



GENERAL DESCRIPTION

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List of Abbreviations

ADDAX IMS	Hardware and Software Integrated Metering System based on ADDAX Technology
SIMS	Smart Integrated Metering System - Software part of ADDAX IMS
AMR	Automated Meter Reading
AMM	Advanced Meter Management
AMI	Advanced Metering Infrastructure
HES	Head-End System
MDMS	Meter Data Management System
CRM	Customer Relationship Management
CIS	Customer Information System
DLMS	Distribution Line Message Specification
MV	Medium Voltage (12kV, 24 kV)
LV	Low Voltage (230 V, 120 V)
DC	Data concentrator
PLC	Power Line Carrier
CIU	Customer Interface Unit
HAN	Home Area Network

1. General

1.1 Scope

ADDAX IMS represents a set of solutions of the challenges facing the modern electricity metering technology in the framework of the AMI concepts.

ADDAX Metering Solution provides meter reading, data collection, data processing, communication and certain functions of data analysis. ADDAX System offers load control and load shedding, multi-rate metering, fraud protection functions and energy quality control. The system provides all the necessary data for meter-to-cash business processes.

1.2 About this document

This document describes the ADDAX Metering Solutions. Some technical details are introduced to give insight into principles of the system operation. The document is divided into sections. In section 1, the overview of the main features of the system is given. In Sections 2 and 3, the structure as well as main components of the ADDAX IMS and communication between them is considered. Section 4 comprises description of key functions and processes. Finally, advantages of services and solutions provided by the ADD Group are described in Section 5. Information on the system deployment and references are provided in Sections 6 and 7 of the document.

1.3 Main features of the ADDAX IMS

The main features of the ADDAX IMS are the following:

- **Open standard-based solution:** Provides interoperability and interconnectivity with measuring devices and compatible components (hardware/software) of the AMR/AMM/AMI systems produced by other manufacturers. Applies open stacks for both the communication and application protocols. Using DLMS/COSEM standards allows manufacturer and communication technology independence.
- **Scalability:** Being flexible and easy scalable metering solution can be seamlessly expanded from small project to large operated system.
- **Easy deployment:** Enables quick and seamless deployment based on "plug & play" connection that essentially decrease installation and maintenance costs. Auto-discovery function makes it easier to manage the newly installed equipment.
- **Security:** Enables the secure access, storage and management of information based on the data encryption and key management.
- **Business oriented solution:** Provides all necessary data for utility needs and billing purposes. Enables optimization of the distribution systems by minimizing the distribution network losses, improving the quality of the electrical power, and eliminating the peak load.
- **Real-time metering:** Permits both scheduled and instantaneous remote metering of electricity/water/gas/heat. Implements a flexible TOU tariffs, which promotes the electricity supply to markets with different customers' capabilities and functional requirements.
- **Tamper-proof** - Allows detecting and ceasing the electricity theft and fraud.

- **Functionality enhancement-** Communication capabilities expansion, Home Area Network (HAN) support. Smart Grid functionality development.

1.4 Role of the ADDAX IMS in the entire meter-to-cash business processes

Figures 1 presents the ADDAX products role in the meter-to-cash business process.

ADDAX IMS is hardware and software metering suite, which comprises end point and communication equipment as hardware components and SIMS (Smart Integrated Metering System) as a Data Collection system. SIMS being the software structural element of ADDAX IMS provides data acquisition and initial processing for up to 500,000 meters.

SIMS takes the initiative and controls the data flow from/to ADDAX electricity meters and 3rd party meters as well as other software applications. ADDAX IMS also provides with the tariff management, operating load control and some other data processing functions (outlined with grey in Fig.1).

Meter reading data, events and some customer information are aggregated and stored in a Head-End System (HES) database. HES transfers metering information to the external Metering Data Management Systems (MDMS), which enables handling of meter data and consumption events for further use by the various utility applications such as billing, data validation, distribution planning and reliability, revenue assurance, etc.

