Relion® 605 series

Feeder/Motor protection and control / Feeder/Motor protection REF601/REJ601/REM601 IEC60870-5-103 Communication Protocol Manual

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Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). This conformity is the result of tests conducted by ABB in accordance with the product standards EN 50263 and EN 60255-26 for the EMC directive, and with the product standards EN 60255-1 and EN 60255-27 for the low voltage directive. The IED is designed in accordance with the international standards of the IEC 60255 series.

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Section 1 IEC 60870-5-103 Protocol Overview

1.1 IEC 60870-5-103 standard

IEC 60870-5-103 is defined as a companion standard for the informative element of protection equipment. While the official IEC 60870-5-103 standard dates back to 1997, the protocol has its roots in the VDEW6 communication protocol from the late 1980's. A VDEW6 device can be seen as a subset of an IEC 60870-5-103 device but not the opposite.

IEC 60870-5-103 defined communication for a serial, unbalanced link only. Communication speeds are defined as either 9600 or 19200 baud.

Standard Documentation

This manual assumes that the reader has basic knowledge of the IEC 60870-5-103 protocol and the standard IEC 60870 documents relating to the protocol.

Table 1: Standard IEC 60870 documents relating to IEC 60870-5-103

IEC 60870 document part	Description
5-1	Transmission frame formats
5-2	Link transmission procedures
5-3	General structure of application data
5-4	Definition and coding of application information elements
5-5	Basic application functions
5-6	Conformance testing guidelines
5-103	Companion standard for the informative interface of protection equipment.

IEC 60870-5-1...6 parts are also used in communication protocols like IEC 60870-5-101 and IEC 60870-5-104.

Interoperability and Interchangeability

An IEC 60870-5-103 device can be interoperable and interchangeable, or only interoperable. Interoperability means that any required application data in the device, which can be coded into an IEC 60870-5-103 data type, can be mapped into the IEC 60870-5-103 address space. This data is recognised by any IEC 60870-5-103 master.

Interchangeability means supporting the application data (informative elements) whose semantics are pre-defined by the IEC 60870-5-103 standard. However, only a very limited set of application data informative elements have been defined by the standard. It should also be noticed that these sets of data are mainly defined for

a single function protection IED. 605 series IEDs in turn are multifunctional protection and control IEDs.

Interoperability list

The standard requires the IEC 60870-5-103 device to provide an interoperability list, which actually is more an interchangeability list. See Section 5 for a complete list of all IEC 60870-5-103 data available in a IED.

Default data mapping principle

Where ever possible, process data is mapped into standard IEC 60870-5-103 function types and information numbers. When this is not possible, the process data is mapped into private function types and information numbers.

Section 2 IED Specific Implementation

2.1 IEC 60870-5-103 Interface details

REF601/REJ601/REM601 is a dedicated feeder protection relay, intended for the protection of utility substations and industrial power systems, in primary and secondary distribution networks. REF601/REJ601/REM601 is a member of ABB's Relion ® product family and part of its 605 series.

The Relay equipped with the optional communication board provides RS485 communication port supporting IEC 60870-5-103 protocol along with Modbus RTU protocol.

Table 2: Relay – Supported Modbus /IEC 60870-5-103 Interface Type

Description	Value
Protocol	Modbus RTU / IEC 60870-5-103
Communication port	RS485 , 2wire

2.2 Protocol parameters

The protocol and link parameters of the IEC 60870-5-103 interface can be programmed by means of a local HMI by selecting Main Menu → Settings → COM Parameters → Protocol → IEC-103

The following parameters are available:

Table 3: Relay IEC60870-5-103 Settings

Sr. No.	Name	Default Value	Range	Description
1	Class 2 SF	1.2	1.2 or 2.4	Class 2 scale factor. This parameter is visible only when IEC103 protocol enabled
2	Class 2 Intv	0 S		Class 2 update period. Period at which measurand data generated in the IED. To be choosen in consistency with the interval of master/remote system. This parameter is visible only when IEC103 protocol enabled
3	Parity	Even	None parity, Even parity,	
4	Baud Rate	9600	9600 or 19200	Only 9600 and 19200 bps are defined in IEC60870-5-103 standard
5	Relay address	001	The unit address 1…247	

