Energy sector

A description of a comprehensive solution for power quality monitoring in electrical distribution companies *MiSMART*

Iskra®

Iskra Sistemi

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1 The problem of power quality monitoring in the electrical grid

The basic challenge which Iskra SISTEMI d.d. is addressing within its solutions for electrical distribution companies is monitoring the power quality of the electrical grid also known as PQMS (Power Quality and Monitoring System). This addresses a comprehensive solution to the problem of control over the quality within the complete electrical power grid in all its segments which represents a global trend in development and modernization of the electrical power grid as a whole.

PQMS projects are of vital importance to electrical distribution companies for many reasons out of which the most crucial ones are stated below:

- ***Centralized monitoring and measuring of electrical power quality both in normal operation and in cases of faults,***
- ***Monitoring the level of electrical power quality within the electrical distribution grid in accordance with regulatory required standard EN50160,***
- ***Connecting data from measuring instruments within the PQMS system with other core business applications (e.g. ERP, CRM systems) as well as with existing control systems (SCADA),***
- ***Analyzing the behavior of the complete electrical power grid system in extreme circumstances during which it can enable an accurate detection of equipment faults within the grid,***
- ***Constant alarm notifications on potential faulty events,***
- ***The capability of electrical power grid quality reporting and exporting data in standardized export formats for established PQ SW tools (PQDiff, Comtrade),***
- ***Load profile monitoring and demand site monitoring of the electrical power grid during its operation,***
- ***Simplifying new investment decisions within electrical power grid based on the data which is acquired through the PQMS system,***
- ***The possibility of establishing a more individualized business approach with larger consumers.***

2 Approaching the power quality monitoring challenge within the electrical grid

Al PQMS projects need to be addressed comprehensively by locating the optimal solution to the customer's problem. The common problem setup can always be represented as consisting out of three basic building blocks:

1. ***Measuring instruments (meters),*** which are normally positioned at the point-of-common-coupling (PCC) of small and medium industrial and commercial energy consumers to monitor quality of delivered electric energy or at medium or low voltage feeders (transformer stations) to monitor the operation of consumers. Their fundamental function is measuring basic electric quantities (U, I, P, Q, f, PF...) as well as power quality parameters (e.g. flickers, unbalances, (inter)harmonics, voltage events...) and sending them at predefined time intervals to the data center through the communication network.

2. ***Communication network*** through which all data is being transferred to a central PQMS collection point. The communication can be established through various infrastructures depending on various factors such as physical terrain configuration, network availability or business requirements. TCP/IP communication is being utilized through communication infrastructure such as:
   a. LAN (local area network within a building),
   b. WiMAX (for long range wireless communication),
   c. GPRS, which utilizes the GSM 2nd generation infrastructure,
   d. Direct optical link,
   e. SMS – which many times represents a cheaper and less signal-dependent alternative to GPRS.

3. ***Data center*** *MiSMART* deployed on a high-availability server with a three tier infrastructure which comprises of:
   a. Collecting data from measuring instruments through the *MiSMART data collector module*. The data can either be sent by the device independently (push principle) or requested by the server on demand (poll principle),
   b. Database for storing collected data from measuring instruments (*MiSMART database module*) which enables connecting to other 3rd party clients by either importing external data or exporting data to external systems. At the same time a backup copy of database data can still be stored locally at each devices' memory,
   c. The presentation level which enables the users to review and interpret all data by means of an advanced web based application using any type of standardized web browsers (*web server module*).

   The main purpose of the MiSMART system is collecting and reviewing of meter data as well as communication with the measuring instruments which are manufactured by Iskra Sistemi d.d. aswell as other manufacturers. Its open architecture allows the system to pair with any type of device which communicates via Modbus protocol.

The three described building blocks are depicted in the following two figures which describe a transition from locally monitoring power quality data (PQMS) at 7 distinct meter points to their centralized collection at a data center with MiSMART:

