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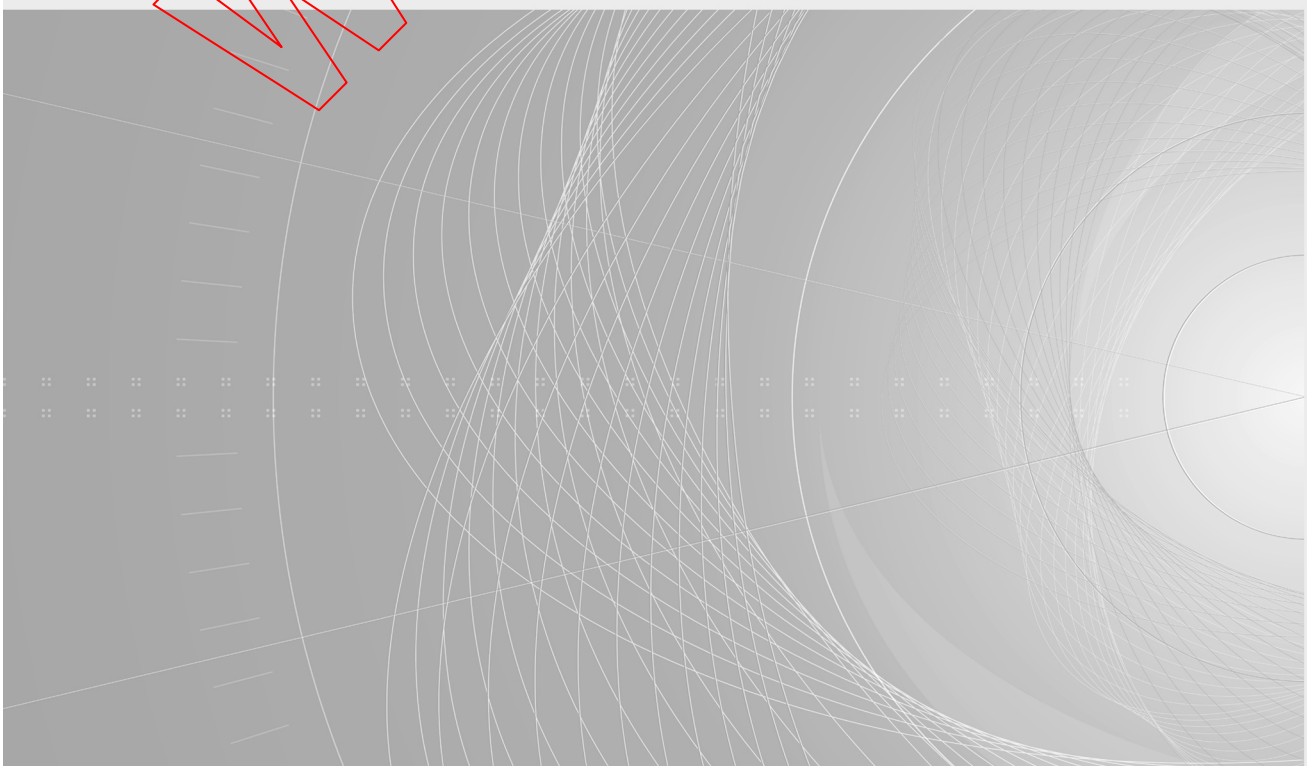
TECHNICAL SPECIFICATION

Power systems management and associated information exchange – Data and communications security –
Part 5: Security for IEC 60870-5 and derivatives



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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

IEC 62351-5, which is a technical specification, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

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

Enquiry draft	Report on voting
57/861/DTS	57/921A/RVC

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.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 62351 series, under the general title: *Power systems management and associated information exchange – Data and communications security*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn,
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POWER SYSTEMS MANAGEMENT AND ASSOCIATED INFORMATION EXCHANGE – DATA AND COMMUNICATIONS SECURITY –

Part 5: Security for IEC 60870-5 and derivatives

1 Scope and object

1.1 Scope

This part of IEC 62351 specifies messages, procedures and algorithms for securing the operation of all protocols based on or derived from the standard IEC 60870-5: Telecontrol equipment and systems – Part 5: Transmission protocols. This specification applies to at least those protocols listed in Table 1.