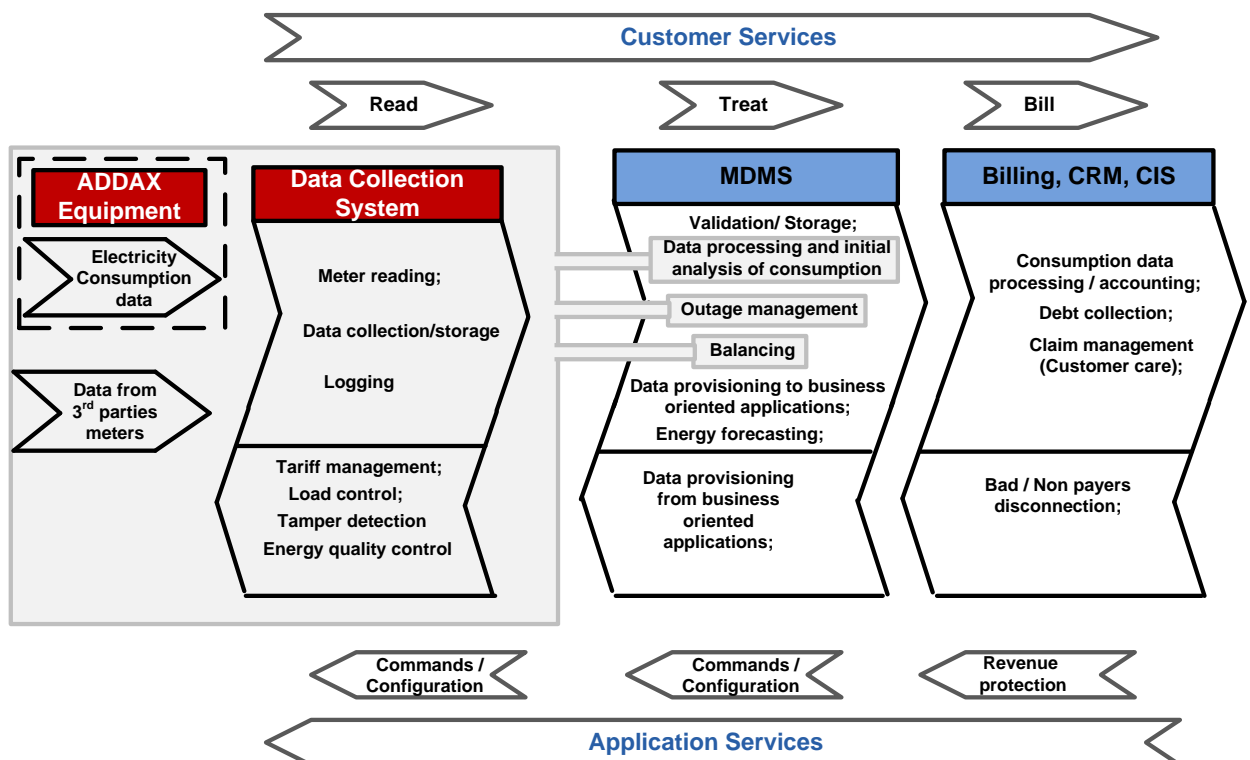


Fig. 1 Meter-to-cash business processes.

ADDAX meters can be a component of 3rd party metering system. In this case instead of SIMS another data collection system is used (see Fig.1). Easy

integration of the meters is possible due to their compliance with open standards.

The main business processes supported by ADDAX AMI are presented below in brief:

Meter reading

The ADDAX meters record parameters on consumed electric energy in the registers such as active/reactive energy, active energy import/export, reactive energy 4 quadrants, active/reactive power, max demand, TOU, etc.

Data collection and processing

Head-End System (HES) supports remote data exchange with end-point devices, data acquisition automatically and on-demand.

The HES Repository stores the collected and processed data from the meters, including interval and real-time readings, event logs, outage history, etc. One can configure remotely from HES the list of parameters to measure and store.

Integration

ADDAX IMS provides 2-way integration with other systems on two levels:

- The backend application level - based on WEB-services architecture.
- The concentrator level using P3.2 protocol of Dutch Smart Metering Requirements companion standard [References, 2].

Open standards and protocols

ADDAX IMS allows interoperability and interconnectivity with measuring devices and compatible components (hardware/software) of the AMR/AMM/AMI systems produced by other manufacturers. Open stacks for both the communication and application protocols are based on DLMS/COSEM standards. DSMR (Dutch Smart Metering Requirements) as backbone functionality is used.

Logging

All the events generated by a meter itself or by its environment are logged with the timestamp, which indicates time and date when an event occurred.

Tariff management

ADDAX meters provide multi-rate metering of consumed active and reactive energy in single-phase and three-phase power networks. The meter can set time-of-use (TOU) tariffs within predefined intervals during the day. The tariff parameters can be remotely configured from the Centre.

Electricity quality control

ADDAX meters measure and report data on power quality (such as voltage min/max, sags/swells, detailed power outage data etc.); organize events by the meter (disconnection/ reconnection of the customer), push alerts to the consumer and head-end systems.

Outage management

Outage control provides detailed information on power off such as number and total duration of outages both for short-term and long-term outages which are less or more than stated limit correspondingly. The limit can be configured from 1 minute.

Load control

ADDAX Solution allows effective load management that provides the ability to remotely disconnect or reconnect a customer's load by use of different type of relays. The basic 80/100A relay allows remote, local (by a function of the meter, e.g. limiter) and manual (by push button) types of control. The remote control can be carried out by address command for a meter and by group command for a group of meters.

The extra relays (one of 5A or two of 2.5 A) permit disconnection/reconnection of consumer's power load from/to supply line via an external contactor in accordance with the specified schedule or directly from the Master Station.

Remote upgrade

The ability of remote firmware upgrade of ADDAX devices allows adding new functionality, optimizations in firmware, eliminating possible defects.

Tamper detection

ADDAX IMS allows immediate notification of any tampering attempts by opening the meter cover or the terminal block cover, altering meter wiring, influencing its function with an external magnetic field. Measuring both in phase and neutral wire provides the ability to detect differential current (a difference between phase and neutral currents) which can be an indicator of the meter operation intervention.

HAN support

ADDAX Solution supports 3rd party HAN metering devices (gas, water, heat meters, in-home displays) and multi-utility applications.

Home appliances access to the network via the following mechanisms which are available in the ADDAX meter:

1. Using communication modules placed under the ADDAX smart meters terminal cover (e.g. M-Bus wired or wireless module)

Balancing

The system provides methods identifying potentially fraudulent behavior by analysis of energy balance, which is the difference between supply and consumption in a network sector.

2. Architecture and main components of ADDAX Solution

2.1 Architecture of the overall solution

ADDAX IMS solution is based on three-level architecture (simplified diagram is presented in Fig.2 and Fig. 3). The lower level comprises customer devices (smart meters, including HAN equipment), and customer interface units). The intermediate level is responsible for managing the communication between end-point equipment and the Master Station, linking all three layers. The main communication technologies at the meter level are PLC LV, Hybrid PLC+RF, Point to Point communication 2G/3G/4G and 3GPP/Ethernet. At Data Concentrator/Gateway level 2G/3G/4G and Fiber optics through Ethernet switch are possible. HAN devices communicate with the ADDAX meters via M-Bus wired/wireless.

The core of the upper level is Data Collection System, which provides all necessary data to MDMS, Billing System etc.

