

# TECHNICAL SPECIFICATION



Telecontrol equipment and systems –  
Part 5-601: Transmission protocols – Conformance test cases for the  
IEC 60870-5-101 companion standard

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IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
Fax: +41 22 919 03 00  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

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### TELECONTROL EQUIPMENT AND SYSTEMS –

#### Part 5-601: Transmission protocols – Conformance test cases for the IEC 60870-5-101 companion standard

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- The subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

This technical specification is to be used in conjunction with IEC 60870-5-101:2003/AMD1:2015. IEC 60870-5-101:2003/AMD1:2015 resolves ambiguities

and inconsistencies discovered by users of the standard and was worked out in parallel with IEC 60870-5-601:2006.

IEC 60870-5-601, which is a technical specification, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

This second edition cancels and replaces the first edition published in 2006. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) Resolving ambiguities and inconsistencies between IEC 60870-5-101:2003 and IEC TS 60870-5-601:2006;
- b) Enhancements and optimisation of test cases which are needed to prove conformance with IEC 60870-5-101:2003;
- c) Additional negative test cases made to avoid circulation of messages not conformant with IEC 60870-5-101:2003.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
57/1528/DTS	57/1590/RVC

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Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above Table.

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The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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## TELECONTROL EQUIPMENT AND SYSTEMS –

### Part 5-601: Transmission protocols – Conformance test cases for the IEC 60870-5-101 companion standard

#### 1 Scope

This part of IEC 60870 describes test cases for conformance testing of telecontrol equipment, Substation Automation Systems (SAS) and telecontrol systems, including front-end functions of SCADA.

The use of this part of IEC 60870 facilitates interoperability by providing a standard method of testing protocol implementations, but it does not guarantee interoperability of devices. It is expected that using this part of IEC 60870 during testing will minimize the risk of non-interoperability.

The goal of this part of IEC 60870 is to enable unambiguous and standardised evaluation of IEC 60870-5 companion standard protocol implementations. The guidelines and conditions for the testing environment are described in IEC 60870-5-6. The detailed test cases per companion standard, containing among others mandatory and optional mandatory test cases per Basic Application Function, ASDU and transmission procedures, will become available as a technical specification (TS). Other functionality may need additional test cases but this is beyond the scope of this part of IEC 60870. For proper testing, it is recommended to define these additional test cases.

IEC TS 60870-5-601:2015

This part of IEC 60870 deals mainly with communication conformance testing; therefore other requirements, such as safety or EMC are not covered. These requirements are covered by other standards (if applicable) and the proof of compliance for these topics is done in accordance with these standards.

#### 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies<sup>1</sup>.

IEC 60870-5-1:1990, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section One: Transmission frame formats*

IEC 60870-5-2:1992, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 2: Link transmission procedures*

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<sup>1</sup> The base standard always takes precedence. In case of ambiguity between this part of IEC 60870 and the base standards (IEC 60870-5-1 to IEC 60870-5-5, IEC 60870-5-101), this part of IEC 60870 needs to be clarified or amended.

When testing negative behaviour is not described in the base standard, the behaviour described in this part of IEC 60870 shall prevail and shall be observed.

The conformance statement produced after testing shall indicate any lack of conformance to either the test plan or the base standard.



IEC 60870-5-3:1992, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 3: General structure of application data*

IEC 60870-5-4:1993, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 4: Definition and coding of application information elements*

IEC 60870-5-5:1999, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 5: Basic application functions*

IEC 60870-5-6, *Telecontrol equipment and systems – Part 5-6: Guidelines for conformance testing for the IEC 60870-5 companion standards*

IEC 60870-5-101:2003, *Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks*  
IEC 60870-5-101:2003/AMD1:2015

IEEE 754, *Standard for Binary Floating-Point Arithmetic*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60870-5-6 apply.

### 4 Abbreviated terms

For the purposes of this document, the abbreviations given in IEC 60870-5-6 apply.

