**1 Table of Contents**

[2 Overview 3](#_Toc141444975)

[3 Initial Setup 3](#_Toc141444976)

[3.1 Install Process 3](#_Toc141444977)

[3.2 Site Setup 3](#_Toc141444978)

[3.2.1 Predefined Modbus Maps 3](#_Toc141444979)

[3.2.2 Generic Devices 3](#_Toc141444980)

[3.2.3 Thresholds 4](#_Toc141444981)

[3.3 Communication Capabilities 4](#_Toc141444982)

[3.3.1 Modbus Addressing over TCP/IP 4](#_Toc141444983)

[3.3.2 Satec ETCs 4](#_Toc141444984)

[3.3.3 Other Protocols 4](#_Toc141444985)

[4 Polling 4](#_Toc141444986)

[4.1 Scheduling 4](#_Toc141444987)

[4.2 Polled Values 4](#_Toc141444988)

[4.2.1 Basic Readings 4](#_Toc141444989)

[4.2.2 Energies 5](#_Toc141444990)

[4.2.3 Harmonics 5](#_Toc141444991)

[4.2.4 Future Modifications 5](#_Toc141444992)

[4.3 Data Log Retrieval 5](#_Toc141444993)

[4.3.1 Communication Errors 5](#_Toc141444994)

[4.3.2 Timestamped Values 5](#_Toc141444995)

[4.3.3 Application Specific Datalogs (Optional Module) 5](#_Toc141444996)

[4.3.4 Waveforms 6](#_Toc141444997)

[4.4 Configuration Information 6](#_Toc141444998)

[4.4.1 Device Information 6](#_Toc141444999)

[4.4.2 Device Basic Setup 6](#_Toc141445000)

[4.4.3 Device Faults 6](#_Toc141445001)

[5 Viewing Data 7](#_Toc141445002)

[5.1 Grouping and Hierarchy 7](#_Toc141445003)

[5.2 Graphical View 7](#_Toc141445004)

[5.2.1 Site View 7](#_Toc141445005)

[5.2.2 Device View 7](#_Toc141445006)

[5.2.3 Trend View 7](#_Toc141445007)

[5.2.4 Custom Dashboards 7](#_Toc141445008)

[5.3 List View 7](#_Toc141445009)

[5.4 Waveform Viewer 7](#_Toc141445010)

[5.5 REPORT TOOL 8](#_Toc141445011)

[6 Events and Alarms 8](#_Toc141445012)

[6.1 Device Triggered Alarms (DFR – Extra Module) 8](#_Toc141445013)

[6.1.1 Polled Alarms 8](#_Toc141445014)

[6.1.2 TCP Notification 8](#_Toc141445015)

[6.2 Software Triggered Alarms 8](#_Toc141445016)

[6.3 Alarm Response 8](#_Toc141445017)

[7 Other Requirements 8](#_Toc141445018)

[7.1 Help Files 8](#_Toc141445019)

[7.2 Firmware Updates and Device Configuration 8](#_Toc141445020)

[7.3 Complete Backup 8](#_Toc141445021)

[7.4 Data Export 8](#_Toc141445022)

[7.5 Site Import/Export 8](#_Toc141445023)

[7.6 Run as a Service/Daemon 8](#_Toc141445024)

[7.7 Encryption and Signed Data (Future) 8](#_Toc141445025)

[7.7.1 Encryption 8](#_Toc141445026)

[7.7.2 Signed Data 8](#_Toc141445027)

[7.8 Headless Operation 9](#_Toc141445028)

[7.8.1 Web Browser Interface 9](#_Toc141445029)

[7.8.2 Command Line Interface (CLI) 9](#_Toc141445030)

[7.9 ExpertPower Client 9](#_Toc141445031)

[7.10 Permissions and Usage Logs 9](#_Toc141445032)

[7.11 Diagnostics and diagnostic logs 9](#_Toc141445033)

[7.12 Digital Twin (Future) 9](#_Toc141445034)

[7.13 Protocol Converter (Future) 9](#_Toc141445035)

[8 Non-Technical Requirements 9](#_Toc141445036)

[8.1 Pricing Model 9](#_Toc141445037)

[8.2 Support 9](#_Toc141445038)

[8.2.1 Termination of support 9](#_Toc141445039)

# Overview

This document details an initial design and description of changes to be made to GPA’s existing software tools to satisfy SATEC’s requirements. In order to minimize cost and effort this design is based on GPA’s existing open-source tools, including the openXDA suite of tools and the openHistorian.