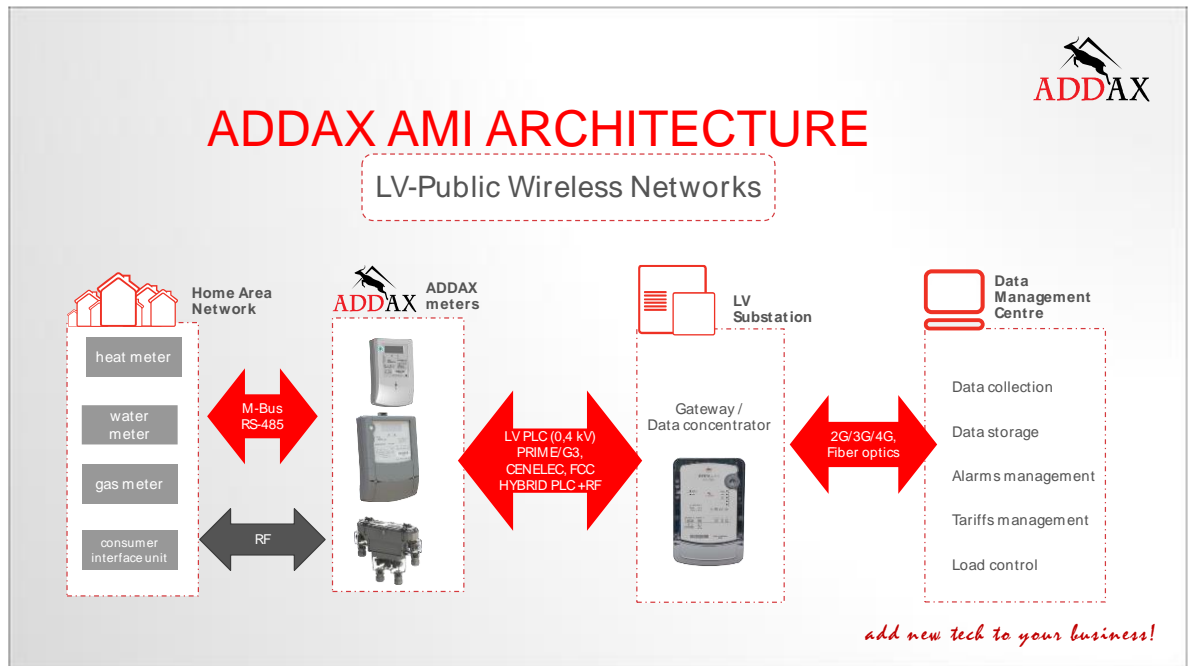


Fig.2 Architecture of ADDAX Solution with Data Concentrator/Gateway

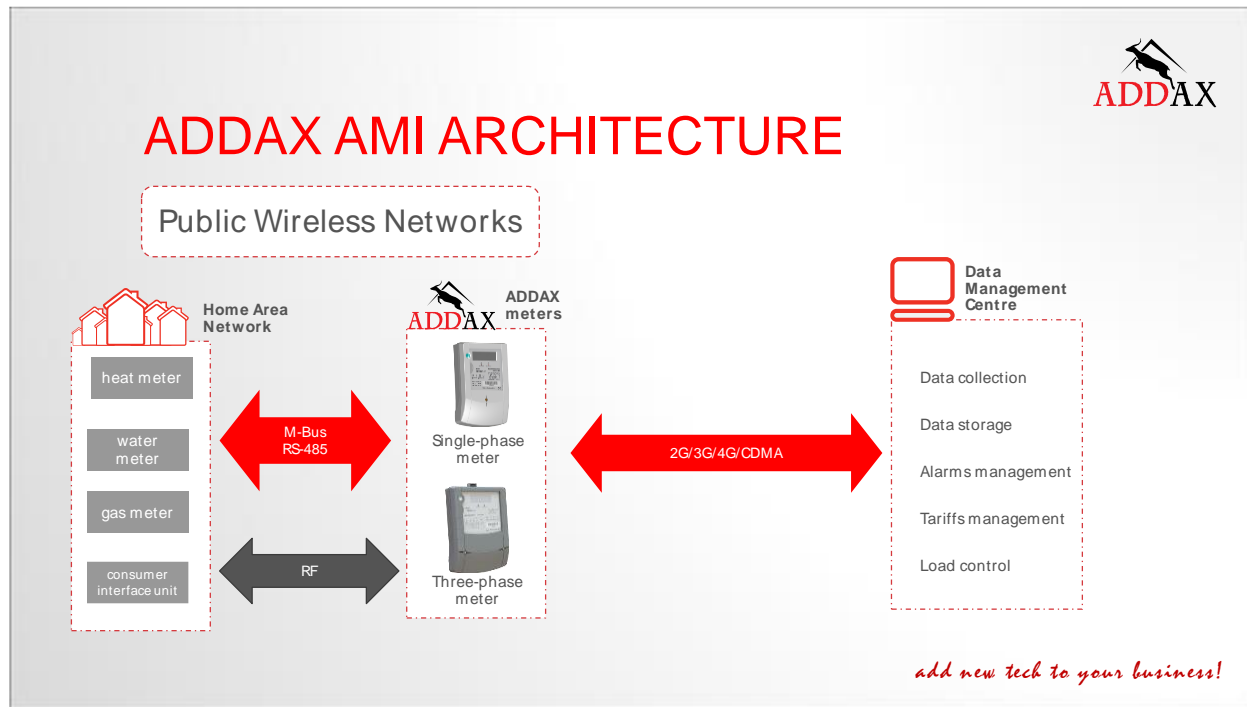


Fig.3 Architecture of ADDAX Solution Point to Point

ADDAX AMI solution architecture is presented in details of communication and protocols in Annex.

2.2 ADDAX Smart meters

The main components of the metering system are the ADDAX Smart meters, such as a single-phase, 2-wire; 3-phase, 4 wire direct connected (with the maximum allowed current up to 100 A) or transformer connected meters with the maximum allowed current up to 10 A and nominal voltages 3x57.7/3x120/3x230 V.

Optionally different communication interfaces can be integrated (M-Bus wired/wireless, RS-485 etc.). The meters are high accurate devices suitable for residential and light industrial metering. Accuracy class for direct connected meters: 1 (active energy) and 2 (reactive energy); for transformer connected meters: 0.5s (active energy) and 1 (reactive energy).



