IEC 60870

Configuration Guide

0742-902-2901-002

Preface

Scope of the User Guide

The IEC 60870 Configuration Guide provides basic information about the IEC 60870 protocol, and how to use the MOX Configuration Software tools to configure MOX Group equipment when using the IEC 60870 protocol.

It is expected that the user of this guide is an engineer, technician, electrician or similar with an understanding of the operating and programming requirements of the MOX system.

Related Documents

A MOX system contains a collection of MOX equipment and several software packages. For this reason, a number of related documents should be read in conjunction with this user guide.

The related documents are noted below:

- MOX Unity Field Controller User Guide
- MOXGRAF Online Help

Conventions Used

	*When you see the "exclamation mark" icon in the left-hand margin, the text to its immediate right will be a special note. Please ensure that you read this information to increase your understanding of the system's operation.*

	*When you see the "stop sign" icon in the left-hand margin, the text to its immediate right will be a warning. This information could prevent injury loss of property or even death (in extreme cases). It is very important that you stop and read this information and ensure that you have complete understanding before continuing with the procedures.*

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1 Overview

IEC 60870-5 is a series of transport protocol standards, applying to telecontrol, teleprotection, and associated telecommunications for electric power systems.

There are a series of Basic Standards for IEC 60870-5. The Basic Standards are as follows:

- IEC 60870-5-1: Transmission Frame Formats
- IEC 60870-5-2: Link Transmission Procedures
- IEC 60870-5-3: General Structure of Application Data
- IEC 60870-5-4: Definition and Coding of Application Information Elements
- IEC 60870-5-5: Basic Application Functions

Based on the Basic Standards, there are a series of Companion Standards for IEC 60870-5. These are as follows:

- IEC 60870-5-101: Basic telecontrol tasks (Communication with RTU)
- IEC 60870-5-102: Transmission of integrated totals
- IEC 60870-5-103: “Informative interface” of protection equipment
- IEC 60870-5-104: Network access for IEC 60870-5-101

Our products now support the following:

- IEC 60870-5-101 master
- IEC 60870-5-103 master
- IEC 60870-5-104 slave

IEC 60870-5-101 is for "Basic telecontrol tasks" which is used for telecontrol information between an RTU and a control center with serial communication.

The IEC 60870-5-101 series protocol is based on the three-layer EPA (Enhanced Performance Architecture) reference model, which includes the physical layer, the link layer and the application layer.

Compared with IEC 60870-5-101, IEC 60870-5-102 &103 define different application layers and user processes. IEC 60870-5-102 is used for communication between an RTU and an ammeter while IEC 60870-5-103 is used between an RTU and protection equipment.

IEC 60870-5-104 does not use the link layer functions of as described in IEC 60870-5-101. IEC 60870-5-104 provides a combination of the application layers of the IEC 60870-5-101 and TCP/IP.

Physical Layer
IEC 60870-5-101&103 supports point-to-point serial communication, e.g. RS232, RS422 and has limited support for half duplex serial networks, e.g. RS485.

For IEC 60870-5-104 implemetations there are various network types that can be utilized within TCP/IP. These include X.25, FR (Frame Relay), ATM (Asynchronous Transfer Mode) and ISDN (Integrated Service Data Network).

Link Layer
There are two kinds of data link layer transmission modes. They are balanced and unbalanced modes.

Unbalanced Mode: In the unbalanced mode of operation only a Master device can transmit primary frames. The Master is the controlling device and all other devices on the network are Slave or controlled devices. Collision avoidance is not necessary in this mode since a Slave device cannot initiate transmissions or retry during failed messages. If the Slave device responds with a NACK (requested data not available), the Master will try again until the Slave receives the data or until a response time-out occurs.

Balanced Mode: In the balanced mode of operation all devices are equal at the link layer. This is the peer-to-peer communications mode where any device on the network can initiate communications. Where there are more than two devices on the network collision avoidance must be considered.

IEC 60870-5-101&103 supports balanced mode under point-to-point two-station links. Multipoint links must use an unbalanced transmission mode. This includes the multipoint-star mode and multipoint-party line mode.

IEC 60870-5-104 provides balanced access via a suitable transport profile.

Application Layer
IEC 60870-5-101&104 provides a series of common application functions as follows:

- Time Synchronization
- Time-stamped events
- Freeze/Clear Counters
- Select before operate
- Polled report by exception
- Unsolicited Responses
- Data groups/classes

IEC 870-5-103 provides a series of common application function as follows:

- Station initialization
- General interrogation
- Clock synchronization
- Command transmission
- Test mode
- Blocking of monitor direction
- Transmission of disturbance data
- Generic services

2 Terms and Definitions

Companion Standard
A companion standard adds semantics to the definitions of the basic standard or a functional profile. This may be expressed by defining particular uses for information objects or by defining additional information objects, service procedures and parameters of the basic standard.

Companion standards do not alter the standards to which they refer, but make explicit the relationship between those used together for a specific domain of activity.

Group (of information objects)
Selection of common addresses or information addresses which is specifically defined for a particular system.

Control direction
Direction of transmission from the controlling station to a controlled station

Monitor direction
Direction of transmission from a controlled station to the controlling station

System parameter
A system parameter (or system-specific parameter) is valid for the complete telecontrol system which uses this companion standard. The telecontrol system consists of the entire controlled and controlling stations which may be connected via different network configurations.

Network-specific parameter
A network-specific parameter is valid for all the stations which are connected via a particular network configuration.

Station-specific parameter
A station-specific parameter is valid for particular stations.

Object-specific parameter
An object-specific parameter is valid for a particular information object or a specific group of information objects.

3 IEC60870-5-101 Master

3.1 Usage

3.1.1 Data Types

IEC 60870 uses a Type ID (TI) to identify each Information Object. An Information Object may contain one or more Information Elements but the TI applies to all information contained within the Application Service Data Unit (ASDU). The TI embodies a function code and data format. The following listed types are supported by MOX controller.

- Digital Input: Single point information
- Integer Input: Step position information, Normalized measured value
- Counter: Binary counter reading
- Float Input: Short Floating Measured Value
- Digital Output: Single Command and Regulating Step Command
- Integer Output: Set Point Command
- System Function: The system function is used to provide specific device control functions for a IEC60870-5-101 Slave device

3.1.2 Address

There are three kinds of addresses, which are all fixed for each slave:

1) Link Address: zero, one or two octets
2) Common Address of ASDUs: one or two octets
3) Information Object Address: one, two or three octets

The Link address is the device address used by IEC 60870-5-101. It prevents peer to peer network of more than two devices and can be unrelated to common address.

The common address is the station address. In most cases, the common address together with the information object address distinguishes the complete set of information elements within a specific system. The combination of both addresses should be unambiguous for each slave.

3.2 Configuration

MOXGRAF is used to configure the master's system parameters, map variables, assign IEC 60870 objects to a group, as well as select the transmission mode and the time tag.

3.2.1 Communication Configuration

In MOXGRAF's configuration view, select Ports tab.

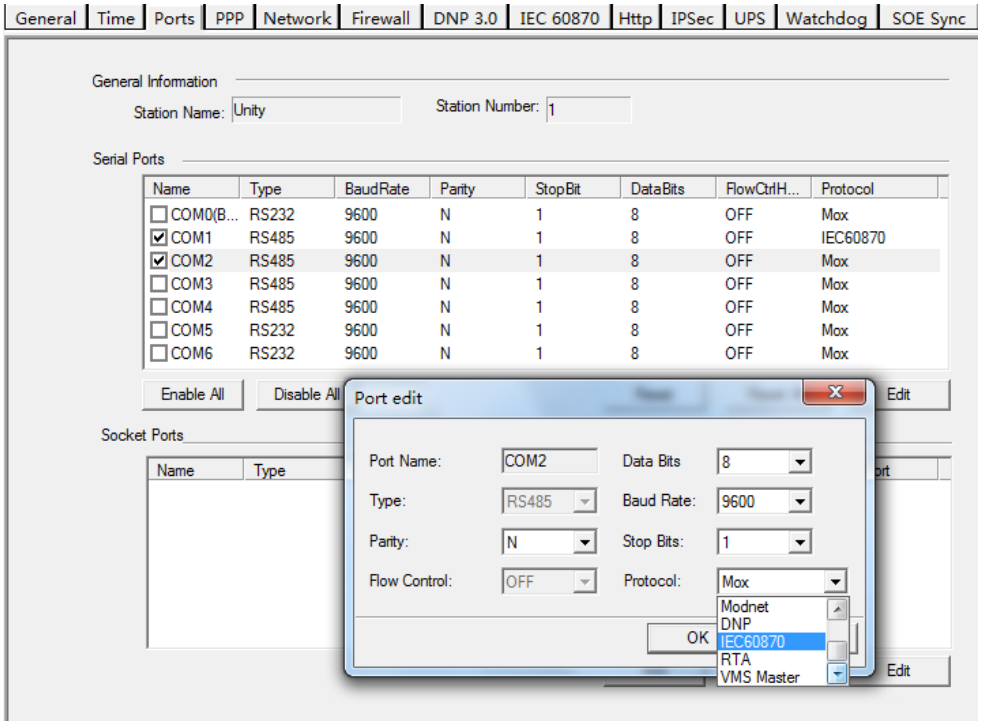

Figure 1 IEC 60870-5-101 Serial Port Settings

Select a serial port and configure its communication options in Port edit window. Note that the protocol of the port shall be IEC60870.

Then from the available configuration pages, select IEC60870 tab. Enable the IEC 60870-5-101 Master and click “Config” button to configure advanced settings.

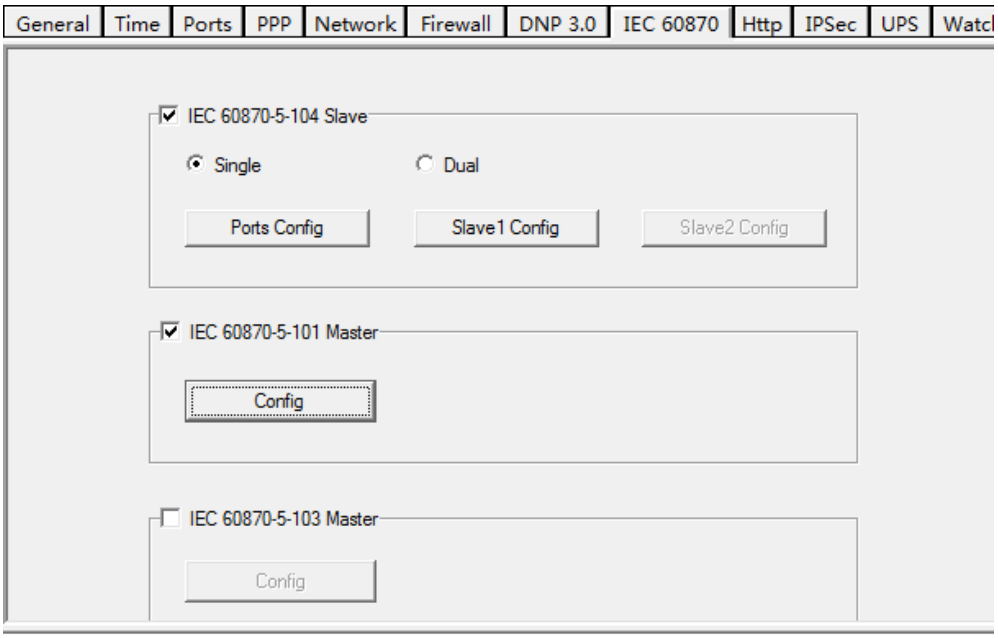

Figure 2 IEC 60870-5-101 Master Function Selection

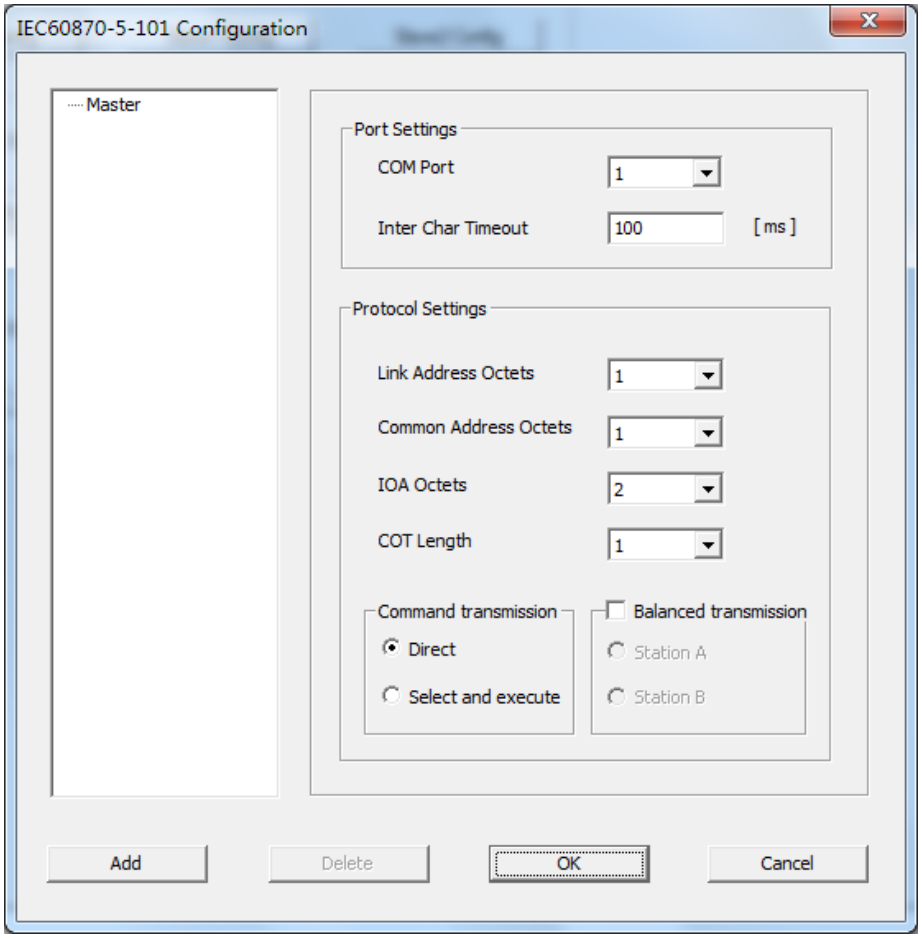

Figure 3 IEC 60870-5-101 Master Parameters Setting

The configurable parameters are listed in the following table.

Name	Default Value	Valid Values	Descriptions
COM Port		0 to 6	serial port used by IEC60870-5-101 master
Link Address Octets	1	0 (Balanced mode only), 1 or 2.	Size of Link Addresses, in number of Octets.
Common Address Octets	1	1 to 2	Size of Common Addresses, in number of Octets.
IOA Octets	2	1 to 3	Size of Information Object Addresses, in number of Octets.
COT Length	1	1 or 2	Length of Cause of Transmission, in bytes.
Inter Char Timeout	100	50ms or more is recommended	Allowable gap between characters in a message from a device.
Command Transmission	0	0 or 1	0: Direct 1: Select and execute
Balanced transmission	0	0 or 1	0: Disable 1: Enable
Station		A or B	Selectable when balanced transmission enabled.

Table 1 IEC 60870-5-101 Master Configurable Parameters

3.2.2 Slave Parameters Configuration

In the IEC60870-5-101 configuration page, click the “Add” button to add a slave. A device number is automatically assigned to the slave and appeared in the Device No. field.