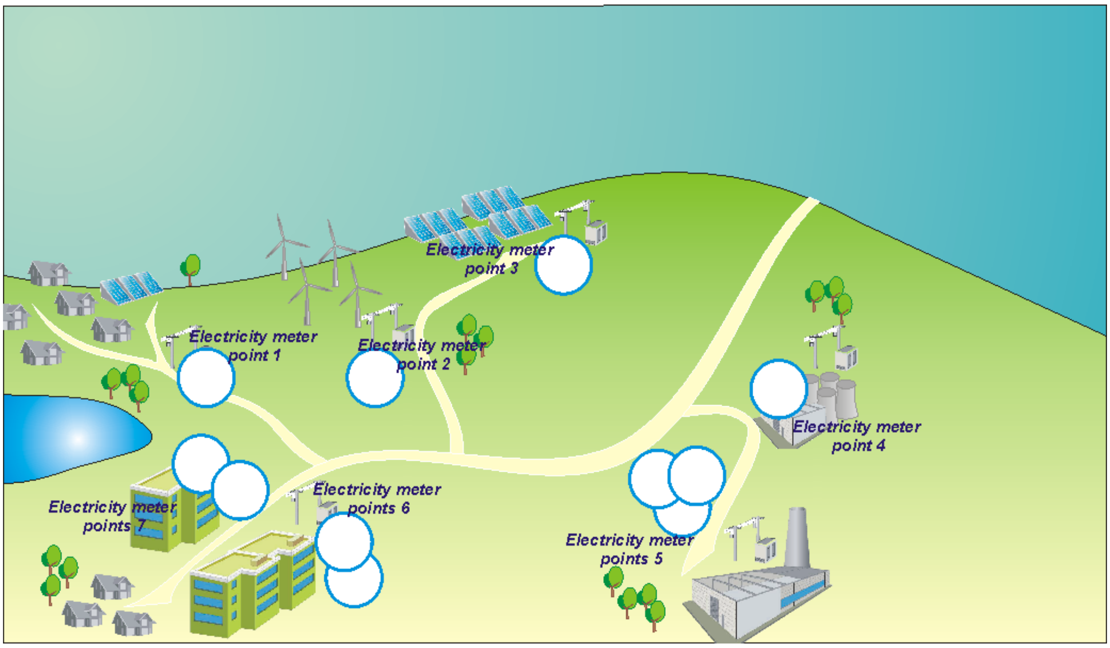


Figure 1: The need for power quality monitoring in the electrical distribution grid

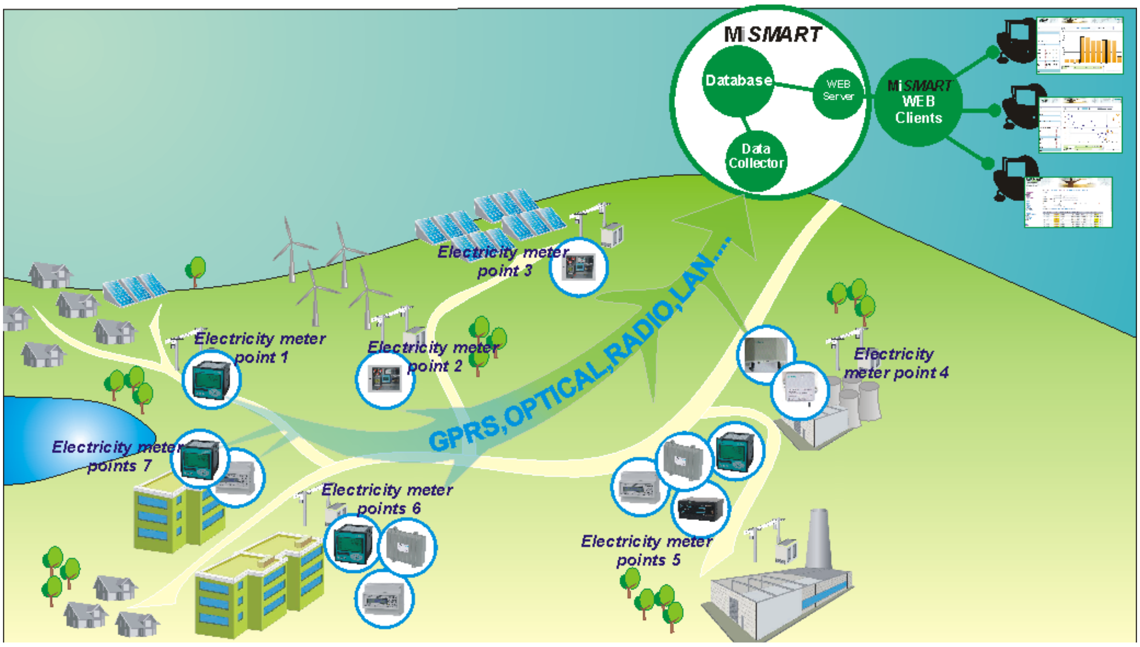


Figure 2: A comprehensive PQMS solution

2.1 General PQMS project characteristics

According to experience we generally state the following business and technical requirements when dealing with typical PQMS projects:

- ***Measuring and monitoring the electrical power quality with consumers of electrical power as well as with its producers***. Together with the existing electrical energy revenue meter system the PQMS system can provide a supplement and hence an independent assessment of the electrical power grid condition and a whole range of other measurement data which is not provided by standard energy meters.

- ***Constant monitoring of the electrical power grid during its normal operation*** through alarm monitoring and reviewing received measurement within the PQMS system. In the starting project phase events corresponding to grid anomalies need to first be defined within the measuring instruments. These events are then propagated through the systems as alarms. If there are no alarms this represents normal operation of the electrical distribution grid.

- ***Analyzing system behavior in case of electrical power grid faults*** which relates to monitoring the appearance of alarm events within the system. When alarm events occur they can be immediately detected within the PQMS system thereby enabling quick interventions following the occurred situation.

- ***Monitoring the level of electrical power quality within the electrical distribution grid in accordance with EN-50160***, which defines criteria for determining the electrical power quality.

- ***The possibility of determining predefined preferred meter points within the PQMS based on the customer requirements*** which is especially useful when there is a very large number of meter points. In such cases this can significantly shorten search time required for locating a desired dataset for displaying.

