FAHAM Interoperability Documents

FID2 Package 1

Interoperability Specification (MI2-SI2)

Rev: 3.0

Prepared by:

FID2 Working Group

Table of Contents

Revision History

Date	Version	Description	Author
09-09-2015	0.0	First Draft.	FARAB
01-02-2016	0.1	Consider comments provided by Monenco, Paudraad , NRI, BST,TFS and update first draft.	Monenco
22-02-2016	0.2	Add some new comments.	Paudraad
28-02-2016	0.3	Change Template of document. Update referenced documents.	EAA
29-02-2016	0.4	Meter reading chapter divided to following chapters: • Meter reading • Profile generic (Billing data transfer to this chapter) • Quality of supply • Interruption information Effect of Events on load profiles added from IDIS but not complete yet Unbalance load and neutral current for single phase should go to event management chapter in next update. Error code on application layer not updated yet (next release)	EAA
06-03-2016	0.5	Add some sections or subsections based on IDIS as follows: • Pre-established association • Power down to profile • SMS as a general communication channel • E-meter security feature • Consumer Information push-using push operation • Wired M-Bus Eliminate some sections or subsections; Modify some sections and sentences as follows: • Error code • Registration	Committee
06-03-2016	0.6	Check Syntax & Writing Rules.	SABA
15-03-2016	1.0	Final Edit.	Monenco
01-06-2016	1.1	Review new comments& Final Check.	SABA& Monenco
20-10-2018	1.2	Finalize new comments base on NRI's FID2 (V1.1) Functional Tests and also CESI comments (In this version implementing CESI comments including ACCESS and ABORT services and Compact data feature are Optional but, they will be mandatory by end of November 2019 as a part of FID2 (V2))	Monenco – Tavanir & Technical Committee
12-05-2020	1.3	Finalize new comments base on NRI's Commennts	Monenco – Tavanir &

			Technical Committee
13-09-2020	2.0	Add Distribution Companies Comments	Monenco
26-03-2022	2.1	Finalize AMI Committee Comments	Monenco-AMI Committee
23-10-2024	3.0	Finalize AMI Committee Comments	Tavanir & AMI Committee

List of main technical changes in Version 3 (compared to version 2.0)	
Item	**Description**
1.	Delete related sections Sub-Meter.
2.	Delete ACCESS services and Compact data feature
3.	Figure 3 is modified
4.	In table 2 and table 5, Set/Action is deleted from Pre-established client
5.	Section 2.2.4 “Enciphering of the Initiate Request field in the RLRQ and AARQ PDUs “,is added
6.	Table 6 and table 8 are modified.
7.	Section 3 is updated.
8.	Device Type in section 4.1.1 is updated.
9.	In FT (function type), bit 2 modified. By Gateway protocol added.
10.	Below of Figure 7, added a Note about load management.
11.	In section 4.3, The device type (two digits) in utility device id, is modified.
12.	Description of Device ID5 of “RamzRayaneh” changed to “shenase ghabz”.
13.	In table 12, Device ID8 (Manufacturer specific) is added.
14.	Data Type of Value in table 14 changed to HEX encoding
15.	Data Type of Value in table 15 changed to HEX encoding
16.	Data Type of Value in table 16 changed to HEX encoding
17.	In table 20, registers that mask to each tariff is modified.
18.	Add Harmonic and THD Feature for DC Meters
19.	Active energy export total (|+A|) (recording interval 2) is added to Maximum Demand Registers and load profile2.
20.	Definition new optional OBIS-Codes for Fundamental current of L1, L2, L3 and Fundamental voltage of L1, L2, L3
21.	In section 9.1.3, Time threshold for voltage cut is modified to 5 sec.
22.	Section 9.1.4 “Effect of Delay Time “, is added
23.	A Note added in section 10.1
24.	OBIS-Code of “Number of Short Power Failure in Any Phases” and “Number of Long Power Failure in Any Phase” are deleted.
25.	Section 11, Disconnect Control is modified
26.	Note in section 11 added for En/Dis switch in DC and Single phase meter
27.	In section 11, Table 37 is added.

List of main technical changes in Version 3 (compared to version 2.0)	
Item	**Description**
28.	Priority for disconnection/reconnection command is added as note1 in section 11.
29.	Definition new OBIS-Codes for Disconnect Control Scheduler (22, 0-0:15.1.1.255)
30.	Definition new OBIS-Codes for Relay Inverse Mode (1, 0-0:146.129.41.255)
31.	A Note is added in subsection 11.3.1.1
32.	Added Gateway Mode.
33.	Added ability for Measuring Harmonics for All 3ph meters.
34.	In section 6.3 change the number of seasons.
35.	The Object {5,1-0:15.24.0.255} is added to Monitored value for single phase meter
36.	Section 11.5 is deleted.
37.	Table 40 is modified.
38.	The size of image_block_size is added as a Note in subsection 14.1
39.	In subsection 15.4.1 added and improved some sentences about alarm register and error register.
40.	In alarm register1, bits 2,3,4 changed to reserved.
41.	In alarm register2, bits 19,20,21,22,23,24,25,26 modified.
42.	Table 41 is added for Abstract examples about alarm register and alarm Descriptor
43.	Section 16.3 is added about GSM Diagnostic
44.	Mode 0 (No Auto Connect) is deleted from table 53
45.	In subsection 16.4.4, push object lists are modified.
46.	Figure 49 is modified.
47.	Section 19 about gateway mode is added.
48.	Subsection 19.1 description about checking RS485connection between meter (gateway) and sub-meters is added.
49.	Added signal strength object
50.	Eliminate the SHA-1 and MD5
51.	Added Energy Management description as section 20.

Abbreviations and Acronyms

AA	Application Associations
AARE	Application Association Response
AARQ	Application Association Request
AL	Application Layer
APDU	Application Protocol Data Unit
APN	Access Point Name
CAS	Central Access System
CII	Consumer Information Interface
CIP	Consumer Information Push
COSEM	Companion Specification for Energy Metering
CS	Central System
CSD	Circuit Switched Data
DC	Data Concentrator
DLMS	Device Language Message Specification
DT	Device Type
DUT	Device Under Test
FAHAM	IRAN Smart Metering and Energy Management System
FC	Frame Counter
FID2	FAHAM Interoperability Document
FT	Function Type
FU	Firmware Upgrade
FW	Firmware
GPRS	General Packet Radio Service
HES	Head-end System
HDLC	High-level Data Link Control
IMEI	International Mobile Equipment Identity
LN	Logical Name
MDM	Meter Data Management System
OUI	Organizationally Unique Identifier
SAP	Service Access Point
SMS	Short Message Service
WAN	Wide Area Network

Figures

Tables

Foreword

This document is intended to provide interoperability specifications for FAHAM products based on open standards and according to FAHAM requirements. The purpose of this document (hereafter called FID2) is to fill the gaps and to define the unspecified items in previous standards and requirements.

This document is based on DLMS/COSEM Colored Books (Blue Book- 2014 -12th Ed. & Green Book - 2014 8th Ed.) and IDIS document Ed 2.0 and they are the main references for any clarification.

Reference Documents

[1] English FAHAM V1.2 [90.03.16].pdf
Specification of General, Economical, Functional, Technical and Communicational Requirements for the Advanced Metering Infrastructure (AMI)
[2] Three Phase CT&PT Connection Meter.pdf
Technical Agreement for three phase CT & PT connected meters
[3] Three Phase CT Connection Meter.pdf
Technical Agreement for three phases CT connected meters
[4] Three Phase Direct Connection (DC) Meter.pdf
Technical Agreement for three phases Direct connected meters
[5] Single Phase Meter.pdf
Technical Agreement for single phase meters
[6] IDIS Package 2, IP Profile, Ed 2.0
[7] IDIS Package 2, Smart Metering Objects, Ed.2.0
[8] DLMS UA 1000-1:2014 12th Ed. (Blue Book).
[9] DLMS UA 1000-2:2014 8th Ed. (Green Book).

1 Scope of This Specification

FAHAM interface architecture is shown in following figure. As has been shown, FAHAM system includes various interfaces.

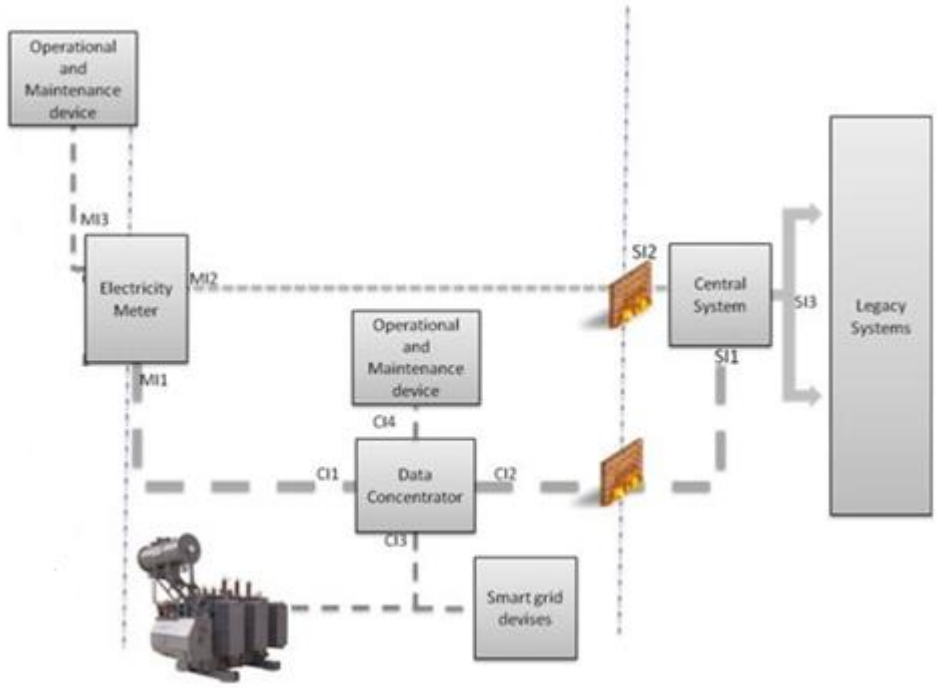


Figure 1: FAHAM (V3.0) System Architecture

The FID2 is divided into three main packages as follows:
FID2-Package 1: MI2-SI2 Interface;
FID2-Package 2: MI1-CI1 Interface;
FID2-Package 3: CI2-SI1 Interface:

2 System Architecture and DLMS Structure

The system architecture of FID2 Package 1 is presented in following figure. The data exchange between electricity meter and HES (Head-end System) is based on IP backbone, SMS services and DLMS protocol. The HES act as DLMS client and Electricity meter takes the role of DLMS server.

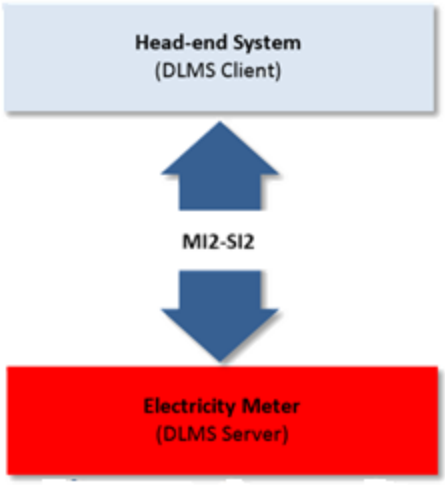


Figure 2: FID2 Package 1 (V3.0) System Architecture

Note: Meter shall be equipped with local port (optical port) and RS-485 interface (as mandatory) port. The RS-485 interface has the same functionality of remote communication.

2.1 Interfaces Specifications

2.1.1 MI2-SI2 (Meters-HES)

This interface is based on IP network and SMS service. The DLMS protocol is used for data exchange between electricity meters and HES. The HES acts as DLMS client and electricity meter as DLMS server. The following communication services shall be provided in this interface:

- GPRS
- CSD/SMS (Wake-up)

Two operating modes are used in this interface as follows:

- Pull
- Push

The “Pull” mode is initiated by HES. It is used for collecting data from meters or sending commands/information to meters and consumer’s interface. The “Pull” is realized by using following DLMS services:

- OPEN
- RELEASE
- GET
- SET
- Action
- ABORT

The “Push” mode is initiated by electricity meter to send some critical information such as Alarms and so on to Head-end system. The DATA-NOTIFICATION service of DLMS is used in this mode. Following

table shows the DLMS services in Pull and Push modes according to the type of communication (IP-based or SMS).

Table 1: DLMS Services in Pull/Push Modes

Operating Mode	DLMS Services	
	IP Communication	SMS Communication
Pull	GET, SET, ACTION, (Confirmed)	SET, ACTION (Unconfirmed)
Push	DATA-NOTIFICATION (Unconfirmed)	DATA-NOTIFICATION (Unconfirmed)

2.2 FAHAM Client/Server Architecture

The COSEM server is structured into three levels as follows:

Level 1: Physical Device
Level 2: Logical Device
Level 3: COSEM Objects

Each physical device (such as an electricity meter) can contain different Logical Devices. In FAHAM, only one logical device is defined as Management Logical Device (SAP: 001). Each logical device has a unique ID as its name. The name of only logical device in FAHAM is stored in COSEM object “COSEM Logical Device Name” (1, 0-0:42.0.0.255).

In FAHAM, the logical device supports four COSEM clients as follows:

- Public Client (SAP: 016)
- Pre-established Client (SAP: 102)
- Management Client (SAP: 001)
- Reading Client (SAP: 002)

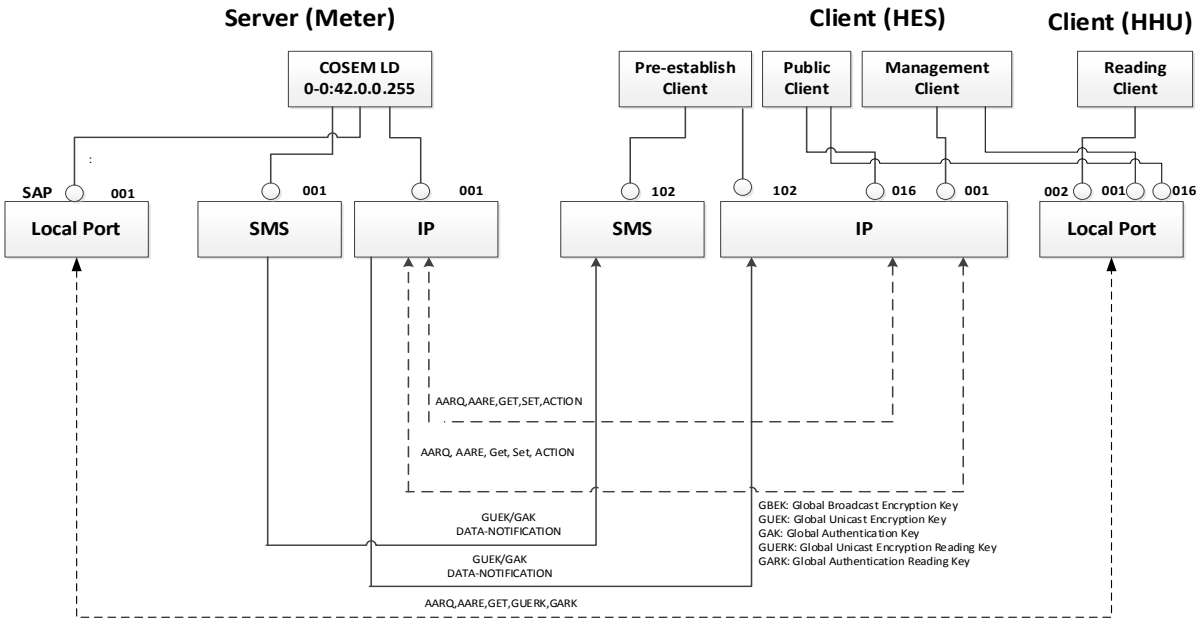


Figure 3: FID2 Client and Server Model

The Public client is provided for reading meter's general information (e.g. logical device name). Because of lowest access level security (no security) in this type of association, this client is permitted to reveal some limited information of meter, and is not allowed to read metering data and performing any programming or changing in meters settings.

The Management client is allowed to perform any operation on devices in point to point connections. In FAHAM, both "Confirmed" and "Unconfirmed" services are used.

The Pre-established is intended to perform broadcasting and multicasting services (unconfirmed) services. This type of association includes only the message exchange (not establishing and releasing). The Pre-established can be considered as an association that has been established previously. The Pre-established association can't be released.

Reading client is for parameters and energy data reading mostly in local access.

The following restrictions apply for the SMS channel:

- Only unconfirmed services can be used.
- The SMS channel can only be used from/to the Pre-established client at HES side.
- In direction to the meter the Broadcast Key must be used.
- In direction to the HES the Global Unicast Key must be used (if required by the security policy).

The permissible activities in each client are presented in following table.

Table 2: Different clients

Client	Activities	Description
Public	Reading device general information	Accessible via remote communication and local interface No security Established using DLMS-OPEN (AARQ) service
Management	Management and any setting/action in device, plus reading values	Accessible via remote communication and local interface With Authentication HLS (LLS backup) Established using DLMS-OPEN (AARQ) service
Pre-established	Unconfirmed application layer services for Data Notification	Accessible only via remote communication/RS485 (optical interface is not allowed) Always Established
Reading	Reading Parameters and Energy data	Accessible via local interface With Security. Established using DLMS-OPEN (AARQ) service With Authentication HLS (LLS backup)

2.2.1 Association Closing Policies

An Association (Logical Communication between Client and Server) can be closed at any time by DLMS-RELEASE and DLMS-ABORT services. But, in some special cases, the association shall be released by meter. They are presented in below table.

Table 3: Association closing in special cases

Client	Comm. Interface	Special Case for Closing
Public	Local (HDLC based Optical)	Time-out (inactivity_time_out of HDLC Setup Object); Power-off;
	Remote Communication (GPRS)/RS485	Time-out (inactivity_time_out of TCP-UDP/HDLC Setup Object); Power-off;
Management	Local (HDLC based Optical)	Time-out (inactivity_time_out of HDLC Setup Object); Power-off;
	Remote Communication (GPRS)/RS485	Time-out (inactivity_time_out of TCP-UDP/HDLC Setup Object); Power-off;
Reading	Local (HDLC based Optical)	Time-out (inactivity_time_out of HDLC Setup Object); Power-off;

Note: The Pre-established association is considered as “Always Established”. So, in case of power-off, it should be re-established again upon power-up.

2.2.2 Parallel Association Policies

The FAHAM meter shall support parallel association establishing. The following policies shall be governed in FAHAM meters about establishing parallel association.

- On the local communication port (IEC 62056-21), only one association can be opened at a time.
- On remote communication port (IP) several associations may be opened at the same time
- At different communication ports, several associations (with the same client or with different clients) may be opened at the same time.
- If a client wants to use several communication ports at the same time it must open an association at each communication port separately.
- Synchronization of internal memory access must be handled by the manufacturer.

Note: Total number of concurrent associations in meter is at least 3 (IP, RS485, local port) Max Receive PDU Size

For remote communication ports negotiated APDU size in AARQ shall be at least 1224 bytes. It means if a message can be transferred by an APDU size of 1224 bytes, it should be transferred only with one APDU and no segmentation shall occur in application layer.

2.2.3 Enciphering of the Initiate Request field in the RLRQ and AARQ PDUs

Context Name Security policy	Logical_Name_ Referencing_ No_Ciphering =0	Logical_Name_ Referencing_ With_Ciphering =0	Logical_Name_ Referencing_ No_Ciphering >0	Logical_Name_ Referencing_ With_Ciphering >0
RLRQ	No InitiateRequest Unciphered InitiateRequest	Ciphered InitiateRequest	Not possible	Ciphered InitiateRequest
AARQ	Unciphered InitiateRequest	Ciphered InitiateRequest	Not possible	Ciphered InitiateRequest

In case security policy >0:
An AARQ carrying non ciphered context information (context_id different from Logical_Name_Referencing_With_Ciphering) must be rejected by the server with an “error action” according to Table 6.

2.3 DLMS Application Layer Services

The COSEM application layer in FAHAM is based on IEC 62056-53 and DLMS UA 1000-2 Ed. 8.0 (Green Book). The LN (Logical Name) referencing is used in FAHAM. The mandatory application layer services in FAHAM are presented in below table.

Table 4: The mandatory application layer services in FAHAM meter

Service	Conformance Block Bit
general-protection	(1)
general-block-transfer	(2)
block-transfer-with-get	(11)
block-transfer-with-set	(12)
multiple-references	(14)
data-notification	(16)

Service	Conformance Block Bit
get	(19)
set	(20)
selective-access	(21)
action	(23)

The DLMS services in each association (Client) can be different. The mandatory services that shall be supported by meter in each association are presented in following table.

Table 5: mandatory services in associations

Client	Services
Public	get block-transfer-with-get
Management	get block-transfer-with-get set block-transfer-with-set selective-access multiple-references action general-block-transfer general-protection
Pre-established	data-notification general-block-transfer general-protection
Reading	get block-transfer-with-get selective-access multiple-references general-block-transfer general-protection

2.3.1 Block Transfer

FAHAM meter shall support block transfer in GET and SET services and General Block Transfer as well.

2.3.2 Invoke-Id-And-Priority Byte

According to the DLMS (Green Book Ed.7 and later), the “Invoke-Id-And-Priority” byte is “Unsigned 8” type with structure as following figure:

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
PRIORITY	SERVICE CLASS	RESERVED		INVOKE ID			

Figure 4: invoke-id-and-priority byte structure

Invoke Id: The “invoke-id” parameter pairs request and response between client and server by assigning an id to each task issued by client (in get, set, and action services). As has been shown in Figure, four bits have been considered for “invoke-id”. The “invoke-id” is assigned by client (HES) during issuing any request.

Service class: “0” means “unconfirmed” and “1” is considered as “confirmed”.

Priority: There are two priorities according to the DLMS definition. “0” means “normal” and “1” provides “high” priority. Normally, the server (meter) serves incoming requests in the order of

reception (FIFS, First In, First Served). HES can send a request with the priority parameter set to high. In this case, meter serves it before the previous requests with priority set to normal. The meter sends the response carries the same priority flag as that of the corresponding request. Managing priority is a negotiable feature (between client and server) and should be specified via bit “9” of conformance block.

Note: in the response, meter must return the invoke-id-and-priority byte same as received by request services.

2.3.3 Data Notification

The “Data-Notification” service is an unsolicited, unconfirmed service. It is used by the server to push data to the client. This service includes the following main parts:

- long-invoke-id-and-priority;
- date-time;
- notification-body;

The long-invoke-id-and-priority isa32 bits parameter with the structure as following figure:

Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	…	Bit 24	Bit 23	…	Bit 0
Priority	Service-Class	Processing-Option	Self-Descriptive	Reserved			Invoke ID		

Figure 5: long-invoke-id-and-priority parameter structure

Invoke id: number is incremented with each invocation of service.

Self-descriptive (bit 28): is fixed to “0”.

Processing-option (bit 29): is fixed to “0”.

Service-class (bit 30): is fixed to “0”

Priority (bit 31): is fixed to “0”.

2.3.4 Selective Access

The “selective access” provides selective access to a portion of an attribute. This is mostly used in reading of contents of buffer in “Profile Generic” (class id: 7) and "Association LN" (class id: 15) COSEM objects. This service is negotiable via conformance block during association establishment. FAHAM meter shall support selective access service by Range as mandatory (selective access by entry is optional). The details of requirements are presented in relevant COSEM object in this specification.

2.3.5 Pre-established Association

Used by the pre-established client. The pre-established application shares the security concept with the management client. The application context is implicitly defined as:

- max receive pdu_size= 1224
- max send pdu_size= 1224
- DLMS version nr= 6
- Quality of service= not used

- Ciphering info= not used
- Conformance= DATA-NOTIFICATION
- Application context name= Logical_Name_Referencing_With_Ciphering
- Security Policy= 3 (Encryption and message authentication)
- Security setup reference= 0-0:43.0.0.255

The objects and attributes which are accessible by the pre-established client are defined in Object List.

2.3.6 DLMS Services Error Handling

The server (meter) shall always answer to any service requested by client (if server and client SAP addresses are correct. In case of wrong server/client address, meter will not answer. Valid addresses are presented in section2.2). The answer can be a proper answer or an error. The errors can be divided into the following main groups:

- Errors in association establishment/releasing;
- Errors inside association (get/set/action/ services);

2.3.7 Errors in Association Establishment/Releasing

The error and reason related to association establishment are included in AARQ in response to AARQ. There are two fields in AARQ message to show the result of association establishment request (AARQ) and reason/source of error happened. They are as follows respectively:

- result (AARQ.result);
- error source (AARQ.result-source-diagnostic)

Following table presents the possible errors in association establishment and the values shall be sent by server via “AARQ-result” and “AARQ-result-source-diagnostic”fields.

Table 6: Error events associated to the AARQ service

Condition NOT fulfilled in the AARQ service	Action performed by the server
Server Id = Management logical device	No response
Client Id = public or broadcast or management	No response
Association NOT OPEN	Exception response [216] state-error=service-not-allowed, [1] serviceerror=operation-not-possible[1]
Protocol Version = OK	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = acse-service-provider.no-common-acse-version [2]
Context Name = RECEIVED	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = acse-service user.applicationcontext-not-supported [2]
Context Name = OK. All optional fields which are present must be tested and the test must be fulfilled.	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = acse-service-user.applicationcontext-not-supported [2]
(Secured Context AND Calling AP Title = RECEIVED) OR (Not Secured Context) The calling AP Title is the system title and it is accepted without any additional checking.	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = acse-service-user.authentication-required [14]

Condition NOT fulfilled in the AARQ service	Action performed by the server
ACSE Requirement = RECEIVED	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = acse-service-user.authentication-required [14]
ACSE Requirement = OK	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = acse-serviceuser.authentication-required [14]
Mechanism Name = RECEIVED	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = acse-serviceuser.authentication-mechanism-required [12]
Mechanism Name = OK	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = acse-serviceuser.authentication-mechanism-not-recognised [11]
Authentication Value = RECEIVED	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = acse-serviceuser.authentification-failure [13]
authentication Value = OK	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = acse-serviceuser.authentification-failure [13]
User Information = RECEIVED	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = acse-service-user.no-reasongiven[1]
Dedicated-Key = OK	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = acse-service-user.no-reasongiven [1] AARE.user-information = ConfirmedServiceError [14]. InitiateError[1].Initiate.other [6][0]
Proposed-dlms-version = 6	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = acse-service-user.no-reasongiven [1] AARE.user-information = ConfirmedServiceError [14]. InitiateError[1].Initiate.dlms-version-too-low[6][1]
Proposed-Conformance = OK	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = acse-service-user.no-reasongiven [1] AARE.user-information = ConfirmedServiceError [14]. InitiateError[1].Initiate.incompatibleconformance [6][2]

Just if security policy is higher than 0, the following application association errors related to the secured AARQ service apply.

Table 7: Error events associated to the secured AARQ service

Condition NOT fulfilled in the service	Action performed by the server
Secured initiate request	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = no reason given [1]
Received Security Header == authenticated & encrypted	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = no reason given [1]
FC received > FC previous	AARE.result = reject-permanent [1] AARE.result-source-diagnostic == no reason given [1]
Authentication succeeded	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = no reason given [1]
Deciphering succeeded	AARE.result = reject-permanent [1] AARE.result-source-diagnostic = no reason given [1]

The errors (and reasons) related to association releasing are included in RLRE in response to RLRQ. Table 8 and Table 9 present possible errors in association releasing and the values shall be sent by server via “RLRQ.reason”.

Table 8: Error events associated to the RLRQ service

Condition NOT fulfilled in the service	Action performed by the server
Association OPEN	RLRE.reason = normal
User Information = RECEIVED	RLRE.reason = not_finished [1]

Table 9: Error events associated to the secured RLRQ service

Condition NOT fulfilled in the service	Action performed by the server
RLRQ secured	RLRE.reason = not_finished [1]
Received Security Header = authenticated & encrypted	RLRE.reason = not_finished [1]
FC received > FC previous	RLRE.reason = not_finished [1]
Authentication succeeded	RLRE.reason = not_finished [1]
Deciphering succeeded	RLRE.reason = not_finished [1]

2.3.8 Errors inside Association

The errors inside the association are related to GET, SET, and ACTION services. They are carried by response of related services (Get/Set /Action response) as an exception response. Table 10 presents errors inside association.

Table 10: Error events associated to GET, SET and ACTION

Condition NOT fulfilled in the service	Action performed by the server
Association opened	Exception response: state-error = service-not-allowed service error=service-not-supported [2]
Get, Set, Action, request encryption or authentication OK	Exception response: state-error = service-not-allowed, service error=operation-not-possible [1]
Get, Set, Action, request tag correct or format is correct	Exception response: state-error =service-not-known, serviceerror=operation-not-possible [1]
Get, request with type = next long get and (“Block number received” in GetRequestNext == last block number sent by the server or “Block number received” in GetRequestNext == last block number sent by the server -1) Example: Last block sent by the server: 3 “Block number received” =3 (server will send block 4) or 2 (server will send block 3 again)	Get response: Data-Access-Result = long-get-aborted [15]
Set, request with type = next long set and (“Block number received” in SetRequestNext == last block number sent by the client or	Set response: Data-Access-Result = long-set-aborted [17]

Condition NOT fulfilled in the service	Action performed by the server
"Block number received" in SetRequestNext == last block number sent by the client -1) Example: Last block sent by the client: 3 "Block number received" =3 (client will send block 4) or 2 (client will send block 3 again) (Block number == block expected) or (block number == block expected -1)	
Get, Set response with data block, the service is present in the negotiated conformance block	Get Set response: Data-Access-Result = scope-of-access violated [13]
For Set request with data block, the service is present in the negotiated conformance block	Set response: Data-Access-Result = scope-of-access-violated [13]
For Get with selective access, the service is present in negotiated conformance block	Get response: Data-Access-Result = scope-of-access-violated [13]
COSEM attribute/method descriptor is correct	Get, Set, Action Response: (Data-Access-Error = object-undefined) [4]
The client has the right access right	Get, Set, Action Response: (Data-Access-Error = read-write-denied) [3]
For Get, Set, Action request with selective access, access selector is correct	Get, Set, Action Response: (Data-Access-Result = scope-of-access-violated) [13]
For Get, Set, Action request with selective access, access parameters are correct	Get, Set, Action Response: (Data-Access-Result = scope-of-access-violated) [13]
Set, Action, data type Ok	Set, Action Response: (Data-Access-Error = type-unmatched) [12]
Set, Action, data content Ok	Set, Action Response: (Data-Access-Error = other-reason) [250]

Note: There aren't any error messages for Data-Notification service and General-Block-Transfer.

2.4 Application Association Object

The Class 15 COSEM object (Association LN) is used as Application Association object. In FAHAM, "Current Association" (15, 0-0:40.0.0.255). The Current Association COSEM object represents the information in open association. This is mandatory in each COSEM logical device.

3 System Use Cases

FAHAM system Use Cases are presented in FAHAM specification reference document (Specification of General, Economical, Functional, Technical and communicational requirements for AMI). If there are different use cases in FID2 and FAHAM technical specification, the most recently published document will be used as reference.

4 Device Identification

This chapter is intended to present identification numbers of FAHAM devices based on DLMS/COSEM model. According to the DLMS/COSEM requirements and to provide the interoperability in whole system, each physical device in system shall be uniquely identified. Each physical device is identified by following designations in system:

Utility Device ID is specified during production. Utility Device ID shall be at least 14 digits. The 8 rightmost for each type of device shall be unique (as product serial number). The leading (the 6 leftmost) is extra information including manufacturer ID (Defined by Tavanir), device type and year of production respectively (details are presented in section4.3). The Utility Device ID will be printed on device body and will be stored in “Device ID7” COSEM object (1, 1-0:0.0.0.255) during manufacturing stage.

The 8 bytes ***System Title*** will be assigned to each physical device (meter, data concentrator and head-end system) during manufacturing stage and based on manufacturer FLAG code, device type and product serial number. The system title is defined in section 4.1of this document.

The 16 bytes ***Logical Device Name*** is another format of the system title and is presented in section4.2 of this document. The Logical Device Name will be stored in “COSEM Logical Device Name” COSEM object (1, 0-0:42.0.0.255) during manufacturing stage.

The System Title is used as physical device unique ID in all communications in system.

