RELION® PROTECTION AND CONTROL

611 series

Cyber Security Deployment Guideline

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Section 1 Introduction

1.1 This manual

The cyber security deployment guideline describes the process for handling cyber security when communicating with the protection relay. The cyber security deployment guideline provides information on how to secure the system on which the protection relay is installed. The guideline can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service.

1.2 Intended audience

This guideline is intended for the system engineering, commissioning, operation and maintenance personnel handling cybersecurity during the engineering, installation and commissioning phases, and during normal service.

The personnel is expected to have general knowledge about topics related to cybersecurity.

- Protection and control devices, gateways and Windows workstations
- Networking, including Ethernet and TCP/IP with its concept of ports and services
- Security policies
- Firewalls
- Antivirus protection
- Application whitelisting
- Secure remote communication

1.3 Product documentation

1.3.1 Product documentation set

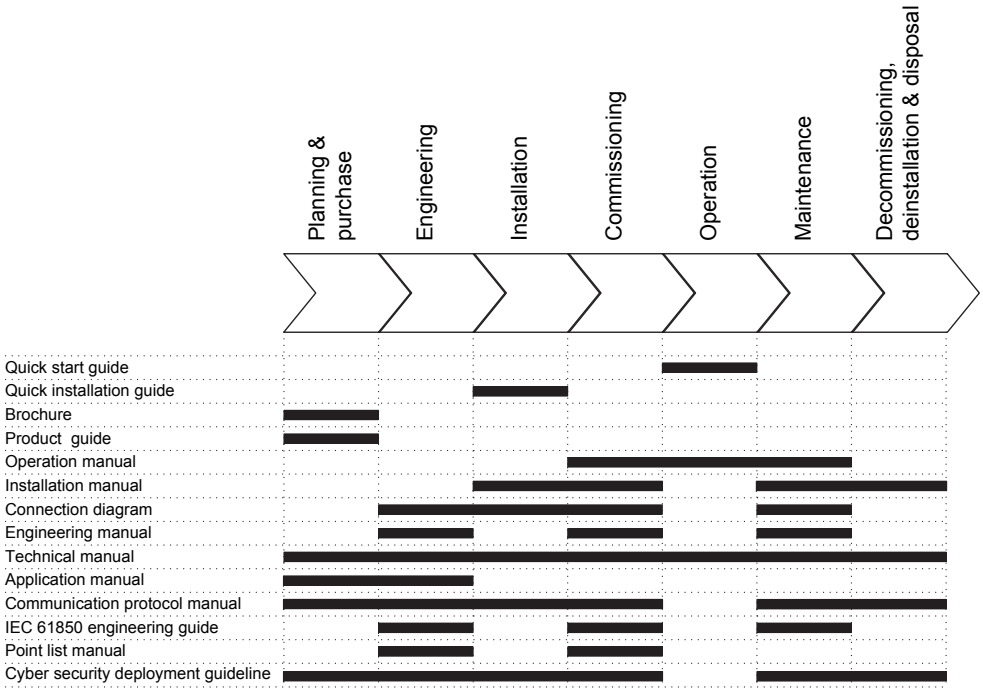

Figure 1: The intended use of manuals in different lifecycles

Product series- and product-specific manuals can be downloaded from the ABB Web site http://www.abb.com/relion.

1.3.2 Document revision history

Document revision/date	Product series version	History
A/2016-02-22	2.0	First release
B/2019-04-10	2.0	Content updated

1.3.3 Related documentation

Product series- and product-specific manuals can be downloaded from the ABB Web site http://www.abb.com/substationautomation.

1.4 Symbols and conventions

1.4.1 Symbols

The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard which could result in corruption of software or damage to equipment or property.

The information icon alerts the reader of important facts and conditions.

The tip icon indicates advice on, for example, how to design your project or how to use a certain function.

Although warning hazards are related to personal injury, it is necessary to understand that under certain operational conditions, operation of damaged equipment may result in degraded process performance leading to personal injury or death. Therefore, comply fully with all warning and caution notices.

1.4.2 Document conventions

A particular convention may not be used in this manual.