- ***Open system architecture enables connectivity to other back-end applications*** within the enterprise such as ERP or CRM systems or other IT systems which may be in place.

- ***Connecting to existing SCADA systems*** which are commonly used in an electrical power grid. Iskra Sistemi's PQMS system MiSMART enables real time communication with a wide range of SCADA systems by means of a proprietary SCU (System Communication Unit) communication interface.

- ***Ineroperability with existing monitoring and measuring instruments*** which are already in use by the company. Open MiSMART architecture which is based on Service Oriented Architecture (SOA) enables system connectivity.

- ***Analyzing the behavior of the complete electrical power grid system in extreme circumstances*** such as voltage swells which can cause significant business damage for the electrical energy distributors. In such events it is of utmost importance to be able to analyze electrical power grid behavior before and after the event has occurred and thereby determining the actual event cause.

- ***Collecting data in a relational SQL database on a high-availability server*** which continually stores all PQMS related data – i.e. measurements, alarms, PQ reports and other relevant data which is being sent by measuring instruments deployed on-site. The database also enables easier data integration with other enterprise IT systems.

- ***Locating equipment faults within the electrical power grid*** which enables operators to fix faults at known sites soon after their appearance. Consequently this can result in business benefits for the electrical distribution company through enabling much shorter fault duration periods.

- ***Continuing alarming about potential faulty events,*** depending on settings stored within instruments on-site which send alarms upon their occurrence. Measuring instruments can be configured remotely from the data center eliminating the need for working on-site. Alarms within measuring instruments are defined as measurement values which are over or under predefined limit values,

- ***The capability of creating electrical power grid quality reports,*** which are generated within the system based on predefined criteria. Different parameters can be defined within the system to which the electrical power grid data should correspond which is then used for creating reports on a predefined time schedule.

- ***Monitoring the load profile and efficiency of the electrical power grid during its operation*** can become feasible through the use of the PQMS system. The system can offer real time insight into the electrical grid behavior therewith enabling easier decisions on future grid development. (which is many times directed towards smart grids and demand side management)

- ***Simplifying new investment decisions within the electrical power grid based on the data acquired through the PQMS system,*** which can unequivocally show the strengths and weaknesses of the electrical power grid. Apart from this the PQMS system also points out to the load level of the electrical power grid points where maintenance or new operations are being conducted. The electrical power grid operator can hence be clearly informed on the potential problems lurking behind such operations.

- ***The possibility of establishing a more individualized business approach with larger consumers*** which can represent a substantial competitive advantage to an electrical distribution company. Based on real time data on consumption and the effect of larger consumers to the electrical power grid behavior an even more firm relationship between the two companies can be established.

2.2 Approaching PQMS project implementation

PQMS projects represent rather complex projects since the environment which the system is introduced to must first be thoroughly examined so that an optimal solution can be proposed to the customer.

Such projects usually depend on a wide range of factors which need to be determined prior to project startup. These factors are usually the following ones:

- On-site electrical requirements for measuring electrical quantities and for sending alarms,
- Geographic meter point distribution,
- Communication infrastructure availability,
- The need for integrating the PQMS system into the existing IT environment (e.g. ERP, CRM, SCADA integrations),
- The final number of system end-users.

To achieve an optimal project approach we address it in multiple phases – from the content perspective these are 3 phases which can in some cases also be reduced to only 2 by joining phases 2 and 3 respectively:

1st PHASE – pilot project

- *Requirement specification:*
    - Determination and agreement of technical requirements and specification of requirements through conversing with the customer and acquiring a technical opinion from remote locations where measuring instruments are to be located (A functional specification for project implementation is produced on the basis of collected data)
- *System preparation:*
    - Development in accordance with the specification
- *Deploying a few meters to agreed meter points:*
    - It is most appropriate to encompass meter points which are expected to show most variations in their data and which have different communication infrastructure (e.g. Measuring instruments communicating via GPRS and those communicating via radio link)
- *Software deployment*:
    - All required software is deployed in full functionality on servers which are agreed by both parties (work can be done remotely or on-site)
- *Using and testing:*
    - Testing, using and monitoring of deployed system behavior
- *Training:*
    - 2 days of training for some key users who will be using the system
- *Phase duration:*
    - 1 week to 3 months

2nd PHASE – extended initial deployment

- *Requirement completion:*
    - Completing the functional specification in accordance to the findings from phase 1
- *System development:*
    - Development in accordance with requirements
- *Installation of a larger number of meter points:*

        - The installation can also be done by local operators based on instructions from the system integrator
    - *Installing software equipment*:
        - SW is installed in its full functionality on predetermined servers
    - *Factory acceptance test - FAT:*
        - Using the system, monitoring its behavior and testing at the premises of the system manufacturer
    - *Site acceptance test – SAT:*
        - Using the system, monitoring its behavior and testing at the premises of the customer
    - *Training:*
        - 1 week training for some key personnel who will be using the system
    - *Phase duration:*
        - 1 to 6 months