2.3 Connectivity diagram

The below diagram (Figure 1and 2) shows the connection details for a standard USB-RS485 converter and REJ/REF601/REM601 R2.2 variant relay

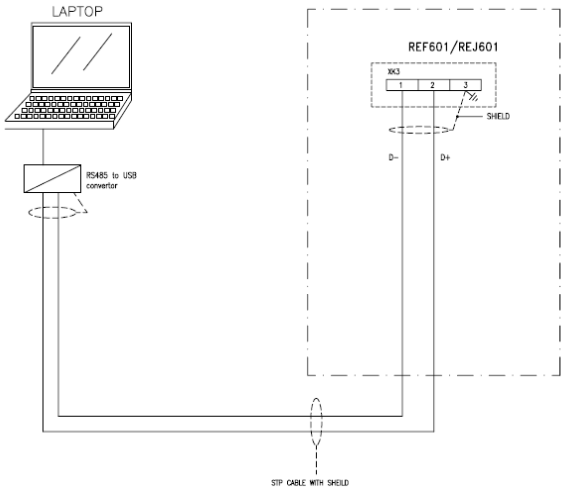


Figure 1: Peer-to-peer connection diagram

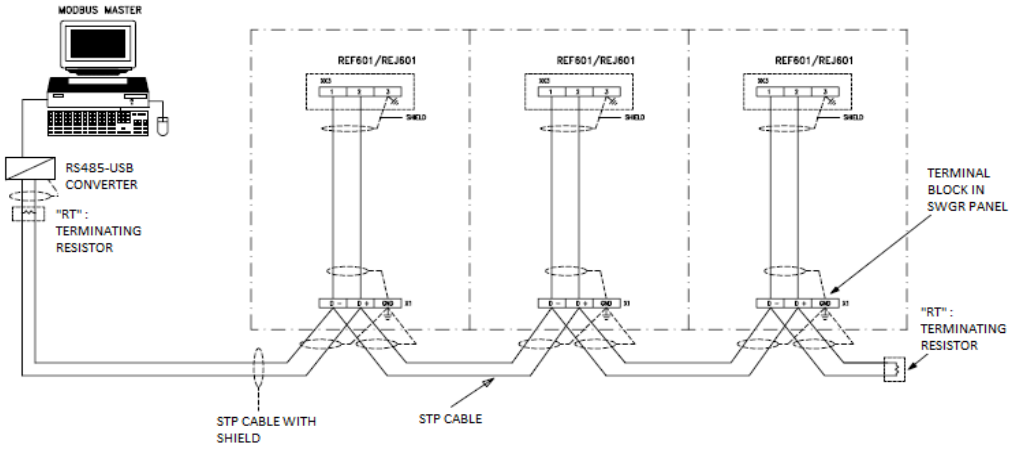


Figure 2: Multiple IED connection diagram

NOTE: The terminating resistor “RT” is recommended to have on both side of the bus. The terminating resistor’s value should be equal to the characteristic impedance “Z0” of STP cable

The following RS485 STP cables with the listed resistor values can be used for connecting the controller.

Belden #9271 (or equivalent with 120 ohm termination resistors (2,000 ft. /610 meters maximum)

Belden #9182 (or equivalent with 150 ohm termination resistors (4,000 ft./1220 meters maximum)

Example used converter for USB-RS485 is MOXA /UPORT-1150.

2.4 Supported functions

The IEC 60870-5-103 protocol in 601 series IEDs are fixed set of informative elements.

2.4.1 Indications

The IEC 60870-5-103 standard defines indications to be of ON/OFF type. The value coding for indications is always DPI, where only values 1 and 2 (binary 01 and 10) are used. Value 1 means OFF and value 2 means ON. Indications are assigned to IEC 60870-5-103 Class 1 data transactions.

Indications relate to general purpose signals or protection signals (start and trip). The standard defines two ASDU object types for indications: ASDU 1 and ASDU2. ASDU 1 type is intended for general purpose objects and ASDU 2 type for protection objects.