- Abbreviations and acronyms are spelled out in the glossary. The glossary also contains definitions of important terms.
- Push button navigation in the LHMI menu structure is presented by using the push button icons.
  To navigate between the options, use ↑ and ↓.
- Menu paths are presented in bold.
  Select **Main menu/Settings**.
- LHMI messages are shown in Courier font.
  To save the changes in nonvolatile memory, select `Yes` and press ↵.
- Parameter names are shown in italics.
  The function can be enabled and disabled with the *Operation* setting.
- Parameter values are indicated with quotation marks.
  The corresponding parameter values are "On" and "Off".
- Input/output messages and monitored data names are shown in Courier font.
  When the function starts, the `START` output is set to TRUE.
- This document assumes that the parameter setting visibility is "Advanced".

Section 2 Security in distribution automation

2.1 General security in distribution automation

Technological advancements and breakthroughs have caused a significant evolution in the electric power grid. As a result, the emerging “smart grid” and “Internet of Things” are quickly becoming a reality. At the heart of these intelligent advancements are specialized IT systems – various control and automation solutions such as distribution automation systems. To provide end users with comprehensive real-time information, enabling higher reliability and greater control, automation systems have become ever more interconnected. To combat the increased risks associated with these interconnections, ABB offers a wide range of cyber security products and solutions for automation systems and critical infrastructure.

The new generation of automation systems uses open standards such as IEC 60870-5-104, DNP3 and IEC 61850 and commercial technologies, in particular Ethernet and TCP/IP based communication protocols. They also enable connectivity to external networks, such as office intranet systems and the Internet. These changes in technology, including the adoption of open IT standards, have brought huge benefits from an operational perspective, but they have also introduced cyber security concerns previously known only to office or enterprise IT systems.

To counter cyber security risks, open IT standards are equipped with cyber security mechanisms. These mechanisms, developed in a large number of enterprise environments, are proven technologies. They enable the design, development and continual improvement of cyber security solutions also for control systems, including distribution automation applications.

ABB understands the importance of cyber security and its role in advancing the security of distribution networks. A customer investing in new ABB technologies can rely on system solutions where reliability and security have the highest priority.

Reporting of vulnerability or cyber security issues related to any ABB product can be done via cybersecurity@ch.abb.com.

2.2 Reference documents

Information security in critical infrastructure like electrical distribution and transmission networks has been in high focus for both vendors and utilities. This together with developing technology, for example, appliance of Ethernet and IP based communication networks in substations, power plants and network control centers creates a need of specifying systems with cyber security.

ABB is involved in the standardization and definition of several cyber standards, the most applicable and referred ones are ISO 2700x, IEC 62443, IEEE P1686 and IEC 62351. Besides standardization efforts there are also several governments initiated requirements and practices like NERC CIP and BDEW. ABB fully understands the importance of cyber security for substation automation systems and is committed to support users in efforts to achieve or maintain compliance to these.

Section 3 Secure system setup

3.1 Basic system hardening rules

Today's distribution automation systems are basically specialized IT systems. Therefore, several rules of hardening an automation system apply to these systems, too. Protection and control relays are from the automation system perspective on the lowest level and closest to the actual primary process. It is important to apply defense-in-depth information assurance concept where each layer in the system is capable of protecting the automation system and therefore protection and control relays are also part of this concept. The following should be taken into consideration when planning the system protection.

- Recognizing and familiarizing all parts of the system and the system's communication links
- Removing all unnecessary communication links in the system
- Rating the security level of remaining connections and improving with applicable methods
- Hardening the system by removing or deactivating all unused processes, communication ports and services
- Checking that the whole system has backups available from all applicable parts
- Collecting and storing backups of the system components and keeping those up-to-date
- Removing all unnecessary user accounts
- Changing default passwords and using strong enough passwords
- Checking that the link from substation to upper level system uses strong enough encryption and authentication
- Separating public network from automation network
- Segmenting traffic and networks
- Using firewalls and demilitarized zones
- Assessing the system periodically
- Using antivirus software in workstations and keeping those up-to-date

It is important to utilize the defence-in-depth concept when designing automation system security. It is not recommended to connect a device directly to the Internet without adequate additional security components. The different layers and interfaces in the system should use security controls. Robust security means, besides product features, enabling and using the available features and also enforcing their use by company policies. Adequate training is also needed for the personnel accessing and using the system.