4.1 System Title

Each physical device in the system, including meters, data concentrators and the Head-end system shall be uniquely identified by its “System Title”. The “System Title” shall be constructed as follows according to DLMS/COSEM definition:

- Its length shall be 8 octets;
- The leading (i.e., the 3 leftmost) octets shall hold the three-letter manufacturer ID (administered by the DLMS UA acting as a registration authority);
- The trailing (i.e. the 5 rightmost) octets specifies device type and its serial number;

4.1.1 FAHAM System Title Structure

The System Title string structure of FAHAM devices is as following figure.

byte1	byte2	byte3	byte4	byte5		byte6	byte7	byte8
MC	MC	MC	DT	FT	SNM	SNM	SNM	SNM

Figure 6: FAHAM System Title Structure

MC: Manufacturer ID (three letters flag) as ASCII (bytes 1, 2, 3);

DT: Device Type

001	1P BS (Terminal Base) Meter
002	1P ANSI (Socket Base) Meter
003	3P Direct Connection Meter
004	3P CT connection Meter
005	3P CT/PT connection Meter
006	Reserved
007	1P Meter (FAHAM2)
006	Reserved
009	3P Direct Connection Meter (FAHAM2)
010	1P Rail mounted Meter (FAHAM2)
011	1P BS (Terminal Base) Meter
012	1P ANSI (Socket Base) Meter
013	3P Direct Connection Meter
014	3P CT connection Meter
015	3P CT/PT connection Meter
16-029	Reserved
030	Data Concentrator
031	Modem Faham2
032	Reserved
033…39	Reserved
040	Head-end System
041…049	Reserved
050	HHU
051-059	Reserved
061	1P BS (Terminal Base) Meter- Faham1,V3
062	1P ANSI (Socket Base) Meter- Faham1,V3
063	3P Direct Connection Meter- Faham1,V3
064	3P CT connection Meter- Faham1,V3
065	3P CT/PT connection Meter- Faham1,V3
066	3P CT connection Panel mounted Meter- Faham1, V3
067…069	Reserved
070	1P Rail mounted Meter - FAHAM2, v5
071	1P BS (Terminal Base) Meter - FAHAM2, v5
072	1P ANSI (Socket Base) Meter- FAHAM2, v5
073…098	Reserved
099…255	Non-FAHAM devices

FT: Function Type. Function type shows whether device supports disconnector, load management and Sub-meter or not. Function Type (FT) for HES and DC is 0.

Note: the bits arrangement is as follow:

bit 3	bit 2	bit 1	bit 0

Figure 7: The Bits Arrangement in FT

In meters:

- bit0=1: Disconnector exists
- bit1=1: Load Management exists
- bit2=1: Sub Meter is supported by Gateway protocol
- bit3=0: reserved for future use by FID2

In modems:

- bit0=1: modem faham2, 0: Data Collector / Modem
- bit1=1: Rail mounted, 0: Terminal Base
- bit2=1: Sub Meter is supported by Gateway protocol
- bit3=0: reserved for future use by FID2

Note: Load Management refers to the Process of controlling specific local loads by means of additional relays beside of Disconnector relay. The objects “Limiter” and the “Supervision monitor x – Fuse supervision Lx”,… are NOT used in Load Management process.

Function Type for a meter with disconnector, Sub meter features will be 0101. Load Management feature is not defined yet in FAHAM.

SNM: Manufacturer specific serial number (the next 28 bits, half of byte5 and bytes 6, 7, 8);

Note: These 28 bits can be derived from the last eight digits of the manufacturing serial number, up to 99 999 999 (equal to 0x5F5E0FF). Values above this, up to 0xFFFFFFF (decimal value 268 435 455) cannot be mapped to the last 8 digits of the manufacturing serial number.

4.1.2 System Title Example

A product from FARAB with FAR as its three letters unique ID (FAR: 46, 41, 52) as single phase meter (DT: 001) that is intended to be used in FAHAM project (FT: 05 equal to 0101) and serial number 12345678 (0x0BC614E) results the following system title (Hex coded):

byte1	byte2	byte3	byte4	byte5	byte6	byte7	byte8
46	41	52	01	05	BC	61	4E

Figure 8: System Title of FARAB Single Phase Meter

4.2 COSEM Logical Device Name

Each COSEM logical device can be identified by its unique COSEM logical device name. The logical device name is defined as an octet-string of up to 16 octets (bytes). The first three octets shall carry the manufacturer identifier (administered by the DLMS User Association). The logical device name structure of FAHAM is as following figure.

byte1	byte2	byte3	byte4	byte5	byte6	byte7	byte8
MC	MC	MC	DT	DT	DT	FT	FT

byte9	byte10	byte11	byte12	byte13	byte14	byte15	byte16
SNM	SNM	SNM	SNM	SNM	SNM	SNM	SNM

Figure 9: Logical Device Name Structure

MC: Manufacturer ID (three letters flag) Code as ASCII (byte1, 2, 3);

DT: Device Type ASCII encoded. Meaning as in 4.1.1;

FT: Function Type ASCII encoded. As in4.1.1;

SNM: The last 8 digits of the manufacturer specific serial number ASCII encoded. Meaning as mentioned 4.1.1;

4.2.1 Logical Device Name Example

A product from FARAB with FAR as its three letters unique ID (FAR: 46, 41, 52) as single phase meter (DT: 001) that is intended to be used in FAHAM project (FT: 05 equal to 0101) and serial number 12345678 (BC, 61, 4E) results the following logical device name FAR0010512345678. The ASCII coded of this logical device name is shown in following figure.

byte1	byte2	byte3	byte4	byte5	byte6	byte7	byte8
46	41	52	30	30	31	30	35

byte9	byte10	byte11	byte12	byte13	byte14	byte15	byte16
31	32	33	34	35	36	37	38

Figure 10: Logical Device Name of FARAB Single Phase Meter

4.3 Barcode and Utility Device ID

A barcode is basically a series of parallel alternating black and white patterns that represents a sequence of numbers or characters. It allows real-time data to be collected accurately and quickly.

The Utility Device ID of all meters (and corresponding barcode according to Code 128 Barcode) in FAHAM shall be printed on meter body. The Utility Device ID is composed of 14digits. The code structure is as following table.

Table 11: Utility Deice ID Format

Part	**1**			**2**
Code Name	Manufacturer ID/Product Type			Product serial number (unique for each type of device)
	Manufacturer ID	Device Type	Production Year	
Digits	2	2	2	8

The device type (two digits) in utility device id is defined as follow:

Left digit (device group)

0	meter- Faham1, V1, V2
1	meter (Digital)
2	reserved
3	data concentrator

4 … 5	reserved for future
6	Meter- Faham1, V3
7	Meter- Faham2, V5
8..9	reserved

Right digit (device in group)

group no.	device no. in group	device name

0 (meter)

1	1p BS (terminal base) meter
2	1p ANSI (socket base) meter
3	3p direct connection
4	3p CT connection
5	3p CT/PT connection
6	reserved for future
7	1P Meter (FAHAM2)
8	Reserved
9	3P Direct Connection Meter (FAHAM2)

1 (meter)

0	1P Rail mounted Meter (FAHAM2)
1	1p BS (terminal base) meter
2	1p ANSI (socket base) meter
3	3p direct connection
4	3p CT connection
5	3p CT/PT connection

3 (DCU)

0	data concentrator
1	Modem- Faham2
2	reserved
1…9	reserved

6 (meter)

1	1P BS (Terminal Base) Meter- Faham1,V3
2	1P ANSI (Socket Base) Meter- Faham1,V3
3	3P Direct Connection Meter- Faham1,V3
4	3P CT connection Meter- Faham1,V3
5	3P CT/PT connection Meter- Faham1,V3
6	3P CT connection Panel mounted Meter- Faham1,V3

7 (meter)

0	1P Rail mounted Meter - FAHAM2, v5
1	1P BS (Terminal Base) Meter - FAHAM2, v5
2	1P ANSI (Socket Base) Meter- FAHAM2, v5

NOTE: These 8 digits product serial number (up to 99 999 999, equal to 0x5f5e0ff) shall not be repeated (reset) each year.

4.3.1 Device ID

The different identifications of each device are presented as device ID. Each device may have different device IDs. Each device ID is stored in a dedicated COSEM object from interface class 1. The device IDs that have been used in FAHAM project are as following table

Table 12: Device ID

Device ID	Type	Description	COSEM Object	Remark
Device ID1	octet-string [8]	E-meter Serial Number (ASCII Coded): Production Serial Number	1, 0-0:96.1.0.255	Stored during manufacturing
Device ID2	octet-string [0-48]	E-meter Identifier (optional text like meter type)	1, 0-0:96.1.1.255	Stored during manufacturing
Device ID3	octet-string [0 - 48]	Function Location (optional text like utility name)	1, 0-0:96.1.2.255	Stored during installation
Device ID4	octet-string [0 - 48]	Location Information (ASCII Coded): GPS Info.	1, 0-0:96.1.3.255	Stored during installation
Device ID5	octet-string [0 - 48]	Consumer Unique Utility Number (ASCII coded): (“shenase ghabz”)	1, 0-0:96.1.4.255	Stored after installation
Device ID6	octet-string [0 –22]	Serial Number of SimCard(ICCID)	1, 0-0:96.1.5.255	Stored after installation
Device ID7	octet-string [14]	Manufacturer Code + Meter/DeviceType + Production Year+ Production Serial Number	1, 1-0:0.0.0.255	Tavanir Definition
Device ID8 (optional)	octet-string [0 - 24]	(ASCII Coded)	1, 0-0:96.1.6.255	Manufacturer specific

5 Registration

Independently of fixed or dynamic IP addressing, the IP address is typically provided to the HES via a Push on Connectivity (section5.1) operation issued by the meter. Logical registration at HES level is typically achieved by the valid system title of the meter provided by the Data-Notification service as defined by the Push setup – On Installation object. Alternatively, logical registration at HES level may be achieved by reading the necessary data (e.g. COSEM logical device name, SAP assignment) by the public client.

5.1 Registration by Data_Notification

After commissioning the meter sends its IP address and its system title to the HES using the Data-Notification service. The FAHAM meter must provide a trigger (e.g. SMS, button) to invoke the push method of the corresponding push object (“Push setup-On Installation” LN: 40, 0-7.25.9.0.255). The execution of the push method results in a transmission of the Data-Notification message to the set IP address destination. If the “Push setup-On Installation” object is configured for SMS communication the Data-Notification message is sent by SMS to the set telephone number destination. After HES received information or data, it should acknowledge to the meter by sending consumer Message code "E_instal " on LCD (1, 0-0:96.13.1.255).

6 Tariff Management

Meter shall have activity calendar object (class id = 20). In this object 2 tariff schemes, “active tariff scheme” and “passive tariff scheme”, can be defined and used.

As per part of default configuration of meter (the configuration programmed in meter at manufacturing time), at least active tariff scheme should exist. “Passive tariff scheme” can be changed/updated later at any time.

Meter should support a configurable “default tariff rate”. This rate is used by meter when meter detects malfunctioning of its clock. When meter’s clock is not running properly, energy values are accumulated in this default tariff rate and no other tariff rates will be used.

The special days shall be defined in electricity meter. At least 50 special days shall be considered.

- **Tariff Management Process**

The eight different interface classes (COSEM objects) are involved in tariff management process. Figure 11 depicts the tariffication process and relationship between different interface classes that are involved in this task.

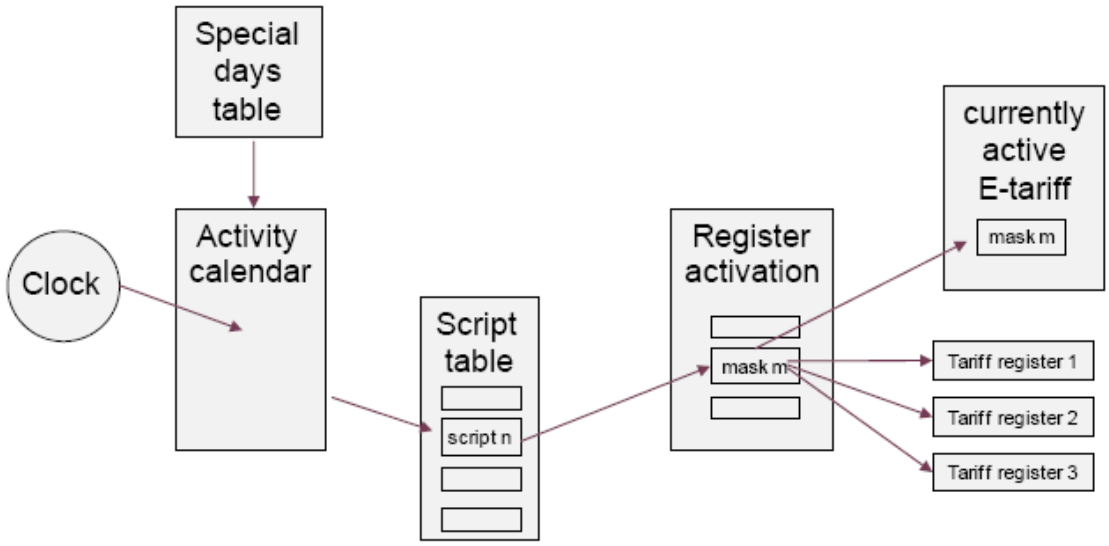


Figure 11: Tariffication Process

The COSEM objects that are involved in tariffication process are as follows:

- Clock (8, 0-0:1.0.0.255);
- Activity Calendar (20, 0-0:13.0.0.255);
- Active Special Days Table (11, 0-0:11.0.0.255);
- Passive Special Days Table (11, 0-0:11.0.1.255);
- Active Tariffication Script Table (9, 0-0:10.0.100.255);
- Passive Tariffication Script Table (9, 0-0:10.1.100.255);
- Register Activation- Energy(6, 0-0:14.0.1.255);

- Register Activation- Maximum Demand (6, 0-0:14.0.2.255);
- Currently Active Energy Tariff (1, 0-0:96.14.0.255);
- Currently Active Maximum Demand Tariff (1, 0-0:96.14.1.255);
- Default Energy Tariff in Case of Invalid Clock (1, 0-0:96.14.9.255);
- Default Max. Demand Tariff in Case of Invalid Clock (1, 0-0:96.14.10.255);
- Energy Registers (3, *-*:*.*.*.*)
- Maximum Demand Registers (4, *-*:*.*.*.*)

6.1 Special Days

The special days shall be defined in electricity meter. The special days is specified by class_id: 11. At least 50 special days shall be considered. The special days interface class (object) is in conjunction with "Activity Calendar" interface classes. The linking data between these classes is day_id. The following table shows the special days that are considered in FAHAM.

Table 13: Special Days Structure

Parameter Name	Day Index	Special Day Date	Day ID
Format	index	specialday_date	day_id*
Type	long-unsigned	octet-string (size (5))	unsigned
Value	1 – 50	byte 04: Year (high byte) byte 03: Year (low byte) byte 02: Month byte 01: Day of month byte 00: Day of week	1 – 8

*The day_id that has been defined in Activity Calendar Object. In this system, there are 8 day types.

Two different types of special days' tables are used in FAHAM as follows:

- Active Special Days Table (11, 0-0:11.0.0.255);
- Passive Special Days Table (11, 0-0:11.0.1.255);

“Passive Special Days Table” and “Active Special Days Table” have same structure, but with different content (values). The “Active Special Days Table” and the “Passive Special Days Table” are mandatory. The “*Entries*” attribute of above mentioned objects is an array including at least 50 special days. Each entry (special day) in array includes three parameters as mentioned in Table 13 (Special Day Table). Two optional methods will be used in special days object. The “Insert” method is intended to enter new special day. If a special day with the same index or the same date as an already defined day is inserted, the old entry will be overwritten. The “Delete” method will be used to remove a day from special day’s table. The day will be specified by its index.

6.2 Activity Calendar

The activity calendar is specified by Class ID:20. This interface class (IC) is intended to handle different tariff structures. This is based on schedule by defining seasons, weeks, days and times in each day. The Activity Calendar object defines the activation of certain scripts, which can perform different activities inside the meter.

6.3 Season

The seasons in Activity Calendar object include three parameters. At least 12 seasons shall be defined in FAHAM. Following table shows the detail of season parameters in Activity Calendar object.

Table 14: Season Parameters

Parameter Name	Season Name	Starting Time	Week Type
Format	season_profile_name	season_start	week_name*
Type	octet-string (size (1))	octet-string (size (12))	octet-string (size (1))
Value	1 – 12 (HEX encoding)	byte 11: Year (high byte) byte 10: Year (low byte) byte 09: Month byte 08: Day of Month byte 07: Day of Week byte 06: Hour byte 05: Minute byte 04: Second byte 03: Hundredths of Sec. byte 02: Deviation (high byte) byte 01: Deviation (low byte) byte 00: Clock Status	1 – 8

*week_name is week_profile_name in Week Profile Table (Table 15)

6.4 Week

The different weeks are defined to use in each season. 8 weeks are considered in FAHAM. There are different day types in each week. Each day type is specified by *day_id*. In each week, the type of day in each day (from Monday to Sunday) shall be specified. Following table shows the week details in Activity Calendar object.

Table 15: Week Structure

Parameter Name	Week Name	Day Type						
		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Format	week_profile_name	day_id	day_id	day_id	day_id	day_id	day_id	day_id
Type	octet-string (size (1))	unsigned	unsigned	unsigned	unsigned	unsigned	unsigned	unsigned
Value (HEX encoding)	1 – 8	1 – 8	1 – 8	1 – 8	1 – 8	1 – 8	1 – 8	1 – 8

6.5 Day

The different day types can be defined in system. It means different profiles can be defined in each day and consequently different day types will be defined. The day types are distinguished according to their ID (*day_id*). 8 day types (8 different day profile) are defined in FAHAM. For each day type, two parameters are defined as follows:

- Scheduled Actions (*script_logical_name* + *script_identifier*);
- Action Times (*start_time*);

At least 8 time intervals shall be defined in each day type. The time intervals in various day types can be different. The starting time of each time interval is specified by TOU1 to TOU8 (for 8 time intervals in each day).

The various actions in different times (to be executed) can be defined in each day. Each Scheduled Action is defined by a script. All scripts (all scheduled actions) are defined in a dedicated table. This table is called "Tariffication Script Table". The Tariffication Script Table is considered as a COSEM object and can be invoked by other COSEM objects. In tariff management, this table (COSEM object) will be invoked by Activity Calendar object (20, 0-0:13.0.0.255). Two Tariffication Script Tables are considers in FAHAM as follows:

- Active Tariffication Script Table (9, 0-0:10.0.100.255);
- Passive Tariffication Script Table (9, 0-0:10.1.100.255);
- Each script (as an action) can be specified by two parameters as follows:
- Script Table Name (*script_logical_name*);
- Script Identifier (*script_identifier* or *script_selector*);

The Script Identifier (*script_identifier* or *script_selector*) is the index of script (action) in Script Table. Following table depicts the Day details in Activity Calendar object.

Table 16: Day Structure

Parameter Name	Day Type	Schedule Actions		
		Action Time	Action	
			Script Table	Script Identifier
Format	day_id	start_time	script_logical_name	script_selector
Type	unsigned	octet-string(size(4))	octet-string(size(6))	long-unsigned
Value	1 – 8 (HEX encoding)	TOU1 byte 03: Hour byte 02: Minute byte 01: Second byte 00: Hundredths of Sec.	00000A0064FF	1 … 8
		TOU2	00000A0064FF	1 … 8
		TOU3	00000A0064FF	1 … 8
		TOU4	00000A0064FF	1 … 8
		TOU5	00000A0064FF	1 … 8
		TOU6	00000A0064FF	1 … 8
		TOU7	00000A0064FF	1 … 8
		TOU8	00000A0064FF	1 … 8

In Table 16, eight time segments have been defined in each day type and different actions (different script) can be assigned for each time period (segment).

6.6 Tariff Management Script Table

The Script Table is specified by Class ID: 9. As mentioned in pervious section, this object includes a table of script entries. Each script specifies an action that can be invoked by other COSEM objects. Two Tariffication Script Tables are considers in FAHAM as follows:

- Active Tariffication Script Table (9, 0-0:10.0.100.255);
- Passive Tariffication Script Table (9, 0-0:10.1.100.255);

These two script tables have same structure, but with different content (values). The scripts in script table, consists of two parameters as follows:

- Script Identifier (script_identifier or script_selector);
- Action Specification (action_specification);

An action in script table can do the following tasks (Action Type):

- Activate a method of a COSEM object within the logical device (meter);
- Modify an attribute of a COSEM object within the logical device (meter);

Each action will be specified with the following parameters:

- Action Type (Activating a method or modifying an attribute, service_id);
- Class ID of COSEM Object to be executed (class_id);
- Logical Name of COSEM Object to be executed (logical_name);
- Attribute/Method Index of COSEM Object to be executed (index);
- Parameter;

Note: the script 0 (script_identifier = 0) is reserved and will not be used. Table 17 shows structure of tariffication script table and its components.

Table 17: Tariffication Script Table

Parameter Name	Script Identifier	COSEM Object (to be executed)		Action Type	Attribute/ Method Index	Parameter	Action Description
		Class ID	Logical Name				
Format	script_selector	class_id	logical_name	NA	NA	NA	NA
Type	long-unsigned	long-unsigned	octet-string	NA	NA	NA	NA
Value	0						Reserved
	1	Class_id: 6	0-0:14.0.1.255 (Register Activation, Energy)	Attribute Modifying	4 (active_mask)	"RX*"	Registers and actions corresponding to energy tariff X, maximum demand tariff Y are activated
		Class_id: 6	0-0:14.0.2.255 (Register Activation, Max. Demand)	Attribute Modifying	4 (active_mask)	"RY*"	
		Class_id: 70	0-0:96.3.10.255	Attribute Modifying	3	1 , 2	
				Method Modifying	1, 2	0	
	2	Class_id: 6	0-0:14.0.1.255	Attribute Modifying	4 (active_mask)	"RX"	"
		Class_id: 6	0-0:14.0.2.255	Attribute Modifying	4 (active_mask)	"RY"	
		Class_id: 70	0-0:96.3.10.255	Attribute Modifying	3	1 , 2	
				Method Modifying	1, 2	0	
	3	Class_id: 6	0-0:14.0.1.255	Attribute Modifying	4 (active_mask)	"RX"	"
		Class_id: 6	0-0:14.0.2.255	Attribute Modifying	4 (active_mask)	"RY"	
		Class_id: 70	0-0:96.3.10.255	Attribute Modifying	3	1 , 2	
				Method Modifying	1, 2	0	
	4	Class_id: 6	0-0:14.0.1.255	Attribute Modifying	4 (active_mask)	"RX"	"
		Class_id: 6	0-0:14.0.2.255	Attribute Modifying	4 (active_mask)	"RY"	
		Class_id: 70	0-0:96.3.10.255	Attribute Modifying	3	1 , 2	
				Method Modifying	1, 2	0	
	5…31	…	…	…	…	…	If needed

* The different tariff rates can be assigned to Max. Demand and Energy in each time interval. So,"X" and "Y" can be selected from 1 to 4. RX means rate X. RY means rate Y.

As mentioned in Table 17, register activation COSEM objects (Register Activation-Energyand Register Activation-Maximum Demand) will be invoked by Script Table object to finalize tariff management.

6.7 Register Activation

As mentioned in previous section and as shown in Table 17, four COSEM objects are used by Tariffication Script Table object to handle required actions and fulfill tariff process. They are as follows:

- Register Activation-Energy (6, 0-0:14.0.1.255);
- Register Activation-Maximum Demand (6, 0-0:14.0.2.255);

Register Activation object (Energy or Maximum Demand) specifies which registers (measuring parameters) shall be considered in each tariff. Two main functions will be done by this COSEM object (Register Activation). They are as follows:

- Register Assignment (*register_assignment*);
- Tariff Rates Defining (*mask_list*);

6.7.1 Register Assignment

All registers related to meter parameters (such as active energy, reactive energy, active demand, etc.) that shall be considered in each tariff will be specified by this attribute (register_assignment). Each register is a COSEM object that will be invoked by this object and will be specified by the following parameters:

- Register Class ID (class_id);
- Register Logical Name (logical_name);

Table 18 and Table 19 show the energy/maximum demand registers (COSEM objects) that are used in different tariffs of FAHAM.

Table 18: Register Assignment Table-Energy

Parameter Name	**Register Index**	**Class ID**	**Logical Name**	**Description**
Format		**Class_id**	**logical_name**	
Type	**Integer**	**long_unsigned**	**Octed-string**	
Value	01	class_id: 3	1-0:1.8.1.255	Active Energy, Import, Rate 1
	02	class_id: 3	1-0:1.8.2.255	Active Energy, Import, Rate 2
	03	class_id: 3	1-0:1.8.3.255	Active Energy, Import, Rate 3
	04	class_id: 3	1-0:1.8.4.255	Active Energy, Import, Rate 4
	05	class_id: 3	1-0:2.8.1.255	Active Energy, Export, Rate 1
	06	class_id: 3	1-0:2.8.2.255	Active Energy, Export, Rate 2
	07	class_id: 3	1-0:2.8.3.255	Active Energy, Export, Rate 3
	08	class_id: 3	1-0:2.8.4.255	Active Energy, Export, Rate 4
	09	class_id: 3	1-0:3.8.1.255	Reactive Energy, Import, Rate 1
	10	class_id: 3	1-0:3.8.2.255	Reactive Energy, Import, Rate 2
	11	class_id: 3	1-0:3.8.3.255	Reactive Energy, Import, Rate 3

Parameter Name	Register Index	Class ID	Logical Name	Description
Format		Class_id	logical_name	
Type	Integer	long_unsigned	Octed-string	
	12	class_id: 3	1-0:3.8.4.255	Reactive Energy, Import, Rate 4
	13	class_id: 3	1-0:4.8.1.255	Reactive Energy, Export, Rate 1
	14	class_id: 3	1-0:4.8.2.255	Reactive Energy, Export, Rate 2
	15	class_id: 3	1-0:4.8.3.255	Reactive Energy, Export, Rate 3
	16	class_id: 3	1-0:4.8.4.255	Reactive Energy, Export, Rate 4
	17	class_id: 3	1-0:15.8.1.255	Active Energy, Combined Total, Rate 1
	18	class_id: 3	1-0:15.8.2.255	Active Energy, Combined Total, Rate 2
	19	class_id: 3	1-0:15.8.3.255	Active Energy, Combined Total, Rate 3
	20	class_id: 3	1-0:15.8.4.255	Active Energy, Combined Total, Rate 4
	21	class_id: 3	1-0:16.8.1.255	Active Energy, Net Total, Rate 1
	22	class_id: 3	1-0:16.8.2.255	Active Energy, Net Total, Rate 2
	23	class_id: 3	1-0:16.8.3.255	Active Energy, Net Total, Rate 3
	24	class_id: 3	1-0:16.8.4.255	Active Energy, Net Total, Rate 4

Table 19: Register Assignment Table-Maximum Demand

Parameter Name	Register Index	Class ID	Logical Name	Description
Format		Class_id	logical_name	
Type	Integer	long_unsigned	Octed-string	
Value	01	class_id: 4	1-0:1.6.1.255	Max. Demand Register 2, (Active Energy Import, Rate 1)
	02	class_id: 4	1-0:1.6.2.255	Max. Demand Register 3(Active Energy Import, Rate 2)
	03	class_id: 4	1-0:1.6.3.255	Max. Demand Register 4(Active Energy Import, Rate 3)
	04	class_id: 4	1-0:1.6.4.255	Max. Demand Register 5(Active Energy Import, Rate 4)
	05	class_id: 4	1-0:2.6.1.255	Max. Demand Register 7(Active Energy Export, Rate 1)
	06	class_id: 4	1-0:2.6.2.255	Max. Demand Register 8(Active Energy, Export, Rate 2)
	07	class_id: 4	1-0:2.6.3.255	Max. Demand Register 9(Active Energy Export, Rate 3)
	08	class_id: 4	1-0:2.6.4.255	Max. Demand Register 10(Active Energy Export, Rate 4)
	09	class_id: 4	1-0:3.6.1.255	Max. Demand Register 12(Reactive Energy Import, Rate 1)
	10	class_id: 4	1-0:3.6.2.255	Max. Demand Register 13(Reactive Energy Import, Rate 2)
	11	class_id: 4	1-0:3.6.3.255	Max. Demand Register 14(Reactive Energy Import, Rate 3)
	12	class_id: 4	1-0:3.6.4.255	Max. Demand Register 15(Reactive Energy Import, Rate 4)
	13	class_id: 4	1-0:4.6.1.255	Max. Demand Register 17(Reactive Energy Export, Rate 1)
	14	class_id: 4	1-0:4.6.2.255	Max. Demand Register 18(Reactive Energy Export, Rate 2)
	15	class_id: 4	1-0:4.6.3.255	Max. Demand Register 19(Reactive Energy Export, Rate 3)
	16	class_id: 4	1-0:4.6.4.255	Max. Demand Register 20(Reactive Energy Export, Rate 4)
	17	class_id: 4	1-0:15.6.1.255	Max. Demand Register 32(Active Energy Combined, Rate 1)
	18	class_id: 4	1-0:15.6.2.255	Max. Demand Register 33 (Active Energy Combined, Rate 2)
	19	class_id: 4	1-0:15.6.3.255	Max. Demand Register 34(Active Energy Combined, Rate 3)
	20	class_id: 4	1-0:15.6.4.255	Max. Demand Register 35 (Active Energy Combined, Rate 4)

6.7.2 Tariff Rates Definition

To define different tariffs, the registers (according to Table 18 and Table 19) in each tariff shall be specified. This is called "Masking". Each mask relates to one tariff rate. Each mask list includes registers that shall be considered in each mask (tariff). Each Mask is

specified with two parameters as follows:

- Mask Name or Tariff Rate Name (mask_name);
- List of Registers in Mask/Tariff Rate (index_list);

Following tables show the registers (COSEM objects) that are considered in each mask (tariff).

Table 20: Tariff(Mask) List-Energy

Parameter Name	Tariff (Mask) Name	Registers
Format	mask_name	index_list
Type	octet-string(size(5))	index_array
Value	"R1"	1, 5, 9, 13,17,21
	"R2"	2, 6, 10, 14,18,22
	"R3"	3, 7, 11, 15,19,23
	"R4"	4, 8, 12, 16,20,24

Table 21: Tariff (Mask) List- Maximum demand

Parameter Name	Tariff (Mask) Name	Registers
Format	mask_name	index_list
Type	octet-string (size (5))	index_array
Value	"R1"	1, 5, 9, 13,17
	"R2"	2, 6, 10, 14,18
	"R3"	3, 7, 11, 15,19
	"R4"	4, 8, 12, 16,20

6.8 Default Tariff

In case of invalid clock, the meter shall load the default tariff. The default tariff is stored in the following COSEM objects:

- Default Energy Tariff in Case of Invalid Clock (1, 0-0:96.14.9.255);
- Default Max. Demand Tariff in Case of Invalid Clock (1, 0-0:96.14.10.255);

The provisions shall be provided in central system to change the values in these COSEM objects.

6.9 Current Active Tariff

The current active tariffs are stored in the following COSEM objects.

- Currently Active Energy Tariff (1, 0-0:96.14.0.255);
- Currently Active Maximum Demand Tariff (1, 0-0:96.14.1.255);

The value of "*active_mask*" attribute of related register activation object is copied to above mentioned objects. The empty octet string represents no tariff is active.

7 Meter Reading

In FAHAM, the meter reading is performed via “GET” and “Data-Notification” services. Implementing these services is mandatory.

7.1 Electricity Meter Registers

The following types of registers shall be supported by FAHAM meters (as mandatory):

- 15 Total Registers (Class 3, +A, -A, |+A|+|-A|, |+A|-|-A|, +Ri, +Rc, -Ri, -Rc, +R, -R, +VA, -VA, Ampere-hours L1, L2, L3);
- 24 Rated Registers (Class 3, +A, -A, +R, -R, |+A|+|-A| and |+A|-|-A| at rates 1, 2, 3 &4);
- 5 Interval Registers (Class 3, +A, -A, +R, -R, |+A|+|-A|);
- 5 Demand Registers (Class 5, +A, -A, +R, -R, |+A|+|-A|);
- 28 Maximum Demand Registers (Class 4, +A, -A, +R, -R, |+A|+|-A| totals & at rates 1, 2, 3 & 4 and Active energy Combined total (|+A|+|-A|) (recording interval 2)), Maximum Demand Register 37 -Active energy import total (|+A|) (recording interval 2), Maximum Demand Register 38 -Active energy export total (|-A|) (recording interval 2);
- 44 Power Quality & monitored values;
- 42 Average, Max and Min values (load profile interval);
- 42 Harmonics value for 3P meters (CT/PT, CT and DC)

7.1.1 Measuring Resolution

The following rules shall be considered for measuring resolution of different parameters:

Table 22: Measuring Resolution

Parameter	Unit	Resolution	Scalar
Current	A	0.01	-2
Voltage	V	0.1	-1
Energy (1P, 3P-DC and 3P-CT)	Wh/VARh	1	0
Energy (CT/PT Meter)	Wh/VARh	0.1	-1
Power Factor	-	0.001	-3
Frequency	Hz	0.01	-2
Harmonics Parameters	%	0.1	-1

Note: the measurement algorithm for power factor calculation is according to" true power factor " method of table 39-BlueBook Ed.12th.

8 Generic Profile

8.1 Profile

Load profile captures and stores several parameters (defined as channels), at specified time intervals. In case of changing any of capture objects or time interval (capture period) of load profile, the load profile shall be reset.
The following types of profiles shall be considered in FAHAM meters:

- Load Profile 1 (hourly based load profile) (7,1-0:99.1.0.255);
- Load Profile 2 (daily load profile) (7,1-0:99.2.0.255);
- Average Values Profile (7,1-0:99.133.0.255);
- Max. Values Profile (7,1-0:99.134.0.255);
- Min. Values Profile (7,1-0:99.135.0.255);
- Harmonics Profile 3P meters (CT/PT, CT and DC) (7, 1-0:99.136.0.255);

Two readout profiles for instantaneous values of energy and power quality at reading time by reading client through local (optical) port have been considered:

- Energy Instantaneous Values (7, 0-0:21.0.6.255);
- Power Quality Instantaneous Values (7, 0-0:21.0.5.255);

8.1.1 Profile Structure

The Profile objects use Profile Generic class (Class ID 7) of DLMS. All Load Profiles have same structure. The different values (registers) can be stored by each Load Profile COSEM object including capture time (as timestamp) and their status (Profile Status of relevant profile object). The status shows the situation of critical events during capturing of values. It is used in central system to validate the values. Figure 12 shows the general structure of Load Profile.