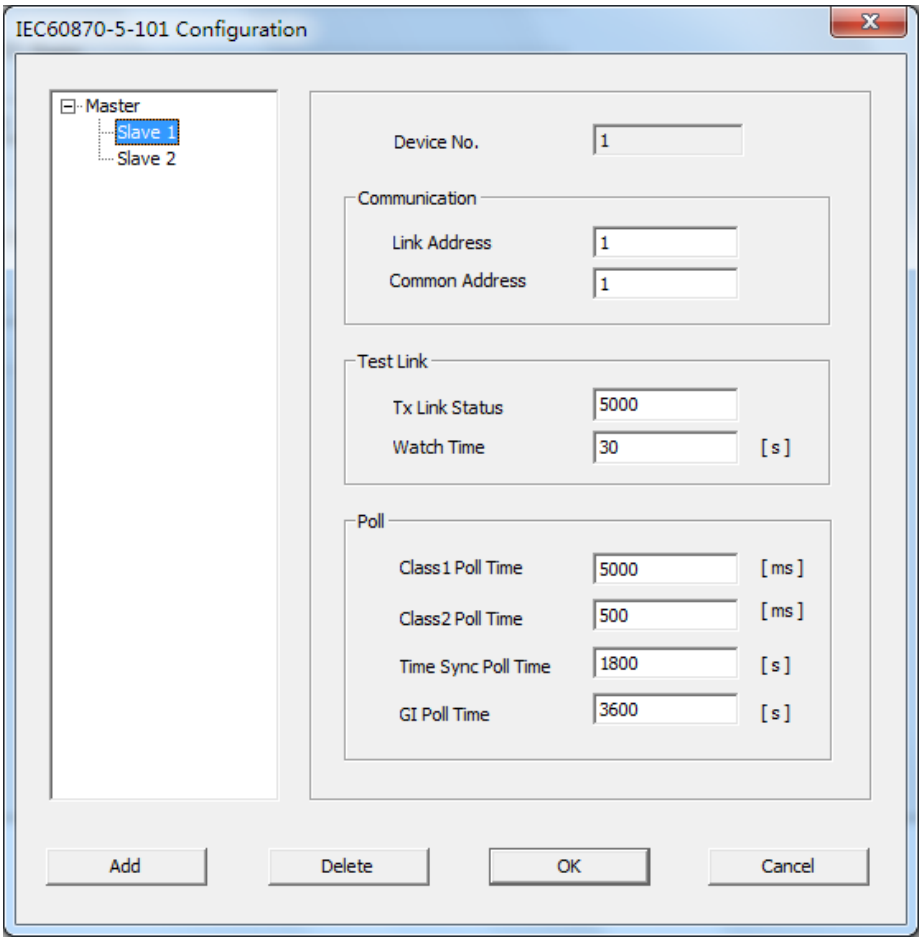

Figure 4 IEC 60870-5-101 Slave Adding

The configurable parameters are visible when the slave has been chosen in the left pane. They are detailed in the following table

Name	Default Value	Valid Values	Descriptions
Link Address	1	0 – 254 (Link Address Octets = 1) or 0 – 65534 (Link Address Octets = 2)	Link Address
Common Address	1	1– 254	Common Address
Tx Link Status	5000	0 – 32767	How often to send Test Link messages in Unbalanced Mode (milliseconds). “0” disable Test Link messages transmission.
Watch Time	30	0 - 60	How long to allow a link to be idle before taking the

			device offline (seconds).
Class1PollTime	5000	0 – 32767	Class1 data poll time (milliseconds)
Class2PollTime	500	0 – 32767	Class2 data poll time (milliseconds)
Time Sync Poll Time	1800	0 - 32767	How often to synchronize a device's time (seconds). Default is 30 minutes. "0" disables time synchronization
GI Poll Time	3600	0 – 32767	GI Poll Time (seconds)

Table 2 IEC 60870-5-101 Configurable Parameters

3.2.3 Download Configuration

Select **Device | Download Configurations** to download the configuration to the controller. You need to reboot the Unity before the settings take effect.

3.2.4 Data Types Mapping

Various IEC 60870 Information Objects can be bound with MOXGRAF variables. The table below shows the matching data type between MOXGRAF Data and IEC 60870-5-101 Data:

MOXGRAF Data		IEC60870-5-101 Data				
Data Types	Direction	Data Types			Direction	Value
BOOL (8 bits)	Internal	Digital Input			Input,	TRUE/FALSE
BOOL (8 bits)	Internal	Digital Output	Value		Output	TRUE/FALSE
SINT (8 bits)	Internal	Digital Output	Control		Output	1: Select/Execute; 2: Select Only; 3: Execute Only; 4: Deactivate)
	Internal	Digital Output	Qualifier		Output	0: Default; 1: Short pulse; 2: Long pulse; 3: Persistent
BOOL (8 bits)	Internal	System Function	Time Sync		Output	TRUE:Time Sync
BOOL (8 bits)	Internal	System Function	GI	Operation	Output	TRUE:Group Interrogation
SINT (8 bits)		System Function	GI	Group		1~16 for specified Group, others for all Group
BOOL (8 bits)	Internal	System Function	Online		Input	TRUE:Online FALSE:Offline
BOOL (8 bits)	Internal	System Function	Reset		Output	TRUE:Reset
SINT (8 bits)	Internal	System Function	CI	Operation	Output	1: Read; 2: Freeze; 3: Reset; 4: Freeze and Reset
		System Function	CI	Group		1~4 specified for single Group, others for all Group
DINT	Internal	Integer Input			Input,	

MOXGRAF Data		IEC60870-5-101 Data			
Data Types	Direction	Data Types		Direction	Value
(32 bits)					
DINT (32 bits)	Internal	Counter		Input,	
DINT (32 bits)	Internal	Integer Output	Value	Output,	
SINT (8 bits)	Internal		Control	Output,	
	Internal		Qualifier	Output,	0: Normalized; 1: Scaled
REAL (32 bits)	Internal	Float Input		Input,	

Table 3 Data Types Mapping between MOXGRAF and IEC 60870-5-101

3.2.5 Mapping Variables

The following procedure describes how to map the variables. First of all, switch MOXGRAF to Resource view; select **Resource | IEC 60870-5-101 Master Setting** to get the pop-up IEC101 Master setting window.

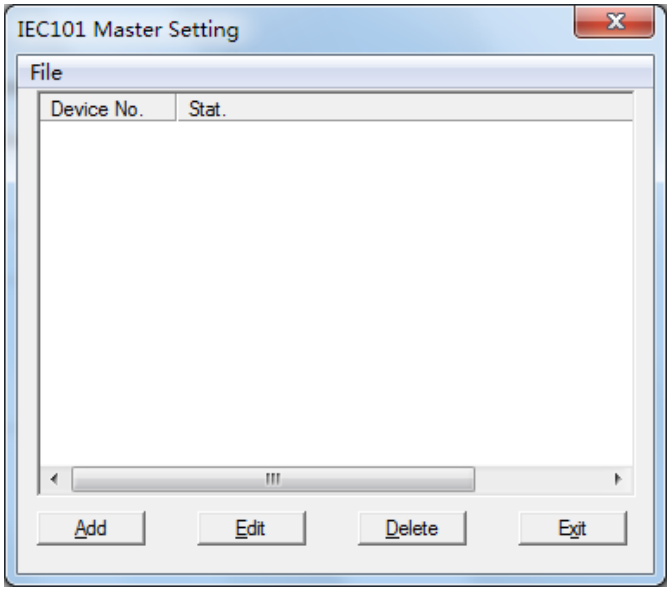

Figure 5 IEC 60870-5-101 Master Setting Window

Click button ‘Add’. In the pop-up window, enter a device number in “Device” field, select data type and click “Add” button to map the variables to that device. The “Device” here is supposed to be the device number which is automatically generated in slave parameters configuration. Refer to 3.2.2 for more information.

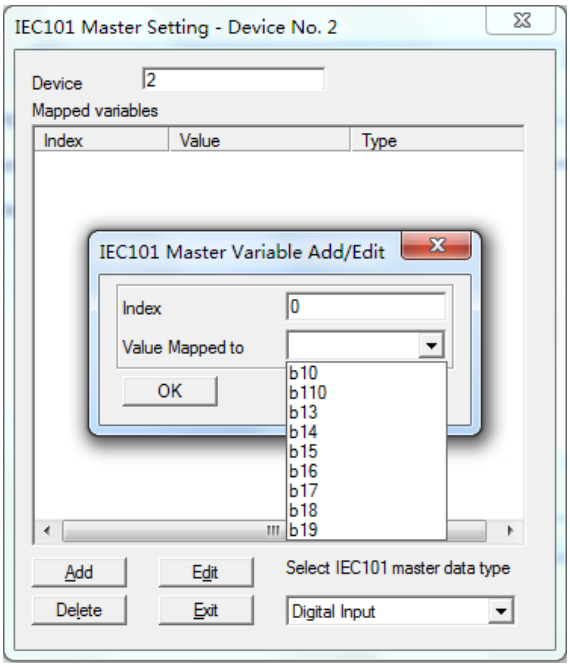

Figure 6 Map IEC 60870-5-101 Digital Input Variables

When adding a Digital Output variable, a control variable is required in the “Control Mapped to field”. The Digital Output variable value only works out after the control variable changes from 0 to 1.

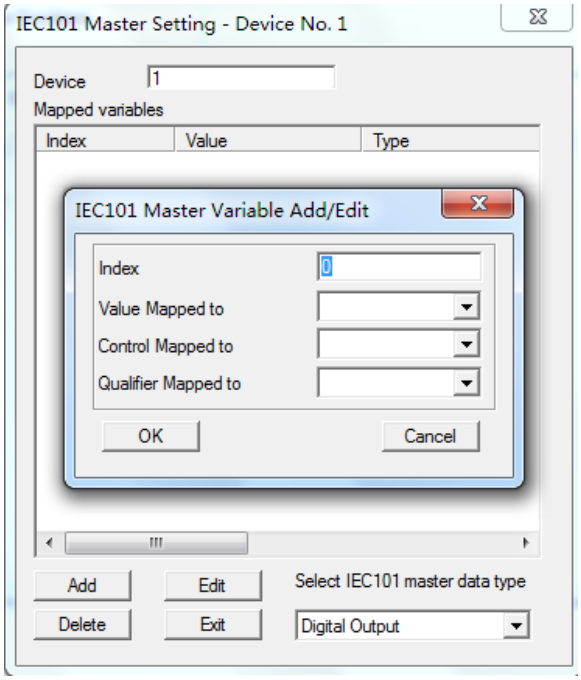

Figure 7 Map IEC 60870-5-101 Digital Output Variables

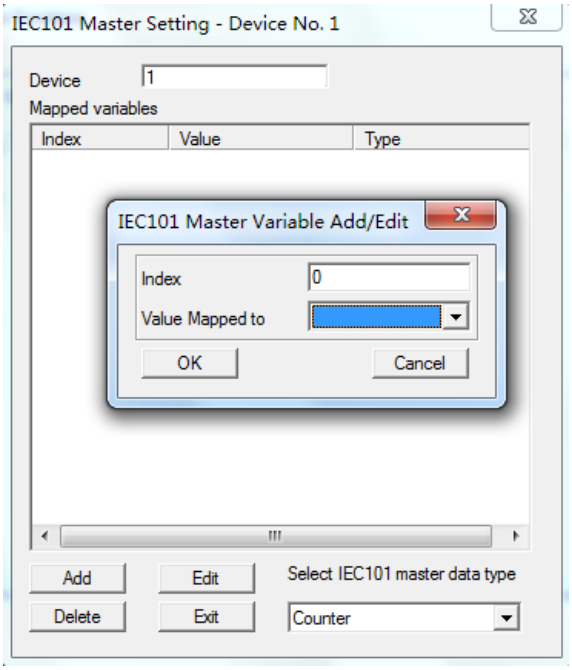

Figure 8 Map IEC 60870-5-101 Counter Variables

The following figure shows how to add a Counter variable. Note that the counter value will be read when system command CI's group is valid and operation performs "Freeze" and "Read". To configure the CI group, add a System Function variable, select "CI" as the system function and set the rest options in the following figure.

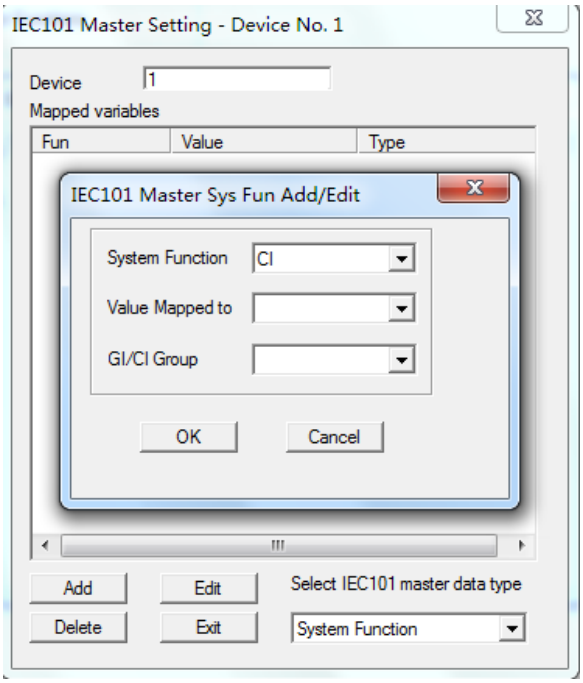

Figure 9 Map IEC 60870-5-101 System Function Variables

3.2.6 Build Data Map Configuration File

In MOXGARF toolbar, select **Resource** | **Build** to build the data map configuration file.

3.2.7 *Export Mapped Variables to .csv File*

The CSV ("Comma Separated Value") file format is saved with values separated by commas and can be opened by either EXCEL or Notepad which is much more convenient for users to check the information of variables.

Select Export from the menu within IEC101 Master Setting window.

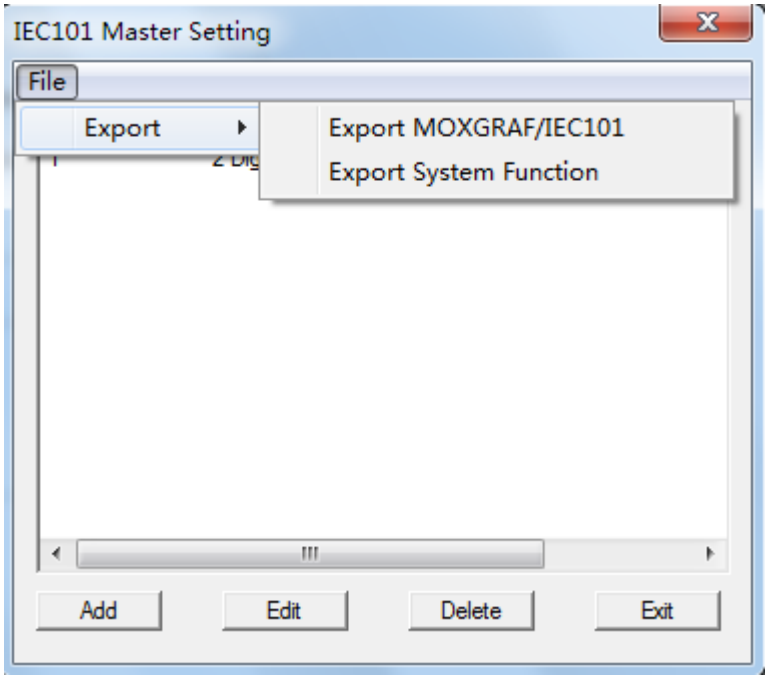

Figure 10 IEC 60870-5-101 Export from Menu

Select the information you want to export. For example, when selecting “Export MOXGRAF/IEC101”, the following window pops up:

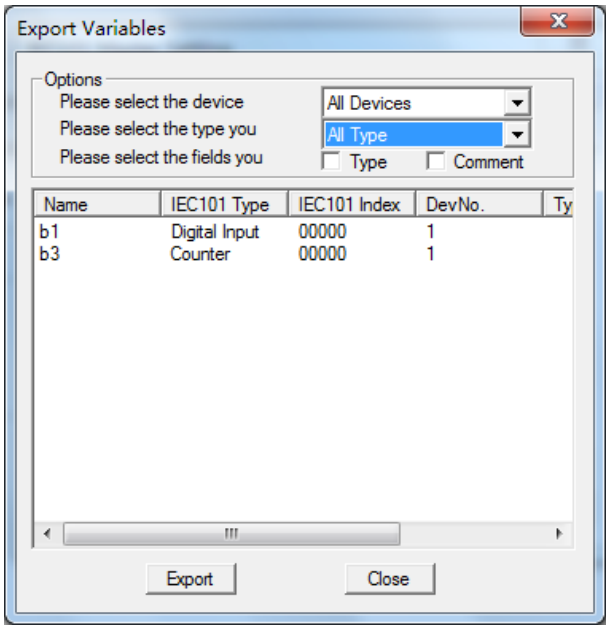

Figure 11 IEC 60870-5-101 Export Window

In this dialog, all information that users can choose is included. All mapped variables are listed in the list box as a default setting. they are sorted by different IEC 60870 Types. Corresponding variables and related information will show in the list box for users to export. Click the “Export” button as shown in the above figure and the user will be prompted to enter a file name and choose the place to export to.

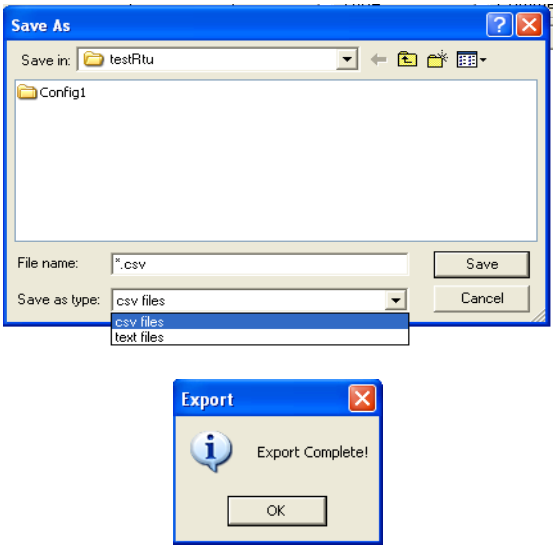

Figure 12 IEC 60870-5-101 Export Complete

The exported file can be saved as either .csv or .txt type.