The Smart meters are capable of two-way communication. Each meter is equipped with built-in PLC-modem, PLC-and-RF modem or 3GPP modules placed under the terminal block cover (optionally) that provide the communication interface to the Data Collection System: via Router/Data concentrator for PLC or directly via 3GPP.

ADDAX meters enable electricity metering, load control and data transmission upwards to the ADDAX HES, as well as enable remote parameterization and remote upgrade of meter software.

ADDAX meters record parameters on consumed electric energy in registers according to DLMS/COSEM requirements:

- Active energy, absolute value

- Active energy in forward direction, import
- Active energy, import, tariff 1...6
- Active energy in reverse direction, export
- Active energy, export, tariff 1... 6
- Instantaneous active power
- Active Max Demand
- Active power for each phase
- Reactive power
- Reactive power for each phase
- Reactive energy in forward direction, import
- Reactive energy in reverse direction, export
- Reactive energy in quadrants
- Instantaneous/average voltage per phase
- Instantaneous/average current per phase
- $\cos \varphi$
- The angle between phase voltages
- THD, apparent power (KVA) for 3-phase meters

Basic consumption data are registered in the meter profiles over 5, 10, 15, 30, 60 minutes intervals.

Depending on the meter type, the Smart meters can be equipped with different type of relays (basic relay 80/100A, extra relays 2.5A, 5A), which are used for the real time load control and power consumption limiting.

The basic relay allows remote, local (by a function of the meter, e.g. thresholds) and manual (by push button) types of control. The remote control can be carried out by address command for a meter and by group command for a group of meters.

The extra relay permits disconnection/reconnection of consumer's power load from/to supply line via an external contactor in accordance with the specified schedule or directly from the Master Station.

The ADDAX meters are equipped with sensors enabling detection of tampering events, such as meter case opening, terminal box opening, strong magnetic field and differential current appearance.

The meters provide possibility of additional communication interfaces:

- for data exchange with other smart devices such as HAN appliances (M-Bus wired/wireless, RS-485)
- for direct communication with the Master Station 3GPP

2.3 Data Concentrator/Router

The ADDAX Data Concentrator/Router (DC/R) provides communication via different channels ensuring data exchange between the end-point devices and HES and long-term data storage.



DC/R supports the downstream communication by PL LV, Ethernet or 3GPP (2G/3G/4G), respectively. Auxiliary communications, such as USB, RS 485 can be supported optionally. DC/R ensures data collection by schedule or on request.

Key features:

- Transmitting metering data and alerts to the HES via Ethernet or 2G/3G/4G;
- Transmitting commands from the HES to the Smart Meters;
- Automatic detection, registration and support of the end-point devices within the network;
- Synchronization of Smart meter's clock with the HES system time;
- Support of up to 1000 end-point devices.

2.4 Customer Interface Unit

Customer Interface Unit (CIU) is intended to visualize metering data, when the meter is installed at an out-of-reach place or if the direct reading-out of the metering data is inconvenient.

CIU supports the following functions:

- Data exchange RF communication channel.
- CIU displays user information on the LCD. The user information comprises metering data from electricity/ water/ heat meters.
- Potential support of STS through keypad CIU
- CIU enables remote load control by means of the push button.
- A customer can be informed or warned by text messages which are sent to the CIU from the Master Station.



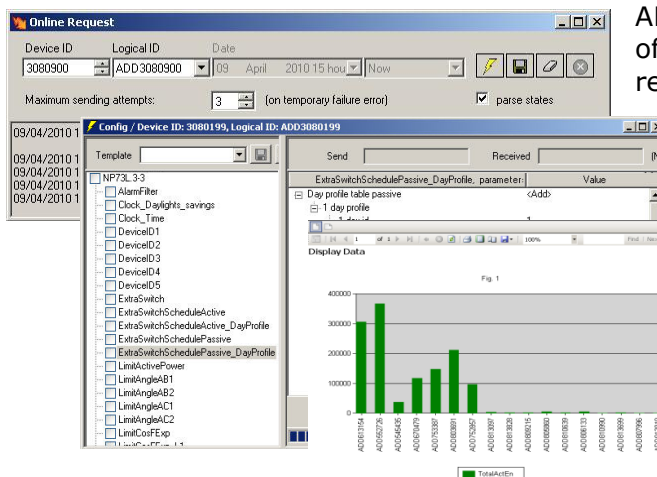
2.5 Smart Integrated Metering System (SIMS)

SIMS represents a key software component of the ADDAX Metering system.

SIMS provides (real-time) meter reading on demand, remote parameterization of

ADDAX devices and firmware upgrade of meter and data concentrators, remote control of meters, e.g., switching on/off, monitoring of alarms and events, etc. SIMS application can be used for up to

500,000 meters



The data stored in non-volatile memory will be automatically requested until the meter sends it or send 'no data' answer. The System validates the meter values on collecting. All invalid data are discarded.

The data is validated in compliance with DLMS/COSEM requirements (Blue book) using the "doubtful" attribute (AMR statuses, e.g. time error, measurement error etc) received from the meter.

SIMS software enables export of accurate information to billing system regularly and on-demand. The system allows tariff planning according to customer needs.

SIMS provides interested parties with the necessary information through WS web-services or file exchange.

SIMS is compatible with Windows XP Professional SP2 or latest operating system. Applications related to the operation of the system utilize the Microsoft.NET framework for interoperability.

The main components of SIMS architecture include:

- **SIMS application server**, which automatically manages the load and processes the tasks. It provides data collection functions necessary to schedule readings of meter interval data and meter registers from data concentrators and store that data in the central database.
- **SIMS application clients** deployed on multiple operator workstations to provide daily operation of the system by monitoring and administering the network, visualizing the data, remote configuring, meters control etc.
- **Relational-type database Microsoft SQL Server** to store the meter register readings, load profile data, as well as all configuration data required to read a meter, and to associate the metering data with metering points, customers, and premises within the network.
- **DNS - Domain Name Server** (optionally) to convert host names and domain names into IP addresses on the Internet or on local networks that use the TCP/IP protocol.