Time Stamp (Clock)	Status (Profile Status)	Value 1 (Register 1)	Value 2 (Register 2)	….	Value “n” (Register “n”)
1394-08-12/00:15:00	08	1234567	4567	….	34567
1394-08-12/00:30:00	08	1234589	4580	….	34590
1394-08-12/00:45:00	08	1234599	4590	….	34625
….					

Figure 12: Profile Structure

8.1.1.1 Sort Method

The buffer may be defined as sorted by one of the capture objects (e.g. the clock values). In FAHAM, for all profile generic objects, the FIFO method and sort method 4 (smallest) are used. In case of changing the sorting method, the load profile will be reset.

8.1.1.2 Capture Method

The capture objects (attributes of other COSEM objects that provide values) can be collected in two different ways as follows:

- Synchronously;
- Asynchronously (Triggered externally)

8.1.1.3 Capture Period

The captured period is controlled by the internal clock and it is synchronized with the internal time, starting always on the full hour (e.g. capture periods of 15 minutes starting at 10:00, 10:15, 10:30,10:45, 11:00, 11:15 etc.).

The capture period can be selected between 0, 60, 300, 600, 900, 1800, 3600 or 86400 seconds. If the capture period is set to 0 then the regular capturing is stopped and an external source (e.g. communication, script table, MDI reset) must be used to trigger the capturing of profile entries. The capture period of 86400 seconds is a special case; it represents daily capturing at midnight. The values are captured once per day at midnight (local time).

The Load Profile 1, Average Values Profile, Min./Max. Values Profiles and Harmonics Profile are high resolution load profile. The default capture time in these profiles is 15 minutes. The load profile 2 is low resolution load profile. This is daily load profile and its default capture time is 24 hours. Following table summarizes the capture period and minimum storing time in meter.

Table 23: Capture Period and Storing Time

Profile	Description	Number of channels*	Capture Time	Storing Time
Load Profile 1	Energy values	5	15 min.	62 Days
Load Profile 2	Daily Billing Data	37	24 hours	31 Days
Avg. Profile	Power Quality	14	15 min.	31 Days
Min. Profile	Power Quality	14	15 min.	31 Days
Max. Profile	Power Quality	14	15 min.	31 Days
Harmonics Profile	Harmonics	42	15 min.	31 Days

*Excluding time stamp and profile status

8.1.1.4 Timestamp

The timestamp is mandatory capture object in each profile. Timestamp contain the value of internal clock at the end of capture period.

8.1.1.5 Access to Stored Values

The stored values of the profile can be retrieved by applying the appropriate xDLMS services to the attribute “buffer” of relevant profile COSEM object. It is possible to read either the entire profile buffer or extract a portion of buffer by using selective access facility (byrange and/or by entry) as defined in DLMS. In FAHAM support of access by range is mandatory. The meter should support a selection of columns to be retrieved. In other words, the array of “selected values“ can be both empty or filled by a selection of capture objects.

In Range Based Collection, the values can be collected according to value (or a range of values) of parameters in buffer table.

In FAHAM, the default method is Range Based Collection based on timestamp. This is mandatory method. The Entry-based Collection is optional.

8.1.1.6 Buffer Reading

Reading of buffer can be done in two methods as follows:

- Normal Reading;
- Compressed Reading;

In “Normal Reading”, all buffer entries within the “From/To” range (Time-based selective access by Range) including the values at the boundaries of range, will be returned to DLMS client (central system, data concentrator or local operator).

In Compressed Reading, the compressed method introduced in IDIS Package 2 (section 7.5.6.2) shall be used. The Compressed Reading is mandatory (default method) in FAHAM. Meter shall support both compressed and normal reading.

8.1.1.6.1 Profile Compression Type

This object "Profile Compression Type" (0-0:94.98.21.255) controls the type of the compression applied on Profile Generic Read Buffer. There are three possible choices:

- (01b) – No Compression,
- (10b) – Partial Compression (entries with the timestamp at midnight are not compressed)
- (11b) –Total Compression (compression algorithm applied as described in IDIS spec IDIS-S02-001 E2.0 IDIS Pack2 IP profile, at chapter 7.5.6.2).

Each Load Profile will have the type of compression encoded on two bits described as follows:

bite 8	bite 7	bite 6	bite 5	bite 4	bite 3	bite 2	bite1
Load Profiles Harmonics		Load Profiles Supervision		Load Profile 2		Load Profile 1	

bite 16	bite 15	bite 14	bite 13	bite 12	bite 11	bite 10	bite 9
Reserved		Reserved		Reserved		Reserved	

Figure 13: Compression object bits definition

8.1.1.6.1.1 Example for partial Compression

Long-unsigned = 0x00AA = 00 00 00 00 10 10 10 10b

bite 8	bite 7	bite 6	bite 5	bite 4	bite 3	bite 2	bite1
1	0	1	0	1	0	1	0

bite 16	bite 15	bite 14	bite 13	bite 12	bite 11	bite 10	bite 9
0	0	0	0	0	0	0	0

Figure 14: Example of Compression object bits definition

8.1.1.7 Profile Status

The Profile Status provides complementary information about the stored values in profiles buffer. The HES/MDM system will use this information to decide about the validity of collected values. The content of Profile Status is captured for every entry (in buffer). There are four profile statuses in FAHAM as follows:

- Profile Status 1 (1, 0-0:96.10.1.255): Profile Status of Load Profile 1;
- Profile Status 2 (1, 0-0:96.10.2.255): Profile Status of Load Profile 2;
- Profile Status 3 (1, 0-0:96.10.9.255): Profile Status of Harmonic Profile;
- Profile Status 4 (1, 0-0:96.10.10.255): Profile Status of Avg./Min./Max. Profile;

The size of Profile Status is one byte and each bit shows a critical situation in meter as shown in following figures for different profile statuses.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ID	PDN	RSV	CAD	RSV	DST	DNV	CIV	ERR
Description	Power Down	Reserved	Clock Adjusted	Reserved	Daylight Saving	Data not Valid	Clock Invalid	Critical Error

Figure 15: Profile Status 1, 2 and 3 Byte Structure

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ID	PDN	UBL	CAD	RSV	DST	DNV	CIV	ERR
Description	Power Down	Unbalance Load	Clock Adjusted	Reserved	Daylight Saving	Data not Valid	Clock Invalid	Critical Error

Figure 16: Profile Status 4 Byte Structure

8.1.2 Profile Values/Parameters

The provisions shall be provided in central system to add/remove the parameters to/from each profile COSEM object (change in Capture Object list). The default parameters of each load profile are mentioned in relevant COSEM objects. The mandatory parameters are as below table:

Table 24: Capture Objects in Profiles

Profile Name	Capture Object Name		Capture Object OBIS Code
Load Profile 1 (7,1-0:99.1.0.255)	Clock		8,0-0:1.0.0.255
	Profile Status 1		1,0-0:96.10.1.255
	Group 1	Active Cumulative Energy Import	3,1-0:1.8.0.255
		Active Cumulative Energy Export	3,1-0:2.8.0.255
		Reactive Cumulative Energy Import	3,1-0:3.8.0.255
		Reactive Cumulative Energy Export	3,1-0:4.8.0.255
	Or Group 2	Active Interval Energy Import (+A)	3,1-0:1.29.0.255
		Active Interval Energy Export (-A)	3,1-0:2.29.0.255
		Reactive Interval Energy Import (+R)	3,1-0:3.29.0.255
		Reactive Interval Energy Export (-R)	3,1-0:4.29.0.255
	Demand Register -Active energy Combined total (|+A|+|-A|)		5,1-0:15.4.0.255
Load Profile 2 (7,1-0:99.2.0.255)	Clock		8,0-0:1.0.0.255
	Profile Status 2		1,0-0:96.10.2.255
	Active Cumulative Energy Import (Total Active Energy Import, +A)		3,1-0:1.8.0.255
	Active Cumulative Energy Export (Total Active Energy Export, -A)		3,1-0:2.8.0.255
	Reactive Cumulative Energy Import (Total Reactive Energy Import, +R/QI+QII)		3,1-0:3.8.0.255
	Reactive Cumulative Energy Export		3,1-0:4.8.0.255

Profile Name	Capture Object Name	Capture Object OBIS Code
	(Total Reactive Energy Export, -R/(QIII+QIV)	
	Active energy (|+A|+|-A|) Combined total	3,1-0:15.8.0.255
	Active energy (|+A|-|-A|) Combined total	3,1-0:16.8.0.255
	Active energy import (+A) rate 1	1-0:1.8.1.255
	Active energy import (+A) rate 2	1-0:1.8.2.255
	Active energy import (+A) rate 3	1-0:1.8.3.255
	Active energy import (+A) rate 4	1-0:1.8.4.255
	Active energy export (−A) rate 1	1-0:2.8.1.255
	Active energy export (−A) rate 2	1-0:2.8.2.255
	Active energy export (−A) rate 3	1-0:2.8.3.255
	Active energy export (−A) rate 4	1-0:2.8.4.255
	Reactive energy import (+R) rate 1	1-0:3.8.1.255
	Reactive energy import (+R) rate 2	1-0:3.8.2.255
	Reactive energy import (+R) rate 3	1-0:3.8.3.255
	Reactive energy import (+R) rate 4	1-0:3.8.4.255
	Reactive energy export (−R) rate 1	1-0:4.8.1.255
	Reactive energy export (−R) rate 2	1-0:4.8.2.255
	Reactive energy export (−R) rate 3	1-0:4.8.3.255
	Reactive energy export (−R) rate 4	1-0:4.8.4.255
	Active energy Combined total (|+A|+|-A|) rate 1	1-0:15.8.1.255
	Active energy Combined total (|+A|+|-A|) rate 2	1-0:15.8.2.255
	Active energy Combined total (|+A|+|-A|) rate 3	1-0:15.8.3.255
	Active energy Combined total (|+A|+|-A|) rate 4	1-0:15.8.4.255
	Active energy net total (|+A|-|-A|) rate 1	1-0:16.8.1.255
	Active energy net total (|+A|-|-A|) rate 2	1-0:16.8.2.255
	Active energy net total (|+A|-|-A|) rate 3	1-0:16.8.3.255
	Active energy net total (|+A|-|-A|) rate 4	1-0:16.8.4.255
	Maximum Demand Register 36 -Active energy Combined total (|+A|+|-A|) (recording interval 2)	1-0:15.54.0.255
	Maximum Demand Register 36 -Active energy Combined total (|+A|+|-A|) (recording interval 2)	1-0:15.54.0.255 – capture time
	Maximum Demand Register 37-Active energy import total (|+A|) (recording interval 2)	1-0:1.54.0.255
	Maximum Demand Register 37 -Active energy import total (|+A |) (recording interval 2)	1-0:1.54.0.255 – capture time
	Maximum Demand Register 38-Active energy export total (|+A|) (recording interval 2)	1-0:2.54.0.255
	Maximum Demand Register 38 -Active energy export total (|+A |) (recording interval 2)	1-0:2.54.0.255 – capture time
	Error Register	1, 0-0:97.97.0.255
	Alarm Register 1	1, 0-0:97.98.0.255
	Alarm Register 2	1, 0-0:97.98.1.255
Average Values Profile (7,1-0:99.133.0.255)	Clock	8,0-0:1.0.0.255
	Profile Status 4	1,0-0:96.10.10.255
	Last Average Value of Voltage L1	3,1-0:32.25.0.255
	Last Average Value of Voltage L2	3,1-0:52.25.0.255
	Last Average Value of Voltage L3	3,1-0:72.25.0.255
	Last Average Value of Current L1	3,1-0:31.25.0.255
	Last Average Value of Current L2	3,1-0:51.25.0.255
	Last Average Value of Current L3	3,1-0:71.25.0.255

Profile Name	Capture Object Name	Capture Object OBIS Code
	Last Average Value of Power Factor L1	3,1-0:33.25.0.255
	Last Average Value of Power Factor L2	3,1-0:53.25.0.255
	Last Average Value of Power Factor L3	3,1-0:73.25.0.255
	Last average value of power factor	3,1-0:13.25.0.255
	Last Average Value of Import Active Power	3,1-0:1.25.0.255
	Last Average Value of Export Active Power	3,1-0:2.25.0.255
	Last Average Value of Import Reactive Power	3,1-0:3.25.0.255
	Last Average Value of Export Reactive Power	3,1-0:4.25.0.255
Max. Values Profile (7,1-0:99.134.0.255)	Clock	8,0-0:1.0.0.255
	Profile Status 4	1,0-0:96.10.10.255
	Max. Value of Voltage L1	3,1-0:32.226.0.255
	Max. Value of Voltage L2	3,1-0:52.226.0.255
	Max. Value of Voltage L3	3,1-0:72.226.0.255
	Max. Value of Current L1	3,1-0:31.226.0.255
	Max. Value of Current L2	3,1-0:51.226.0.255
	Max. Value of Current L3	3,1-0:71.226.0.255
	Max. Value of Power Factor L1	3,1-0:33.226.0.255
	Max. Value of Power Factor L2	3,1-0:53.226.0.255
	Max. Value of Power Factor L3	3,1-0:73.226.0.255
	Max. Value of Power Factor	3,1-0:13.226.0.255
	Max. Value of Import Active Power	3,1-0:1.226.0.255
	Max. Value of Export Active Power	3,1-0:2.226.0.255
	Max. Value of Import Reactive Power	3,1-0:3.226.0.255
	Max. Value of Export Reactive Power	3,1-0:4.226.0.255
Min. Values Profile (7,1-0:99.135.0.255)	Clock	8,0-0:1.0.0.255
	Profile Status 4	1,0-0:96.10.10.255
	Min. Value of Voltage L1	3,1-0:32.223.0.255
	Min. Value of Voltage L2	3,1-0:52.223.0.255
	Min. Value of Voltage L3	3,1-0:72.223.0.255
	Min. Value of Current L1	3,1-0:31.223.0.255
	Min. Value of Current L2	3,1-0:51.223.0.255
	Min. Value of Current L3	3,1-0:71.223.0.255
	Min. Value of Power Factor L1	3,1-0:33.223.0.255
	Min. Value of Power Factor L2	3,1-0:53.223.0.255
	Min. Value of Power Factor L3	3,1-0:73.223.0.255
	Min. Value of Power Factor	3,1-0:13.223.0.255
	Min. Value of Import Active Power	3,1-0:1.223.0.255
	Min. Value of Export Active Power	3,1-0:2.223.0.255
	Min. Value of Import Reactive Power	3,1-0:3.223.0.255
	Min. Value of Export Reactive Power	3,1-0:4.223.0.255
Harmonic Profile (7,1-0:99.136.0.255)	Clock	8,0-0:1.0.0.255
	Profile Status 3	1,0-0:96.10.9.255
	Current Average value of 3th harmonic voltage L1	1-0:32.24.3.255
	Current Average value of 3th harmonic voltage L2	1-0:52.24.3.255
	Current Average value of 3th harmonic voltage L3	1-0:72.24.3.255
	Current Average value of 5th harmonic voltage L1	1-0:32.24.5.255
	Current Average value of 5th harmonic voltage L2	1-0:52.24.5.255
	Current Average value of 5th harmonic voltage L3	1-0:72.24.5.255
	Current Average value of 7th harmonic voltage L1	1-0:32.24.7.255
	Current Average value of 7th harmonic voltage L2	1-0:52.24.7.255
	Current Average value of 7th harmonic voltage L3	1-0:72.24.7.255
	Current Average value of 9th harmonic voltage L1	1-0:32.24.9.255

Profile Name	Capture Object Name	Capture Object OBIS Code
	Current Average value of 9th harmonic voltage L2	1-0:52.24.9.255
	Current Average value of 9th harmonic voltage L3	1-0:72.24.9.255
	Current Average value of 11th harmonic voltage L1	1-0:32.24.11.255
	Current Average value of 11th harmonic voltage L2	1-0:52.24.11.255
	Current Average value of 11th harmonic voltage L3	1-0:72.24.11.255
	Current Average value of 13th harmonic voltage L1	1-0:32.24.13.255
	Current Average value of 13th harmonic voltage L2	1-0:52.24.13.255
	Current Average value of 13th harmonic voltage L3	1-0:72.24.13.255
	Current Average value of THD of voltageL1	1-0:32.24.124.255
	Current Average value of THD of voltage L2	1-0:52.24.124.255
	Current Average value of THD of voltage L3	1-0:72.24.124.255
	Current Average value of 3th harmonic Current L1	1-0:31.24.3.255
	Current Average value of 3th harmonic Current L2	1-0:51.24.3.255
	Current Average value of 3th harmonic Current L3	1-0:71.24.3.255
	Current Average value of 5th harmonic Current L1	1-0:31.24.5.255
	Current Average value of 5th harmonic Current L2	1-0:51.24.5.255
	Current Average value of 5th harmonic Current L3	1-0:71.24.5.255
	Current Average value of 7th harmonic Current L1	1-0:31.24.7.255
	Current Average value of 7th harmonic Current L2	1-0:51.24.7.255
	Current Average value of 7th harmonic Current L3	1-0:71.24.7.255
	Current Average value of 9th harmonic Current L1	1-0:31.24.9.255
	Current Average value of 9th harmonic Current L2	1-0:51.24.9.255
	Current Average value of 9th harmonic Current L3	1-0:71.24.9.255
	Current Average value of 11th harmonic Current L1	1-0:31.24.11.255
	Current Average value of 11th harmonic Current L2	1-0:51.24.11.255
	Current Average value of 11th harmonic Current L3	1-0:71.24.11.255
	Current Average value of 13th harmonic Current L1	1-0:31.24.13.255
	Current Average value of 13th harmonic Current L2	1-0:51.24.13.255
	Current Average value of 13th harmonic Current L3	1-0:71.24.13.255
	Current Average value of THD of current L1	1-0:31.24.124.255
	Current Average value of THD of current L2	1-0:51.24.124.255
	Current Average value of THD of current L3	1-0:71.24.124.255
	Fundamental current of L1 (optional)	1-0:31.7.1.255
	Fundamental current of L2 (optional)	1-0:51.7.1.255
	Fundamental current of L3 (optional)	1-0:71.7.1.255
	Fundamental voltage of L1 (optional)	1-0:32.7.1.255
	Fundamental voltage of L1 (optional)	1-0:52.7.1.255
	Fundamental voltage of L1 (optional)	1-0:72.7.1.255

Note: the meter shall be able to store the profile information for at least 31 days.

8.1.3 Averaging Interval

The averaging period of each parameter in average profile (includes last average values of current, voltage, power factor and power) and harmonic profile is same as the capture period time of related profile COSEM object.

8.2 Effect of events on load profiles

The following section describes the behavior of profile and the setting of status bits considering different events.

NOTE: The capture period used in all examples, is 60 minutes.

8.2.1 Season Change

The activation or deactivation of the daylight saving time does not create any additional entries in the buffer. The timestamp together with the DST bit contains enough information to clearly identify when the season change occurred and if the buffer data was captured when daylight saving time was active or not.

8.2.2 Power Down

The following section describes the behavior of the profile and the setting of the status bits considering different power down events. A “Power Down” event starts with the complete loss of power in all connected phases and ends with the restoration of the power in at least one of the connected phases.

8.2.2.1 Power Down within one capture period

The Power Down event affects only one specific capture period. The affected capture period will be marked with Power Down (PDN) bit in the profile status at the end of the capturing period. Figure 17 and

Table 25 show a power down event (from 20:15 to 20:19) within the capture period of 20:00 to 21:00. The entry at 21:00 will be marked with the PDN flag. Since a power down doesn't affect the validity of billing data, the DNV flag is not set.

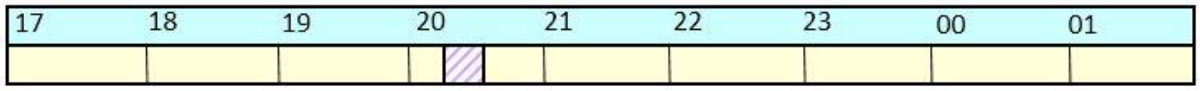


Figure 17: Power failure within capture period

Table 25: Power down event within capture period

Date/Time	Status bits				Register_1	Register_2
	PDN	CAD	DNV	CIV		
1383-08-12/20:00:00	0	0	0	0	2052	115
1383-08-12/21:00:00	1	0	0	0	2070	115
1383-08-12/22:00:00	0	0	0	0	2098	115
1383-08-12/23:00:00	0	0	0	0	2167	117
1383-08-12/00:00:00	0	0	0	0	2180	118

8.2.2.2 Power Down across several capture periods

Figure 18 and Table 26 show a power down event (from 01:15 to 04:52) affecting all capture periods between 01:00 and 05:00. For the capture periods which completely fall into the power down event (03:00, 04:00) no entry is registered in the load profile buffer.

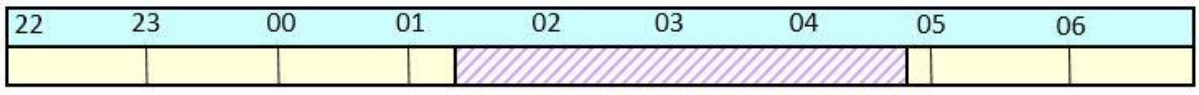


Figure 18: Power failure within capture period(s)

Table 26: Power Down event across several capture periods

Date/Time	Status bits				Register_1	Register_2
	PDN	CAD	DNV	CIV		
1383-08-13/00:00:00	0	0	0	0	2180	118
1383-08-13/01:00:00	0	0	0	0	2201	118
1383-08-13/02:00:00	1	0	0	0	2205	119
1383-08-13/05:00:00	1	0	0	0	2224	121
1383-08-13/06:00:00	0	0	0	0	2252	121

8.2.2.3 Power Down over a season change

Since there are no additional entries generated with a season change power down events over a season change are treated similar to8.2.2.1 and 8.2.2.2.

8.2.2.4 Exhaust of power reserve

Table 27shows the situation when a long power down event leads to a discharged power reserve- and therefore to an invalid clock. The power down event starts on 12.08.1383/ 21:15 and ends on 30.08.1383/ 08:45. The power-down is too long to keep the real time clock running with the super cap, the power reserve is exhausted. After power up (30.08. / 08:45), profile entries continue with the time set to the first capture time after the power down (12.08. / 22:00) – with the PDN=1, DNV=1 and CIV=1. Capturing continues using the invalid clock and keeping CIV=1 and DNV=1 until the clock is set.

Date/Time	Internal Clock
…	….
30.08. 08:45	12.08. / 22:00
30.08. 09:45	12.08. / 23:00
30.08. 10:45	12.08. / 24:00
30.08. 11:45	13.08. / 01:00
….	….

Assuming 3 hours and 50 min after power up the clock is set to 30.8.1383 / 12:35, the next regular entry will take place at 30.8.1383 / 13:00. Since the entry does not represent a full capture period the CAD flag will be set to 1.

Date/Time	Internal Clock
…	…
30.08. 12:35	30.08. / 12:35
30.08. 13:00	12.08. / 13:00
…	…

The entry at 13.8.1383 / 2:00 is stored as if time was advanced over the end of the next period i.e. CAD and DNV are set to 1. Additionally due to the fact power reserve is exhausted also CIV is set to 1.

Table 27: Exhaust of power reserve – late clock adjustment

Date/Time	Status bits				Register_1	Register_2
	PDN	CAD	DNV	CIV		
1383-08-12/20:00:00	0	0	0	0	2052	115
1383-08-12/21:00:00	0	0	0	0	2070	115
1383-08-12/22:00:00	1	0	1	1	2125	116
1383-08-12/23:00:00	0	0	1	1	2167	117
1383-08-13/00:00:00	0	0	1	1	2180	118
1383-08-13/01:00:00	0	0	1	1	2201	118
1383-08-13/02:00:00	0	1	1	1	2202	119
1383-08-30/13:00:00	0	1	0	0	2206	120
1383-08-30/14:00:00	0	0	0	0	2257	120
1383-08-30/15:00:00	0	0	0	0	2274	121
1383-08-30/16:00:00	0	0	0	0	2352	121

If the time adjustment occurs before the end of the 1st capture period after a power-up, the generated entries are additionally marked with the PDN flag.

Remark: due to the exhaust of the power reserve the internal clock stops running and loses its time. At the time of the power up the clock restarts. At the next capture time (12.08 22:00) the CIV bit is set to 1.

In the example of Table 28, the clock is set to 30.8.1386 / 08:45 just after power-up (12.08.1386/ 21:15). Therefore, the entry at 12.08.1386/ 22:00 is closed and marked with PDN set to 1 due to the fact power down was detected in this period (at 21:15), CIV and DNV set to 1 since the clock is due to exhaust of power reserve - not running correctly. In addition, the CAD is set to 1 since shortly after the power up the time was adjusted. At the next capture time (30.08/ 09:00) the incomplete registration period is marked with PDN=0, CAD=1, DNV=0, CIV=0.

Table 28: Exhaust of power reserve – immediate clock adjustment

Date/Time	Status bits				Register_1	Register_2
	PDN	CAD	DNV	CIV		
1386-08-12/20:00:00	0	0	0	0	2052	115
1386-08-12/21:00:00	0	0	0	0	2070	115
1386-08-12/22:00:00	1	1	1	1	2071	116
1386-08-30/09:00:00	0	1	0	0	2106	118
1386-08-30/10:00:00	0	0	0	0	2157	120
1386-08-30/11:00:00	0	0	0	0	2174	121

8.2.3 Setting Time

Clock adjustment larger than a defined synchronization limit is recorded in the event profile and the affected entries in the load profile are marked with the CAD flag.

8.2.3.1 Time changes within capture period

Figure 19 and Table 29 show a clock adjustment from 21:15 to 21:20. The entry at 22:00:00 will be marked with the CAD flag.

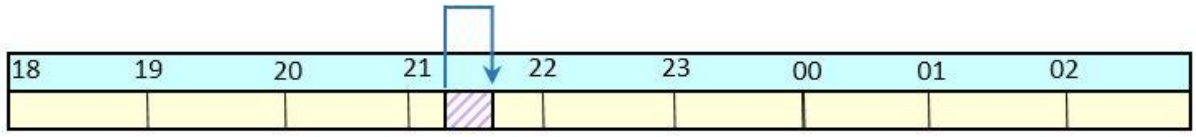


Figure 19 Forward clock synchronization within capture period

Table 29: Time changes within capture period

Date/Time					Register_1	Register_2
	PDN	CAD	DNV	CIV		
1394-08-12/20:00:00	0	0	0	0	2052	115
1394-08-12/21:00:00	0	0	0	0	2070	115
1394-08-12/22:00:00	0	1	0	0	2098	115
1394-08-12/23:00:00	0	0	0	0	2167	117
1394-08-12/00:00:00	0	0	0	0	2180	118

Any clock adjustment (forward or backwards) within the capture period is marked in this way. If the clock adjustment is smaller than the synchronization limit (depending on parameter setting) no entry is recorded.

8.2.3.2 Advancing the time over the end of the period

Figure 20 and

Table 30 show a clock adjustment from 21:15:37 to 22:22:00. At 22:00:00 an entry is generated with the CAD flag set since the period was not closed correctly. The entry at 23:00:00 is marked with the CAD flag.

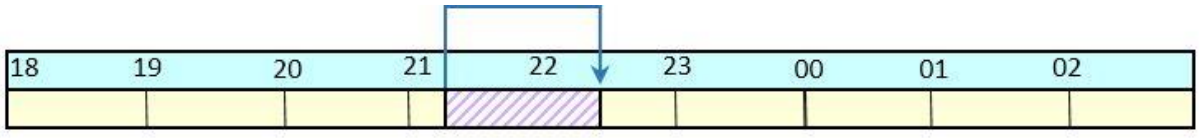


Figure 20: Forward clock synchronization across two consecutive capture periods

Table 30: Advancing the time over the end of the period

Date/Time	Status bits				Register_1	Register_2
	PDN	CAD	DNV	CIV		
1383.08.12/20:00:00	0	0	0	0	2052	115
1383.08.12/21:00:00	0	0	0	0	2070	115
1383.08.12/22:00:00	0	1	0	0	2075	116
1383.08.12/23:00:00	0	1	0	0	2080	117
1383.08.12/00:00:00	0	0	0	0	2090	118
1383.08.12/01:00:00	0	0	0	0	2101	118

8.2.3.3 Advancing the time over a season change

No additional recordings are generated. The profile acts the same way as with advancing the clock over one or more periods.

8.2.3.4 Setting the time back – sorted

Due to the fact that the profile is sorted, in case of a time change backwards the new entry will be stored at the appropriate position in the buffer.

Figure 21 and Table 31 show a profile after a clock adjustment backwards from 23:15 to 18:42

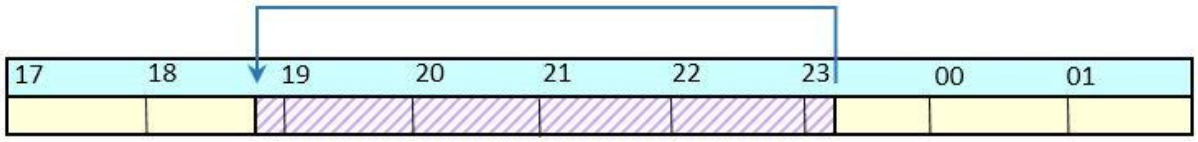


Figure 21: Setting the time back across several capture periods

Before the time change:

Table 31: Profile before setting the time back

Date/Time	Status bits				Register_1	Register_2
	PDN	CAD	DNV	CIV		
1383.08.12/16:00:00	0	0	0	0	2041	109
1383.08.12/17:00:00	0	0	0	0	2047	109
1383.08.12/18:00:00	0	0	0	0	2052	110
1383.08.12/19:00:00	0	0	0	0	2125	117
1383.08.12/20:00:00	0	0	0	0	2201	120
1383.08.12/21:00:00	0	0	0	0	2206	120
1383.08.12/22:00:00	0	0	0	0	2220	121
1383.08.12/23:00:00	0	0	0	0	2257	122

After the time change backwards to 18:42:

The next regular entry is created at 19:00, marked with the CAD flag. If an entry with the same time stamp already exists then the old entry will be overwritten (like Table 32).

Table 32: Profile after setting the time back

Date/Time	Status bits				Register_1	Register_2
	PDN	CAD	DNV	CIV		
1383.08.12/16:00:00	0	0	0	0	2041	109
1383.08.12/17:00:00	0	0	0	0	2047	109
1383.08.12/18:00:00	0	0	0	0	2052	110
1383.08.12/19:00:00	0	1	0	0	2260	123

8.2.3.5 Setting the time back – unsorted

In case of an unsorted profile all profile entries remain in the buffer which will lead to duplicated entries.

Table 33 shows a profile before and after (Table 34) a time change backwards from 23:15 to 18:42.

Before the time change:

Table 33: Setting the time back – before

Date/Time	Status bits				Register_1	Register_2
	PDN	CAD	DNV	CIV		
1383.08.12/16:00:00	0	0	0	0	2041	109
1383.08.12/17:00:00	0	0	0	0	2047	109
1383.08.12/18:00:00	0	0	0	0	2052	110
1383.08.12/19:00:00	0	0	0	0	2125	117
1383.08.12/20:00:00	0	0	0	0	2201	120
1383.08.12/21:00:00	0	0	0	0	2206	120
1383.08.12/22:00:00	0	0	0	0	2220	121
1383.08.12/23:00:00	0	0	0	0	2257	122

After the time change backwards to 18:42:
All entries between 19:00 and 23:00 are remaining in the buffer after the time change. The next regular entry is marked with the CAD flag.

Table 34: Setting the time back – after

Date/Time	Status bits				Register_1	Register_2
	PDN	CAD	DNV	CIV		
1383.08.12/16:00:00	0	0	0	0	2041	109
1383.08.12/17:00:00	0	0	0	0	2047	109
1383.08.12/18:00:00	0	0	0	0	2052	110
1383.08.12/19:00:00	0	0	0	0	2125	117
1383.08.12/20:00:00	0	0	0	0	2201	120
1383.08.12/21:00:00	0	0	0	0	2206	120
1383.08.12/22:00:00	0	0	0	0	2220	121
1383.08.12/23:00:00	0	0	0	0	2257	122
1383.08.12/00:00:00	0	1	0	0	2258	122
1383.08.12/19:00:00	0	1	0	0	2260	123

8.2.4 Profile Reset

If the reset method is executed explicitly or implicitly (as a consequence of a modification in the data structure of the profile, (comp.DLMS UA 1000-1 Ed. 11 .0:2013) the first entry after the reset will contain a valid registration period (considering the modified data structure, if the reset was the consequence of a modification).Table 35 shows the first entry after a reset at 15:45:35.