Table 1 – Scope of application to standards

Number	Name
IEC 60870-5-101	Companion standard for basic telecontrol tasks
IEC 60870-5-102	Companion standard for the transmission of integrated totals in electric power systems
IEC 60870-5-103	Companions standard for the informative interface of protection equipment
IEC 60870-5-104	Network access for IEC 60870-5-101 using standard transport profiles
DNP3	Distributed Network Protocol (based on IEC 60870-1 through IEC 60870-5 and controlled by the DNP Users Group)

1.2 Intended audience and use

The initial audience for this specification is intended to be the members of the working groups developing the protocols listed in Table 1. For the measures described in this specification to take effect, they must be accepted and referenced by the specifications for the protocols themselves. This document is written to enable that process.

The subsequent audience for this specification is intended to be the developers of products that implement these protocols.

Portions of this specification may also be of use to managers and executives in order to understand the purpose and requirements of the work.

1.3 Items outside of scope

This part of IEC 62351 focuses only on application layer authentication and security issues arising from such authentication, per directions from IEC Technical Committee 57 Working Group 3. Other security concerns – in particular, protection from eavesdropping or man-in-the-middle attacks through the use of encryption – are considered to be outside the scope. Encryption may be added through the use of this specification with other specifications.

1.4 Use with other standards

The working groups developing the protocols listed in Table 1 may issue standards to be applied in conjunction with this specification. It is expected that these standards will describe a mapping of this authentication mechanism to the messages and procedures of each specific protocol.

Such documents shall not override any of the security measures described in this specification as mandatory and normative.

When applied to IEC 60870-5-104, this specification shall be applied in conjunction with IEC/TS 62351-3: Power systems management and associated information exchange – Data and communications security – Part 3: Communication network and system security – Profiles including TCP/IP.

1.5 Document organization and approach

This document is organized working from the general to the specific, as follows.

- Clauses 2 through 4 provide background terms, definitions, and references.
- Clause 5 describes the problems this specification is intended to address.
- Clause 6 describes the mechanism generically without reference to a specific protocol.
- Clauses 7 and 8 describe the mechanism more precisely and are the primary normative part of this specification.
- Clause 9 describes a few particular implementation issues that are special cases.
- Clause 10 describes the requirements for other standards referencing this specification
- Clause 11 describes the protocol implementation conformance statement (PICS) for this mechanism.

1.6 Compliance

Unless specifically labelled as informative or optional, all clauses of this specification are normative.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60870-5-102, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 102: Companion standard for the transmission of integrated totals in electric power systems*

IEC 60870-5-103, *Telecontrol equipment and systems – Part 5-103: Transmission protocols - Companion standard for the informative interface of protection equipment*

IEC 60870-5-104, *Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles*

IEC/TS 62351-1, *Power systems management and associated information exchange – Data and communications security – Part 1: Communication network and system security – Introduction to security issues*

IEC/TS 62351-2, *Power systems management and associated information exchange – Data and communications security – Part 2: Glossary of terms*

IEC/TS 62351-3, *Power systems management and associated information exchange – Data and communications security – Part 3: Communication network and system security – Profiles including TCP/IP*

ISO/IEC 9798-4, *Information technology – Security techniques – Entity authentication – Part 4: Mechanisms using a cryptographic check function*

FIPS 186-2, *Digital Signature Standard (DSS)*

FIPS 197, *Advanced Encryption Standard (AES)*

FIPS 198-1, *The Keyed-Hash Message Authentication Code*

RFC 2104, HMAC: *Keyed-Hashing for Message Authentication*

RFC 3174, *Secure Hash Algorithm (SHA-1)*

RFC 3394, *Advanced Encryption Standard (AES) Key Wrap Algorithm*

RFC 3629, UTF-8, *a transformation format of ISO 10646*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

They are described here because they are specific to the IEC 60870-5 standards and may be useful for reading this specification as an independent document.

Refer to IEC/TS 62351-2 for a list of applicable terms and definitions.

3.1
controlling station
the device or application that initiates most of the communications and issues commands

It is commonly called a “master” in some protocol specifications.