4 IEC60870-5-103 Master

4.1 Usage

4.1.1 Data Types

IEC 60870 uses a Type ID (TI) to identify each Information Object. An Information Object may contain one or more Information Elements but the TI applies to all information contained within the Application Service Data Unit (ASDU). The TI embodies a function type and data format. The following listed types are supported by MOX controller.

- DPI：Double-point information
- DCO: Double command
- Measurand: Measurands
- Measurand-I: Measurands I
- Measurand-II: Measurands II
- System Function: The system function is used to provide specific device control functions for a IEC60870-5-103 Slave device.

4.1.2 Address

There are three kinds of addresses, which are all fixed for each slave:

1) Link Address: zero, one or two octets
2) Common Address of ASDUs: one or two octets
3) Information Object Address: one, two or three octets

The Link address is the device address used by IEC 60870-5-103. It prevents peer to peer network of more than two devices and can be unrelated to common address.

The common address is the station address. In most cases, the common address together with the information object address distinguishes the complete set of information elements within a specific system. The combination of both addresses should be unambiguous for each slave.

4.2 Configuration

MOXGRAF is used to configure the master's system parameters, map variables, assign IEC 60870 objects to a group, as well as select the transmission mode and the time tag.

4.2.1 Communication Configuration

From the configuration view, select Ports tab.

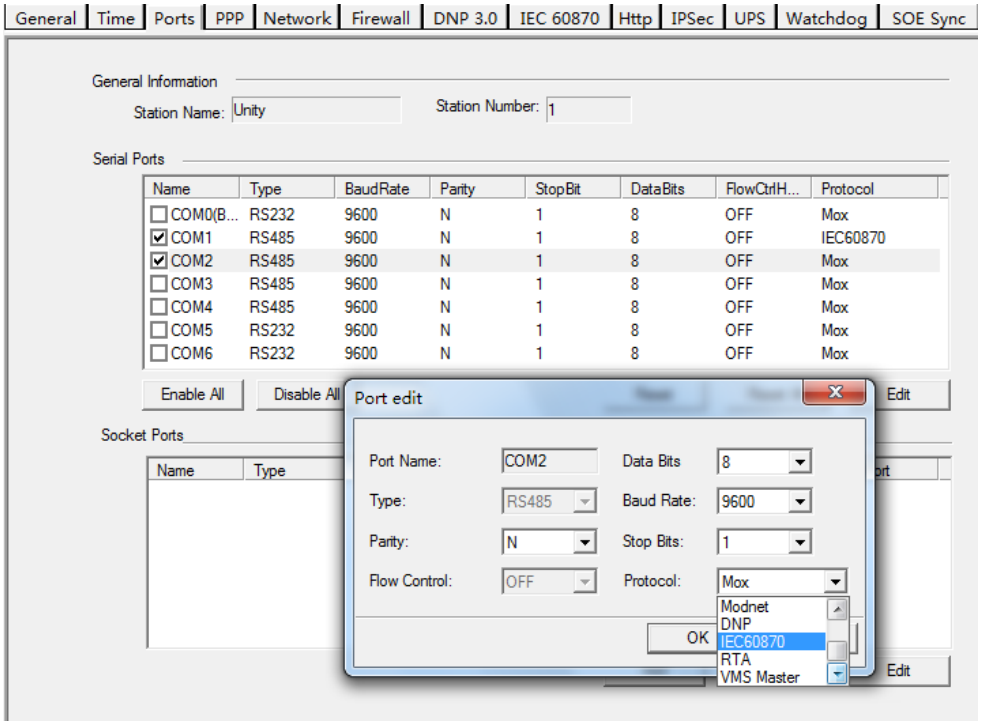

Figure 13 IEC 60870-103 Serial Port Settings

Select a serial port and configure its communication options in Port edit window. Note that the protocol of the port shall be IEC60870

Then from the available configuration pages, select IEC60870 Tab. Enable the IEC 60870-5-103 Master and click “Config” button to configure advanced settings.

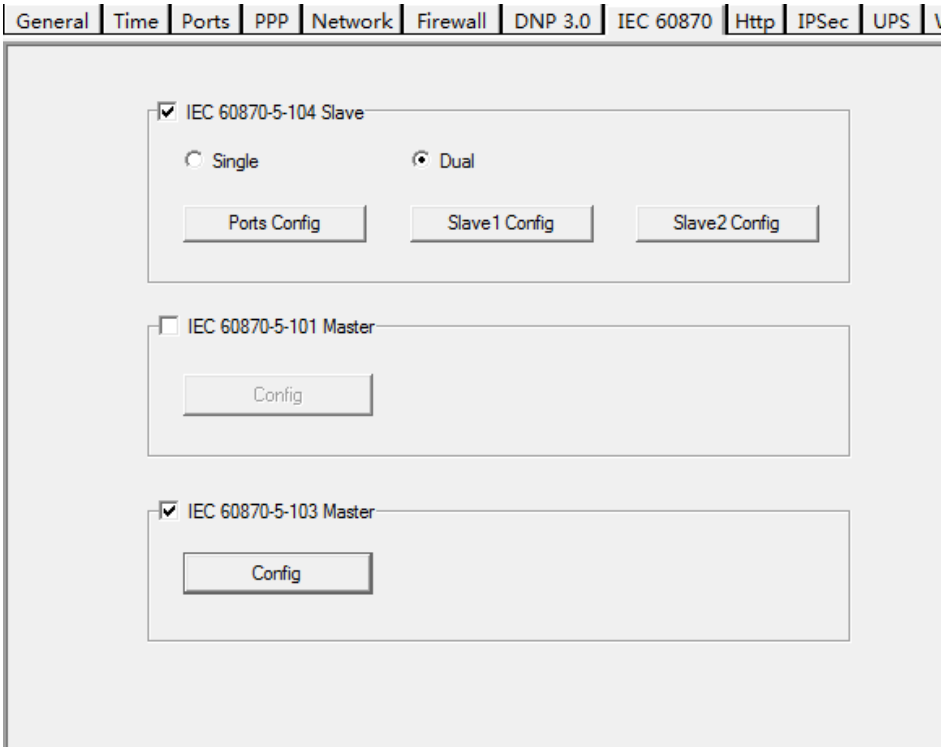

Figure 14 IEC 60870-103 Master Function Selection

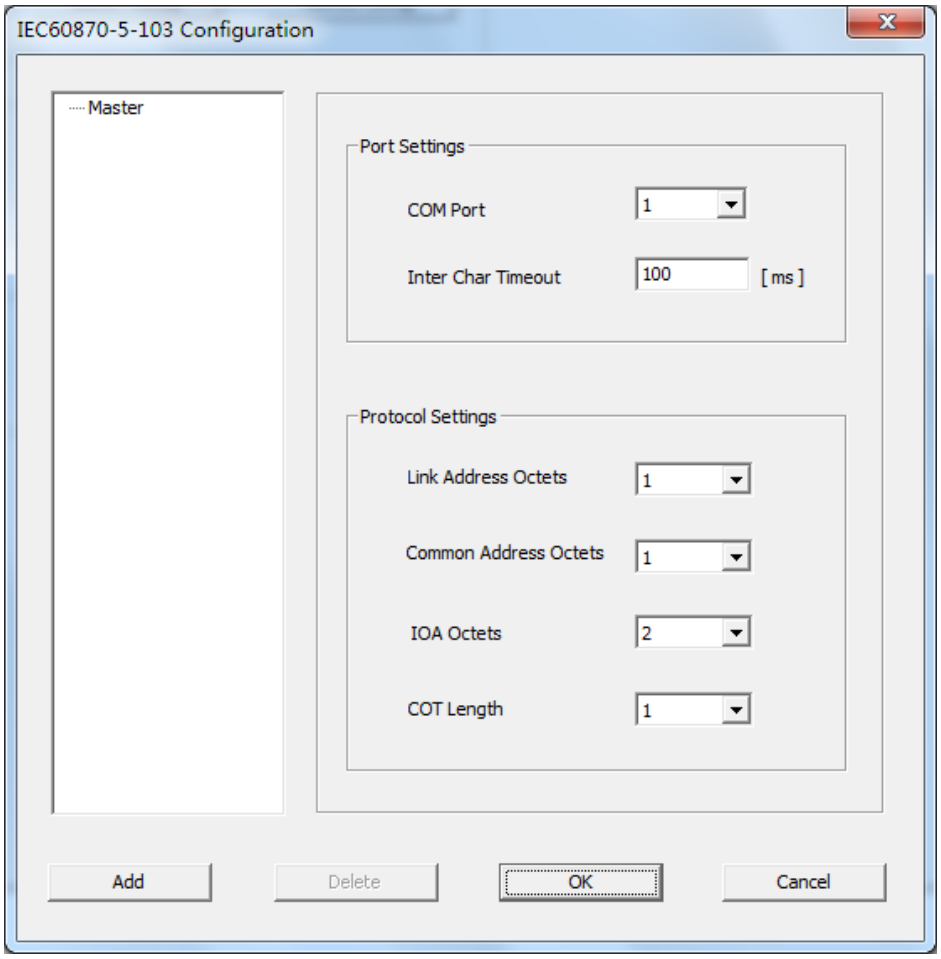

Figure 15 IEC 60870-103 Master Parameters Setting

The configurable parameters are listed in the following table.

Name	Default Value	Valid Values	Descriptions
COM Port		0 to 6	serial port used by IEC60870-5-103 master
Inter Char Timeout	100	50ms or more is recommended	Allowable gap between characters in a message from a device.
Link Address Octets	1	0 (Balanced mode only), 1 or 2.	Size of Link Addresses, in number of Octets.
Common Address Octets	1	1 to 2	Size of Common Addresses, in number of Octets.
IOA Octets	2	1 to 3	Size of Information Object Addresses, in number of Octets.
COT Length	1	1 or 2	Length of Cause of Transmission, in bytes.

Figure 16 IEC 60870-103 Master Configurable Parameters

4.2.2 Slave Parameters Configuration

In the IEC60870-5-103 configuration page, click the “Add” button to add a slave. A device number is automatically assigned to the slave and appeared in the Device No. field.

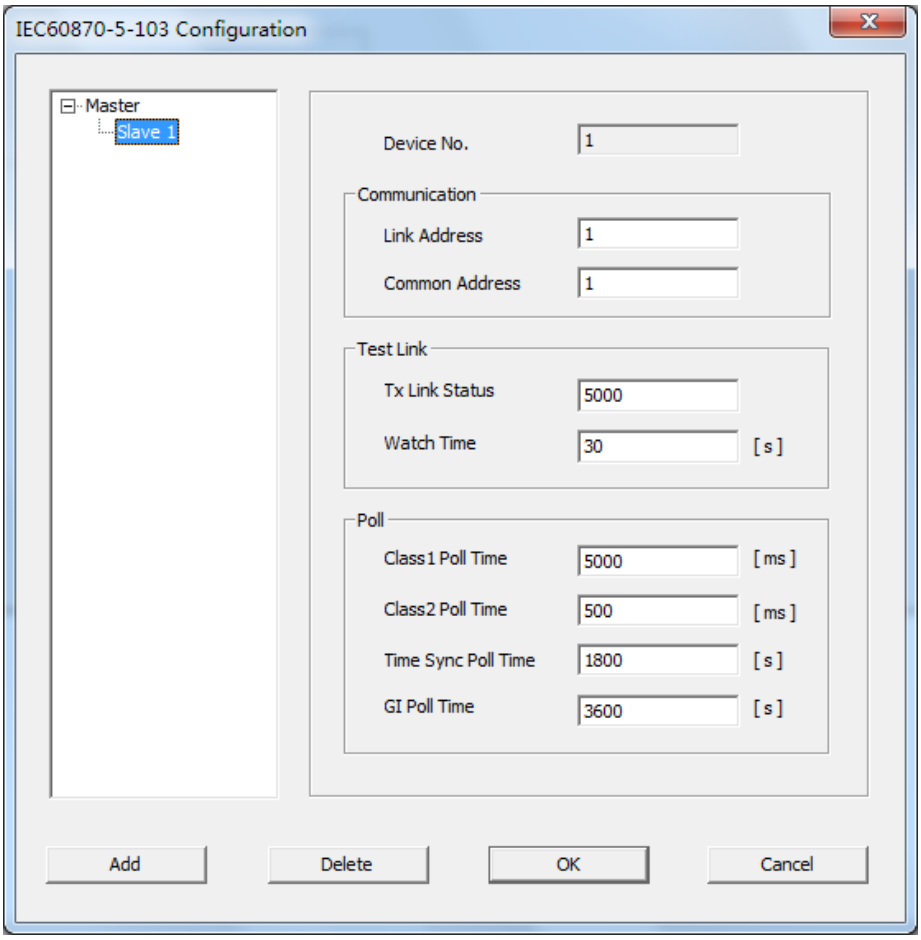

Figure 17 IEC 60870-5-103 Slave Adding

The configurable parameters are visible when the slave has been chosen in the left pane. They are detailed in the following table

Name	Default Value	Valid Values	Descriptions
Link Address	1	0 – 254 (Link Address Octets = 1) or 0 – 65534 (Link Address Octets = 2)	Link Address
Common Address	1	1– 254	Common Address
Tx Link Status	5000	0 – 32767	How often to send Test Link messages in Unbalanced Mode (milliseconds). “0” disable Test Link messages transmission.
Watch Time	30	0 - 60	How long to allow a link to be idle before taking the device offline (seconds).
Class1PollTime	5000	0 – 32767	Class1 data poll time (milliseconds)

Class2PollTime	500	0 – 32767	Class2 data poll time (milliseconds)
Time Sync Poll Time	1800	0 - 32767	How often to synchronize a device's time (seconds). Default is 30 minutes. "0" disables time synchronization
GI Poll Time	3600	0 – 32767	GI Poll Time (seconds)

Figure 18 IEC 60870-5-103 Configurable Parameters

4.2.3 Download Configuration

Select **Device | Download Configurations** to download the configuration to the controller. You need to reboot the Unity before the settings take effect.

4.2.4 Data Types Mapping

Various IEC 60870 Information Objects can be bound with MOXGRAF variables. The table below shows the matching data type between MOXGRAF Data and IEC 60870-5-103 Data:

MOXGRAF Data		IEC60870-5-103 Data				
Data Types	Direction	Data Types			Direction	Data Types
BOOL (8 bits)	Internal	DPI			Input	TRUE/FALSE
BOOL (8 bits)	Internal	DCO	Value		Output	TRUE/FALSE
			Control		Output	TRUE/FALSE
REAL (32 bits)	Internal	Measurand			Input	REAL range
DINT (32 bits)	Internal	Measurand-I			Input	DINT range
DINT (32 bits)	Internal	Measurand-II			Input	DINT range
BOOL (8 bits)	Internal	System Function	Time Sync		Output	TRUE: Time Sync
BOOL (8 bits)	Internal		GI	Operation	Output	TRUE:Group Interrogation
BOOL (8 bits)	Internal		Online		Input	TRUE:Online FALSE:Offline

Table 4 Data Types Mapping between MOXGRAF and IEC 60870-5-103

4.2.5 Mapping Variables

The following procedure describes how to map the variables. First of all, switch MOXGRAF to Resource view; select **Resource | IEC 60870-5-103 Master Setting** to get the pop-up IEC103 Master Setting window.

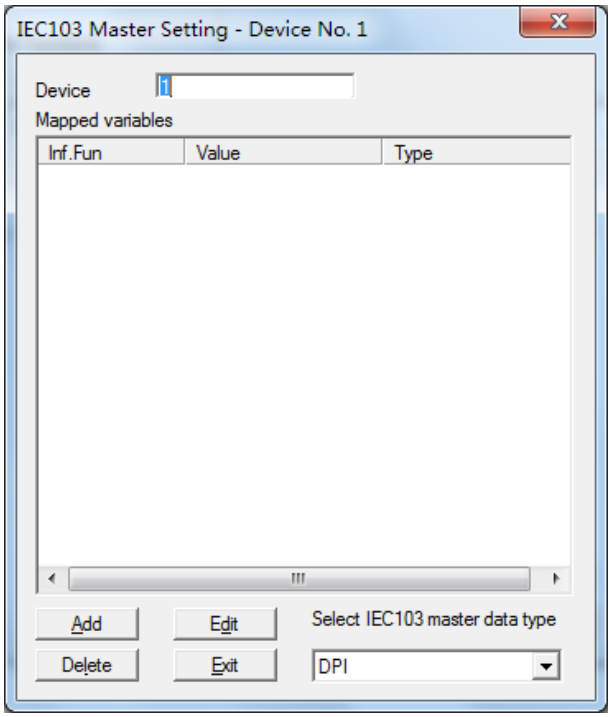

Figure 19 IEC 60870-5-103 Master Setting Window

Click button ‘Add’. In the pop-up window, the “Device” is supposed to be the device number which is automatically generated in slave parameters configuration. Refer to 4.2.2 for more information. Enter a device number in “Device” field, select data type and click “Add” button. The IEC103 Master Variable Add/Edit window appears. The ‘Inf’ is the second octet of the INFORMATION OBJECT IDENTIFIER; it defines the INFORMATION NUMBER within a given FUNCTION TYPE. The ‘Fun’ is the first octet of the INFORMATION OBJECT IDENTIFIER; it defines the FUNCTION TYPE of the protection equipment used.
Enter ‘Inf’ and ‘Fun’ information and select a variable from the drop down list. Thus, the variable is mapped to that specific device.