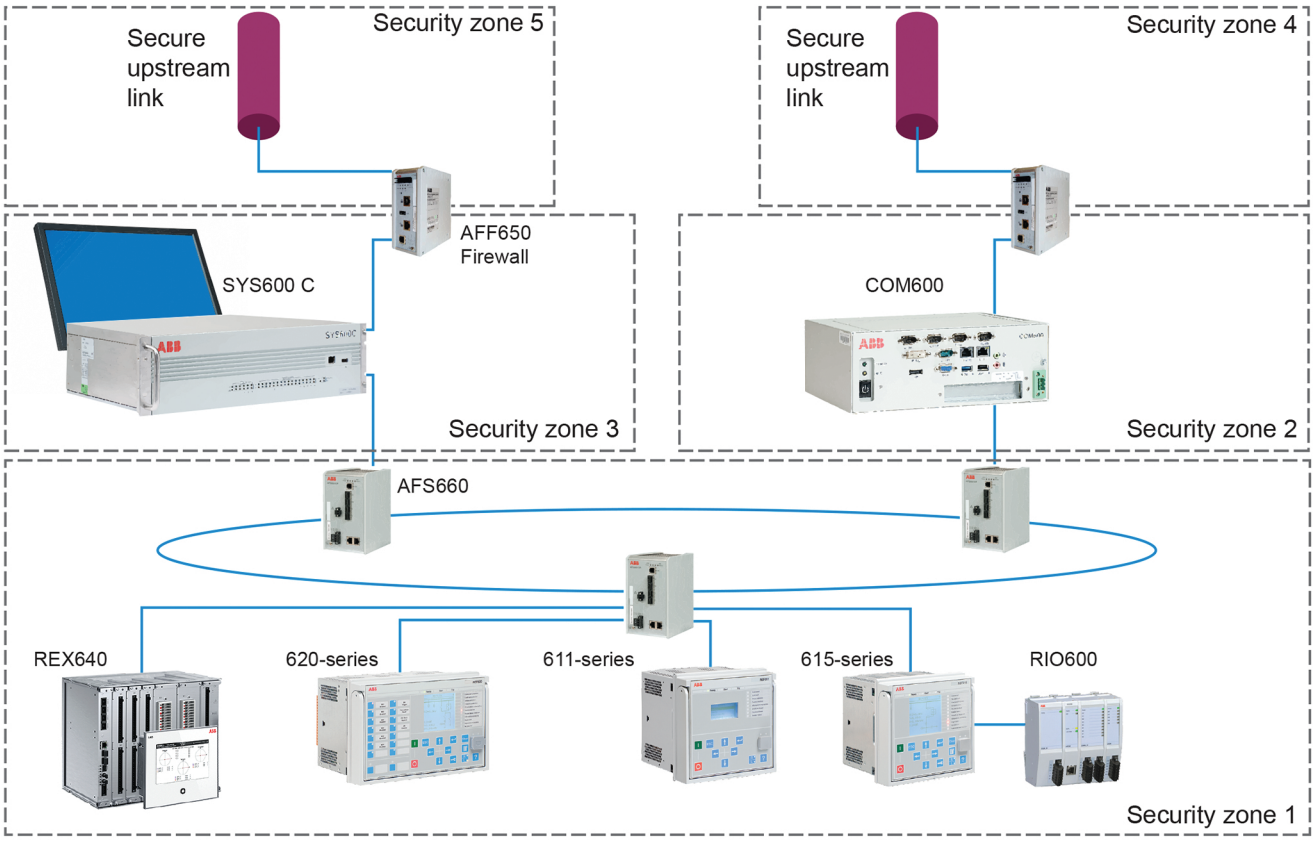

Figure 2: Distribution substation example

3.2 Relay communication interfaces

All physical ports dedicated for station bus communication can be opened and closed in relay configuration. Front port is used for engineering and it can be used only for point-to-point configuration access with PCM600 or WHMI. Front port should not be connected to any Ethernet network.

Table 1: Physical ports on relay's communication cards

Port ID	Type	Default state	Description
X1...X3	RJ-45 or fiber optic	Open	Ethernet station bus
X5	RS-485	Closed	Serial station bus
X6	RS-232/RS-485	Closed	Serial station bus
Front port	RJ-45	Open	LHMI service access

If the protection relay is ordered with station bus option, serial ports are closed by default and Ethernet ports are open. All protocol instances except for IEC 61850 are by default off and do not respond to any protocol requests in serial or Ethernet

ports.IEC 61850 protocol and rear Ethernet ports are by default activated as those are used for engineering of the protection relay. Front port is segregated from rear ports' station bus communication.