3.2
controlled station
the remote device that transmits data gathered in the field to the controlling station

It is commonly called the “outstation” or “slave” in some protocols.

3.3
control direction
data transmitted by the controlling station to the controlled station(s)

3.4
monitoring direction
data transmitted by the controlled station to the controlling stations

The following terms are described here because they are specific to this protocol:

3.5
challenger
station that issues authentication challenges

It may be either a controlled or controlling station.

3.6
responder
station that responds or reacts to authentication challenges

It may be either a controlled or controlling station.

4 Abbreviated terms

Refer to IEC/TS 62351-2 for a list of applicable abbreviated terms. The following term is included here because it is specifically used in the affected protocols and used in the discussion of this authentication mechanism.

ASDU Application Service Data Unit. The application layer message submitted to lower layers for transmission.

5 Problem description

5.1 Overview of clause

This clause is informative only. It describes:

- the security threats that this specification is intended to address;
- the unique design problems in implementing authentication for IEC 60870-5 and derived protocols;
- the resulting design principles behind the mechanism.

5.2 Specific threats addressed

This specification shall address only the following security threats, as defined in IEC/TS 62351-2:

- spoofing;
- modification;
- replay;
- non-repudiation – to the extent of identifying individual users of the system.

5.3 Design issues

5.3.1 Overview of subclause

This subclause describes the challenges faced in developing an authentication proposal that can be applied to all the IEC 60870-5 and derivative protocols. This subclause is supplied for the benefit of security experts reviewing this document who may not be familiar with the electrical utility protocol environment.

5.3.2 Asymmetric communications

All the protocols affected by this specification share the concept of inequality between the communication stations. In each of these protocols, there is a designated controlling station and a designated controlled station, each having different roles, responsibilities, procedures and message formats. In particular, the controlling station is in many cases responsible for flow control and media access control.

The existence of a definite controlled/controlling station designation has two impacts on the design of this authentication mechanism:

- the format of messages in each direction will differ, even if the functions are the same;
- key distribution is simplified because they will always be issued by the controlling station.

5.3.3 Message-oriented

All of the affected protocols are message-oriented. This means that authentication must be performed on a message-by-message basis, rather than authenticating only at the beginning of a data stream and occasionally thereafter, as some connection-oriented protocols do.

5.3.4 Poor sequence numbers or no sequence numbers

A common security technique to address the threat of replay is to include in the message a sequence number. Combined with tests for message integrity, the sequence number makes it harder for an attacker to simulate a legitimate user by just copying an existing message, because the messages must be transmitted in a particular order.

Unfortunately, none of the affected protocols includes a sequence number that would provide adequate protection. Those sequence numbers that do exist have very low maximum values, permitting an attacker to attempt a replay after gathering only a small number of messages.

Therefore, the design of this specification must include its own sequence numbers and other time-varying data to protect against replay.

5.3.5 Limited processing power

The lack of processing power available on many power utility devices has been a major design concern for the affected protocols since their creation. This design requirement necessarily affects the authentication mechanism also. The concern is heightened by the fact that many of these devices are single-processor machines; a denial-of-service attack would affect not only the communications capability of such devices but their function as an electrical control, protection, or monitoring device also.

Therefore, the use of security measures requiring extremely high processing power, such as public-key encryption and very large key sizes, has been avoided as much as possible.

5.3.6 Limited bandwidth

The limited amount of bandwidth available in utility networks has been the prime design concern (after message integrity) of the affected protocols. Links of 1 200 bits per second and lower are still a reality for many applications of these protocols. Some communications links also charge costs per octet transmitted.

Therefore, the authentication mechanism must not add very much overhead (i.e. few octets) to the affected protocols. The size of the challenge and authentication data has therefore been limited and truncated as much as possible while retaining an adequate level of security. Other measures may be taken in the implementations in each protocol.

5.3.7 No access to authentication server

The nature of the utility networks in which the affected protocols are deployed is that the controlling station is often the only device with which the controlled station can communicate. If there is any access to other networks, it is often achieved through the device implementing the controlling station.

The impact of this fact on the authentication mechanism is that any system requiring on-line verification of the controlling station's security credentials by a third party is not practical.