### 5 Conformance testing for IEC 60870-5-101

#### 5.1 Overview and legend

Procedural and functional testing should always start with the Station Initialization function and proceeds with the next Basic Application Functions. The procedure in each test case should be followed, which means that the DUT is able to function as described in the specific test case.

The test procedures in Tables 1 to 14 should be tested with no errors detected during testing of all the Basic Application Functions in Tables 15 to 32. These tests are preferably automatically performed by the used test platform.

In addition to the performance criteria listed in the test procedures, Subclause 5.3 lists the protocol specifications that should be verified automatically by the testing software or verified manually by review of the test history log after execution of the test procedures. The verification should result in no errors detected during the complete test procedure.

This test plan has a direct reference to the PICS and possibly a PIXIT. Without a reference to a PICS or PIXIT, this test plan is obsolete.

Test case numbering syntax is Subclause number + Table number + test case number.

Test cases are mandatory depending on the description in the column 'Required'. The following situations are possible:

- M = Mandatory test case regardless if enabled in the PICS/PIXIT, not only in one situation but during execution of all the tests as in the PICS and/or PIXIT
- PICS, x.x = Mandatory test case if the functionality is enabled in the PICS (by marking the applicable check box), with a reference to the Subclause number of the PICS (x.x); For example: PICS 8.x always refers to IEC 60870-5-101:2003, Clause 8
- PIXIT = Mandatory test case if the functionality is enabled/described in the PIXIT. Verification of these test cases by the user/owner of the PIXIT is required before the test is started

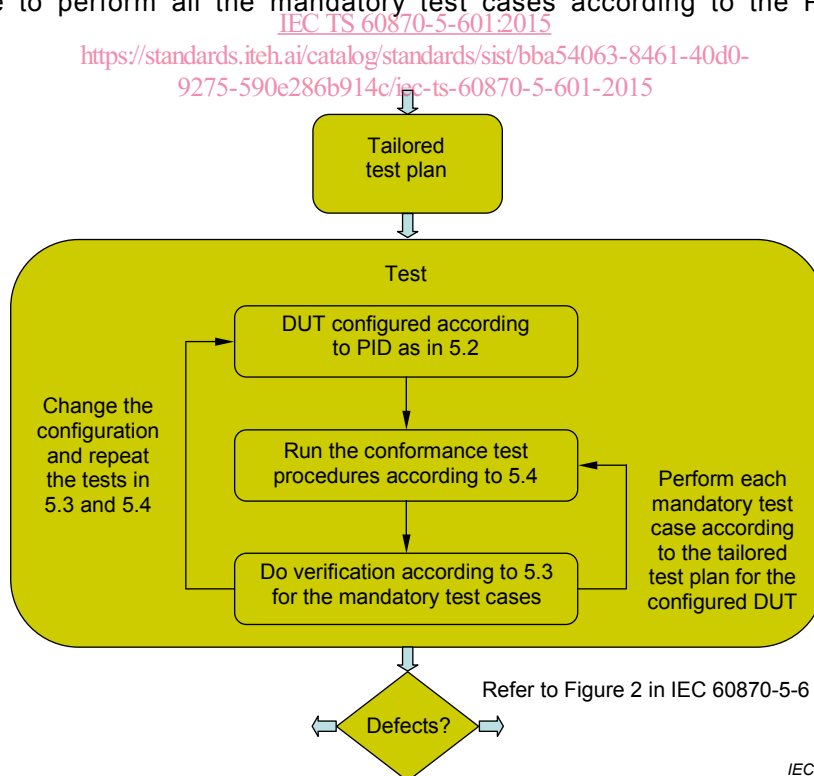
For each test case, the test results need to be marked in the appropriate column of the test result chart in 5.5 and 5.6. Each test case can either pass the test (Passed), fail the test (Failed), be not applicable when the configuration value is not supported by the device (N.A.), or the test case was not performed (Empty). Ideally there should be no empty boxes when testing is complete.