3rd PHASE – final system deployment

- *Deploying the remaining meter points:*
    - The installation can also be done by local operators based on instructions from the system integrator
- *Installing software equipment*:
    - If necessary the remaining SW is installed in its full functionality on predetermined servers
- *Factory acceptance test - FAT:*
    - Using the system, monitoring its behavior and testing at the premises of the system manufacturer
- *Site acceptance test – SAT:*
    - Using the system, monitoring its behavior and testing at the premises of the customer
- *Training:*
    - Done upon requirement
- *Phase duration:*
    - Up to 2 months

2.3 Practical cases

<u>*Case 1:*</u>

ABOUT THE PROJECT:

The customer:	Elektro Gorenjska
Location:	Kranj, Slovenija
Project:	MV/LV transformer station power quality monitoring
Capacity:	1100 TS (53 already equipped) 53 measuring devices of which: 25 pcs. MC750 Network Recorders, 28 pcs. MC760 Power Quality Analysers

Main benefits as seen by the customer:

- Quick reaction time based on measuring instrument alarms – the reaction time has dropped from several days to only a few hours or even minutes
- Easier investment priority determination based on data acquired from the PQMS system,
- The possibility of establishing an individualized approach to bigger customers,
- Acquiring electrical power quality data in accordance with the regulatory organ under EN-50160 and generating reports for the regulatory organ
- Monitoring all meter points from a centralized location – easier power grid future development planning,
- System open architecture for integrating to other back end systems (technical database, customer database – CRM, ERP system),
- Analysing the system during faulty behaviour such as voltage sags, …

TECHNICAL PROJECT PART:

Communication infrastructure:

WiMAX, GPRS, Ethernet

Measurements:

Up to 22 measurements from each device (E, PF, U, I, P, Q, f)
Sampling time 5 minutes

Alarms: Immediate response in the following events:
voltage absence
voltage high/low
voltage high/low
frequency high/low
current high

Additional monitored signals:

Temperature – analogue signal
Intrusion detection – digital signal

Power Quality:

4 devices MC760 (all in SUB on medium voltage)

Server: IBM.....

Database: MS SQL

Software: MiSmart Management Tools
MiSmart Data Viewer
MiSmart Alarm Notificator
MiSmart Online Monitor
MiQen Setting Software
OPC server

<u>*Case 2:*</u>

ABOUT THE PROJECT:

The customer:	Georgian electro distribution company JSC Telasi
Location:	Tbilisi and surrounding
Project:	Pilot project
Capacity:	43 measuring points of total 3000 51 measuring devices of which: 47 pcs. MC750 Network Recorders (all TS and RTS), 4 pcs. MC760 Power Quality Analysers (all SUB)

Main benefits as seen by the customer:

- Quick reaction time based on measuring instrument alarms – the reaction time has dropped from several days to only a few hours or even minutes
- The capability of locating meter points with high losses - direct financial effect
- Easier investment priority determination based on data acquired from the PQMS system
- The possibility of establishing an individualized approach to bigger customers
- Acquiring electrical power quality data in accordance with the regulatory organ under EN-50160 and generating reports for the regulator
- Monitoring all meter points from a centralized location – easier power grid future development planning
- Analysing the system during faulty behaviour such as voltage sags, …
- Investment protection – e.g. temperature sensors and Buchholz relays at TS

TECHNICAL PROJECT PART:

Communication infrastructure:
Tetra radio communication on 41 locations (all TS and RTS)
Optical communication on 2 locations (all SUBs)

Measurements:
22 measurements from each device (E, PF, U, I, P, Q, f)
Sampling time 15 minutes

Alarms:

TS:	voltage absence
RTS:	voltage high/low
SUB:	voltage high/low
	frequency high/low
	current high

Immediate response

Additional monitored signals:
Temperature – analogue signal
Intrusion detection – digital signal

Power Quality:
4 devices MC760 (all in SUB on medium voltage)

Server: IBM.....
Database: MS SQL
Software: MiSmart Management Tools
MiSmart Data Viewer
MiSmart Alarm Notificator
MiSmart Online Monitor
MiQen Setting Software
OPC server

3 Measuring instruments of Iskra Sistemi d.d.

Within PQMS projects various measuring instruments from Iskra Sistemi can be used according to the customer on-site requirements.

There are many devices within the product portfolio which enables comprehensive approach in addressing the needs and requirements of our customers.

3.1 Multifunctional measuring instruments

These devices can be either:

- *Measuring centers or*
- *Measuring transducers.*

Which are used for the following purposes:

- Measuring electrical power grid parameters
- Collecting auxiliary analog and digital signals
  (such as temperature sensors, oil level sensors, unauthorized access sensors,, Buchholz relay, fuses, swithovers, …)
- Scheduled data acquisition,
- Alarms in real-time,
- Recording required relevant parameters for longer periode of time
- Control and supervision …

3.2 Energy counters

- billing of industrial clients
- sub-metering

3.3 Widely usable industrial PC - MiBOX

Many times there is a need for a general-purpose PC which can serve either as a concentrator or a complete all-in-one server including the following components:

- operational tools
- modem drivers
- data collection from devices connected to:
  - serial port RS232, RS485
  - USB
  - Ethernet
- standalone software unit

3.4 Software for measurement instrument configuration – MiQEN

MiQen software is intended for supervision and setting of instruments via PC. Network and the device setting, display of measured and stored values and analysis of stored data in the device are possible via the serial, Ethernet or USB communication.