Table 35: Profile Reset

Date/Time	Status bits				Register_1	Register_2
	PDN	CAD	DNV	CIV		
1383.08.12/16:00:00	0	0	0	0	2041	109

9 Quality of supply

9.1 Power Quality Information

Meter shall register and provide (for Central System) the power quality information. The power quality parameters include the following:

- Under Voltage and Over Voltage;
- Voltage Cut (Missing Voltage);
- Average Voltage;
- Voltage Sag and Swell in Meters;
- THD in 3P meters (CT/PT, CT and DC);
- Harmonics 3P meters (CT/PT, CT and DC);

9.1.1 Average Voltage

The average voltage is determined in each phase. The average voltage values are stored in the following COSEM objects:

- Average voltage L1 (3, 1-0:32.24.0.255);
- Average voltage L2 (3, 1-0:52.24.0.255);
- Average voltage L3 (3, 1-0:72.24.0.255);

The average voltage is determined according to the configurable aggregation time interval between 1 min to 60 min. This value can be configured by central system via COSEM object "Measurement Period 3 for Instantaneous Value" (3, 1-0:0.8.2.255). The default value is 10 minutes. At the start of aggregation interval, the meter starts sampling phase voltage and averages them at the end of time interval.

9.1.1.1 Voltage Level Monitoring based on EN 50160

The voltage level (measured average voltage level, ULX average) can be divided into two main groups as follow (based on definition in EN 50160).

U_{LX} Normal: During each period of one week 95 % of U_{LX} average shall be within the range of U_N +/- 10 %; and all U_{LX} average shall be within the range of UN as defined in -15% to +10% (according to EN50160.)

ULX Bad: Any other cases

In case of "U_{LX} Bad" voltage, an event will be generated regarding each phase. The following events are considered:

- Event Code 92: Bad Voltage Quality L1
- Event Code 93: Bad Voltage Quality L2
- Event Code 94: Bad Voltage Quality L3

9.1.2 Under/Over Voltage (All Types of Meters)

The meter detects the under voltage and over voltage in all phases. The threshold of under voltage is from -5% VREF to -20% VREF by 1V steps and for overvoltage is from +5% VREF to +15% VREF by 1V steps. The threshold values of under voltage and over voltage are stored in the following COSEM objects and can be set/adjust remotely by central system.

- Threshold for Under Voltage (3, 1-0:12.31.0.255);
- Threshold for Over Voltage (3, 1-0:12.35.0.255);

The under/over voltage will not be recorded unless they continue for equal or greater than the time set for under voltage and overvoltage threshold. This time is adjustable and shall be set via the following COSEM object:

- Time Threshold for Over Voltage (3, 1-0:12.44.0.255);
- Time Threshold for Under Voltage (3, 1-0:12.43.0.255);

The time threshold for over voltage is between 1 (second) to 1440 (second) and the default value is 180 second). The time threshold for under voltage is between 1(second) to 1440 (second). The default value is 180 (second)

If any under voltage and Over Voltage happens, an event will be logged. The following COSEM object from class ID 7 are in charge of capturing the over voltage and under voltage events.

- Power Quality Event Log (7, 0-0:99.98.4.255);

The COSEM object "Power Quality Event Log" (0-0:99.98.4.255 Class ID: 7) is in charge of capturing the over voltage and under voltage. The different events will be generated for starting and ending of under voltage and over voltage events in each phase. The event codes76, 77, 78, 79, 80, 81 are considered to show the starting time of under/over voltages and event codes 217, 218, 219, 220, 221 and 222 are generated in case of ending events.

The total number of over/under voltage, the duration of last over/under voltage and magnitude of last over/under voltage are stored in the following dedicated COSEM objects.

- Number of Under Voltage in Phase L1 (1, 1-0:32.32.0.255);
- Number of Under Voltage in Phase L2 (1, 1-0:52.32.0.255);
- Number of Under Voltage in Phase L3 (1, 1-0:72.32.0.255);
- Duration of Last Under Voltage in Phase L1 (3, 1-0:32.33.0.255);
- Duration of Last Under Voltage in Phase L2 (3, 1-0:52.33.0.255);
- Duration of Last Under Voltage in Phase L3 (3, 1-0:72.33.0.255);
- Magnitude of Last Under Voltage in Phase L1 (3, 1-0:32.34.0.255);
- Magnitude of Last Under Voltage in Phase L2 (3, 1-0:52.34.0.255);
- Magnitude of Last Under Voltage in Phase L3 (3, 1-0:72.34.0.255);
- Number of Over Voltage in Phase L1 (1, 1-0:32.36.0.255);
- Number of Over Voltage in Phase L2 (1, 1-0:52.36.0.255);
- Number of Over Voltage in Phase L3 (1, 1-0:72.36.0.255);
- Duration of Last Over Voltage in Phase L1 (3, 1-0:32.37.0.255);
- Duration of Last Over Voltage in Phase L2 (3, 1-0:52.37.0.255);
- Duration of Last Over Voltage in Phase L3 (3, 1-0:72.37.0.255);

- Magnitude of Last Over Voltage in Phase L1 (3, 1-0:32.38.0.255);
- Magnitude of Last Over Voltage in Phase L2 (3, 1-0:52.38.0.255);
- Magnitude of Last Over Voltage in Phase L3 (3, 1-0:72.38.0.255);

Note: these COSEM objects are intended to provide over/under voltage information in local reading. For details information of over/under voltages or to read from central system, the related event log COSEM objects shall be considered.

At the starting of Over/Under voltage events (event codes 76, 77, 78, 79, 80, 81), the following parameters shall be captured by Power Quality Event Log COSEM object (7, 0-0:99.98.4.255):

- Number of Over/Under Voltage;
- Starting time of Over/Under Voltage;

At the end of Over/Under voltage events (event codes 217, 218, 219, 220, 221, 222), the following parameters shall be captured by Power Quality Event Log COSEM object (7, 0-0:99.98.4.255):

- End time of Over/Under Voltage;
- Duration of Last Over/Under Voltage;
- Magnitude of Last Over/Under Voltage;

9.1.3 Voltage Cut (Missing Voltage)

If the voltage drops below the "Threshold for Voltage Cut" and continues for the "Time Threshold for Voltage Cut" seconds, the situation will be considered as Voltage Cut and an event will be logged (event codes 82, 83 and 84 for L1, L2 and L3 respectively).

The threshold of voltage cut is adjustable and can be set by central system. The default value is -30% VREF for CT/PT meters and -50% VREF for CT Meters. The threshold value is stored in the following COSEM object and can be set/adjust remotely by central system.

- Threshold for Missing Voltage (Voltage Cut) (3, 1-0:12.39.0.255);

As mentioned, the voltage cut will not be recorded unless it continues for equal or greater than the specific time. Time threshold for voltage cut is between 5 sec. to 30 sec. Time threshold less than 5 sec. is optional. and the default value is 5 sec. This time is adjustable and can be set via the following COSEM object:

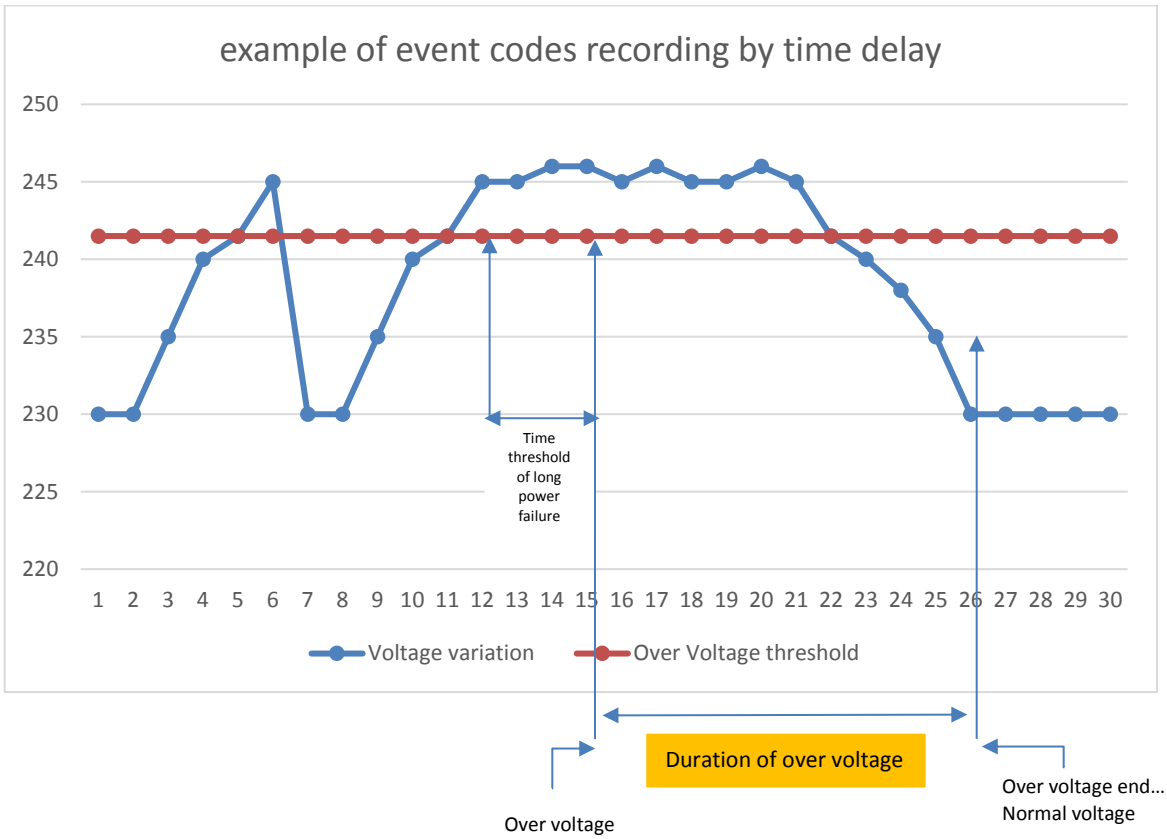
- Time Threshold for Voltage Cut (3, 1-0:12.45.0.255);

The voltage cut events are considered as Power Quality events and are captured by Power Quality Event Log (7, 0-0:99.98.4.255). The events codes 82, 83 and 84 are considered as starting of voltage cut in phases L1, L2 and L3 respectively and events codes 223, 224 and 225 as end of voltage cut.

9.1.4 Effect of Delay Time (Time threshold for long power failure, missing voltage, over voltage and under voltage)

Figure 22 shows the effect of delay time on the monitoring of a value with the example of an over voltage. The delay time is the time threshold for over voltage in this example, i.e. the over voltage must in principle occur for 180 seconds. As soon as the meter detects an overvoltage therefore it calculates the delay time. After 180 seconds over voltages the meter shall record the over voltage event and if the voltage falls below the threshold again, the meter first begins to calculate the delay.

It then records overvoltage end with amplitude - duration and simultaneously if the measured voltage is in normal range the meter should record voltage normal event after that, it means that the end of over voltage event is recorded before normal voltage event. The start and end are displaced, by the delay time (here 180 seconds).



Over voltage threshold = 241.5
Time threshold for over voltage = 180 seconds

Figure 22: example of event codes recording by time delay

The delay time prevents the meter responding too sensitively when monitoring a value, i.e. it should not for example record every brief overvoltage or every voltage failure, but only the relevant deviations.
This concept is extended to long Power failure, missing voltage and under voltage and their own event codes.

Note: Detail objects are presented in FID2 –Object list V3 document.

9.1.5 Harmonics/THD Measuring (3P meters (CT/PT, CT and DC))

In three phase meters (CT/PT, CT and DC), the harmonics and THD shall be measured and stored. The harmonics numbers up to 13th and THD in each phase for current and voltage are stored in dedicated COSEM object from Class ID3.

9.1.6 Unbalance Load

The load unbalancing shall be detected by FAHAM meters. Load Unbalance situation is condition when the current value in at least one phases is greater than a minimum value (as precondition to start load unbalance detection process) and in unbalance loads, at least one phase current deviates from average three phase current more than a defined threshold. The asymmetry results generating event and alarm (event code: 90) and setting bit 6 of COSEM object "Profile Status 4 (Avg., Min., Max.)" (1, 0-0:96.10.10.255).

Note: The "Load Unbalance" event (code: 90) should be only generated only when the unbalance situation has not been detected in previous unbalance calculation period. But, setting profile status bit should be done at any unbalance detection period.

The asymmetry event is logged by "Power Quality" event log. Following figure depicts the load unbalance situation.

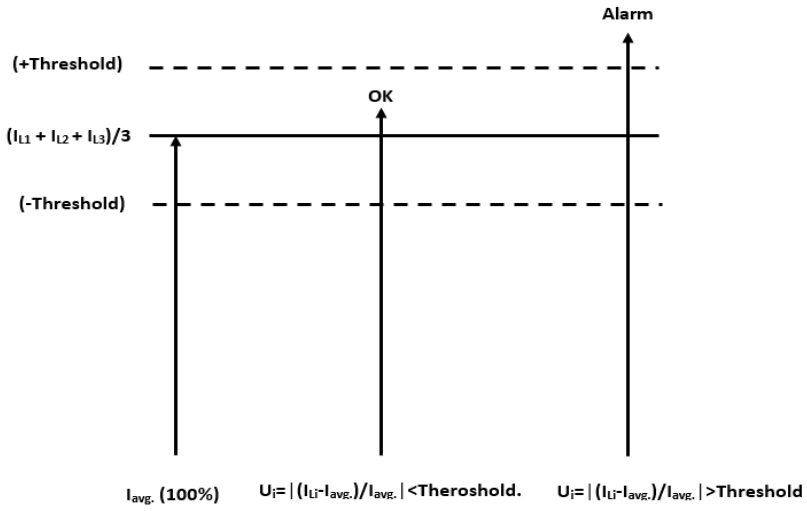


Figure 23: Load Unbalance Situation

I_{Li} (that has been shown in figure 23) is last average value of phase L_i that has been captured by Average Values Profile COSEM object (7, 1-0:99.133.0.255). The averaging period (to detect the unbalancing situation) is same as capture period of Average Value Profile (default value is 15 min.).

Events for unbalance load are always generated at the end of aggregation period (capture period of Average Values Profile), when meter stores average phase values in Average Values Profile. At the same time also dedicated alarm is set or cleared. However, if alarm bit is cleared by the central system before meter detects normal condition (which can only happen at the end of next aggregation period), alarm is immediately set back.

The minimum current in phases (to start asymmetry detection process) in ampere and threshold value for asymmetry detection in percentage can be set as parameters in COSEM object "Unbalance Load Detection" (1, 0-0:94.98.15.255). The setting parameters in this COSEM object are as follows:

- Minimum Current (A);
- Unbalance Threshold (%);

These parameters can be set by central system. The default value for Unbalance threshold is 50%.

10 Power Interruption Information

10.1 General

FAHAM meter shall provide power failure/interruption. The power failure/interruption happens when the voltage is lost in phase(s). It is based on voltage Cut threshold (Section 9.1.3). There three types of power failure in FAHAM as follows:

- Short Power Failure/Interruption (Simply “Power Failure”);
- Long Power Failure/Interruption;
- Power Down;

The power interruption less than "T" is considered as “Short Power Failure” (or simply “Power Failure”) and greater than it is called “Long Power Failure”. The "T" is configurable and its default value is 3 minutes. The COSEM object "Time Threshold for Long Power Failure" (3, 0-0:96.7.20.255) is intended to store this value. This value shall be configurable by central system. The power interruption in all phases is considered as “Power Down”.

Note1: Time threshold for power failure is allowed to change between 1 to 60 min.

Note2: Time Threshold for short Power Failure is as the same as Time Threshold of missing voltage.

Meter detects and registers power failures per phase, for any phase and for all phases. Registration of power failures is done by, incrementing dedicated counters, setting alarms and storing events in “Standard” and “Power Failure” event logs.

10.1.1 Power Interruption Information

There are different policies about registration of information of Short and Long power failure/interruption. In Short Power interruption, the following information shall be provided:

- Number of Interruptions;
- Regarding the Long Power Interruption, the following information shall be provided:
- Number of Interruptions;
- Interruption Duration;
- Timestamp of interruption;

The number and duration of interruptions are stored in dedicated COSEM object. They are presented in following sections.

10.1.2 Power Interruption Counters

There different power failures are considered in FAHAM, to count and store the number of short and long power failures. The counters and their related COSEM objects are as follow:

- Number of Short Power Failures in All Phases (1, 0-0:96.7.0.255);
- Number of Short Power Failures in L1 (1, 0-0:96.7.1.255);
- Number of Short Power Failures in L2 (1, 0-0:96.7.2.255);
- Number of Short Power Failures in L3 (1, 0-0:96.7.3.255);
- Number of Long Power Failures in All Phases (1, 0-0:96.7.5.255);
- Number of Long Power Failures in Phase L1 (1, 0-0:96.7.6.255);

- Number of Long Power Failure in Phase L2 (1, 0-0:96.7.7.255);
- Number of Long Power Failure in Phase L3 (1, 0-0:96.7.8.255);

The counter's value is incremented by "1" in cases of any related event. The counter can't be reset. It is rest automatically, if it reaches the maximum value according to its size.

10.1.3 Power Interruption Duration Registers

The duration of last long power failure shall be registered by meter. The following registered are considered in FAHAM to store the duration of last long power failure.

- Duration of Last Long Power Failure in All Phases (3, 0-0:96.7.15.255);
- Duration of Last Long Power Failure in Phase L1 (3, 0-0:96.7.16.255);
- Duration of Last Long Power Failure in Phase L2 (3, 0-0:96.7.17.255);
- Duration of Last Long Power Failure in Phase L3 (3, 0-0:96.7.18.255);
- Duration of Last Long Power Failure in Any Phase (3, 0-0:96.7.19.255);

10.1.4 Power Failure Event Log

There is one event log (from Class 7) in FAHAM for power failure as COSEM object "Power Failure Event Log" (7, 1-0:99.97.0.255). The power failure event log contains all events related to long power outages. It stores the time stamp, duration of long power failures in any phase (where the time stamp represents the end of power failure) and event code related to phase (that long power failure occurred).The more detailed view into the duration of the power outage events is provided via dedicated COSEM object for each phase (section10.1.3). Each entry recorded in Power Failure Event Log contains the following information about power failure events:

- Time of power return after long power failure;
- Duration of long power failure (in phase L1, L2 and L3);
- Event code related to long power failure in L1, L2 and L3;

10.2 Measurement of Difference between Phase and Neutral Currents (Single Phase Meter)

In FAHAM single phase meter, the difference of current between phase and neutral shall be measured and related events (205 and 206) should be recorded in fraud log file. Meter shall measure energy by phase calculation.

11 Disconnect Control

There are three ways to control the internal relay (contactor) of meter. They are as follows:

- Remote Control;
- Manual;
- Locally (as internal process);

The local control of relay will be done by an internal function (or process) of meter. There is one internal function to control the meter's internal relay (as internal process). This is “Limiter Control”.

The 4 states have been defined for internal relay (contactor) as follows:

- Disconnected;
- Ready for Reconnection;
- Connected;
- Always Connected;

Note: DC meter and Single phase meter shall be equipped with a switch (En/Dis switch) to disable receiving disconnection/reconnection commands (remote, local, manual). When En/Dis switch is in disable state, the relay is in always connected state.

Figure 24 depicts the states and possible/permissible transitions.

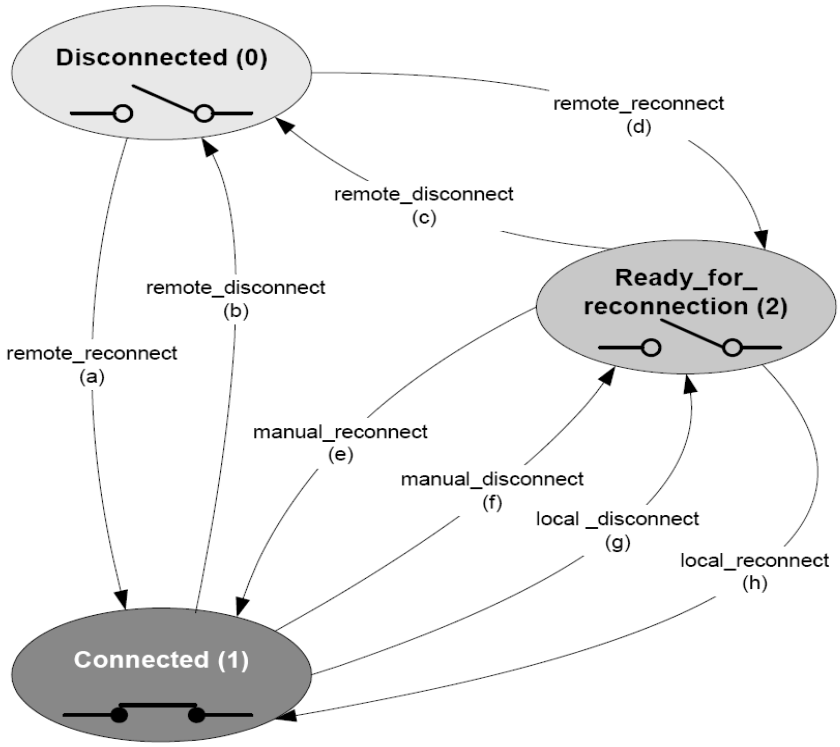


Figure 24: Disconnect Control, State Diagram and Transitions

As has been shown in figure 24, the possible transitions have been specified by letters ("a" to "h"). The different "Control Mode" can be defined based on possible/permissible transitions between states. The defined "Control Modes" are presented in Table 36.

Table 36: Disconnect Control Schedule Object Parameters

Control Mode	Transitions	Remark
0	-	Always connected
1	(b), (c), (g), (d), (e)	No manual disconnection
2	(b), (a)	No manual disconnection
3	(b), (c), (g), (d), (e)	No manual disconnection
4	(b), (c), (g), (a), (e)	No manual disconnection
5	(b), (c), (f), (g), (d), (e), (h)	
6	(b), (c), (g), (d), (e), (h)	No manual disconnection

The desired control mode can be set (chosen) by central system (software). The default mode in FAHAM is 0.

Action-Result on Control function is described in table 37.

Table 37: Action-Result on disconnect Control function

	The state of the meter relay when sending the Remote disconnect/connect command to meter	The expected response of meter
1	Relay mode is 0	other-reason (250)
2	Relay mode is not 0 but the selected mode doesn't support the remote disconnect /connect command	other-reason (250)
3	the current state of relay is connected then try to connect again or the current state of relay is disconnected then try to disconnect again	other-reason (250)
4	Disconnection function disabled (In case of En/Dis switch disabled)	scope-of-access-violated (13)

Note1: Priority for disconnection/reconnection command is based on the following principles:

1) When the control mode is 0, then relay remains connected.
2) Priority of Remote disconnect is higher than other reconnect mechanism except remote reconnection.
3) When the credit management mode (1-0:94.98.56.255) is 2: Priority of disconnection by credit management function is the same as remote disconnection. Reconnection is possible just by remote reconnect and manual connect (subject to assigning the new credit or inactivating the credited management function).
4) Priority of disconnection by fuse supervision is the same as remote disconnect. Reconnection is possible just by remote or fuse supervision mechanisms.
5) Priority of daily disconnect/reconnect scheduler is higher than disconnect/reconnect by tariff table.
6) Between limiter and tariff table, disconnection has higher Priority.
7) Between limiter and daily schedule, disconnection has higher Priority.

11.1 COSEM Objects of Disconnect Control

The following COSEM objects are involved in disconnect control process.

- Disconnect Control (70, 0-0:96.3.10.255)
- Reconnect Control Scheduler (22, 0-0:15.0.1.255);
- Disconnect Control Scheduler (22, 0-0:15.1.1.255);
- Disconnector Script Table (9, 0-0:10.0.106.255);
- Limiter (71, 0-0:17.0.0.255);
- Reclosing Configuration (1, 0-0:94.98.28.255);
- Supervision monitor L1 (21, 1-0:31.4.0.255);
- Supervision monitor L2 (21, 1-0:51.4.0.255);
- Supervision monitor L3 (21, 1-0:71.4.0.255);
- Limiter Threshold Scheduler (22, 0-0:94.98.18.255);
- Limiter Script Table (9, 0-0:94.98.25.255);

Note: connect/disconnect of external Circuit breaker or contactor (in the case of CT and CT/PT meters) will be done base on the Relay Inverse Mode object (1, 0-0:146.129.41.255).

Figure 25 shows the interaction between different COSEM objects to control the internal relay.
The schedule will be configured by central system. There is no priority and they can be based on internal logic (limiter), time (schedule) and permissible states.

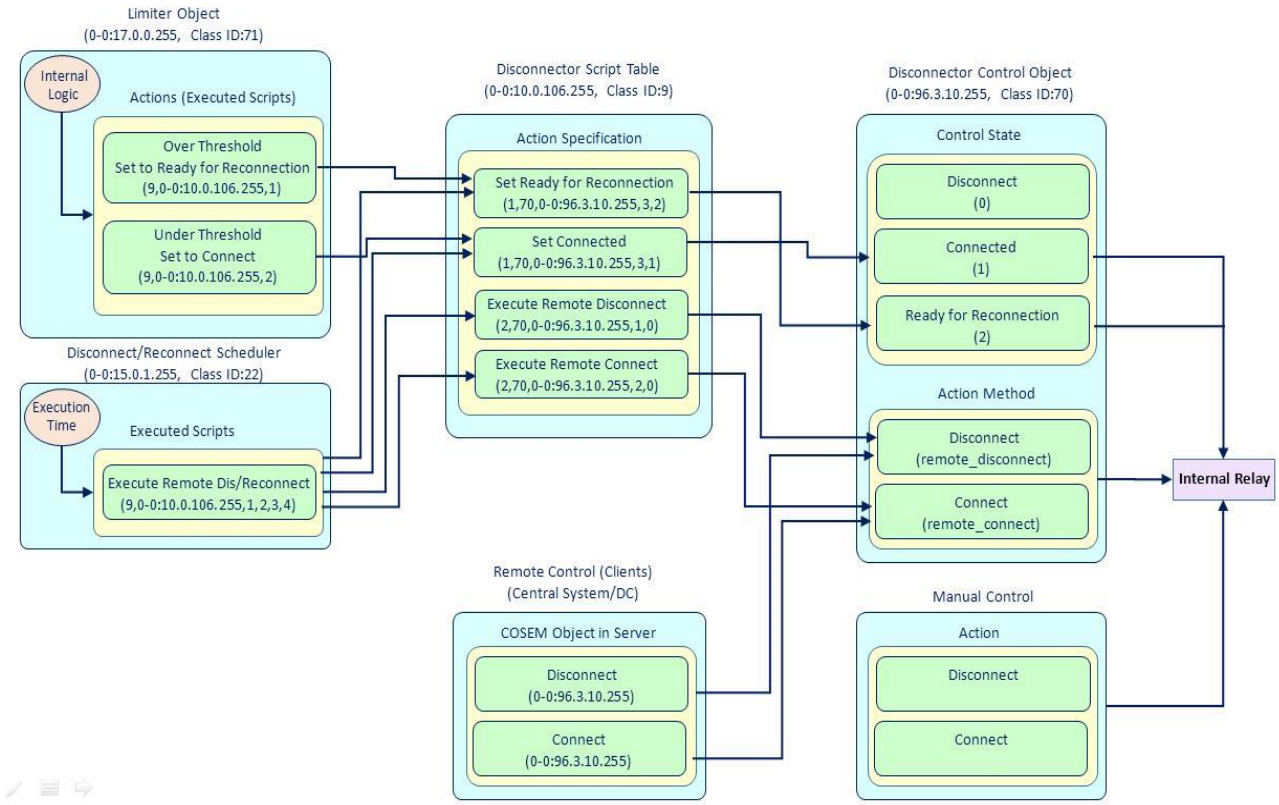


Figure 25: Disconnect Control COSEM objects

11.2 Schedule Control

The schedule control of internal relay will be handled by COSEM objects “Discount/Reconnect Control Scheduler” (22, 0-0:15.0.1.255). This schedule can be used for both disconnection and reconnection of internal relay. Figure 26 depicts the disconnect/reconnect control process by schedule.

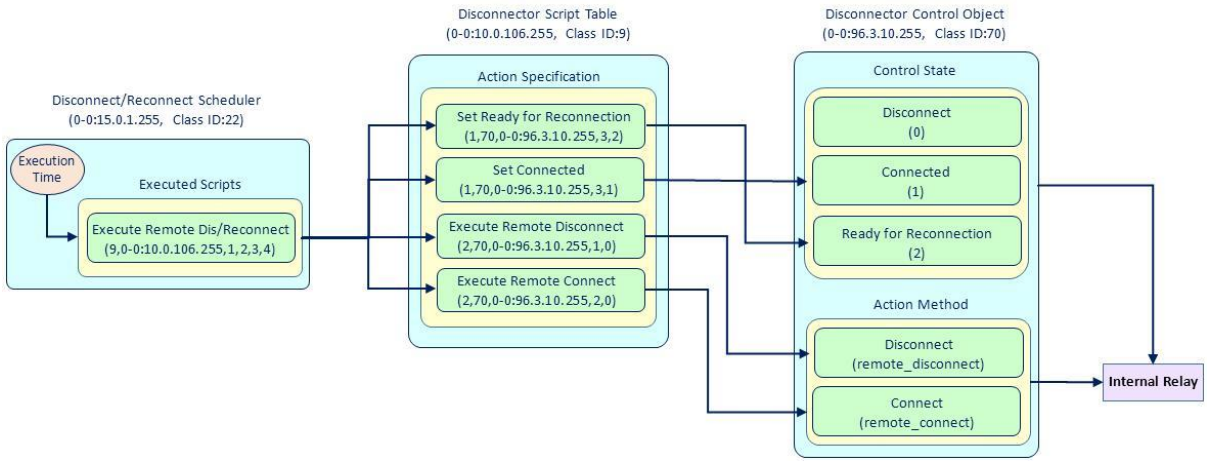


Figure 26: Schedule Control Process

The schedule (from Class ID: 22) is single action schedule. As depicted in table 38, the Scheduler object (Disconnect or Reconnect) call “Disconnector Script Table” COSEM object (9, 0-0:10.0.106.255) to make an action (connect/disconnect). The following parameters shall be specified in Scheduler object to fulfill the task:

- Executed Script (Action);
- Execution Time;

The data value and parameters of this object is specified in Table 38:

Table 38: Disconnect Control Schedule Object Parameters

Parameter Name	Type	Execution Time Index	Executed Script (Action)		Execution Time	
			Script Table Name	Script Identifier	Time	Date
Format	type		script_logical_name	script_selector	time	date
Type	enum		octed-string(size(6))	long-unsigned	octet-string (size (4))	octet-string (size(5))
Value	1**	01	0-0:10.0.106.255	3:Execute Remote Disconnect (for Disconnect Action) 4:Execute Remote Connect (for Reconnect action)	byte 03: Hour byte 02: Minute byte 01: Second* byte 00: Hundredths*	byte 04: Year (High Byte) byte 03: Year (Low Byte) byte 02: Month byte 01: Day of Month byte 00: Day of Week
		02	0-0:10.0.106.255	3:Execute Remote Disconnect (for Disconnect Action) 4:Execute Remote Connect (for Reconnect action)	byte 03: Hour byte 02: Minute byte 01: Second* byte 00: Hundredths*	byte 04: Year (High Byte) byte 03: Year (Low Byte) byte 02: Month byte 01: Day of Month byte 00: Day of Week
		n	0-0:10.0.106.255	3:Execute Remote Disconnect (for Disconnect Action) 4:Execute Remote Connect (for Reconnect action)	byte 03: Hour byte 02: Minute byte 01: Second* byte 00: Hundredths*	byte 04: Year (High Byte) byte 03: Year (Low Byte) byte 02: Month byte 01: Day of Month byte 00: Day of Week

*The Second and Hundredth of seconds must be zero.

**In this type (enum=1), The wildcards in *date* are allowed.

Note: The execution (schedule) can be disabled with writing {"FFFFFFFF", "FFFFFFFFFF"}.

As has been mentioned in Table 38, a common schedule (“Discount/Reconnect Control Scheduler”/0-0:15.0.1.255) is used for both Disconnection and Reconnection actions. It can be done by changing the calling script in *executed_script* atttribue of COSEM object 22, 0-0:15.0.1.255. Calling script “3” is used for disconnection and “4” is considered for reconnection.

11.2.1 Schedules Disconnection/Reconnection during Power-off

If any scheduled tasks happened within power-off situation, the task (scheduled disconnection/connection) shall be fulfilled after recovering power in grid (power-on). Because a common schedule is used for both actions (Disconnection and Reconnection), during power-off situation, only one of these two actions can be happened.

11.3 Limiter Control

The limiter control is intended to limit the demand at a defined value (that has been specified by utility). The limiter issues command to disconnect the internal relay (contactor) when the monitored value crosses the threshold value and stay for specific time duration. The limiter control is handled by COSEM object "Limiter" (71, 0-0:17.0.0.255). As has been mentioned in section11, the limiter control acts as internal process and change the relay state from connected to ready for reconnection and vice versa.

Two disconnecting profiles are defined in meter as follows:

- Normal Operation;
- Emergency Operation;

Two separate threshold values are provided for normal and emergency operations. The provisions are provided in central system (software) to select the monitored values and to specify the thresholds.