For testing reverse direction, the same test procedures apply in the opposite direction (replace "Controlling" with "Controlled" and vice versa), except for COT44-47 which are only defined in Monitor direction (only a controlled station is allowed to send these COT).

The test Tables are divided into five subclauses:

- Subclause 5.2, Configuration Parameters for IEC 60870-5-101
- Subclause 5.3, Verification of IEC 60870-5-101 communication
- Subclause 5.4, Conformance Test Procedures
- Subclause 5.5, Test Result Chart
- Subclause 5.6, Test Results of Command Transmission

The procedure to perform all the mandatory test cases according to the PID is shown in Figure 1.



**Figure 1 – Test procedure**

## 5.2 Configuration parameters for IEC 60870-5-101

Since IEC 60870-5-101 contains a number of configuration parameters affecting protocol behaviour, it should be tested that the functionality in 5.3 and 5.4 is correct for the configuration(s) in Table 1.

**Table 1 – Configuration Parameters for IEC 60870-5-101**  
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Test No.	Test	Description	Reference	Required
5.2.1.1	System definition	Controlling station test (Master)		PICS, 8.1
5.2.1.2		Controlled station test (Slave)		PICS, 8.1
5.2.1.20	Physical layer	Transmission speed(s) in control direction test maximum baud rate, minimum baud rate, and one other baud rate. Perform all applicable test cases for one baud rate. For the other tested baud rates, perform the following test cases: 5.4.15.1/5.4.15.10 and 5.4.22.1.	IEC 60870-5-101, 5.1	PICS, 8.3
5.2.1.21		Transmission speed(s) in monitor direction test maximum baud rate, minimum baud rate, and one other baud rate. Perform all applicable test cases for one baud rate. For the other tested baud rates, perform the following test cases: 5.4.15.1/5.4.15.10 and 5.4.22.1.	IEC 60870-5-101, 5.1	PICS, 8.3
5.2.1.30	Link Layer	Unbalanced transmission	IEC 60870-5-2, 6	PICS, 8.4
5.2.1.31		Balanced transmission	IEC 60870-5-2, 6	PICS, 8.4
5.2.1.40	Address field of the Link	Zero (0) octets for address field (balanced only)	IEC 60870-5-2, 5.1.3, 6.1.3	PICS, 8.4
5.2.1.41		One (1) octet for address field	IEC 60870-5-2, 5.1.3, 6.1.3	PICS, 8.4
5.2.1.42		Two (2) octets for address field	IEC 60870-5-2, 5.1.3, 6.1.3	PICS, 8.4
		If more than one link address length is supported (see PICS, 8.4), then perform all applicable test cases for one link address length. For the other link address lengths, perform the following test cases: 5.4.15.1/5.4.15.10 and 5.4.22.1.		PICS, 8.4
5.2.1.50	Frame length	Maximum length L (control direction)	IEC 60870-5-101, 6.2	PICS, 8.4
5.2.1.51		Maximum length L (monitor direction)	IEC 60870-5-101, 6.2	PICS, 8.4
5.2.1.60	Assignment Class 2 messages	Standard assignment of class 2 messages	IEC 60870-5-101, 6.2, 7.4.2	PICS, 8.4
5.2.1.61		Special assignments of class 2 messages	IEC 60870-5-101, 6.2, 7.4.2	PIXIT

Table 1b – Conformance Test Procedures only for system testing (for example in the case of interoperability testing)