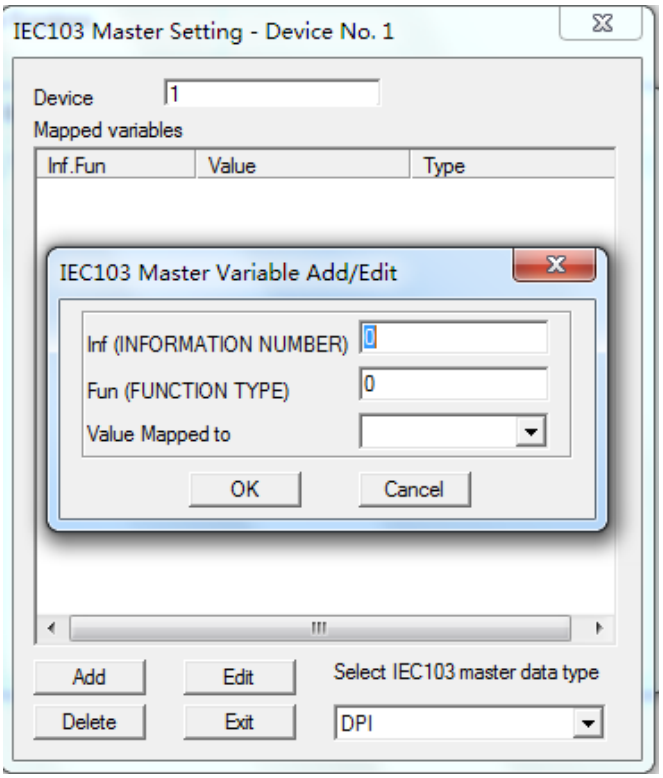

Figure 20 Map IEC 608705-103 DPI Variables

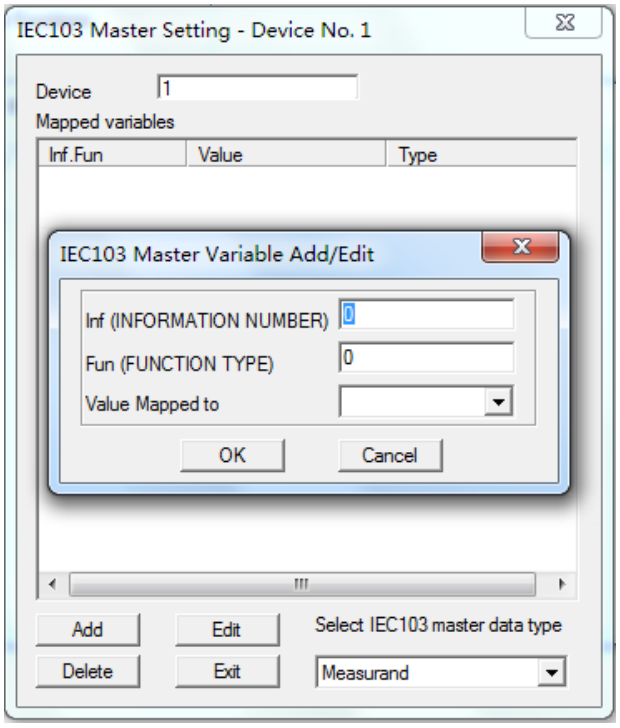

Figure 21 Map IEC 608705-103 Measurand Variables

When adding a DCO variable, a control variable is required in the “Control Mapped to field”. The DCO variable value only works out after the control variable changes from false to true.

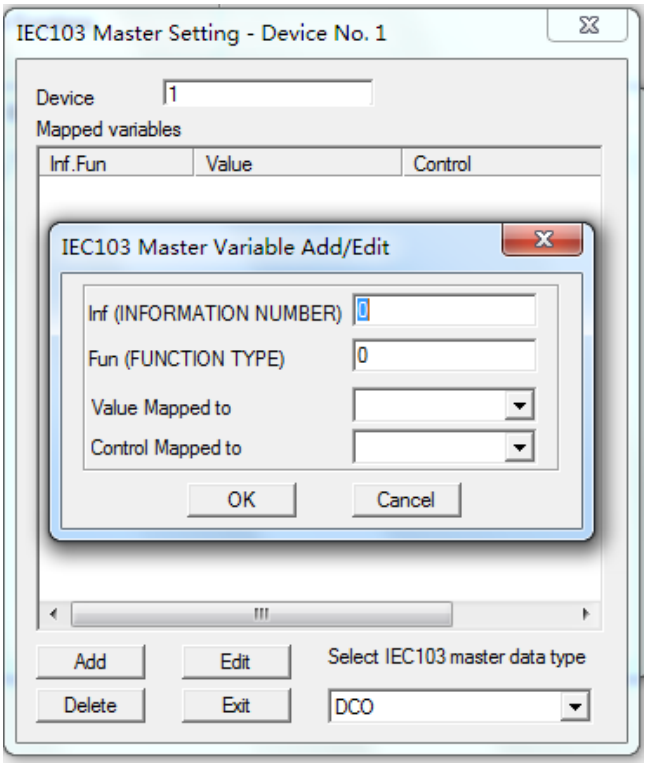

Figure 22 Map IEC 608705-103 DCO Variables

4.2.6 Build Data Map Configuration File

In MOXGARF toolbar, select **Resource** | **Build** to build the data map configuration file.

4.2.7 Export Mapped Variables to .csv File

The CSV ("Comma Separated Value") file format is saved with values separated by commas and can be opened by either EXCEL or Notepad which is much more convenient for users to check the information of variables.

Select Export from the menu within IEC103 Master Setting window.

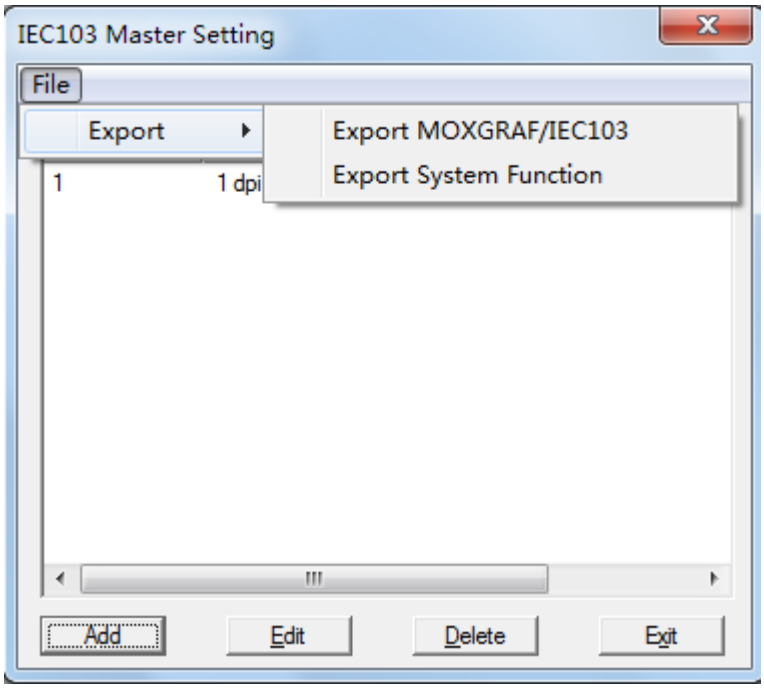

Figure 23 IEC 60870-5-103 Export from Menu

Select the information you want to export. For example, when selecting “Export MOXGRAF/IEC103”, the following window pops up:

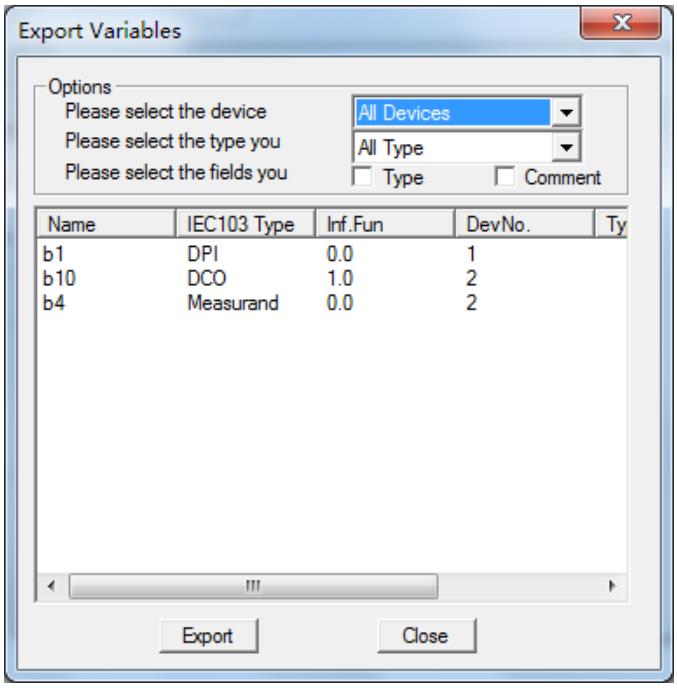

Figure 24 IEC 60870-5-103 Export Window

In this dialog, all information that users can choose is included. All mapped variables are listed in the list box as a default setting. They are sorted by different IEC 60870 Types. Corresponding variables and related information will show in the list box for users to export. Click the “Export” button as shown in the above figure and the user will be prompted to enter a file name and choose the place to export to.

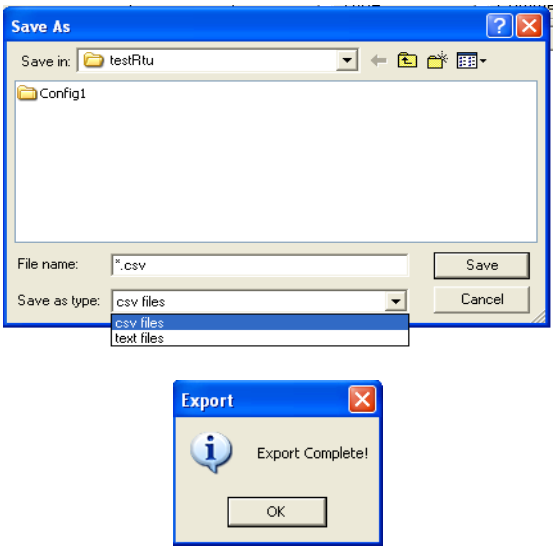

Figure 25 IEC 60870-5-103 Export Complete

The exported file can be saved as either .csv or .txt type.

5 IEC60870-5-104 Slave

5.1 Usage

5.1.1 Data Types

IEC 60870 uses a Type ID (TI) to identify each Information Object. An Information Object may contain one or more Information Elements but the TI applies to all information contained within the Application Service Data Unit (ASDU). The TI embodies a function code and data format. In general, all information object element types can be sorted into the following categories:

- Digital Inputs: Single point information
- Integer Inputs: Step position information, Normalized measured value and Integrated total (Counters)
- Float Inputs: Short Floating Measured Value
- Digital Outputs: Single Command and Regulating Step Command
- Integer Outputs: Set Point Command
- Float Outputs: Set short floating point value

5.1.2 Address

There are three kinds of addresses, which are all fixed for each slave:

1) Link Address: zero, one or two octets
2) Common Address of ASDUs: one or two octets
3) Information Object Address: one, two or three octets

The Link address is the device address used by IEC 60870-5-104. It prevents peer to peer network of more than two devices and can be unrelated to common address.

The common address is the station address. In most cases, the common address together with the information object address distinguishes the complete set of information elements within a specific system. The combination of both addresses should be unambiguous for each slave.

5.1.3 Data Transfer

There are two kinds of data (acquisition) transfer modes for monitored information objects:

- Spontaneous and Station Interrogation (and Background Scan)
- Cyclic/Periodic

A spontaneous data transfer has the highest priority and efficiency, in which most communication is unsolicited, but the master occasionally sends station interrogation to verify if its database is up to date. It needs to transmit only when there is a change of state or measured value. Station interrogation can be used to verify whether its database is up to date. In order to avoid data lose, a background scan may be used as an additional safeguard. A background scan data transfer has the lowest priority and a long period, such as 10 minutes, 20 minutes or even longer.

Cyclic data transfer has comparatively lower priority and efficiency. This mode is used for unimportant and slow changing points. Cyclic data is different to a station interrogation transfer and also cannot be configured as background scan data. A cyclic data transfer ensures that analog data is refreshed at regular intervals and is supplementary to a changed data type transmission.

5.1.4 Event Buffer

A controlled station stores all local events with queue. When working in a balanced communications mode, it will report unsolicitedly. If the system is working in unbalanced mode the controlled station has to wait to be polled by the controlling station. When an event buffer overflows, it will discard either the latest or oldest value. Which value is discarded depends on the users' configuration.

5.1.5 Data Class and Group

IEC 60870 supports Class 1 and Class 2 user data. Class 1 user data has a higher priority than Class 2 user data. The Data Class priority is fixed by the system so that a user can only select different data transfer modes to meet different priorities. Detailed priorities for Class 1 and Class 2 user data are listed below.

5.1.5.1 Class 1 User Data

The priority is in descending order from 1 to 16:

Priority	ASDU
1	Confirm of Application Request
2	End of Initialization
3	Command Transmission – Control Command
4	Command Transmission – Control Command
5	Command Transmission – Control Command
6	Event Reporting – Change of State
7	Event Reporting – Change of Measure
8	Clock Synchronization
9	Acquisition of Transmission Delay
10	Read
11	Test
12	Reset Process
13	Parameter Loading
14	Station Interrogation
15	Integrated Totals
16	Sequence of Event

Table 5 Class 1 User Data Priorities

5.1.5.2 Class 2 User Data

The priority is in descending order from 1 to 3:

Priority	ASDU
1	Cyclic Data
2	File Transfer
3	Background Scan

Table 6 Class 2 User Data Priorities

5.1.5.3 Group

When a system involves a large amount of variables a user can divide them into different groups according to specific requirements. These are from Group 1 to Group 16. In this case, group interrogation is a more effective way of data transfer if a user needs a certain group of variables. Another alternative available to the user is to choose to adopt global variable interrogation.

5.1.6 Multiple Logical Entities

A slave implementation using a MOX Unity can currently support multiple logical entities, i.e. logical RTUs.

5.1.7 Redundancy Features

In a MOX Unity system, a slave configured implementation would currently support ***controller*** and ***data path redundancy.***

5.1.7.1 MOX Unity Redundancy

Redundant MOX Unitys would automatically backup the data between Primary Slave and Standby Slave as shown in the following figure.

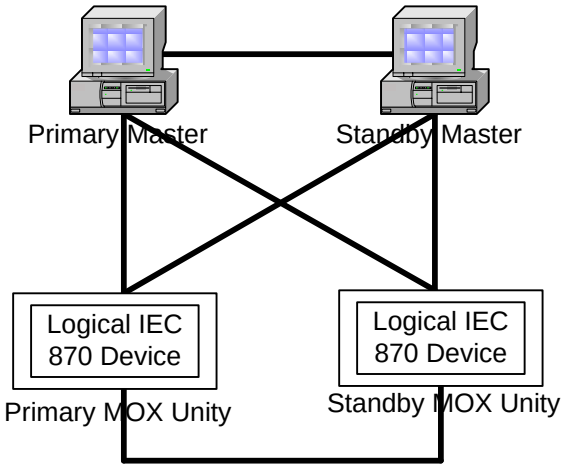

Figure 26 Controller Redundancy

5.1.7.2 Data Path Redundancy (101)

In a MOX Unity system, each logical IEC 60870 slave supports data path redundancy. Which data path is primary or standby is determined by the Data Path's Priority Parameter. The data path with the highest priority is the primary data path and other data paths are standby data paths. If two data path's priorities are the same, then the first data path, in the configured list, will be primary data path by default.