GPA currently has two sets of applications that satisfy most requirements listed in the SATEC document. The openXDA suite of tools, which is a set of applications designed to retrieve, process, analyze and visualize Power Quality type data. This includes Point on Wave Event Records as well as PQ Interval Data.



The primary component of this suite of tools that satisfies several SATEC requirements out of the box is openMIC. openMIC is designed to retrieve Power Quality data from various field devices (including DFRs and PQ Meters) and store that data on a central file share in a standard file format (PQDIF, COMTRADE). In order to satisfy data storage and data management requirements, GPA proposes to enhance openMIC with the integration of the openHistorian application.

openHistorian is a Time Series Data Store that was originally developed for Synchrophasor Data. GPA has previously made changes to the openHistorian engine to store other types of data including Point on Wave and PQ Interval Data.

In addition to openMIC and openHistorian, GPA has developed a wide range of PQ Data visualization applications including PQ Dashboard [1], PQ Browser [2], PQ Digest [3] and openSEE [4]. All of GPA’s applications are built on modern browser technology and designed to be highly modular.

In this document GPA proposes to develop a custom, branded, closed-source version of openMIC that includes the openHistorian engine for data storage and management and various parts of GPA’s visualization applications to meet the requirements established by SATEC at lowest possible cost.

Please note that this is a preliminary design and is to be used as technical and commercial overview only.

The proposed solution would be developed to complement SATEC’s other software offerings, namely PAS and ExpertPower.

The SATEC-branded openMIC would continuously poll SATEC Meters, while the openHistorian engine would store the data, allowing the user to view the meter data, statistics, and trends in the visualization applications.

# Initial Setup

## Install Process

All of GPA’s current tools are compatible with recent versions of the Windows operating system (64-bit Windows Server or newer and 64-bit Windows 7 or newer).

While there is currently no Linux version, all GPA products are built using .NET Technology and can be ported to Linux with low effort if necessary.

None of GPA’s software requires operating system admin privileges to be installed, nor does it require those privileges to run.

## Site Setup

When setting up a site, adding devices is straight forward, allowing the user to add each device individually with a simple way to configure the communication for each device. Adding devices in bulk/as a group is currently supported via SQL script. Development of a user interface for this process could be developed.

Each device can be defined by a human-readable, user-configurable device name. On top of that, the user can assign labels to a group or device, allowing for easy filtering.

A screenshot of a computer

Description automatically generated

Figure : Adding a new device in openMIC

### Predefined Modbus Maps

The software can be provided to the end user with predefined Modbus register maps for all SATEC devices; this exists currently for other devices and would simply need to be developed for SATEC.

As SATEC continuously develops new devices, the software can easily add new devices to future updates without much backend development effort.

### Generic Devices

The software allows Modbus maps of generic devices to be defined and added to the device tree. The software allows the user to save the custom configurations so that the user can reuse the map when adding similar devices to the site.

The user can use an existing device’s Modbus map as a starting point to modify the existing map and then save it with a different name. This can also be used to add generic Modbus addresses to the existing device for expanded monitoring, for example monitoring Ios on the device.

### Thresholds

For each monitored value, the user can define the minimum and maximum value. This allows for devices with different ranges to be compared to each other.

## Communication Capabilities

The software can communicate with the devices using Modbus over TCP/IP or Serially over COM ports.

The software analyzes the communication setup and notifies the user of any contradictions. If devices that share the same COM port have different baud rates, the software notifies the user of this contradiction but does not block the configuration.

Communication using ExpertPower Client would require development.

