPRO2** under *Project Editor*, select **Send CID**; the configured CID file will be sent to the unit LPRO2.
12. Cycle power to the unit for changes to take effect.

### Use L-PRO 4000 Offliner to create setting files:

#### A. Create LPRO1's setting:

1. Open L-PRO 4000 Offliner; make a new version 402 setting file.
2. Do a 'correct relay identification' to match the unit configuration. To ensure the setting can be loading correctly onto the relay, the following information must be correctly configured under the identification section:

*Nominal CT Sec. Current*

*Nominal System Frequency*

*Optional I/O*

*Network Card*

*Ignore Serial Number can be checked if unit serial number is uncertain*



3. Select *Virtual Inputs* under Identification in left hand tree.

Name *Virtual Input 1* to **Rec'd from LPRO1**

4. Select *Output Matrix* under *Setting Group 1*, scroll the right hand screen to *Virtual Inputs* section, and check the *Virtual Input 1*'s output to *Output Contact 1* as follows:

VI 1 [Rec'd from LPRO1]	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
VI 2 [Virtual Input 2]	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 8: Output matrix mapping on LPRO2

5. Save the setting file as **LPRO2.lps**.

### Use Relay 4000 Control Panel to load the Offliner settings.

1. Connect to the unit LPRO1 using RCP.
2. Import *LPRO1.lps* to the *Saved Setting* list under *Configuration* tab on RCP.
3. Select the imported file and click on *Load to IED* to load the file on LPRO1.
4. Connect to the unit LPRO2 using RCP.
5. Import the *LPRO2.lps* to the *Saved Setting* list under *Configuration* tab on RCP.
6. Select the imported file and click on *Load to IED* to load the file on LPRO2.

### Handshaking demonstration

Since the whole handshaking sequence happened within 1 sec, two units must be synced precisely using the same IRIG-B source.

1. Login to LPRO1 using RCP.
2. Go to *Utilities>Virtual Inputs*.
3. Select *Close LPRO1 OUT1* (Virtual Input 2) in the drop down list, and then click on the *Latch On* button.
4. Go to *Events* in the main menu and check the events log. Here's how events appear after clicking on the *Latch On* button for *Virtual Input 2*:

TIME	EVENT
2010Aug12 10:14:09.165	Close LPRO1 OUT2:OUT2 : Closed
2010Aug12 10:14:09.134	Rec'd from LPRO2:VI1 : High
2010Aug12 10:14:09.101	Send to LPRO2:OUT1 : Closed
2010Aug12 10:14:09.067	Close LPRO1 OUT1:VI2 : High

Figure 9: Events show in LPRO1

5. Login to LPRO2 using RCP.
6. Go to *Events* to check the events log on LPRO2. Here's a sample events log:

TIME	EVENT
2010Aug12 10:14:09.125	Send to LPRO1:OUT1 : Closed
2010Aug12 10:14:09.106	Rec'd from LPRO1:VI1 : High

Figure 10: Events shows in LPRO2.

1. If we combine the sequence events log from LPRO1 and LPRO2 according to the time stamp, the entire sequence of operation will be show in the following way:

- LPRO1 SOE:
- i. 2010Aug12 10:14:09.067 Close LPRO1 OUT1:VI2 : High
  - ii. 2010Aug12 10:14:09.101 Send to LPRO2:OUT1 : Closed
- LPRO2 SOE:
- iii. 2010Aug12 10:14:09.106 Rec'd from LPRO1:VI1 : High
  - iv. 2010Aug12 10:14:09.125 Send to LPRO1:OUT1 : Closed
- LPRO1 SOE:
- v. 2010Aug12 10:14:09.134 Rec'd from LPRO2:VI1 : High
  - vi. 2010Aug12 10:14:09.165 Close LPRO1 OUT2:OUT2 : Closed

Sequence of operation:

- i. Manually latch *Virtual Input 2* to close *Output Contact 1* on LPRO1.
- ii. 34 ms later, *Output Contact1* of LPRO1 was closed.
- iii. 5 ms later, LPRO2 acknowledged that it received a request from LPRO1.
- iv. 19 ms later, LPRO2 sent a request to LPRO1.
- v. 9 ms later, LPRO1 acknowledged that it received a request from LPRO2.
- vi. 31 ms later, LPRO1 closed its *Output Contact 2*.

We can estimate the close-loop handshaking time will be the time difference between event "v" and event "ii", which is approximately 33 ms.

Note: Since the GOOSE messages are published in multicast way, the time of response will be different depending which of the multicast messages was subscribed to.