2.4.1.1 ASDU 2 type fault number and relative time data

In addition to the absolute event time stamp, the ASDU 2 type requires fault number and relative time data. IEC 60870-5-103 stack in IED increments the fault number by ONE on arrival of start event. Relative time is calculated from the time stamp of the start and trip event. It is represented as a 16 bit millisecond value which saturates to its maximum value of 65535 mS if necessary.

Currently all protection start and trip events are mapped to 2 common data points reported through ASDU 2 as shown in the table below

Table 4: Relay IEC60870-5-103 Settings

Fun Type	INF	Description	Remarks
160	68	General Trip	Reported on “Raised Only”
160	84	General Start	Reported on “Raised”/”Cleared”

2.4.1.2 Class 1 event overflow

The size of the Class 1 event buffer in the IED is 10 events. The IEC 60870-5-103 standard does not define any method to indicate Class 1 event buffer overflow. Instead, the standard suggests that master performs a general interrogation integrity scan for every 15 minutes (or more), in order to detect indications that have not been updated.

2.4.1.3 Class 1 data message priorities

1. Class 1 change events
2. General interrogation data responses (low priority)

NOTE: When operator does IED's LHMI Menu navigation (Local Mode), the real-time events are not reported to IEC 60870-5-103 master. As soon as IED goes back to default menu (remote mode), the stored/buffered events are reported with correct time stamp. But measurand values, BO status still be reporting during this time.

2.4.2 Controls

The IEC 60870-5-103 standard defines remote control of indications or control of objects without corresponding indication. Example of a controllable indication could be circuit breaker ON/OFF/Intermediate whose position can be monitored as a normal ASDU 1 indication, and which also can be controlled ON or OFF by the IEC 60870-5-103 client. Example of a control object without corresponding indication could be an acknowledge object, for example LED/Remote Reset.

According to the standard the remote control operations are performed using the ASDU 20 object type. Circuit breaker can only be controlled with DIRECT ON/OFF commands. Controllable indications usually can be controlled into two positions, ON or OFF. Acknowledge points can only be controlled ON. If the IED is in local mode, the remote CB controls are rejected.

2.4.3 Measurands

Measurands are transmitted as a set of Class 2 data, referred to as a Class 2 measurands frame. According to the standard the coding of IEC 60870-5-103 measurand objects must be 13 bit signed values in the range of -1…+1. The raw 12 bit values (-4096 … + 4095) are relative to (2.4 or 1.2) x nominal values.

When an IEC 60870-5-103 measurand, for example phase current, is scaled as 2.4, it means that the measurand value 1 corresponds to (2.4 x nominal value) of phase current. If the measurand value exceeds (2.4 x nominal value), the IEC 60870-5-103 object value saturates at its maximum value and an overflow flag is set in the IEC 60870-5-103 object.

REF601 device supports following measurand values.

Table 5: Measurand ASDUs supported in REF601/REJ601/REM601

ASDU	FUN	INF	Data in Class 2 Frame
3.4	160	147	Measurand I (In)
9	160	148	Measurand II (IL1, IL2, IL3)

Example of Measurand scaling:

CT Primary (I_{pn}): 500 [A]
CT Secondary(I_{sn}):5 [A]
Scale factor selected: 1.2

When the IEC 60870-5-103 Master receives the value of 1706, the corresponding primary and secondary currents are calculated like this.