The basic functionalities of MiQEN include:

- Setting both online and offline instrument parameters,
- Viewing current measured readings and stored data,

- Setting and resetting energy counters,
- Complete I/O modules configuration,
- Evaluation of the electricity supply quality in compliance with SIST EN 50160,
- Upgrading instruments firmware,
- Searching the net for devices,
- Virtual interactive instruments,
- Comprehensive help support,
- Exporting instrument data in standard Windows formats,
- Multilingual support,
- Supports Windows XP, Vista, W7 operating systems.

Every measuring instrument must be properly configured upon installment at a particular meter point. In this process the following parameters are typically set:

- Current and voltage connection parameters (nominal values, transfomer ratios…),
- Measurements which should be transmitted to the data center,
- Time interval for sending data to the data center,
- Time intervals for determining average measurement readings,
- Data format for sending data to the data center,
- A unique device identification name,
- …

Measuring instruments can be configured either through the device menus (only for devices featuring a display) or remotely by utilizing the MiQEN setting studio software – this software package enables a user friendly configuration process and comes together with every measuring instrument. The configuration can be done either through a serial link, USB or through Ethernet (depends on product type).

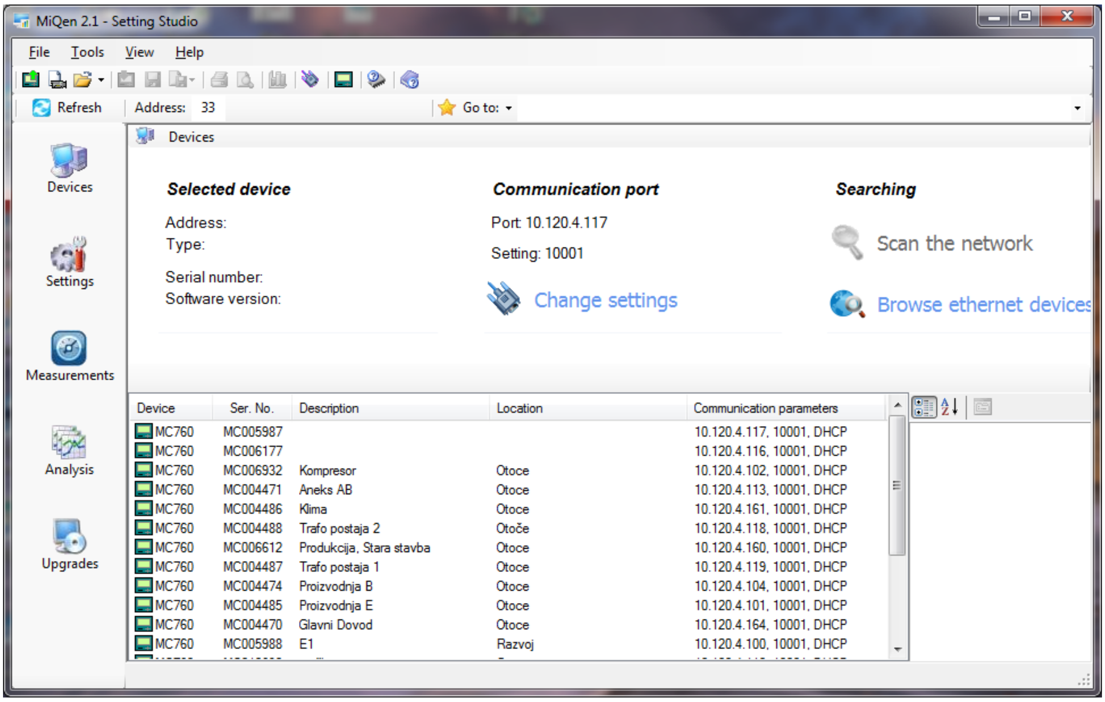


Figure 3: MiQEN Setting studio

3.5 Measurement instrument communication to the data center

Measurement instruments can easily be used within the existing communication infrastructure which should enable direct Ethernet connectivity and operation of devices such as:

- Optical networks
- GPRS communication modems
- Cable modems
- Wimax…

Or in radio networks such as

- Tetra radio

in combination with MiBox.

A complete overview of all instruments can be seen at:
http://www.iskrasistemi.si/products/20071212152244/

4 Data center - MiSmart, a brief technical description

Among other things MiSmart represents the crucial software component when addressing PQMS projects and is part of a broader spectrum of energy monitoring solutions offered by Iskra Sistemi d.d. The main application purpose is collecting data and communicating with measurement instruments manufactured by Iskra Sistemi and other manufacturers. The system utilizes an MS SQL relational database for storing data from network attached devices, while the MiSmart data monitor web application enables displaying this data to the end-user.

