Part of the SmartGate product family, the G Smart is an innovative controller for distribution networks that integrates both MV and LV network control and monitoring. While targeting advanced transformer station automation and MV circuit/feeder automation together with smart metering gateway and meter data concentrator, G Smart units can also be applied in advanced smart grid applications.

By integrating multiple automation functions with downstream LV smart meter data collection and management through multiple standard communication interfaces, G Smart enables true smart grid solutions from MV and LV network automation through street lighting, demand-side management, EV smart charging and microgeneration control.

The G Smart includes built-in Web server, I/O, data storage, fault detection, communications, condition monitoring, local energy metering and power quality analysis, as well as extensive self-monitoring. Full programmability in IEC 61131-3 languages along with software APIs allow user-defined algorithms and advanced applications to be implemented according to the needs of each project.

Virtual G Smart, a software-only variant of the G Smart controller, is also available for smart metering data collection applications.
G Smart is a product that provides numerous features related to monitoring, control, and management. It is CE marked and designed to fulfill all applicable international requirements, including isolation, immunity and emission. The G Smart is supplied nominal voltage at 230 V a.c. and can work with the presence of only one of three phases.

**Product Features**

**Construction and I/O Interfaces**

The standard factory device provides 4 digital inputs and 4 digital outputs. There are two optical expansion cards available, one for I/O capacity extension with additional 16 digital inputs and 8 digital outputs, and another for power quality measurement and management.

The G Smart is CE marked and is designed to fulfill all applicable international requirements, including isolation, immunity and emission. The G Smart supplied nominal voltage is 230 V a.c. and it can work with the presence of only one of three phases.

**Communication Interfaces**

The G Smart includes a wide range of communication options to enable multiple system architectures. The serial interfaces are commonly used for connectivity between SmartGate family products or third party devices on the TAN (Transformer Area Network), the PLC port is mainly used for interfacing LV meters and the GPRS/UMTS modem or Ethernet ports are used to integrate the system in the WAN. All communication interfaces include extensive self-monitoring, including online data and statistics.

**Management Interface**

For diagnostics and device management both the Ethernet ports as well as the two USB ports and one RS485 port can be used. Mounted on the device, four diagnostic LEDs are available (POWER, RUN and active and reactive power optical pulse counters).

Through the Ethernet ports G Smart provides an embedded web server for diagnostics, management, control and record extraction regarding all available functions on the device, including management of downstream units such as smart meters or external modules.

**Communication Protocols**

The G Smart provides numerous protocols that allow integration in several system configurations. The common setup includes IEC 60870-5-104 (TCP/IP) for remote control, Web Services for remote management, DLMS/COSEM for LV network communications and MODBUS protocol for local station communication. Those protocols can be used through several interfaces such as Ethernet, GPRS/UMTS, RS485, PLC or RF Mesh.

The web services functionality and supported DLMS protocol, widely used by distribution operators, enable user with several functionalities, such as general configuration of G Smart and smart meters; load diagrams, logs and tariffs configuration; demand management configuration; Power latching relay; cyclical tasks configuration; spontaneous events management; and others. In addition the web services are interacting with Efacc commissioning tool view4grid or DSO central systems.

Real-time clock synchronization can be performed via SNTP when the devices integrated in the network SNTP/NTCP clock availability. Multiple NTP time servers are supported for redundancy as well as several NTP communication modes for enhanced flexibility.

**Web-based Interface**

G Smart is supplied with a powerful HMI in an embedded web server that allows user-friendly and secure access to device configuration, system monitoring and control as well as meter network management. This functionality can be accessed securely with password protected user login through the Ethernet ports or GPRS/UMTS modem.

G Smart HMI modules allow, among other, to customize all G Smart functions, perform device management and access all logs, visualize all data collected locally or received from remote meters. Locally stored information can also be exported to CSV files for offline analysis or visualized through lists with convenient filters.

For operational purposes it is also possible to create and deploy user-defined mimics like in any sophisticated HMI, including graphical animation and control execution. Device management includes task programming, configuration, measurements and historic visualization, firmware upgrades, etc.