Test No.	Test	Description	Reference	Required
5.2.1.70	COMMON ADDRESS of ASDU	One (1) octet for Common Address of ASDU (CASDU)	IEC 60870-5-101, 7.2.4	PICS, 8.5
5.2.1.71		Two (2) octets for Common Address of ASDU (CASDU) If more than one Common Address of ASDU length is supported (see PICS, 8.5), then perform all applicable test cases for one Common Address of ASDU length. For the other Common Address of ASDU length, perform the following test cases: 5.4.15.1/5.4.15.10 and 5.4.22.1.	IEC 60870-5-101, 7.2.4	PICS, 8.5
5.2.1.80	INFORMATION OBJECT ADDRESS	One (1) octet for Information Object Address (structured or unstructured)	IEC 60870-5-101, 7.2.5	PICS, 8.5
5.2.1.81		Two (2) octets for Information Object Address (structured or unstructured)	IEC 60870-5-101, 7.2.5	PICS, 8.5
5.2.1.82		Three (3) octets for Information Object Address (structured or unstructured) If more than one Information Object Address length is supported (see PICS, 8.5), then perform all applicable test cases for one Information Object Address length. For the other Information Object Address lengths, perform the following test cases: 5.4.15.1/5.4.15.10 and 5.4.22.1.	IEC 60870-5-101, 7.2.5	PICS, 8.5
5.2.1.90	CAUSE OF TRANSMISSION	One (1) octet for COT field	IEC 60870-5-101, 7.2.3	PICS, 8.5
5.2.1.91		Two (2) octets for COT field (2 <sup>nd</sup> octet is Originator address) If more than one Cause of Transmission length is supported (see PICS, 8.5), then perform all applicable test cases for one Cause of Transmission length. For the other Cause of Transmission length, perform the following test cases: 5.4.15.1/5.4.15.10 and 5.4.22.1.	IEC 60870-5-101, 7.2.3	PICS, 8.5
5.2.1.95	Total address length	If multiple values for the lengths of the Link address, Common Address of ASDU, Information Object Address or Cause of Transmission can be configured, then perform test cases 5.4.15.1/5.4.15.10 and 5.4.22.1 for the minimum possible total length.	IEC 60870-5-101, 7.2.3	PICS, 8.4 PICS, 8.5
5.2.1.96		If multiple values for the lengths of the Link address, Common Address of ASDU, Information Object Address or Cause of Transmission can be configured, then perform test cases 5.4.15.1/5.4.15.10 and 5.4.22.1 for the maximum possible total length.	IEC 60870-5-101, 7.2.3	PICS, 8.4 PICS, 8.5
5.2.1.100	System definition	System test (in case of interoperability testing)		PICS, 8.1
5.2.1.110	Network configuration	Point-to-point	IEC 60870-5-101, 5.1	PICS, 8.2
5.2.1.111		Multiple point-to-point	IEC 60870-5-101, 5.1	PICS, 8.2
5.2.1.112		Multipoint party line	IEC 60870-5-101, 5.1	PICS, 8.2
5.2.1.113		Multipoint star	IEC 60870-5-101, 5.1	PICS, 8.2
5.2.1.120	Address field of the Link	Link address unstructured	IEC 60870-5-2, 5.1.3, 6.1.3	PICS, 8.4
5.2.1.121		Link address structured	IEC 60870-5-2, 5.1.3, 6.1.3	PICS, 8.4, PIXIT
5.2.1.130	INFORMATION OBJECT ADDRESS	Information Object Address unstructured	IEC 60870-5-101, 7.2.5	PICS, 8.5
5.2.1.131		Information Object Address structured	IEC 60870-5-101, 7.2.5	PICS, 8.5 PIXIT

### 5.3 Verification of IEC 60870-5-101 communication

This subclause lists the protocol specifications that should be verified automatically by the testing software or verified manually by review of the test history log after execution of the test procedures. Each test case describes a functionality that has passed the test if the functionality as in the description column was proved to be correct. Correct means: the functionality should be checked either automatically or manually, and also be checked by the test engineer in a human readable format log-file. For example, to test the IV qualifier of some information elements, the ASDU containing this element should be sent with the IV=1. This should be automatically checked by the test software or observed by the test engineer in the log-file. Each test case marked "Passed"; should be verifiable during testing and archived in log-files for post assessment.