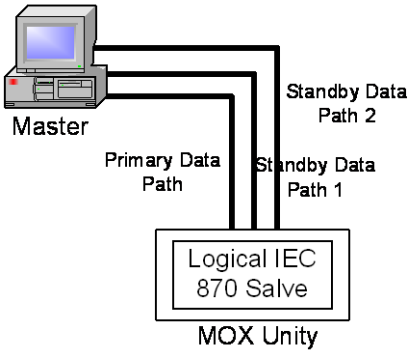

Figure 27 Typical data path redundancy (I)

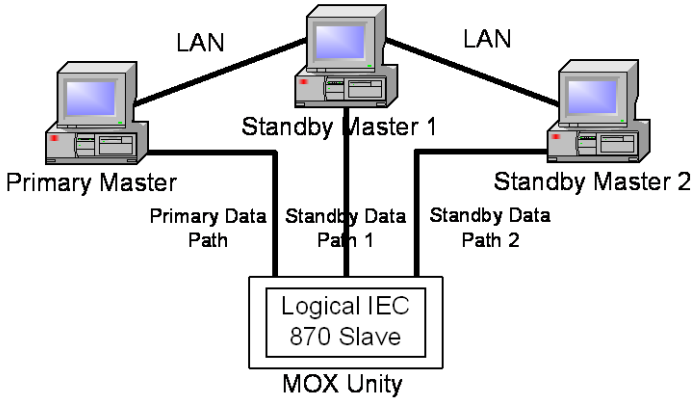

Figure 28 Typical data path redundancy (II)

Data Path Redundancy Rule

The rule will be explained for using the various communication paths where there are three data paths: a Primary data path, Standby data path 1 and Standby data path 2. All communication paths are connected to one logical IEC 60870 slave.

1) When a Primary Data Path failure is detected, the MOX Unity will try Standby Data Path 1. If Standby Data Path 1 also fails then the MOX Unity will try Standby Data Path 2.
2) When MOX Unity uses Standby Data Path 1 or 2, it still keeps checking the Primary Data Path. Ten minutes after the Primary Data Path recovers the MOX Unity will switch back from the Standby Data Path 1 or 2 to the Primary Data Path.
3) When the MOX Unity is using the Primary Data Path, it will not check Standby Data Paths 1 or 2.
4) When the MOX Unity receives data from an inactive data path, this data path will become active. For example, the MOX Unity communicates with the Master through the Primary Data Path. The MOX Unity then receives a poll static objects command through Standby Data Path 2. Standby Data Path 2 will now become active. In this case the MOX Unity considers that the Primary Data Path has failed.
5) Data path redundancy is only available within IEC 60870-5-101. There is no data path redundancy for IEC 60870-5-104. Furthermore, serial ports and network ports cannot be set as path redundancies for each other.

⚠	*There is no data path redundancy implemented for IEC 60870-5-104.*

5.2 Configuration

MOXGRAF is used to configure the slaves' system parameters, map variables, assign IEC 60870 objects to a group, as well as select the transmission mode and the time tag.

From the available configuration pages, Select IEC 60870 Tab.

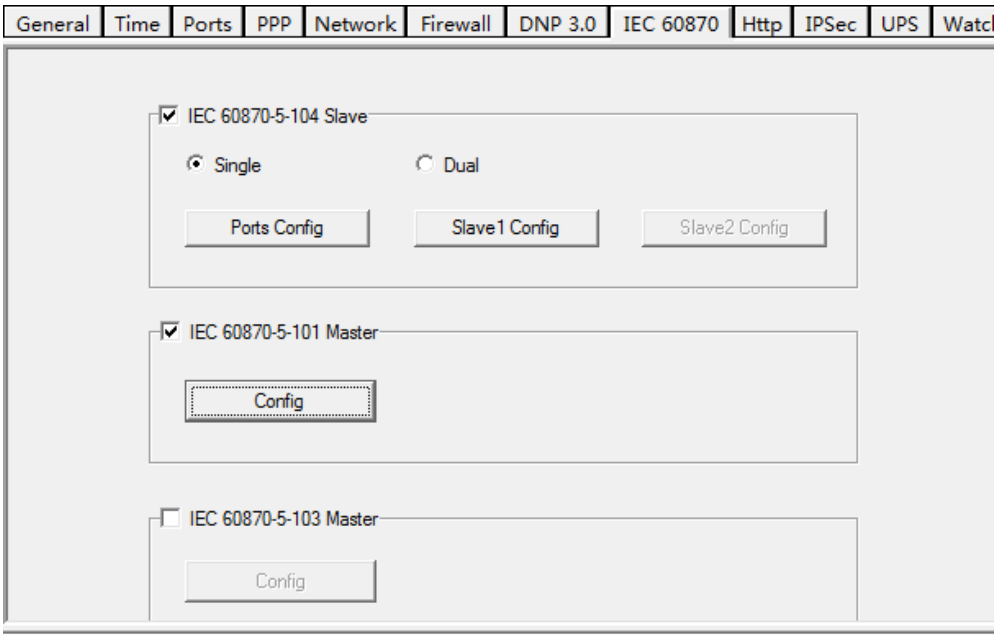

Figure 29 IEC 60870 Function Selection

Selectable IEC 60870-104 Function descriptions:

1) Single – the MOX Unity supports one logical IEC 60870 slave.
2) Dual – the MOX Unity supports two logical IEC 60870 slaves. (Slave addresses must be different.)

5.2.1 Ethernet Ports Configuration

In the IEC 60870-5-104 configuration page, click the "Ports Configure" button. The "Ethernet Ports" configuration dialog will pop up. The Ethernet port configuration is used for IEC 60870-104, which only works in balanced mode since it has no data link layer.

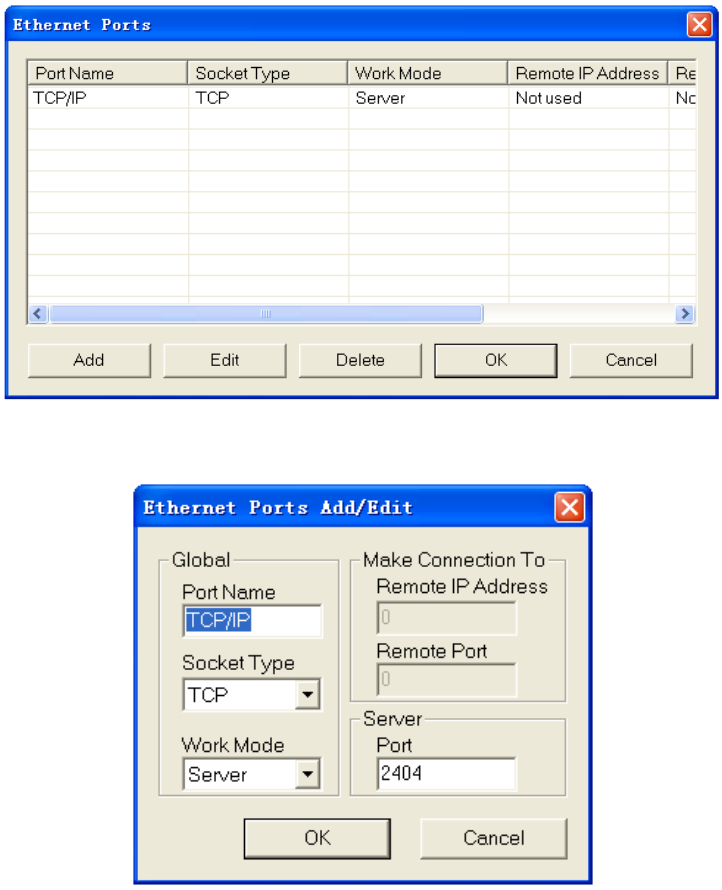

Figure 30 IEC 60870-5 -104 Ethernet Port Setting

5.2.2 Slave Parameters Configuration

In the IEC 60870-5-104 configuration page, click the “Slave1 Configure” or “Slave2 Configure” button. The configuration dialog will pop up.

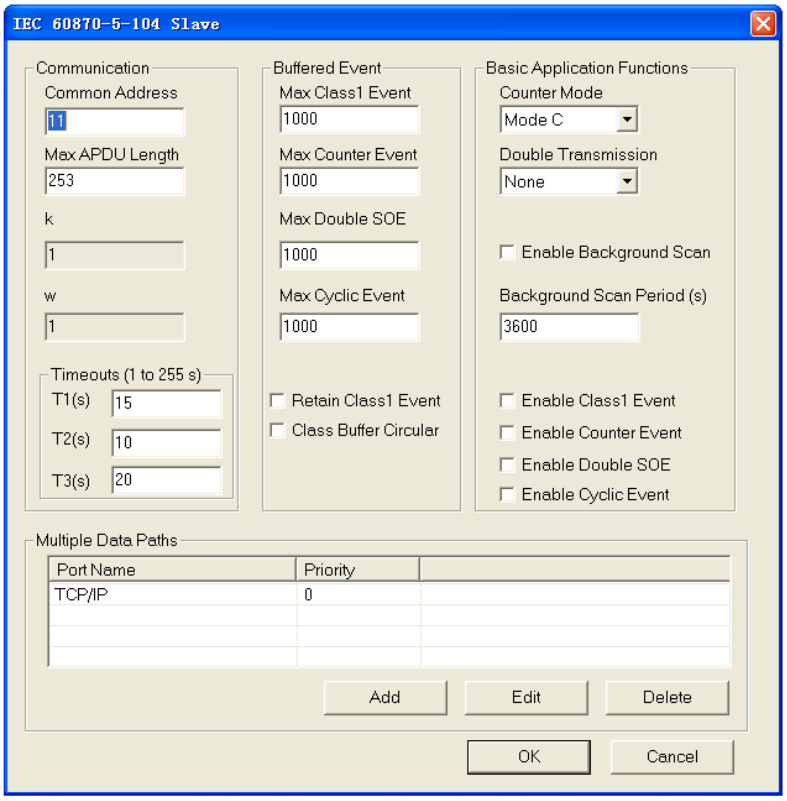

Figure 31 IEC 60870-5 -104 Slave Parameters Setting

The following table gives specific descriptions of each item within IEC 60870-104 Slave Parameters Setting window:

Items		Descriptions	Value
Communication	Common Address	IEC 60870 address of the MOX Unity	0 ~ 255
	Max APDU Length	Max length of APDU	0 ~ 255
	k	Max APDUs sent out before confirm	Fixed as 1 at present
	w	Max APDUs to be confirmed	Max APDUs to be confirmed
	T1	Time-out of send or test APDUs	1 ~ 255, default value 15s
	T2	Time-out for acknowledges in case of no data messages T2 < T1	1 ~ 255, default value 10s
	T3	Time-out for sending test frames in case of a long idle state	1 ~ 255, default value 20s
Buffered Event	Max Class1 Event	Class1 event is used for normal state change and soe event	1 ~ 65,535
	Max Counter Event	Counter event is used for integrated totals	1 ~ 65,535
	Max Double SOE	Double SOE event is used for double transmission	1 ~ 65,535
	Max Cyclic Event	Cyclic event is used for cyclic data	1 ~ 65,535
	Retain Class1 Event	Save events to a file. After MOX Unity restart, restore events from the file. Only Class1 Event can be retained since other events have no need to restore.	
	Class Buffer Circular	*Enable class buffer circular:* discard the oldest value when buffer overflow *Disable class buffer circular:* discard the latest value when buffer overflow	
Basic Application Functions	Counter Mode	*Mode A*: Local freeze with spontaneous transmission *Mode B*: Local freeze with counter interrogation *Mode C*: Freeze and transmit by counter-interrogation commands *Mode D*: Freeze by counter-interrogation command, frozen values reported	
	Double Transmission	First send stat change event without time stamp in time and then send event with time stamp in succession.	
	Enable Background Scan	Enable Background scan.	
	Background Scan Period	Background scan period if it is enabled.	
	Enable Class1 Event	Enable Class1 Event.	1 ~ 65,535
	Enable Counter Event	Enable Counter Event.	
	Enable Double SOE	Enable Double SOE.	
	Enable Cyclic Event	Enable Cyclic Event.	
Multiple Data Paths Description	Only a single path is supported for IEC 60870-5-104.		

Table 7 IEC 60870-5-104 Slave Parameters Setting Descriptions

5.2.3 Download Configuration

Select **Device | Download Configurations** Click to download the configuration to the controller. You may need to reboot the Unity before the settings take effect.

5.2.4 Multiple Logical Slaves

In some systems, it is desirable to have multiple IEC 60870 master stations simultaneously accessing the same outstation. This may be required for some redundant schemes or multiple users of single outstation data. Such a setup requires that the outstation have some way for uniquely identifying the various masters depending on how the data is reported. Each master may have access to different data or have different access permissions. The outstation must also maintain a set of state information which may consist of variables and event buffers for each master with which it communicates.

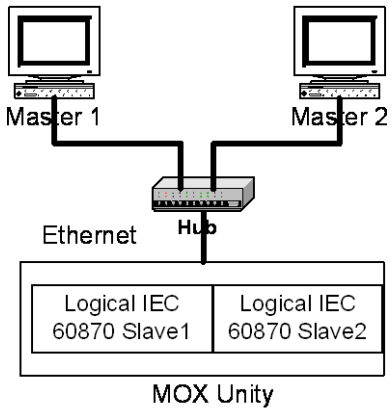

Figure 32 Typical Double Slaves (104)

Typical double slaves (104) description:
This scheme of typical double slaves requires the connection management layer to listen on different ports. Each logical IEC 60870 slave is assigned to a specific port so the IEC 60870 message routing is predefined.

Note:

1) All multiple IEC 60870 slaves' variables are the same in MOXGRAF. That means there is only one IEC 60870 setting (configured by MOXGRAF) to map MOXGRAF variables to IEC 60870 variables.
2) Multiple IEC 60870 slaves are independent. Every IEC 60870 slave has its own Class1, Class2 buffer, etc. It also means every IEC 60870 slave has its own parameters.
3) If multiple IEC 60870 masters are connected to the MOX Unity, each master can control the MOXGRAF variables. The privileges (such as event reports, changing the value of analog outputs, etc) that the IEC 60870 masters have and the control they exercise via the MOX Unity are designed by user.

Configuration:

To configure this option, Select "Dual" . Both Slave 1 and Slave 2 buttons will be enabled.

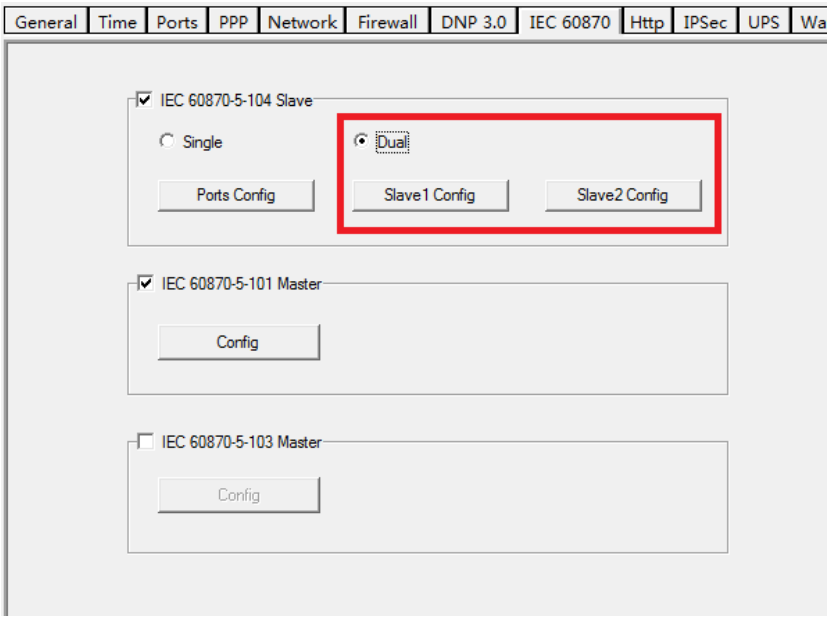

Figure 33 IEC 60870-5 -104 Dual Slave Configuration

For configuration of Ethernet and Slave Parameters, please refer to 5.2.1 Ethernet Ports Configuration as well as 5.2.2 Slave Parameters Configuration.

Parameters of Slave 1 and Slave 2 should be configured separately.

5.2.5 Data Types Mapping

Various IEC 60870 Information Objects can be bound with MOXGRAF variables. The table below shows the matching data type between MOXGRAF Data and IEC 60870-5-104 Data:

MOXGRAF Data Types	IEC 60870-5-104 Data Types
BOOL (8 bits)	Digital Inputs
DINT (32 bits)	Integer Inputs
REAL (32 bits)	Float Inputs
BOOL (8 bits)	Digital Outputs
DINT (32 bits)	Integer Outputs
REAL (32 bits)	Float Outputs

Table 8 Data Types Mapping between MOXGRAF and IEC 60870-5 -104

5.2.6 Mapping Variables

The following procedure describes how to map the variables. First of all, switch MOXGRAF to Resource view; select **Resource | IEC 60870-5-104 Slave Setting** to get the pop-up IEC 60870-5-104 setting window.