### Modbus Addressing over TCP/IP

When using TCP/IP Modbus addressing is supported, allowing for multiple slaves to share the same IP address. In the cases where multiple slaves do share the same IP address and port, the software does not have multiple sockets opened simultaneously, but rather it closes the socket after reading the values.

The software closes sockets whenever they aren’t in use in order to prevent device limitations around the number of simultaneous open sockets.

### SATEC ETCs

The software allows for a configuration that is wired through SATEC ETC.

### Other Protocols

The software currently supports communication over FTP, SFTP, and Modem RAS with FTP in addition to Modbus.

# Polling

## Scheduling

The software allows the user to customize the polling frequency of the devices. The software is able to modify the schedule on a per device basis, while a per value basis would require some development.

The software offers a separate polling schedule for datalogs and device configuration values.

To make sure the storage requirements are deterministic, the user can configure the amount of time the data is retained, where the oldest polled values are deleted. The software also displays to the user the expected storage requirements for the specific configurations. The user can define the max storage size and the software estimates the total log time for that configuration.

## Polled Values

The software includes Modbus maps for the following values:

### Basic Readings

Voltage – Per Phase

Current – Per Phase (Including I4 and Neutral where applicable)

THD Voltage and Current – Per Phase

Active Power, Reactive Power, Apparent Power, and Power Factor – Per Phase and total

Frequency

Present Volt Demand – Per Phase

Present Ampere Demand – Per Phase (Including I4 where applicable)

kW, kvar, kVA demands - Total

### Energies

On devices that support phase energies, these are logged as well:

kWh and kvarh – import

kWh and kvarh – export

kWh and kvarh – net

kWh, kvarh and kVAh – total

### Harmonics

Fundamental Magnitude Values for – V1, V2, V3, V4, I1, I2, I3, I4, kW L1, kW L2, kW L3, kvar L1, kvar L2, kvar L3, kVA L1, kVA L2, kVA L3, PF L1, PF L2, PF L3

Fundamental Phase Angles for – V1, V2, V3, V4, I1, I2, I3, I4s

\*Unless otherwise specified all values are 1 second average values.

### Future Modifications

As market demands evolve, the software is implemented in a way that would allow for the Mobus maps to be easily updated.

## Data Log Retrieval

### Communication Errors

In the event of a lapse in communication, the software can fill in the missing data (if available) from the data log.

### Timestamped Values

In the cases where accurate time stamped values are necessary, the software can pull time stamped data from the device.

### Application Specific Datalogs (Optional Module)

The software can periodically poll application specific datalogs and generate reports. The following features are included:

* Power Quality (PQ) Event Log
* Power Quality Compliance Reports, Statistics Report, and Harmonics Reports supporting both IEC50160 and IEEE1159
* Ability to export PQ reports in industry-standard file formats such as PQDIF and COMTRADE
* Event Log
* Sequence of events (SOE) log
* Fault (DFR) Log with distance to fault calculations

### Waveforms

On devices that support waveforms, all waveform logs are polled and stored.

Waveforms that correlate to events in PQ, SOE, or DFR logs are linked from the event in the respective record to the corresponding waveform and added to the log viewer.

## Configuration Information

The software polls the device for its configuration values for validation.

### Device Information

The following information is logged periodically by a module contained in a separate application that can be integrated into the proposed solution:

Device model ID – Compared to the configured device with a warning indicated if the values don’t match.

Device Serial Number – A notification can be sent if this value has changed.

Device Firmware version and build number.

### Device Basic Setup

The following configurations are logged allowing for future validation of the data by a module contained in a separate application that can be integrated into the proposed solution:

Wiring mode, PT ratio, CT primary current, Nominal line frequency, Phase order, Power demand period, Number of demand periods in a sliding window, Power calculation mode.

Currently users with elevated privileges can modify basic setup for **non-SATEC devices**. This includes the ability to enter the device passwords to modify these settings. The software can store the device password in a secure manner and only allows users with elevated privileges to make use of this. As GPA has already implemented this feature for other devices, we are confident in our ability to implement this for SATEC devices.