11.3.1 Limiter in Normal Operation

Demand limitation in normal condition should be adjustable based on following objects in data model for import / combined / net demand for three phase meters and sliding average current for single phase meters:

Limiter (71, OBIS: 0-0:17.0.0.255, 2)

Attribute2 = monitored_value

- For three phase meter: sliding demand

  Average import power (+A): {5, 1-0:1.24.0.255, 2}
  Average Net Power (|+A|-|-A|) : {5,1-0:16.24.0.255, 2}
  Average Total Power (|+A|+|-A|): {5,1-0:15.24.0.255, 2}

- For single phase meter: Sliding average current

  Sliding Average current {5, 1-0:31.4.0.255, 2}
  {5,1-0:15.24.0.255, 2}

Whenever monitored_value for more than *min_over_threshold_duration* (T1 second) exceeds from the value of *threshold_norma*l / threshold emergency, the internal relay/auxiliary relay should be triggered based on the value of attribute 11 (action):

Action=Limiter (71, OBIS: 0-0:17.0.0.255, 11)

Maximum value for *threshold_normal*/ threshold emergency for demand (without applying CT or CT/PT coefficients whenever applicable) in 3-phase meters should be limited to:

Max_demand_threshold (normal/emergency) < (number of phase) $*I_{max}*V_{nom}$

Maximum value for *threshold_normal/threshold_emergency for sliding average current in single phase meter should be limited to:*

Max_sliding_average_current_threshold (normal/emergency) $<1.10*I_{max}$

If the internal relay is triggered by exceeding the demand (current) limitation it should keep its state, then if the *monitored_value* goes down the *threshold_active* and stays there for the min_under_threshold_duration (T2) seconds, output state of relay should be updated based on *the actions* defined in (attribute 11)

Note: "1.1*Imax" does not mean the meter have to tolerate this current permanently.

11.3.1.1 Limited Disconnection

Due to the law restrictions, the longtime disconnection of the consumer's load is not permitted currently even if the consumption exceeds the demand threshold. A feature has been added to meter to disconnect the load in limited periods when the meter experiences a demand deviation. To adapt to future legislation, flexible options have been added in this feature too.

For controlling number of disconnections, the following object added to data model:

- Reclosing Configuration (1, 0-0:94.98.28.255)

  - Attribute 2: value
    Structure {

Number of Reclosing_normal:	unsigned
Middle_timeout_normal (T3 minute):	long-unsigned
Final_state_normal:	enum (0, 1), (0 = connected),
Number of Reclosing_emergency:	unsigned
Middle_timeout_emergency(T4 minute):	long-unsigned
Final_state_emergency:	enum (0, 1), 1 (disconnected)
End_timeout (T5 minute):	long-unsigned

}

Number of Reclosing_normal/emergency:

When the number of disconnect/ reconnect attempts exceeds this value (depending Final_state value=0, 1 correspondingly), the limiter functionality should be disabled (T5 timeout is started).
Value 0 means number of retry is unlimited, in other words, normal operation of limiter is permitted.

Note: if the meter is in final state time out, and the transient has occurred between normal and emergency conditions, then meter should restart its limiter cyclic function.

Middle_timeout_normal/emergency (T3/T4): **<**Timeout between two successive violations>
If after a reconnection that has happened due to a violation, another violation does not occur in times greater than T3/T4, then the counter of reconnect attempts will be reset. (Re-closer state is initiated). The minimum chosen value for T3/T4 should meet below condition:

T3/T4 ≥ 4*(demand integration period)

(e.g. if number of period is 15 and demand period is 1 minute then demand integration period is 15*1=15 minutes therefore T3/T4 should be set in meter with values greater than or equal 60 minutes)

Note: it is recommended for meter is deployed in field value of T1 and T2 be greater than equal “demand integration period divided by three”

Final_state_normal/emergency:
0: within T5 timeout disconnection actions is disabled (update attribute 11 accordingly)
1: within T5 timeout reconnection actions is disabled (update attribute 11 accordingly)

End_timeout(T5):
Time, in minutes, after final reconnect (disconnect), number of violations will be reset and limiter functionality will be enabled again. (Re-closer state is initiated)

11.3.2 Limiter in Emergency Operation

Demand limitation in emergency condition should be adjustable based on following objects in data model for import / combined / net demand for three phase meters and sliding average current for single phase meters:

Limiter (71, OBIS: 0-0:17.0.0.255, 2)

Attribute2: Monitored value

- For three phase meter: sliding demand

  Average import power (+A): {5, 1-0:1.24.0.255, 2}
  Average Net Power (|+A|-|-A|) : {5,1-0:16.24.0.255, 2}
  Average Total Power (|+A|+|-A|): {5,1-0:15.24.0.255, 2}

- For single phase meter: Sliding average current

  Sliding Average current {5, 1-0:31.4.0.255, 2}
  {5,1-0:15.24.0.255, 2}

Limiter (71, OBIS: 0-0:17.0.0.255, 8)

Attribute8: Emergency profile

•Emergency Profile ID (emergency_profile_id);
• Activation Time (emergency_activation_time);
• Duration (emergency_duration);

Limiter (71, OBIS: 0-0:17.0.0.255, 9)

Attribute9: Emergency Group ID List (emergency_profile_group_id);

The Emergency Profile is activated when the time/date (Activation time) that is defined at attribute 8, reaches and the Emergency Profile ID matches one of IDs that has been mentioned in Emergency Group ID List. If the Emergency Profile is activated, it has priority to limiter normal operation.

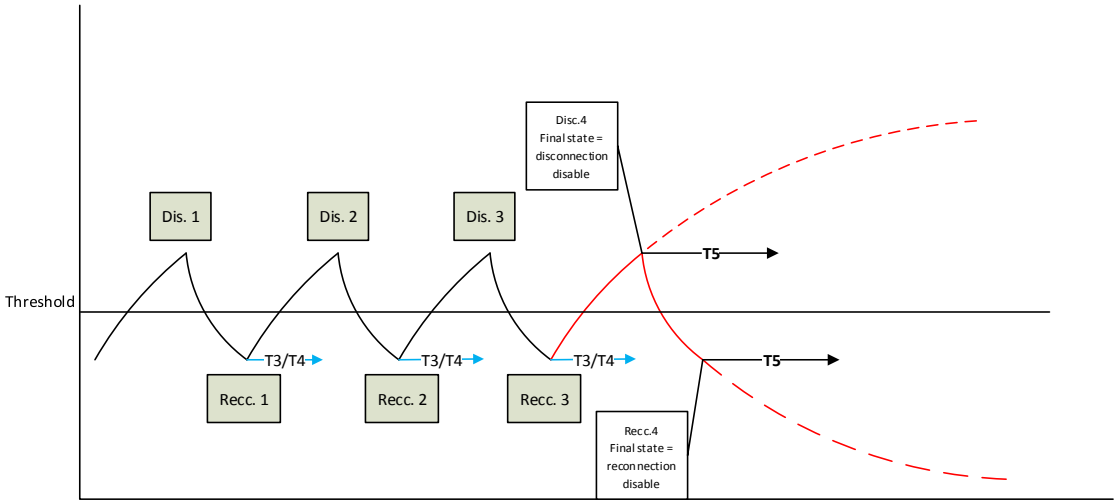


Figure 27: Schedule Control Process

11.3.3 Reclosing Procedure Configuration

All parameters of reclosing procedures in normal and emergency situations can be configured via COSEM object “Reclosing Configuration” (1, 0-0:94.98.28.255) and “Limiter” (71, 0-0:17.0.0.255). The setting parameters are presented in below table.

Table 39: Disconnect Control Schedule Object Parameters

Parameter	Designation	Range	Default	Remark
Reclosing Time Interval (normal/Emg.)	T_1	1 to 3600 sec.	300 sec.	“*min_over_threshold_duration*” attribute of COSEM object “Limiter” (71, 0-0:17.0.0.255)
Reclosing Number (Normal)	n_1	0, 1,…,n_1	3	“Reclosing Configuration” (1, 0 0:94.98.28.255) -

Reclosing Time Interval (normal/Emg.)	T_2	1 to 3600 sec.	300 sec.	"*min_under_threshold_duration*" attribute of COSEM object "Limiter" (71, 0-0:17.0.0.255)
Reclosing Number (Emg.)	n_2	0,1,…,n_2	3	"Reclosing Configuration" (1, 0 0:94.98.28.255) -
Middle Timeout (Normal)	T_3	1 to 1440 min.	60 min.	"Reclosing Configuration" (1, 0 0:94.98.28.255) -
Middle Timeout (Emg.)	T_4	1 to 1440 min.	60 min.	"Reclosing Configuration" (1, 0 0:94.98.28.255) -
End Timeout (normal/Emg.)	T_5	1 to 14400 min.	180 min.	"Reclosing Configuration (0:94.98.28.255)

Note: T_1 are set via attribute "min_over_threshold_duration" of COSEM object "Limiter" (71, 0-0:17.0.0.255)

Note: T_2 are set via attribute "min_under_threshold_duration" of COSEM object "Limiter" (71, 0-0:17.0.0.255)

11.4 Assigning Threshold Values by Schedule

The threshold values for both normal and emergency can be set via setting the attributes 4 and 5 of Limiter COSEM objects respectively. Furthermore, it shall be possible to set these values by schedule. The COSEM object "Limiter Threshold Scheduler" (22, 0-0:94.98.18.255) is intended to handle this feature. This schedule calls scripts 1 and 2 of "Limiter Script Table" (9, 0-0:94.98.25.255) for setting the normal and emergency thresholds respectively.

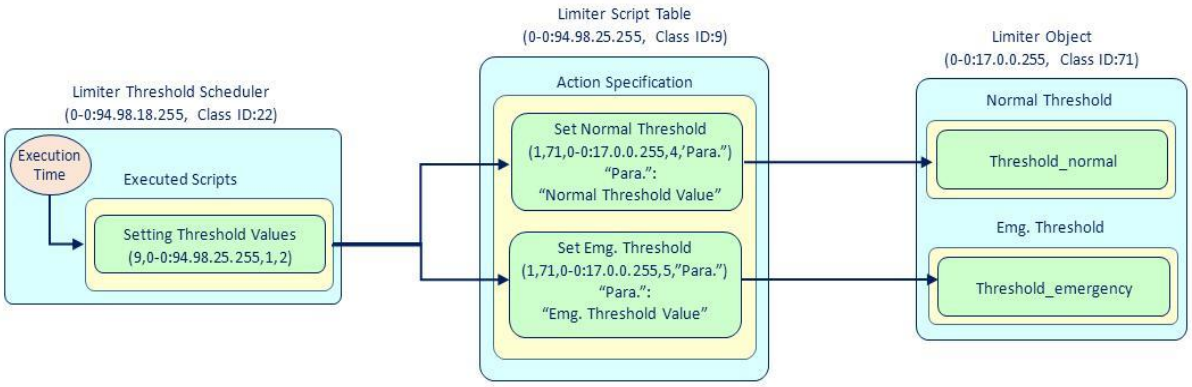


Figure 28: Limiter Script Table

12 Billing Profile

The billing profile is used as monthly billing in FAHAM. In the billing profile the capturing of the data is managed by the combination of a single-action schedule (Class ID 22) and a predefined script table "MDI reset / end of billing period" (Class ID 9). In addition, asynchronous capturing is possible via local or remote triggering. The collected data is stamped with the time when the actual capturing is triggered. The following COSEM objects are involved in billing data collection:

- MDI Reset/End of Billing Period (9, 0-0:10.0.1.255);
- End of Billing Period 1 Scheduler (22, 0-0:15.0.0.255);
- Data of Billing Period 1 (monthly) (7, 0-0:98.1.0.255);
- Disable/Enable Manual Demand Reset (1,0-0:94.98.27.255)

The regular billing intervals are defined by the date and time definitions specified in the execute_time attribute of a single action schedule ("End of Billing Period 1 Scheduler"). When the time of the internal clock reaches the time instance specified in the single action schedule the capture method of the profile is invoked via the corresponding script defined in the "MDI Reset/End of Billing Period" script table (9, 0-0:10.0.1.255). In FAHAM, the default capture time of monthly billing is every first day of month at 00:00.

Note: Provisions shall be provided in central system (HE/MDM) to change the capture time of monthly billing. It should be able to change the capture time during the month by day/minute (specifying any time in any day of month).

Note: Data may be captured asynchronously by external triggering (e.g. by remote invocation of the execute method of the "MDI reset/end of billing period" script or by manual reset). In this case, the registered data is stamped with the time instance of the execution of the triggering.

The default parameters of billing profile are mentioned in relevant COSEM objects. The mandatory parameters are in Table 40.

Table 40: Capture Objects in Billing Profiles

Capture Object Name	Capture Object OBIS Code
Clock	{8,0-0:1.0.0.255,2,0}
Active energy import (+A)	{3, 1-0:1.8.0.255}
Active energy import (+A), Rate 1	{3, 1-0:1.8.1.255}
Active energy import (+A), Rate 2	{3, 1-0:1.8.2.255}
Active energy import (+A), Rate 3	{3, 1-0:1.8.3.255}
Active energy import (+A), Rate 4	{3, 1-0:1.8.4.255}
Active energy export (-A)	{3, 1-0:2.8.0.255}
Active energy export (-A), Rate 1	{3, 1-0:2.8.1.255}
Active energy export (-A), Rate 2	{3, 1-0:2.8.2.255}
Active energy export (-A), Rate 3	{3, 1-0:2.8.3.255}
Active energy export (-A), Rate 4	{3, 1-0:2.8.4.255}
Reactive energy import (+R)	{3,1-0:3.8.0.255}
Reactive energy import (+R), Rate 1	{3,1-0:3.8.1.255}
Reactive energy import (+R),Rate 2	{3,1-0:3.8.2.255}

Capture Object Name	Capture Object OBIS Code
Reactive energy import (+R), Rate 3	{3,1-0:3.8.3.255}
Reactive energy import (+R), Rate 4	{3,1-0:3.8.4.255}
Reactive energy export (-R)	{3,1-0:4.8.0.255}
Reactive energy export (-R), Rate 1	{3,1-0:4.8.1.255}
Reactive energy export (-R), Rate 2	{3,1-0:4.8.2.255}
Reactive energy export (-R), Rate 3	{3,1-0:4.8.3.255}
Reactive energy export (-R), Rate 4	{3,1-0:4.8.4.255}
Reactive energy QI (+Ri)	{3,1-0:5.8.0.255,2,0}
Reactive energy QII (+Rc)	{3,1-0:6.8.0.255,2,0}
Reactive energy QIII (-Ri)	{3,1-0:7.8.0.255,2,0}
Reactive energy QIV (-Rc)	{3,1-0:8.8.0.255,2,0}
Active energy (|+A|+|-A|) Combined total	{3,1-0:15.8.0.255,2,0}
Active energy (|+A|+|-A|) Combined total Rate 1	{3,1-0:15.8.1.255,2,0}
Active energy (|+A|+|-A|) Combined total Rate 2	{3,1-0:15.8.2.255,2,0}
Active energy (|+A|+|-A|) Combined total Rate 3	{3,1-0:15.8.3.255,2,0}
Active energy (|+A|+|-A|) Combined total Rate 4	{3,1-0:15.8.4.255,2,0}
Active energy (|+A|-|-A|) Net total	{3,1-0:16.8.0.255,2,0}
Active energy (|+A|-|-A|) Net total Rate 1	{3,1-0:16.8.1.255,2,0}
Active energy (|+A|-|-A|) Net total Rate 2	{3,1-0:16.8.2.255,2,0}
Active energy (|+A|-|-A|) Net total Rate 3	{3,1-0:16.8.3.255,2,0}
Active energy (|+A|-|-A|) Net total Rate 4	{3,1-0:16.8.4.255,2,0}
Maximum Demand Register 1 - Active energy import (+A)	{4, 1-0:1.6.0.255,2,0} {4, 1-0:1.6.0.255,5,0}
Maximum Demand Register 6 - Active energy export (–A)	{4, 1-0:2.6.0.255,2,0} {4, 1-0:2.6.0.255,5,0}
Maximum Demand Register 11 - Reactive energy import (+R)	{4, 1-0:3.6.0.255,2,0} {4, 1-0:3.6.0.255,5,0}
Maximum Demand Register 16 - Reactive energy export (-R)	{4, 1-0:4.6.0.255,2,0} {4, 1-0:4.6.0.255,5,0}
Maximum Demand Register 31 -Active energy Combined (|+A|+|-A|)	{4, 1-0:15.6.0.255,2,0} {4, 1-0:15.6.0.255,5,0}
Credit amount	{1,0-0:94.98.54.255,2,0}
Duration of violation of Demand	{1,1-0:1.37.0.255,2,0}

12.1 Power Down

This subsection is considered based on section 7.6.1 (Power down) of IDIS.

12.1.1 Power failure across capture periods

The regular billing intervals are defined by the date and time definitions specified in the execute_time attribute of a single action schedule. When the time of the internal clock reaches the time instance specified in the single action schedule the capture method of the profile is invoked via the corresponding script defined in the "MDI reset/end of billing period" script table. In the examples bellow is assumed that the single action schedule is configured to trigger a capturing event every first day of the month at 00:00 (FFFFFF01FF, 00000000). Figure 29 and table 41 show a power down from 1392.02.29 23:25 until 1392.03.01 2:15. The buffer values with the time stamp 1392.03.01 / 00:00:00 contain the register values at the time of the power down (1392.02.29, 23:25).

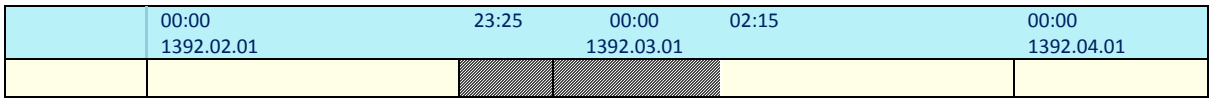


Figure 29: Power failure across billing interval(s)

Table 41: Power failure across billing interval(s)

Date/Time	Register 1	Register 2
1392-02-1 / 00:00:00	2180	115
1392-03-1 / 00:00:00	2201	118
1392-04-1 / 00:00:00	2252	121

12.1.2 Setting Time

12.1.2.1 Advancing the time over the end of the billing interval

figure 30 and table 42 show the effects of a clock advancement from 1392.02.29 23:25 to 1392.03.012:15.

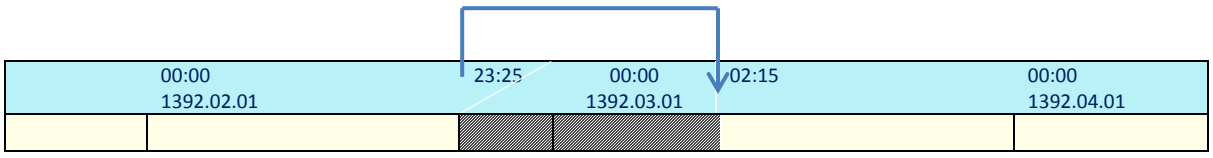


Figure 30: Advancing time over billing interval(s)

Table 42: Advancing time over billing interval(s)

Date/Time	Register 1	Register 2
1392-02-1 / 00:00:00	2180	115
1392-03-1 / 00:00:00	2201	118
1392-04-1 / 00:00:00	2252	121

The buffer values with the time stamp 1392-03-01 / 00:00:00 contain the register values at the time of the clock advancement (1392.02.29, 23:25).

12.1.2.2 Setting the time back over the start of billing interval

Figure 31 and table 43 show the effects of a clock retarding from 1392.03.012:15 to 1392.02.2923:25.

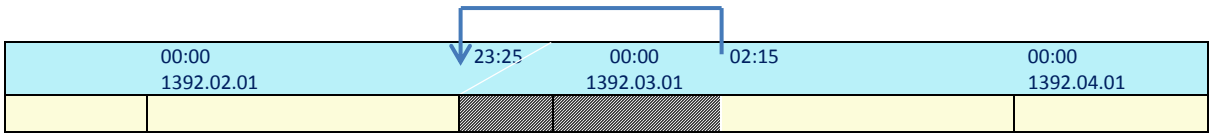


Figure 31: Setting the time back over the start of billing interval

Table 43: Setting the time back over the start of billing interval

Date/Time	Register 1	Register 2
1392-02-1 / 00:00:00	2180	115
1392-03-1 / 00:00:00	2201	118
1392-04-1 / 00:00:00	2252	121
1392-03-1 / 00:00:00	2231	124
1392-04-1 / 00:00:00	2252	143

The buffer values with the first time stamp 1392-03-01 / 00:00:00 contain the register values at thetime1392-03-01 / 00:00:00 before the clock retarding.
The buffer values with the first time stamp 1392-04-01 / 00:00:00 contain the register values at the time of the clock retarding (1392.03.01, 02:15).
The buffer values with the second time stamp 1392-03-01 / 00:00:00 contain the register values at the time 1392-03-01 / 00:00:00 after the clock retarding.
The buffer values with the second time stamp 1392-04-01 / 00:00:00 contain the register values at the time 1392-04-01 / 00:00:00 after the clock retarding.

12.1.2.3 Asynchronous billing period reset/end

Data may be captured asynchronously by explicit triggering. e.g. by pressing the local reset button or by remote invocation of the execute method of the “MDI reset/end of billing period” script. The registered data is stamped with the time instance of the execution of the triggering.

Figure 32 and Table 44 show a billing profile in case when asynchronous triggers are combined with regular triggers

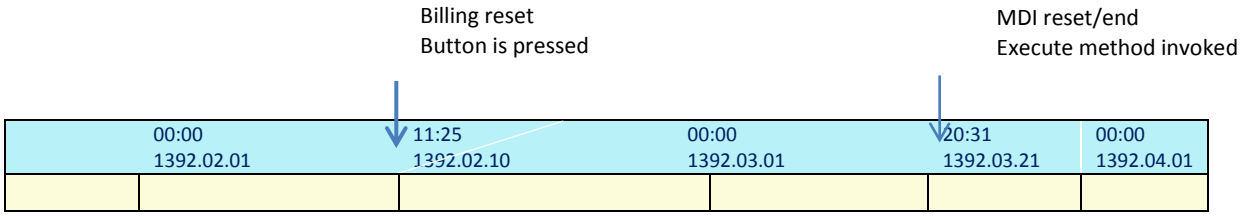


Figure 32: Asynchronous triggering between regular triggering intervals

Table 44: Asynchronous billings

Date/Time	Register 1	Register 2
1392-02-1 / 00:00:00	2180	90
1392-02-10 / 11:25:00	2201	118
1392-03-1 / 00:00:00	2223	121
1392-03-21 / 20:31:00	2238	124
1392-04-1 / 00:00:00	2252	143

12.2 Max Demand Registers

The maximum demand represents the biggest average value happened in each average demand registers. The COSEM extended register class (class ID 4) is used to register the maximum demand values. At the end of each measurement period, the Last Average Value (from Demand Register COSEM objects, Class ID5) is compared with the maximum demand value. If the Last Average Value is bigger, it replaces the value stored in maximum demand register and will be considered as latest maximum demand value.

The following COSEM objects are considered to register the maximum demand values:

- **Maximum Demand Register 1**-Total Active Energy Import (+A) (4, 1-0:1.6.0.255);
- **Maximum Demand Register 2**-Active Energy Import (+A)-Rate1 (4, 1-0:1.6.1.255);
- **Maximum Demand Register 3**-Active Energy Import (+A)-Rate2 (4, 1-0:1.6.2.255);
- **Maximum Demand Register 4**-Active Energy Import (+A)-Rate3 (4, 1-0:1.6.3.255);
- **Maximum Demand Register 5**-Active Energy Import (+A)-Rate4 (4, 1-0:1.6.4.255);
- **Maximum Demand Register 6**-Total Active Energy Export (- A) (4, 1-0:2.6.0.255);
- **Maximum Demand Register 7**-Active Energy Export (- A)-Rate1 (4, 1-0:2.6.1.255);
- **Maximum Demand Register 8**-Active Energy Export (- A)-Rate2 (4, 1-0:2.6.2.255);
- **Maximum Demand Register 9**-Active Energy Export (- A)-Rate3 (4, 1-0:2.6.3.255);
- **Maximum Demand Register 10**-Active Energy Export (- A)-Rate4 (4, 1-0:2.6.4.255);
- **Maximum Demand Register 11**-Total Reactive Energy Import (+R) (4, 1-0:3.6.0.255);
- **Maximum Demand Register 12**-Reactive Energy Import (+R)-Rate1 (4, 1-0:3.6.1.255);
- **Maximum Demand Register 13**-Reactive Energy Import (+R)-Rate2 (4, 1-0:3.6.2.255);
- **Maximum Demand Register 14**-Reactive Energy Import (+R)-Rate3 (4, 1-0:3.6.3.255);

- **Maximum Demand Register 15**-Reactive Energy Import (+R)-Rate4 (4, 1-0:3.6.4.255);
- **Maximum Demand Register 16**-Total Reactive Energy Export (-R) (4, 1-0:4.6.0.255);
- **Maximum Demand Register 17**-Reactive Energy Export (-R)-Rate1 (4, 1-0:4.6.1.255);
- **Maximum Demand Register 18**-Reactive Energy Export (-R)-Rate2 (4, 1-0:4.6.2.255);
- **Maximum Demand Register 19**-Reactive Energy Export (-R)-Rate3 (4, 1-0:4.6.3.255);
- **Maximum Demand Register 20**-Reactive Energy Export (-R)-Rate4 (4, 1-0:4.6.4.255);
- **Maximum Demand Register 31**-Active Energy Combined Total (|+A|+|-A|) (4, 1-0:15.6.0.255);
- **Maximum Demand Register 32** -Active Energy Combined Total (|+A|+|-A|) Rate 1 (4, 1-0:15.6.1.255);
- **Maximum Demand Register 33** -Active Energy Combined Total (|+A|+|-A|) Rate 2 (4, 1-0:15.6.2.255);
- **Maximum Demand Register 34** -Active Energy Combined Total (|+A|+|-A|) Rate 3 (4, 1-0:15.6.3.255);
- **Maximum Demand Register 35** -Active Energy Combined Total (|+A|+|-A|) Rate 4 (4, 1-0:15.6.4.255);
- **Maximum Demand Register 36** -Active Energy Combined Total (|+A|+|-A|) (In Load Profile 2) (4, 1-0:15.54.0.255);
- **Maximum Demand Register 37** -Active Energy +A|(In Load Profile 2) (4, 1-0:1.54.0.255);
- **Maximum Demand Register 38** -Active energy export total (|-A|) (In Load Profile 2) (4, 1-0:2.54.0.255);

As mentioned, the Current Average demand value (from Demand Register COSEM objects, Class ID5) is used as reference to compare with the latest maximum value (that is stored as maximum demand value). The following COSEM objects are considered to provide the current average value of demand.

- **Demand Register 1**-Active Energy Import (+A) (5, 1-0:1.4.0.255);
- **Demand Register 2**-Active Energy Export (-A) (5, 1-0:2.4.0.255);
- **Demand Register 3**-Reactive Energy Import (+R) (5, 1-0:3.4.0.255);
- **Demand Register 4-**Reactive Energy Export (-R) (5, 1-0:4.4.0.255);
- **Demand Register 5**-Active energy Combined total (|+A|+|-A|) (15, 1-0:15.4.0.255);

Note: All maximum demand values are set to "0" at the end of monthly billing period. The Maximum Demand Register 36 (4, 1-0:15.54.0.255) and maximum demand register 37 (4, 1-0:1.54.0.255) are used in Load Profile 2 (as daily billing) and is set to “0” after capturing by Load Profile 2 COSEM object.

13 Clock Synchronization

The time in the electricity meters is synchronized by applying the SET service to the attribute“time” of the “Clock” COSEM object (8, 0-0:1.0.0.255). The meter’s time is regularly synchronized by central system. The “time” attribute in “Clock” COSEM object is a 12 bytes value including the following parameters:

- Year (Two Bytes);
- Month (One Byte);
- Day of Month (One Byte);
- Day of Week (One Byte);
- Hour (One Byte);
- Minute (One Byte);
- Second (One Byte);
- Hundredths of Second (One Byte);
- Deviation (Two Bytes);
- Clock Status (One Byte);

In FAHAM, dates should be based on Persian (Jalali) calendar in all devices and also for exchanging data between all interfaces. In reading time attribute of the clock object, then the “date_time”attribute contains the information on the local time of the meter (after applying UTC and DST deviations by meter). In setting the time attribute of the “Clock” object, the “date_time” field contains the information according to Table 45.

Table 45: Parameters in “date_time” Attribute in Setting Time

Year, Month, Day of Month, Day of Week, Hour, Minute, Second, Hundredths of Seconds	Deviation	Clock Status
Local time based on Persian (Jalali) calendar (after applying UTC and DST deviations)	0x8000 (Not-specified)	0xFF (DST Undefined) 0x80/0x00 (DST Defined)

The local time deviation to UTC (Coordinated Universal Time) is stored in minutes in “time_zone” attribute of “Clock” object. The default value is -210 minutes in FAHAM (IRAN Local Time).

13.1 Clock Time Shift

If during time synchronization, the difference between new time and old time of meter is greater than a predefined value (Clock Time Shift Limit), two events should be logged by meter as follows:

- Clock Adjusted 1 (Event Code: 4);
- Clock Adjusted 2 (Event Code: 5);

These two events should be logged by Standard Event log (7, 0-0:99.98.0.255).The date/time that is stored in the event log is old date/time (before adjusting the clock) for “Clock Adjusted 1” event (event code: 4). Regarding “Clock Adjusted 2” (event code:5), the date/time that is stored in the event log is new date/time (after adjusting the clock).

If the difference between new time and old time of meter is less than a predefined value (Clock Time Shift Limit), no events are logged by meter. In both cases, the time shall be adjusted by meter.

The “Clock Time Shift Limit” value is stored in COSEM object “Clock Time Shift Limit” (3, 1-0:0.9.11.255). This parameter can be configured by central system. The default value is 60 seconds.

13.2 Time Presentation

Any time presentation (on meter’s LCD) shall be based on Jalali (Persian) calendar. The changes (between two calendars) shall be done by meter. The following COSEM objects are intended to store changed time (to Jalali/Persian Calendar) and date values for display readout purposes.

- Local Time (1, 1-0:0.9.1.255);
- Local Date (1, 1-0:0.9.2.255);

14 Firmware Upgrading

This chapter specifies the firmware upgrade procedure in devices (meter and communication module) used in FAHAM. Devices may have several firmwares (image) inside.

In order to ensure the correct reception of the FW (Firmware) when servers (meters) from different vendors are upgraded, the broadcast services shall not be used. Only unicast (as default) and multicast services shall be used in firmware upgrade process. The provision shall be provided in central system to make different groups of devices (meters, and so on) as multicast groups.

All equipment shall be able to store two versions of firmware. The current version that is used and the new version that is intend to be installed. The devices are not allowed to discard any of the stored firmware (current or old versions) until the final confirmation of new firmware has been done and the new version has been installed.

The FU (Firmware Upgrade) is done based on DLMS/COSEM image transfer services and the new firmware will be sent to devices by image transfer object. The firmware upgrade process is done in four main steps as follows:

- Initial Phase;
- Firmware (Image) Transfer;
- Firmware (Image) Check;
- Firmware (Image) Activation;

The COSEM client uses the services provided by the objects listed below to transfer the firmware (image) to devices and fulfill all steps in firmware upgrade process.

- Image transfer (18, 0-0:44.0.0.255);
- Image Transfer Activation Scheduler (22, 0-0:15.0.2.255);
- Image Activation Script (9, 0-0:10.0.107.255);
- Active Firmware Identifier 1 (Meter Application Relevant Firmware) (1, 1-1:0.2.0.255);
- Active Firmware Identifier 2 (GPRS Communication Module Firmware) (1, 1-2:0.2.0.255);
- Active Firmware Signature (1, 1-0:0.2.8.255);
- Active Firmware Signature 1 (1, 1-1:0.2.8.255);
- Active Firmware Signature 2 (1, 1-2:0.2.8.255);

Note: Upgrading any part of firmware of meter shall not stop or affect meter’s metrology.

14.1 Firmware (Image) Structure

The firmware (image) is the information is intended to be transferred to devices in order to perform the firmware upgrade process. The firmware (or firmware image) is divided in smaller elements called "ImageBlock". The size of firmware (image) is called "ImageSize" and the size of image block is named "ImageBlockSize". They are measured in bytes. Figure 33 depicts the firmware (image) construction and its parts (Blocks).

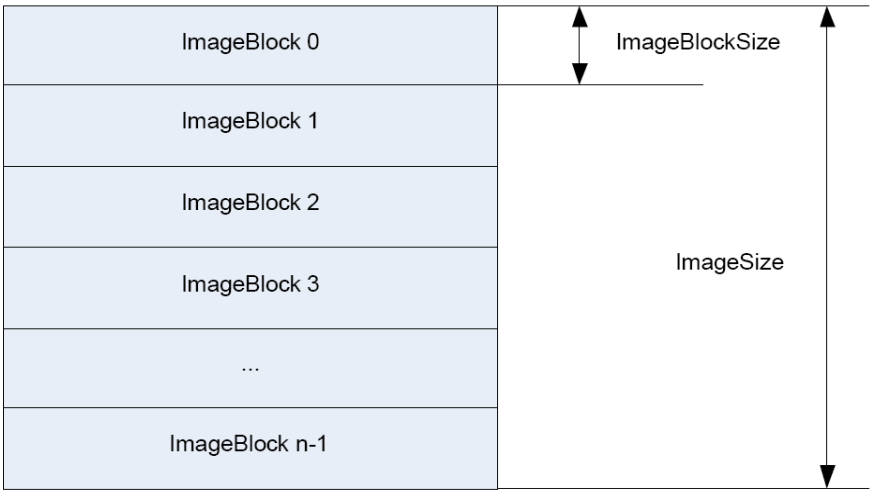


Figure 33: Firmware (Image) Structure

The first step of firmware upgrade (image transfer) process is the specifying of image block size that can be supported by server (meter) as receiver of new firmware. There are two ways to find this value as follows:

- Predefined by Vendor;
- On-system Inquiry;

In first way (Predefined by Vendor), the supplier of firmware specifies the image block size supported by its device and it will be set in central software as firmware upgrade setting value.