To identify if a test case is mandatory, it is necessary to read 5.1 carefully.

<https://standards.iech.ai/cata.log/standards/sisv/bba54063-8461-40d0-9275-590e286b914c/> **Table 2 – Verification of the physical level**

Test No.	Test	Description	Reference	Required
5.3.2.1	BYTEFRAME	Start-/stop-bit, even parity	IEC 60870-5-1:1990, 6.2.4.2	M

**Table 3 – Verification of the Link Level (1 of 4)**

Test No.	Test	Description	Reference	Required
5.3.3.10	FT1.2 FRAME LAYOUT (Single, Fixed and Variable)	Single control character I: E5 <sub>H</sub>	IEC 60870-5-1:1990, 6.2.4.2	PIXIT
5.3.3.11		Start character of fixed length frames: 10 <sub>H</sub>	IEC 60870-5-1:1990, 6.2.4.2	M
5.3.3.12		0 octets (No User data) as Link User data length of fixed length frames	IEC 60870-5-1:1990, 6.2.4.2	M
5.3.3.13		Start character of variable length frames: 68 <sub>H</sub>	IEC 60870-5-1:1990, 6.2.4.2	M
5.3.3.14		Configured number of octets L (repeated) as the maximum number of User Data octets from Controlling to Controlled station in variable length frames: max. 255	IEC 60870-5-1:1990, 6.2.4.2	PICS, 8.4 Frame length
5.3.3.15		Configured number of octets L (repeated) as the maximum number of User Data octets from Controlled to Controlling station in variable length frames: max. 255	IEC 60870-5-1:1990, 6.2.4.2	PICS, 8.4 Frame length
5.3.3.16		Second start character of variable length frames: 68 <sub>H</sub>	IEC 60870-5-1:1990, 6.2.4.2	M
5.3.3.17		Single octet Control Field	IEC 60870-5-1:1990, 6.2.4.2	M
5.3.3.18		Configured number of octets for Link address field	IEC 60870-5-1:1990, 6.2.4.2	M
5.3.3.19		Checksum (8-bit arithmetic sum)	IEC 60870-5-1:1990, 6.2.4.2	M
5.3.3.20		Stop character of fixed and variable length frames: 16 <sub>H</sub>	IEC 60870-5-1:1990, 6.2.4.2	M

Table 3 (2 of 4)

Test No.	Test	Description	Reference	Required
5.3.3.30	BYTELAG	Line idle intervals (stream of "1" bits) between characters of a frame do not exceed one bit time (octets are received within 110 % of raw transmission time)	IEC 60870-5-1:1990, 6.2.4.2 IEC 60870-5-101:2003, 6.1	M
5.3.3.40	CONTROL FIELD	High-order bit RES = 0 (unbalanced only)	IEC 60870-5-2:1992, 5.1.2	PICS, 8.4 Unbalanced
5.3.3.41		DIR = 1 for messages from Controlling station (A) to Controlled station (B) (balanced only)	IEC 60870-5-2:1992, 6.1.2	PICS, 8.4 Balanced
5.3.3.42		DIR = 0 for messages from Controlled station (B) to Controlling station (A) (balanced only)	IEC 60870-5-2:1992, 6.1.2	PICS, 8.4 Balanced
5.3.3.43		PRM = 0 in messages from the Controlling station	IEC 60870-5-2:1992, 5.1.2, 6.1.2	M
5.3.3.44		PRM = 0 only FCODEs 0, 7, 8, 9, 11, 14, or 15 (unbalanced only)	IEC 60870-5-2:1992, 5.1.2	PICS, 8.4 Unbalanced
5.3.3.45		PRM = 0: only FCODEs 0, 1, 11, 14, or 15 (balanced only)	IEC 60870-5-2:1992, 6.1.2	PICS, 8.4 Balanced
5.3.3.46		PRM = 1 in messages from the Controlling station	IEC 60870-5-2:1992, 5.1.2, 6.1.2	M
5.3.3.47		PRM = 1: only Primary FCODEs 0, 1, 3, 4, 8, 9, 10 or 11 (unbalanced only)	IEC 60870-5-2:1992, 5.1.2	PICS, 8.4 Unbalanced
5.3.3.48		PRM = 1: only Primary FCODEs 0, 1, 2, 3, 4 or 9 (balanced only)	IEC 60870-5-2:1992, 6.1.2	PICS, 8.4 Balanced
5.3.3.49		In case of FCV = 1 and FCB unchanged, the last message is repeated	IEC 60870-5-2:1992, 5.1.2, 6.1.2	M
5.3.3.50		In case of reset commands F-CODE 0 or 1 FCB = 0 (expect next FCB=1)	IEC 60870-5-2:1992, 5.1.2, 6.1.2	M
5.3.3.51		DFC = 0: further messages are acceptable	IEC 60870-5-2:1992, 5.1.2, 6.1.2	M