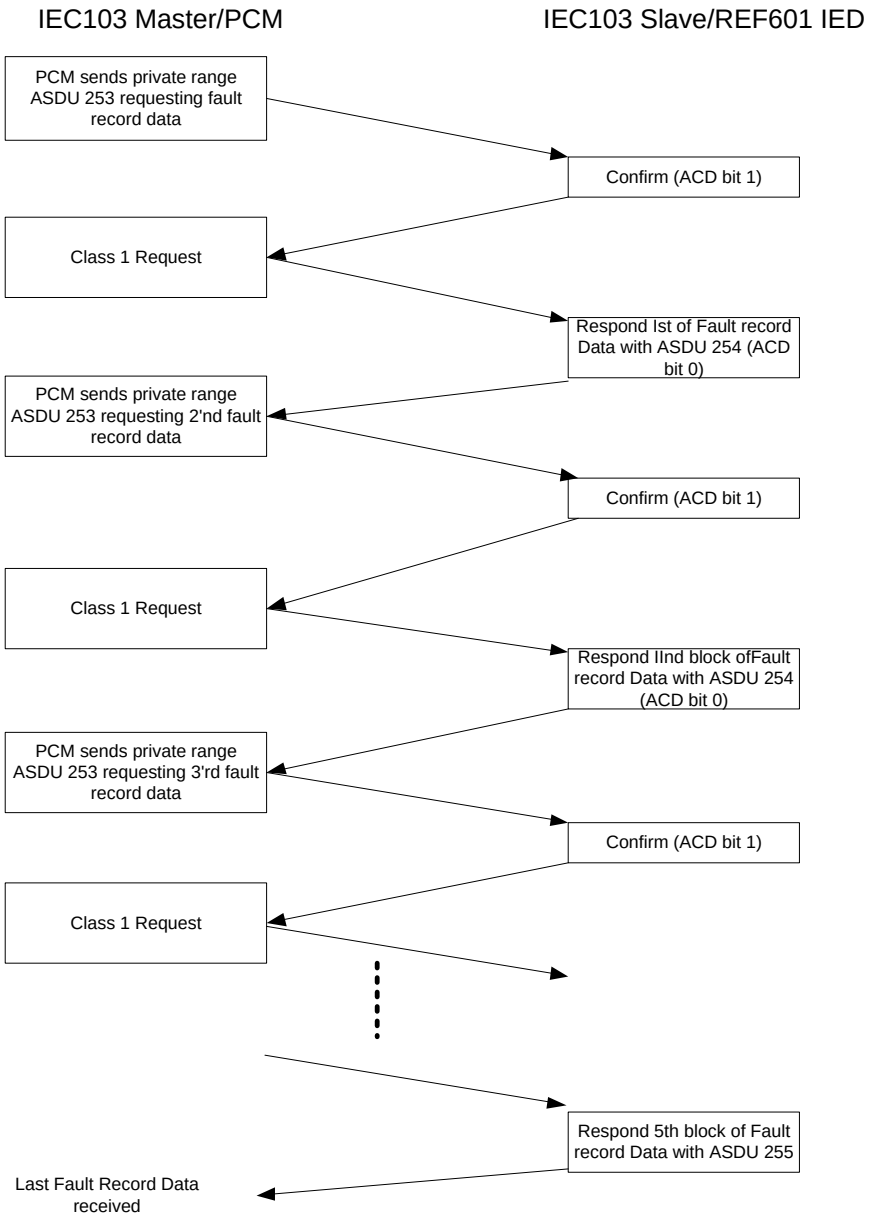
Primary current: $1706 * \frac{1.2*500\ [A]}{4096} = 250[A]$

Secondary Current: $1706 * \frac{1.2*5\ [A]}{4096} = 2.5[A]$

Section 3 Fault Record Data

3.1 Retrieval of fault record data

IEC103 protocol feature supports retrieval of fault records of last five faults from the IED. Private range ASDUs 253, 254 & 255 are used for transfer of fault record data.



Each fault record contains 5 instances current values with 1 pre-start, start along with time stamp, trip along with time stamp and 2 post-trip values. As shown in the flow chart diagram, the master system shall request one fault record at a time by specifying the fault number with latest fault as fault number 1. The master protocol request fault record number with ASDU 253. IED shall respond with corresponding fault record with ASDU 254. When the last fault record (fault record number 5) is requested, IED sends the last fault record data with ASDU 255.