3. Communication

ADDAX IMS supports 2-way communication:

- Upstream - meter reads and events from ADDAX and 3rd party meters are transmitted via DC/router to the Master Station. Meters that are equipped with 3GPP modem transmit data directly to the Master Station.
- Upstream - 3rd party multi-utility meters transmit metering data and events to ADDAX electricity meters.
- Downstream - commands for remote disconnect/reconnect are sent from the Master Station via DC/routers or directly via 3GPP interface to the meters
- Downstream - parameterization and FW updating tasks are transmitted from the Master Station to DC/routers or meters, CIU, and other equipment (via DC/routers).

3.1 Communication channels and interfaces

3.1.1 PL LV communication

PL LV is a basic communication technology of ADDAX solution, which uses existing communication lines, and thus providing a low-cost transmission of data in the system.

ADDAX PLC covers different modulations:

- OFDM PRIME, data rates 21-64 kbps with coding (on physical layer).
- OFDM G3-PLC, compliant with G3 Alliance G3-PLC specification, data rates 20-46 kbps with coding .

Key features:

- EMC standards compliance;
- DLMC/COSEM compliance;
- CENELEC and FCC;
- Auto-discovery;
- Repeating mechanism.

Any ADDAX device with PLC-modem can operate as a repeater on the long network distances. Maximum possible distance subject to the repetition mechanism can reach more than 2.5 km (8x350m).

Data exchange through PLC LV on the customer side is provided by the ADDAX Smart Meters.

3.1.2 Hybrid Solution

Currently the Hybrid solution represents fully merged PLC + RF Network based on G3-PLC. Each node has PLC or PLC+RF connectivity to others (or RF only). The route is built with hop-to-hop selecting between the "best" channel. The channel selection is automatically done during network setup and dynamically adjusted based on the media status as in regular G3-PLC.

The hybrid protocol stack is built using open standards IEEE 802.15.4-2015 in addition to the existing ITU-T G.9903 G3-PLC protocol. The G3-PLC Hybrid

profile is fully compatible and interoperable with existing G3-PLC implementations, so it is possible to mix hybrid and non-hybrid nodes.

In the PLC channel everything remains as described in 3.1.1. RF Channel currently can operate in frequencies around 432, 868, 915 MHz.

3.1.3 M-Bus interface

Home appliances access to the network via the ADDAX smart meters by standard M-Bus wired or wireless interface. ADDAX meter operates as a master. The readout of HAN meters is performed periodically by the ADDAX meter which stores the consumption data of HAN meters and makes it available for the Master Station via PLC or 3GPP. There is no direct access from the Master Station to HAN meters.

M-Bus wired/wireless channel allows transmission frequency ranges from 300 to 928 MHz in compliance with EN 13757-4.

3.1.4 RS485 interface

RS485 interface serves several purposes.

It is the interface for connection of 3GPP module to enable meter communication directly with the server.

It supports multidrop configurations, thus allowing the connection of multiple meters to a single bus using one meter with 3GPP module as master.

It represents a P1 interface for consumer access as described in Dutch Smart Metering Requirements (DSMR)

4. Key Functions and Processes

4.1 Identification

Each ADDAX meter and each type of measurement values are clearly identified according to Blue book, COSEM Identification System and Interface Classes.

There are several identifiers for use within the frame of ADDAX IMS:

Device ID 1	Electricity meter serial number (Serial number of the device, handled by the manufacturer)
Device ID 2	Electricity meter equipment identifier (Owned and handled by the utility, has no meaning to the device)
Device ID 3	Function location (Owned and handled by the utility, has no meaning to the device.)
Device ID 4	Location information (Owned and handled by the utility, has no meaning to the device.)
Device ID 5	No special meaning defined (General purpose ID for any identification purposes. Owned and handled by the utility, has no meaning to the device)
COSEM Logical Device Name	Device logical identifier comprising a prefix (usually it is Company-Manufacturer name) and a number, which depends on the device type (for meters it is unique ID). The logical name contains an OBIS identifier
Customer code	Identifier of the customer, to which device is assigned. It is the unique identifier within a system, which links System device with an external system
Bar code	EAN code is used for marking on the meter nameplate
OBIS codes	Identify the meter parameters according to IEC 62056-61

4.2 Device Registration

To register newly installed meters, the discovery procedure is started automatically. Details of the registration process are presented in [3].

4.3 Parameterization

Parameterization can be carried out remotely from the Master Station using available communication channels (Ethernet, 3GPP) or manually via the optical port.

There are several default meter configurations, which can be used at the production stage. The default configuration can be customized to the specific needs of the customer on negotiating.

4.4 Synchronization

The ADDAX system supports continuous remote meter's clock synchronization. DC sends broadcast time synchronization messages to meters. The message transmission is latency-dependant, considering the number of repetition levels to reach the meter. DC time is synchronized automatically with NTP server.

If the time deviation between DC and the meter clock times is larger than configurable synchronization limit, this is logged as the following events: clock adjusted old time and clock adjusted new time.

4.5 Manual acquisition

Data can be collected manually via the optical port using PC with specialized software or requested from the Master Station (ADDAX Client) by on-line commands.

4.6 Data export

ADDAX IMS supports two different types of export:

- in **automatic mode** data are exported to external information systems in accordance with predefined schedule at specified time and with specified periodicity;
- in **manual mode** data can be exported spontaneously at any time.

External Information System can get metering data (for example: for commercial accounting, electrical energy quality control) and at the same time can send third-party files as a feedback. These files allows authorized third-party systems to disconnect/reconnect customer meters remotely by a preset schedule, or fraud attempts are detected and sanctions are to be imposed.