Table 3 (3 of 4)

Test No.	Test	Description	Reference	Required
5.3.3.52		DFC = 1: further messages may cause data overflow. Only applicable for Balanced communication	IEC 60870-5-2:1992, 5.1.2, 6.3.3	PICS, 8.4 Balanced
NOTE The following tests are only for Unbalanced systems (PICS 8.4). If 'M' is mentioned, the test case is mandatory for unbalanced systems.				
5.3.3.60	UNBALANCED TRANSMISSION PROCEDURE	Unbalanced transmission (standards.iteh.ai)	IEC 60870-5-2:1992, Clause 5	PICS, 8.4 Unbalanced
5.3.3.61		Service S1 – SEND/No reply	IEC 60870-5-2:1992, 4.1	PIXIT
5.3.3.62		Service S2 – SEND/CONFIRM expected	IEC 60870-5-2:1992, 4.2	M
5.3.3.63		Service S3 – REQUEST/RESPOND expected	IEC 60870-5-2:1992, 4.3	M
5.3.3.64		Primary F-CODE 0: answered with Secondary F-CODE 0,1,14,15	IEC 60870-5-2:1992, 4.2.2, 5.1.2	PIXIT
5.3.3.65		Primary F-CODE 1: answered with Secondary F-CODE 0,1,14,15	IEC 60870-5-2:1992, 4.2.2, 5.1.2	PIXIT
5.3.3.66		Primary F-CODE 3: answered with Secondary F-CODE 0,1,14,15	IEC 60870-5-2:1992, 4.2.2, 5.1.2	PIXIT
5.3.3.67		Primary F-CODE 4: not answered by Secondary	IEC 60870-5-2:1992, 4.1.2, 5.1.2	PIXIT
5.3.3.68		Primary F-CODE 8: answered with Secondary F-CODE 11, 14, 15	IEC 60870-5-2:1992, 4.3.2, 5.1.2	PIXIT
5.3.3.69		Primary F-CODE 9: answered with Secondary F-CODE 11, 14, 15	IEC 60870-5-2:1992, 4.3.2, 5.1.2	PIXIT
5.3.3.70		Primary F-CODE 10: answered with Secondary F-CODE 8, 9, 14, 15	IEC 60870-5-2:1992, 4.3.2, 5.1.2	PIXIT
5.3.3.71		Primary F-CODE 11: answered with Secondary F-CODE 8, 9, 14, 15	IEC 60870-5-2:1992, 4.3.2, 5.1.2	PIXIT
5.3.3.72		Primary F-CODE 2, 5...7, 12...15: answered with Secondary F-CODE 15	IEC 60870-5-2:1992, 4.2.2, 5.1.2	PIXIT
5.3.3.73		A not supported or implemented F-code is answered with Secondary F-CODE 14 or 15	IEC 60870-5-2:1992, 4.2.2, 5.1.2	M