MiSMART represents a software platform which is basically a group of interconnected applications and technologies meant for the following purposes:

- *Centralized and automated collection and storing data from measurement instruments,*
- *Distributing acquired data and information to the end-user.*

The product operation schematics is shown below:

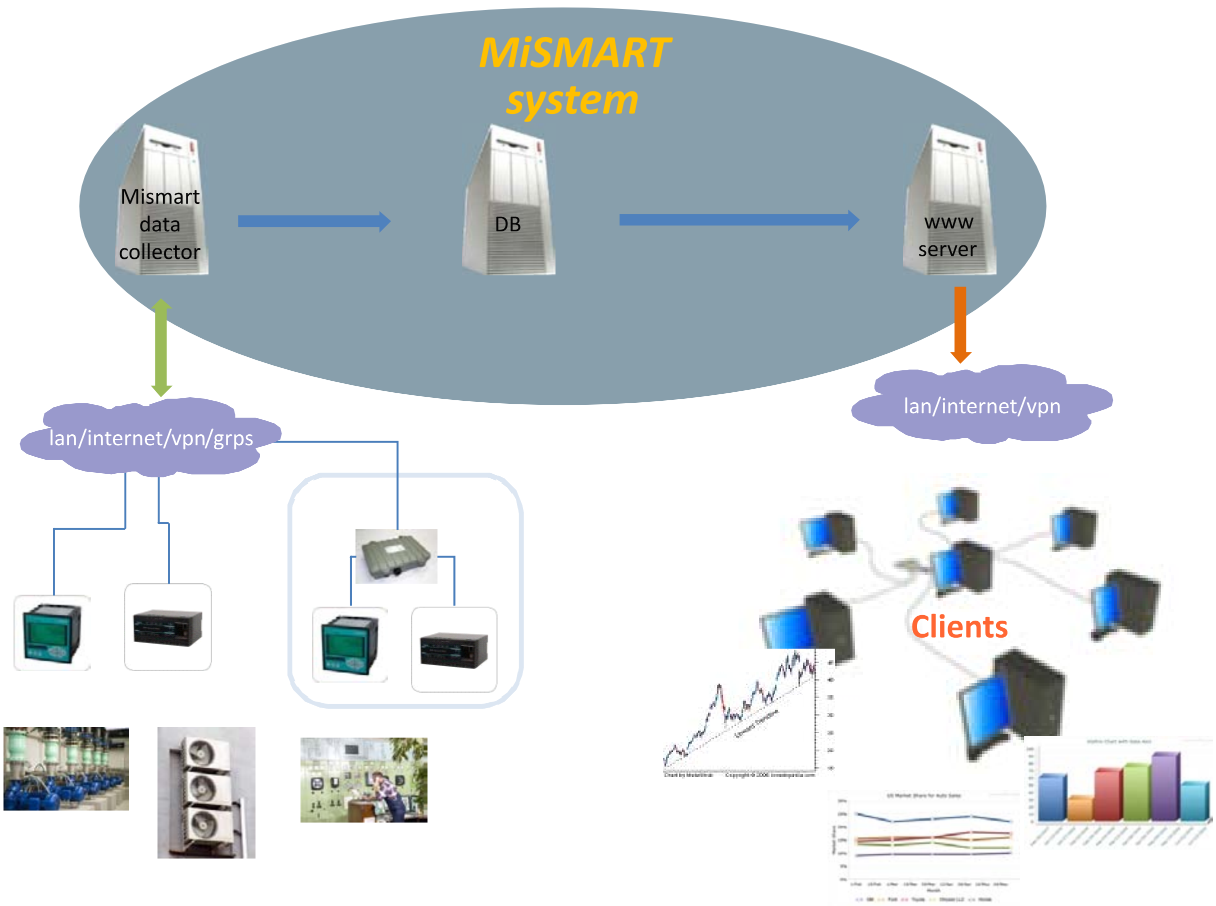


Figure 4: MiSMART operation schematics

4.1 Operation principle

Measurement instruments which are installed on-site send measurement data according to the way they are configured. MiSMART ensures all necessary components for store-ing this data into the database where they are available to various user related tools. MiSMART offers tools for data monitoring (MiSMART data monitor) and tools for system configuration (MiSMART configuration tools).

Accessing the system can be done through the use of a standardized web browser such as MS Internet Explorer, Mozilla Firefox… There are 2 access levels to the system:

- Administration level where user and system related settings can be configured and
- The user level wher many users can access data and analyze them in graphical or table form

4.2 Basic product functionalities

- Modular measurement instrument integration,
- Hierarchical organization of attached devices – tree structure which comprises of group and meter point nodes,
- Web user interface – supporting all web browser types,
- 3 tier user architecture (admin, master user, user)
- User groups, common data display usage,
- Periodic measurement data and EN50160 report acquisition,
- Alarm acquisition in real-time,
- Autonomous data sending from devices to the data center - (push system),
- reading instantaneous measurement data from devices– (polling system)
- supported devices:
    - Iskra - MC7xx in MT5xx (with buffer),
    - Iskra - X4 (X4-G, X4-W),
    - Iskra - C2/C100, C200
    - 3th part devices
- Supported device protocols::
    - TCP/IP - xml,
    - TCP/IP – C100?
    - SMS (MDDS),
- MS SQL database data storage,
- time synchronization of devices where this is enabled by the device,
- exporting data to Excel, Word, PDF
- importing historic data from device based recorders through MiQEN configuration software for off-line measurement instruments,
- inporting PQDIF and COMTRADE files into the system
- accessindata on measurements and alarms from instruments with a customizable graphic and table views,
- customizable user access rights,
- OPC server support,

- Integration to various SCADA systems viaOPC server,
- The platform is based on Microsoft server and web based technologies (MS Windows, .NET, IIS, MSMQ ...)