There are different formats of export patterns:

- **Simple** – exported file in text format. Data are converted into text forming a table with preset separators between rows, for example - CSV-format;
- **Extended** – allows specific formatting of each column separately. For example: to display data in binary form, to set different separators between different rows, etc.;
- **Preset** – simple format previously set to facilitate a user work.

ADDAX IMS also provides full 2-way integration with other systems based on XML-files and WEB-services architecture.

4.7 Alarm handling

If an alarm occurs, the proper flag in the alarm register is set and the alarm data are sent to the Master Station.

The alarm flag in the alarm register remains active until it is cleared from the Master Station.

The list of events, which are treated as alarms, is configurable. Typically it includes fraud attempts and critical errors.

In all load profiles a simplified status code is used for every entry. It can only be used for profiles containing cumulative values.

The alarm is transmitted to the Master Station if its duration is more than specified value. The minimum alarm duration is configurable; by default, it is equal to five seconds.

The meter with 3GPP channel is able to transmit an alarm to the AMR system even in case of 3-phase outage (within the stated time interval) as "last gasp" notification.

4.8 Logging

Events on ADDAX devices operation are generated by external and internal reasons that influence their operation. Events are aggregated and stored in different logs depending on the event type. For example:

- **Fraud Detection Log** – events related to fraud attempts (terminal cover and meter cover opening, strong magnetic field detection).
 - **Disconnecter Control Log** - events related to the basic relay (local/remote connection/disconnection, limiter threshold state). This log is applied only for direct connected meters.
 - **Standard Event Log** – all general events, not recorded in special logs (power state, daylight changeover adjustment, battery state, TOU changing, error/alarm register state, measurement system errors, configuration changes, clock errors, etc.).
- and others.

Each log is registered up to 300 entries. According to predefined rules, specific actions can be initiated:

- Flag is set and an event is recorded in the Error/Alarm Register, when an error or failure occurs.
- Event is reporting to external system.
- Event flag is displayed if the flag for such type of event exists.
- Load is disconnected.

4.9 Scheduling

To support the data collection and processing the schedule mechanism is used. The schedule is set remotely in accordance with a prescribed template and determines time within a day to execute jobs. Different types of schedules are provided for different processes:

- **Data collection** – data request schedule for parameters: daily, hourly, an interval during a day
- **Tasks execution** – auto backup, switch tasks from a file
- **Device operation** (meter extra relay). The schedule is set in accordance with a specified profile, which comprises information on required disconnection/reconnection modes for different daily periods.
- **Tariffication** (time-of-use tariffs)

- **Data export** by using preliminary specified schedule (see 4.6 for details).

4.10 Repetition mechanism

Direct communication between a router/DC and remote meters can become impossible if the PL-trunk is too noisy or is too long. In this case, the data exchange in the PL-trunk is enabled by using the repetition mechanism. Thus, all the meters are arranged in a trunk by access levels. The meters of zero access level are those with which the router is connected directly. The meters are of the first level if their connection with router is realized through meters of zero level and so on. The frames repetition is carried out by the meters of the “visible” levels.

The maximum distance via LV network is not less than 2.5 km and via MV – 35 km subject to the repetition.

4.11 Software platform

The following system software is recommended:

Basic software / Operating system:

MS Windows 8.1 Professional

MS Windows Server 2008 R2 Standard/Enterprise

Microsoft Windows 2012 R2 Server Standard /Enterprise

Microsoft SQL Server Standard Edition 2012

Database Server:

MSSQL Server 2008 or 2012 Standard/Enterprise

All data, such as metering values, events, statuses, configurations are stored in a SQL database. ADDAX IMS provides means to backup collected information by a schedule. Data backup as well as export files with necessary information can be stored during arbitrary long time.

4.12 Task management

The system supports a task mechanism for data collection, parameterization, relay switching etc. Parameters of the task can be defined preliminary and automatically start according to the schedule for different intervals and start times, for an individual meter or group of meters.

Using tasks allows increasing efficiency of the system and simplifies its management. Special Shell Manager as a part of ADDAX Framework provides means to create, edit and delete tasks.

There are different type of tasks in the system, such as:

- **Auto backup task** – makes a copy of a specified database by predefine schedule.
- **Export task (Information systems)** – sends data to external Information Systems in accordance with the predefined export template and schedule.

- **Configuration task** – allows setting parameters and sending configuration to a group of ADDAX devices.
- **Switch task** – provides connection/disconnection of consumers according to the predefined file.

4.13 Network management

ADDAX IMS allows real time monitoring of current network status and provides tools (automatic and semi-automatic) for maintaining the network in working state. Network management is based on the following main functions:

- detecting network changes;
- identifying type of new devices;
- configuring data routing;
- displaying reports on associated devices statuses and history, time synchronization events;
- detailed software and hardware information of network devices.

4.14 Overall security solution

The security policy is implemented within the frame of standard solutions. Security is provided at different levels: communication, Data Collection System and ADDAX equipment in compliance with DLMS/COSEM security requirements.

Communication:

- AES-GCM-128 security suite is used as a PLC security feature for data encryption and authentication and key transport methods. The application protocol features several levels of security depending on the meter model:
 - Security is not imposed (default).
 - All messages are authenticated.
 - All messages are encrypted.
 - All messages are encrypted and authenticated.
- On transmitting data over public channels Virtual Private Networks (VPN) are organized between the concentrator and central system.
- GPRS authentication and encryption is based on algorithms, encryption keys and criteria specified in 3GPP specifications.
- Access rights for operating via communication interfaces are determined by security features imposed for different access levels by means of DLMS/COSEM standard.

Data Collection System

Security ensures by MS SQL means. The access is protected by standard security policy.

In addition, the right to access functions and data is managed by the administrator for each user group. Users activity (e.g. change of configuration etc.) is logged.