**Data and Event Logging**

The G Smart provides a range of organized logs to help the user access important logged data. Through the Alarm List it is possible to check relevant alarms and its timestamps, corresponding to user defined operational constraints out of range values, equipment events, metering and power quality events, etc. The device Event log stores all G Smart related events for offline analysis. A specific Power Quality event Log is also available for events and statistics compliant with EN 50160.
**Application Functions**

**MV/LV Station Automation and IEC 61131-3 Programming**

The G Smart can be applied as a smart RTU and MV/LV station automation unit providing built-in functions, such as MV fault detection, transformer monitoring and control, MV circuit breaker control, and several measures (RMS values, power factor and others).

As a standard-based controller, the G Smart is programmable with IEC 61131-3 languages that enables the deployment of user-defined programs such as MV self-healing sequences, generic switching sequences, alarm grouping and handling, among others. The IEC 61131-3 engine provides Boolean logic, integer and floating point arithmetic, standard blocks such as flip-flops, counters and timers. The programming environment is fully integrated in Automation Studio.

**MV/LV Station Condition Monitoring**

As more and more systems turn to condition monitoring for improved asset management, the G Smart becomes an invaluable help in performing local data acquisition and health assessment. Several operating conditions and alarms such as intrusion, fire, flood, LV circuit status transformer and cabinet temperature can be monitored, detected, reported and integrated for advanced algorithms.

**Street Lighting Control**

G Smart provides an optional software module for street light control, including not only manual control, status and lighting statistics, but also scheduling and management including:

- Time table: flexible user-defined scheduling, including support for schedule exceptions;
- Astronomic clock: street light is automatic controlled by sunrise and sunset time;
- Association to street light meters: street light schedule is setup via meter configuration and monitoring of lighting statistics, energy consumption monitoring and additional smart meter control is also available.

Configuration options can be locally managed through the web-interface or through remote and central street light management platforms such as eLumen.

**Smart Meter Management**

The G Smart is completely prepared to communicate with Efacc or third-party smart meters. It offers several features for easy integration and management such as meter plug-and-play, automatic detection of powered smart meters, collection and reporting of metering records and events, manage and control tariffs, power cuts, load profiles, billing data, etc.

### Smart Meter Management and Meter Reading

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV Meter Concentrator (Residential Meters, Micro-Producers, etc)</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>Meter Management (Tariffs, Power Cuts, Messaging, Contractual Max. Power, etc)</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>Meter Plug and Play</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>Automatic Meter Reading (Load Profiles, Billing data, etc)</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>Automatic Meter Phase Association</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>Energy Balance</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>Load Unbalances</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>LV Fault Detection</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>Demand Side Management</td>
<td><strong>-</strong></td>
</tr>
</tbody>
</table>

* Communication Protocol-Dependent.

**LV Energy Balance**

Monitoring of the relation between energy supplied by the power transformers and consumed by the attached clients is possible with the LV energy balance function, which provides a straightforward mechanism to detect technical and non-technical losses by generating alarms and reports. Multiple configuration options are available including multi-period energy balancing, multiple measured quantities and balancing parameters. The smart meters installed in the distribution cabinets along the LV network, enable the identification of the consumers where the problem can exist.

**LV Load Unbalance**

The function of load unbalance is part of a set of protection algorithms of G Smart. This function detects load unbalance between phases of the LV network according to established detection parameters, including fixed or relative levels, and generates convenient alarms or reports.

**Clients under Outage**

With this alarm function the user can quickly detect potential faults in the LV distribution and/or outages of critical clients. Parameterization of this function includes minimum percentage of clients under outage for different priority levels and also different geographic areas.

**LV Fault Detection**

By correlating the aggregated smart meter communication failure data, and information from the sensors installed along the LV network, G Smart can detect faults. It can also provide geolocation and phase association information, not only to accurately detect LV circuit failures, but also to provide troubleshooting information to aid in the system restoration, thus decreasing the time under outage.

### Monitoring of Power Quality

The G Smart, when equipped with the Power Quality expansion board, can analyze, monitor and register power quality parameters from the local measured voltages. Measurements and their aggregation mechanism fulfill Class A uncertainty requirements as well as measurement aggregation requirements and flagging concept according IEC 61000-4-30.

Furthermore, it is possible to monitor voltage parameters and generate alarms by setting operational thresholds and integration times for frequency, voltage magnitudes, flicker, THD, harmonic content, voltage unbalance.

Concerning voltage disturbances, G Smart provides statistics that includes counters and total time for each type of disturbance and for each phase.