3.3 TCP/IP based protocols and used IP ports

IP port security depends on specific installation, requirements and existing infrastructure. The required external equipment can be separate devices or devices that combine firewall, router and secure VPN functionality. When the network is divided into security zones, it is done with substation devices having firewall functionality or with dedicated firewall products. Security zone boundaries are inside the substation or between the substation and the outside world.

The relay supports an option with multiple station communication Ethernet ports. In this case, all ports use the same IP and MAC address regardless of what redundancy option is activated in the relay configuration.

To set up an IP firewall the following table summarizes the IP ports used by the device. All closed ports can be opened in the configuration. Ports which are by default open are used for configuring the protection relay.

Table 2: IP ports used by the relay

Port number	Type	Default state	Description
20, 21	TCP	Open	File Transfer protocol (FTP and FTPS)
102	TCP	Open	IEC 61850
80	TCP	Open	Web Server HTTP
443	TCP	Open	Web Server HTTPS
123	UDP	Not active	Simple Network Time Protocol
502	TCP	Closed	Modbus TCP

FTP and IEC 61850 are primary services needed for relay configuration and those cannot be disabled. Additionally, the protection relay uses layer 2 communications in GOOSE, IEEE 1588 (PTP) and HSR/PRP supervision services, which needs to be taken into account when designing the network.

In addition to the HTTP and FTP protocols, the relay supports the Ethernet-based substation automation communication protocol Modbus. IEC 61850 is always enabled, and the relay can be ordered with one additional station bus protocol. Additional protocols must be enabled in the configuration, otherwise the communication protocol TCP/UDP port is closed and unavailable. If the protocol service is configured, the corresponding port is open all the time.

See the relay series' technical manual and the corresponding protocol documentation for configuring a certain communication protocol.

In Modbus it is possible to assign the TCP or UDP port number if required and it is also possible to allow connection requests only from configured client IP address.

3.4 Secure communication

The protection relay supports encrypted communication according to the principles of IEC 62351 in secured communication for WHMI and file transfer. If the *Secure Communication* parameter is activated in the relay, protocols require TLS protocol based encryption method support from the clients. In this case WHMI must be connected from a Web browser using the HTTPS protocol. In case of file transfer, the client must use FTPS. PCM600 supports FTPS and is able to download and upload configuration files in encrypted format from relay.

The *Secure Communication* parameter is enabled by default. It can be accessed via HMI path **Main menu/Configuration/Authorization/Security**.

3.4.1 Certificate handling

For encryption and secure identification, HTTPS and FTPS protocols in the protection relay use public key certificates that bind together a public key with an identity, that is, information such as the name of an organization, their address and so on. The server certificate used by the protection relay is generated by the relay itself as a self-signed certificate and not issued by any certification authority (CA).

Certificates use encryption to provide secure communication over the network. A self-signed X.509 certificate and an RSA key-pair with key-length of 1024 bits is generated by the protection relay. The RSA key stored in the certificate is used to establish secure communication.

The certificate is used to verify that a public key belongs to an identity. In case of HTTPS, the WHMI server in the protection relay presents the certificate to the Web client giving the client the public key and the identity of the server. The public key is one part of an asymmetric key algorithm in which one key is used to encrypt a message and another key is used to decrypt it. The public private key pair (asymmetric key) is used to exchange the symmetric key, which is used to encrypt and decrypt the data that is exchanged between server and client.

Messages encrypted with the public key can only be decrypted with the other part of the algorithm, the private key. Public and private key are related mathematically and represent a cryptographic key pair. The private key is kept secret and stored safely in the protection relay, while the public key may be widely distributed.

Once the protection relay certificate has been manually trusted in a separate dialog box, the certificate is trusted in communication between the relay and PCM600. For WHMI use, the certificate signed by the protection relay must be accepted in the Web browser when opening the connection to WHMI.

Web browser displays a warning because WHMI uses self-signed certificates.

3.4.2 Encryption algorithms

TLS connections are encrypted with either AES 256 or AES 128. At start-up a negotiation decides between these two options.

A hashed representation of the passwords with SHA 256 is stored in the protection relay. These are not accessible from outside via any ports. No passwords are stored in clear text within the protection relay.