To ensure secure patch management the following processes are included:

- Security patches along with the detailed description and their possible impact on the system are provided.

- All standard security tools (e.g. used in Windows OS) are tested and the correspondent recommendations are provided.

ADDAX Equipment

The ADDAX meters are equipped with sensors enabling detection of anti-tampering events, such as meter case opening, terminal box opening, strong magnetic field and differential current appearance.

5. Advantages

5.1 Anti-fraud protection

The ADDAX meters provide continuous anti-tampering monitoring and control. Timely alarming and data logging allow essential reduction of fraud losses. All meters are equipped with built in anti-tampering sensors to secure against unauthorized actions such as:

- meter cover opening sensor;
- meter terminal box cover opening sensor;
- magnetic field sensor;
- differential current sensor to measure a difference between the currents in the phase and neutral wires both for the single-phase and 3-phase meters.

The presence of the differential current indicates about the possible fraud attempt. The minimum value of admissible differential current can be remotely configured by using the ADDAX software.

To protect the meters from burglar, the split meter with separated measuring and information parts was designed. In this case, the measuring part is installed in the hard-to-reach place. All information necessary for customer is displayed on the remote user display (customer interface unit). The data exchange between measuring and information parts is implemented via PL or RF communication.

5.2 Balance metering

Consumption metering, both on transformer substation and consumer side, allows the comparison of energy supply and consumption to detect and control distribution network losses.

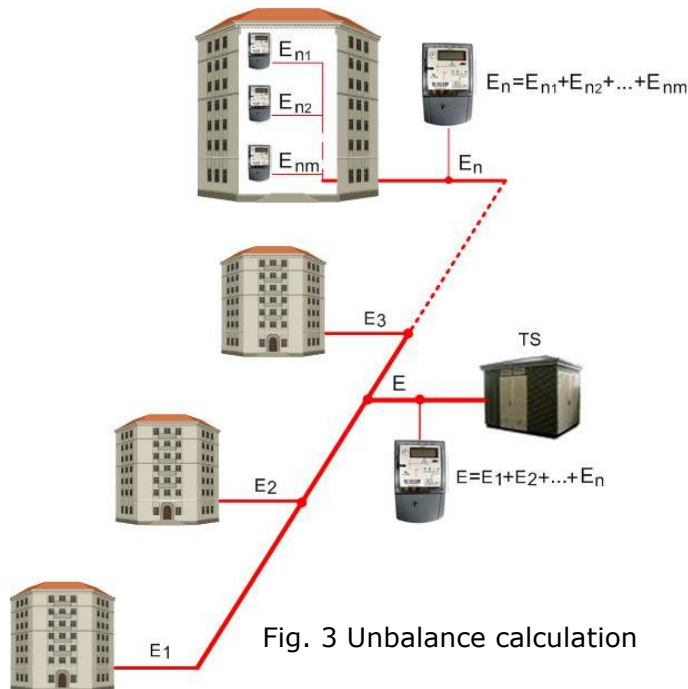


Fig. 3 Unbalance calculation

Load profiles, which register data on the specified interval, can be used to detect the imbalance on the distribution network, distinguish technical losses and fraud attempts as well as implement necessary operations to reduce losses. Time synchronization ensures accurate reading and load profile synchronization for all the meters under control.

The ADD Router collects data from the meters installed in the local premises as well as from the balance meter, which

measures the energy that flows through the distribution transformer, and transmits the data further to the HES.

ADDAX system allows controlling of the active energy consumption balance for different sectors and levels of distribution network (see Fig. 3):

- The balance within the transformer substation
- The feeder balance
- The balance inside an apartment house or entrance
- Separate phases balance.

5.3 Demand Side Management

For reducing electric energy consumption during peak load hours, Demand Side Management (DSM) is supported. The DSM provides the limitation and redistribution of the daily load in power networks by means of remote scheduled load control.

The ADDAX meters are equipped with relays to control consumer's primary load (using basic relay 80/100 A) and secondary load (via external contactor by extra relay 5 A). The relays are used for the emergency load control, scheduled load control, and power consumption limiting.

Emergency load control

Allows a quick customer disconnection, which promptly reduces peak load. The specified meter can be remotely switched off in the HES.

Scheduled load control

Is used to shed the load by an extra relay during peak hours. The pre-defined schedule is remotely set in the meter in accordance with a specified profile, which comprises information on required disconnecting/reconnecting modes for different periods of a day. This shedding provides customers with an improved support to shift the consumption to off-peak periods.

Power consumption limiting

Is another efficient method to decrease peak loads. The load control is a built-in feature presented in the all ADDAX meters. It permits to disconnect the consumers when the power consumption exceeds the predefined maximum value.

5.4 Electricity quality control

Electricity quality monitoring allows optimizing both the distribution systems and technical costs. It provides a complete picture of current energy and resource usage; that can be applied to improve the system reliability and efficiency as well as to detect the energy losses caused by leakages or fraud. It is possible to solve easily the problems related to consumer's complaints about the electricity quality.

For each phase, the following power quality indices can be monitored:

- instantaneous voltage and current;
- voltage sags and swells;
- outages;
- power factor;
- phase absence etc.

When the predefined limits are exceeded (e.g. maximum current, voltage etc.) the system can automatically disconnect the consumer to ensure his safety.

The outage control provides detailed information on the power absence, number and total duration of outages both for short-term and long-term outages.

The delivery of the alarms on energy quality can be configured remotely from the Data Management Center. Scheduled alarms and data logging prevent losses in the distribution systems.