In "On-system Inquiry" method, at the beginning of firmware upgrade process (as first step according to DLMS definition), the client (central system) gets the " image_block_size " supported (from the server) to transfer the image blocks in right size. The " image_block_size " supported by each server is held in image_block_size attribute of “Image Transfer” object (18, 0-0:44.0.0.255) and it can be different in different devices (servers) from different vendors or in different models of each vendor.

Note: image_block_size should be at least 512 bytes.

For known devices and to reduce data exchange in firmware upgrade procedure, the image block size supported by each device will be specified by vendor and will be stored in central system as firmware upgrade setting parameters. If the image block size is not specified by vendor, the "On-system Inquiry" mode will be selected by system operator during firmware upgrade process setting stage and consequently the central system reads the "image_block_size" attribute of “Image Transfer” object (18, 0-0:44.0.0.255) of server to find the image block size supported by that device.

14.2 Initial Phase

The initial phase is the first phase of firmware upgrade process. In this phase the information of new firmware (image) is sent to target server(s). This includes the following information:

- Firmware Identifier;
- Firmware Size;

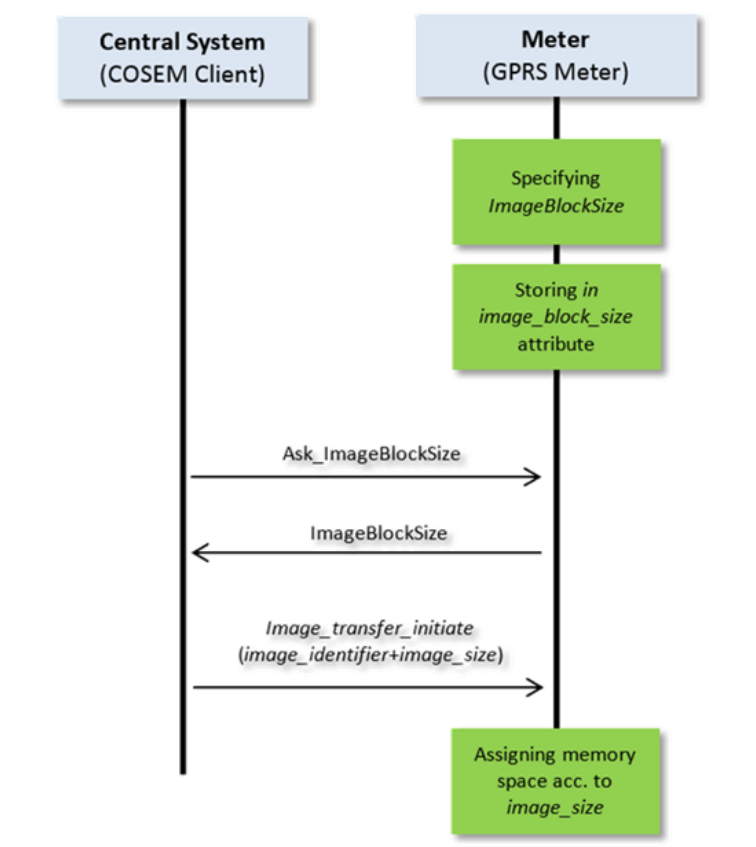


Figure 34: Steps 1 and 2 without data concentrator (GPRS Meter)

After determining the image block size (Predefined or On-system Inquiry), the initiation is performed by invoking the image_transfer_initiate method of COSEM object “Image Transfer” (18, 0-0:44.0.0.255). The method invocation parameter holds the Firmware Identifier (image_identifier) and Firmware Size (image_size) of the Image to be transferred. Figure 34 depicts the steps 1 and 2 of firmware upgrade (according to steps defined by DLMS) in case of "On-system Inquiry" mode.

Note: as mentioned before, step 1 (asking image block size) is optional and in case of specifying of Image Block size (supported by device) by vendor, the first step depicted in Figure 34 (asking for Image Block Size) will not be done.

Note: The image identifier is specified by vendor.

Aftersuccessful initiating, the server assigns the required memory space for new firmware(s) and waits to receive it. Also, the value of image_transfer_status attribute of "Image Transfer" COSEM object is set to "1" to show the successful initiation.

14.3 Image Transfer

After successful initiation, the value of the image_transfer_status attribute of “Image Transfer” object (18, 0-0:44.0.0.255) will be set to "1" (in meter). It means the firmware upgrade process has been successfully initiated and servers (meters) are ready to receive image blocks from client. In this step, the image blocks are transferred to servers sequentially.

The image block transfer is performed by invoking the image_block_transfer method of “Image Transfer” object (18, 0-0:44.0.0.255). There are two parameters in this method as follows:

- Image Block Number (image_block_number);
- Image Block Value (image_block_value);

Each image block will be specified by its number. This will be specified by image_block_number parameter of image_block_transfer method of Image Transfer object (18, 0-0:44.0.0.255). This is a 32 bits number (double long unsigned).

Note: if any communication problems happen during image transfer, the process shall be continued (from the last block that has been sent) automatically as soon as the communication established again.

14.4 Image Check

After successful transferring of new firmware (image), the server (meter) starts checking the received file.

If new firmware (image file) passes successfully all of check, the "Firmware Ready for Activation" event (event code: 17) will be generated and the next step in firmware upgrade process (activation step) can be started. If one of these checks has not been done successfully, an event ("Firmware Verification Failed", event code: 51) will be generated.

14.5 Firmware (Image) Activation

The firmware (image) activation is the last step of firmware upgrade process. The firmware activation will be done at time and date specified by central system. The firmware activation includes three steps as follows:

- Using (Activating) New Firmware;
- Testing New Firmware;
- Discarding Firmware (New or Old);

In the first step, the meter will be rebooted by its new firmware, but old firmware shall be kept until third step. After new firmware activation, it enters the next step (Testing New Firmware).

14.5.1 Firmware Activation Time

The activation time of all firmware is specified by central system. The firmware activation can be done via one of two following ways:

- Immediate Activation;
- Scheduled Activation;

It is handled by Image Transfer Activation Scheduler object (22, 0-0:15.0.2.255). The time and date of firmware activation is specified by execution_time attribute of mentioned object.

If the execution_time attribute is set the valid time (date + time), the Scheduled activation will be used. Otherwise, after verification, firmware will be activated immediately.

The parameters of Image Transfer Activation Scheduler object (0-0:15.0.2.255) are as table 46.

Table 46: Image Transfer Activation Schedule Structure

Parameter Name	Executed Script (Action)	Type	Execution Time	
			Date	Time
Format	Executed_script	type	date	time
Type	Array	enum	octed-string (size(5))	octed-string (size(4))
Value	1, 0-0:10.0.107.255 (Image Activation Script)	1	byte 04: Year(high byte) byte 03: Year (low byte) byte 02: Month byte 01: Day of month byte 00: Day of week	byte 03: Hour byte 02: Minute byte 01: Second byte 00: Hundredths

The central system specifies the data and time according the structure mentioned in above table.

Note: All of received firmware's (images) will be activated at the time specified by this object. The list of images ready for activation are stored in "image_to_activate_info" attribute of "Image Transfer" COSEM object (18, 0-0:44-0-0-255).

Note: If the firmware transfer process is not finished by the time specified in schedule as activation time, the firmware shall be activated as soon as after finishing the firmware transfer.

14.5.2 Firmware (Image) Activation Process

Three COSEM objects are involved in firmware (image) activation process. They are as follows:

- Image Transfer Activation Scheduler (22, 0-0:15.0.2.255);
- Image Activation Scripts (9, 0-0:10.0.107.255);
- Image Transfer (18, 0-0:44.0.0.255);

Figure 35 shows the relationship between mentioned COSEM objects to handle firmware activation process.

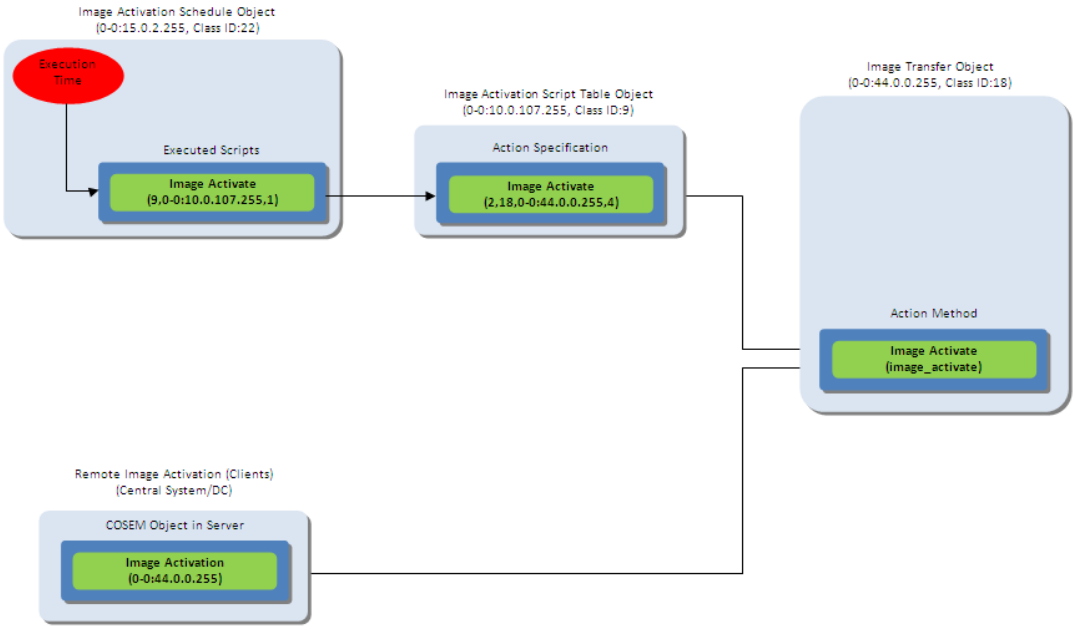


Figure 35: Image Activation Process

As indicated in Figure 35, the main trigger of new firmware (image) activation is the time (and date) specified in Image (Transfer) Activation Schedule object.

The provisions are provided to activate image by central system in on demand fashion. It will be done by invoking image activate method (image_activate) of Image Transfer object.

After successful activation of new firmware, the value of image_transfer_status attribute of COSEM object Image Transfer will be set to "6" to show that the new firmware is successfully activated. After successful activation of new firmware, an event (Firmware Activated, event code: 18) will generated by server. If the meter can't activate the new firmware, the value of image_transfer_status attribute of COSEM object Image Transfer will be set to "7" and device (meter) discards the new firmware and reboots again with old firmware.

Note: If power-off situation happens during firmware activation, the meter shall reboots again with old firmware, but the new firmware shall not be discarded. In this case, meter shall continue firmware upgrade again.

14.6 Active Firmware Identification

Each firmware is specified by a unique number called Firmware (Image) Identification. This is six bytes octet-string value. The identification of all images (firmware) used in devices stored in the following COSEM objects.

- Active Firmware Identifier (Metrology Relevant Firmware) (1, 1-0:0.2.0.255);
- Active Firmware Identifier 1(Meter Application Relevant Firmware) (1, 1-1:0.2.0.255);
- Active Firmware Identifier 2(GPRS Communication Module Firmware) (1, 1-2:0.2.0.255);

Each COSEM object keeps the list of images (firmware) identification in each group of images (firmware). Each object includes an array with at least 10 elements. It means, each object can store

10 identifications. COSEM client (Central System) can know about the version of active images (firmware) in each device by reading the value of mentioned object.

15 Event Management

Each device in system should be able to log the events with the date, time and required parameters in which they occurred. The events will be processed by Central System (or Legacy Systems). Meters shall report all events on request of the Concentrator/Central System (Pull mode). The Alarms (important events) shall be sent automatically to the Concentrator/Central System (Push mode).

Meter shall log all activities that modify the device's statement/configuration/setting or any attempt to do it as a dedicated event. Each logged event shall contain at least the following information:

- Timestamp of the logged event;
- Activity type of the logged event (event code);
- Parameters of the logged event (Where specified);
- Equipment identifier (for the equipment that raised the Error/Alarm);

The events are divided into two main groups as follows:

- Normal Events (Status);
- Alarm;

The Normal Events are collected (by Data Concentrator or Central System) as "Pull" mode but the alarms are sent to Data Concentrator (or Central System) via "Push" mechanism. The Alarms are most important events and the central system shall be informed about them as soon as possible that they happened.

15.1 Event Management Objects

The following COSEM objects are involved in event management process.

- Error register (1,0-0:97.97.0.255)[1];
- Alarm Register 1 (1, 0-0:97.98.0.255);
- Alarm Register 2 (1, 0-0:97.98.1.255);
- Alarm Descriptor 1 (1, 0-0:97.98.20.255);
- Alarm Descriptor 2 (1, 0-0:97.98.21.255);
- Alarm Filter 1 (1, 0-0:97.98.10.255);
- Alarm Filter 2 (1, 0-0:97.98.11.255);
- Alarm Monitor 1 (21, 0-0:16.1.0.255);
- Alarm Monitor 2 (21, 0-0:16.1.1.255);
- Push Script Table (9, 0-0:10.0.108.255);
- Push Setup-Alarm (40, 0-4:25.9.0.255);
- Standard Events Log (7, 0-0:99.98.0.255);
- Fraud Detection Events Log (7, 0-0:99.98.1.255);
- Disconnect Control Events Log (7, 0-0:99.98.2.255);
- Power Quality Event Log (7, 0-0:99.98.4.255);
- Communication Events Log (7, 0-0:99.98.5.255);
- Power Failure Events Log (7, 1-0:99.97.0.255);

[1]The bit map of the Error Register is the same as the Alarm Register 1.

15.2 Event Groups and Event Log Objects

All devices generate events. There are different types of events. They are mentioned in event list document. The events are divided into Six main groups as follows:

- Standard Events;
- Fraud Detection Events;
- Disconnect Control Events;
- Power Quality Events;
- Communication Events;
- Power Failure Events;

Each event has a unique event code (as event ID). Upon occurrence of an event, its code will be put in a dedicated COSEM object from interface class 1 (Class ID: 1). There is no storage capability in this interface class (Class 1). This COSEM object always keeps the last event that is happened and the new event overwrites. Their objects are as follows:

- Event Object -Standard Event Log (1,0-0:96.11.0.255)
- Event Object –Fraud Detection Log (1,0-0:96.11.1.255)
- Event Object –Disconnect control Log (1,0-0:96.11.2.255)
- Event Object -Power Quality Log (1, 0-0:96.11.4.255)
- Event Object -Communication Log (1, 0-0:96.11.5.255)
- Event Object -Power Failure Log (1,0-0:96.11.6.255)

Another dedicated COSEM object from class7 (Class ID: 7) is considered for each group of event to store the events happened in relevant group. These types of COSEM objects (Interface Class 7) are able to capture, store, sort and provide access to data groups or data series, called capture objects. A dedicated COSEM objects based on Class 7 of DLMS has been considered for each event log. These are as follows:

- Standard Events Log (7, 0-0:99.98.0.255);
- Fraud Detection Events Log (7, 0-0:99.98.1.255);
- Disconnect Control Events Log (7, 0-0:99.98.2.255);
- Power Quality Log (7, 0-0:99.98.4.255);
- Communication Events Log (7, 0-0:99.98.5.255);
- Power Failure Event Log (7, 1-0:99.97.0.255);

Note: It is considered Object (1, 0-0:94.98.24.255) as fraud lock time. It means the same type fraud event will not be recorded repeatedly if the duration time of occurrence is less than fraud lock time duration.

15.3 Event Log Object Structure

The Event Log objects use Profile Generic class (Class ID 7) of DLMS to capture and store the event. All event logs have same structure.

The event collector COSEM object (from Class ID 7) has a buffer to store the captured data (event code and all supplementary information such as time and so on). Each buffer (in fact, each event collector COSEM object from class ID 7) can be considered as a table in memory. Figure 36 shows the structure of this table and its components definition.

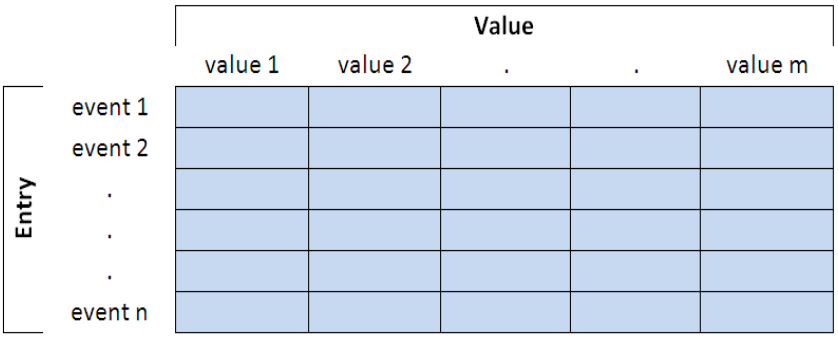


Figure 36: Event Buffer Structure

Each row of buffer belongs to one event. Different values can be defined for each event such as event code, time, duration (e.g. in long power failure event), magnitude (e.g. in over voltage/under voltage events) and so on. The values related to each event are specified as columns.

In each event log, different values are stored in case of event (as “Capture Objects”). The values are considered as “Event Parameters” and are collected by central system to analysis the event. These values (Event Parameters) are captured form some other COSEM objects. The values of each event log (Event Parameters) and the source COSEM objects are presented in below table:

Table 47: Event Log COSEM Objects and Event Parameters

Event Log	Event Parameter	
	Parameter Name	**Source COSEM (Capture) Object**
Standard Events Log (7, 0-0:99.98.0.255)	Clock (Timestamp)	{8,0-0:1.0.0.255,2,0}
	Event Code	{1,0-0:96.11.0.255,2,0}
	Event Parameter (Sub-events)	{1,0-0:96.11.10.255,2,0}
Fraud Detection Events Log (7, 0-0:99.98.1.255)	Clock (Timestamp)	{8,0-0:1.0.0.255,2,0}
	Event Code	{1,0-0:96.11.1.255,2,0}
Communication Events Log (7, 0-0:99.98.5.255)	Clock (Timestamp)	{8,0-0:1.0.0.255,2,0}
	Event Code	{1,0-0:96.11.5.255,2,0}
Disconnect Control Events Log (7, 0-0:99.98.2.255)	Clock (Timestamp)	{8,0-0:1.0.0.255,2,0}
	Event Code	{1, 0-0:96.11.2.255, 2, 0}
	Active Threshold Value of Limiter	{71, 0-0:17.0.0.255, 3, 0}

Event Log	Event Parameter	
	Parameter Name	**Source COSEM (Capture) Object**
Power Quality Log (7, 0-0:99.98.4.255)	Clock (Timestamp)	{8,0-0:1.0.0.255,2,0}
	Event Code	{1,0-0:96.11.4.255,2,0}
	Magnitude of Power Quality Event	{1,0-0:96.11.11.255,2,0}
	Duration/Number* of Power Quality Event	{1,0-0:96.11.12.255,2,0}
Power Failure Event Log (7,1-0:99.97.0.255)	Clock (Timestamp)	{8,0-0:1.0.0.255,2,0}
	Event Code	{1,0-0:96.11.6.255,2,0}
	Duration of Long Power Failure in Any Phase	{1,0-0:96.7.19.255,2,0}

*Number at the start of event and duration at the end of event is recorded

15.3.1 Sort Method

In FAHAM, the FIFO method is used.

15.3.2 Capture Method

The capture objects (attributes of other COSEM objects that provide values) can be collected in two different ways as follows:

- **synchronously**;
- **Asynchronously** (Triggered externally);

All event logs in 48 are captured asynchronously.

15.3.3 Event Parameters (Sub-events)

In some cases, an event can be originated from different sources in meter. To distinguish between different event sources and to specify the exact source of event, the sub-events are considered for some standard events. The COSEM object “Events Parameter, Standard Event Log (1, 0-0:96.11.10.255) is considered to store the sub-events in cases of occurrence of some of standard events. The standard events and sub-events related to them are presented in following table.

Table 48: Sub-events in standard Events

Standard Event	Sub-events
Event 14 (Non Volatile Memory Error)	1 - Source Metrology 2 - Source Application
Event 19 (Passive time of use programmed)	1 – Calendar name 2 – Calendar season table 3 – Calendar week table 4 – Calendar day table
Event 47 (Parameter Changed)	1 – Demand register 1,2,3,4,7 period 2 - Demand register 1,2,3,4,7 number of period 3 - Limiter Threshold Normal 4 - Limiter Threshold Emergency 5 – LP1 Capture Period 6 - LP2 Capture Period 7 - LP Average Capture Period 8 - LP Max Capture Period 9 - LP Min Capture Period 10 - LP Harmonics Capture Period 11 – Secret change 12 – Security policy changed (meter) 15 – Transformer ratio- current numerator changed 16 – Transformer ratio- voltage numerator changed 17 – Transformer ratio- current denominator changed 18 – Transformer ratio- voltage denominator changed 19- Limiter action activated (Attr. 11, IC 71, changed to any action) 20- Limiter action deactivated (Attr. 11, IC 71, changed to any action) 21- Minimum Time Under Threshold 22- Minimum Time Over Threshold 23- Time Threshold for Under Voltage Detection 24- Time Threshold for Over Voltage Detection 25- Threshold for Under Voltage Detection 26- Threshold for Over Voltage Detection 27- Time Threshold for Missing Voltage 28- Threshold for Missing Voltage 29- Time threshold for long power failure 87- Credit Rates Changed 88- Credit Activated 89- Credit Deactivated
Event 48 (Key(s) Changed)	1 – Authentication Key for meter change 2 – Encryption Unicast key for meter change 3 – Encryption Broadcast key for meter change 6 – Master Key Change 7- Authentication Key for Local Port 8- Encryption Unicast Key for Local Port
Event 254 (Load profile cleared)	1 – Monthly 2 – LP1 (hourly) 3 – LP2 (daily) 4 - Supervision Average 5 - Supervision Minimum 6 - Supervision Maximum 7 –Harmonics Profile

15.3.3.1 Access to Stored Values

The stored values of the profile can be retrieved by applying the appropriate xDLMS services to the attribute “buffer” of relevant profile COSEM object. It is possible to read either the entire profile buffer or extract a portion of buffer by using selective access facility (by range and/or by entry) as defined in DLMS. In FAHAM support of access by range is mandatory. The meter should support a selection of columns to be retrieved. In other words, the array of “selected values“ can be both empty or filled by a selection of capture objects.

In Range Based Collection, the values can be collected according to value (or a range of values) of parameters in buffer table.

In FAHAM, the default method is Range Based Collection based on timestamp. This is mandatory method. The Entry-based Collection is optional.

15.3.3.2 Buffer Reading

Reading of buffer can be done in two methods as follows:

- Normal Reading;
- Compressed Reading;

In “Normal Reading”, all buffer entries within the “From/To” range (Time-based selective access by Range) including the values at the boundaries of range, will be returned to DLMS client (central system, data concentrator or local operator).

In Compressed Reading, the compressed method introduced in IDIS Package 2 (section 7.5.6.2) shall be used. The Compressed Reading is mandatory (default method) in FAHAM. Meter shall support both compressed and normal reading.

15.3.4 Unread_Log_Files_Status_Register

This status register (1, 0-0:94.98.26.255) is two bytes register. Each bit in this register is related to a family of events. If any event happens in each family, the corresponding bit in "Unread_Log_Files_Status_Register" will be set to “1” and if the related log file buffer is read this bit will be cleared automatically. Figure 37 shows structure of this register.

Byte	Bit	Bit Description
1	0	Standard Events
	1	Security (Fraud) Events
	2	Disconnect Control Events
	3	Power Quality Event
	4	Comm. Events
	5	Power Failure Events
	6	
	7	
2	0	
	1	

Byte	Bit	Bit Description
	2	
	3	Reserved
	4	Reserved
	5	Reserved
	6	Reserved
	7	Reserved

Figure 37: Unread_Log_Files_Status_Register

This status register is kept by COSEM object "Unread_Log_Files_Status_Register". During event collection process (by Central system), this COSEM object can be read to find which new event (s) happened in which event group. Then the group event log will be checked to specify the event.

15.4 Alarm Handling

Some of the critical events are considered as Alarms. The Alarms are sent to central system by push mode. The Data Notification Service of DLMS is used to send the Alarms to central system. The Alarm sending process is depicted in figure 38.

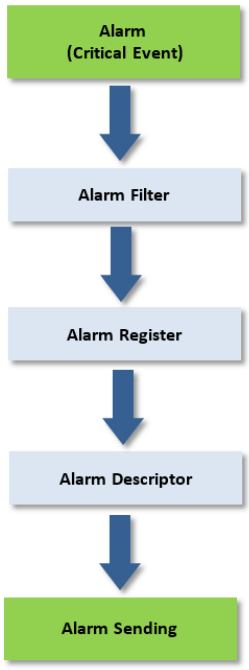


Figure 38: Alarm Handling Process

As has been shown in figure 38, the different parts are involved in alarm handling process. These parts are as follows:

- Alarm Filtering;
- Alarm Register;
- Alarm Descriptor:
- Reporting (sending) Alarm;

The detail of each part is presented in the following sections.

15.4.1 Alarm Register

Alarm Register is intended to log the occurrence of alarms. This is a four bytes register. Each bit in alarm register represents an alarm or a group of alarm. If any alarm occurs, the corresponding flag in alarm register is set and an alarm is then raised via communication channel. All alarm flags in the alarm register remain active until the alarm registers are cleared. The value in the Alarm Registers is a summary of all active and inactive alarms at that time.

all bits shall be able to reset externally by the client by executing a SET =0 service to the Alarm Registers attribute as long as the "cause of the alarm" is not repeated, the corresponding bit will not be set to 1, again. Bit1 of Alarm Registers (battery replace) may be internally reset if the “cause of the alarm” has disappeared (if the battery has been exchanged).

Note: Error register bit map is same as Alarm register1, however, if the "cause of the alarm" disappears, the corresponding bit will be internally reset as well.

There are two Alarm Registers in FAHAM as “Alarm Register 1” and “Alarm Register 2” as mandatory. More Alarm Register can be considered (as optional) in special cases to push more events to central system as Alarm. Table 49 and table 50 show the bit assignment of Alarm Register 1 and 2 respectively.

Table 49: Alarm Register 1, Bit Assignment

Bit	Alarm Description	Triggering Event(s)
0	Clock Invalid	06
1	Battery Replace	07
2	Reserved	-
3	Reserved	-
4	Reserved	-
5	Reserved	-
6	Reserved	-
7	Reserved	-
8	Program Memory Error	12
9	RAM Error	13
10	NV Memory Error	14
11	Measurement System Error	16
12	Watchdog Error	15
13	Fraud Attempt	40, 42, 44, 46, 49, 50,200,201,202
14	SIM Card Ok	143
15	Reserved	-

Table 50: Alarm Register 2, Bit Assignment

Bit	Alarm Description	Triggering Event(s)
0	Power Down	01
1	Power Up	02
2	Voltage Missing Phase L1	82
3	Voltage Missing Phase L2	83
4	Voltage Missing Phase L3	84
5	Voltage Normal Phase L1	85
6	Voltage Normal Phase L2	86
7	Voltage Normal Phase L3	87
8	Missing Neutral	89
9	Phase Asymmetry	90
10	Current Reversal	91
11	Wrong Phase Sequence	88
12	Unexpected Consumption	52
13	Key Exchanged	48
14	Bad Voltage Quality L1	92
15	Bad Voltage Quality L2	93
16	Bad Voltage Quality L3	94
17	External Alert	20
18	Local Communication Attempt	158
19	Auxiliary power Connected	21
20	Auxiliary power Disconnected	22
21	Firmware ready for activation	17
22	Reserved	-
23	Limiter threshold exceed	65
24	Limiter threshold ok	66
25	Relay Connected	61 237,239,242,244,246
26	Relay Disconnected	60, 236,238, 240,241,243,245
27..30	Reserved	-
31	Disconnect/Reconnect Failure	68

Alarm Registers 1 and 2 are presented by following COSEM objects from Class 1:

- Alarm Register 1 (1, 0-0:97.98.0.255);
- Alarm Register 2 (1, 0-0:97.98.1.255);

The “value” attribute of these two COSEM objects keep the four bytes value of alarm registers.

In order to re-enable the alarm reporting process the HES must reset the reported bits in the Alarm Register. This can only be done by setting all the bits of the Alarm Registers to 0 using the SET service. Prior to this action the HES must read the latest value of the Alarm Register.
Note: in case of any fraud (security) events, the tamper sign shall be shown on LCD. Removing the tamper sign (from meter’s LCD) can be done by resetting the Alarm Register 1.
Note: Only battery replace alarm (Bit 1 in alarm register 1) should be rest by meter, others alarms will be rest by HES.

15.4.2 Alarm Descriptor

The Alarm Descriptors have exactly the same structure as the Alarm Registers. Whenever a bit in the Alarm Registers changes from 0 to 1, then the corresponding bit of the Alarm Descriptors is set to 1. There are two alarm descriptors in FAHAM as Alarm Descriptor 1 and 2 related to Alarm Register 1 and 2 respectively. Resetting the Alarm Registers does not affect the Alarm Descriptors. The set bits of the Alarm Descriptor scan be reset by DLMS Client (Head-end).
The following COSEM objects are considered to store the Alarm Descriptors values:

- Alarm Descriptor 1 (1, 0-0:97.98.20.255);
- Alarm Descriptor 2 (1, 0-0:97.98.21.255);

If any alarm happens, the corresponding bit in Alarm Register and consequently in Alarm Descriptor will be set to 1. In this case, the Alarm Descriptor (the "value" attribute of above mentioned COSEM objects) is sent to central system by using Data-Notification service of DLMS.
In order to acknowledge the reception of the Alarm, the Head-end system has to reset the Alarm Descriptors by applying the SET=0 service at bits set to 1 on Alarm Descriptors value. Upon reception of this SET service, the meter clears the corresponding bits in the Alarm Descriptors.
The central system is informed about the alarm by data notification. If more details about the alarm are needed, the central system can read the relevant event log (Class 7) by invoking "GET" service and reading the buffer value.

step	Alarm Register (AR)	Alarm Descriptor (AD)	Meter→ HES communication	Meter ← HES communication
0	0000...	0000...		
1	1000...	1000...	Data-Notification (AD: =1000…) →	
2	0000...	0000...		← SET Request (AD:=0) ← SET Request (AR:=0)
3				If more details about the alarm are needed, the central system can read the relevant event log (Class 7) by invoking "GET" service and reading the buffer value.
4	1000...	1000...	Data-Notification (AD: =1000…) →	
5	1100...	1100...	Data-Notification (AD: =1100…) →	
6	0000...	0000...		← SET Request (AD:=0) ← SET Request (AR:=0)
7				If more details about the alarm are needed, the central system can read the relevant event log (Class 7) by invoking "GET" service and reading the buffer value.

Figure 39: Abstract examples

15.4.3 Alarm Filter

In some cases, there is no need to send some of the defined alarms to central system. To mask out unwanted alarms, the Alarm Filters are considered. There are two alarm filters as Alarm Filter 1 and 2 to mask the Alarm Registers 1 and 2 respectively. The Alarm Filters have exactly the same structure as the Alarm Registers. To mask out unwanted alarms, the corresponding bits in Alarm Filters should be set to "0". The Alarm Filters are realized via following COSEM objects:

- Alarm Filter 1 (1, 0-0:97.98.10.255);
- Alarm Filter 2 (1, 0-0:97.98.11.255);

The provisions shall be provided in central system to configure the Alarm Filters remotely.

15.4.4 Sending Alarm

The last part of Alarm Handling process is "Alarm Sending/Reporting". The Data Notification service of DLMS (via Class ID 40) is used to send Alarms. The Data Notification service of COSEM is unsolicited, non-client/server data communication. In case of GPRS, if an Alarm happens, first, the GPRS connection shall be established (if the always-on mode is not used).

The alarm sending process is done via three COSEM objects from COSEM classes 21, 9 and 40. Figure 40 depicts the alarm sending process.