***4.4.2.1 RTC Synchronization***

The software polls the RTC and stores the drift, giving the user the ability to view timestamps on the server.

The software offers the ability to periodically update the on-device time using the time zone registers on the device **for non-SATEC devices**. Given this has already been implemented for other devices, GPA is confident in our ability to implement this for SATEC devices.

### Device Faults

The software monitors the device for faults and diagnostic flags, alerting the user in the event of a fault.

# Viewing Data

## Grouping and Hierarchy

When viewing the data, the device is displayed in a hierarchical manner, where child devices can be minimized or expanded at the parent node in the tree.

The software allows filtering by labels where devices with the selected labels can be hidden or displayed. For example, if the user only wants to view meters monitoring the HVAC system or if he/she wishes to view only meters on the third floor in building 6.

The user can save the different display configurations to a file allowing the user to reuse the view later.

## Graphical View

The default view is a graphical dashboard of the entire site with key parameters displayed for each device or group.

The views are user modifiable, allowing for dashboard creating in a user-friendly manner.

### Site View

The user can add small widgets that can be displayed for each device; these can be a list of select values, a small trend chart, or a gauge. If thresholds are defined, the user can select between absolute values or scaled values.

When configuring widgets for a group, the user can select if the value being displayed is the average, sum, max, or min of the children; when the max or min are viewed the device ID should be specified, allowing the user to know which device is associated with the max or min value.

The user can define a formula using basic arithmetic and not just display a single value.

### Device View

When clicking on a device in the site view, the user is shown the device view. When clicking on a group of values, the user can select if the values being displayed are the average, sum, max, or min of the children.

The software allows the user to configure a custom dashboard with different widgets showing the user relevant information for that specific device.

***5.2.2.1 Device Info***

The basic information about the device.

***5.2.2.2 History***

A user configurable trend plot, histogram, or heat map of the measured values.

***5.2.2.3 Diagnostics and Alarms***

Diagnostics and Alarms from the device, both real-time showing if the device is ok or if there are any active faults or errors, as well as a log of historical alarms and faults.

***5.2.2.4 Phasor Diagram***

A phasor diagram of all the three phases (I4 when available), current and voltage.

***5.2.2.5 Logs***

An option to view a list of data logs and the ability to open them.

### Trend View

The user can easily generate graphs and plots from all the measured values; this can be an individual value, a formula combining multiple values, or statistical values.

***5.2.3.1 Delta Values***

When viewing accumulated values, there is an advantage to being able to view delta values. The trend view can plot the deltas between each point in the plot. This data is usually presented best as a bar graph where each bar represents the accumulated value for the specified date range.

***5.2.3.2 Heat Maps***

Another useful graphical view is a heat map where values are displayed in a grid with a color scale.

An example grid can be:

* A weekly view with days on the vertical axis and hours on the horizontal axis.
* A monthly view with weeks on the vertical axis and days on the horizontal axis.

The value for each box can be the average, min, max, or the delta value for that time slot.

### 5.2.4 Custom Dashboards

The software allows the user to create custom dashboards like the device view but aggregating data from the entire site.

Aside from the mentioned widgets, the software can generate a Sankey Diagram for each parent in the device tree.

## List View

List view is a table of user selectable values allowing for easy comparison and custom report generation.

The list view can be exported to file formats to be used with common spread sheet software.

The software allows the user to store templates of different lists for quick and easy report generation.

## Waveform Viewer

In some cases, mainly when supporting DFRs, the meters record waveforms. The software can respond to the fault by polling and storing the waveform (this is done in a similar manner to the datalogs).

A screenshot of a computer screen

Description automatically generated

Figure : openSEE event waveform view

The user can view multiple waveforms on either a single plot or on multiple plots.

## REPORT TOOL

The software has a method of generating reports of the polled data, allowing the user to create custom reports from subsets of data. The user can also save a report template to generate repeated reports.

# Events and Alarms

Alarms can be defined either on the device or in the software.