5.4.1 1 or 2 phase interruption for 3-phase meters

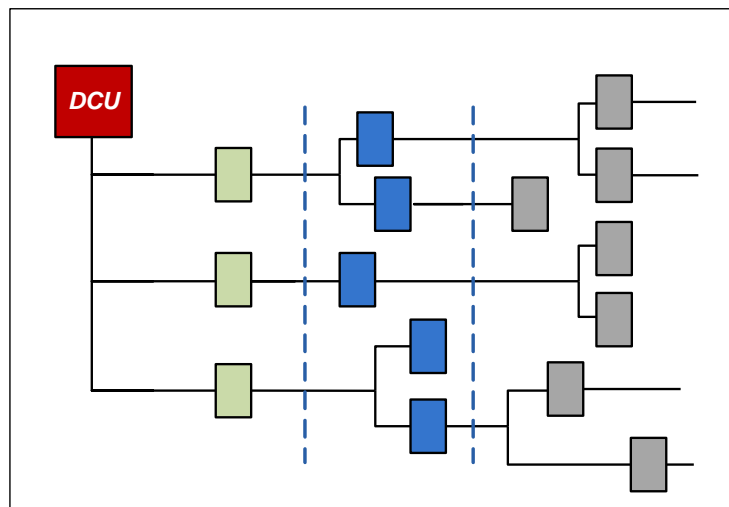
The event of 1 or 2 phases absence is monitored by the meter and the relevant flag is set in the Master Station as well as the proper symbol is displayed on the meter LCD. The phase absence events are logged in Extra Event Log with indication of time when the event occurs.

5.4.2 3-phase interruptions for 3-phase meters

As it known the main reason of power off incidents (power failures) is automatic feeder breaker actuation in the event of interphase short-circuits, abrupt change in loading, earth faults, etc. at cable breakdown.

To control the feeder state the current statistics of PL communication with specified control points is used. These control points which are usually 3-phase meters with PL-communication module can be selected during the system installation stage or later when the communication quality is analyzed.

The meters to be selected should be located fairly close to the concentrator (DCU) so that the communication between meters and concentrator is stable without using repeaters.



Data Concentrator (DCU) pings the control meters periodically, e.g. once per minute (the periodicity is configurable). If there is no answer from the nearest control meter (green boxes in the figure above) the concentrator requests the meter placed on the next level on the same feeder (blue boxes). In case the next level control meter does not respond the concentrator sends 3-phase interruption alarm to the Master Station. The meter distribution along the feeder can be obtained from the Distribution Management System.

For 1-phase and 3-phase meters with 3GPP modem the following solution is used.

In case of 3-phase outage within the stated time interval the meter transmits the respective alarm to the AMR system as “last gasp” notification, by establishing 3GPP connection or by sending SMS

5.4.3 Phase interruption for single-phase meters with PLC-modems

The mechanism for feeder alarm detecting is similar to that described for 3-phase meters.

As a rule one single-phase meter is installed for each phase as control point device. Data Concentrator (DCU) interrogates the control meters periodically. If there is no answer from the control meter the concentrator requests the meter placed on the next level on the same phase. In case the next level control meter does not respond the concentrator sends power interruption alarm to the Master Station.

5.5 Multi-utility metering

The ADDAX Integrated metering enables the management of several resources (electricity, gas, water, and heat) within the framework of a single metering solution. Figure 2 shows communication between the components of the ADDAX system and different metering equipment of external suppliers. The meter from the external suppliers are integrated in the ADDAX AMI by means of the M-Bus or USB interfaces. All market players (Grid Companies, Suppliers, and Service providers) can access their metering data.

To integrate external devices the ADDAX electricity meters are used as a gateway for both the Home Appliances Network and high level distribution system. For this purpose, the ADDAX meters are equipped with additional communication module.

The ADDAX electricity meters can be remotely configured in the HES to store the metering data in the nonvolatile memory, to deliver the data to the HES on a schedule or request, and to monitor the status of the integrated equipment.

Using a common communication infrastructure, the integration of the different resources in the common system results in a substantial decrease in the deployment and operating costs.

6. Deployment

ADDAX IMS can be deployed by several stages because its architecture is highly adaptive to the specific conditions of the deployment. Using of the S-FSK/OFDM modulations makes it possible to speed up PL-communications, providing a great volume of transmitted application data, the reliability of data transmission, and remote device upgrading in case of its application functionality.

ADDAX equipment represents a set of plug-and-play devices which are registered automatically in the system after their installation and successful communication with a router/concentrator.

The whole system is scalable and can be easily deployed by performing the following activities:

- Installation of routers/data concentrator at the current transformer station
- Installation and commissioning of the data collection system: hardware and software
- Installation of single/three phase meters.
- Installation of additional equipment (e.g., CIU)
- Commissioning of communication systems for the meters
- Integration of the Data Collection System with the Billing, CIS, and CRM systems.
- Overall commissioning of the entire end-to-end metering and data collection system.

To provide the normal functionality of PL-communication the ADD Network Filters, RML Monitors, and Coupling Units (CUs) are used as system tools.

- Network Filters: Applying of filters allows considerable increasing of signal/noise ratio that leads to improving of stability and communication quality in data collection and transmission network.
- RML Monitors: The RML Monitor is intended for testing the signal/noise ratio via PL-trunk at the local places in the LV-MV Lines. It is also used to determine a phase shift, network frequency, level of the total and useful signal, length of a packet, phase on which the packet was transmitted, number of received and loosed packets. It can detect the packets from the indicated device. It listens to the communication between master and clients and fixes channel logs.
- Coupling Units (CU) operate as an "intermediary link" between the Data concentrator and MV line. It enables transfer of high-frequency low-voltage signal produced by the MV modem to 6/15/22 kV line. Depending on the line types (overhead or ground cables) capacitor or inductive coupling units are used.

7. References

No.	Ref.	Title
1	DLMS UA 1000-2: 2007, Sixth Edition	Architecture and Protocols "Green Book"
2	Dutch Smart Metering Requirements	P3.2 Companion Standard, DSMR, v2.31
3	ADDAX Maintenance documentation	Data Concentrator version 8. Technical Description"
4	ADDAX Maintenance documentation	ADDAX meters. Technical Description and User Guide.