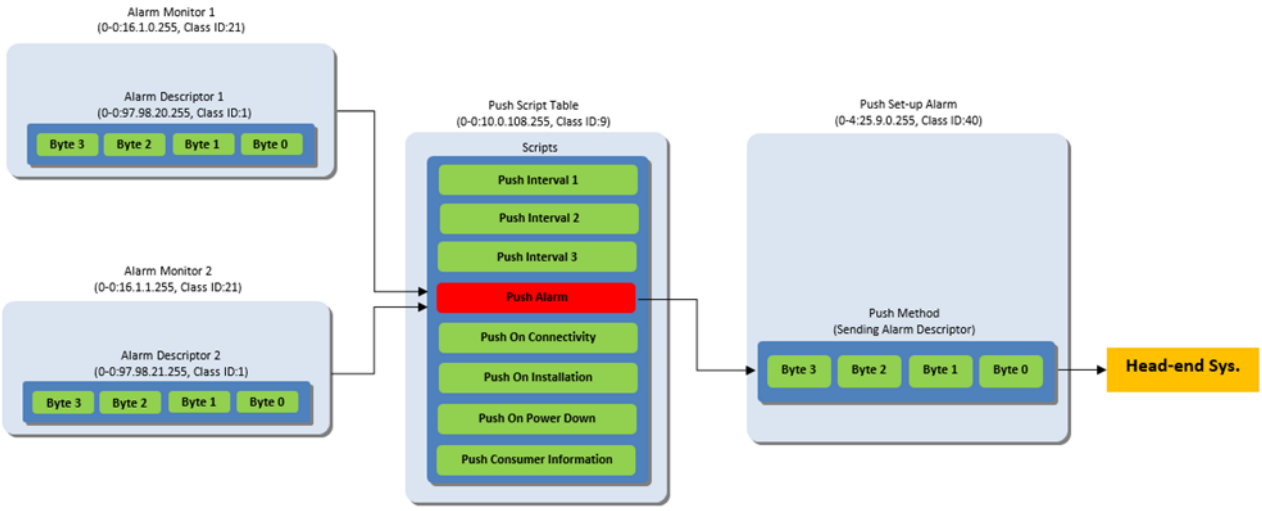


Figure 40: Alarm Sending Process

As has been shown in figure 40, the COSEM objects "Alarm Monitor 1" (21, 0-0:16.1.0.255) and "Alarm Monitor 2" (21, 0-0:16.1.1.255) have been used to monitor the content of Alarm Descriptors 1 and 2 respectively. In FAHAM, the Alarm Monitor Threshold value is set to zero. Therefore, the Alarm Monitor action is invoked when any of the bits in the Alarm Descriptors value changes from 0 to 1.

Upon occurrence of alarm in device, the Alarm Monitor COSEM objects call fourth script in "Push Script Table" object (9, 0-0:10.0.108.255) and the called script invokes the "Push" method of "Push Setup-Alarm" object (40, 0-4:25.9.0.255). The "Push Setup-Alarm" object sends the Alarm Descriptor value HES (or Data Concentrator in PLC meters).

The following COSEM objects are involved in alarm sending process:

- Alarm Monitor 1 (21, 0-0:16.1.0.255);
- Alarm Monitor 2 (21, 0-0:16.1.1.255);
- Push Script Table (9, 0-0:10.0.108.255);
- Push Setup Alarm (40, 0-4:25.9.0.255);

16 GPRS Connection

The COSEM TCP-UDP/IP based communication is used in WAN level of AMI system. The WAN level is intended to provide communication backbone between Central System (CS) and the followings devices in system:

- Data Concentrators (DC);
- GPRS Connected Meters (Meters that are connected to CS directly, not through DC);

The COSEM TCP-UDP/IP based communication profile includes the protocol layers as follows:

- COSEM Application Layer;
- COSEM TCP-UDP Wrapper Layer;
- TCP/UDP Transport Layer;
- Internet Protocol (IPv4) Network Layer;
- IPv4 Supporting Data Link Layer;
- Physical Layer;

Figure 41 and Figure 42 depict the architecture of COSEM TCP-UDP/IP based communication profiles in both COSEM client (Central system) and COSEM server (meter and data concentrator) sides respectively.

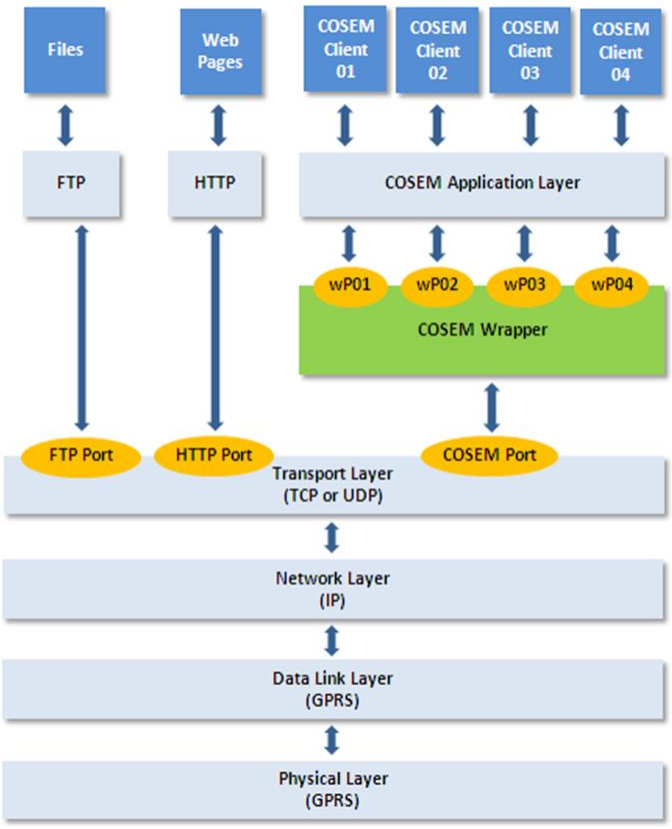


Figure 41: COSEM TCP-UDP/IP Based Communication Structure (COSEM Client Side)

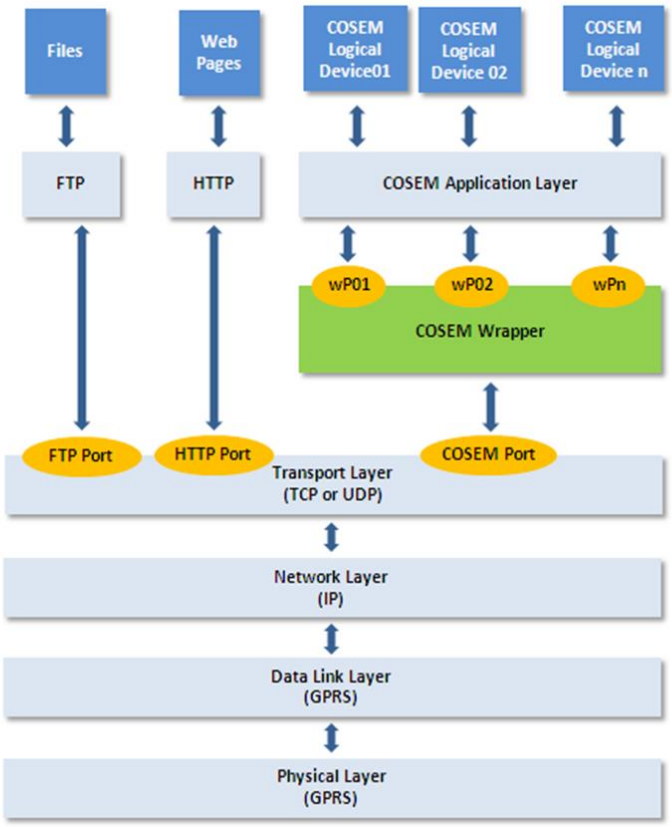


Figure 42: COSEM TCP-UDP/IP Based Communication Structure (COSEM Server Side)

COSEM application layer (and COSEM Clients/Logical Device) uses the services of TCP or UDP Transport layers via COSEM Wrapper sub-layer. The Transport layer (TCP or UDP) and COSEM wrapper together is called COSEM Transport layer. In FAHAM, the meter should support both TCP and UDP transport layer.

16.1 Identification and Addressing

In COSEM TCP-UDP/IP based network (in WAN level), all COSEM physical devices are identified in system by their network IP address. This is an address in network layer of each device. There are three types IP addresses in each device in network for different addressing purpose. They are as follows:

- Broadcast IP Address;
- Multicast IP Address;
- Device Unique IP Address;

16.1.1 Broadcast IP Address

The Broadcast address is an address at which all devices connected to network are enabled to receive datagrams. A message sent to a broadcast address is typically received by all network-attached hosts. This is an all-ones rest field IP address and can be defined in each defined network.

16.1.2 Multicast IP Address

The Multicast address is an address for a group of devices in network, that are available to process datagrams or frames intended to be multicast for a designated service. The several groups can be defined in system according to different requirements (such as devices from different vendors that can be divided into different groups with different multicasting IP address) and a multicast IP address will be assigned to each group. Provisions shall be provided in central system to define groups of devices. The Multicast IP address of each device will be specified by Central System by writing in “multicast_IP_address” attribute of COSEM object "IPv4 Setup" (42, 0-0:25.1.0.255).

16.1.3 Device Unique IP Address

The Device Unique IP address assigned to device in network. The meter should support both of the static and dynamic IP address types.

16.1.4 Applications Identification

As can be seen in figure 41 and figure 42, different Applications can be used in a physical device (such as FTP, HTTP, COSEM Clients or COSEM Logical Devices). To distinguish between different Applications in each physical device, an additional addressing is needed inside the device. Both TCP and UDP provide this addressing capability at the Transport layer. This is called Port. As depicted figure 41 and figure 42, different Ports can be defined in upper side of transport layer to distinguish between different Applications of physical devices.

The transport layer (TCP or UDP) adds the source and destination Port number to data from upper layer and use it in receiving side to specify the source application in receiver. The Port number is a 2 bytes value.

16.1.5 COSEM Clients/Logical Devices Identification

The Application Layer (AL) is listening only on one TCP (or UDP) port for data exchanging. On the other hand, a single physical device can have several COSEM Clients (in COSEM Client Side) or various COSEM Logical Devices (in COSEM Server Side) inside its COSEM application only. So additional addressing capability is needed inside the COSEM application. This requirement is provided by a new sub-layer called COSEM Wrapper. The COSEM Wrapper provides additional addressing inside COSEM Application layer. This is called wPort. Same as Port definition in upper side of transport layer, a dedicated wPort is assigned to each COSEM Client (in COSEM Client side) and each COSEM Logical Device (in COSEM Server side).

The COSEM Wrapper sub-layer adds a header to Application layer's data (DLMS APDU) to provide addressing feature (wPort number) inside COSEM Application layer. Figure 43 shows the details of COSEM Wrapper header.

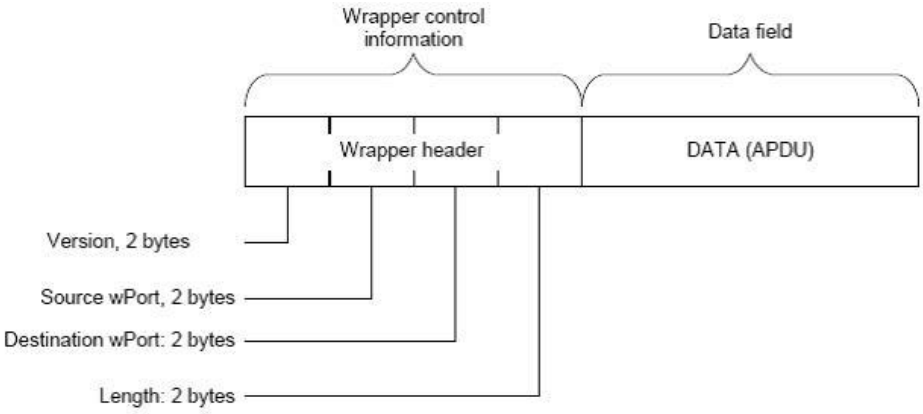


Figure 43: COSEM Wrapper Header Details

As has been shown in figure 43, the COSEM Wrapper header includes the wPort number of COSEM Application (Client or Logical Device) in source and destination (COSEM Client or COSEM Server).

In FAHAM, Four COSEM clients (Public, Management, Reading and Pre-established) and one COSEM logical device (Management) have been defined. The wPort number of COSEM clients in this system are presented in table 51.

Table 51: wPort Number of COSEM Applications

Name	COSEM Application Location (Side)	COSEM Application Type	eWport Number
Public Client	Client (CS)	Client	016
Management Client	Client (CS)	Client	001
Pre-established Client	Client (CS)	Client	102
Reading Client	Client (CS)	Client	002
Management Logical Device	Server (DC or Meter)	Logical Device	001

16.2 Communication Configuration Information

To establish communication and exchange data between parties (COSEM Client and Server), all layers shall be configured. In this section, the parameters to configure each layer are presented. The following COSEM objects are involved in communication configuration process.

- Physical Layer Configuration:
  - GPRS Modem Setup (45, 0-0:25.4.0.255);
- Data Link Layer Configuration:
  - MAC Address Setup (43, 0-0:25.2.0.255);
  - PPP setup (44, 0-0:25.3.0.255)
- Network Layer Configuration:
  - IPv4 Setup (42, 0-0:25.1.0.255);
  - IPv6 Setup (48, 0-0:25.7.0.255)

- Transport Layer Configuration:
  - TCP-UDP Setup (41, 0-0:25.0.0.255);

16.2.1 Physical Layer Configuration (GPRS Modem Setup)

The COSEM object GPRS Modem Setup (45, 0-0:25.4.0.255) is considered to configure GPRS modem. The following parameters are included in this COSEM object:

- APN;
- PIN Code;
- Quality of Service;

Provisions shall be provided in central software to configure these values. The initial values of these parameters will be set during commissioning of system (first installation).

- Each GPRS module has a unique "IMEI" that is hold by (1, 0-0:94.98.22.255).

16.2.2 Data Link Layer Configuration (PPP Setup)

The interface class 44 (PPP Setup) is used to configure the data link layer.

- PPP Setup (44, 0-0:25.3.0.255);

The COSEM object “PPP Setup” (44, 0-0:25.3.0.255) is considered for PPP configuration in the case of using this protocol as data link layer.

Note: The PAP is used in FAHAM as authentication protocol in PPP. The User Name and Password are stored in “user-name” and “PAP-password” parameters of “PPP_authentication” of COSEM object “PPP Setup” (44, 0-0:25.3.0.255). This COSEM object can be used also in any APN authentication.

16.2.3 Network Layer Configuration

Two dedicated COSEM object from classes IC 42 and IC 48 are used for each data link layer (physical interface) used in device. The following COSEM objects are considered to configure network layer.

- IPv4 Setup (42, 0-0:25.1.0.255);
- IPv6 Setup (48, 0-0:25.7.0.255);

The following parameters are considered in these COSEM objects concerning each physical communication interface.

Related Data Link Layer (DL_reference): the content of this attribute is the COSEM object contains the setting of Data Link layer relates to IPv4 Setup COSEM objects. The logical name of related COSEM object should be mentioned in this attribute.

Multicast IP Address: Each device can belong to several groups. A dedicated multicast IP address will be assigned to each group. The Multicast addresses are a "Class D" IP address in the range of 224.0.0.0 to 239.255.255.255. The multicast IP address of each group is specified by Central System

and is stored in multicast_IP_address attribute of IPv4 Setup-GPRS (42, 0-0:25.1.0.255) COSEM object of device.

Table 52 shows the information related to each multicast group that should be considered in Central System (CS).

Table 52: Multicast Group Information

	Multicast Group Name	Multicast Group IP Address	Multicast Group Members	Multicast Group Short Description
Parameter Description	(Name of Group)	(A Class D IP address)	(the unique ID/System title of devices included in this group)	(A short description about group)
Parameter Name	Multicast_group_name	Multicast_IP_address	Multicast_group-member ID	NA

Provisions shall be provided in Central Software to define different groups and assign devices to each group according to information mentioned in table 52.

DHCP Flag: This flag specifies whether the device IP address (and other parameters such as subnet mask and gateway IP address) will be specified dynamically (during registration process) or they should be set locally. It is specified by use_DHCP_flag attribute of IPv4 Setup-GPRS (42, 0-0:25.1.0.255) COSEM object of device. The value of this attribute can be TRUE (for dynamically setting of network parameters) or FALSE (locally set).

In FAHAM, all network parameters (device unique IP address, subnet mask, gateway IP address and so on are specified dynamically by CS (Central System). So, the value of use_DHCP_flag attribute of IPv4 Setup-GPRS (42, 0-0:25.1.0.255) COSEM object is "TRUE" by default.

Network Parameters (Subnet Mask and Gateway IP Address): The network parameters such as Subnet Mask and Gateway IP address will be set dynamically during device registration. The value of these parameters will be stored in subnet_mask and gateway_IP_address of IPv4 Setup-GPRS (42, 0-0:25.1.0.255) COSEM object of device respectively.

DNS Setting: The IP address of primary and secondary Domain Name Servers (DNS) are stored in primary_DNS_address and secondary_DNS_address attributes of IPv4 Setup-GPRS (42, 0-0:25.1.0.255) COSEM object of device respectively. In FAHAM, there is no need to use DNS server and the value of mentioned attributes is set "0".

16.2.4 Transport Layer Configuration (TCP-UDP Setup)

In TCP-UDP/IP based communication, all COSEM Application Associations (AAs) between a physical device (hosting one or more COSEM clients) and a physical device (hosting one or more COSEM server logical devices) rely on a single TCP or UDP connection. The TCP-UDP configuration is done by TCP-UDP Setup COSEM object (Class ID 41). An instance of TCP-UDP Setup object shall be considered for each data link layer is supported by physical device. In FAHAM, the following TCP-UDP Setup objects is considered for GPRS meters:

- TCP-UDP Setup (41, 0-0:25.0.0.255);

The following parameters are considered in TCP-UDP Setup objects to configure transport layer:

- TCP-UDP Port Number (TCP-UDP_port);
- Related IP Setup Object (IP_reference);
- Maximum Segment Size (MSS);
- Max. Number of Simultaneous Connections (nb_of_sim_conn);
- TCP Time Out (inactivity_time_out);

Provisions shall be provided in Central System (CS) to set the above-mentioned parameters during system operation.

TCP-UDP Port Number: As mentioned in16.1, to distinguish between different Applications in each physical device (COSEM client or server), an additional addressing is provided inside the device at transport layer. Both TCP and UDP handle this addressing capability at the Transport layer. This is called Port. Each Application in physical device has its own TCP-UDP port number. The COSEM is considered as an Application in physical device (meter, data concentrator or central system) and a unique TCP-UDP port number is assigned to it. The 4059 port numbershave been considered by IANA for DLMS/COSEM. This value is stored in TCP-UDP_port attribute of TCP-UDP Setup COSEM object (Class ID: 41). The value of this attribute is 4059 in all TCP-UDP Setup objects of device by default.

Related IP Setup Object: As mentioned, an instance of TCP-UDP and IPv4 Setup objects shall be considered for each data link layer is supported by physical device. The IP_reference attribute connect the TCP-UDP Setup to IPv4 Setup objects that relates to same data link layer. In FAHAM, the value of this attribute is logical name of COSEM object “IPv4 Setup-GPRS” (42, 0-0:25.1.0.255).

Maximum Segment Size: the default value is 1280 in FAHAM.

Max. Number of Simultaneous Connections: This parameter specifies the maximum number of simultaneous connections supported by COSEM TCP-UDP based transport layer.

TCP Timeout: This parameter defines the time (in seconds) over which, if no frame is received from the COSEM client, the TCP connection shall be aborted. The default value is "180" seconds. The "0" value means a TCP connection, once established, will never be aborted by the COSEM server in normal condition (no power failure and so on). This parameter can be changed by Central System during operation.

16.2.5 COSEM Addressing Configuration (wPort Number Setup)

As mentioned in previous sections, the Application Layer (AL) is listening only on one TCP (or UDP) port for data exchanging. Besides, a single physical device can have several COSEM Clients (in COSEM Client Side) or various COSEM Logical Devices (in COSEM Server Side) inside its COSEM application only. Within a physical device, each COSEM AP (client AP or server logical device) is

bounded to a unique port number provided by COSEM Wrapper sub-layer and called wPort. The wPort is also called SAP (Service Access Point) address and it is stored in SAP Assignment COSEM object (17, 0-0:41.0.0.255).

In this system, there are one Logical Device (Management Logical Device) in COSEM server side and four Clients (Public, Reading, Management and Pre-establish) in client side. The following SAP address (wPort number) is considered:

- COSEM Server Side
    - Management Logical Device: 001
- COSEM Client Side
    - Management Client: 001
    - Public Client: 016
    - Reading Client: 002
    - Pre-establish Client: 102

All COSEM AP (logical devices or clients) defined in physical devices with their wPort number (SAP Address) are presented in SAP_assignment_list attribute of SAP Assignment object (17, 0-0:41.0.0.255) of devices.

16.3 GSM Diagnostic

The cellular network is undergoing constant changes in terms of registration status, signal quality etc. It is necessary to monitor and log the relevant parameters in order to obtain diagnostic information that allows identifying communication problems in the network.

The COSEM object that save and hold values is " GSM diagnostic" (1, 0-0:94.98.60.255).

The following parameters are included in this COSEM object:

operator Holds the name of the network operator e.g. "YourNetOp"

ps_status the *ps_status* value field indicates the packet switched status of the modem.

ps_status enum:
(0) inactive,
(1) GPRS,
(2) EDGE,
(3) UMTS,
(4) HSPDA,
(5) LTE,
(6) CDMA,
(7) LTE Cat M1,
(8) LTE Cat NB1,
(9) LTE Cat NB2,
(10) ..(255) reserved.

cell_ID Four-byte cell ID in hexadecimal format

location_ID Two-byte location area code (LAC) in the case of GSM networks or Tracking Area Code (TAC) in the case of UMTS, CDMA or LTE networks in hexadecimal format (e.g. "0x00C3" equals 195 in decimal)

signal_strength The Received Signal Strength Indicator value
(0) –113 dBm or less,
(1) –111 dBm,
(2)..(30) –109…-53 dBm,
(31) –51 dBm or greater,
(99) not known or not detectable,
other reserved,

Note: meter should be able to support GSM900, GSM1800, GPRS, LTE cat1 (B3, B7) cellular networks.

16.4 Network Connecting Mechanisms

There are several mechanisms to make connection to network. They are presented in figure 44.

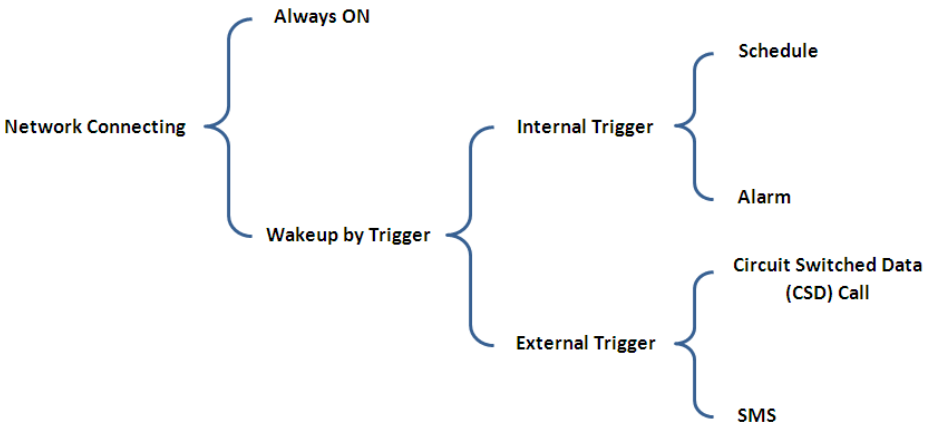


Figure 44: Network Connection Mechanisms

As has been shown in figure 44, the GPRS communication module can be either always online or are not continuously online and has to be woken up by a trigger. The trigger can be the result of an internal process inside the device (meter) such as Alarm or reaching a time specified by a schedule, or an external trigger initiated by Central System such as sending SMS or calling GPRS modem via circuit switched network.

The network connecting mechanism used in system is specified by “mode” attribute of "Auto Connect" object (29, 0-0:2.1.0.255). The different modes and their description are presented in below table.

Table 53: Auto Connect Modes

Mode No.	Description
1	Auto Dialing Anytime
2	Auto Dialing within the validity time
3	Regular Auto Dialing
4	SMS via PLMN
5	SMS via PSTN
6	Email Sending
7 … 99	Reserved
101	Always On (Connected)
102	The GPRS device is permanently connected to the communication network within the validity time of the calling window. The GPRS device is disconnected outside the calling window. No connection possible outside the calling window.
103	The GPRS device is permanently connected to the communication network within the validity time of the calling window. The GPRS device is disconnected outside the calling window Connection to communication network is possible as soon as the connect method is invoked.
104	The GPRS device is usually disconnected. It connects to the communication network as soon as the connect method is invoked.
105 … 199	Reserved

FAHAM meters shall support modes 101, 102, 103 and 104. Mode 101 is Always-On mode. Mode 104 is used in wake-up by trigger mechanisms. The mode value is configured by CS (Central System). Provisions should be provided in Central Software to set this value.

If the "Wakeup by Trigger" is chosen (mode 104), there will be 4 options as depicted in figure 44. In this case, the "Alarm" (triggered by Alarm to send alarm happened) is always active. The activation of other choices (Schedule, SMS and CSD) is done by related COSEM objects (see following sections).

16.5 Pushing Process

The pushing process is done by using three main groups of COSEM objects as follows:

- Triggering Objects;
- Script Table;
- Push Set-up;

Below figure depict the COSEM objects are involved in Pushing process and their relationship.

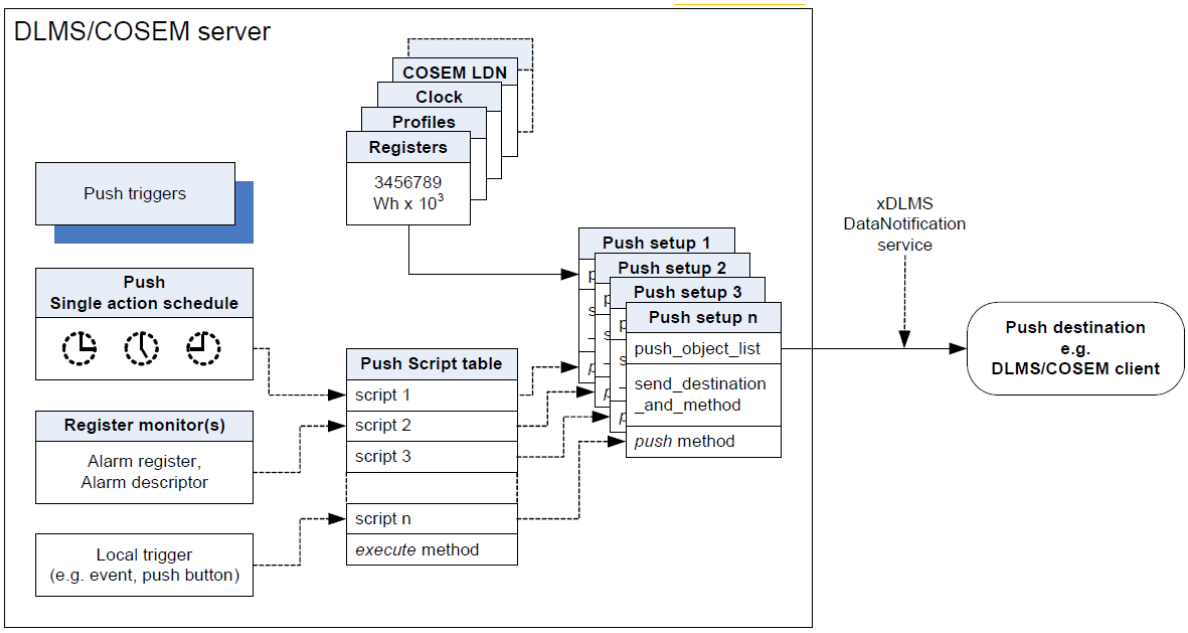


Figure 45: Pushing Process

As mentioned in previous section and as has been shown in figure 45, the devices can be woken up by a trigger (internally or externally) to connect to network and exchange data with Central System. This is called Triggering Process. The following COSEM objects are considered to provide triggering:

- Push action scheduler – Interval_1(22, 0-1:15.0.4.255);
- Push action scheduler – Interval_2 (22, 0-2:15.0.4.255);
- Push action scheduler – Interval_3 (22, 0-3:15.0.4.255);
- Alarm Monitor 1 (21, 0-0:16.1.0.255);
- Alarm Monitor 2 (21, 0-0:16.1.1.255);
- Auto Answer (CSD Call/SMS) (28, 0-0:2.2.0.255);

A trigger calls a script in Push Script Table (9, 0-0:10.0.108.255) and the called script invokes the "Push" method of relevant "Push Setup" objects. At the end, the "Push" method of "Push Setup" object sends the specified message/data to Central System.

Note: The number of push Setup is 4 (n = 4).

16.5.1 Triggering Scheduler

Three different schedules have been defined in FAHAM for triggering the making GPRS AND 4G connection and pushing message to CS (Central System). They are as follows:

- Push action scheduler – Interval_1
- Push action scheduler – Interval_2
- Push action scheduler – Interval_3

The "Push action scheduler – Interval_1" is intended to trigger making connection with CS (Central System) at the specific time or regular fashion to activate the PDP context and establish new GPRS

session. This will be done to establish connection with CS (Central System) at some specific time points.

The "Push action scheduler – Interval_1" has been defined by COSEM object (22, 0-1:15.0.4.255). The structure of this object has been shown in table 54.

Table 54: Push action scheduler 1 Structure

Parameter Name	Executed Script	Type of Execution Time	Execution Time
Attribute	executed_script	type	execution_time_date
Type	Structure {script_logical_name, script_selector}	enum	Structure {time,date*}
Value	{00000A006CFF,2}	5 (Fixed daily time. The wildcards in data are allowed)	Time: {time,date}

*date can be defined as wildcard.

At the time specified in "executed_time" attribute of this COSEM object, the GPRS connection will be established by GPRS modem and a message will be sent to CS (Central System). The execution time (executed_time) shall be just after expiring of existing PDP context.

The data is intended to be sent to CS is specified by "push_object_list" attribute of COSEM object "Push Setup – Interval_1" (40, 0-1:25.9.0.255). The following information will be sent to CS in this case:

- Logical Device Name;
- OBIS code of " Push action scheduler– Interval_1" (first attribute of COSEM object 22, 0-1:15.0.4.255);

The provisions should be provided in CS (or central software) to configure the times, dates and data to be sent to CS in this case.

The " Push action scheduler– Interval_2" (22, 0-2:15.0.4.255) is provided to send regularly reading values to CS (Central System). The structure of this object has been shown in table 55.

Table 55: Push action scheduler

Parameter Name	Executed Script	Type of Execution Time	Execution Time
Attribute	executed_script	type	execution_time_date
Type	Structure {script_logical_name, script_selector}	enum	Structure {time,date*}
Value	{00000A006CFF,2}	5 (fixed daily time. The wildcards in data are allowed)	Time: {time,date}

*date can be defined as wildcard.

At the time specified in "executed_time" attribute of this COSEM object, the GPRS connection will be established by GPRS modem and a reading values will be sent to CS (Central System). The values to be sent to CS, are specified by "push_object_list" attribute of COSEM object "Push Setup-Scheduler-02" (0-2:25.9.0.255, Class ID: 40). The following information will be sent to CS in this case:

- Logical Device Name (1, 0-0:42.0.0.255,2);
- Load Profile 2 (7,1-0:99.2.0.255) (the last record should be pushed);

The provisions should be provided in CS (or central software) to configure the times, dates and values to be sent to CS in this case.

Note: The schedule can be disabled with writing {{"FFFFFFFF", "FFFFFFFFFF"}} value as execution time.

16.5.2 Triggering by Alarm

If an Alarm happens, the GPRS connection should be established and the Alarm Descriptor shall be sent to CS (Central System). The COSEM objects "Alarm Monitor 1" (21, 0-0:16.1.0.255) and "Alarm Monitor 2" (21, 0-0:16.1.1.255) from Class ID21 have been used to handle triggering by Alarm.

If an Alarm happens in device, these objects calls a fourth script in "Push Script Table" object (9, 0-0:10.0.108.255) and the called script invokes the "Push" method of "Push Setup-Alarm" object (40, 0-4:25.9.0.255). The "Push Setup-Alarm" objects send the Alarm Descriptor Central System.

16.5.3 Triggering by GPRS Connection Detection

The Push on GPRS Connection Detection (Connectivity) is triggered each time a new network connection is established. A new network connection may be caused internally (e.g. reconnection in mode 101, starting a new connection window in mode 102 and 103) or externally by sending a wake-up signal to the meter in mode 104 or 103 (e.g. CSD Call or SMS).

The CSD and SMS (as external triggering) is handled by "Auto Answer" COSEM object (28, 0-0:2.2.0.255). The listening window is always active in case of external triggering mechanism is used. The device answers (receives) only (message from) to the calling numbers that are specified in "list_of_allowed_callers" attribute of mentioned COSEM object. The capacity of the array of attribute of "list_of_allowed_callers" shall be at least 5. Each entry may contain wild cards.

The data to be sent to CS is specified by "push_object_list" attribute of COSEM object "Push Setup-On Connectivity (40, 0-0:25.9.0.255). The following data will be sent to CS in this case:

- Logical Device Name (1, 0-0:42.0.0.255, 2);
- IP Address of Device, IP_address attribute of COSEM object "IPv4 setup-GPRS" (42, 0-0:25.1.0.255);

The provisions should be provided in CS (or central software) to add the allowed calling numbers.

16.5.4 Pushing Message

The final stage in triggering process is pushing the message (data or information). This stage is handled by "Push Setup" objects from Class 40. The following "Push Setup" objects have been used in FAHAM:

- Push Setup-Interval-01 (40, 0-1:25.9.0.255);
- Push Setup-Interval-02 (40, 0-2:25.9.0.255);
- Push Setup-Interval-03 (40, 0-3:25.9.0.255);
- Push Setup-On-Alarm (40, 0-4:25.9.0.255);
- Push Setup-On-Connectivity (On-Connectivity) (40, 0-0:25.9.0.255);
- Push Setup-Meter On-Installation (40, 0-7:25.9.0.255);
- Push Setup- Consumer Information (40, 0-6:25.9.0.255).