3.1.1 Private range data frames for reading fault records

Table 6: Fault Record Request Frame type 253 (0XFD) from IEC 60870-5-103 Master

Octet	Value(h)	Description
1	68h	Start Flag
2	7	Length of the Information Field
3	7	Repeated Length of the Information Field
4	68h	Start Flag
5	73h	Control Field
6	1	Station Address
7	FDh	Frame Type Identification
8	1h	Variable Structure Qualifier
9	5	Cause of Transmission
10	1	ASDU Address
11	-	Data (Fault Record Number 1 to 5)
12	7Ah	Checksum
13	16h	End Flag

Table 7: Fault Record Response Frame type 254/255 (0XFD/FE) from IED

Octet	Value(h)	Description
1	68h	Start Flag
2	42	Length of the Information Field
3	42	Repeated Length of the Information Field
4	68h	Start Flag
5	08h	Control Field
6	1	Station Address
7	-	Frame Type Identification (0xFF - Last Fault Record, 0xFE - NOT a last Fault Record)
8	81h	Variable Structure Qualifier
9	40h	Cause of Transmission
10	1	ASDU Address
11	A2h	Function Type
12	-	Data (Fault Record Number 1 to 5)
13	-	Data (Positive ACK - 0x00; Negative ACK - 0x0F)
13	-	Data (Error Code; 0x01 - EEPROM busy so unable to read data; 0x02 - CRC failed for the read Fault Record)
14	-	Data (56 Bytes)
71	7Ah	Checksum
72	16	End Flag

Section 4 Interoperability Profile

4.1 Physical Layer

4.1.1 Electrical Interface

☒ EIA RS-485
☒ Number of loads 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.

4.1.2 Optical Interface

☐ Glass fibre
☐ Plastic fibre
☐ F-SMA type connector
☐ BFOC/2.5 type connector

4.1.3 Transmission Speed

☒ 9600 bit/s
☒ 19200 bit/s

4.2 Link Layer

There are no choices for the link layer.

4.3 Application Layer

4.3.1 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.

4.3.2 Common address of ASDU

☒ One Common Address of ASDU (identical with station address)

☐ More than one Common Address of ASDU

4.3.3 Selection of standard information numbers in monitor direction

4.3.3.1 System functions in monitor direction

	INF	Semantics
☒	<0>	End of general interrogation
☒	<0>	Time synchronization
☒	<2>	Reset FCB
☒	<3>	Reset CU
☒	<4>	Start/restart
☒	<5>	Power on

4.3.3.2 Status indications in monitor direction

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

4.3.3.3 Supervision indications in monitor direction

	INF	Semantics
☐	<32>	Measurand supervision I

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

4.3.3.4 Earth fault indications in monitor direction

	INF	Semantics
☐	<48>	Earth fault L1
☐	<49>	Earth fault L2
☐	<50>	Earth fault L3
☐	<51>	Earth fault forward, i.e. line
☐	<52>	Earth fault reverse, i.e. busbar

4.3.3.5 Fault indications in monitor direction

	INF	Semantics
☐	<64>	Start /pick-up L1
☐	<65>	Start /pick-up L2
☐	<66>	Start /pick-up L3
☐	<67>	Start /pick-up N
☒	<68>	General trip
☐	<69>	Trip L1
☐	<70>	Trip L2
☐	<71>	Trip L3
☐	<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 L1
☐	<87>	Trip measuring system L2
☐	<88>	Trip measuring system L3
☐	<89>	Trip measuring system E
☐	<90>	Trip I> (We will define in private range)
☐	<91>	Trip I>>
☐	<92>	Trip IN>
☐	<93>	Trip IN>>

4.3.3.6 Auto-reclosure indications in monitor direction

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

4.3.3.7 Measurands in monitor direction

	INF	Semantics
☐	<144>	Measurands I
☐	<145>	Measurands I, V
☐	<146>	Measurands I, V, P, Q
☒	<147>	Measurands IN,
☒	<148>	Measurands IL1,2,3,

4.3.3.8 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

4.3.4 Selection of standard information numbers in control direction

4.3.4.1 System functions in control direction

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

4.3.4.2 General commands in control direction

	INF	Semantics
☐	<16>	Auto-recloser on/off
☐	<17>	Teleprotection on/off
☐	<18>	Protection on/off
☒	<19>	LED reset
☒	<23>	Activate characteristic 1
☒	<24>	Activate characteristic 2
☐	<25>	Activate characteristic 3
☐	<26>	Activate characteristic 4