3.5 Web HMI

The WHMI is one of the available user access services in the protection relay. By default the service is enabled and the HTTP and HTTPS TCP ports are open. WHMI can be disabled with the *Web HMI mode* parameter via LHMI menu path **Main menu/ Configuration/HMI**.

The relay supports HTTPS protocol to provide encryption and secure identification in the communication to the WHMI. The *Secure Communication* parameter is active by default, and WHMI access is automatically opened in HTTPS mode. When the *Secure Communication* parameter is inactive, both HTTP and HTTPS protocols can be used for WHMI.

The WHMI requires that certain technical features must be supported and enabled by the used Web client.

- HTTP 1.1
- HTML 4 and HMTL 5
- XSLT 2.0
- CSS1 and CSS2.1
- AJAX
- JavaScript 1.2
- DOM 1.0
- HTTP Digest Access Authentication
- HTTP session cookies
- HTTP compression
- SVG 1.1 [1]

In case of HTTPS access the Web client must support HTTPS via TLS 1.0 or TLS 1.1/1.2. The WHMI is verified with Internet Explorer 8.0, 9.0, 10.0 and 11.0.

[1] SVG Viewer is required for Internet Explorer 8.0

The access to the relay's WHMI is protected by the HTTP Digest Access Authentication (DAA) that requires a user name and password. DAA ensures that the user credentials are encrypted secure before sending over the network. See RFC2617 "HTTP Authentication: Basic and Digest Access Authentication" for detailed information about DAA.

User authentication is always required in WHMI.

If the Internet Explorer is used as Web client the advanced option "Show friendly HTTP error messages" might be enabled by default. It is recommended to disable this option. If this option is enabled, detailed error information of the WHMI is shown. The option can be found in the "Advanced" tab of the "Internet Options".

Section 4 User management

4.1 User roles

Four user categories have been predefined for the LHMI and the WHMI, each with different rights and default passwords.

The default passwords in the protection relay delivered from the factory can be changed with Administrator user rights. Relay user passwords can be changed using LHMI, WHMI or the IED User Management tool in PCM600 and the user information is stored to the protection relay's internal memory.

User authorization is disabled by default for the LHMI and can be enabled with the *Local override* parameter via the LHMI path **Main Menu/Configuration/Authorization/Passwords**. WHMI always requires authentication. Changes in user management settings do not cause the protection relay to reboot. The changes are taken into use immediately after committing the changed settings on menu root level.

Table 3: Predefined user categories

Username	User rights
VIEWER	Read only access
OPERATOR	• Selecting remote or local state with (only locally) • Changing setting groups • Controlling • Clearing indications
ENGINEER	• Changing settings • Clearing event list • Clearing disturbance records • Changing system settings such as IP address, serial baud rate or disturbance recorder settings • Setting the protection relay to test mode • Selecting language
ADMINISTRATOR	• All listed above • Changing password • Factory default activation

If the *Remote override* parameter from the **Main menu/Configuration/Authorization/Passwords** menu has been disabled, changes have to be made in the IED's object properties in PCM600. When the protection relay uses remote

authentication, the activated user level and its password are required when the protection relay is configured using PCM600.

Table 4: Object properties to change

Object Properties field	Value
Is Authentication Disabled	False
Is Password used	True
Password	Write the correct password

When communicating with the protection relay with PCM600 tools and with the relay authentication enabled, the relay username and password must be given when prompted. When setting the technical key, the username and password must be given twice.

If the PCM600 authentication has been enabled in PCM600 System Settings, a relay user can be linked to the current PCM600 user by selecting the Remember me check box in the Login dialog. After that, the user credentials are no longer asked at tool communication as logging in PCM600 also provides the authentication credentials to the protection relay.

When *Remote override* is disabled, also MMS clients need authentication using correct password.

FTP always requires authentication.

4.2 Password policies

Passwords are settable for all predefined user categories. The LHMI password must be at least four and WHMI password at least nine characters. The maximum number of characters is 8 for the LHMI password and 20 for the WHMI password. Only the following characters are accepted.

- Numbers 0-9
- Letters a-z, A-Z
- Space
- Special characters !"#%&'()*+´-./:;<=>?@[\]^_`{|}~

User authorization is disabled by default and can be enabled via the LHMI or WHMI path **Main Menu/Configuration/Authorization/Passwords**.