## Device Triggered Alarms (DFR – Extra Module)

SATEC meters can allow users to define setpoints and alarms for recording faults with a high precision timestamp. The software can respond to the alarm by polling the relevant datalogs as well as initiating a user-defined alarm response.

### Polled Alarms

The software polls the devices to detect a flag and respond accordingly to that event.

### TCP Notification

Some of SATEC’s meters support a TCP notification mechanism where upon an event, the device will access a Modbus server and write values to 16 registers detailing the fault.

To implement this, the software would need to implement a Modbus server allowing the device to write to it. The software would then need to respond to the device accordingly.

## Software Triggered Alarms

The software gives the user the ability to define formulas, conditions, and setpoints to trigger alarms based on the measured values.

## Alarm Response

Aside from logging alarms within the software allowing a user to see previous alarms, the software also supports the ability to send e-mails and SMS in response to alarms.

# Other Requirements

## Help Files

The addition of built-in help files and tutorials showing the user how to use the software is possible.

It would be possible to have these instructions available directly from the applicable section (without needing to search).

## Firmware Updates and Device Configuration

The ability to write to the devices for basic configuration or updating device firmware would require development.

Developing this feature for use as a batch operation where the user can select multiple devices and the software would run the operation on all the selected devices, presenting the user with a report of which devices were successful and for which devices an error was encountered could be included.

## Complete Backup

The ability for the software to store a complete backup including the entire site configuration along with all previously logged data would require development, including the ability to use this backup to migrate from the MDM solution to ExpertPower.

Automatic backups could be included in this, along with the option to store only snapshots/deltas so as not to require full storage for each backup.

## Data Export

The software allows the user to export all polled data to common data file formats such as CSV, XML, and JSON.

## Site Import/Export

The ability for site configurations to be imported and exported would require development, along with templates of common configurations.

## Run as a Service/Daemon

The software runs as a Service where it runs in the background, starts automatically at boot, and restarts itself in the event of a crash.

## Encryption and Signed Data (Future)

### Encryption

Development would be required to allow for communication over Secure Modbus, though SFTP has been implemented elsewhere, so this is possible.

### Signed Data

For the software to have the ability to read and confirm that the read data is coming from the specified device using an authentication protocol would need to be developed.

## Headless Operation

The software supports headless operations where the software is run on a server without an HMI device.

### Web Browser Interface

The software exposes a subset of features using a webserver allowing for remote access using a web browser. This feature requires login and is limited with user access control.

### Command Line Interface (CLI)

To allow for remote control of the software, CLI can be used by users accessing the PC via SSH or similar methods.

## ExpertPower Client

In some cases, the devices can’t be assigned a fixed IP. In such cases, SATEC has implemented the ExpertPower Client model which allows the device to initiate communication with software and can be identified by its MAC address. After a socket has been established, the software will communicate with the device as a standard Modbus client.

## Permissions and Usage Logs

When enabled, the software allows for the creation of different user accounts where each account is given different levels of control and visibility, configurable on a per-module basis.

The following are the different permissions roles and their capabilities:

Admin – Full access.

Data Pusher –

Engineer –

Viewer – View only access.

The software currently logs (with timestamps):

* Failed access including username tried.
* Successful logins.

The following would need to be developed:

* Usage time.
* Any changes made and the user who performed them (some changes are currently timestamped, and the user is logged, but not all).

## Diagnostics and diagnostic logs

The software includes usage and diagnostic logs so the user and the SATEC support team can troubleshoot errors.

## Digital Twin (Future)

While it is not being implemented yet, it is believed that in the future the software will need to have the capabilities to synchronize with digital twin platforms.

## Protocol Converter (Future)

The ideal software solution will also serve as a protocol converter, allowing for other software systems that don’t use Modbus to read the device data. These can be local software systems such as BMS software where BACnet is required or cloud software that uses a RESTful API.

Another application would be able to integrate with the end user’s third-party software, for example VI software used for energy efficiency analysis.

While these specifications aren’t clearly defined at this point, the software package should be implemented in a way that would allow this to be implemented (relatively) easily.