4.3 Platform architecture

By utilizing a modular aproach to the complete platform design we try to achieve a loosely coupled system. The system's implementation is based on service oriented architecture (SOA) and composes of a 3 tier architecture where every part represents a logically coupled unit:

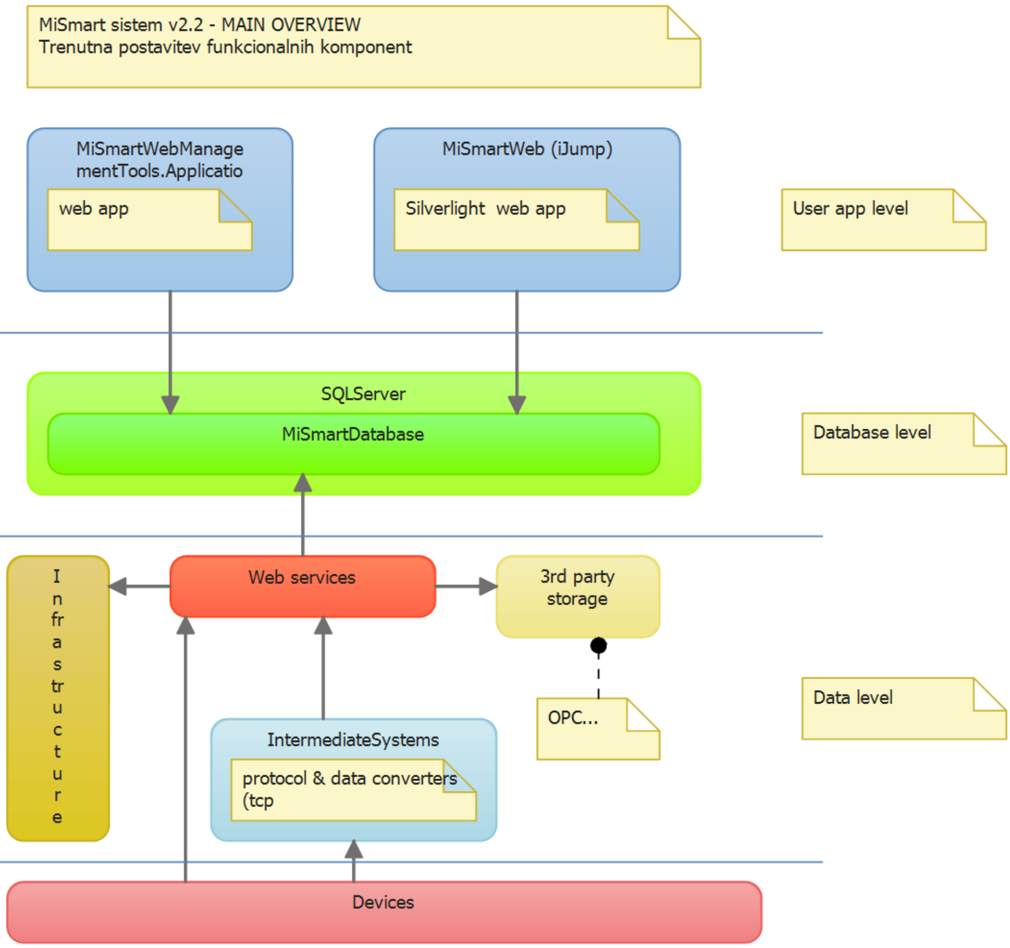


Figure 5: MiSMART platform architecture

Currently the system supports devices which are capable of sending measured data by means of a push principle. These data are autonomously transmitted to the network when they are available within the device:

- Via TCP/IP protocol in a specified xml format directly to a web service responsible for data collecting or
- Via protocol/data converter (e.g. SMS, IP) which transforms data from certain device types to a predefined format for the data collecting web service.

There can be multiple collection web services which store data into a centralized database. Simultaneous data sending to other external processes is also possible such as data integration via an OPC server to SCADA systems or other data warehouses.