The following parameters are specified by mentioned COSEM objects before pushing (sending) message (data or information) to CS (Central System).

- Data/Information/Message to be sent (push_object_list);
- Destination Address and Sending Method (send_destination_and_method);
- Communication Details:
    - Communication Window (calling_window);
    - Start Time Randomization (randomization_start_interval);
    - Repeating Attempts (repetitions);
    - Time Delay of Repeating Attempts (repetition_delay);

Data/Information/Message to be sent (push_object_list)

This attribute contains the list of attribute (s) or object (s) to be sent to CS (Central System). The data to be pushed to CS by each triggering mechanism have been presented in previous sections.
Push setup- Interval-01: {40,0-1:25.9.0.255,1,0 - 7,1-0:99.1.0.255,2,4097}
Push setup- Interval-02: {40,0-2:25.9.0.255,1,0 - 7,1-0:99.2.0.255,2,4097}
Push setup- Interval-03: {40,0-3:25.9.0.255,1,0 - 7,1-0:99.133.0.255,2,4097}
Push Setup-On-Connectivity: {40,0-0:25.9.0.255,1,0 - 1,0-0:42.0.0.255,2,0 - 1,0-0:96.1.5.255,2,0 - 1,1-0:0.0.0.255,2,0 - 1,0-0:94.98.60.255,2,0}
Push Setup- Consumer Information: {40,0-6:25.9.0.255,1,0 - 7,1-0:99.136.0.255,2,4097}

Destination Address and Sending Method

The "send_destination_and_method" attribute specifies the following parameters:

- Destination Address;
- Pushing Communication Type;
- Data (to be sent) Type;

The destination address is the address of CS (Central System). It can be a phone number, email address, IP address of CS according to the type of communication specified.

The type of communication can be one of the followings:

- TCP
- UDP
- FTP
- SMTP
- SMS

The message type can be one of the following:

- COSEM APDU;
- XML COSEM APDU;
- Manufacturer Specific;

16.5.5 SMS as a general communication channel

The SMS channel supports xDLMS services with the following restrictions:

- SMS is used as one-way channel only,
- therefore, only unconfirmed services are allowed (from client: SET, ACTION, unconfirmed, to client: Data-Notification),
- therefore, communication is restricted to/from the Pre-established client only (comp. Figure 20),
- used security key from HES: Global Broadcast Key,
- used security key to HES: Global Unicast Key,
- more details on security can be found in section17,
- erroneous APDUs or confirmed service requests are ignored by the meter without any error message,
- the max APDU size for SMS communication is 138[2]

16.5.6 Communication Details

The communication details to configure connection setup in triggering mechanism are as follows:

- Communication Window (communication_window);
- Start Time Randomization (randomization_start_interval);
- Number of Retries (number_of_retries);
- Time Delay of Repeating Attempts (repetition_delay);

The Communication Window specifies the time interval that the pushing data to Central System is activated (after Start Time) and will be inactivated (after end time).

To avoid pushing collision and simultaneous network connections when a lot of devices want to establish connection with CS (Central System) at the same time, the randomization mechanism is provided. The randomization mechanism can be active or inactive (the "0" value in randomisation_start_interval attribute means no randomization). If it is active, the pushing data is not started immediately at the beginning of first communication window and it will be started

[2]If liable SMS service for longer messages can be provided the max PDU size may be extended to 1224

randomly delayed (delay is determined by randomization). Figure 46 depicts the randomization mechanism when the trigger happens before the communication window started. As indicated in Figure 46, in this case, the random delay time (for pushing data) is determined form start time of communication window.

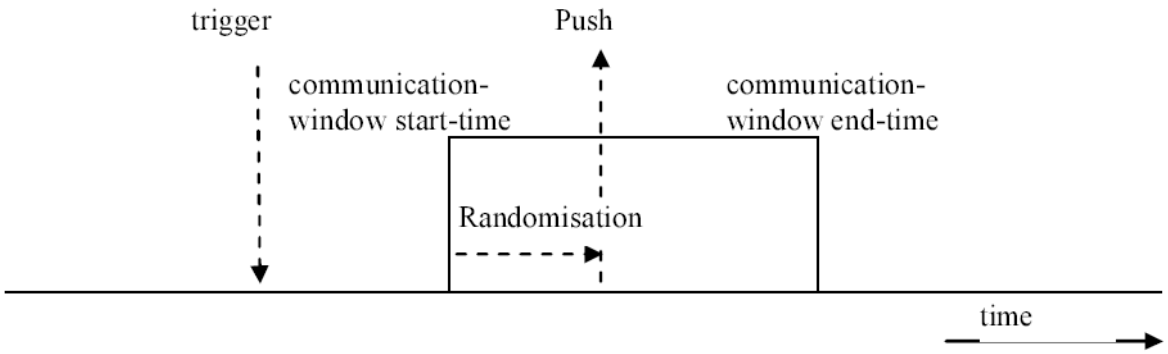


Figure 46: Randomization, Trigger before Communication Window

Figure 47 shows the case that the trigger happens within the communication window. In this circumstance, the random delay time (for sending data) is determined form the start time of trigger. If the calculated random delay time falls outside the communication window, the new random delay time will be calculated in the next communication window.

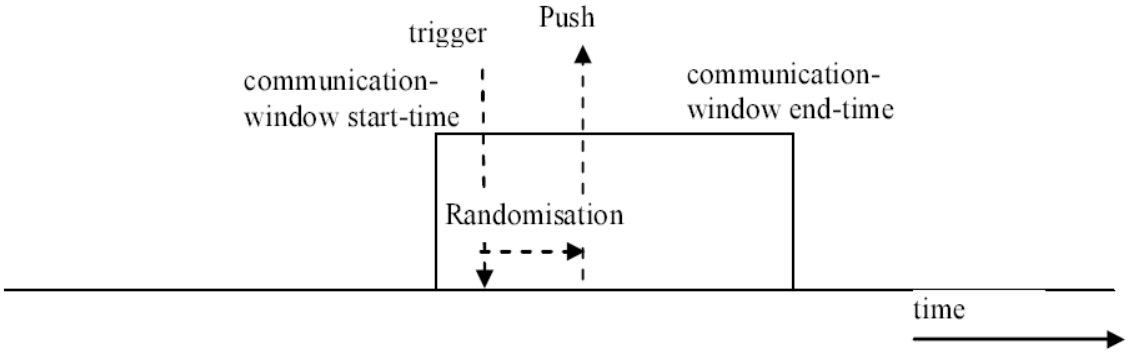


Figure 47: Randomization, Trigger within Communication Window

The provisions should be provided in Central System (and Central Software) to configure the communication details value. By default, in FAHAM, the communication window is active all time (pushing data is possible without limitations and the "calling_window" attribute is empty) and the randomization mechanism is not used (the "randomisation_start_interval" attribute set to "0").

The "Push" process is treated as successful, if the lower layer transmission confirmation has been received. If the "Push" was not successful, the next "Push" attempt is made after a delay. The delay time in seconds is specified by "repetition_delay" attribute of Push Setup COSEM object. If the first retry is not successful, the second attempt and more will be made. The maximum number of retries is specified by "number_of_retries" attribute of Push Setup COSEM object. The retries procedure, in Push process is shown in Figure 48.

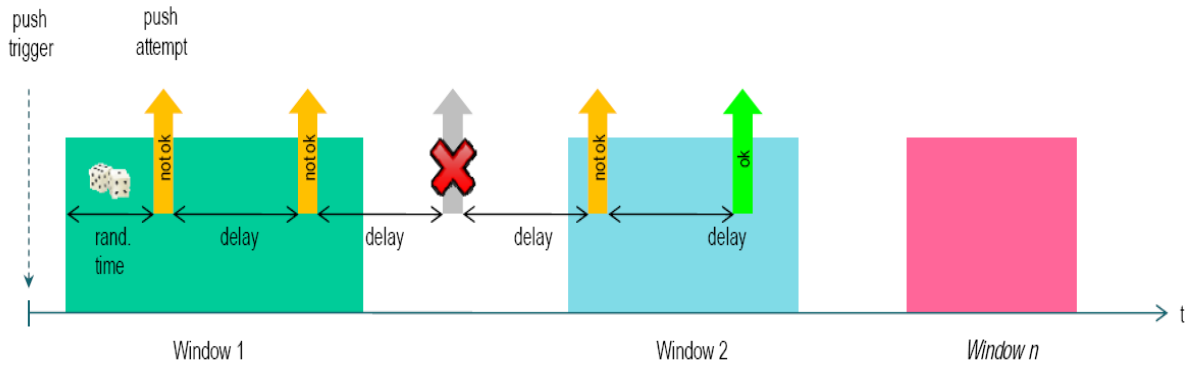


Figure 48: Retries Procedure

16.6 Connecting Mechanism Activation

The network connecting mechanism used in system is specified by “mode” attribute of "Auto Connect" object (29, 0-0:2.2.1.255). The different modes and their description are presented in below table.

The COSEM object "Auto Connect" object (29, 0-0:2.2.1.255) is used to select "Always On" or "Triggering" modes.

The provisions shall be provided in CS (Central System) to activate/inactivate each connecting mechanism according to mentioned mechanisms.

17 E-Meter Security Features

- In FID2 package 1 the use of dedicated keys is mandatory.

- In FAHAM, the local ports should limit illegal access times. It is implemented by Local Authentication protection object (1, 0-0:94.98.20.255).

17.1 Association Establishment

For High level Security the AA establishment is done using the GMAC authentication mechanism (mechanism_id(5)),The association establishment follows the process as described in sect. 9.2.4.8.4 of DLMS UA 1000-2 Ed. 7.0:2010.

In pass 3 and 4 of the peer authentication process, the global unicast encryption key and the authentication key (if in use) are used.

NOTE: there is only ONE association object; i.e. the “current association” (15, 0.0.40.0.0.255).

17.2 Default passwords and global keys for interoperability testing

For testing purposes the following (comp. table 56) default security material should be used:

Table 56: Default Values for Security Parameters

Security parameter	Default value (hex)
LLS default password	To be announced in secure way Generated by key management process
Global Authentication key	
Global Broadcast Encryption key	
Global Unicast Encryption key	
Global CIP Authentication key	
Global CIP Encryption key	
Global Reading Authentication key	
Global Reading Encryption key	
Master key	

17.3 Security Setup

The meter should support 3 security setup objects as follows:

- Security Setup (Management Client/Pre-Establishment Client) (64, 0-0:43.0.0.255)
- Security Setup (Consumer Information) (64, 0-0:43.0.1.255)
- Security Setup (Reading Client) (64, 0-0:43.0.2.255)

17.4 Use of the Frame Counters

Each FID2 server (meter) must store the following invocation counters per security context (GET access via public client). As Electricity Meter uses the Global key to secure outgoing messages, the transmit frame counter is incremented for every message sent independently on the channel (SMS, pre-established IP, management IP). On the other hand, for each ingoing messages, the received Invocation counter is incremented for every message.

Table 57: Frame counters stored in a server

Key	FC Transfer	FC Receive
Broadcast	NA	FCR
Unicast	FCT	FCR

Each FID2 client (HES) must store the following frame counters for per meter, otherwise if a new HES (or for de-synchronization), it should read Invocation counter using public client.

Table 58: Frame counters stored in a client for each server

Key	FC
Broadcast	Yes
Unicast	Yes

In FAHAM, meters should save the frame counters that received from HES. They are accessible via public and management client. The objects that save frame counters in meter are as follows:

- Security - Receive Frame Counter - Unicast Key (Remote) (1, 0-0:43.1.0.255);
- Security - Receive Frame Counter – Broadcast Key (Remote) (1, 0-0:43.1.1.255);
- Security - Receive Frame Counter - Unicast Key (Local) (1, 0-0:43.1.2.255).

17.4.1 Rules applying FC in Client and server

- The client shall process the frame counter in the received message for each receiving channel (SMS, pre-established IP, management IP) individually: for each specific channel the HES validates the received frame counter according to the following rule:
- A message received on a specific channel is discarded if the frame counter in the received message is smaller or equal to the frame counter expected by the receiver on this channel.
- When each key is changed, the corresponding IC is reset to 0. Just after power up, the Electricity Meter must not reset IC values. The Electricity Meter must store and recover at power up the frame counter values present at power down.

- When the maximum value of the IC has been reached, any following invocation of the authenticated encryption function shall return an error and the IC shall not be incremented.
- Frame Counters used with dedicated keys are independent of the FCs used with global keys.
- Frame Counters used with dedicated keys are handled internally in the meter (no access via COSEM object provided).
- FCs used with dedicated keys are reset (to 0) when a new association is established (new dedicated key generated by HES – transmitted with InitiateRequest, encrypted with global key).
- As Electricity Meter uses the GUEK to secure outgoing messages, the transmit frame counter is incremented for every message sent independently on the channel (SMS, pre-established IP, management IP).
- In Management client whenever there is local access involving security then the unicast FC (FCRxu) is updated. Due to the local access the HES is not aware of the updating of the FC. In this situation the HES must resynchronize.

17.4.2 FC in Pre-established association

- Prior deciphering the Message sequence is re-ordered according to increasing frame counters.
- A message is rejected if the frame counter in the received message is smaller or equal to the frame counter in the previously received message for any of the individual channels.
- Consistency is checked using additional information in the frames (e.g. block counters, invoke-id). Inconsistent frames are rejected.

17.4.3 Re-synchronization of Frame counters

When operating with global keys then the HES re-synchronizes its FCs by reading the suitable FCs from the meters (via public client).

When operating with dedicated keys the HES re-synchronizes its FCs by first, closing the current association (using global unicast keys) and after re-opening the association (using global unicast keys) by changing the dedicated keys (the FCs are automatically reset).

17.5 System-Title Management

System-title parameter is used by AES-GMC-128 just in order to be part of the fixed part the initialization vector, identifying the security context used (for detailed information, just check DLMS UA 1000-2 Ed. 8.0 chapter 9.2.3.3.7.3).

When using the management association on remote communication, client_system_title and server_system_title parameters are interchanged as part of the association establishment mechanism. The following rules concerning the System_titleapply:

17.5.1 Management Client on remote communication

- The client_system_title is transmitted as part of the AARQ and copied into the COSEM object security setup, attribute: client_system_title.
- From this time instance on the meter uses this client_system_title to decipher the PDUs from the Management Client.
- After closing the association, the attribute client_system_title remains in the COSEM object security setup, attribute: client_system_title.

17.5.2 Management Client on local port

- client_system_title is transmitted as part of the AARQ BUT NOT copied into the COSEM object security setup, attribute: client_system_title.
- From this time instance on the meter uses this client_system_title to decipher the PDUs on the local port.

17.5.3 Pre-established Client on remote communication

- When using the pre-established association, there is not AARQ/AARE to interchange system_titleparameters. The client_system_title is used by the server in the pre-established association and the value is stored in the COSEM object security setup, attribute: client_system_title.
- Any of the attributes granted GET access for the Management client may be pushed to the Pre-established client via the Data-Notification service.

17.5.4 CIP Client on local port

- The client_system_title used by the server in the CIP association is the value stored in the CIP COSEM object security setup, attribute: client_system_title.

17.5.5 Public Client on local port

- client_system_title is NOT transmitted as part of the AARQ.

17.6 The use of keys

For each Security setup objects is defined separated key that are shown in below table.

Table 59: Different keys

Security Setups	Keys
Security Setup (Management Client/Pre-Establishment Client) (64, 0-0:43.0.0.255)	Unicast Global Encryption Key Broadcast Global Encryption Key Authentication Key Master Key
Security Setup (Reading Client) (64, 0-0:43.0.2.255)	Unicast Global Reading Key Authentication Key
Security Setup (Consumer Information) (64, 0-0:43.0.1.255)	CIP Unicast Global Key CIP Authentication Key

The following rules concerning the keys apply:

- The lifetime of the Global Keys (Encryption and Authentication) is limited by the range of the dedicated Frame Counters. The global key must be changed explicitly by the client (using the method “global_key_transfer” of the object “Security Setup”). The new global key is encrypted with the master key. The global keys are generated and managed by the HES.
- The use of Dedicated Keys in FAHAM is mandatory. Consequently: FAHAM meters must accept RLRQ and AARQ with a Dedicated Key. FAHAM meters may accept RLRQ and AARQ in Public Client.
- Dedicated keys are valid during the lifetime of an association; i.e. the dedicated key is generated and taken in use with the opening of the association. The key is destroyed automatically by the server upon closing of the association.
- If SET/ACTION services from a client to an electricity Meter need to be protected, then the general-glo-ciphering [219] service must be used for this purpose. The Electricity Meter will remove the APDU protection by using the general-glo-ciphering system title field.
- Just if the Data-Notification service from an electricity Meter to a client needs to be protected, then the general-glo-ciphering [219] service must be used for this purpose. The client will remove the APDU protection by using the general-glo-ciphering system title field.
- Any of the attributes granted GET access for the Management client may be pushed to the Pre-established client via the Data-Notification service (see object model).

17.7 Rules to change the Key

All global keys are changed by using the security_setup. global_key_transfer method. The method is accessible only via the Management Client.

- If the “new” key is accepted, then the meter sends Action Response (same invoke_id and priority as the request): SUCCESS ciphered with “currently used” key. From this point on, meter uses the “new” key (replacing the “currently used” key with “new” key) and resets FC.
- If the type of the data in the Action Request is not correct then the meter answers with Action Response (same invoke_id and priority as the request): Data_Access_Error=Type unmatched.
- If the meter cannot decrypt the pdu (request encrypted with invalid key) Response (state-error=service-not-allowed, service-error=operation-not-possible).

17.8 Changing the Security Policy

The Security Policy may be changed by invoking the security_activate method of the security setup object, or by setting the security_policy attribute of the security setup object. Only the Management Client can change the security policy, considering the following rules:

Security Policy	APDU
Increase	Un-ciphered (if starting from security policy = 0) or ciphered
decrease	ciphered only

18 Consumer Information Push (CIP) using PUSH operation

In conjunction with PUSH operation FID2 package 1, meters may support the provision of local Consumer Information. This information consists of a predefined set of attributes which are periodically transmitted to a local port serving as Consumer Information Interface (CII). Depending on the market request, this local port may be connected to a suitable home gateway. However, the specification of the home gateway and the binding of any external device to the meter is not in the scope of FID2 package 1.

18.1 Client - Server structure for the optional CIP client

In order to support the optional CIP functionality the general Client Server architecture described in 2.2 is extended with a CIP client as shown in figure 49.
The Consumer Information Push (CIP) shall use a dedicated Client [103] with at minimum Data-Notification service supported. The Client is pre-established and has its own security context.
For Conformance testing:

- CIP Client related tests are only performed if the optional CIP functionality is supported in an FID2 DUT.
- The local port must be identified by the manufacturer and the manufacturer must provide a suitable converter allowing the COM port of the FID2 test tool to be connected to the local port of the DUT.

Foreseen communication is one way only i.e. Push from Server [1] to Client [103].

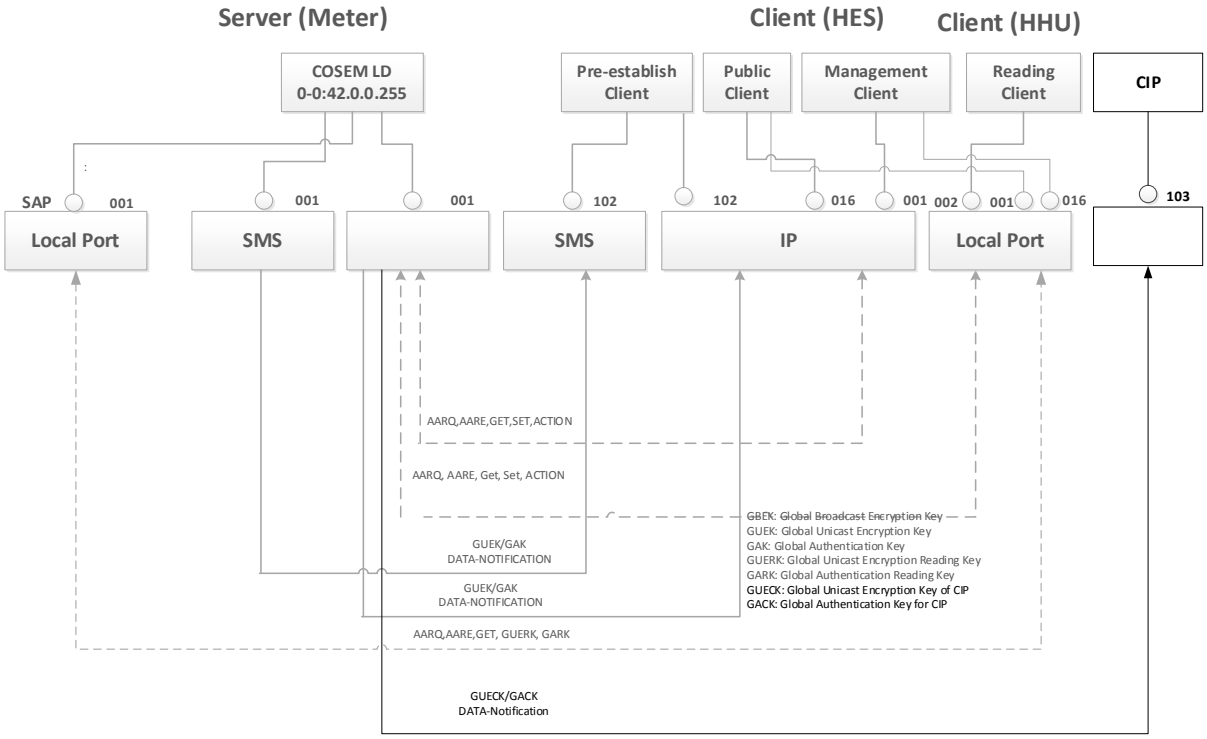


Figure 49: FID2 Client-Server structure with the optional CIP Client

18.2 CIP protocol stack

- The protocol stack is of three layer collapsed type.
- Frame type 3 and the non-basic frame format transparency according to IEC 13239, sect.4.3.3 is used.
- The meter acts as HDLC primary/control station according to IEC 13239 (sect. 6.13 Unbalanced connectionless operations).
- The control station sends unsolicited UI frames carrying the data as configured in the PUSH setup.
- According to IEC 13239 sect. 6.13.4.2.1: whenever the control station is ready to send a UI command frame, it shall send it immediately since there is no flow control in connectionless class service. The tributary station(s) shall only send UI response frames when given permission to do so.
- The connection is unidirectional from meter to client 103 and therefore the meter never gives permission to the tributary station to UI responses.

18.3 Security on the Consumer Information Interface

The data from the meter pushed to the CII (via CIP) may be secured (encryption and/or authentication) by the meter.

- If it is secured, then security suite 0 is applied.
- The security material used for this Meter-CII- Consumer Equipment communication is independent of the security material used for the remote Meter-HES communication.

The CIP security context is defined in a dedicated security setup object (according to 17.3) The keys (CIP keys) used for the data pushed to the CII are managed by the HES. To change a CIP key:

1. The HES wraps the new CIP key with the meter's master key,
2. The HES sends the wrapped key to the meter using the method global_key_transfer of the object "Security setup-Consumer Information" (64, 0-0:43.0.1.255) via the Management Client association.

The delivery of the appropriate key to the consumer equipment (user of the CII) is out of scope of FID2 Package 1.

The CIP frame counters used for the data pushed to the CII are not accessible from outside the meter (neither by the HES nor by the consumer equipment). Upon reception of a new set of keys from the HES the meter resets the CIP frame counters. The meter increments the frame counter with every message pushed.
The Consumer equipment is expected to perform the frame counter validation on every message received according to the following validation rule:

- After the consumer equipment receives a new set of global keys it will accept the first message (assuming that is encoded/authenticated with the right key) independent of the value of the frame counter. The value of the received first frame counter is then used as "initial" frame counter value.
- All the following messages are only accepted if the frame counter of the currently received message is larger than the frame counter of the previously received message.

18.4 CIP System Title and Error Handling

- The System title used for the CIP communication is the Meter's system title.
- The Error handling for the CII to consumer equipment communication is not in the scope FID2 Package 1.

18.5 Object model and Use cases covered

If the optional CIP functionality is supported then the following objects are mandatory:

Table 60: Mandatory COSEM objects for FID2 meters supporting the optional CIP functionality

Instance name	IC	OBIS	Use Case
Push action scheduler – Consumer Information	22	0-4:15.0.4.255	Defines the time instances (by default every 15sec) when the meter is pushing information (as set in Push setup) to the CII (CIP Client 103). The HES may access the settings of the scheduler via the Management Client. The single action schedule is of type 5. With an array of n-execution times in order to provide enough granularity of scheduled action. The scheduler's executed_script references the Push script table [0-0:10.0.108.255].
Push setup –Consumer Information	40	0-6:25.9.0.255	Definition of the set of data the meter will push to the CII. The data will be pushed according to the corresponding push action scheduler execution_time.
Security setup Consumer Information	64	0-0:43.0.1.255	Security setup instance managing the global keys used to secure the meter data pushed to the CII (via CIP).
HDLC CIP port	23	0-1:22.0.0.255	CIP HDLC configuration

19 Gateway Mode

The top layer of any DLMS/COSEM communication profile is the DLMS/COSEM application layer.
In order to leave both, the suite of lower layers and the DLMS/COSEM AL unaffected, the task of routing each message from the client to the end device on the LAN is solved by pre-fixing the COSEM APDUs with a few bytes specifying the network to be used and the address of the device on the LAN and vice versa.
The gateway extracts the payload, a COSEM APDU – together with the application addresses – from the WAN/NN protocol and puts it as a payload to the LAN protocol, and the other way round.
The structure of the prefix with four fields is shown in Table 61.

Table 61: The Fields used for Prefixing the COSEM APDUs

Pre-fixed fields				APDU
Header	Network ID	Address length L	Physical device address	Application layer payload (COSEM APDU)
1 byte 0xE6/E7	1 byte	1 byte	L bytes	N bytes

- the value of the first byte (header) is either 0xE6 or 0xE7. It indicates that the following bytes don't contain a plain COSEM APDU but contain a COSEM APDU with a prefix:
  - 0xE6 indicates a request message from a DLMS/COSEM client to a DLMS/COSEM server
  - 0xE7 indicates a response from the DLMS/COSEM server to the DLMS/COSEM client;
- the second byte carries an identifier of the destination network where the messages are transferred to. This allows accessing several networks using the same or different communication protocols through the same gateway. The network ID is not linked to the communication protocol and can be set to any value. If only one network exists, 0x00 shall be used.
- the third byte defines the length of the physical device address given in the next 2 bytes.
- bytes 4 and 5 carry the physical device address of the end device or the HES as requested by the communication protocol. The physical address is specified as 4 digits to the right of the meter serial number + 1000.

Note: Gateway device[3] (Smart meter or FAHAM2 Modem) shall send response to MDM, if it doesn't receive a response from sub meter on RS485 connection after 6 seconds; format of response Message is based on following format and prefix shall be equal to the HDLC address of the submeter.

Exception response [216]
State-error = service-not-allowed [1]
Service-error = sub-meter-communication-failed [128] IMPLICIT NULL

Note: In case of observing any link layer error in the received response from the sub meter, the Smart meter/FAHAM2 Modem shall send an exception message to the MDM.
Format of response message is based on following format and prefix shall be equal to the HDLC address of the submeter.

Exception response [216]
State-error = service-not-allowed [1]
Service-error = sub-meter-communication-failed [129] IMPLICIT NULL

[3] If there are difference between FID2-V3 and FAHAM2 modem specification, the FAHAM2 modem-V2 specification will be used as reference.

19.1 Relay messages algorithm

This function will used for checking RS485connection between meter (gateway) and sub-meters.
Note: if the meter didn't receive any messages after each 6s timeout. It should jump to "Start" state.

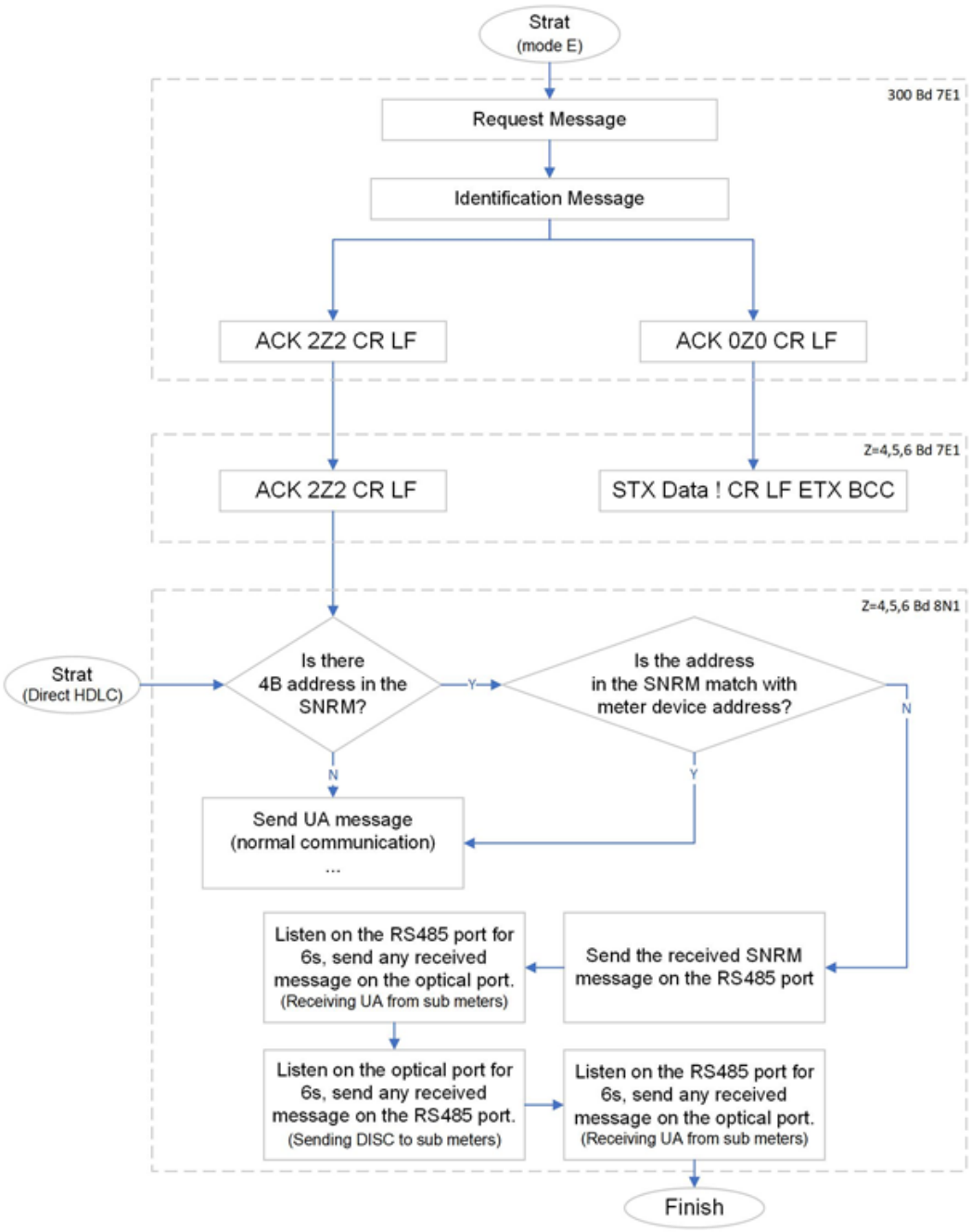


Figure 50: Relay messages algorithm

20 Energy Management

Meter shall have energy management object (Class id=1). FAHAM model for energy management have 3 objects as mentioned below:

- Energy management – credit (1, 0-0:94.98.51.255)
- Tariffication rates (1, 0-0:94.98.52.255)
- Credit amount (1, 0-0:94.98.54.255)

When credit management is inactive, it means consumer can use energy and there is no credit limitation.

The description of energy management modes is defined in table 62

Table 62: energy management modes

Mode	functionality
0- (Default Mode)	Credit management is inactive
1	Credit management Active; no action at the end
2	Credit management active, disconnect relay at the end
3	Credit management active, Limiter activated with critical threshold

Note 1: in mode 1; Credit management active, no action at the end; Once Credit expired, just event recorded/ captured data in billing profile.

Note 2: in mode 2; Credit management active, disconnect relay at the end; Once Credit expired, As well as record event and captured data in billing profile, then after extension time expired, execute disconnect command (record related event) priority is the same as remote disconnect.

Note 3: in mode 3; Credit management active, Limiter activated with critical threshold; Once Credit expired, as well as record event and captured data in billing profile, then after extension time expired, Limiter thresholds substitute with new Threshold until new credit assign or credit management deactivated.

- Extension Time(sec.): Once Credit management were activated after Credit expired customer has this dead line for payment (default 0)
- ended credit Critical threshold coefficient: in Mode=3 once Extension time expired Emergency and Normal threshold (in Limiter object class 71) will be substituted with multiplication of this value to Emergency threshold (default 100% Emergency threshold)
- low credit threshold: (default 20% of assigned credit)