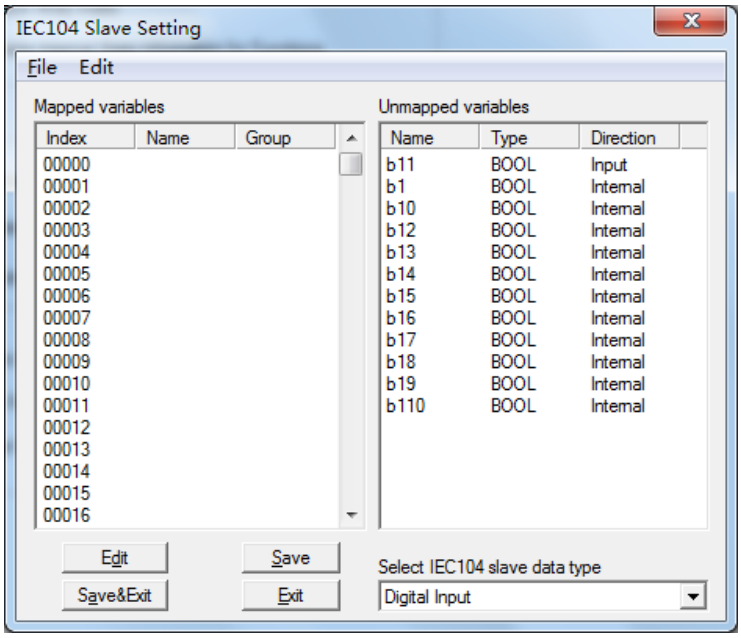

Figure 34 IEC 60870-5 -104 Slave Setting Window

Select the index from the **Mapped variables** list on the left and then double click the variable you want to map to the selected index from **Unmapped variables** list on the right. This variable will immediately go to the left list. In order to map more variables, just repeat this procedure. Click the **Save** or the **Save&Exit** button to save the changes.

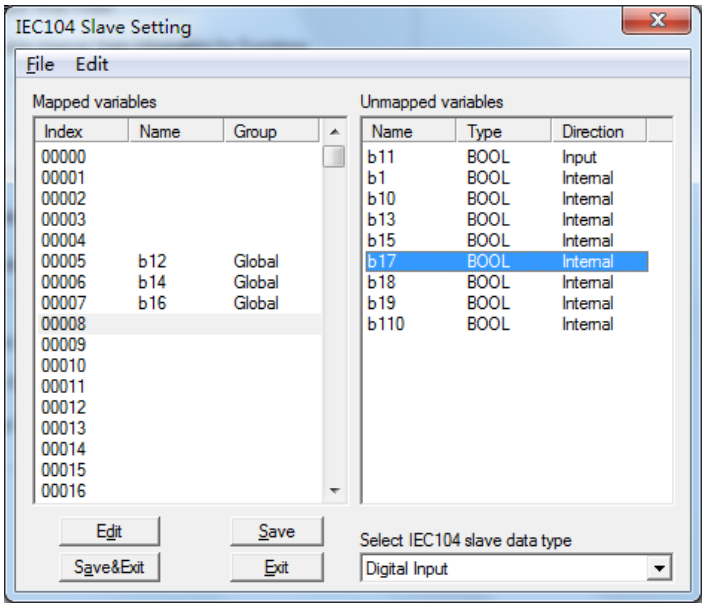

Figure 35 Map IEC 60870-5 -104 Variables

5.2.7 Unmapping Variables

To unmap variables do the following; in the **Mapped variables** list, double click the row you want unmapped. To unmap more variables, just repeat the procedure. Click **Save** or **Save&Exit** button to save the changes.

5.2.8 *Edit Mapped Variables' Group and Other Settings*

In the **Mapped variables** list, select the row you want to edit and click the **Edit** button. The edit dialog will pop up. Change the Group and any other settings according to your requirements, then click the **OK** button to close the dialog and click **Save** button on the IEC 60870 Slave Setting window.

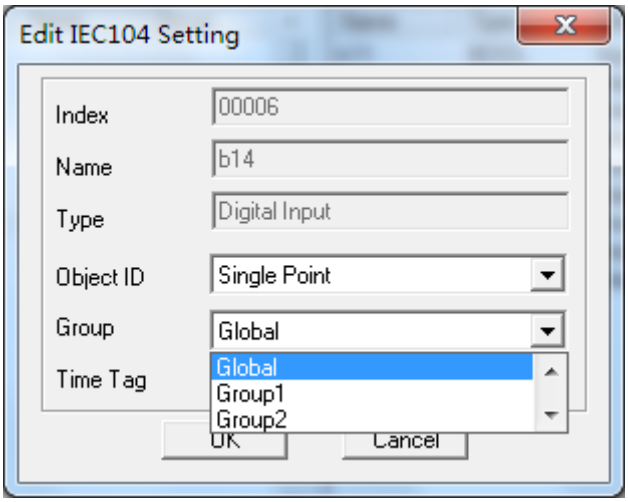

Figure 36 IEC 60870-5 -104 Group Setting

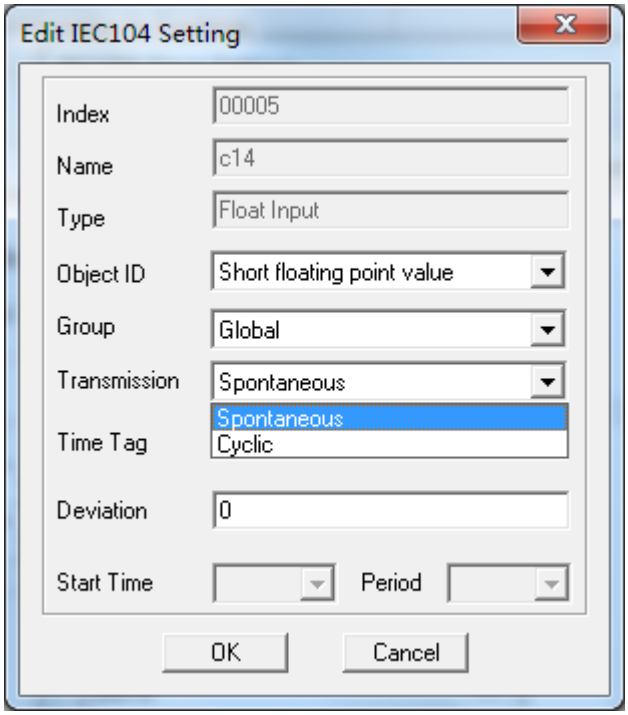

Figure 37 IEC 60870-5 -104 Transmission Setting

Following are the specific descriptions of each item that can be changed by the user in the settings window:

IEC 60870 Data Types

Data Type = Digital Input, Type ID = 1/30, Single-point information
Data Type = Integer Input, Type ID = 9/34, Measure value, normalized value
Data Type = Float Input, Type ID = 13/36, Measure value, short floating point value
Data Type = Counter, Type ID = 15/37, Integrated totals
Data Type = Digital Output, Type ID = 45, Single Command
Data Type = Integer Output, Type ID = 48, Set point command, normalized value
Data Type = Float Output, Type ID = 50, Set point command, short floating point value

Object ID

One *Data Type* may be supported by several Type IDs. For example, a digital input may be represented by a single point, a double point or a step position.

However, the current implementation only supports a single Type ID for each Data Type.

Group

All input variables including Digital Inputs, Integer Inputs and Float Inputs can be divided into groups. These groups are Group1 to Group16. This feature is used to respond to group interrogation commands. For the counter data type, only the general counter is supported at present.

Transmission

There are two kinds of transmission types available: Spontaneous and Cyclic. The former is controlled by deviation while the latter is controlled by start time and period. A digital input's data is transmitted whenever reversion occurs.

Time Tag

All input variables can be selected either without time tag or with seven-octet time tag.

Deviation

In the spontaneous transmission mode, integer and float are controlled by deviation. When the deviation value exceeds the defined value, a normal state change event will be produced.

Start Time & Period

In cyclic transmission mode for integer and float, Start Time & Period are used to control the start time and cyclic period.

5.2.9 Build Data Map Configuration File

In MOXGARF toolbar, select **Resource** | **Build** to build the data map configuration file.

5.2.10 Export Mapped Variables to .csv File

The CSV ("Comma Separated Value") file format is saved with values separated by commas and can be opened by either EXCEL or Notepad which is much more convenient for users to check the information of variables.

Select Export from the menu within IEC104 Slave Setting window.

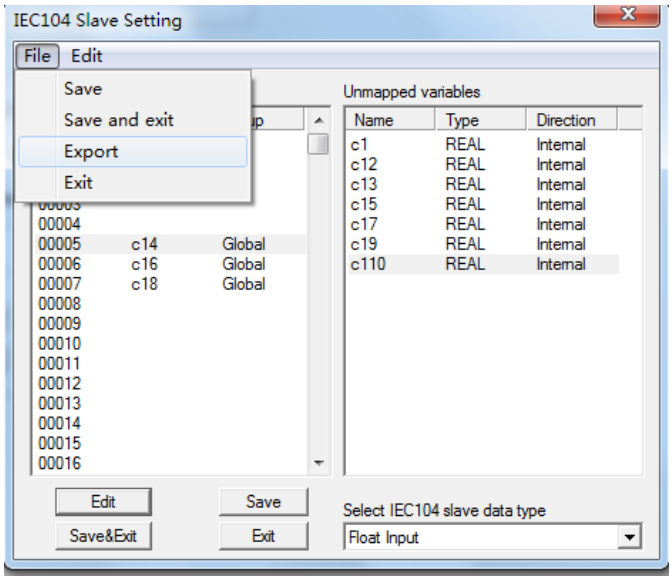

Figure 38 IEC 60870-5 -104 Export from Menu

The following window pops up:

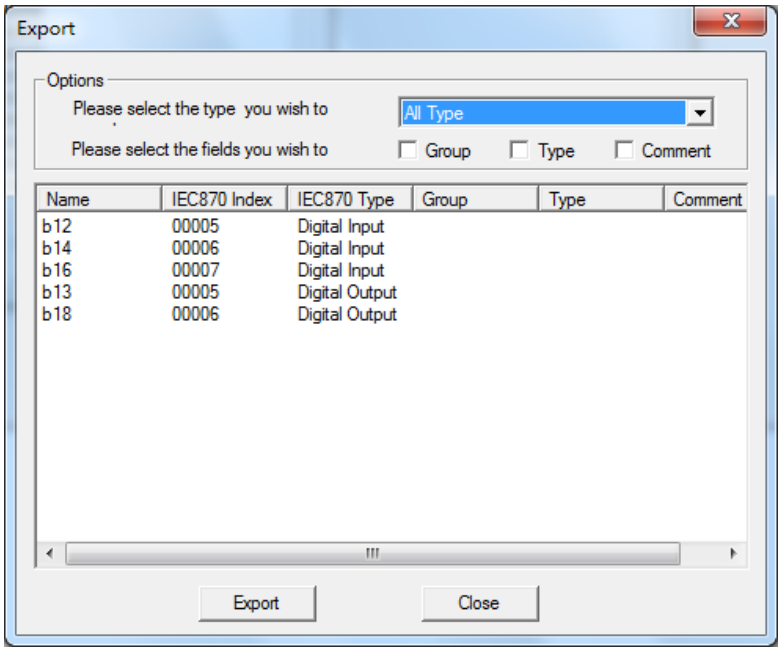

Figure 39 IEC 60870-5 -104 Export Window

In this dialog, all information that users can choose is included. All mapped variables are listed in the list box as a default setting. “Name”, “IEC 60870-5-104 Index” and “IEC 60870-5-104 Type” are compulsory while “Group”, “Type” and “Comment” are optional. Variables are sorted by different IEC 60870 Types. Corresponding variables and related information will show in the list box for users to export. The sequence of items in the list box can also be changed by “drag-and-drop” operation. Click the “Export” button as shown in the above figure and the user will be prompted to enter a file name and choose the place to export to.

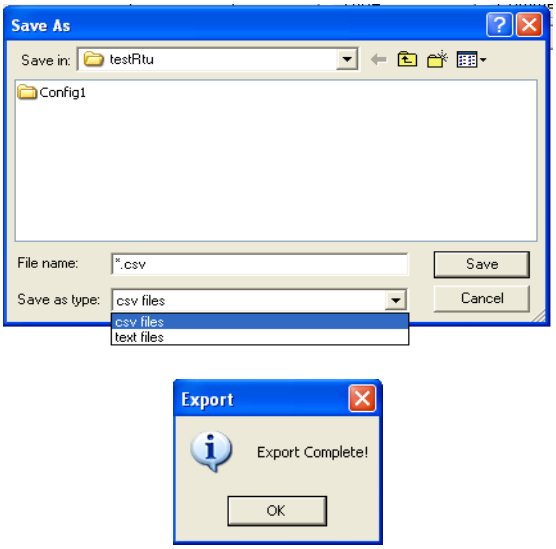

Figure 40 IEC 60870-5 -104 Export Complete

The exported file can be saved as either .csv or .txt type.
The following is the exported file which has been opened using Microsoft EXECL. The contents are exactly the same as those shown in the list box.

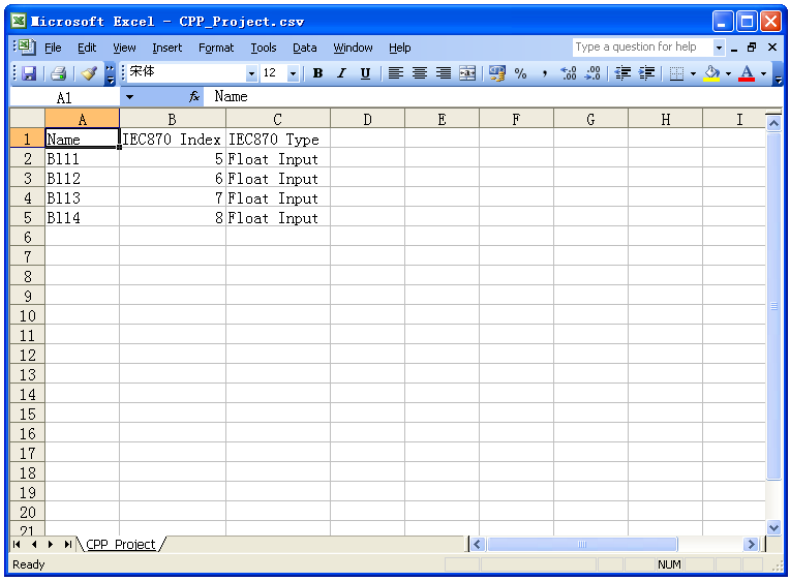

Figure 41 Exported IEC 60870-5 -104 File

Appendix A IEC60870-5-101 Master Interoperability

This companion standard presents sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameter values, such as the number of octets in the COMMON ADDRESS of ASDUs represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications. This Clause summarizes the parameters of the previous Clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers, it is necessary that all partners agree on the selected parameters.

The selected parameters should be marked in the white boxes as follows:

☐ Function or ASDU is not used

☒ Function or ASDU is used as standardized (default)

R Function or ASDU is used in reverse mode

B Function or ASDU is used in standard and reverse mode

The possible selection (blank, X, R, or B) is specified for each specific Clause or parameter.

NOTE: In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.

1. System or device

(system-specific parameter, indicate the definition of a system or a device by marking one of the following with an "**X**")

☐ System definition

☒ Controlling station definition (master)

☐ Controlled station definition (slave)

2. Network configuration

(network-specific parameter, all configurations that are used are to be marked with an "X")

☒ Point-to-point

☒ Multiple point-to-point

☒ Multipoint-partyline

☐ Multipoint-star

3. Physical layer

(network-specific parameter, all interfaces and data rates that are used are to be marked with an "X")

Transmission speed (control direction)

Unbalanced interchange Circuit V.24/V.28 Standard	Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200 bit/s	Balanced interchange Circuit X.24/X.27	
☐ 100 bit/s	☒ 2 400 bit/s	☒ 2 400 bit/s	☐ 56 000 bit/s
☐ 200 bit/s	☒ 4 800 bit/s	☒ 4 800 bit/s	☐ 64 000 bit/s
☐ 300 bit/s	☒ 9 600 bit/s	☒ 9 600 bit/s	
☐ 600 bit/s		☒ 19 200 bit/s	
☐ 1 200 bit/s		☒ 38 400 bit/s	

Transmission speed (monitor direction)

Unbalanced interchange Circuit V.24/V.28 Standard	Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200 bit/s	Balanced interchange Circuit X.24/X.27	
☐ 100 bit/s	☒ 2 400	☒ 2 400 bit/s	☐ 56 000 bit/s
☐ 200 bit/s	☒ 4 800	☒ 4 800 bit/s	☐ 64 000 bit/s
☐ 300 bit/s	☒ 9 600	☒ 9 600 bit/s	
☐ 600 bit/s		☒ 19 200 bit/s	
☐ 1 200		☒ 38 400 bit/s	

4. Link layer

(network-specific parameter, all options that are used are to be marked with an "X". Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the type ID and COT of all messages assigned to class 2.)

Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.