Beyond measurement and recording, G Smart also detects, stores and reports power quality events with millisecond precision, such as disturbances in the measured voltage value, alarms associated with monitoring, user actions.

### Smart Meter Management and Meter Reading

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Disbalance Analysis (Dips, Swells, Interruptions)</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>Voltage Harmonics Measurement (up to 50th order)</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>Total Voltage Harmonics Distortion</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>PV Balance with Calculated U1, u0 and u2</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>Flicker (PfL, PfL)</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>Frequency</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>Power Quality Alarms</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>Aggregated Measurement Recording</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>Power Quality Data Export (PQDIF, CSV)</td>
<td><strong>-</strong></td>
</tr>
</tbody>
</table>

* Communication Protocol-Dependent.

**-** Optional Feature.
Advanced Applications

The G Smart is also uniquely positioned to host a number of advanced applications such as automatic voltage control, smart load shedding and restoration, active demand-side management (DSM), combined microgeneration and storage control, electric vehicle smart charging or even more advanced applications like virtual power plant management.

Automatic Voltage Control

The G Smart automatic voltage control functionality is based on an advanced algorithms that with data received from attached smart meters is enable to detect over/under voltage at the LV network. With advanced calculations, the achieved set points are sent to grid elements (solar panels, batteries, homes, transformer taps, or electrical vehicles) in order to solve the over/under voltage situation. This algorithm is centralized and acts at the LV grid's level.

Smart Load Shedding and Restoration

The G Smart provides the ability to perform real-time selective and iterative load shedding in the attached LV network, according to current load status shedding set points and load criticality. It also supports ensuing load restoration. By applying smart load shedding and restoration as a preventive function, distribution network QoS can be enhanced and finer grain control over load and generation balancing achieved.

DSM Autonomous Controller

The G Smart can be equipped with an algorithm that manages the consumption of energy downstream, by sending DSM set-points to attached smart meters to reduce or restore the individual demand of each customer’s selected circuits/appliances depending on previous commercial framework. Network operation can be autonomously optimized by combining local control with network set points, reducing technical losses and control of voltage profiles within the regulatory limits, hence resulting in QoS improvement and system performance enhancement with limited investment.

Electrical Vehicle Management

G Smart can monitor the EV charging stations, being responsible for the integration of the EV with the electrical network. Furthermore, not only it manages the operational data but it can also perform intelligent functions according to the real-time system condition. The G Smart processing capabilities allows smart charging strategies to be implemented, coordinating the EV charging cycles in order to minimize the impact on the distribution network operation. Moreover, when permitted by the EV manufacturer, vehicle-to-grid can be performed offering ancillary services and capacity availability for optimal renewable integration.

Virtual Power Plant

As yet another advanced smart grid scenario, the VPP comprises the aggregation of various distributed resources that can be used in the same manner as conventional generation. The G Smart, given its processing capabilities, control strategies and the concentration of data collected from lower voltage levels, is ideally suited to coordinate microgeneration unit clusters.

G Smart units may be applied as VPP management computers in advanced grid applications, by managing DER (Distribution Energy Resources) options according to technical and commercial VPP strategies. Intelligent control algorithms combine data obtained from LV connected smart devices and dispatch solutions in real-time to microgeneration units and storage devices according to technical and market conditions.

Architecture

[Diagram of G Smart Architecture]
Applications

Application Overview

**G Smart** is a smart controller targeted for Smart Grid deployments. By bundling intelligent functions and capabilities, it is a focal point for smart monitoring, metering, management and control of advanced distribution networks in an economical, secure, safe and environmental friendly way.

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Application Description

**Advanced Transformer Station Automation**

- RTU and MV cell monitor and control
- MV fault detection
- Local energy metering and power quality analysis
- Station and transformer condition monitoring
- Multiple transformer arrangements

**Smart Metering Gateway**

- Meter reading/collector
  - Local storage
- Meter management
  - Meter plug-and-play
  - Meter events
  - Tariffs
  - Messaging

**Integrated Smart Grid Applications**

- Metering gateway
- Local energy metering and power quality analysis
- RTU and MV automation
- Street light management
- Microgeneration control
- EV Integration and smart charging
- Technical infrastructure management (MV and LV)

**Advanced Smart Grid Applications**

- Demand-side management
- Combined control of consumption, storage, EV charging and microgeneration
- Islanded and grid-connected operation
- Technical and economical energy management