The protection relays are delivered from the factory with default passwords. It is recommended to change the default passwords.

Table 5: Predefined user categories and default passwords

Username	LHMI password	WHMI password	User rights
VIEWER	0001	remote0001	Only allowed to view
OPERATOR	0002	remote0002	Authorized to make operations
ENGINEER	0003	remote0003	Allowed to change protection relay parameters, but no operation rights
ADMINISTRATOR	0004	remote0004	Full access

For user authorization for PCM600, see PCM600 documentation.

4.2.1 Setting passwords

If user authorization is off or the user is logged in as an administrator, user passwords can be set via the LHMI or WHMI or with PCM600.

Local passwords can be changed only via the LHMI. Remote passwords can be changed via the LHMI or WHMI or with PCM600.

1. Select **Main menu/Configuration/Authorization/Passwords**.
2. Select the password to be reset with ↑ or ↓.
3. Press ↵, change the password with ↑ or ↓ and press ↵ again.
4. Repeat steps 2 and 3 to set the rest of the passwords.

If the administrator password is lost, contact ABB's technical customer support to retrieve the administrator level access.

Section 5 Security logging

5.1 Audit trail

The protection relay offers a large set of event-logging functions. Critical system and protection relay security-related events are logged to a separate nonvolatile audit trail for the administrator.

Audit trail is a chronological record of system activities that allows the reconstruction and examination of the sequence of system and security-related events and changes in the protection relay. Both audit trail events and process related events can be examined and analyzed in a consistent method with the help of Event List in LHMI and WHMI and Event Viewer in PCM600.

The protection relay stores 2048 audit trail events to the nonvolatile audit trail. Additionally, 1024 process events are stored in a nonvolatile event list. Both the audit trail and event list work according to the FIFO principle. Nonvolatile memory is based on a memory type which does not need battery backup nor regular component change to maintain the memory storage.

Audit trail events related to user authorization (login, logout, violation remote and violation local) are defined according to the selected set of requirements from IEEE 1686. The logging is based on predefined user names or user categories. The user audit trail events are accessible with IEC 61850-8-1, PCM600, LHMI and WHMI.

Table 6: Audit trail events

Audit trail event	Description
Configuration change	Configuration files changed
Firmware change	Firmware changed
Firmware change fail	Firmware change failed
Attached to retrofit test case	Unit has been attached to retrofit case
Removed from retrofit test case	Removed from retrofit test case
Setting group remote	User changed setting group remotely
Setting group local	User changed setting group locally
Control remote	DPC object control remote
Control local	DPC object control local
Test on	Test mode on
Test off	Test mode off
Reset trips	Reset latched trips (TRPPTRC*)
Setting commit	Settings have been changed
Table continues on next page	

Audit trail event	Description
Time change	Time changed directly by the user. Note that this is not used when the protection relay is synchronised properly by the appropriate protocol (SNTP, IRIG-B, IEEE 1588 v2).
View audit log	Administrator accessed audit trail
Login	Successful login from IEC 61850-8-1 (MMS), WHMI, FTP or LHMI.
Logout	Successful logout from IEC 61850-8-1 (MMS), WHMI, FTP or LHMI.
Password change	Password changed
Firmware reset	Reset issued by user or tool
Audit overflow	Too many audit events in the time period
Violation remote	Unsuccessful login attempt from IEC 61850-8-1 (MMS), WHMI, FTP or LHMI.
Violation local	Unsuccessful login attempt from IEC 61850-8-1 (MMS), WHMI, FTP or LHMI.

PCM600 Event Viewer can be used to view the audit trail events and process related events. Audit trail events are visible through dedicated Security events view. Since only the administrator has the right to read audit trail, authorization must be used in PCM600. The audit trail cannot be reset, but PCM600 Event Viewer can filter data. Audit trail events can be configured to be visible also in LHMI/WHMI Event list together with process related events.

To expose the audit trail events through Event list, define the *Authority logging* level parameter via **Configuration/ Authorization/Security**. This exposes audit trail events to all users.