Link transmission procedure

- ☒ Balanced transmission
- ☒ Unbalanced transmission

Address field of the link

- ☒ Not present (balanced transmission only)
- ☒ One octet
- ☒ Two octets

Frame length

5. Application layer

Transmission mode for application data

262 Maximum length L (control direction)	☐ Structured
	☒ Unstructured
262 Maximum length L (monitor direction)	

Mode 1 (least significant octet first), as defined in 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

Common address of ASDU
(system-specific parameter, all configurations that are used are to be marked with an "**X**")

☒ One octet	☒ Two octets

Information object address
(system-specific parameter, all configurations that are used are to be marked with an "**X**")

☒ One octet	☐ Structured
☒ Two octets	☒ Unstructured
☒ Three octets	

Cause of transmission
(system-specific parameter, all configurations that are used are to be marked with an "**X**")

☒ One octet	☒ Two octets (with originator address) Originator address is set to zero if not used

Selection of standard ASDUs

Process information in monitor direction

(station-specific parameter, mark each type ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

[X]	<1> :=	Single-point information	M_SP_NA_1
[ ]	<2> :=	Single-point information with time tag	M_SP_TA_1
[ ]	<3> :=	Double-point information	M_DP_NA_1
[ ]	<4> :=	Double-point information with time tag	M_DP_TA_1
[ ]	<5> :=	Step position information	M_ST_NA_1
[ ]	<6> :=	Step position information with time tag	M_ST_TA_1
[ ]	<7> :=	Bitstring of 32 bit	M_BO_NA_1
[ ]	<8> :=	Bitstring of 32 bit with time tag	M_BO_TA_1
[X]	<9> :=	Measured value, normalized value	M_ME_NA_1
[ ]	<10> :=	Measured value, normalized value with time tag	M_ME_TA_1
[X]	<11> :=	Measured value, scaled value	M_ME_NB_1
[ ]	<12> :=	Measured value, scaled value with time tag	M_ME_TB_1
[X]	<13> :=	Measured value, short floating point value	M_ME_NC_1
[ ]	<14> :=	Measured value, short floating point value with time tag	M_ME_TC_1
[X]	<15> :=	Integrated totals	M_IT_NA_1
[ ]	<16> :=	Integrated totals with time tag	M_IT_TA_1
[ ]	<17> :=	Event of protection equipment with time tag	M_EP_TA_1
[ ]	<18> :=	Packed start events of protection equipment with time tag	M_EP_TB_1
[ ]	<19> :=	Packed output circuit information of protection equipment with time tag	M_EP_TC_1
[ ]	<20> :=	Packed single-point information with status change detection	M_PS_NA_1
[ ]	<21> :=	Measured value, normalized value without quality descriptor	M_ME_ND_1
[X]	<30> :=	Single-point information with time tag CP56Time2a	M_SP_TB_1
[ ]	<31> :=	Double-point information with time tag CP56Time2a	M_DP_TB_1
[ ]	<32> :=	Step position information with time tag CP56Time2a	M_ST_TB_1
[ ]	<33> :=	Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
[X]	<34> :=	Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
[X]	<35> :=	Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
[X]	<36> :=	Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
[X]	<37> :=	Integrated totals with time tag CP56Time2a	M_IT_TB_1
[ ]	<38> :=	Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
[ ]	<39> :=	Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
[ ]	<40> :=	Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

Process information in control direction

(station-specific parameter, mark each type ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

[X]	<45> :=	Single command	C_SC_NA_1
[ ]	<46> :=	Double command	C_DC_NA_1
[ ]	<47> :=	Regulating step command	C_RC_NA_1
[X]	<48> :=	Set point command, normalized value	C_SE_NA_1
[ ]	<49> :=	Set point command, scaled value	C_SE_NB_1
[ ]	<50> :=	Set point command, short floating point value	C_SE_NC_1
[ ]	<51> :=	Bitstring of 32 bit	C_BO_NA_1

System information in monitor direction

(station-specific parameter, mark with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

[ ]	<70> :=	End of initialization	M_EI_NA_1

System information in control direction

(station-specific parameter, mark each type ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

[X]	<100>:=	Interrogation command	C_IC_NA_1
[X]	<101>:=	Counter interrogation command	C_CI_NA_1
[ ]	<102>:=	Read command	C_RD_NA_1
[X]	<103>:=	Clock synchronization command	C CS NA 1
[ ]	<104>:=	Test command	C_TS_NA_1
[X]	<105>:=	Reset process command	C_RP_NA_1
[ ]	<106>:=	Delay acquisition command	C_CD_NA_1

Parameter in control direction

(station-specific parameter, mark each type ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☐	<110>:=	Parameter of measured value, normalized value	P_ME_NA_1
☐	<111>:=	Parameter of measured value, scaled value	P_ME_NB_1
☐	<112>:=	Parameter of measured value, short floating point value	P_ME_NC_1
☐	<113>:=	Parameter activation	P_AC_NA_1

File transfer

(station-specific parameter, mark each type ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☐	<120>:=	File ready	F_FR_NA_1
☐	<121>:=	Section ready	F_SR_NA_1
☐	<122>:=	Call directory, select file, call file, call section	F_SC_NA_1
☐	<123>:=	Last section, last segment	F_LS_NA_1
☐	<124>:=	Ack file, ack section	F_AF_NA_1
☐	<125>:=	Segment	F_SG_NA_1
☐	<126>:=	Directory {blank or X, only available in monitor (standard) direction}	F_DR_TA_1

6. Basic application functions

Station initialization
(station-specific parameter, mark with an "**X**" if function is used)

[X] Remote initialization

Read procedure
(station-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

[ ] Read procedure

Station interrogation
(station-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

[X] global
[X] group 1
[X] group 2
[X] group 3
[X] group 4
[X] group 5
[X] group 6
[X] group 7
[X] group 8
[X] group 9
[X] group 10
[X] group 11
[X] group 12
[X] group 13
[X] group 14
[X] group 15
[X] group 16

Information object addresses assigned to each group must be shown in a separate table

Clock synchronization
(station-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

[X] Clock

Command transmission
(object-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

- [X] Direct command transmission
- [X] Direct set point command transmission
- [X] Select and execute command
- [X] Select and execute set point command
- [ ] C_SE ACTTERM used

- [ ] No additional definition
- [ ] Short-pulse duration (duration determined by a system parameter in the controlled station)
- [ ] Long-pulse duration (duration determined by a system parameter in the controlled station)
- [ ] Persistent output

Transmission of integrated totals
(station- or object-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

- [X] Mode A: local freeze with spontaneous transmission
- [X] Mode B: local freeze with counter interrogation
- [X] Mode C: freeze and transmit by counter interrogation commands
- [X] Mode D: freeze by counter-interrogation command, frozen values reported spontaneously

- [X] Counter read
- [X] Counter freeze without reset
- [X] Counter freeze with reset
- [X] Counter reset

- [X] General request counter
- [ ] Request counter group 1
- [ ] Request counter group 2
- [ ] Request counter group 3
- [ ] Request counter group 4

Parameter loading
(object-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

- ☐ Threshold value
- ☐ Smoothing factor
- ☐ Low limit for transmission of measured value
- ☐ High limit for transmission of measured value

Parameter activation
(object-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

- ☐ Act/deact of persistent cyclic or periodic transmission of the addressed object

Test procedure
(station-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

- ☐ Test procedure

File transfer
(station-specific parameter, mark with an "**X**" if function is used)

File transfer in monitor direction

- ☐ Transparent file
- ☐ Transmission of disturbance data of protection equipment
- ☐ Transmission of sequences of events
- ☐ Transmission of sequences of recorded analogue values

File transfer in control direction

- ☐ Transparent file

Appendix B IEC60870-5-103 Master Interoperability

1. **Physical layer**

1.1 Electrical interface

[X] EIA RS-485

[X] Number of loads .....32..... for one protection equipment

NOTE – EIA RS-485 standard defines unit loads so that 32 of them can be operated on one line. For detailed information refer to clause 3 of EIA RS-485 standard.

1.2 Optical interface

[ ] Glass fibre

[ ] Plastic fibre

[ ] F-SMA type connector

[ ] BFOC/2,5 type connector

1.3 Transmission speed

[X] 9 600 bit/s

[X] 19 200 bit/s

2. **Link layer**

There are no choices for the link layer.

3. **Application layer**

3.1 Transmission mode for application data

Mode 1 (least significant octet first), as defined in 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

3.2 Common address of ASDU

[X] One COMMON ADDRESS OF ASDU (identical with station address)

[ ] More than one COMMON ADDRESS OF ASDU

3.3 Selection of standard information numbers in monitor direction

3.3.1 System functions in monitor direction

	INF	Semantics
[X]	<0>	End of general interrogation
[X]	<0>	Time synchronization
[ ]	<2>	Reset FCB

☐	<3>	Reset CU
☐	<4>	Start/restart
☐	<5>	Power on

3.3.2 Status indications in monitor direction

	INF	Semantics
X	<16>	Auto-recloser active
X	<17>	Teleprotection active
X	<18>	Protection active
X	<19>	LED reset
X	<20>	Monitor direction blocked
X	<21>	Test mode
X	<22>	Local parameter setting
X	<23>	Characteristic 1
X	<24>	Characteristic 2
X	<25>	Characteristic 3
X	<26>	Characteristic 4
X	<27>	Auxiliary input 1
X	<28>	Auxiliary input 2
X	<29>	Auxiliary input 3
X	<30>	Auxiliary input 4

3.3.3 Supervision indications in monitor direction

	INF	Semantics
X	<32>	Measurand supervision I
X	<33>	Measurand supervision V
X	<35>	Phase sequence supervision
X	<36>	Trip circuit supervision
X	<37>	I>> back-up operation
X	<38>	VT fuse failure
X	<39>	Teleprotection disturbed
X	<46>	Group warning
X	<47>	Group alarm

3.3.4 Earth fault indications in monitor direction

	INF	Semantics
X	<48>	Earth fault L_1

X	<49>	Earth fault L_2
X	<50>	Earth fault L_3
X	<51>	Earth fault forward, i.e. line
X	<52>	Earth fault reverse, i.e. busbar

3.3.5 Fault indications in monitor direction

	INF	Semantics
	<64>	Start /pick-up L_1
	<65>	Start /pick-up L_2
	<66>	Start /pick-up L_3
	<67>	Start /pick-up N
	<68>	General trip
	<69>	Trip L_1
	<70>	Trip L_2
	<71>	Trip L_3
	<72>	Trip I>> (back-up operation)
	<73>	Fault location X in ohms
	<74>	Fault forward/line
	<75>	Fault reverse/busbar
	<76>	Teleprotection signal transmitted
	<77>	Teleprotection signal received
	<78>	Zone 1
	<79>	Zone 2
	<80>	Zone 3
	<81>	Zone 4
	<82>	Zone 5
	<83>	Zone 6
	<84>	General start/pick-up
	<85>	Breaker failure
	<86>	Trip measuring system L_1
	<87>	Trip measuring system L_2
	<88>	Trip measuring system L_3
	<89>	Trip measuring system E

☐ <90> Trip I>

☐ <91> Trip I>>

☐ <92> Trip IN>

☐ <93> Trip IN>>

3.3.6 Auto-reclosure indications in monitor direction

	INF	Semantics
X	<128>	CB 'on' by AR
X	<129>	CB 'on' by long-time AR
X	<130>	AR blocked

3.3.7 Measurands in monitor direction

	INF	Semantics
X	<144>	Measurand I
X	<145>	Measurands I, V
X	<146>	Measurands I, V, P, Q
X	<147>	Measurands I_N, V_{EN}
X	<148>	Measurands $I_{L1,2,3}$, $V_{L1,2,3}$, P, Q, f

3.3.8 Generic functions in monitor direction

	INF	Semantics
☐	<240>	Read headings of all defined groups
☐	<241>	Read values or attributes of all entries of one group
☐	<243>	Read directory of a single entry
☐	<244>	Read value or attribute of a single entry
☐	<245>	End of general interrogation of generic data
☐	<249>	Write entry with confirmation
☐	<250>	Write entry with execution
☐	<251>	Write entry aborted

3.4 Selection of standard information numbers in control direction

3.4.1 System functions in control direction

	INF	Semantics
X	<0>	Initiation of general interrogation
X	<0>	Time synchronization

3.4.2 General commands in control direction

INF	Semantics

- [X] <16> Auto-recloser on/off
- [X] <17> Teleprotection on/off
- [X] <18> Protection on/off
- [X] <19> LED reset
- [X] <23> Activate characteristic 1
- [X] <24> Activate characteristic 2
- [X] <25> Activate characteristic 3
- [X] <26> Activate characteristic 4

3.4.3 Generic functions in control direction

	INF	Semantics
☐	<240>	Read headings of all defined groups
☐	<241>	Read values or attributes of all entries of one group
☐	<243>	Read directory of a single entry
☐	<244>	Read value or attribute of a single entry
☐	<245>	General interrogation of generic data
☐	<248>	Write entry
☐	<249>	Write entry with confirmation
☐	<250>	Write entry with execution
☐	<251>	Write entry abort

3.5 Basic application functions

- [ ] Test mode
- [ ] Blocking of monitor direction
- [ ] Disturbance data
- [ ] Generic services
- [ ] Private data

3.6 Miscellaneous

Measurands are transmitted with ASDU 3 as well as with ASDU 9. The maximum MVAL can either be 1,2 or 2,4 times the rated value. No different rating shall be used in ASDU 3 and ASDU 9, i.e. for each measurand there is only one choice.

Measurand	**Max. MVAL = rated value times**		
	1,2	**or**	**2,4**
Current L_1	X		X
Current L_2	X		X

Current L_3	X	X
Voltage L_{1-E}	X	X
Voltage L_{2-E}	X	X
Voltage L_{3-E}	X	X
Active power P	X	X
Reactive power Q	X	X
Frequency f	X	X
Voltage L_1 - L_2	X	X

Appendix C IEC60870-5-104 Slave Interoperability

The interoperability list is defined as in IEC 60870-5-101 and extended with parameters used in this standard. The text descriptions of parameters which are not applicable to this companion standard are strike-through (corresponding check box is marked black).

1. **System or device**
   (system-specific parameter, indicate definition of a system or a device by marking one of the following with "**X**")

☐ System definition

☐ Controlling station definition (Master)

☒ Controlled station definition (Slave)

2. **Network configuration**
   (network-specific parameter, all configurations that are used are to be marked "**X**")

■ ~~Point-to-point~~

■ ~~Multipoint partyline~~

■ ~~Multiple point-to-point~~

■ ~~Multipoint-star~~

3. **Physical layer**
   (network-specific parameter, all interfaces and data rates that are used are to be marked "**X**")

Transmission speed (control direction)

Unbalanced interchange Circuit V.24/V.28 Standard	Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200 bit/s	Balanced interchange Circuit X.24/X.27	
■ ~~100 bit/s~~	■ ~~2 400 bit/s~~	■ ~~2 400 bit/s~~	■ ~~56 000 bit/s~~
■ ~~200 bit/s~~	■ ~~4 800 bit/s~~	■ ~~4 800 bit/s~~	■ ~~64 000 bit/s~~
■ ~~300 bit/s~~	■ ~~9 600 bit/s~~	■ ~~9 600 bit/s~~	
■ ~~600 bit/s~~		■ ~~19 200 bit/s~~	
■ ~~1 200 bit/s~~		■ ~~38 400 bit/s~~	

Transmission speed (monitor direction)

Unbalanced interchange	Unbalanced interchange	Balanced interchange

Circuit V.24/V.28
Standard

- ■ ~~100 bit/s~~
- ■ ~~200 bit/s~~
- ■ ~~300 bit/s~~
- ■ ~~600 bit/s~~
- ■ ~~1 200 bit/s~~

Circuit V.24/V.28
Recommended if >1 200 bit/s

- ■ ~~2 400 bit/s~~
- ■ ~~4 800 bit/s~~
- ■ ~~9 600 bit/s~~

Circuit X.24/X.27

- ■ ~~2 400 bit/s~~
- ■ ~~4 800 bit/s~~
- ■ ~~9 600 bit/s~~
- ■ ~~19 200 bit/s~~
- ■ ~~38 400 bit/s~~
- ■ ~~56 000 bit/s~~
- ■ ~~64 000 bit/s~~

4. **Link layer**
   (network-specific parameter, all options that are used are to be marked "X". Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the Type ID and COT of all messages assigned to class 2.)