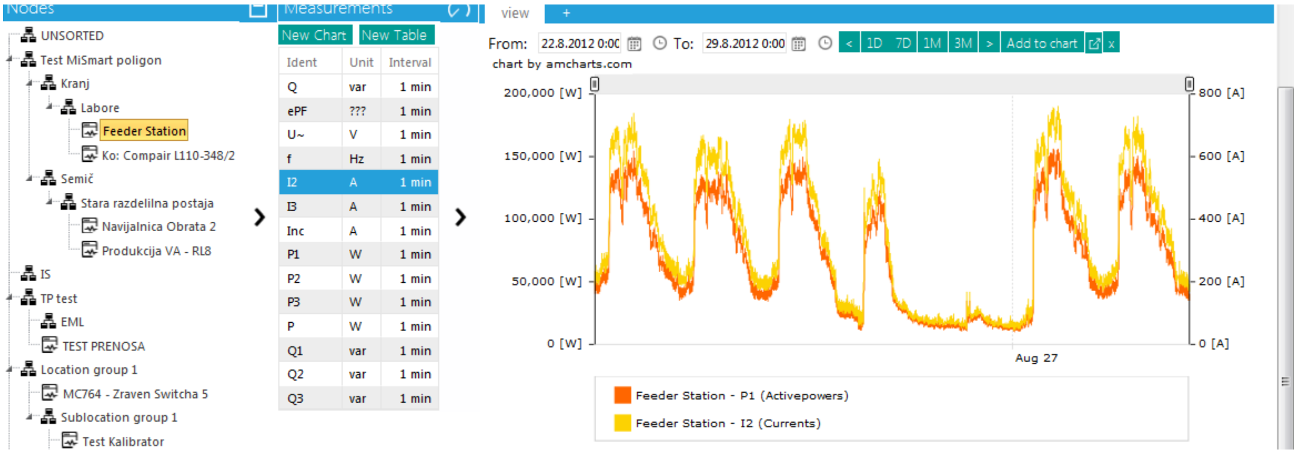
Data which is stored in the database is available to user applications for reviewing, manipulating and analysis. Currently the system consists of 2 applications:

- Configuration tools for system configuration
- Data monitor for graphic and table data reviewing

4.4 *Data reviewing with MiSMART*

4.4.1 Measurement reviewing

Measurement data is reviewed by first defining a filter for display, then selecting a particular meter point and then selecting a measurement quantity for displaying. Multiple measurement quantities from various meter points having different units can be displayed on one single chart at once:



Ident	Unit	Interval
Q	var	1 min
ePF	???	1 min
U~	V	1 min
f	Hz	1 min
I2	A	1 min
I3	A	1 min
Inc	A	1 min
P1	W	1 min
P2	W	1 min
P3	W	1 min
P	W	1 min
Q1	var	1 min
Q2	var	1 min
Q3	var	1 min

Figure 6:A chart containing two measurements

Apart from this it is also possible to show measurement data on multiple charts in multiple tabs and in an alternative – table form view. A case where 2 quantities are displayed in one chart is shown in the figure above.

Any displayed view can be saved and re-applied later on.

4.4.2 Alarm reviewing

Alarms can be reviewed in a similar way as measurements by selecting a particular meter point. The only difference is that an alarm table is shown for all alarms which have occurred in the specified time period for a selected meter point regardless of the measurement quantity they relate to:

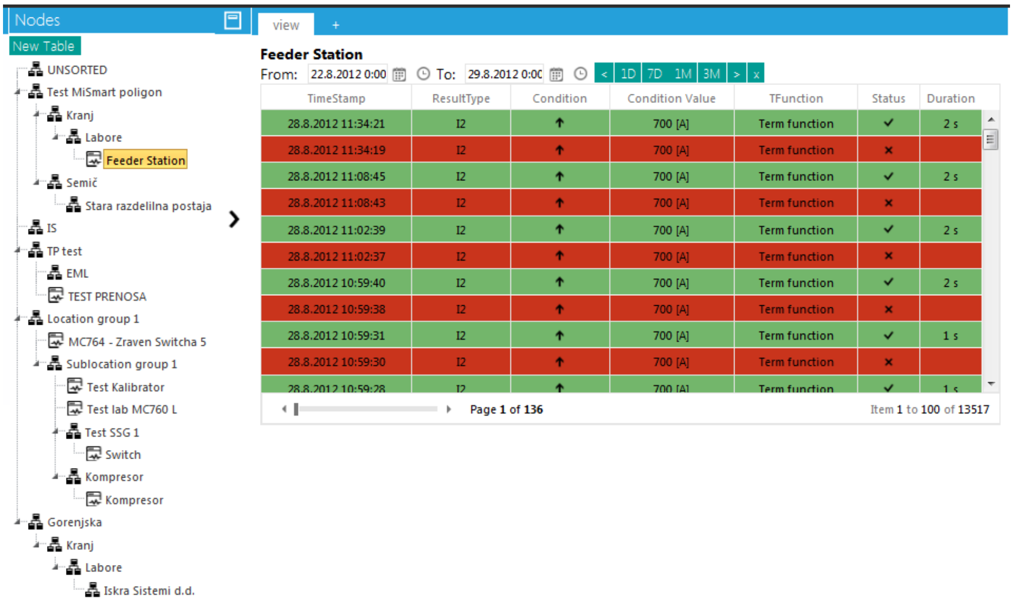


Figure 7: A table showing all alarms related to a selected meter point

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