Table 7: Comparison of authority logging levels

Audit trail event	Authority logging level					
	None	Configuration change	Setting group	Setting group, control	Settings edit	All
Configuration change		•	•	•	•	•
Firmware change		•	•	•	•	•
Firmware change fail		•	•	•	•	•
Attached to retrofit test case		•	•	•	•	•
Removed from retrofit test case		•	•	•	•	•
Setting group remote			•	•	•	•
Setting group local			•	•	•	•
Control remote				•	•	•
Control local				•	•	•
Test on				•	•	•

Table continues on next page

Audit trail event	Authority logging level					
Test off				•	•	•
Reset trips				•	•	•
Setting commit					•	•
Time change						•
View audit log						•
Login						•
Logout						•
Password change						•
Firmware reset						•
Violation local						•
Violation remote						•

Section 6 Using the HMI

6.1 Using the local HMI

To use the LHMI, logging in and authorization are required. Password authorization is disabled by default and can be enabled via the LHMI.

To enable password authorization, select **Main menu/ Configuration/Authorization/Passwords**. Set the *Local override* parameter to “False”.

6.1.1 Logging in

1. Press ← or → or ↵ to activate the login procedure.
2. Press ↑ or ↓ to select the user level.

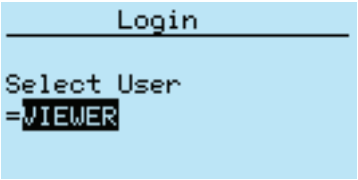

Figure 3: Selecting access level

3. Confirm the selection with ↵.
4. Enter the password when prompted digit by digit.
   - Activate the digit to be entered with ← and →.
   - Enter the character with ↑ and ↓.

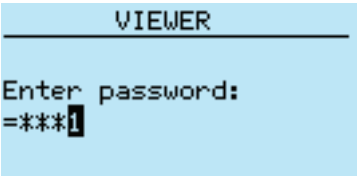

Figure 4: Entering password

5. Press ↵ to confirm the login.
   - To cancel the procedure, press ESC.

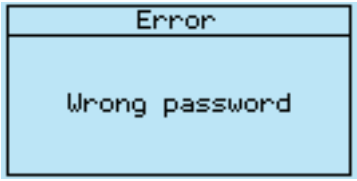

Figure 5: Error message indicating wrong password

The current user level is shown on the display's upper right corner in the icon area.

6.1.2 Logging out

An automatic logout occurs 30 seconds after the backlight timeout.

1. Press ← for three seconds in the main menu.
2. To confirm logout, select `Yes` and press ↵.

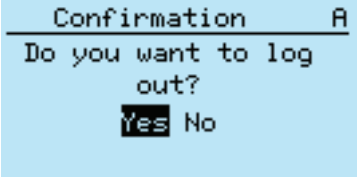

Figure 6: Logging out

- To cancel logout, press ESC.

6.2 Using the Web HMI

WHMI is enabled by default. As secure communication is enabled by default, the WHMI must be accessed from a Web browser using the HTTPS protocol.

If the WHMI was previously disabled, it can be enabled again via the LHMI.

1. To enable the WHMI, select **Main menu/Configuration/HMI/Web HMI mode** via the LHMI.
2. Reboot the relay for the change to take effect.
3. Log in with the proper user rights to use the WHMI.

To establish a remote WHMI connection to the protection relay, contact the network administrator to check the company rules for IP and remote connections.

Disable the Web browser proxy settings or make an exception to the proxy rules to allow the protection relay's WHMI connection, for example, by including the relay's IP address in **Internet Options/ Connections/LAN Settings/Advanced/Exceptions**.

6.2.1 Logging in

1. Open Internet Explorer.
2. Type the protection relay's IP address in the Address bar and press ENTER.
3. Type the username with capital letters.
4. Type the password.

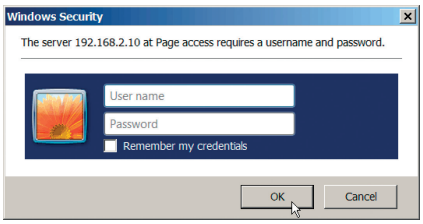

Figure 7: Entering username and password to use the WHMI

5. Click **OK**.
   The language file starts loading and the progress bar is displayed.

6.2.2 Logging out

The user is logged out after session timeout. The timeout can be set in **Main menu/ Configuration/HMI/Web HMI timeout**.

- To log out manually, click **Logout** on the menu bar.