~~Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.~~

Link transmission

- ■ ~~Balanced transmission~~
- ■ ~~Unbalanced transmission~~

Frame length

- ■ ~~Maximum length L (number of octets)~~

Address field of the link

- ■ ~~not present (balanced transmission only)~~
- ■ ~~One octet~~
- ■ ~~Two octets~~
- ■ ~~Structured~~
- ■ ~~Unstructured~~

When using an unbalanced link layer, the following ASDU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

■ ~~The standard assignment of ASDUs to class 2 messages is used as follows:~~

Type identification	Cause of transmission
9, 11, 13, 21	<1>

■ ~~A special assignment of ASDUs to class 2 messages is used as follows:~~

Type identification	Cause of transmission

~~Note: (In response to a class 2 poll, a controlled station may respond with class 1 data when there is no class 2 data available).~~

5. **Application layer**

Transmission mode for application data

Mode 1 (Least significant octet first), as defined in 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

Common address of ASDU

(system-specific parameter, all configurations that are used are to be marked "**X**")

■ ~~One octet~~	[X] Two octets

Information object address

(system-specific parameter, all configurations that are used are to be marked "**X**")

■ ~~One octet~~	[ ] Structured
■ ~~Two octets~~	[X] Unstructured
[X] Three octets	

Cause of transmission

(system-specific parameter, all configurations that are used are to be marked "**X**")

■ ~~One octet~~	[X] Two octets (with originator address). Originator address is set to zero if not used

Length of APDU

(system-specific parameter, specify the maximum length of the APDU per system)

The maximum length of the APDU is 253 (default). The maximum length may be reduced by the system.

253 Maximum length of APDU per system

Selection of standard ASDUs

Process information in monitor direction

(station-specific parameter, mark each Type ID "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

[X]	<1>	:= Single-point information	M_SP_NA_1
[ ]	~~<2>~~	~~:= Single-point information with time tag~~	~~M_SP_TA_1~~
[ ]	<3>	:= Double-point information	M_DP_NA_1
[ ]	~~<4>~~	~~:= Double-point information with time tag~~	~~M_DP_TA_1~~
[ ]	<5>	:= Step position information	M_ST_NA_1
[ ]	~~<6>~~	~~:= Step position information with time tag~~	~~M_ST_TA_1~~
[ ]	<7>	:= Bitstring of 32 bit	M_BO_NA_1
[ ]	~~<8>~~	~~:= Bitstring of 32 bit with time tag~~	~~M_BO_TA_1~~
[X]	<9>	:= Measured value, normalized value	M_ME_NA_1
[ ]	~~<10>~~	~~:= Measured value, normalized value with time tag~~	~~M_ME_TA_1~~
[ ]	<11>	:= Measured value, scaled value	M_ME_NB_1
[ ]	~~<12>~~	~~:= Measured value, scaled value with time tag~~	~~M_ME_TB_1~~
[X]	<13>	:= Measured value, short floating point value	M_ME_NC_1
[ ]	~~<14>~~	~~:= Measured value, short floating point value with time tag~~	~~M_ME_TC_1~~
[X]	<15>	:= Integrated totals	M_IT_NA_1
[ ]	~~<16>~~	~~:= Integrated totals with time tag~~	~~M_IT_TA_1~~
[ ]	~~<17>~~	~~:= Event of protection equipment with time tag~~	~~M_EP_TA_1~~
[ ]	~~<18>~~	~~:= Packed start events of protection equipment with time tag~~	~~M_EP_TB_1~~
[ ]	~~<19>~~	~~:= Packed output circuit information of protection equipment with time tag~~	~~M_EP_TC_1~~
[ ]	<20>	:= Packed single-point information with status change detection	M_SP_NA_1
[ ]	<21>	:= Measured value, normalized value without quality descriptor	M_ME_ND_1

[X]	<30>	:= Single-point information with time tag CP56Time2a	M_SP_TB_1
[ ]	<31>	:= Double-point information with time tag CP56Time2a	M_DP_TB_1
[ ]	<32>	:= Step position information with time tag CP56Time2a	M_ST_TB_1
[ ]	<33>	:= Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
[X]	<34>	:= Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
[ ]	<35>	:= Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
[X]	<36>	:= Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
[X]	<37>	:= Integrated totals with time tag CP56Time2a	M_IT_TB_1
[ ]	<38>	:= Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
[ ]	<39>	:= Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
[ ]	<40>	:= Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

Either the ASDUs of the set <2>, <4>, <6>, <8>, <10>, <12>, <14>, <16>, <17>, <18>, <19> or of the set <30> – <40> are used.

Process information in control direction

(station-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

[X]	<45> :=	Single command	C_SC_NA_1
[ ]	<46> :=	Double command	C_DC_NA_1
[ ]	<47> :=	Regulating step command	C_RC_NA_1
[X]	<48> :=	Set point command, normalized value	C_SE_NA_1
[ ]	<49> :=	Set point command, scaled value	C_SE_NB_1
[X]	<50> :=	Set point command, short floating point value	C_SE_NC_1
[ ]	<51> :=	Bitstring of 32 bit	C_BO_NA_1
[ ]	<58> :=	Single command with time tag CP56Time2a	C_SC_TA_1
[ ]	<59> :=	Double command with time tag CP56Time2a	C_DC_TA_1
[ ]	<60> :=	Regulating step command with time tag CP56Time2a	C_RC_TA_1
[ ]	<61> :=	Set point command, normalized value with time tag CP56Time2a	C_SE_TA_1
[ ]	<62> :=	Set point command, scaled value with time tag CP56Time2a	C_SE_TB_1
[ ]	<63> :=	Set point command, short floating point value with time tag CP56Time2a	C_SE_TC_1
[ ]	<64> :=	Bitstring of 32 bit with time tag CP56Time2a	C_BO_TA_1

Either the ASDUs of the set <45> – <51> or of the set <58> – <64> are used.

System information in monitor direction

(station-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

[X]	<70> :=	End of initialization	M_EI_NA_1

System information in control direction

(station-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

[X]	<100>:=	Interrogation command	C_IC_NA_1
[X]	<101>:=	Counter interrogation command	C_CI_NA_1
[ ]	<102>:=	Read command	C_RD_NA_1
[X]	<103>:=	Clock synchronization command	C_CS_NA_1
[ ]	~~<104>:=~~	~~Test command~~	~~C_TS_NA_1~~
[X]	<105>:=	Reset process command	C_RP_NA_1
[ ]	~~<106>:=~~	~~Delay acquisition command~~	~~C_CD_NA_1~~
[ ]	<107>:=	Test command with time tag CP56Time2a	C_TS_TA_1

Parameter in control direction
(station-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☐	<110>:=	Parameter of measured value, normalized value	P_ME_NA_1
☐	<111>:=	Parameter of measured value, scaled value	P_ME_NB_1
☐	<112>:=	Parameter of measured value, short floating point value	P_ME_NC_1
☐	<113>:=	Parameter activation	P_AC_NA_1

File transfer
(station-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☐	<120>:=	File ready	F_FR_NA_1
☐	<121>:=	Section ready	F_SR_NA_1
☐	<122>:=	Call directory, select file, call file, call section	F_SC_NA_1
☐	<123>:=	Last section, last segment	F_LS_NA_1
☐	<124>:=	Ack file, ack section	F_AF_NA_1
☐	<125>:=	Segment	F_SG_NA_1
☐	<126>:=	Directory {blank or X, only available in monitor (standard) direction}	F_DR_TA_1

Type identifier and cause of transmission assignments
(station-specific parameters)

Shaded boxes: option not required.
Black boxes: option not permitted in this companion standard
Blank: functions or ASDU not used.

Mark Type Identification/Cause of transmission combinations:

"**X**" if only used in the standard direction;
"**R**" if only used in the reverse direction;
"**B**" if used in both directions.

Type identification		**Cause of transmission**																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1																			
~~<2>~~	~~M_SP_TA_1~~			■		■						■	■							
<3>	M_DP_NA_1																			
~~<4>~~	~~M_DP_TA_1~~			■		■						■	■							

Type identification		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<5>	M_ST_NA_1																			
~~<6>~~	~~M_ST_TA_1~~			■		■						■	■							
<7>	M_BO_NA_1																			
~~<8>~~	~~M_BO_TA_1~~			■		■														
<9>	M_ME_NA_1																			
~~<10>~~	~~M_ME_TA_1~~			■		■														
<11>	M_ME_NB_1																			
~~<12>~~	~~M_ME_TB_1~~			■		■														
<13>	M_ME_NC_1																			
~~<14>~~	~~M_ME_TC_1~~			■		■														
<15>	M_IT_NA_1																			
~~<16>~~	~~M_IT_TA_1~~			■												■				
~~<17>~~	~~M_EP_TA_1~~			■																
~~<18>~~	~~M_EP_TB_1~~			■																
~~<19>~~	~~M_EP_TC_1~~			■																
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1																			
<31>	M_DP_TB_1																			
<32>	M_ST_TB_1																			
<33>	M_BO_TB_1																			
<34>	M_ME_TD_1																			
<35>	M_ME_TE_1																			

Type identification		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<36>	M_ME_TF_1																			
<37>	M_IT_TB_1																			
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1																			
<40>	M_EP_TF_1																			
<45>	C_SC_NA_1																			
<46>	C_DC_NA_1																			
<47>	C_RC_NA_1																			
<48>	C_SE_NA_1																			
<49>	C_SE_NB_1																			

Type identification		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<50>	C_SE_NC_1																			
<51>	C_BO_NA_1																			
<58>	C_SC_TA_1																			
<59>	C_DC_TA_1																			
<60>	C_RC_TA_1																			
<61>	C_SE_TA_1																			
<62>	C_SE_TB_1																			
<63>	C_SE_TC_1																			

<64>	C_BO_TA_1																		
<70>	M_EI_NA_1*																		
<100>	C_IC_NA_1																		
<101>	C_CI_NA_1																		
<102>	C_RD_NA_1																		
<103>	C_CS_NA_1																		
~~<104>~~	~~C_TS_NA_1~~																		
<105>	C_RP_NA_1																		
~~<106>~~	~~C_CD_NA_1~~																		
<107>	C_TS_TA_1																		
<110>	P_ME_NA_1																		
<111>	P_ME_NB_1																		
<112>	P_ME_NC_1																		
<113>	P_AC_NA_1																		
<120>	F_FR_NA_1																		
<121>	F_SR_NA_1																		
<122>	F_SC_NA_1																		
<123>	F_LS_NA_1																		
<124>	F_AF_NA_1																		
<125>	F_SG_NA_1																		
<126>	F_DR_TA_1*																		

* Blank or X only

6. **Basic application functions**

Station initialization

(station-specific parameter, mark "**X**" if function is used)

[X] Remote initialization

Cyclic data transmission

(station-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

[X] Cyclic data transmission

Read procedure
(station-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☐ Read procedure

Spontaneous transmission
(station-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☒ Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous
(station-specific parameter, mark each information type "**X**" where both a Type ID without time and corresponding Type ID with time are issued in response to a single spontaneous change of a monitored object)

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

☒ Single-point information M_SP_NA_1, M_SP_TA_1, M_SP_TB_1 and M_PS_NA_1
☐ Double-point information M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1
☐ Step position information M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1
☐ Bitstring of 32 bit M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1 (if defined for a specific project)
☒ Measured value, normalized value M_ME_NA_1, M_ME_TA_1, M_ME_ND_1 and M_ME_TD_1
☐ Measured value, scaled value M_ME_NB_1, M_ME_TB_1 and M_ME_TE_1
☒ Measured value, short floating point number M_ME_NC_1, M_ME_TC_1 and M_ME_TF_1

Station interrogation
(station-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☒ global
☒ group 1
☒ group 2
☒ group 3
☒ group 4
☒ group 5
☒ group 6
☒ group 7
☒ group 8
☒ group 9
☒ group 10
☒ group 11
☒ group 12
☒ group 13
☒ group 14
☒ group 15
☒ group 16

Information object addresses assigned to each group must be shown in a separate table.

Clock synchronization
(station-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☒ Clock synchronization

Command transmission

(object-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

- [X] Direct command transmission
- [X] Direct set point command transmission
- [X] Select and execute command
- [X] Select and execute set point command
- [ ] C_SE ACTTERM used

- [ ] No additional definition
- [ ] Short-pulse duration (duration determined by a system parameter in the outstation)
- [ ] Long-pulse duration (duration determined by a system parameter in the outstation)
- [ ] Persistent output

- [ ] Supervision of maximum delay in command direction of commands and set point commands

[ ] Maximum allowable delay of commands and set point commands

Transmission of integrated totals
(station- or object-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

- [X] *Mode A: Local freeze with spontaneous transmission*
- [X] *Mode B: Local freeze with counter interrogation*
- [X] *Mode C: Freeze and transmit by counter-interrogation commands*
- [X] *Mode D: Freeze by counter-interrogation command, frozen values reported spontaneously*

- [X] Counter read
- [X] Counter freeze without reset
- [X] Counter freeze with reset
- [X] Counter reset

- [X] General request counter
- [ ] Request counter group 1
- [ ] Request counter group 2
- [ ] Request counter group 3
- [ ] Request counter group 4

Parameter loading
(object-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☐ Threshold value
☐ Smoothing factor
☐ Low limit for transmission of measured values
☐ High limit for transmission of measured values

Parameter activation
(object-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☐ Act/deact of persistent cyclic or periodic transmission of the addressed object

Test procedure
(station-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☐ Test procedure

File transfer
(station-specific parameter, mark "**X**" if function is used).
File transfer in monitor direction

☐ Transparent file
☐ Transmission of disturbance data of protection equipment
☐ Transmission of sequences of events
☐ Transmission of sequences of recorded analogue values

File transfer in control direction

☐ Transparent file

Background scan
(station-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☒ Background scan

Acquisition of transmission delay
(station-specific parameter, mark "**X**" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

■ ~~Acquisition of transmission delay~~

Definition of time outs

Parameter	Default value	Remarks	Selected value

t_0	30 s	Time-out of connection establishment	
t_1	15 s	Time-out of send or test APDUs	
t_2	10 s	Time-out for acknowledges in case of no data messages $t_2 < t_1$	
t_3	20 s	Time-out for sending test frames in case of a long idle state	

Maximum range of values for all time-outs: 1 to 255 s, accuracy 1 s.

Maximum number of outstanding I format APDUs *k* and latest acknowledge APDUs (*w*)

Parameter	Default value	Remarks	Selected value
k	12 APDUs	Maximum difference receive sequence number to send state variable	
w	8 APDUs	Latest acknowledge after receiving *w* I format APDUs	

Maximum range of values *k*: 1 to 32767 ($2^{15}-1$) APDUs, accuracy 1 APDU

Maximum range of values *w*: 1 to 32767 APDUs, accuracy 1 APDU (Recommendation: *w* should not exceed two-thirds of *k*).

Portnumber

Parameter	Value	Remarks
Portnumber	2404	In all cases

Appendix D Product Support

Warranty Information

All MOX manufactured products are warranted to be free from defects in material and workmanship. Our obligation under this warranty will be limited to repairing or replacing, at our option, the defective parts within 1 year of the date of installation, or within 18 months of the date of shipment from the point of manufacture, whichever is sooner. Products may only be returned under authorization. The purchaser will prepay all freight charges to return any products with a valid return authorization number to the designated repair facility.

This limited warranty does not cover loss or damage that may occur in shipment of the goods or due to improper installation, maintenance, misuse, neglect or any cause other than ordinary commercial or industrial use. Warranty is also void if case is opened without manufacturer's consent. This limited warranty is in lieu of all other warranties whether oral or written, expressed or implied.

Liability associated with all MOX products shall not exceed the price of the individual unit that is the basis of the claim. In no event will there be liability for any loss of profits, loss of use of facilities or equipment or other indirect, incidental or consequential damages.

Contact Details

To obtain support for MOX products, call MOX Group on the following numbers, or your designated support provider and ask for MOX Support.

E-mail addresses:

support@mox.com.au

sales@mox.com.au

Visit our web page at:

http://www.mox.com.au

Service Information

If you require service, contact your local MOX Group representative. A trained specialist will help you to quickly determine the source of the problem. Many problems are easily resolved with a single phone call. If it is necessary to return a unit, an RMA (Return Material Authorization) number will be provided.

All returned materials are tracked with our RMA system to ensure speedy service. You must include this RMA number on the outside of the box so that your return can be processed immediately.

Your MOX Group authorized applications engineer will complete an RMA request for you. If the unit has a serial number, we will not need detailed financial information. Otherwise, be sure to have your original purchase order number and date purchased available.

We suggest that you provide a repair purchase order number in case the repair is not covered under our warranty. You will not be billed if the repair is covered under warranty.

Please supply us with as many details about the problem as you can. The information you supply will be written on the RMA form and supplied to the repair department before your unit arrives. This helps us to provide you with the best service, in the fastest manner. Most repairs are completed within two days. During busy periods, there may be a longer delay.

If you need a quicker turnaround, ship the unit to us by airfreight. We give priority service to equipment that arrives by overnight delivery. Many repairs received by midmorning (typical overnight delivery) can be finished the same day and returned immediately.

We apologize for any inconvenience that the need for repair may cause you. We hope that our rapid service meets your needs. If you have any suggestions to help us improve our service, please give us a call. We appreciate your ideas and will respond to them.

For Your Convenience:

Please fill in the following information and keep this manual with your MOX system for future reference:

P.O. #: _____ Date Purchased: _____

Purchased From: _____

MOX Group
Web: www.mox.com.au/
Email: info@mox.com.au