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 in 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

4.3.5 Basic Application functions

- ☒ Test Mode
- ☐ Blocking of Monitoring direction
- ☐ Disturbance Data
- ☐ Generic Services
- ☒ Private data

4.3.6 Miscellaneous

Measurands are transmitted with ASDU 3 as well as with ASDU 9. As defined in 7.2.6.8, 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 II	**Max. MVAL = rated value times**	
	1,2	**or 2,4**
Current L1	☒	☒
Current L2	☒	☒
Current L3	☒	☒
Voltage L1-E	☐	☐
Voltage L2-E	☐	☐
Voltage L3-E	☐	☐
Active power P	☐	☐
Reactive power Q	☐	☐
Frequency f	☐	☐
Voltage L1 - L2	☐	☐

Section 5 Summary of Interoperable Public and Private data

Summary of Public and private codes (INF numbers) covered in the table below.

Abbreviations	
ASDU	Application Service Data Unit
FUN	Function Type
INF	Information Number
TYP	ASDU Type
GI	General Interrogation
COT	Cause of Transmission
DIR	Direction of Events
RO	Raised Only
RC	Raised and Cleared
S	Standard
P	Private Range
X	Supported
-	Not Supported

COT	Description
Monitor Direction	
1	Spontaneous Events
2	Cyclic
3	Reset Frame Count Bit (FCB)
4	Reset Communication Unit (CU)
5	Start / Restart
6	Power ON
7	Test Mode
8	Time Synchronization
9	General Interrogation
10	Termination of General Interrogation
11	Local Operation
12	Remote Operation
20	Positive Acknowledgement of Command
21	Negative Acknowledgement of Command
Control Direction	
8	Time Synchronization
9	Initiation of General Interrogation
20	General Command

FUN	INF	Description	GI	TYP / ASDU	COT	Standard / Private
Monitor Direction						
255	0	End of General Interrogation	-	8	10	S
255	0	Time Synchronization		6	8	S
160	2	Reset FCB	-	5	3	S
160	3	Reset CU	-	5	4	S
160	4	Start/Restart	-	5	5	S
160	5	Power ON	-	5	6	S
160	21	Test Mode	✓	1	9, 11	S
160	22	Setting Change	✓	1	9, 11	S
160	23	Active Setting Group 1	✓	1	1, 9, 11, 12, 20, 21	S
160	24	Active Setting Group 2	✓	1	1, 9, 11, 12, 20, 21	S
160	27	Status of Binary Input 1	✓	1	1, 9	S
160	28	Status of Binary Input 2	✓	1	1, 9	S
160	29	Status of Binary Input 3	✓	1	1, 9	S
160	30	Status of Binary Input 4	✓	1	1, 9	S
160	68	General Trip	-	2	1	S
160	84	General Start	✓	2	1, 9	S
160	147	Measurand I (In)	-	3.4	2	S
160	148	Measurand II (I1, I2, I3)	-	9	2	S
162	0	Status of Binary Output 1	✓	1	1, 9	P
162	1	Status of Binary Output 2	✓	1	1, 9	P
162	2	Status of Binary Output 3	✓	1	1, 9	P
162	3	Status of Binary Output 4	✓	1	1, 9	P
162	4	Status of Binary Output 5	✓	1	1, 9	P
162	5	Status of Binary Output 6	✓	1	1, 9	P
162	6	Breaker Opened or Closed command status	✓	1	1, 9, 11, 12, 20, 21	P
162	7	Local Mode	✓	1	9, 11	P
162	8	Remote Mode	✓	1	9, 11	P
162	9	Circuit Breaker Position	✓	1	9, 11	P
Control Direction						
160	19	LED Reset	-	20	20	S
160	23	Setting Group 1	-	20	20	S
160	24	Setting Group 2	-	20	20	S
162	10	Breaker Open / Close	-	20	20	P
162	-	Fault Record	-	253	64	P
255	0	Initiation of General Interrogation	-	7	9	S
255	0	Time Synchronization		6	8	S

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