Section 7 Protection of relay and system configuration

7.1 Backup files

Backups are not directly part of the cyber security but they are important for speeding up the recovery process, for example, in case of failure of the protection relay. Backups need to be updated when there are changes in configuration.

7.1.1 Creating a backup from the relay configuration

1. Use the “Read from IED” function from the IED context menu in PCM600 to back up the relay configuration.

   User authorization is needed before using the tool.

2. Enter the user credentials if the default administrator password has been changed.
   Administrator or engineer credentials are needed for authorization.

7.1.2 Creating a backup from the PCM600 project

Backup from the PCM600 project is made by exporting the project.

1. On the **File** menu, click **Open/Manage Project** to open the project management.
2. Select the project from the **Currently available projects** dialog box.
3. Right-click the project and select **Export Project** to open the **Create target file for the project export** dialog box.
4. Browse the target location and type the name for the exported file.
   All project related data is compressed and saved to one file, which is named and located according to the definitions.

7.2 Restoring factory settings

In case of configuration data loss or any other file system error that prevents the protection relay from working properly, the whole file system can be restored to the

original factory state. All default settings and configuration files stored in the factory are restored. Only the administrator can restore the factory settings.

1. Select **Main menu/Configuration/General/Factory setting** and press ↵.
2. Set the value with ↑ or ↓ and press ↵.
3. Confirm by selecting **Yes** with ↑ or ↓ and press ↵.

The protection relay restores the factory settings and restarts. Restoring takes 1...3 minutes. Confirmation of restoring the factory settings is shown on the display a few seconds, after which the relay restarts.

Avoid the unnecessary restoring of factory settings, because all the parameter settings that are written earlier to the relay will be overwritten with the default values. During normal use, a sudden change of the settings can cause a protection function to trip.

Restoring factory settings also resets the IP address for the rear port and the corresponding subnet mask to the factory default settings.

To restore factory settings from bootloader mode, press ESC + → simultaneously for 5 seconds.

7.3 Restoring the administrator password

If authentication is enabled in the protection relay and the administrator password is lost, it is no longer possible to change passwords or operate the relay with full access rights.

- Contact ABB technical customer support to retrieve back the administrator level access to the protection relay.

Section 8 Glossary

BDEW	Bundesverband der Energie- und Wasserwirtschaft
CA	Certification authority
DAA	HTTP Digest Access Authentication
DNP3	A distributed network protocol originally developed by Westronic. The DNP3 Users Group has the ownership of the protocol and assumes responsibility for its evolution.
DOM	Binary output module, four channels
DPC	Double-point control
EMC	Electromagnetic compatibility
Ethernet	A standard for connecting a family of frame-based computer networking technologies into a LAN
FIFO	First in, first out
FTP	File transfer protocol
FTPS	FTP Secure
GOOSE	Generic Object-Oriented Substation Event
HMI	Human-machine interface
HSR	High-availability seamless redundancy
HTML	Hypertext markup language
HTTPS	Hypertext Transfer Protocol Secure
IEC	International Electrotechnical Commission
IEC 60870-5-104	Network access for IEC 60870-5-101
IEC 61850	International standard for substation communication and modeling
IEC 61850-8-1	A communication protocol based on the IEC 61850 standard series
IED	Intelligent electronic device
IEEE	Institute of Electrical and Electronics Engineers, Inc.
IEEE 1686	Standard for Substation Intelligent Electronic Devices' (IEDs') Cyber Security Capabilities
IP	Internet protocol
IP address	A set of four numbers between 0 and 255, separated by periods. Each server connected to the Internet is assigned

	a unique IP address that specifies the location for the TCP/IP protocol.
IRIG-B	Inter-Range Instrumentation Group's time code format B
ISO	International Standard Organization
LHMI	Local human-machine interface
MMS	1. Manufacturing message specification 2. Metering management system
Modbus	A serial communication protocol developed by the Modicon company in 1979. Originally used for communication in PLCs and RTU devices.
NERC CIP	North American Electric Reliability Corporation - Critical Infrastructure Protection
PCM600	Protection and Control IED Manager
PRP	Parallel redundancy protocol
PTP	Precision Time Protocol
RJ-45	Galvanic connector type
RS-232	Serial interface standard
RS-485	Serial link according to EIA standard RS485
SNTP	Simple Network Time Protocol
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
UDP	User datagram protocol
VPN	Virtual Private Network
WHMI	Web human-machine interface

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